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In the mid2030s, the health of the baby boomers will have deteriorated and many in these large cohorts will be in need of formal and/or informal long-term care.

This "**care wave**" will transform two generations: the baby boomers in need of care and their children who may supply care. It will have significant implications for labour supply, especially for women, saving behaviour, and therefore for productivity, economic growth and its inclusiveness.

The overarching objective of BB-Future is to understand the size and the implications of the care wave on economic and social outcomes, to appreciate the quality of this second ageing-related transformation and to develop policy recommendations for advance planning on the EU and Member State levels.

BB-Future evaluates social policy with the help of formal models based on individuals who think in a life cycle context with perfect foresight, full information and in a time-consistent manner. This deliverable sheds light on several aspects of social policy evaluation when these assumptions do not hold, using a multi-country model of procrastinating households. Our focus is on the interaction between the share of procrastinators in a country, the speed and extent of population aging, and the size of public social security systems encompassing long-term care, healthcare and public pensions. We conclude that saving and labor supply behaviors do not change qualitatively, but quantitatively depending on the extent of shortsightedness. However, welfare implications also change qualitatively.

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Social policy when households have biased expectations and procrastinate

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Abstract

BB-Future evaluates social policy with the help of formal models based on individuals who think in a life cycle context with perfect foresight, full information and in a time-consistent manner. This deliverable sheds light on several aspects of social policy evaluation when these assumptions do not hold, using a multi-country model of procrastinating households. Our focus is on the interaction between the share of procrastinators in a country, the speed and extent of population aging, and the size of public social security systems encompassing long-term care, healthcare and public pensions. We conclude that saving and labor supply behaviors do not change qualitatively, but quantitatively depending on the extent of shortsightedness. However, welfare implications also change qualitatively.

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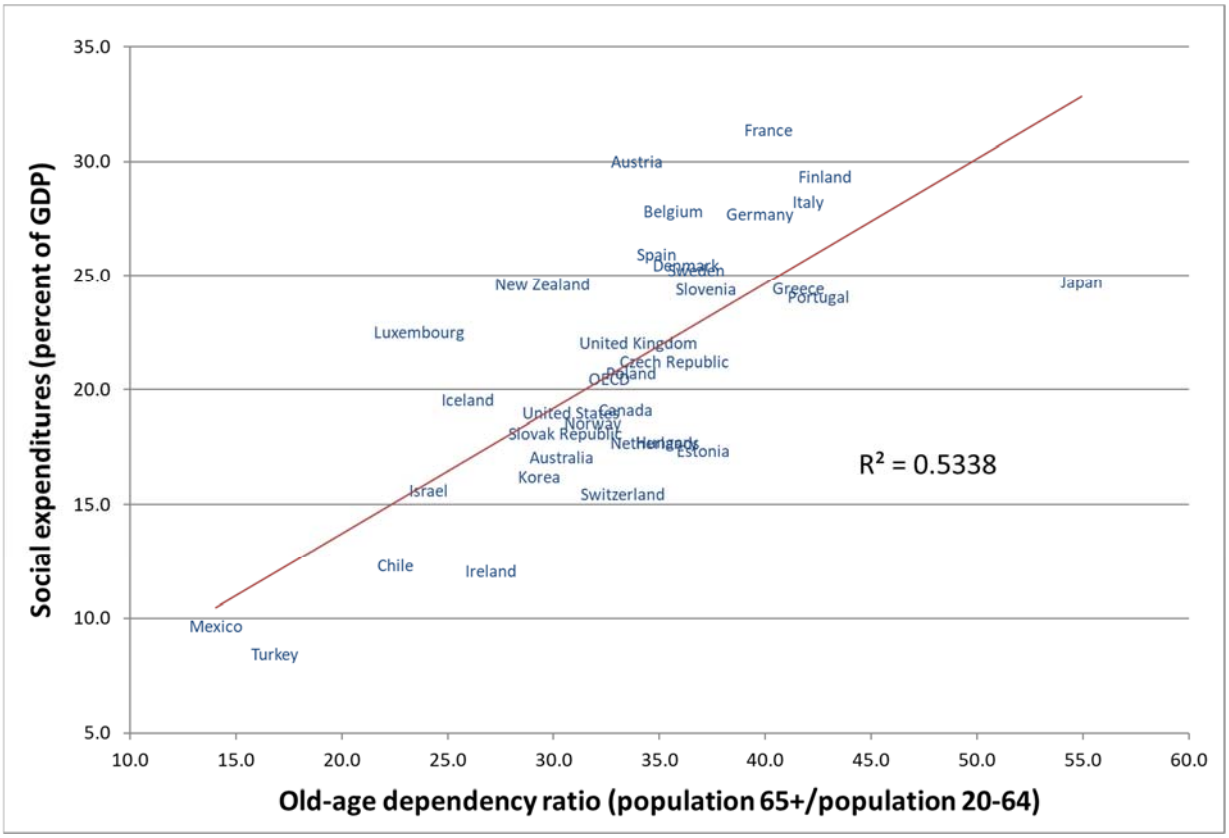
1. Introduction

The uncertain future of social security systems -- here encompassing public long-term care, public healthcare and public pension systems – due to population aging is a topic of high priority and large controversy. The pressures on these systems are particularly pronounced in Europe, because the number of retirees per number of workers is already very high and still increasing until about 2050. This strain will affect all types of social security systems, whether they are pay-as-you-go (PAYG), fully-funded (FF), defined benefit (DB), or defined contribution (DC), albeit to a very different extent.

A large number of older individuals per working age population in a country exerts pressures on the economy of a country since these social expenditures demand a high share of GDP, ranging in Europe from 12 percent in Ireland to 32 percent in France (Figure 1, horizontal axis).

FIGURE 1: Social expenditures (percent of GDP) by old-age dependency ratio



Source: OECD Pensions at a glance (2015). Old-age dependency ratio is population age 65+ divided by population of age 15-64 (2013 data). Public and private pension expenditures are share of GDP (2012 data).

However, the alignment between the extent of population aging and social expenditures is far from perfect, as the R-squared of 53% indicates. Many European countries have public social expenditures significantly above the regression line (e.g. France and Austria), while many Asian countries have much smaller social security systems relative to their demographic status

(e.g. Japan and Korea). Some European countries also have much lower social expenditures than expected given their demography, e.g. the Netherlands and Estonia. These deviations from the regression line are mainly due to the many design differences between national social security systems, which have complex eligibility rules and often highly non-linear benefit assignments. Hence, when studying the impact of population aging on social security systems, particularly in an internationally comparative context as done in the BB-Future project, it is important to take account not only of international differences in demography but also these complex design differences.

The complexity and non-linearity of social policy rules is the reason why the BB-Future project uses structural models rather than extrapolation models to analyze existing and new social policies. Well-known extrapolation models are Leaf et al. (2020) who have developed the "Future America Model", which projects morbidity and mortality among US Americans as a function of healthcare and other interventions, and the microsimulation models of Ben Jelloul et al. (2022) who predict future care needs based on transition probabilities from healthy to dependency status. These extrapolation models cannot take behavioral feedback reactions into account and therefore tend to overestimate policy effects and mislead incidence analyses as pointed out in the famous critique by Lucas (1976).

In order to overcome the Lucas critique, economists with an interest in pensions, healthcare and long-term care (LTC) have traditionally employed formal models based on individuals in overlapping generations who think in a life cycle context with perfect foresight, full information and in a time-consistent manner (e.g.: Auerbach and Kotlikoff, 1987; Börsch-Supan et al. 2023). There is, however, a large body of evidence indicating that individuals fail to make decisions in a time-consistent manner, lack full information and are much more present-oriented than assumed in the perfect foresight life-cycle model. Opinions among citizens range from complete ignorance about how serious the challenges are to the equally faulty belief that pension systems are doomed to a complete failure (Boeri et al., 2001; 2002; Walker et al., 2014).

