Who cares about the day after tomorrow? Pension issues when households are myopic or time inconsistent

Axel Börsch-Supan¹,²,³ | Klaus Härtl¹,² | Duarte Nuno Leite¹,⁴

¹Munich Center for the Economics of Aging (MEA) at the Max Planck Institute for Social Law and Social Policy (MPISOC), München, Germany
²Technical University of Munich (TUM), München, Germany
³National Bureau of Economic Research (NBER), Cambridge, MA
⁴Center for Economics and Finance at University of Porto (CEF-UP), Porto, Portugal

Abstract
Pension economics has traditionally guided pension 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. Associated macro models were mostly based on a single country. This paper sheds light on several aspects of pension economics when these assumptions do not hold using—to our knowledge—the first 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 an existing PAYG-DB pension system. Starting from the insight that procrastination reduces the volume of savings, we focus on three questions that are particularly relevant for the quickly aging Asian economies: What are the consequences for the balance between pay-as-you-go and fully funded pension systems? Where will retirement savings be invested in a globally linked world with very different pension systems and demographics? How large are global spillover effects of pension reforms in one region for the other regions in the world?

1 | INTRODUCTION

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

Figure 1 shows the demographic pressure, expressed by the support ratio—the number of working age individuals, defined as ages 15 to 64, divided by total population size—for the four countries/country groups that will be the focus of this paper.

Japan features the most progressed aging process in the world and it has a large PAYG-financed public pension system. EU3 represents the three largest countries of Continental Europe—France, Germany, and Italy. These countries have also substantially aged and have similarly large public PAYG pension systems as Japan. In contrast, the United States has a much smaller social security system and a much less pronounced population aging process. Finally, Asia2 denotes the two countries with the largest population in Asia, China and India, which have very small pension systems and are still young, but will face a very fast aging process in the future. After 2050, the Asia2 countries will actually have a lower support ratio than the United States (as shown in Figure 1). These international differences in the demographic development have important economic implications as they may induce capital and labor movements between faster and slower aging countries (e.g., Brooks, 2003; Fehr, Jokisch, & Kotlikoff, 2003; Domeij & Floden, 2006, Attanasio, Kitao, & Violante, 2007; Börsch-Supan, Ludwig, & Winter, 2007), which in turn have implications for national pension systems.

A large number of older individuals per working age population in a country exerts pressures on the economy of a country since pension expenditures demand a high share of GDP. The alignment between the extent of population aging and pension expenditures, however, is far from perfect (Figure 2). Most European countries have pension expenditures significantly above the regression line (Italy, Austria, France, and Poland), while most Asian countries have much smaller pension systems relative to their demographic status (Japan, Korea, Australia, and New Zealand). This is mainly due to the many design differences between national pension systems. When studying the impact of population aging on pension expenditures, particularly in an internationally comparative context, it is therefore important to take account not only of international differences in demography but also these design differences.

FIGURE 1 Support ratio in the United States, European Union and Asia [Color figure can be viewed at wileyonlinelibrary.com]

Source. EU3 and United States: Human Mortality Database (2008). Japan and Asia2: United Nations (2012) Population Trends. Support ratio is population aged 15 to 64 divided by total population size.
In order to do so, pension economics has 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 & Kotlikoff, 1987; Feldstein & Samwick, 1998). 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, Börsch-Supan, & Tabellini, 2001, 2002; Walker, Reno, & Bethell, 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, Bucher-Koenen, Coppola, & Lamla, 2015, Börsch-Supan, Bucher-Koenen, Ferrari, Kutlu Koc, & Rausch, 2016, for Germany; Knoef et al. (2016), for Netherlands; and Crawford & O’Dea, 2012, for the United Kingdom). In the United States, such undersaving for retirement has received widespread attention (Poterba, Venti, & Wise, 2012; Repetto, Laibson, & Tobacman, 1998; Madrian and Shea, 2001).

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

**FIGURE 2** Pension expenditures (percent of GDP) by old-age dependency ratio [Color figure can be viewed at wileyonlinelibrary.com]

Source. *Pensions at a glance* (OECD, 2015). Old-age dependency ratio is population age 65+ divided by population of age 15 to 64 (2013 data). Public and private pension expenditures are share of GDP (2012 data).
existence of a public pension system. Such elements include poverty alleviation and longevity risks (Börsch-Supan, Härtl, & Leite, 2016), income risks, market failures, and information costs (Chan & Stevens, 2008; Bucher-Koenn & Lusardi, 2011; Lusardi & Mitchell, 2011, 2014; Lusardi, Michaud, & Mitchell, 2017).

This paper focusses on a second strand of research that more radically replaces the neoclassical paradigm with models of time-inconsistent behavior (Thaler, 1994; Laibson, 1997, 1998; Angeletos, Laibson, Repetto, Tobacman, & Weinberg, 2001; Choi, Laibson, Madrian, & Metrick, 2002; Rabin, 2013a,b; Della Vigna & 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 & Pollak, 1968; Pollak, 1968; Thaler & Shefrin, 1981) but have only found widespread attention when they were applied to retirement saving in the United States (Laibson, 1997, 1998; Madrian & Shea, 2001).

This paper is concerned with the implications of such time-inconsistent behavior for pension policy. Moreover, it adds the international context to the analysis. It constructs and calibrates—the first multi-country model of procrastinating households (Section 2) in order to shed light on several aspects of pension economics and pension policy when the traditional assumptions do not hold. There are a handful of macroeconomic models with time-inconsistent agents in a one-country setting, and there are many models and papers about international capital flows and population aging, but the combination is novel and does deliver new insights, especially in the asymmetric cases: for some countries it is actually advantageous to deviate from the neoclassical path.¹ Our model is designed to shed light on the global interactions among three traits that characterize a country: the share of procrastinators, the speed and extent of population aging and the size of an existing PAYG-DB pension system.

We focus on three questions that are particularly relevant for the quickly aging Asian economies:

1. What are the consequences of procrastination for pay-as-you-go, fully funded pension systems and their relative weights in the typical mixed pension systems (Section 3)?

2. Where will retirement savings be invested in a globally linked world with very different shares of procrastinating households and what does this mean for the national pension systems (Section 4)?

