Retirement Behavior in the U.S. and Europe*

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Abstract

In this paper, we develop a retirement model featuring various endogenous exit routes: unemployment, disability, private and public pensions. The model allows for saving and uncertainty along several dimensions including health and mortality. The preference parameters are estimated on data from the U.S. and European longitudinal data and make use of institutional variation across countries. We analyze the roles played by preferences and institutions in explaining international heterogeneity in retirement behavior. Our preliminary estimates suggest that a model with a single set of preferences for individuals from the U.S., the Netherlands and Spain does not fit the data well. If Europeans were to have the same preferences as Americans, they would save less than they actually do. Furthermore, the Dutch and Spanish would work more hours than observed in the data.

Key words: Retirement; saving; institutions; structural estimation

JEL-Codes: D91; J14; J26; H31

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1 Introduction

Over the last 40 years, economics literature has identified a number of incentives embodied in social insurance programs which affect retirement behavior. For example, the large body of work produced by the *Retirement Around the World* project (Gruber and Wise, 1999) has argued effectively that there is a strong correlation between the tax placed on workers who may wish to delay retirement and actual labor force participation of older workers. This work well illustrates the power of international comparisons.

Reduced-form models using cross-country or times series variation in retirement incentives have identified a clear link between behavior and incentives. However, these models have a hard time fitting spikes in retirement hazards. Furthermore, they do not allow for assessment of the effect of policy changes as the estimates generally do not allow to disentangle preferences from constraints. In response to these limitations, structural retirement models have been used to understand the effect of retirement incentives on behavior (Gustman and Steinmeier, 1986; Rust and Phelan, 1997; French, 2005; Van der Klaauw and Wolpin, 2008; French and Jones, 2011; Van der Klaauw, 2012). The estimation of such models has for the most part of studies been limited to the U.S., exploiting only within-country variation in wealth and wages to estimate preference parameters.

In this paper, we develop a retirement model which allows to model effectively the heterogeneity in retirement incentives found in the U.S. and Europe. We then estimate preference parameters using institutional variation across countries, making use of the comparable longitudinal data from the Health and Retirement Study (HRS) and a subset of countries from the Survey of Health, Aging and Retirement in Europe (SHARE). The two European countries chosen are the Netherlands and Spain All of these papers have Pay-As-You-Go pension systems with different institutional retirement incentives. We compare the fit of a model with common preferences for all countries with that of models in which preferences are country-specific; this enables us to disentangle the roles played by preferences and institutions in explaining international heterogeneity in retirement behavior. We follow a

Method of Moments approach and choose preference parameters such that we match observed patterns of wealth and labor supply. The model is rich and allows workers to leave the labor force through any of the following exit routes: unemployment, disability, and private and public pensions. Furthermore, it allows for saving and uncertainty in health, medical expenses and mortality.

Moreover, we *estimate* the model parameters by means of the method of simulated moments and test for preference heterogeneity while accounting for institutional differences. Our preliminary results suggest with a single set of preferences for individuals in all countries, the model does not fit the data well. We simulate a hypothetical case,if Europeans were to have the same preferences as Americans, they would then save less than they actually do. The Dutch and Spanish would work more hours than observed in the data.

The rest of the paper is structured as follows; in section 2, we review the literature on the determinants of retirement behavior which are relevant for the model we develop. Section 3 presents the model and section 4 describes the data and the auxiliary processes. The estimation strategy is explained in section 5. Section 6 contains estimation results and section 7 shows various policy simulations. Section 8 concludes.

2 Background

Our paper ties in with the growing literature on empirical lifecycle models of saving and retirement, which have focused mostly on the U.S. Gustman and Steinmeier (1986) present an early example of a structural model of labor supply that is able to track observed retirement behavior closely; in particular, the peaks in the retirement hazard at ages 62 and 65 (the early and normal retirement ages for social security in the U.S.). Subsequent work improved the realism of the institutional framework in which agents make their decisions, and of the decision process itself, for instance by incorporating uncertain future health and medical expenditures. Institutions such as Medicare affect the medical expenditures incurred when in bad health and affect labor supply (Rust and Phelan, 1997) and saving (Palumbo, 1999).

Gourinchas and Parker (2002) introduce exogenous labor income uncertainty and estimate preference parameters by means of the method of simulated moments, while earlier papers applied maximum likelihood estimation. Their estimates indicate that the precautionary motive plays an important role up to age 40, and that saving for retirement becomes more important around ages 40-45 (Gourinchas and Parker, 2002). French (2005) also allows for wage uncertainty and adds an explicit bequest motive. He finds that the earnings test for social security, by which benefits are cut if individuals continue to work while claiming, poses a strong disincentive for continued employment for men aged 65 and older. Van der Klaauw and Wolpin (2008) formulate a rich model that incorporates multiple decision makers per household and find that singles and husbands tend to respond more strongly to changes in incentives than do couples and wives.

Recent papers emphasize heterogeneity in savings and/or labor supply. De Nardi et al. (2010) focus on heterogeneity in the wealth decumulation of single retirees across different income groups. They find that out-of-pocket medical expenditures increase with income and thus are an important driver of savings even for the income-rich. For the same reason, the presence of a means-tested consumption floor in the spirit of Hubbard et al. (1994, 1995) is important for households across the income distribution. French and Jones (2011) revisit the role of Medicare and medical expenditures with an elaborate model of saving and health insurance. The availability of Medicare at age 65 remains an important determinant of retirement behavior even if employer-provided insurance is taken into account. Lockwood (2010) uses the take-up of long-term care insurance in combination with the pattern of saving across the wealth distribution to disentangle bequest and precautionary motives, finding that the former are widespread and important.

A few papers can be found which analyze retirement with lifecycle models in Spain and the Netherlands.[1] Structural retirement behavior papers in Spain focus on how different reforms can affect the delay of the retirement age (i.e., Sanchez-Martin et al. (2014) and

[1]Some studies also examine retirement behavior at the macroeconomic level using general equilibrium overlapping generation models: for example Sanchez-Martin (2001), Diaz-Gimenez and Diaz-Saavedra (2009) and Catalan et al. (2010) for Spain, Fehr (2000) and Beetsma et al. (2003) for the Netherlands.

Jimenez-Martin and Sanchez-Martin (2007)). Jimenez-Martin and Sanchez-Martin (2007) estimate the behavioral parameters of a lifecycle model to analyze the impact of the Spanish minimum pension system on retirement. They estimate the model with the maximum likelihood method and provide simulation of the effect of the minimum pension on early retirement. Their findings show that the early retirement is almost a half larger with minimum pensions than without a minimum pension system. The paper focuses on the modeling of minimum pension system, abstracting other institutional elements from retirement behavior. The Sanchez-Martin et al. (2014)'s study calibrates a search dynamic rational expectation model to analyze exits of labor market including retirement and unemployment. It studies the effects of the Spanish pension reform in 2011 that delays the early and normal retirement ages on the labor supply. With the reform, the employed workers delay retirement and consequently the labor supply increases. Finally, Heyma (2004) estimates a structural model analysing Dutch retirement behavior by examining the different exit routes to retirement. Different simulations examine different incentives in elderly labor participation. For example, some results show that low pension benefits do not avoid early retirement rates.