In many countries, one can also observe the widespread failure to provide sufficiently early and consistently for retirement income in the sense that such saving is sufficient to offset actual and future benefit cuts (Börsch-Supan et al. (2015), Börsch-Supan et al. (2016a) for Germany; Knoef et al. (2016) for Netherlands, and Crawford and O'Dea (2012) for the UK). In the US, such under-saving for retirement has received widespread attention (Poterba et al., 2012; Repetto et al., 1998; Madrian and Shea, 2001).

Individuals seem to realize these failures – but too late. Börsch-Supan et al. (2022) conducted an Internet survey among individuals aged 60 and older. The results of the survey show a substantial prevalence of regret over previous saving decisions. 60% of the respondents wished that they had saved more when they were younger. High demand for commitment devices, even when they are costly, provides more evidence to this finding (Rabin, 2013a; b; Ashraf et al., 2006; Beshears et al., 2011).

In order to tackle this evidence, several strands in the literature emerged. A first strand enriches the neoclassical textbook model of time-consistent households by elements that justify the existence of a public pension system. Such elements include poverty alleviation and longevity risks (Börsch-Supan, Härtl and Leite, 2016), income risks, market failures and information costs (Chan and Stevens, 2008; Bucher-Koenen and Lusardi, 2011; Lusardi and Mitchell 2011; 2014; Lusardi et al., 2013).

This deliverable focusses on a second strand of research which more radically replaces the neoclassical paradigm with models of time-inconsistent behavior (Thaler, 1994; Laibson, 1997; 1998; Angeletos et al., 2001; Choi et al., 2002; Rabin, 2013a; b; Della Vigna and Malmendier, 2006). There are several avenues to model imperfect household decisions, such as myopia, present bias and procrastination, each of which carries different implications for social insurance and population aging. These modeling approaches are by no means new (Strotz, 1956; Phelps and Pollak, 1968; Pollak, 1968; Thaler and Shefrin, 1981) but have only found widespread attention when they were applied to retirement saving in the US (Laibson, 1997; 1998; Madrian and Shea, 2001).

This deliverable is concerned with the implications of such time-inconsistent behavior for social policy evaluation. This includes long-term care – particularly relevant for the BB-Future project – but also healthcare and public pensions. It employs a multi-country model of procrastinating households developed by Börsch-Supan et al. (2018) in order to shed light on several aspects of social policy when the traditional assumptions do not hold. While there are a handful of macroeconomic models with time-inconsistent agents in a one-country setting (e.g., Imrohoroglu et al. 2003 and Fehr et al. 2008), the novelty here is to take account of the international embeddedness of the European countries not only within the European Union but also within a global context. Our model is designed to compare the EU with the US and Japan, and to shed light on the interactions among three traits that characterize these countries: the share of procrastinators, the speed and extent of population aging and the size of public social security systems that are financed PAYG and follow the DB-principle by defining benefits ex

ante. Section 2 describes the modelling framework, Section 3 provides the results, and Section 4 summarizes the main conclusions.

2. Theoretical framework

Departure for our model is the insight stressed in the introduction that the effects of demographic change on social security systems, their design and individual saving behavior strongly interact in a global context. On the one hand, the provision of social insurance reduces risks for households which may be hard, or even impossible, to cover on an individual basis. On the other hand, it reduces the need for private savings to provide for old-age consumption and may thus reduce the level of productive capital in an economy. Population aging tends to sharpen this trade-off. International movements especially of capital, in turn, may alleviate the demographic pressures since retirement savings of households in quickly aging countries can be invested in countries with a more advantageous demography.

This section describes a model of how these trade-offs and alleviating mechanisms work under the assumption that households fail to plan ahead. It is taken from Börsch-Supan et al. (2018). Does this assumption fundamentally change how these trade-offs and alleviating mechanisms are affected by population aging versus the traditional model of perfect foresight and time-consistency? The model also sheds new light on some of the key controversies among economists interested in saving behavior and social insurance to be discussed in Section 3.

2.1 Household behavior

2.1.1 A generalized model of consumption, saving and labor supply

A first and very simple way to model the failure to plan ahead is to extend the neoclassical model by assuming that welfare evaluation is still following a time-consistent perfect-foresight program, although the actual decision function is subjected to individual short-sightedness. This will be the basic building block on households' behavior that will be later integrated into the general equilibrium model. Household i at time t receives utility from consumption $c_{t,j}$ and leisure $1\text{-}l_{t,j}$, where $l_{t,j}$ is the time spent working. The most conventional specification is a per-period utility function given by

$$(1) \qquad u(c_{t,j},1-l_{t,j}) = \frac{1}{1-\theta}\left(c_{t,j}^{\phi}\cdot\left(1-l_{t,j}\right)^{1-\phi}\right)^{1-\theta},$$

where risk aversion and intertemporal substitution are jointly described by the single parameter θ while ϕ denotes the utility weight of consumption versus leisure. The household

solves a utility maximization program over the entire life-cycle, such that the maximization problem of a cohort born in period t at $j=0$ is given by

$$\max \{ u(c_{t,0}, 1-l_{t,0}) + \delta \sum_{j=1}^{J} \beta^j \sigma_{t+j,j} u(c_{t+j,j}, 1-l_{t+j,j}) \}. \quad (2)$$

There are three different elements of discounting the future utility from consumption and leisure. First, β represents the pure time discount factor:

$$\beta = 1/(1+\rho). \quad (3)$$

Second, households discount future utility with their unconditional survival probability $\sigma_{t,j}$, expressing the uncertainty about the time of death.

Third, the parameter $0 \leq \delta \leq 1$ defines the degree of short-sightedness or present bias. At one extreme, $\delta = 0$. In this case, the household is totally myopic and disregards all future utility. At the other extreme, $\delta = 1$, we are back to the neoclassical model of time-consistent behavior. In the intermediate cases, future utility is discounted more than exponentially relative to present utility.

Populations may not be homogenous in their degree of short-sightedness or present bias. In some applications, we will divide the population into two groups: γ is the share of households who have present bias ($\delta < 1$) while 1-γ of the population plans and behaves in a time-consistent manner.

We do not include intended bequests in our model and assume that accidental bequests resulting from premature death are taxed away by the government at a confiscatory rate and used for otherwise neutral government consumption.

Households earn an age-specific labor income $l_{t,j} \cdot w_{t,j}$ until retirement age R (where $w_{t,j}$ denotes the hourly wage) and may then receive a social security benefit $p_{t,j}$. This benefit represents a combination of social security benefits that accrue as individuals age, composed of public pensions, healthcare and long-term care. It is financed by a contribution proportional to the labor income at rate τ_t. Hence, current disposable non-asset income $y_{t,j}$ is

$$y_{t,j} = \lambda \cdot l_{t,j} \cdot w_{t,j}(1-\tau_t) + (1-\lambda) \cdot p_{t,j}, \quad (4)$$

where $\lambda=1$ for $j=0,\ldots,R$ and $\lambda=0$ for $j \geq R+1$.

Denoting total assets by $a_{t,j}$, maximization of the household's intertemporal utility is subject to a dynamic budget constraint given by

(5) $$a_{t+1,j+1} = a_{t,j}(1+r_t) + s_{t,j}$$

where discretionary saving, $s_{t,j}$, is defined as

(6) $$s_{t,j} = y_{t,j} - c_{t,j}\,.$$

2.1.2 Procrastinating households

Myopia ($\delta = 0$ in equation (2)) is an extreme assumption. A milder deviation from the perfect-foresight life-cycle model is self-control problems. The key assumption is that households plan according to the life-cycle model but then fail to execute their plan, e.g., by procrastinating the decision to set up and pay into a retirement savings account.