3. How large are global spillover effects of pension reforms in one region for the other regions in the world (Section 5)?

Section 6 summarizes our main conclusions. The interaction effects of the share of procrastinators, especially in asymmetric situations in which one country group has a different share of procrastinators than another country group, with the size of the pension system and the speed and extent of the aging processes are complex and large, often yielding counterintuitive results. First, since the volume of savings for old-age provision is substantially lower in a world with many short-sighted households, interest rates are higher and wages lower. This increases contribution rates to PAYG-DB pension systems but nevertheless shifts the relative merits of mandatory PAYG-DB systems versus voluntary FF pension systems towards PAYG. Second, international capital flows are lower when households are procrastinating since they are saving less, but these effects are asymmetric and depend, in a complex and highly nonlinear way, on demography and pension systems. Third, parametric pension reforms in one part of the world will have global spillover effects. Changes in key labor market parameters, especially retirement age, in Europe would
also improve the sustainability of pension systems and economic growth in Asia pointing to the important role of international policy coordination. This role becomes even more important when the extent of time-inconsistent behavior is different across countries.

2 | THEORETICAL FRAMEWORK

Departure for our model is the insight stressed in the introduction that the effects of demographic change on pension 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 that 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 tradeoff. 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 provides a model of how these tradeoffs and alleviating mechanisms work under the assumption that households fail to plan ahead. Does this assumption fundamentally change how these tradeoffs and alleviating mechanisms are affected by population aging versus the traditional model of perfect foresight and time-consistency? This section also sheds new light on some of the key controversies among economists interested in saving behavior and social insurance (see Section 3). Being the result of aggregate private savings decisions, capital flows are also strongly influenced by imperfect household decisions, which will be examined in Sections 3 and 4.

Subsection 2.1 describes household behavior. Subsection 2.2 will then embed this household module into a multi-country model of the four countries/regions (Japan, China & India, France & Germany & Italy, USA) introduced in Figure 1, characterized by very different demographic developments and different mixtures of PAYG and FF pension systems.

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 $c_{i,j}$ and leisure $1 - l_{i,j}$, where $l_{i,j}$ is the time spent working. The most conventional specification is a per-period utility function given by

\[
u(c_{i,j}, 1 - l_{i,j}) = \frac{1}{1 - \theta} \left( c_{i,j}^\phi \cdot (1 - l_{i,j})^{1-\phi} \right)^{1-\theta},
\]

where risk aversion and intertemporal substitution are jointly described by the single parameter $\theta$ while $\phi$ 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 \left\{ u(c_{t,0}, 1 - l_{t,0}) + \delta \sum_{j=1}^{J} \beta^j \sigma_{t+j,0} u(c_{t+j,0}, 1 - l_{t+j,0}) \right\}.

(2)

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

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

(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: $\gamma$ is the share of households who have present bias ($\delta < 1$) while $1 - \gamma$ 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 $l_{t,j} w_{t,j}$ until retirement age $R$ (where $w_{t,j}$ denotes the hourly wage) and may then receive a public pension $p_{t,j}$, which is financed by a contribution proportional to the labor income at rate $s_t$. Hence, current disposable nonasset income $y_{t,j}$ is

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

(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

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

(5)

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

$$s_{t,j} = y_{t,j} - c_{t,j}.$$  

(6)

### 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, for example, 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 & Shefrin, 1981). The model has three main features: (i) the addition of a present bias parameter $\delta$ that discounts the immediate future additionally to
the standard discount factor $\beta$ and mimics hyperbolic discounting, (ii) the distinction between the present bias $\delta$ of the current self from the belief about the present bias of the future self, denoted by $\hat{\delta}$, and consequently, (iii) 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 as a result of 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-inconsistent manner although they have consistently violated this belief in the past, that is, $\hat{\delta} = 1$, the more sophisticated households correctly foresee that their future selves will also behave in a time-inconsistent way, that is, $\hat{\delta} = \hat{\delta} < 1$. 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

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

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

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

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

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

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

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

Preferences are time-inconsistent because the present bias parameters $\delta$ 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 with 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, Habermann, & Kindermann, 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 that are time-inconsistent owing to present bias and procrastination as described in Equations 7 to 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 FF pension systems for countries with a strongly aging population is that the assets can be invested in countries that have a less pronounced aging process, while PAYG pension 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, Ludwig, & Winter, 2006; Attanasio et al., 2007; Börsch-Supan and Ludwig, 2009, 2010, 2013; Attanasio, Bonfatti, Kitao, & Weber, 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 literature tried to explain this observation. According to Coakley, Kulasi, and Smith (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 that 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 in Figure 1 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 that 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 \( c = t - j \) and are the survivors of the original birth cohort \( N_{c,0} \):

\[
N_{t,j} = \sigma_{t,j} \cdot N_{c,0}.
\]
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 $c = t - j$:

$$N_{c,0} = \sum_{k=0}^{\infty} f_{c,k} \cdot N_{c,k}.$$

(12)

Population aging has therefore three demographic components that 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 (HMD, 2008) (EU3 and the United States) and the United Nations (2012) Population Trends (Japan and Asia2). Households are the decision units. They enter economic life at an age that 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 that is essential for modeling pension issues.

2.2.2 | Pension system

The next building block is the PAYG-DB pension system. Revenue in year $t$ is the product of the contribution rate $\tau$, the average labor income $l_{t,j} \cdot w_t$ and the number of workers $NW_t$ defined as:

$$NW_t = \sum_{j=0}^{R} N_{t,j},$$

(13)

where $R$ denotes the retirement age. Expenditure in year $t$ is the product of the average pension benefit $p_t$ and the number of pensioners $NP_t$, defined as:

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

(14)

This results in the PAYG budget equation:

$$\tau \cdot l_{t,j} \cdot w_t \cdot NW_t = p_t \cdot NP_t.$$

(15)

The PAYG system is of the defined benefit type where a cohort of retirees is promised a pension benefit $p_t$ defined by a replacement rate $q_0$ that relates pensions to the net wage but is independent from the demographic and macroeconomic environment:

$$p_t = q_0 \cdot w_t \cdot (1 - \tau).$$

(16)

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:

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

(17)

As described in the introduction, the size of the PAYG-DB pension systems is very different across the four countries/country groups. Table 1 shows this, expressed as the replacement rate $q_0$:
The internal rate of return of a PAYG-DB pension system is calculated by setting the expected present discounted value of the lifetime contributions paid by a cohort $c$ equal to the expected present discounted value of the lifetime pension benefits received by that cohort:

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

If wages grow at a constant rate $g$, if the relative number of workers grows at a constant rate $n$ and if pensions 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:

$$irr = g + n.$$  \hspace{1cm} (19)

Figure 3 shows the burden of the large PAYG-DB systems as a result of 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 owing to the rapid decline in their support ratios. The internal rate of return stabilizes in the EU3 countries.