The study closest to ours that captures the cross-country dimension is Laun and Wallenius (2013). The authors use a lifecycle model to analyze the role of institutions as drivers of international labor supply differences. The key features of their model are that people choose when to stop working and whether to apply for disability and pension benefits; that the awarding of disability benefits is imperfectly correlated with health; and that people can partially insure against health shocks by investing in a stock of health capital. They calibrate the model to the U.S. and find that it predicts even larger differences in employment rates than observed, raising the question of why Europeans work as hard as they do given the incentives that they face (Laun and Wallenius, 2013). Our approach of estimating international heterogeneity in preferences answers this question.

3 Model

3.1 Overview

This section provides a general overview of the way we model decisions, institutions and preferences. We develop a dynamic structural model of individual employment with different exit routes to retirement. We carefully model institutions and decisions related to retirement behavior for three countries: the U.S., Spain, and the Netherlands. All countries have Pay-As-You-Go pension systems but with different exit route incentives. Individuals decide on saving and labor supply, and they choose whether and when to claim disability insurance, unemployment insurance and public and private pensions. They value both leaving behind a bequest and their own consumption and leisure.

The model is a discrete-time finite-horizon model. Let t denote age. We consider an individual who starts his life-cycle employment and retirement decisions at age $t = 50$. [2] Heterogeneity is introduced through six sources, three of which are the same in all countries. In all of them, the agent has wealth, w_t, a wage on their current job, j_t and workers are in one of two self-reported health statuses at age t ($m_t = 1$ if in poor health and $m_t = 2$ if in good health). All workers are endowed with initial wealth, w_{50}, initial wage on their current job, j_{50}, and initial health status at age 50, m_{50}.

The final three characteristics differ internationally. First, The defined benefit pension, db_t. Second, the levels of pension benefit and/or unemployment and disability insurance depend on a vector of summary measures of the earnings history. Third, the eligibility for unemployment benefits, ui_t and disability benefits, di_t. Initial values for all variables are given at $t = 50$:

1. In the US and the Netherlands, but *not* in Spain, a worker's job may offer a defined benefit (db) pension. Denote by $db_t = 2$ if the job has a db pension and $db_t = 1$ if not.

2. In all countries, the levels of pension benefits and/or unemployment and disability

[2] We restrict attention to modeling the behavior of workers from age 50 onwards who have attachment to the labor force and are currently working.

insurance depend on a vector of summary measures of the earnings history. We call this vector $earnhist_t$. For the US, the earnings history is summarized by an average monthly earnings measure ame_t. In the Netherlands and Spain it is represented by the combination of the number of years worked, $yrswrk_t$, and the earnings during the last year or years in which the individual worked $prevearn_t$.

3. The final characteristics that define an individual in our model is eligibility for unemployment and disability insurance. There is international variation in these eligibility rules. In the US, eligibility for unemployment benefits is binary: individuals who worked during the previous period are eligible ($ui_t = 2$) and those who did not are not ($ui_t = 1$). In the Dutch system each year of work entitles a worker to 1 month of benefits, with a maximum of three years. Expressed in years, eligibility for unemployment benefits can take 4 values. $ui_t = 1$ if the individual is not, or no longer, entitled and $ui_t = 4$ if the individual is entitled to 3 years of benefits. Spain has similar eligibility rules for unemployment benefits: a longer work history entitles the worker to receive benefits for longer.

   If in poor health, $m_t = 1$, a worker can decide to apply for disability benefits in which case he cannot work simultaneously. The details of the application procedure differ between countries to reflect international differences in generosity of the disability insurance programs. In the United States, there is a waiting period after application and the possibility of denial of benefits. In particular, if an individual applies ($diclaim_t = 2$), he may start receiving benefits in the following year if he remains in poor health ($m_{t+1} = 1$) and his application is accepted ($di_{t+1} = 2$). There is a probability p_d that the application is rejected, in which case the di status remains unchanged ($di_{t+1} = 1$). If he does not apply $diclaim_t = 1$ and $di_{t+1} = 1$. In Europe application for disability insurance is quicker and there is no uncertainty. If an individual applies, $diclaim_t = 2$, he receives benefits in the same period. As explained above, depending on the country, disability benefits are transformed into public pension benefits at some age. For example, the U.S. system automatically transforms disability benefits into social security benefits at the normal retirement age.

We model institutions for the period during which data was collected for each of the countries. For the U.S., this period runs from 1992 to 2010, while the European data spans the period 2004-2011. Detailed descriptions of the institutional landscape for all three countries can be found in Appendix A. Table 1 provides a summary of the state variables that define a worker in each country.

Table 1: State variables by country

	United States	The Netherlands	Spain
Wealth (w_t)	$[0; 10^6]$	$[0; 10^6]$	$[0; 10^6]$
Wage (j_t)	$[5; 100]$	$[5; 100]$	$[5; 100]$
Health (m_t)	$\{1 =$ poor, $2 =$ good$\}$	$\{1 =$ poor, $2 =$ good$\}$	$\{1 =$ poor, $2 =$ good$\}$
DB pension (db_t)	$\{1 =$ no DB scheme, $2 =$ DB scheme$\}$	$\{1 =$ no DB scheme, $2 =$ DB scheme$\}$	
Benefit level	ame_t	$yrswrk_t$, $prevearn_t$	$yrswrk_t$, $prevearn_t$
DI (di_t)	$\{1 =$ not eligible, $2 =$ eligible$\}$	$\{1 =$ not eligible, $2 =$ eligible$\}$	$\{1 =$ not eligible, $2 =$ eligible$\}$
UI (ui_t)	$\{1 =$ not eligible, $2 =$ eligible$\}$	$\{1 =$ not eligible, ... $4 =$ fully eligible$\}$	$\{1 =$ not eligible, ... $7 =$ fully eligible$\}$

Detailed descriptions of our models of institutions for each country can be found in Appendix A.

The agent derives utility from consumption and leisure. The utility obtained from consumption, c_t and leisure, l_t, at age t is given by:

$$u(c_t, l_t, t) = n_t \frac{((\frac{c_t}{n_t})^{\kappa} l_t^{1-\kappa})^{1-\sigma} - 1}{1-\sigma} - \phi \mathbf{I}\{di_t > 1\} - \xi \mathbf{I}\{ui_t > 1\}$$

Starting at age 50, workers decide how many hours they work, h_t. They have a maximum of four options corresponding to 0, 1500, 2000 and 2500 hours per year ($h_t \in \{0, 1500, 2000, 2500\}$).

We assume no one works beyond age 70. Leisure consumed, l_t, is given by

$$l_t = L_{max} - h_t - \gamma \mathbf{I}\left\{h_t > 0\right\}$$

where γ is a fixed cost of working and L_{max} is set to 4000 hours ($\mathbf{I}\left\{.\right\}$ is an indicator function equal to one if the argument in curly brackets is true). Individuals also decide every period how much to consume, c_t, and to save for future consumption or bequests.

n_t is an equivalence scale increasing in household size, σ determines agents' risk aversion and their inter temporal rate of substitution and κ is the weight on consumption in the composite good. ϕ and ξ are stigma or hassle costs associated with receiving disability (di_t) and unemployment insurance (ui_t) respectively. If the worker dies, he obtains utility from leaving bequests behind. The specification follows from French (2005):

$$b(w_t) = \theta \frac{(w_t + K)^{\kappa(1-\sigma)}}{1-\sigma}$$

where θ is the weight attached to bequests and K sets the concavity of the bequest function.