Procrastinating behavior is modeled as a continuing game between the current and future self, where the immediate future is discounted more strongly relative to the present than two equally distant events further in the future (Thaler and Shefrin, 1981). The model has three main features: (a) the addition of a present bias parameter δ which discounts the immediate future additionally to the standard discount factor β and mimics hyperbolic discounting, (b) the distinction between the present bias δ of the current self from the belief about the present bias of the future self, denoted by $\hat{\delta}$, and consequently, (c) the distinction between actual consumption behavior c_j from beliefs about future consumption behavior $\hat{c}_{j+1}$. The notion of different "selves" with changing preferences allows us to model different features of individuals and how saving and consumption behavior changes due to these characteristics and the sequence of these "selves" with conflicting preferences and future beliefs. Since the behavior of these households moves away from the traditional assumptions, but still stems from such causes as monetary or psychic costs of decision making, we always refer to these households as time-inconsistent. In specifying future beliefs, according to O'Donoghue and Rabin (1999), it is possible to distinguish between "naïve" and "sophisticated" hyperbolic households. They only differ in their own perception of future preferences. While the naïve households believe that their future selves will behave in a time-consistent manner although they have consistently violated this belief in the past, i.e. $\hat{\delta}=1$, the more sophisticated households correctly foresee that their future selves will also behave in a time-inconsistent way, i.e. $\hat{\delta}=\delta < 1$. Therefore, sophisticated households seek to overcome this misbehavior by constraining their future consumption. We therefore avoid terms such as "rational" and "irrational" behavior.

The current self at age j maximizes the objective function

(7) $\max \{ u(c_j) + \delta \cdot \beta \cdot \sigma_{j+1} \cdot \hat{V}(z_{j+1}) \}$

by choosing current consumption c_j, subject to the budget constraint (equation (5)) and his beliefs $\hat{V}(z_{j+1})$ about the behavior of his future selves for the future state z_{j+1}. The value function $\hat{V}(z)$ for future beliefs is computed recursively by

(8) $\hat{V}(z_j) = u(\hat{c}_j) + \beta \cdot \sigma_{j+1} \cdot \hat{V}(z_{j+1})$.

Note that the present bias δ of the current self does not appear in the value computation. His future self who is at age $j + 1$ will maximize

(9) $\max \{ u(\hat{c}_{j+1}) + \hat{\delta} \cdot \beta \cdot \sigma_{j+2} \cdot \hat{V}(z_{j+2}) \}$

by choosing future consumption $\hat{c}_{j+1}$, where δ is replaced by $\hat{\delta}$ compared to (7). Finally, welfare is computed based on the actual behavior of households:

(10) $V(z_j) = u(c_j) + \beta \cdot \sigma_{j+1} \cdot V(z_{j+1})$.

Preferences are time-inconsistent because the present bias parameters δ and $\hat{\delta}$ appear in the decision problems (7) and (9) but not in the calculation of the value functions (8) and (10). Sophisticated hyperbolic consumers (where $\delta = \hat{\delta} < 1$) behave differently compared to time-consistent consumers (where $\delta = \hat{\delta} = 1$). For naïve hyperbolic consumers (where $\delta < 1$ and $\hat{\delta} = 1$), however, the decision rules and the respective value functions of current and future selves do not coincide (Fehr et al., 2008; Imrohoroglu et al., 2003).

Equations (7) to (10), jointly with equations (1) to (6), solve the household model and constitute the household module of the general equilibrium model presented in the next section. We first set $\delta = 1$ and apply the dynamic budget constraint (equation (5)), but do not impose a borrowing constraint. We then deviate from this neoclassical set-up and model households which are time-inconsistent due to present bias and procrastination as described in equations (7) through (10).

2.2. The international macroeconomic perspective

We now leave the microeconomic perspective and take the view of international macroeconomics. An important argument in favor of fully-funded (FF) social security systems for countries with a strongly aging population is that the assets can be invested in countries

which have a less pronounced aging process, while PAYG social security systems depend on the size and productivity of the domestic work force. Earlier research has demonstrated the beneficial effects of such international diversification (Reisen, 2000; Rios-Rull, 2001; Brooks, 2003; Börsch-Supan et al., 2006; Attanasio et al., 2007; Börsch-Supan and Ludwig 2009; 2013; Attanasio et al. 2016). This section investigates whether these results also hold when households are time-inconsistent. Specifically, we simulate the size of capital flows and welfare when the share of time-inconsistent households differs between the capital exporting and the capital importing countries. We employ several variants of computational general equilibrium (CGE) models with an overlapping generations (OLG) structure that permits a quantitative assessment of capital flows and their welfare implications.

We do not model frictions to the capital market and allow for free capital flows across countries. This assumption appears to contradict the seminal work by Feldstein and Horioka (1980) who found a strong positive correlation between a country's investments and savings (for OECD countries), which was interpreted by the literature as evidence for lower than perfect capital mobility between countries. Contradicting conventional wisdom about free international capital flows, Obstfeld and Rogoff (2000) called this finding "The Feldstein-Horioka Puzzle" and included it in their list of the six major puzzles in international macroeconomics. A large number of follow-up literatures tried to explain this observation. According to Coakley et al. (1998) and Apergis and Tsoumas (2009), the majority of studies in modern literature find theoretical or econometric explanations for this effect, implying that Feldstein and Horioka's puzzle does not collide with the free capital flow hypothesis. This paper adds another explanation for relatively small international capital flows which is based on myopic behavior and/or procrastination.

The following subsections describe the multi-country macroeconomic model. It uses the building blocks from Subsection 2.1 and closes the model with a simple production sector. We then compute the general equilibrium for the four countries/country groups introduced at the beginning of this section with three dimensions of international exchange: First, there is trade in the goods and services produced by each country. Second, there are corresponding capital flows between countries. Saving and investment decisions are governed by a common global interest rate which, via international capital flows, equalizes the return to capital across countries. Assets held by households in a country are therefore not necessarily equal to the domestic capital stock in that country, nor does saving necessarily equal investment in a single country. Third, there is migration which we will treat as exogenous such that the international equilibrium is uniquely defined by the world interest rate.

2.2.1 Demography

Demography is described by the initial size of each cohort and the survival of that cohort. In the notation below, we abstract from migration although in our simulations we add the historical average of net migration as a constant to population size. Let $N_{t,j}$ denote the number of individuals of age j at time t. They were born in year $c = t\text{-}j$ and are the survivors of the original birth cohort $N_{c,0}$:

$$(11) \quad N_{t,j} = \sigma_{t,j} \cdot N_{c,0} \, .$$

Here, $\sigma_{t,j}$ denotes the unconditional probability to survive until age j which will be in year t. The original cohort size for cohort c depends on the fertility of women aged k at time $c = t\text{-}j$:

$$(12) \quad N_{c,0} = \sum_{k=0}^{\infty} f_{c,k} \cdot N_{c,k} \, .^{1}$$

Population aging has therefore three demographic components which differ significantly across countries: past and future increases of *longevity*, expressed by $\sigma_{t,j}$; the *historical transition from baby boom to baby bust* expressed by past changes of $f_{t,k}$; and *fertility* below replacement in many countries expressed by current and future low levels of $f_{t,k}$.