**TABLE 1** Replacement rate of PAYG-DB pension systems

| Country       | Replacement Rate |
|---------------|------------------|
| France        | 60%              |
| Germany       | 60%              |
| Italy         | 70%              |
| Japan         | 60%              |
| United States | 30%              |
| China         | 10%              |
| India         | 10%              |

**FIGURE 3** The impact of population aging on PAYG-DB pension systems [Color figure can be viewed at wileyonlinelibrary.com]

Source. Own computations.
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, however, reflect the very different replacement rates of the pension systems (Table 1).

### 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

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

(20)

where $K_{t,i}$ denotes the capital stock and $L_{t,i}$ is the aggregate labor volume in country $i$ at time $t$. $\alpha$ denotes the capital share (set to 33 percent) 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 percent p.a.) for all countries.\(^3\) The initial technology levels $A_{t,i}$ are calibrated to reflect GDP per capita at the year 2005 and we use the U.S. technology level as the benchmark (see Table 2).

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

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

(21)

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

(22)

where $k_t$ is the capital stock per productivity weighted unit of labor and $\Delta$ is the depreciation rate of productive capital, set to 5 percent.

### Table 2 | Initial technology levels (calibrated for 2005)

| Country     | Initial Technology Level |
|-------------|-------------------------|
| France      | 0.93                    |
| Germany     | 0.96                    |
| Italy       | 0.62                    |
| Japan       | 1.33                    |
| United States | 1.00                  |
| China       | 0.025                   |
| India       | 0.017                   |

### 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 pension 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 pension systems satisfy the balancing condition, and all markets clear in every country and every period:

\[ L_{t,i} = \sum_{j=0}^{\infty} l_{t,j,i} N_{t,j,i} \text{ for all } t, i, \]  

(23)

\[ \sum_{i=1}^{l} K_{t+1,i} = \sum_{i=1}^{l} \sum_{j=0}^{\infty} a_{t+1,j+1,i} N_{t,j,i}. \]  

(24)

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

(25)

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, pension 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 the calibration period in order to determine the structural parameters of the model. Our projections run from 2015 until 2060.4

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 3 gives an overview.

The discount rate \( \rho \) is set to 0.02 (see overview by Frederick, Loewenstein, & O’Donoghue, 2002). The risk preference parameter \( \theta \) is assumed to be 2, which makes the household slightly risk averse and lies in the middle of estimates in the literature (for overviews, see Bansal & Yaron, 2004; Browning, Hansen, & Heckman, 1999).

| Parameter                          | Values |
|------------------------------------|--------|
| Discount rate (\( \rho \))         | 0.01   |
| Risk preference (\( \theta \))     | 2      |
| Consumption preferences (\( \phi \)) | 0.6   |
| Degree of present bias (\( \delta \)) | 0.7   |
| Share of present biased households (\( \gamma \)) | [0%-100%] |
| Capital share in production (\( \alpha \)) | 0.33 |
| Depreciation rate of capital (\( \Delta \)) | 0.05 |
| Growth rate of labor productivity (\( g \)) | 0.015 |
3 IMPLICATIONS OF TIME INCONSISTENCY FOR PENSION SYSTEMS

This section analyzes how standard insights of pension economics change when households are myopic or procrastinating rather than time-inconsistent. For analytical reasons, the setting is national but we point out how different pension system designs and demographic contexts affect our conclusions. Section 4 then introduces feedback effects in an international setting, in particular when the extent of time-inconsistency differs across countries.

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 retirement and do not save. Without a pension system, they would suffer from starvation once deteriorating health forces them to retire. A mandatory pension system, whether PAYG or FF, DB, or DC, thus has large beneficial effects. As opposed to the life-cycle model, a mandatory pension 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 pension 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 pension system at all but whether a mandatory PAYG-DB system (such as the U.S. Social Security system or the Bismarckian systems in Continental Europe and Japan) is preferable to a FF system of voluntary savings (such as IRAs and 401k plan in the United States or the German Riester pension plans). Models with heterogeneous households are instructive in this case because they demonstrate the tradeoff between social protection and economic efficiency. In order to keep things transparent, assume a population with two types of households: a fraction $c$ of households is myopic; the other households are time-consistent. While a PAYG-DB pension system is beneficial for the myopic households as argued above, this is different for the time-consistent households because they have to cofinance the pensions 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 pension system is preferable to a FF system for society as a whole therefore depends on $c$ 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 3). 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.5

3.2 Procrastinating households

The case is more complex in a general equilibrium model with a share $c$ 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 much 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 $\gamma$, both behaviors change the general equilibrium outcome of 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 pension system as well as the accumulated assets in a FF system. Finally, the relative advantage of a PAYG-DB versus a FF pension system depends on the share of procrastinating households.

As a starting point, Figure 4 depicts the trajectory of accumulated assets for different shares of procrastinating households $\gamma$. It shows the familiar result that procrastinating households save less than time-consistent households (lower two lines vs. upper three 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.

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 5. For an 80 percent share of procrastinating households, interest rates are higher by about 2 percentage points in comparison with an economy with time-consistent households. The difference depends on two parameters, the extent of overconsumption by procrastinating households $\delta$, which we keep fixed at 0.7 (see Table 3), and the share of procrastinating households $\gamma$. Two observations are important. On the one hand, the difference between an economy with 80 percent 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 5. Notably, there is no “asset meltdown” in the sense that returns become negative owing to population aging (Poterba, 2001; Rios-Rull, 2001).