There are a maximum of four exit routes to retirement: unemployment, disability, private and public pensions. These in turn determine income in each period. Figure 1 gives an outline of the options that are available to individuals in the different countries at various ages. Dashed lines indicate the early and normal retirement ages for relevant retirement schemes, as mentioned in the table notes (the early retirement age is abbreviated to ERA and the normal retirement age is NRA). As explained above, individuals in all countries decide on their consumption regardless of their age. Moreover, between the ages of 50 and 70 they also decide how much to work. In none of the countries can individuals choose to work while claiming social insurance or pension benefits. Despite these similarities, the options regarding pensions and social insurance differ between countries.

In the U.S. there is no age limit on claiming unemployment insurance (UI) benefits, but one cannot claim UI and pension benefits at the same time. Hence, in our model the restriction that everybody retires at age 70 means that workers can only claim UI up to

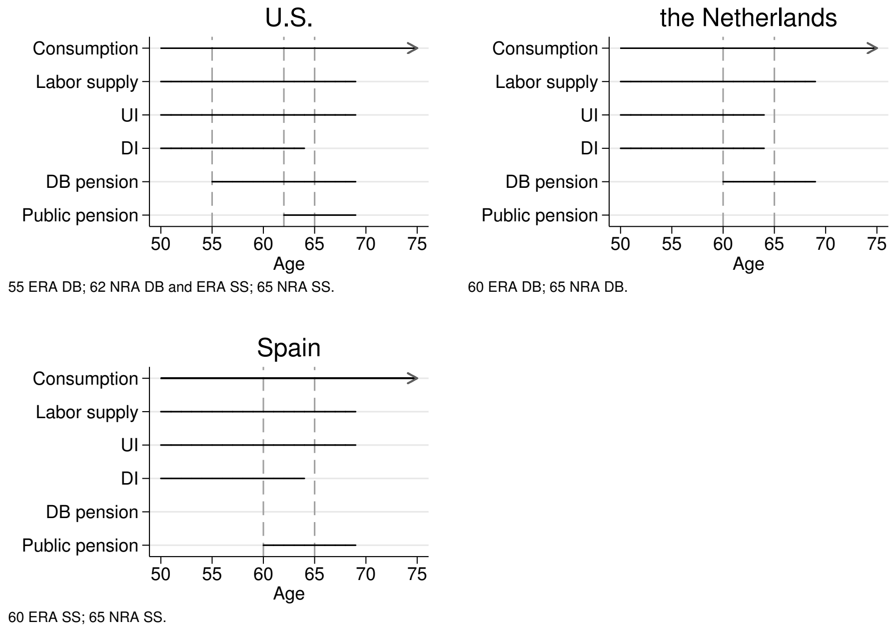

Figure 1: Structure of the model – decisions to be taken at various ages

that age. Disability insurance (DI) can be claimed up to the normal retirement age for social security, which is 65. Afterwards there is an automatic transfer into social security. DI and UI cannot be claimed simultaneously and they cannot be combined with either type of pension. Private DB pensions can be claimed starting from the early retirement age of 55, but an actuarial adjustment penalizes claims prior to the normal retirement age of 62 and rewards delayed claiming up to age 70. Such actuarial adjustments are in place for all pension schemes with a flexible age of claiming. For instance, social security, the U.S. public pension, can be claimed from the early retirement age of 62, but full benefits can only be claimed at the normal retirement age of 65. Even higher benefits await if claiming is delayed further.

In the Netherlands neither UI nor DI are available when an individual starts to receive a public pension at age 65. Receipt of such public pension is not a decision for a Dutch worker: benefits start automatically. Private DB pensions can be claimed from age 60, with a normal retirement age of 65. Like the U.S., Spain allows UI claiming up to age 70 and DI claiming up to the normal retirement age for the public pension (age 65). Private pensions do not play an important role in Spain. Public pensions can be claimed from age 60 onward, with a normal retirement age of 65. The following sections describe the income sources in more detail.

3.2 Resources

The agent has six potential sources of income. First, the agent has earnings if he works, y_t^e. Second, he can have income from disability insurance, y_t^{di}. Third, the agent can have private pension benefits, y_t^{db}. Forth, the agent can have unemployment benefits, y_t^{ui}. Fifth, he can have public pension benefits, y_t^{ss}. Finally, interest income is given by $y_t^w = rw_t$ where r is the real rate of return (which we set to 3%). Income is subject to taxes. Denote net income by y_t^n. Net income is given by

$$y_t^n = \tau(y_t^e, y_t^{di}, y_t^{db}, y_t^{ui}, y_t^{ss}, y_t^w)$$

where $\tau(.)$ is a tax function which returns net income and takes as inputs the various income sources of the worker.

Depending on their age t and their health status m_t, workers will incur out-of-pocket medical expenditures, $oop_t = o(t, m_t)$. Government transfers are provided if cash-on-hand is below a certain minimum consumption floor, c_{min}. Let cash-on-hand be given by

$$x_t = w_t + y_t^n - oop_t.$$

Transfers are given by

$$tr_t = \max(n_t c_{min} - x_t, 0)$$

where, as before, n_t is an equivalence scale. Hence, the law of motion of wealth is given by

$$w_{t+1} = w_t + y_t^n + tr_t - c_t - oop_t$$

Next subsections will describe the different sources of income with more detail. We also provide more information in Appendix B.

3.2.1 Earnings

If working, earnings are given by

$$y_t^e = \exp\left(-\pi \mathbf{I}\left\{h_t = 1500\right\}\right) j_t h_t.$$

where π is a part-time wage penalty. For example, Gustman and Steinmeier (1986) estimate that working part-time entails a penalty of approximately 25% in the U.S. Wages are assumed flat after age 50.

3.2.2 Disability Insurance Benefits

Disability benefits in all countries are a function of age and past earnings $earnhist_t$. Provided eligibility is met, benefits are thus given by

$$y_t^{di} = b_{di}(earnhist_t, t)$$

For the U.S., past earnings are given by ame_t. In the Netherlands and Spain they are captured by previous earnings $prevearn_t$. If a disability insurance recipient looses eligibility, he can decide to work or apply for other programs (including disability insurance).

3.2.3 Private Pension Benefits

Private pensions did not play an important role in Spain during the period covered by their samples, so we do not model them for those countries. For the U.S. and the Netherlands, those with $db_t = 2$ can claim private pension benefits when they reach the early retirement age of the plan, era_{db}. Benefits cannot be claimed while continuing to work.

The benefit formula depends on past earnings $earnhist_t$ and on age t. Provided eligibility and that the worker chooses to claim, we have

$$y_t^{db} = b_{db}(earnhist_t, t)$$

Again, the exact form in which past earnings enter the benefit formula differs between countries. For the U.S., we impute DB benefits from full-time earnings, $j_t \times 2000$. In the Netherlands, benefits are a function of past earnings which are summarized through final earnings prior to retirement, $prevearn_t$, and a replacement rate that is a function of the number of years worked $yrswrk_t$.