We treat all three demographic forces as exogenous. The actual data are the medium variants of the long-term population forecasts provided by the Human Mortality Database and the UN Population Trends. Households are the decision units. They enter economic life at an age which we denote by j=0 and have a finite life span defined by the high mortality at very old age. This generates the OLG structure of the CGE model which is essential for modeling social security issues.

2.2.2 Social security system

The next building block is the public PAYG-DB social security system, representing public pensions, healthcare and long-term care. Revenue in year t is the product of the contribution rate τ_t, the average labor income $l_{t,j}\, w_t$ and the number of workers NW_t defined as:

$$(13) \quad NW_t = \sum_{j=0}^{R} N_{t,j} \, ,$$

where R denotes the retirement age. Expenditure in year t is the product of the average social

[1] We use the convenience of an infinite summation to avoid the assumption of a fixed time of death. The notation does not imply households with infinite lifespans. Since $\sigma_{t,j}$ and $f_{c,k}$ become very small for j>100 and k>50 respectively, $N_{t,j}$ is zero for large j and all sums in this chapter are finite.

security benefit p_t and the number of social security recipients NP_t, defined as:

$$(14) \quad NP_t = \sum_{j=R+1}^{\infty} N_{t,j} .$$

This results in the PAYG budget equation:

$$(15) \quad \tau_t \cdot l_{t,j} \cdot w_t \cdot NW_t = p_t \cdot NP_t .$$

The PAYG system is of the *defined benefit* type where a cohort of retirees is promised a benefit p_t defined by a replacement rate q_0 which relates social security benefits to the net wage but is independent from the demographic and macroeconomic environment:

$$(16) \quad p_t = q_0 \cdot w_t \cdot (1-\tau_t).$$

Making all types of social security benefits proportional to the wage is a strong assumption since healthcare and LTC benefits are related to health rather than wage. Two observations justify this simplifying assumption. First, wage-related public pensions are the main element of social security benefits and make up between 40 and 60 percent of total benefits. Second, healthcare and LTC have wage-related components such as paid sick leave and compensation for informal care. Third, wealthier individuals spend more on healthcare and LTC in form of additional services nevertheless financed by public insurance.

The contribution rate to the system must then be adjusted up or down to keep the PAYG-DB system balanced such that current workers cover the demographic risk for the benefit of the retirees:

$$(17) \quad \tau_t = q_0 \cdot NP_t / (q_0 \cdot NP_t + l_{t,j} \cdot NW_t).$$

The internal rate of return of a PAYG-DB social security system is calculated by setting the expected present discounted value of the life-time contributions paid by a cohort c equal to the expected present discounted value of the life-time social security benefits received by that cohort:

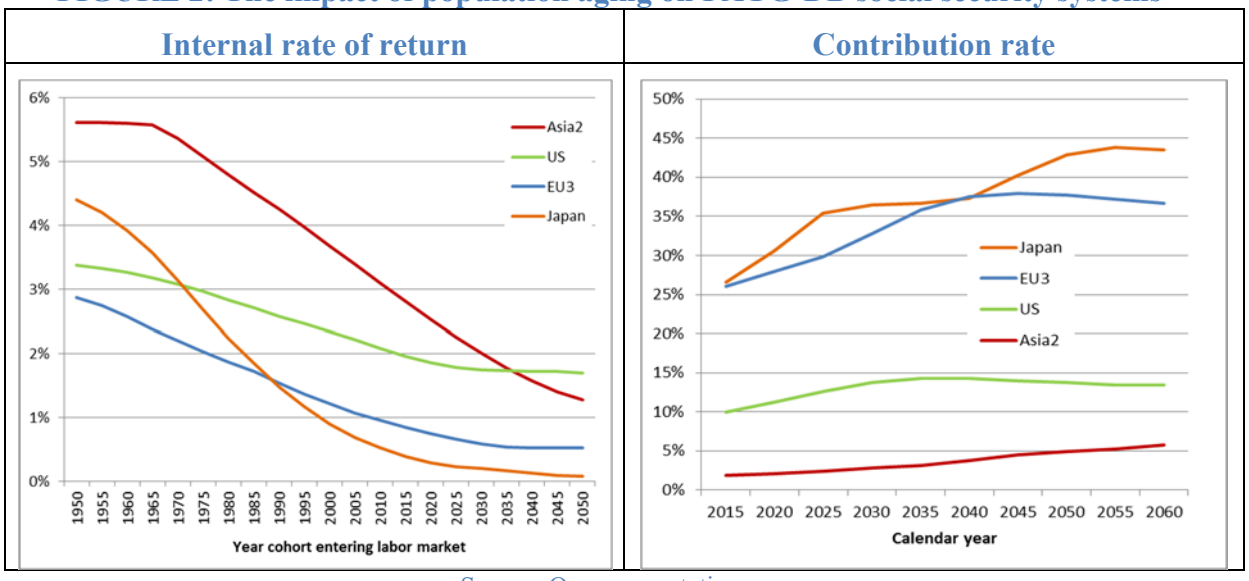
$$(18) \quad \sum_{j=0}^{R} \tau_{c+j} \cdot w_{c+j} \cdot \sigma_{c+j,j} \cdot (1/(1+irr_c))^j = \sum_{j=R+1}^{\infty} p_{c+j} \cdot \sigma_{c+j,j} \cdot (1/(1+irr_c))^j .$$

If wages grow at a constant rate g, if the relative number of workers grows at a constant rate n and if social security benefits are set according to the DB rule, equation (16), then the internal rate of return of the PAYG-DB system is roughly equal to the growth rate of the labor force n plus the growth rate of wages g experienced during the lifespan of this cohort:

$$(19) \quad irr = g + n.$$

Figure 2 shows the burden of the large PAYG-DB systems due to the aging process in two metrics, the internal rate of return and the equilibrium contribution rate. The large and negative growth rate of the labor force *n* in Japan is reflected in the fast decrease of the Japanese internal rate of return of the PAYG-DB system. It also decreases quickly in China and India, due to the rapid decline in their support ratios. The internal rate of return stabilizes in the EU3 countries for cohorts entering the labor market after about 2035. The internal rate of return in Japan becomes very low but increases for cohorts entering the labor market after about 2050. Contribution rates are plotted by calendar year and show similar trends. The levels reflect the national differences in demography and system generosity.

FIGURE 2: The impact of population aging on PAYG-DB social security systems



Source: Own computations.

2.2.3 Production sector

The final building block which closes the CGE model is the *production sector* of country *i.* It consists of a representative firm that uses a Cobb-Douglas production function given by

$$(20) \quad Y_{t,i} = F\left(A_{t,i}, K_{t,i}, L_{t,i}\right) = K_{t,i}^{\alpha}(A_{t,i}L_{t,i})^{1-\alpha},$$

where $K_{t,i}$ denotes the capital stock and $L_{t,i}$ is the aggregate labor volume in country *i* at time *t*. α denotes the capital share (set to 33%) and $A_{t,i}$ the technology level of country *i* which is assumed to grow at an exogenous rate *g* and is also assumed to be equal (1.5% p.a.) for all countries. The initial technology levels $A_{t,i}$ are calibrated to reflect GDP per capita.

The firm's problem is static such that wages and the rate of return rates are given by

$$(21) \quad w_{t,i} = A_{t,i}(1-\alpha)k_t^{\alpha},$$

(22) $r_t = \alpha k_t^{\alpha-1} - \Delta,$

where k_t is the capital stock per productivity weighted unit of labor and Δ is the depreciation rate of productive capital, set to 5%.