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 6, which depicts asset 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).

**FIGURE 4** Life-cycle asset holdings—different shares of procrastinating households [Color figure can be viewed at wileyonlinelibrary.com] 
*Source.* Own computations. This graph refers to the United States. Results for the other countries are qualitatively similar.
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 6. 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 owing to the higher interest rates that 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 pension system on voluntary savings.

Figures 4 and 6 represent the U.S. case; the other countries/country groups show qualitatively similar patterns. The relative size of the direct and the general equilibrium effects, however, are quite different. This is summarized in Figure 7. The general equilibrium effects, mainly working through the interest rate channel, generate total effects that are much larger in Japan and the European Union. This reflects the further progression of aging and the larger size of the PAYG-DB systems in Japan and the European Union, which lead to lower levels of aggregate saving and higher interest rates.

Procrastinating households also exhibit a very different labor-supply behavior than their time-consistent counterparts (Figure 8). 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 hours’ profiles of time-consistent and procrastinating households. This relative difference between time-consistent and procrastinating households holds for both scenarios.
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 8. Even though procrastinating households work more during their lifetime than their time-consistent counterparts, total average labor 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 9, left panel), which have negative incentive effects on households’ labor supply and thus drive total labor supply in the economy down (Figure 9, right panel).

Since an economy with more procrastinating households provides less hours of work, they also contribute less to a PAYG-DB pension system and contributions must rise in order to balance the pension system according to Equation 17. Figure 10 depicts the increase in the contribution rate relative to an economy with time-consistent households. This increase is not identical across

**FIGURE 6** Economy-wide accumulated assets [Color figure can be viewed at wileyonlinelibrary.com]

*Source.* Own computations. This graph refers to the United States. Results for the other countries are qualitatively similar.

**FIGURE 7** Decline of economy-wide assets with higher share of procrastinating households [Color figure can be viewed at wileyonlinelibrary.com]

*Source.* Own computations.
countries. This is due to the size of the pension 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 European Union with a very high level of contribution rates, the effect of higher shares of procrastinating households is much stronger than in the United States because labor supply is already reduced in Japan and the European Union owing to their high contribution rates.

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 pension 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 owing 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 11 presents the

**FIGURE 8** Labor supply over the life cycle [Color figure can be viewed at wileyonlinelibrary.com]

*Source.* Own computations. This graph refers to the United States. Results for the other countries are qualitatively similar.

**FIGURE 9** Wages and aggregate labor supply for different shares of procrastinating households [Color figure can be viewed at wileyonlinelibrary.com]

*Source.* Own computations. This graph refers to the United States. Results for the other countries are qualitatively similar.
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 $\delta$, 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 percent.

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 percent. 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 procastinators have similar internal rates of return thresholds because the behavior of both types tends to become similar when the present bias is low.

4 | INTERNATIONAL DIVERSIFICATION AND ITS IMPLICATIONS

The accumulated assets characterized in the previous section are invested internationally. This section models how these retirement savings are distributed across the four countries/country groups introduced in Figure 1 in the course of population aging, how this changes with the share of procastinating households, and how this affects pension systems, consumption per capita, and the welfare of cohorts. As we will see, the effects are particularly strong and interesting when the share of time-inconsistent households is different across countries. This may reflect fewer international differences in short-sightedness than difference in traditions, rules, and institutions, which provide commitment devices that lead to more time-consistent behavior. We therefore do not take the share of procastinators in an economy and their short-sightedness strictly literally; it may as well describe the dearth of commitment devices that force or nudge individuals in a behavior resembling perfect foresight.

As described in Subsection 2.2, 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. The net position of country $i$ at time $t$ is calculated as

$$NP_{t,i} = \sum_{j=1}^{\infty} a_{j,t,i} - K_{t,i},$$

(26)

where $a_{j,t,i}$ denotes assets owned by households in country $i$ that are invested in country $j$ at time $t$ and $K_{t,i}$ is the domestic capital stock. Net international capital flows from a country to all other countries are computed as the change in a country’s net position, which equals the difference between saving and investment:

$$ncf_{t,i} = NP_{t,i} - NP_{t-1,i} = SAV_{t,i} - INV_{t,i},$$

(27)

where $SAV_{t,i} = \sum_{j=1}^{\infty} a_{j,t,i} - \sum_{j=1}^{\infty} a_{j,t-1,i}$ and $INV_{t,i} = K_{t,i} - K_{t-1,i}$.

Our model thus does not explain gross flows from one country into another country and therefore also does not explain the portfolio shares of gross foreign direct investments or what is commonly referred to as foreign direct investments.

4.1 | International diversification when all countries have the same share of procastinators

Figure 12 depicts the net position of the four countries/country groups and how they change in the course of population aging. In addition, Figure 12 shows the difference between the assumption that these four economies consist of time-consistent households (solid lines) and the assumption that 80 percent of the households in these four economies are procastinators with a present bias parameter $\delta = 0.7$ (dashed lines).

Japan has large capital outflows, which will increase its net position to a first peak around 2025. With the retirement of the early baby boomers, some of that capital is repatriated; hence
Japan’s net position will decline until the savings of the secondary baby boom are invested abroad, slightly increasing Japan’s net position again. When also these savings will be repatriated, Japan’s net position will strongly decline and even become negative. The EU3 countries have a later baby boom and thus a later repatriation phase. They also start from a much lower level of outflows. China and India follow a path of steadily increasing investments abroad, while the United States with its large GDP receives the foreign investments. This role is strongly declining in the period after 2045 when Europe and Japan repatriate their assets.

This pattern is qualitatively similar under both behavioral assumptions, time-consistency and procrastination. However, the direction and the extent of the differences between the two behavioral assumptions vary strongly across countries/country groups. Japan and the EU3 countries actually strengthen their net position when more households are procrastinators, while the net position of China and India will weaken. The reason is the interaction with the PAYG-DB pension systems. First, since procrastinating households save substantially less, international capital flows are generally smaller than in the situation with time-consistent households, see Figure 13.9 Both outflows and inflows will increase less as population aging advances. In this figure, all capital flows are normalized to begin with zero in 2015 in order to isolate the difference between time-consistent and procrastinating households regarding the effect of population aging on capital flows. This normalization removes the differences in the levels of the net positions between the model with time-consistent households and the model with procrastinating households. The large Asian countries will experience ever growing outflows in the time range presented while the United States has more inflows of capital and will only face growing outflows later on when it starts to age more quickly than currently. The European Union and Japan exhibit the same wide swings that we have already seen in Figure 12 reflecting the aging of the primary and secondary baby booms.