The dependence on age is due to actuarial adjustments that penalize retirement prior to the normal retirement age nra_{db} and reward delayed retirement. This would imply that we need to keep track of the age at which db benefits are claimed. Instead, we adjust the wage, j_{t+1} such that

$$b_{db}(j_{t+1}, nra_{db}) = b_{db}(j_t, t)$$

at the age t when benefits are first claimed. This is valid since the wage is constant while working and workers are not allowed to work after claiming db pensions. Therefore, we only need the new wage j_{t+1} if a person is a prior claimer ($db_t = 3$).

3.2.4 Public Pension Benefits

The rules that govern public pensions differ markedly between countries. In most countries public pension benefits depend on the age at which benefits are claimed for the first time and/or on the earnings history of the worker:

$$y_t^{ss} = b_{ss}(earnhist_t, t)$$

In the Netherlands, public pensions do not depend on previous earnings and receipt is automatic at the normal retirement age nra_{ss}. Individuals are allowed to simultaneously work and receive their public pension. Because neither disability nor unemployment insurance are available from the normal retirement age onward, those benefits cannot be combined with the public pension.

In the U.S., workers have the freedom to choose when to start receiving their pension and to trade off early receipt against higher benefits. Public pensions can be drawn once the worker has reached the early retirement age era_{ss}. The benefit formula depends on age t as well as on average life-time earnings ame_t. The dependence on t again reflects an actuarial adjustment factor which depends on a normal retirement age nra_{ss}. In order not to keep track of the age at which benefits start to be drawn, we adjust ame_{t+1} at the time of claiming t using

$$b_{ss}(ame_{t+1}, nra_{ss}) = b_{ss}(ame_t, t).$$

The agent cannot work while receiving public pension benefits. He cannot receive disability insurance benefits simultaneously but can receive private pension benefits. Let $ss_t = 2$ if benefits have been claimed and $ss_t = 1$ if not.

The Spanish system of public pensions is similar to that of the U.S. in that individuals are free to choose when to start claiming from the early retirement age of 60 onward. Benefits are calculated using a replacement rate relative to the individual's average earnings over the preceding 15 years. That replacement rate depends on the number of years a person worked during his lifetime and reaches 100% for workers with at least 35 working years behind them. Benefits are capped at the earnings base for the social security premium. Moreover, benefits are subject to actuarial adjustments that penalize retirement before the normal retirement age of 65 and reward late retirement.

3.2.5 Unemployment insurance Benefits

If the worker is not eligible for any other program yet he is eligible for unemployment insurance, he automatically collects unemployment benefits. These benefits may depend on age t as well as previous earnings $earnhist_t$:

$$y_t^{ui} = b_{ui}(earnhist_t, t)$$

For the U.S. the earnings history is captured by earnings from full-time employment $j_t \times 2000$. For the European countries previous earnings are summarized by the same measure that governs the level of income-dependent pension benefits (DB pensions for the Netherlands and public pensions for Spain).

3.3 Health and Mortality

The health status of a worker is uncertain. We assume a first-order markov process which depends on age t and current health status m_t. Let the probability of being in good health next year given current health status and age be given by:

$$p_m(m_t, t) = \frac{\exp\left(\gamma_0 + \gamma_t t + \gamma_m \mathbf{I}\left\{m_t = 2\right\}\right)}{1 + \exp\left(\gamma_0 + \gamma_t t + \gamma_m \mathbf{I}\left\{m_t = 2\right\}\right)}$$

Mortality depends on current health and age in a similar way. Let $p_s(m_t, t)$ be the one year survival probability given current health and age. We assume the worker dies with certainty at age $t = 100$.

3.4 Maximization Problem

A worker maximizes the sum of expected discounted utility given his current state. He discounts future utility with a factor β. Depending on the specification we either restrict preferences to be the same for all individuals, or we allow for preference heterogeneity across countries. We always allow choice sets and constraints to differ between countries in order to capture international differences in institutions. Let the current state at age t in country k be given by the state space $s_{t,k} = (j_t, w_t, ss_t, db_{t,k}, di_{t,k}, ui_{t,k}, earnhist_{t,k})$ and health status m_t. Let $\mathcal{D}_k(s_{t,k}, m_t)$ be the country-specific set which combines all possible decisions, other than consumption, which the agent can make given he is in state $s_{t,k}$ and m_t. An element in that set is denoted by d_k and may consist of decisions regarding labor supply and claiming of disability and unemployment insurance as well as private and public pensions. We write the value of choosing option d_k as

$$
\begin{aligned}
V^d\left(s_{t,k}, m_t\right) = \max_{c_t} \Big\{ & u(c_t; d_k, t) \\
& + \beta \left[p_s^k(m_t, t)\mathbb{E}\left[V(s_{t+1,k})\right] + (1 - p_s^k(m_t, t)) b(w_{t+1}) \right] \Big\} \\
& \text{s.t. budget constraints}
\end{aligned}
$$

where $\mathbb{E}\left[V(s_{t+1,k})\right]$ takes the expectation over future health states (and for the U.S. also over disability insurance status given the rejection probability). p_s^k is the probability of surviving until the next year in country k, which is a function of age and current health. The unconditional value of a given state is the maximum among all values that correspond to the different discrete decisions that are available to the individual. This unconditional value $V(s_{t,k}, m_t)$ is given by

$$
V(s_{t,k}, m_t) = \max_{d_k \in \mathcal{D}_k(s_{t,k}, m_t)} (V^1(s_{t,k}, m_t), ..., V^{D_k}(s_{t,k}, m_t))
$$

where D_k is the number of options in $\mathcal{D}_k(s_{t,k}, m_t)$.

The problem can be solved by backward recursion for each worker given initial conditions. We compute $V^d(s_{t,k}, m_t)$ for each option by discretizing the country-specific state space. For instance, we discretize wealth into 32 points and *ame* into 24 points. We use 10 points for wages. Optimal consumption at t is found using the Golden-section search algorithm. Once $V^d(s_{t,k}, m_t)$ is computed we can compute $V(s_{t,k}, m_t)$.

4 Data and Auxiliary Processes

4.1 Data

Estimation of a dynamic model of consumption and labor supply from exogenous, international, variation in institutions requires longitudinal data from different countries. We use the Health and Retirement Study (HRS) for the U.S. and the Survey of Retirement, Aging and Health in Europe (SHARE) for European countries that includes our studied countries (Spain and the Netherlands). Both surveys are sources of comparable data and include representative samples for the 50+ populations. We refer the reader to Appendix B for more detailed information. In our analysis, we use HRS data from the period 1992 to 2010,[3] and the period covered by our European samples is 2004-2011.[4]

Our estimation sample is constructed as follows.[5] We first drop all women, since our model does not take their behavior into account. The auxiliary processes for health, mortality, out-of-pocket medical expenses and equivalence scales are estimated using all observations for men in the age range 50-110. In order to generate initial conditions for simulations, we further restrict the sample based on characteristics of workers during their first interview. We construct samples for which our model is appropriate by dropping individuals who were older than 56; not working; or self employed at the time of their first interview. Data moments used in estimation are calculated using all observations for the individuals that feature in the initial conditions, supplemented with older men whom the job episodes dataset shows were working at age 50.

4.2 Auxiliary Processes

In order to solve the worker's optimization problem, we need to estimate country-specific processes for health, mortality, out-of-pocket medical spending and equivalence scales. This subsection presents our estimates.