2.2.4 General equilibrium

The solution of the CGE model is given by a set of equilibrium conditions. The outcome variables are sequences of disaggregate variables on the household level $\{c_{t,j,i}, l_{t,j,i}, a_{t,j,i}\}$, sequences of aggregate quantities $\{L_{t,i}, K_{t,i}\}$ and prices for labor $\{w_{t,i}, \tau_{t,i}\}$ on the country level, where the difference between the net and the gross wage is defined by the contribution rate to the social security system, and a sequence of interest rates $\{r_t\}$ on the global level. Given the initial capital stocks $K_{0,i}$ in each country, the general equilibrium of the world economy is obtained when households maximize their life-time utility subject to the constraints given by the two model variants, factor prices equal their marginal productivities, the PAYG-DB social security systems satisfy the balancing condition, and all markets clear in every country and every period:

(23) $$L_{t,i} = \sum_{j=0}^{\infty} l_{t,j,i} N_{t,j,i} \quad \text{for all } t,i\,,$$

(24) $$\sum_{i=1}^{I} K_{t+1,i} = \sum_{i=1}^{I} \sum_{j=0}^{\infty} a_{t+1,j+1,i} N_{t,j,i}\,,$$

(25) $$\sum_{i=1}^{I} \sum_{j=0}^{\infty} c_{t,j,i} N_{t,j,i} + \sum_{i=1}^{I} K_{t+1,i} = \sum_{i=1}^{I} K_{t,i}^{\alpha} (A_{t,i} L_{t,i})^{1-\alpha} - (1-\Delta) \sum_{i=1}^{I} K_{t,i}\,.$$

This CGE model has to be solved numerically. The algorithm searches for equilibrium paths of consumption, hours worked, capital to output ratios and, in case there are social security systems, social security contribution rates in each country. We determine the equilibrium path of the OLG model by using the modified Gauss-Seidel iteration as described in Ludwig (2007). The solution of the life-cycle optimization is solved recursively by taking initial guesses for consumption at last age. Then, the model is solved using recursive methods on first order conditions, taking into account the logic of time-inconsistent behavior described in Subsection 2.1, and appropriately handling the constraints of the model described above. This procedure delivers guesses for the vectors of consumption and hours worked. We then calculate savings and assets, applying the budget constraint (5). The consumption profile including consumption at last age is then updated. This procedure is repeated until consumption and the hours profile converge. Our

time line has four periods: a phase-in period, a calibration period, a projection period, and a phase-out period. First, we start calculations 110 years before the calibration period begins with the assumption of an "artificial" initial steady state in 1850. The time period between 1960 and 2005 is then used as calibration period in order to determine the structural parameters of the model. Our projections run from 2015 until 2060.

The life-span of the household is assumed to be 100 years. The household enters the labor market at age 15. The structural parameters of the household model are chosen with reference to other studies. Table 1 gives an overview:

Table 1 – Parameter calibration

Parameter	Values
Discount rate (ρ)	0.01
Risk preference (θ)	2
Consumption preferences (ϕ)	0.6
Degree of present bias (δ)	0.7
Share of present biased households (γ)	[0%-100%]
Capital share in production (α)	0.33
Depreciation rate of capital (Δ)	0.05
Growth rate of labor productivity (g)	0.015

The discount rate ρ is set to 0.02 (see overview by Frederick et al. (2002). The risk preference parameter θ is assumed to be 2 which makes the household slightly risk averse and lies in the middle of estimates in the literature (see overview by Bansal and Yaron (2004) and Browning et al. (1999)).

3 Implications of time inconsistency for social security systems

This section analyzes how standard insights of social security economics change when households are myopic or procrastinating rather than time-consistent.

3.1 Myopic households

It is insightful to begin with the extreme case of complete myopia in which households focus on current utility only and ignore future utility. They therefore do not anticipate old age and do not save. Without a social security system, they would suffer from starvation once deteriorating health forces them to retire. A mandatory social security system, whether PAYG or FF, DB or DC, thus has large beneficial effects. As opposed to the life-cycle model, a mandatory social security system has no negative incentive effects in this model (e.g., crowding out and moral hazard) since these myopic households would not save under any circumstance. Population

aging will increase the financial volume of the social security system but there are no policy implications to be drawn as preventing starvation is indispensable. This arguably extreme example shows that welfare and policy implications are radically different from the perfect-foresight case.

More realistically, different degrees of myopia prevail among households, and a more relevant question is not whether to have a mandatory social security system at all but whether a mandatory PAYG-DB system (such as the US Social Security system or the Bismarckian systems in Continental Europe and Japan) is preferable to a FF system of voluntary savings for consumption, health and LTC spending in old age. Models with heterogeneous households are instructive in this case because they demonstrate the trade-off between social protection and economic efficiency. In order to keep things transparent, assume a population with two types of households: a fraction γ of households is myopic; the other households are time-consistent. While a PAYG-DB social security system is beneficial for the myopic households as argued above, this is different for the time-consistent households because they have to co-finance the social security benefits of the myopic households which reduces their utility. Moreover, the PAYG-DB system will crowd out private saving which may earn a higher rate of return (Feldstein, 1985).

Whether a PAYG-DB social security system is preferable to a FF system for society as a whole therefore depends on γ and the difference between the market interest rate r and the internal rate of return irr which are, in turn, functions of the extent of population aging (Figure 2). If the share of myopic households is large, a mandatory PAYG-DB system is always beneficial, even for quickly aging countries with very low internal rates of return. The opposite is the case for a large share of time-consistent households and a mild aging process.[2]

3.2 Procrastinating households

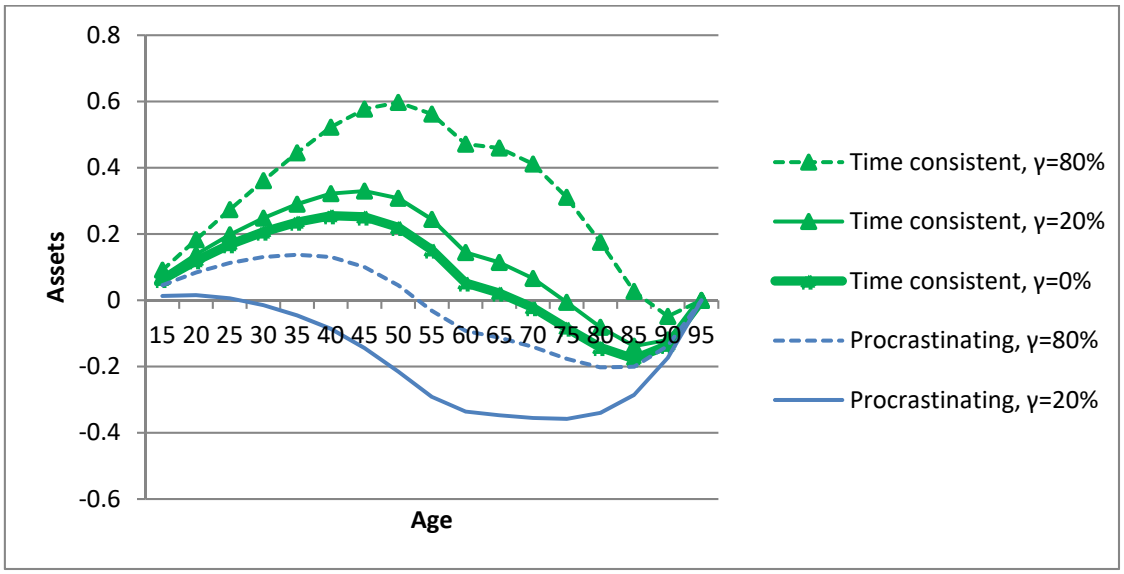
The case is more complex in a general equilibrium model with a share, γ, of procrastinating households. As is well known, these households exhibit overconsumption in the beginning of their life cycle relative to time-consistent households at the expense of lower consumption later in life and therefore save less than time-consistent households. They also have a more tilted life-course trajectory of labor supply than time-consistent households. Depending on the share of procrastinating households, γ, both behaviors change the general equilibrium outcome of

[2] Börsch-Supan, Härtl and Leite (2016) provide a formal treatment.

interest rates and wages (with repercussions on individual behavior) relative to the traditional case. This in turn affects the contribution rate and the internal rate of return of a PAYG-DB social security system as well as the accumulated assets in a FF system. Finally, the relative advantage of a PAYG-DB versus a FF social security system depends on the share of procrastinating households.