4.2 International diversification with asymmetric shares of procrastinating households

Some of these effects become much larger when the share of procrastinating households is asymmetric across countries. In addition to the two symmetric scenarios:
(i) all households in all countries are time-consistent, and
(ii) in all countries, 80 percent of households procrastinate with a present bias parameter $\delta = 0.7$,
we now model two additional asymmetric scenarios:
(iii) the Asian countries (Japan, China, and India) have a share of 80 percent procrastinating house-
holds while this share is only 20 percent in all other countries/country groups, and
(iv) the EU3 countries (France, Germany, and Italy) have a share of 80 percent procrastinating
households while this share is only 20 percent in all other countries/country groups.

Figures 14 and 15 present the resulting net positions for the two asymmetric scenarios with the
time-consistent scenario as a reference.

Since households who are time-consistent save dramatically more than procrastinating house-
holds, the capital flows react very sensitively to asymmetric shares of procrastinating households. When Asia or the EU3 countries save relatively little owing to their high share of procrastinating households, the United States assumes the role of a capital exporting nation while the EU3 and Japan, the countries with the fastest aging process, will have negative capital flows (increasing inflows) owing to their high share of procrastinating households with very little saving and their large PAYG-DB pension systems.

4.3 Implications for pension systems

As we have seen in Figure 10, contribution rates are substantially higher than in the time-consis-
tent case if a country has a large share of procrastinating households. This is due to the increase of
interest rates relative to wages, which generates negative incentives to work, which lead to lower
labor supply and, subsequently, higher contribution rates in order to keep a balanced pension sys-

![Figure 13](wileyonlinelibrary.com)

Source. Own computations.
Figures 16 and 17 show the percentage changes in contribution rates relative to the scenario with all time-consistent households. The two scenarios with asymmetrical shares of procrastinating households are the same as described in the previous subsection.

Generally speaking, while contribution rates increase in all countries owing to population aging, countries with a large share of procrastinating households have a smaller increase of their contribution rates than countries with a smaller share of procrastinating individuals. These are Japan, China, and India in Figure 16 and the EU3 countries in Figure 17. At first sight, this appears to contradict the results depicted in Figure 10. However, the relation between contribution rate to a PAYG-DB pension system, the world interest rate, and share of procrastinators is more complex owing to counter-effects in the countries with a high share of procrastinating households. Since these households tend to over-consume and work less in the first years of their lives, they have to work more hours later on. Depending on the population structure of each country, this labor-supply behavior of procrastinating individuals can have either a strengthening or a weakening effect on the change in contribution rates. The effects are especially large with an older age structure, that is, more people close to retirement. If the population is composed mainly of younger people, the effects are weaker. Therefore, in relatively old countries such as Japan and EU3, the overall effect of having procrastinating households leads to lower contribution rates as compared to the time-consistent scenario (e.g., Japan in Figure 16 and EU3 in Figure 17). For relatively young economies, like China, India, and the United States, the interest rate effect dominates. In these countries, having an asymmetrically larger share of procrastinating households does therefore not lead to lower contribution rates (e.g., Asia2 in Figure 16).

The presence of procrastinating households has thus quite complex implications on PAYG-DB pension systems. They are dependent on many factors, namely the population structure, the degree of present bias, and the share of procrastinating households, all of which differ across countries. In
a world where procrastination is equally distributed across countries, PAYG-DB pensions systems are always negatively affected in form of increasing contribution rates. If only some countries have a greater share of procrastinating households, this could even mean an advantage for the pension system since contribution rates could be lower and/or increase more slowly. Whether there is such an advantage, however, depends on the specific population structure of each country.

4.4 Implications for per capita consumption

As a first step in understanding whether procrastination makes people better off in a world, in which countries may have different degrees of procrastination, we look at the development of per
capita consumption. We distinguish the same scenarios as described at the outset of Subsection 4.2. In all scenarios, consumption per capita declines owing to population aging.

Figure 18 shows the trajectories for 2015 to 2060, Figure 19 focuses on the decline from 2015 to 2040. The implications of procrastination for per-capita consumption are relatively small when the extent of procrastination is symmetric across all countries, see the difference between the thin broken and the solid lines in Figure 18. They are, however, quite substantial in the asymmetric cases in which procrastination is concentrated in the own country (thick dashed lines in Figure 18). An example is the case of Asia2 (uppermost thick dashed line). If the share of procrastinators is 80 percent in Asia but in the other countries only 20 percent, then the decline in per capita consumption would be around 5 percentage points in 2040 (see Figures 18 and 19). During the time range presented in Figure 18, this corresponds to a decreasing trajectory of consumption per capita, which is steeper than in the symmetric case (uppermost thin dashed line).

In fact, in the asymmetric cases, consumption per capita in the countries with a high share of procrastinators declines much faster with population aging than in the scenario with time-consistent households. This is shown more distinctly in Figure 20. In the other countries, however, the decline is in some cases even smaller than in the time-consistent scenario in spite of a 20 percent share of procrastinating households. This shows again that the effects of procrastination are complex when the share of procrastination varies across countries. The reason behind this larger decline when the majority of households are procrastinating is the balance between higher returns on savings (via interest rate), but lower savings owing to present bias. Procrastinating households save less and although consumption may increase via higher consumption shares, the interest rate effect is diluted. Hence, households accumulated fewer assets that could benefit from a higher rate of return.

4.5 Implications for the welfare of cohorts

Higher consumption per capita at a given point in time does not imply higher welfare for all individuals. This has two reasons. First, welfare includes not only the utility from consumption but also from leisure. Second, consumption per capita at a given point in time aggregates over the different cohorts living at this point of time. This subsection therefore investigates the welfare gains
FIGURE 18  Consumption per capita with different and asymmetric shares of procrastinating households [Color figure can be viewed at wileyonlinelibrary.com]
Source. Own computations.