4.2.1 Health

Health is the first source of uncertainty faced by workers. It determines individuals' eligibility for disability insurance. We model health using an autoregressive logit model in which future health depends on current health and on age. Figure 2 shows the estimated probability of being in good health during the following year as a function of current health and age for all

[3]See Juster and Suzman, 1995, for more details on the HRS or go to http://hrsonline.isr.umich.edu.
[4]See http://www.share-project.org.
[5]See Appendix B for more details.

countries in our dataset. For all countries we find that the probability of being in good health in the future depends strongly on current health: it is around 60-80 percentage points higher if one is currently in good health. Moreover, for the U.S., the Netherlands and especially for Spain we find that the likelihood of good health decreases significantly with age.

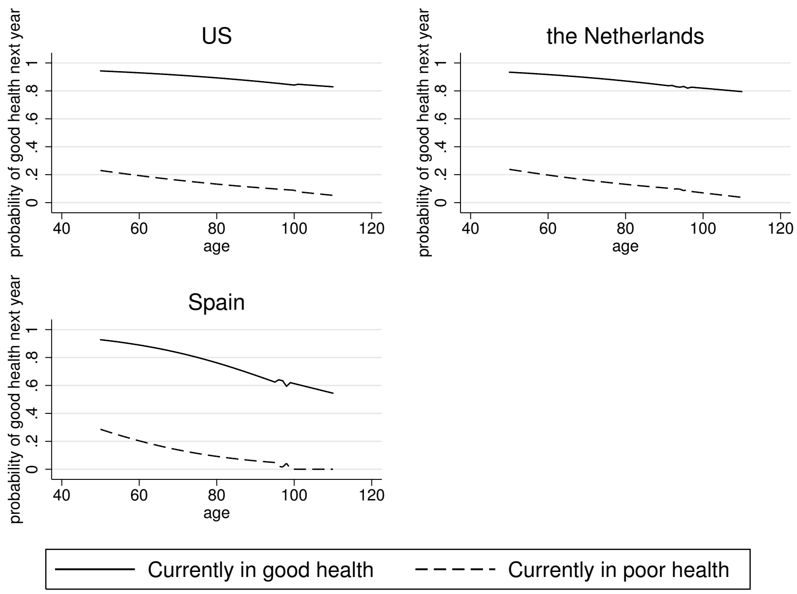

Figure 2: Estimated health processes – the probability of being in good health next year as a function of age and current health

4.2.2 Mortality

The second source of uncertainty is longevity: individuals do not know how long they will live. We use the method proposed by French (2005) and combine life table mortality probabilities with the observed probability of being in good health conditional on dying before the next survey wave to construct mortality probabilities that condition on age and current health. The estimated mortality processes are shown in Figure 3. As expected, the probability of dying is higher for people who are in poor health and increases with age for all countries.

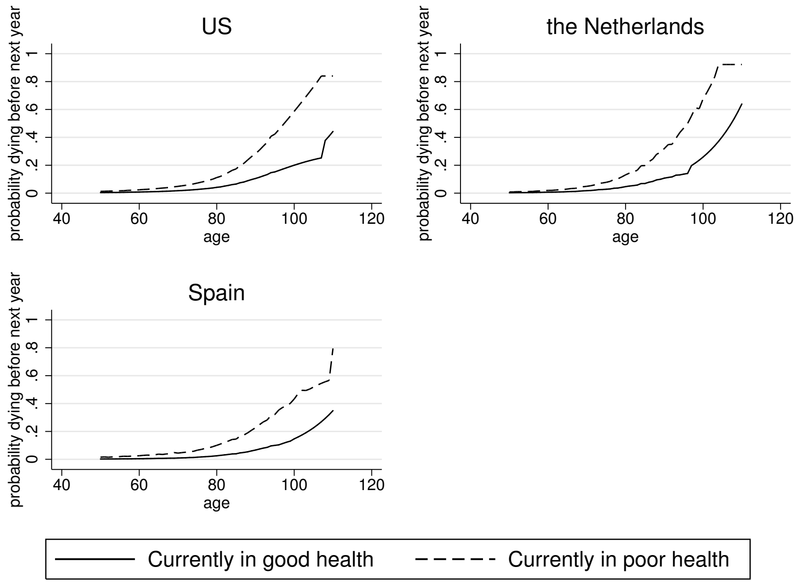

Figure 3: Estimated mortality processes – the probability of dying before next year as a function of age and current health

4.2.3 Out-of-Pocket Spending

We assign a fixed value of out-of-pocket medical spending to each individual depending on his age and current health status.[6] These age- and health-contingent expenditures are estimated by means of kernel regressions of out-of-pocket expenses on age, run separately on sub-samples of healthy and unhealthy individuals. Figure 4 shows the estimated expenditure profiles. Out-of-pocket medical spending is of limited importance for all European countries: yearly expenditures are below 2,000 dollar regardless of age and health. Such patterns are plausible, since the countries that we look at all have mandatory health insurance with universal coverage. For the U.S., on the other hand, average out-of-pocket medical spending rises to over 6,000 dollar per year for retirees older than 90 who are in poor health.

[6]We do not model medical spending as an additional source of uncertainty.

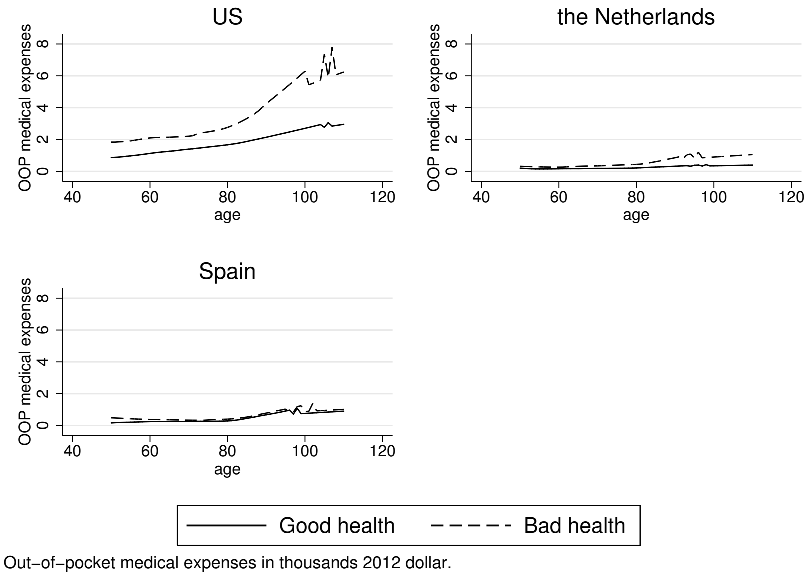

Figure 4: Estimated out-of-pocket medical spending – average expenditures as a function of age and current health

4.2.4 Equivalence Scales

We estimate equivalence scales by age for each country to incorporate consumption economies of scale within the household. The equivalence scales n_t shown in Figure **??** are the averages across workers of $n_{i,t} = HH_{i,t}^{0.7}$, where $HH_{i,t}$ is the number of individuals living in the household of worker i of age t. The average equivalence scales of the U.S. and the Netherlands look similar: they decrease from around 2 at age 50 to close to 1 at age 110. On average households in those countries contain between 2 and 3 persons at age 50 while workers who survive to age 110 are alone in their household. For Spain we note that households are larger on average for all ages.