As a starting point, Figure 3 depicts the trajectory of accumulated assets for different shares of procrastinating households, γ. It shows the familiar result that procrastinating households save less than time-consistent households (blue lines vs. green lines). More importantly, this figure also shows that both types of households save more with a higher share of procrastinating households. This effect is substantial and shows how important it is to model general equilibrium effects.

FIGURE 3: Life-cycle asset holdings – different shares of procrastinating households

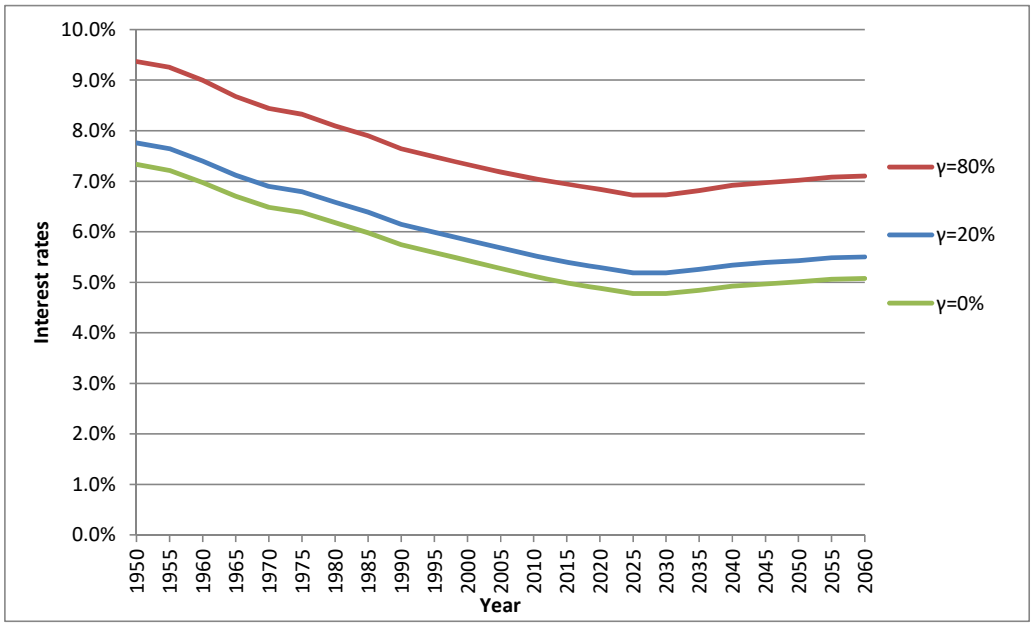


Source: Own computations. This graph refers to the EU3 countries.

Lower savings lead in equilibrium to a lower capital stock and consequently to a higher rate of return to productive capital, *r*. This is shown below in Figure 4. For an 80% share of procrastinating households interest rates are higher by about 2 percentage points in comparison to an economy with time-consistent households. The difference depends on two parameters, the extent of overconsumption by procrastinating households, δ, which we keep fixed at 0.7, and the share of procrastinating households, γ. Two observations are important. On the one hand, the difference between an economy with 80% procrastinating households and the traditional case is quantitatively large. On the other hand, population aging affects the return to productive capital similarly in all three cases depicted in Figure 4. Notably, there is no "asset meltdown"

in the sense that returns become negative due to population aging (Poterba, 2001; Rios-Rull, 2001).

Figure 4: Rate of return to productive capital



Source: Own computations.

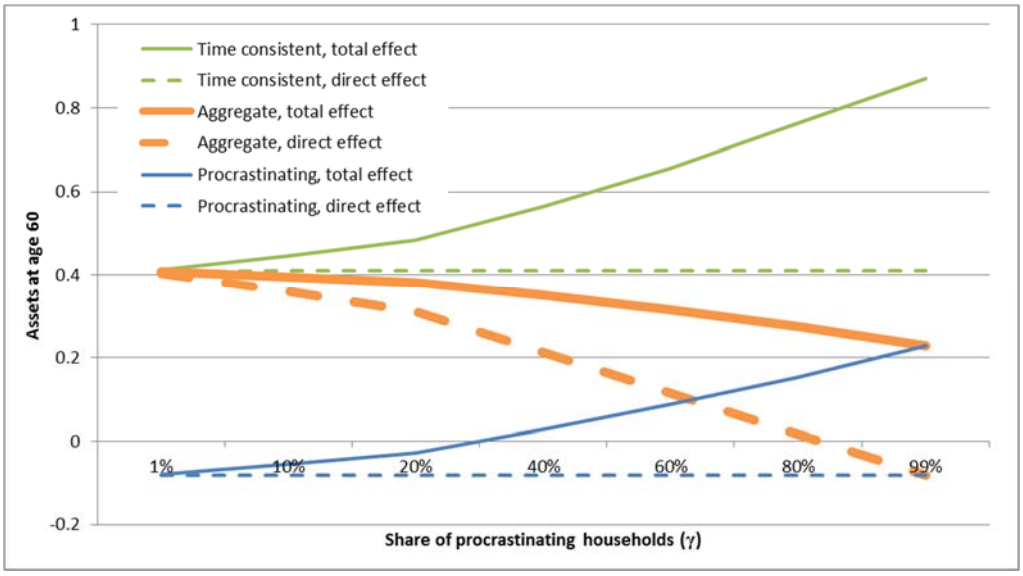
The general equilibrium effect of higher interest rates with a higher share of procrastinating households does not offset the direct effect of lower saving behavior. This is shown in Figure 5 which depicts assets holdings at old age (age 60) for an increasing share of procrastinating households as we go from the left to right, distinguishing between time-consistent households, procrastinating households and the average household in this economy (weighted by the shares of time-consistent and procrastinating households). It also distinguishes between the partial equilibrium (direct) and the general equilibrium (total) effects.

The partial equilibrium effect is the direct behavioral effect and abstracts from feedback effects on interest rates and wages by holding them constant between the scenarios in Figure 5. It is independent from the share of procrastinating households in the economy. Time-consistent households have accumulated higher savings at the time before retirement than their procrastinating counterparts.

The total effect includes all direct and feedback effects modeled in our general equilibrium setting. Savings at old age are substantially higher in the general equilibrium setting due to the higher interest rates which incentivize savings in our model. This effect becomes stronger for a higher share of procrastinating households because the interest rate effect is not linear. In addition, time-consistent households profit more from the total effect than procrastinating

households. This is due to higher savings of the former compared to overconsumption and undersaving of the latter. In the aggregate (thick lines; measuring total assets as weighted mean of assets held by time-consistent and procrastinating households), the interest effect compensates about two thirds of the direct effect. This is an important result if one wishes to base a part or even the entire social security system on voluntary savings.