FIGURE 19  Decline of per capita consumption from 2015 to 2040 [Color figure can be viewed at wileyonlinelibrary.com]
Source. Own computations.

or losses for individual cohorts owing to a higher share of procrastinators. Figure 21 shows the trajectories of life-time welfare under two scenarios, an economy in which the share of procrastinating households $\gamma$ is low (20 percent), and an economy where it is high (80 percent). Time is indicated by the year in which each cohort of households enters the labor market. The figure distinguishes between time-consistent (thin solid line) and procrastinating households (thin dashed line). Aggregate welfare (thick line) is weighted by the share of each household type. Figure 21 takes the case of Japan as an example.
Figure 21 permits several conclusions. First, as we know from Subsection 2.1.2, time-consistent households enjoy higher life-time welfare than procrastinating households. Second, as we know from the internal rates of return and the rise of contribution rates visible in Figure 3, younger cohorts are worse off as population aging progresses. Third, aggregate welfare is higher in an economy with a relatively low share of procrastinators. The trajectories for each homogenous household type are more complex. For the cohorts entering the labor market until about now, each household type is better off living in an economy with a high share of procrastinators. For later cohorts, however, the opposite is the case.

Measuring welfare in utility units has the advantage of an intuitive interpretation but suffers from the fact that utility has arbitrary units. Figure 22 expresses the differential effects therefore as the life-time consumption-equivalent variation (CEV) of a cohort of a specific type, either time-consistent or procrastinating. Since we cannot compare different types of individuals, there are separate lines for time-consistent households (solid) and procrastinating households (dashed). Units are in percent of life-time consumption. The reference scenario is an economy with 20 percent procrastinating households. A positive value means that households of a cohort entering the labor market at the given time must receive the indicated percentage of life-time consumption to be as well off as the alternative scenario in which a much higher share of households are procrastinating. If the CEV is positive, households in the alternative scenario are therefore better off than in the reference scenario.

For example, in 2015 one has to pay 3 percent of life-time consumption to time-consistent households in the Asia2 countries, assuming that the share of procrastinating households takes the reference value of 20 percent, to make them as well off as in the alternative situation in which 80 percent of households are procrastinating. In turn, a future Japanese procrastinating household entering the labor market in 2050 prefers a situation with a small share of procrastinating households as we have already pointed out in Figure 21.
Note that we do not argue that time-consistent households are worse off than procrastinating households. We state that welfare differences between procrastinating households in different scenarios increase more than differences between welfare of time-consistent individuals in the same scenarios. As we have shown in Figure 21, time-consistent individuals have higher welfare than procrastinating households in the different scenarios.

In general, all types of households are better off in terms of consumption-equivalent variation under the higher share of procrastinating households in the economy. Some exceptions are Japan and the EU3 countries where cohorts entering the labor market after about 2020 are worse off when there is a higher share of procrastinating households. In Figure 21, this was indicated by the crossing of the respective trajectories.

There are several mechanisms explaining these results. First, the interest rate is higher under a higher share of procrastinating households than in the case of a lower share; therefore, individuals profit from higher interest rates when they have sizeable private savings. Hence, especially countries with smaller pension systems benefit more from higher returns on savings because individuals save mostly privately for retirement. This explains mainly the outcomes for China, India, and the United States. Moreover, the pattern of welfare over time, measured as consumption-equivalent variation, interacts with demographics. In both scenarios, countries with large pension systems have intrinsically higher contribution rates, which suffer from a larger increase over time compared with contribution rates in countries with small pension systems. Most importantly, contribution rates are higher when the share of procrastinating households is large. Moreover, this difference

**FIGURE 21** Trajectory of welfare if share of procrastinating households is low or high [Color figure can be viewed at wileyonlinelibrary.com]

*Source.* Own computations.
even increases over time. Figure 22 shows that until around 2020 the higher interest rate effect dominates the effect of higher contribution rates. After 2020, the contribution rates effect becomes the dominant effect that decreases welfare for later cohorts. This explains why cohorts entering the labor market after 2020 can be worse off in the scenario with a high share of procrastinating households.

The relation between welfare and the share of procrastinating households is complex and not linear. Figure 23 compares welfare of both procrastinating households and time-consistent counterparts as a function of the share of procrastinators. The consumption-equivalent variation is relative to an economy with a very small, but still positive share of time-consistent households. Taking again the example of procrastinating households in Asia2 who live in an economy with 1 percent procrastinators, one would need to give these households around 5 percent more lifetime consumption to make them indifferent to the situation with a share of 90 percent procrastinators.

In the other countries, especially the EU3 and Japan, initial increases of the share of procrastinating households have a negative effect on welfare. This stems from the large sizes of their pension systems that lead individuals to borrow more during their life cycle and therefore are penalized by higher interest on their debt. However, for some higher shares of procrastinating households there is an inversion point where the negative impact dilutes and welfare impacts become positive or close to positive (time-consistent households in the EU). This happens mainly because of the interest rate effect and life-cycle behavior of individuals. A higher share of procrastinating households increases interest rates. However, at the same time there is still too much borrowing, which hinders the positive effect that higher savings could have on savings. Therefore, only when interest rates are high enough, can households profit from large savings and interest that yields from them. The same argument regarding size of pension systems and interest rates applies between countries. Therefore, households in countries with smaller pension systems profit more than households in countries with large pension systems.
5 | GLOBAL SPILLOVER EFFECTS OF PENSION AND LABOR MARKET REFORM

In the aging countries of Asia and Europe, pension and labor market reforms have been on the agenda since the 1990s in order to increase labor supply and to reduce the tax and contribution burden to the younger generation. Börsch-Supan and Ludwig (2009) have shown that such reforms have effects not only on the reforming country itself but also beneficial spillover effects to other countries. This section investigates whether these spillover effects also hold, or even are strengthened, when households are present biased. This is a salient and important topic because it strengthens the case for international policy coordination, that is, via institutions such as the Group of Twenty (G20). This section uses a prototypical reform package in the EU3 countries as an example and investigates the spillover effects on Japan, the Asia2 countries and the United States.