4.2.5 Exogenous income of the spouse

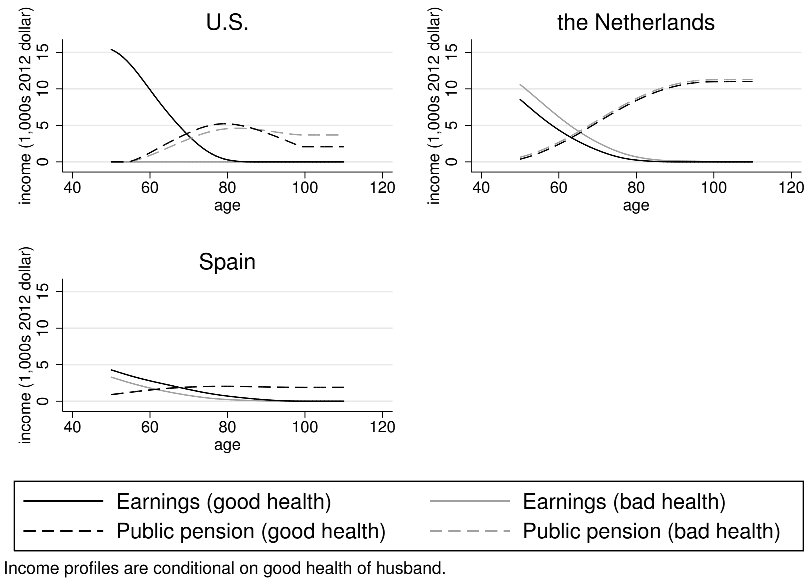

Figure 5: Exogenous income of the spouse

4.3 Institutional Parameters

Having estimated the exogenous processes that introduce uncertainty and affect preferences, we now turn to the institutional framework within which workers make their decisions. Section 3.1 provides a general description of the various exit routes available to workers in the countries we consider. In this section, we illustrate the type of international heterogeneity in institutions that we exploit in our estimation routine by sketching the relevant tax schedules. More details regarding the exact parametrization of the institutions for each country can be found in Appendix A.

We use the 2003/2004 version of the OECD report *Taxing Wages* as our starting point for modeling tax functions (OECD, 2004). *Taxing Wages* provides a detailed description of the tax rules in place in all OECD member countries. It describes not only the rules for taxation of income, but also available tax allowances and credits and mandatory contributions to social insurance schemes such as disability and unemployment insurance. We verified our functions by comparing the implied proportion of income paid in taxes with graphs reported in another OECD publication: *Pensions at a Glance* (OECD, 2005).

Figure 6 describes the incentives inherent in the various income tax systems by means of the marginal tax rate schedule for each country. Marginal rates are given as a function of income divided by average earnings and apply to non-retired workers for whom wage earnings are the only source of income. Based on their income tax system, the countries in our sample can be divided in two groups. The U.S. and Spain form one group with relatively low rates and flat profiles. The marginal rate faced by a worker with an average income is 30% in both countries, increasing only to 35-38% for a worker who earns 2.5 times the national average. The Netherlands, on the other hand, has more progressive tax systems characterized by higher rates. The marginal rate for an average earner is 45% in the Netherlands while the rate for somebody who earns 2.5 times the average income is 50-53%.

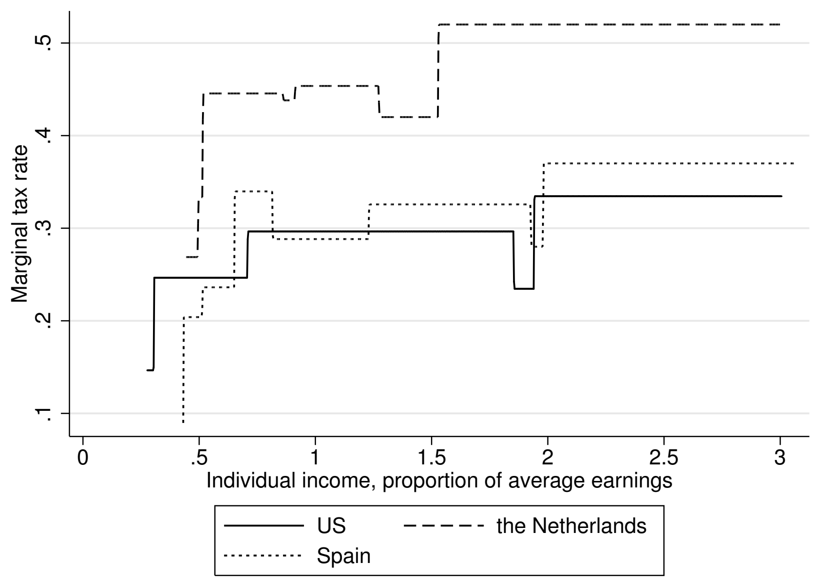

Figure 6: International heterogeneity in marginal tax rates

We exploit the international variation in incentives faced by workers to identify preference parameters. Doing so has at least two methodological advantages. Firstly, variation in institutions is likely to be exogenous to the preferences of individual workers. We consider it plausible that a majority of workers do not choose their country of residence based on preferences with respect to labor supply and savings. Secondly, by matching moments from different countries, we can use fewer moments per country in order to identify parameters. This allows us to limit ourselves to moments that can easily be estimated from available data, such as the average hours worked and quartiles of wealth for various age bins.

5 Estimation

5.1 Estimation algorithm

Our Method of Simulated Moments (MSM) estimation algorithm is adapted from French (2005) and French and Jones (2011). For a given value of preference parameters we first solve the worker's optimization problem for all countries. We then use those solutions to simulate life cycles for 5,000 workers per country and calculate moments from the simulated data. Those simulated moments are compared with their observed counterparts computed from actual data from the HRS and SHARE. This comparison is done by means of a method of moments objective function. The parameter estimates are the minimizers of that function, which we obtain using a simulated annealing algorithm.

We match model simulations to observed data based on moments that concern labor supply and wealth. In particular, the moments used in estimation measure average hours worked and quartiles of wealth for ten two-year age bins between ages 50 and 68. Cohort and family size effects are removed from the hours and wealth profiles by means of fixed effects regressions. Estimation is based on 40 moment conditions per country, 10 for hours worked and 30 for wealth, for a total of 160 moments from which to identify 8 preference parameters. More information on the computation of moments and the construction of the objective function can be found in Appendix C.

5.2 Initial conditions

We simulate workers starting from initial conditions that are taken from the data. We use the first observation of each individual, provided they were aged 50-56, working and not self-employed. Those initial observations are then replicated and 5000 are selected at random from the expanded dataset and used as starting points for simulations.