Figure 5: Economy-wide accumulated assets



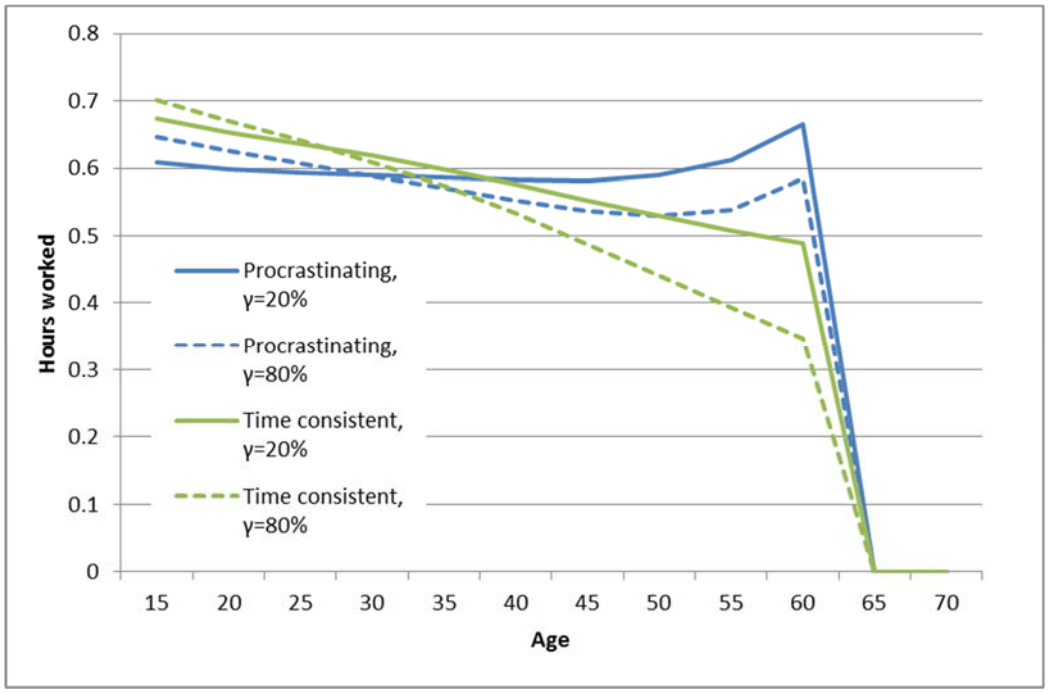
Source: Own computations.

Procrastinating households also exhibit a very different labor supply behavior than their time-consistent counterparts (Figure 6). They supply fewer hours of work when they are young but more than compensate this when they are older. This overcompensation can be seen by comparing the areas between the blue and the green hours' profiles. This relative difference between time-consistent and procrastinating households holds for both scenarios (high and low share of procrastinating households, indicated by the dashed and solid lines) and corresponds to the direct (or partial equilibrium) effect that is generated by the different labor supply behaviors.

In addition, however, there are again strong general equilibrium effects. They are reflected in the difference between the solid and the dashed lines in Figure 6. Even though procrastinating households work more during their lifetime than their time-consistent counterparts, total average labour supply decreases. This stems from the fact that savings and, accordingly, the capital stock are lower in an economy with a higher share of procrastinating households. Consequently, labor is less productive. This translates in lower wages (Figure 7, left panel)

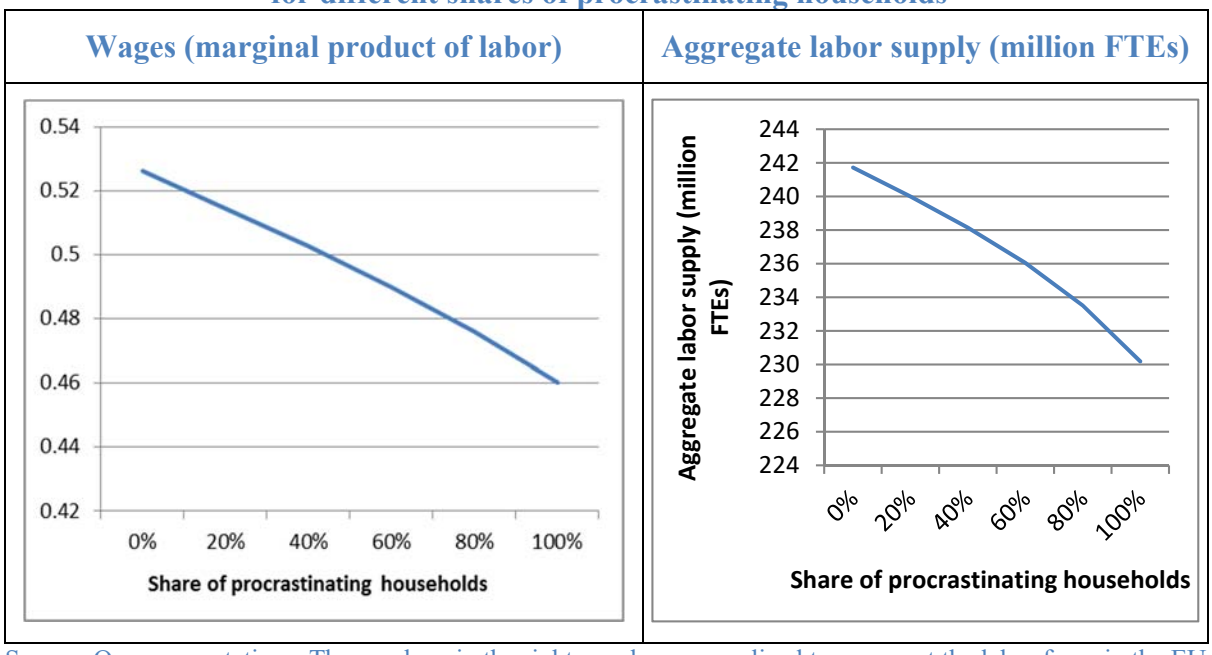
which have negative incentive effects on households' labor supply and thus drive total labor supply in the economy down (Figure 7, right panel).

Figure 6: Labor supply over the life cycle



Source: Own computations.

Figure 7: Wages and aggregate labor supply for different shares of procrastinating households

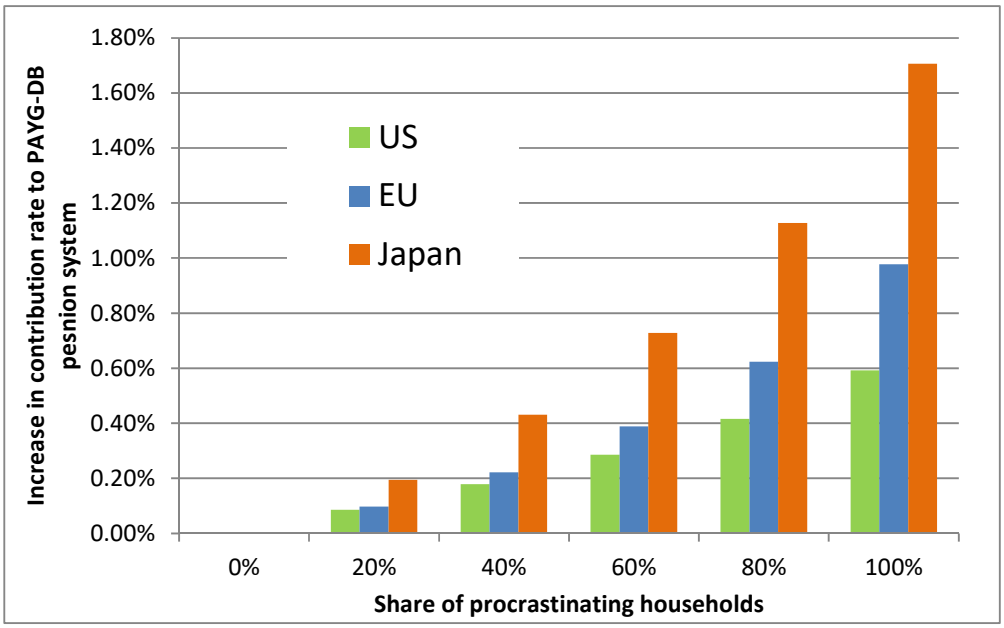


Source: Own computations. The numbers in the right panel are normalized to represent the labor force in the EU.