5.1 | The reform package in Europe and its direct effects

The prototypical reform package is composed of four elements that are motivated by historical interventions in the European Union. The key parameters to be changed are:

1. An increase in the retirement age by 2 years;
2. A decrease in the job entry age by 2 years;
3. Convergence of female labor force participation to 90 percent of the rate for men;
4. A reduction in unemployment to 4 percent.

All four parametric reform steps will together be phased in linearly between 2005 and 2050 in our EU3 model economies. We assume that labor supply is exogenous and abstract from

FIGURE 23 CEV comparison between shares of procrastinating households [Color figure can be viewed at wileyonlinelibrary.com]

Source. Own computations.
“backlash” effects described by Börsch-Supan, Härtl, and Ludwig (2014). Hence, the reforms increase labor supply to their full extent. Otherwise, the set-up is the one of Section 3 with the four countries/country groups: United States, EU3, Japan, and Asia2.

These four reform elements are motivated by the corresponding historical reform steps:

1. The German parliament decided in 2007 to gradually increase the statutory retirement age from 65 to 67 years until the year 2029. The French government increased the pensionable age of 60 to 62 in 2010. In Italy, the Monti-government (2011 to 2013) abolished several labor market restrictions and advanced the scheduled increase of the retirement age and abolished several pathways to early retirement.

2. The change in the high school and university system all across the EU starting in 2001 (the so-called Bologna process) is expected to decrease duration in schooling by about 2 years.

3. All three EU3 countries have experienced a strong increase in female labor force participation, partially because of improvements of the ability to combine job and family.

4. In Germany, the so-called Hartz reforms announced in 2002 have dramatically reduced unemployment to a level that may be regarded as the long-term stable rate of unemployment.

The effects of this reform package have been predicted using a similar model as the one described in Section 3 by Börsch-Supan et al. (2014) for an economy with time-consistent households. They can be summarized as follows.

First, the decline in the total labor volume owing to population aging in the EU3 economies is offset by more than a half through the labor-supply reform. This has beneficial effects for contribution rates to the PAYG-DB pension systems in Europe. Since there is more labor supply in the economy, contribution rates to the PAYG-DB pension system at the peak of population aging around the year 2040 about 2.8 percentage points lower in the reform case than in a scenario without a reform.

Second, higher labor supply increases saving and investment, leading to an increase in the domestic capital stock relative to the baseline scenario without reform. Since both factors of production increase, the percentage effect of the reform package on GDP per capita is larger than the increase in employment. Since increasing labor also increases aggregate savings, some households’ savings flow from the aging EU3 countries abroad. This is the reason for the global spillovers to be discussed in the following subsection.

Third, the reform package leads to an increase in the market interest rate because every unit of capital is getting more productive when more labor becomes available (Table 4). The higher interest rate is beneficial for savers and allows them to increase their consumption further. This is shown in Figure 24 where the thick lines represent EU3. Solid lines are pre-reform while broken lines are after the labor-supply reform. Rather than declining by 17 percent, consumption per capita only declines by about 8 percent. The reform thus offsets about half of population aging.

In spite of the financial crisis since 2008, these predictions are largely in line with the actual development in Germany experienced so far where the reform package has been realized to a large extent. Specifically, labor supply has increased, unemployment declined to a historical low, contribution rates to the German PAYG-DB could be stabilized, and GDP and consumption per capita have been increasing at a moderate but steady pace in spite of rapid population aging owing to the current effects of the baby boom–baby bust transition.
5.2 | Global spillover effects on Asia and the United States

Global spillover effects work through the interest rate channel: a higher labor force in Europe increases the world interest rate because every unit of capital is getting more productive when there is more labor input (Table 4). The higher interest rate, in turn, generates higher GDP per capita also in the other countries that in turn increases consumption per capita. These spillover effects to the other countries—here measured in terms of consumption per capita—are small but visible in Figure 24. Table 4 shows that they are largest for Japan where they amount to about two thirds of a percentage point of annual consumption in 2040.

**Table 4** Reform effects on interest rate and consumption per capita

| Year 2030 | Effect on interest rate | Effect on consumption per capita |
|-----------|-------------------------|----------------------------------|
| Asia $\gamma = 0\%$, E.U. $\gamma = 0\%$ | 0.079 | 2.69 | 0.32 | 0.42 | 0.30 |
| Asia $\gamma = 80\%$, E.U. $\gamma = 20\%$ | 0.081 | 2.65 | 0.30 | 0.40 | 0.33 |
| Asia $\gamma = 20\%$, E.U. $\gamma = 80\%$ | 0.086 | 2.84 | 0.33 | 0.44 | 0.32 |
| Asia $\gamma = 80\%$, E.U. $\gamma = 80\%$ | 0.087 | 2.79 | 0.31 | 0.41 | 0.34 |

| Year 2050 | Effect on interest rate | Effect on consumption per capita |
|-----------|-------------------------|----------------------------------|
| Asia $\gamma = 0\%$, E.U. $\gamma = 0\%$ | 0.064 | 6.63 | 0.69 | 0.73 | 0.56 |
| Asia $\gamma = 80\%$, E.U. $\gamma = 20\%$ | 0.065 | 6.64 | 0.65 | 0.68 | 0.57 |
| Asia $\gamma = 20\%$, E.U. $\gamma = 80\%$ | 0.080 | 6.93 | 0.73 | 0.78 | 0.58 |
| Asia $\gamma = 80\%$, E.U. $\gamma = 80\%$ | 0.078 | 6.89 | 0.68 | 0.71 | 0.59 |

Source: Own computations.

This interest rate effect interacts with the share of procrastinators’ households in an economy. The presence of procrastinating consumers increases the interest rate further because of lower savings at all times. Figure 25 shows this interaction for three scenarios: the symmetric scenario in which EU3 and the Asian countries Japan, China, and India have a share of 80 percent procrastinating households, and two asymmetric scenarios in which one country group has a higher share of procrastinators (80 percent) than the other country groups (20 percent). As a reference, the first line of Table 4 reports the case of time-consistent households in all countries.