Table 2: Initial conditions

	N	Mean	Std. Dev.	P25	Median	P75
a. United States						
Health (1 = good)	5000	0.88	0.32	1	1	1
Private pension (1 = entitled)	5000	0.46	0.50	0	0	1
Hourly wage (2012 $)	5000	33.09	26.21	16.33	24.71	36.42
AME (1000s 2012 $)	5000	3.59	2.03	1.86	3.15	5.23
Wealth (1000s 2012 $)	5000	199.50	239.85	31.34	117.49	268.55
b. The Netherlands						
Health (1 = good)	5000	0.87	0.34	1	1	1
Private pension (1 = entitled)	5000	0.93	0.26	1	1	1
Hourly wage (2012 $)	5000	25.05	16.39	16.51	21.77	28.90
Years worked	5000	22.46	10.79	15	26	30
Previous earnings (1000s 2012 $)	5000	50.37	36.67	32.66	43.83	59.37
Wealth (1000s 2012 $)	5000	370.92	346.54	111.32	279.80	520.51
c. Spain						
Health (1 = good)	5000	0.91	0.29	1	1	1
Hourly wage (2012 $)	5000	14.39	14.92	6.91	10.95	15.40
Years worked	5000	23.29	11.26	14	26	33
Previous earnings (1000s 2012 $)	5000	26.95	29.44	15.26	22.89	31.79
Wealth (1000s 2012 $)	5000	278.38	312.79	66.55	179.02	373.99

Descriptive statistics of the initial conditions can be found in Table 2. Around 90 percent of each of the samples is in good health. 71 percent of the U.S. workers and 94 percent of the Dutch are entitled to defined benefit private pensions. The rate of DB pension ownership of the Dutch corresponds closely to that mentioned by Bovenberg and Meijdam (2002), according to whom 90 percent of Dutch workers is entitled to such pensions. Wages are highest in the U.S., with a median of 29 dollar per hour. The Netherlands follows with hourly wages of around 22 dollar and Spain has markedly lower wages with a median of 12 dollar per hour. Average monthly earnings (AME), used to calculate public pension benefits in the U.S., are around 3,500 dollar per month, for a yearly total of close to 43,000 dollar. Private pensions in the Netherlands and public pensions in Spainare based on the number of years worked and, like the U.S. public pension, on the income earned while working. The number of years worked is slightly lower for the Netherlands than for Spain, with medians of 25, 29 and 30 years respectively. At 44,500 dollar per year previous earnings for the Netherlands are in line with those for the U.S., but for Spain they are lower with a median of 24,000 dollar per year. Finally, the Dutch stand out as being relatively wealthy: the median value of wealth owned by the Dutch is close to 350,000 dollar, while the other countries have medians ranging from 107,000 to 180,000 dollar.

5.3 Preference Parameters

The parameter vector to be estimated, $\boldsymbol{\psi}$, consists of eight parameters that determine preferences. Recall from preferences equation in the Overview section 3.1 that σ governs the concavity of the utility function, which determines agents' risk aversion and their intertemporal rate of substitution. κ is the weight on consumption in the composite good. γ is a fixed utility cost associated with working, while ϕ and ξ are stigma costs associated with disability and unemployment insurance respectively. We also estimate the discount factor β. Finally, θ is the weight attached to bequests and K sets the concavity of the bequest function.

One of our aims is to determine whether international variation in retirement behavior can be explained by differences between institutions alone. Therefore, we first estimate the model under the restriction that all elements of $\boldsymbol{\psi}$ are the same for all countries. Then we contrast the fit of that model with the less restrictive case in which all parameters are allowed to be country-specific. Comparing the model fit and estimates of these two specifications allows us to disentangle the relative importance of international differences in preferences and institutions as determinants of the observed variation in retirement behavior.

5.4 Data moments

Figures 7 and 8 present the moments that we use in estimation. Quartiles of the wealth distribution as observed in the data are shown in Figure 7. The age profiles of wealth differ markedly across countries. For the U.S. all three quartiles increase with age, and this increase is especially pronounced for the third quartile. We observe a similar pattern for Spain, though smaller sample sizes make the profiles of all European countries fickler. For the Netherlands, the third quartile is stable while the median and particularly the first quartile decrease with age.

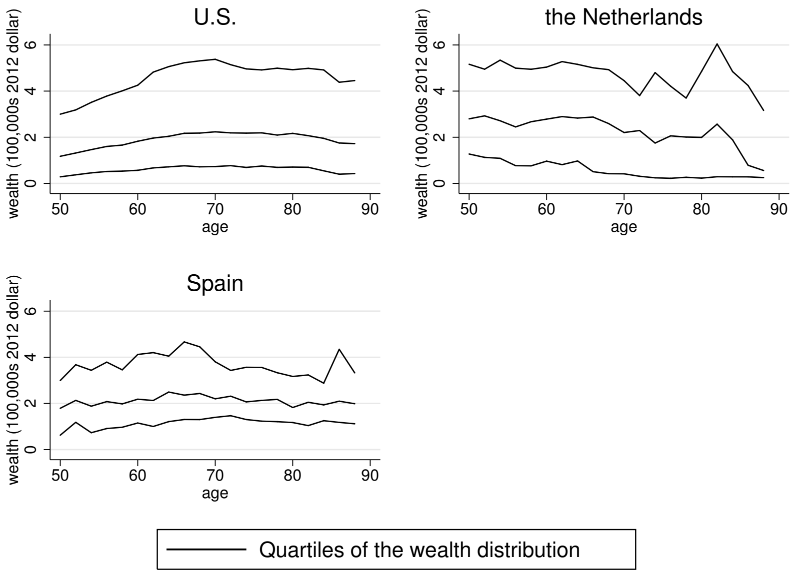

Figure 7: Moments used in estimation – quartiles of the wealth distributions

In addition to wealth quartiles, we also match average hours worked by two-year age bins. Figure 8 shows the hours profiles for all countries. Again, we observe large international differences. Workers in the Netherlands and Spain work relatively few hours on average at all ages: their labor supply declines from 1500 hours around age 50 to close to zero around age 65, compared with a decline from around 2000 hours to 500 in the U.S. Appendix B shows that up to age 60 this difference is driven primarily by the prevalence of part-time jobs in the Netherlands and Spain.

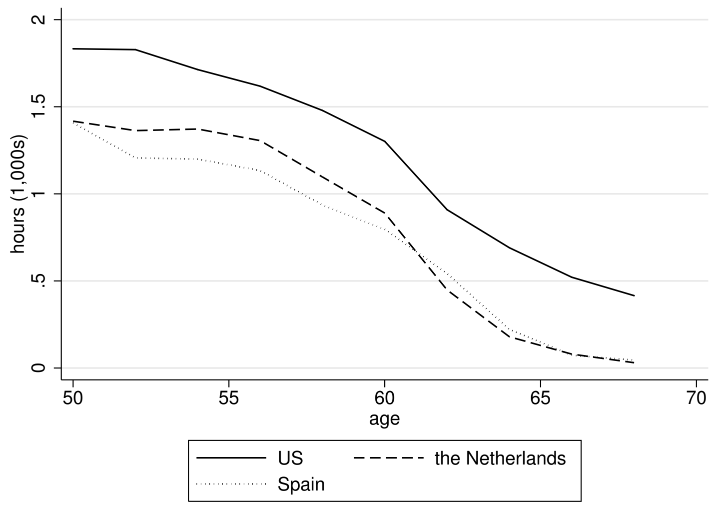

Figure 8: Moments used in estimation – mean hours worked

6 Results

6.1 Estimation of preferences

In order to disentangle the roles of preferences and institutions as drivers of the international heterogeneity in saving and labor supply described in section 5.4, we estimate two specifications of the model. The first specification restricts preferences to be the same in all countries, attributing international differences in behavior to variation in institutions. The second specification is less restrictive and allows for international differences in preferences. This section presents the estimates of both specifications and discusses model fit.