Since an economy with more procrastinating households provides less hours of work, they also contribute less to a PAYG-DB social security system and contributions must rise in order to

balance the social security system according to equation (17). Figure 8 depicts the increase in the contribution rate relative to an economy with time-consistent households. This increase is not identical across countries. This is due to the size of the social security system and their corresponding level of contribution rates which in turn reflects the different replacement rates and the different aging processes in these three countries. For Japan and the EU with a very high level of contribution rates, the effect of higher shares of procrastinating households is much stronger than in the US because labor supply is already reduced in Japan and the EU due to their high contribution rates.

Figure 8: Increase in contribution rate to PAYG-DB social security system as a function of the share of procrastinating households



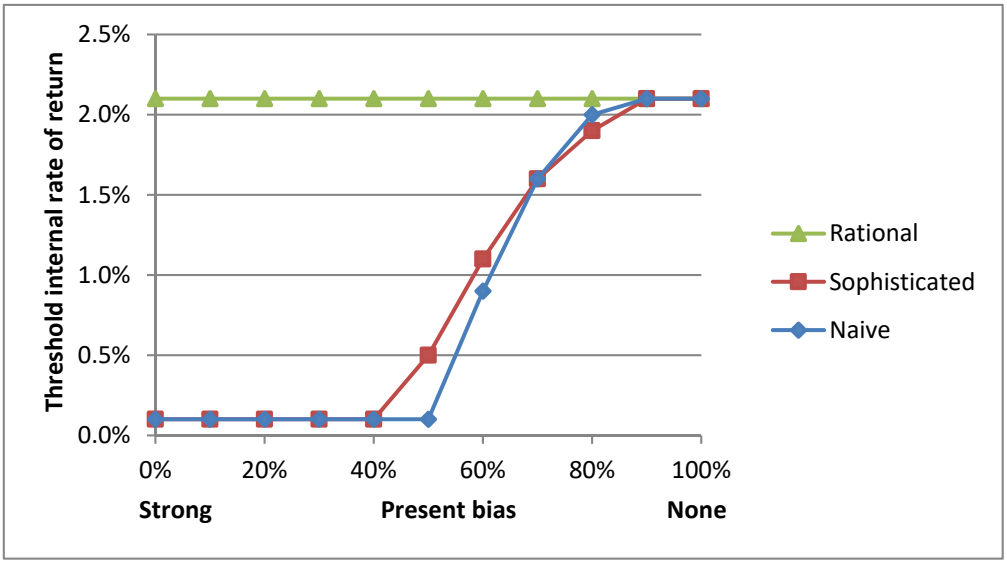
Source: Own computations.

Finally, the extent of present bias in an economy with procrastinating households changes the weights in the perennial debate whether a mandatory PAYG-DB or a voluntary FF social security system based on private savings provides higher welfare. As already pointed out in Subsection 3.1, totally myopic households benefit from a mandatory PAYG-DB system because they would starve at old age due to their lack of savings in a voluntary FF system. This argument also holds in an economy with procrastinating households, although in a more subtle way. Figure 9 presents the threshold internal rates of return for which households with a specific type have higher welfare under a PAYG-DB system than under a voluntary FF system. Household types are time-consistent, sophisticated procrastinators and naïve procrastinators, each distinguished by their extent of present bias, δ, according to equation (2). Welfare is

measured as the consumption-equivalent variation relative to a situation in which a PAYG-DB system delivers an internal rate of return of 3%.

Time-consistent households would be better off in a mandatory PAYG-DB system only if this system were to deliver an internal rate of return of at least 2.1%.[3] Procrastinating households save less and suffer from substantially lower consumption in old age. They are therefore better off in a mandated PAYG-DB system even if this system delivers much lower internal rates of return than in a voluntary FF system. One may identify this difference with the value of the mandatory PAYG-DB system as a commitment device. Sophisticated procrastinators tend to require higher internal rates of return because they are less time-inconsistent than naïve procrastinators. For lower degrees of present bias, sophisticated and naive procrastinators have similar internal rates of return thresholds because the behavior of both types tends to become similar when the present bias is low.

Figure 9: Relative advantage of PAYG vs FF



Source: Own computations. Note: The vertical axis represents the rate of return generated by a PAYG social security system that keeps individuals indifferent between a PAYG and a FF system. A rate higher than this threshold makes the household better off in the PAYG system. The extent of present bias for each household type is indicated on the horizontal axis and measured by the parameter delta in equation 2. Delta=0% gives zero weight to the future, delta=100% gives full weight to future events.

[3] The difference to 3% is explained by the insurance against longevity included in a mandatory PAYG-DB system as opposed to voluntary saving plans, cf. Börsch-Supan, Härtl and Leite (2016).

4. Conclusions

Economics has traditionally guided social policy with the help of formal models based on individuals who think in a life-cycle context with perfect foresight, full information and in a time-consistent manner. The BB-Future project follows this tradition. This paper sheds light on several aspects of social policy when these behavioral assumptions do not hold. For this purpose, we constructed and calibrated a multi-country model of procrastinating households. We focus on the interaction between the share of procrastinators in a country, the speed and extent of population aging, and the size of an existing PAYG-DB social security system. Since the BB-Future project has an internationally comparative point of view, we apply our analyses to a world consisting of the EU (represented by France, Germany and Italy), the US and Asia (represented by China, India and Japan) and shed light on the interactions among different demographic developments, different generosity of social security systems and different extents of present bias.

We do not take the share of procrastinators in an economy and their short-sightedness strictly literally. It may as well describe the dearth of commitment devices which have been created by traditions, rules and institutions and force or nudge individuals in a behavior resembling perfect foresight.

Our main results are:

- Savings are substantially lower if a substantial fraction of households is myopic or procrastinating with hyperbolic time preferences.
- Moreover, the life-cycle trajectory of labor supply changes. Procrastinators work less when young and more when older, with a more incisive transition to retirement.
- Both together have repercussions on the interest rate and national wages, affecting the relative merits of PAYG versus FF social security systems. Contribution rates to PAYG-DB systems rise with a higher share of procrastinating households in an economy. This is more pronounced for the EU and Japan than for the US.
- Nevertheless, PAYG-DB systems with their mandatory contributions provide higher welfare if there are many procrastinators since these systems prevent the low consumption in old age that would emerge from the low savings by procrastinating households.

What does this mean for the results of the BB-Future project? The figures in this paper show that saving and labor supply behaviors do not change qualitatively, but quantitatively depending on the extent of shortsightedness. The consequences of a high share of shortsighted households

are more relevant for the welfare implications of social policies since they also change qualitatively. “Old fashioned” mandatory social security systems that are funded pay-as-you-go and define benefits ex-ante are less efficient in economic terms than voluntary fully-funded saving plans to finance pensions, healthcare and long-term care, but they provide more welfare since they prevent shortsighted households from saving too little and thus consuming too little in old age, in particular when they need to spend more on healthcare and long-term care.

Caveats apply: It is important to note that we do not compare a mandatory PAYG system with a mandatory FF system. Rather, we compare the merits of a stylized PAYG-DB social security system that is typical for many large industrialized countries (EU, US, Japan) with voluntary saving instruments for old-age consumption, healthcare and long-term care. We also do not model a transition from one system to the other; rather, we compare the two systems in their steady states.

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