The interaction of reform and procrastination changes the paths of consumption in a similar way as we have seen in Figure 20. The spillover effects are largest in the asymmetric scenario in which the EU3 has the highest share of procrastinating households. This is due to the large PAYG-DB pension systems in the EU3 countries, which make pension and labor market reform particularly effective in the presence of procrastinating households.

Regarding life-time welfare across cohorts, the qualitative pattern is common for all above-mentioned scenarios with different shares of procrastinating households and similar to what we have observed in Subsection 4.4. While consumption per capita increases for the average household, cohorts entering the labor market before 2005 are better off than in the scenario without a labor market-reform; cohorts entering afterwards are slightly worse off. The reason is the increase of the interest rate owing to the reform. Cohorts that are already old and possess much savings profit a lot from a higher interest rate; young cohorts who may even go into debt are worse off if they face a higher interest rate early in life.
CONCLUSIONS

Economics has traditionally guided pension 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, often in a single-country economy. This paper sheds light on several aspects of pension economics when these behavioral assumptions do not hold and when the macroeconomic development takes place in a globalized economy. For this purpose, we construct and calibrate—to our knowledge—the first 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 an existing PAYG-DB pension system.

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 that have been created by traditions, rules, and institutions and force or nudge individuals in a behavior resembling perfect

FIGURE 24 Reform effects on consumption per capita, all time-consistent [Color figure can be viewed at wileyonlinelibrary.com]
Source. Own computations.

FIGURE 25 Differential effect relative to time-consistent scenario [Color figure can be viewed at wileyonlinelibrary.com]
Source. Own computations.
foresight. This point is especially important when we consider different shares of procrastinators across countries or regions.

We focus on three aspects that are particularly relevant for the quickly aging Asian economies: What are the consequences for the balance between pay-as-you-go and fully funded pension systems? Where will retirement savings be invested in a globally linked world with very different pension systems and demographics? How large are global spillover effects of pension reforms in one region for the other regions in the world? Regarding the first aspect, it is well-known that 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. Both together have repercussions on the world interest rate and national wages, affecting the relative merits of PAYG versus FF pension systems. Contribution rates to PAYG-DB systems rise with a higher share of procrastinating households in an economy. This is particularly pronounced for Japan. Nevertheless, PAYG-DB systems provide higher welfare in this case owing to the low consumption in old age that can be financed by the relatively low savings that procrastinating households accumulate in a FF system based on voluntary saving.

It is important to note from a policy point of view that we do not compare a mandatory PAYG system with a mandatory FF system. Rather, we compare the merits of a stylized PAYG-DB pension system that is typical for many large industrialized countries (Japan, United States, Continental Europe) with voluntary saving instruments such as IRAs or 401k plans in the United States or the Riester pensions in Germany. Regarding the second aspect, international capital flows are generally lower if households are procrastinating since they are saving dramatically less. This general pattern, however, does not hold once population processes are very different across countries. Matters are even more complex when the share of procrastinators across countries or regions differs. While contribution rates to PAYG-DB pension systems generally increase with the share of procrastinators, countries with a high share of procrastinators and a large PAYG-DB pension system may have a slower increase of the contribution rate than in a time-consistent scenario if the labor-supply effects dominate the effects generated by a higher world interest rate. The point of policy relevance here is that reforms that change a PAYG-DB pension systems in ways that increase the self-commitment of individuals to save (in an extreme case: a transition to a fully funded system) must be carefully evaluated in the context of the potentially asymmetric shares of procrastinating households in a globally linked economy.

International capital flows in a world with asymmetric shares of procrastinators also affect welfare. First, time-consistent households enjoy higher life-time welfare than procrastinating households. Second, younger cohorts will have lower life-time welfare than older cohorts owing to the population aging progress. Third, aggregate welfare is higher in an economy with a relatively low share of procrastinators. These are well-known results. The trajectories for each homogenous household type are more complex. For the cohorts entering the labor market until about the year 2020, each household type is better off living in an economy with a high share of procrastinators. For later cohorts, however, the opposite is the case. This holds especially for young households in Japan.

Regarding the third and final aspect of this paper, parametric labor market and pension reforms in one part of the world (Europe) have global spillover effects through the global interest rate. Changes in key labor market and pension parameters, especially retirement age, in Europe also improve the sustainability of pension systems and economic growth in Asia. This is a salient and important point because it strengthens the case for international policy coordination, for example, via institutions such as the Group of Twenty (G20). Spillover effects are largest in the asymmetric scenario in which the EU3 has the highest share of procrastinating households. This is due to the
large PAYG-DB pension systems in the EU3 countries, which make pension and labor market
reform particularly effective in the presence of procrastinating households.

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ENDNOTES

1 Examples for one-country OLG models with procrastinating households are Imrohoroglu et al. (2003) and Fehr
et al. (2008). Models describing population aging and international capital flows are discussed in Subsection 2.2.
2 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 \( \alpha_{t,i} \) and \( f_{e,k} \) 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.
3 Börsch-Supan and Ludwig (2009) show the effect of different growth rates on returns. In this paper, we want to
focus on the joint effects of demography and pension systems and therefore keep productivity growth fixed at a
common level.
4 For technical reasons, the model then runs further during a transition to a steady-state population in 2150 and an
additional 100-year period until the model reaches its final steady state in 2250.
5 Börsch-Supan, Härtl, and Leite (2016) provide a formal treatment.
6 Especially procrastinating households borrow against future income. We decided not to impose a borrowing con-
straint because it complicates the numerical solution that is impractical for the large number of scenarios computed
in this paper. For the baseline scenario, imposing a borrowing constraint does not change the results on capital
flows, hours worked, consumption, and welfare in a substantive way.
7 The difference to 3 percent is explained by the insurance against longevity included in a mandatory PAYG-DB
system as opposed to voluntary savings in an IRA or 401k plan, compare Börsch-Supan, Härtl, and Leite (2016).
8 A mandatory FF system with mandatory annuitization would provide an even higher welfare if it could be intro-
duced without transition costs. This, however, is an unrealistic option in countries with an already established
PAYG system such as the United States, Japan and the large Continental European countries.
9 An exception is EU3 between 2020 and 2035 caused by to the accelerating aging process.

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