Table 3 contains our estimates for the models with a common set of preferences for all countries (leftmost column) and with country-specific preferences (columns on the right). Looking first at the value of the objective function at the estimates, we find that the overall fit of the model with common preferences is worse than the combined fit of the model with country-specific preferences. The MSM criterion is 4,736.5 for the specification with common preferences compared with 979.65 under country-specific preferences.[7] This large

[7] The value of the objective function for the model with country-specific preferences is not equal to the sum of the values in Table 3, since it has to be adjusted for the differences in scaling factors that reflect the number of observed versus the number of simulated individuals in the estimation samples for each country.

Table 3: Estimates of preference parameters

	Common preferences	Country-specific preferences: United States	the Netherlands	Spain
σ – concavity utility				
γ – fixed cost work (hrs)				
κ – consumption share				
ϕ – stigma DI (hrs)				
ξ – stigma UI (hrs)				
β – discount factor				
θ – bequest weight				
K – beq. concavity (100,000$)				
Number of individuals	10,866	7,727	1,432	1,219
Number of observations	42,749	37,833	2,348	1,729
Objective function	4,736.5	221.0	103.7	99.8

ESTIMATES ARE PRELIMINARY – PLEASE DO NOT QUOTE
Standard errors to be added.

and statistically significant difference suggests that heterogeneity in institutions alone is not enough to explain international differences in retirement and saving. However, we should emphasize that the estimates in Table 3 are preliminary: we have yet to verify that the estimates reported here correspond to global rather than local optima. Hence, the large difference in fit between the specifications may indicate that the model with common preferences converged to an inferior local minimum rather than the global optimum. For now, we focus on the estimates that allow for preference heterogeneity.

Our estimates of σ, which determine the curvature of the utility functions, show that Americans and the Dutch place a higher value on smoothing utility than the Spanish: estimates are close to 5.0 for the former and around 4.55 for the latter countries. The estimate for the U.S. is in the range provided by earlier work by French and co-authors, who estimated coefficients of relative risk aversion between 3.2 and 7.7, with most estimates around 3.8 (French, 2005; De Nardi et al., 2010).

There is also considerable variation in the fixed cost of work γ, which ranges from a negligible XX hours for XXXX to more than 1,700 hours for the Netherlands. Such large differences in γ are required to rationalize the international variation in average hours worked seen in Figure 8. Again, the estimate for the U.S. is plausible given the previous literature (e.g. French, 2005).

The same is true for the share of consumption in the composite good κ, which affects the tradeoff people make between leisure and consumption. The estimate is close to 0.7 for the U.S., indicating a strong preference for consumption. The consumption share is lower for the remaining countries, which also have lower labor supply: it is 0.57 for Spain and 0.46 for the Netherlands.

The stigma costs for claiming UI and DI benefits, ϕ and ξ, are prohibitively high for all countries, leaving few hours of leisure in case those benefits are claimed (recall that the total leisure endowment is 4000 hours per year). This indicates that incentives are such that residents of all countries have to be very averse to drawing benefits in order to work as much as observed in the data.

We estimate relatively low discount factors. The estimated discount factor for the U.S. is 0.86 and for the Netherlands and Spain we even estimate discount factors close to 0.5.[8]

Finally, the strength of the bequest motive also varies across countries. Two parameters govern the value of leaving a bequest: θ is the weight placed on bequests and K determines the curvature of the bequest utility function. We find that Americans place a large weight on bequests, while the Spanish and especially the Dutch care more about their own consumption and leisure. Our estimate of the bequest motive for he U.S. places less importance on bequests than those reported in De Nardi et al. (2010), who estimate the bequest weight θ to be around 2,400 and the curvature around 250,000.

6.2 Goodness of Fit

We assess model fit by comparing the data profiles from Figures 7 and 8 with simulations based on the estimates from Table 3. Figure 9 shows model predictions and data for the moments related to wealth, allowing for different preferences for each country. We find that the model fits the data very closely for the U.S. and also provides a reasonable fit for the Netherlands and Spain.

[8] We want to emphasize that ESTIMATES ARE PRELIMINARY and likely to change in future versions

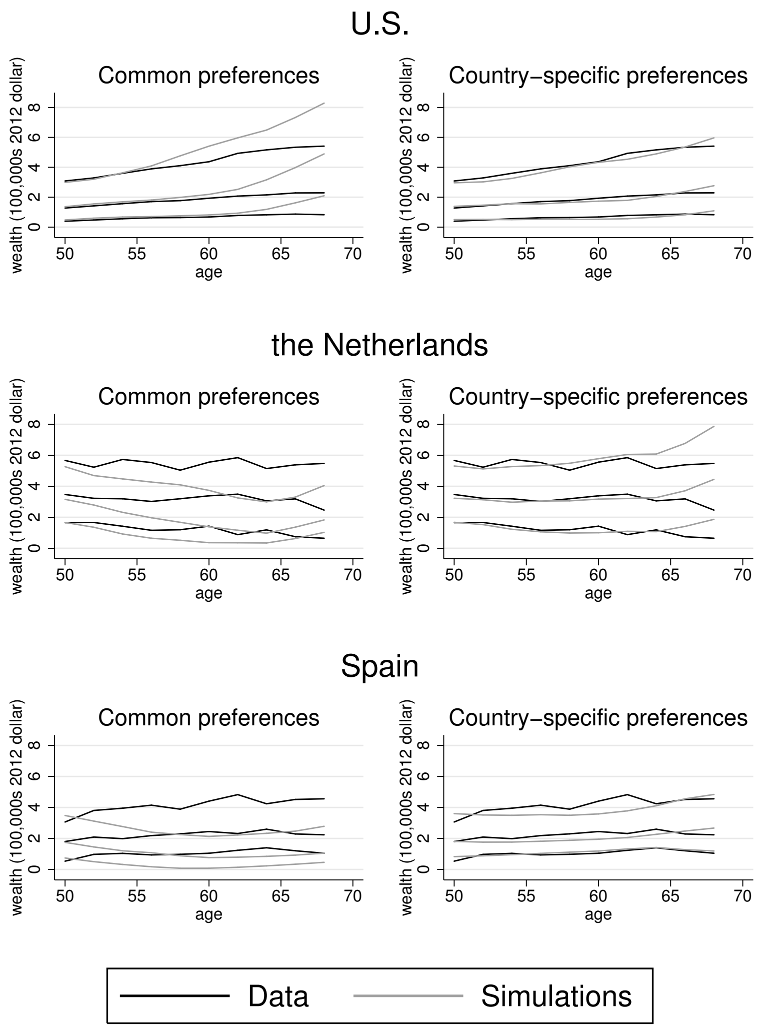

Figure 9: Data and simulated moments – net wealth

Figure **??** shows model fit for the profiles of average hours worked, again allowing for country-specific preferences. Analogously to the wealth profiles, we find the fit to be satisfactory for the U.S., the Netherlands and Spain. The largest deviation of simulations from the data for these countries is a dip in the simulated labor supply profile for Spain at age 60, which is the early retirement age for the Spanish public pension. The Spaniards do not respond as strongly to the availability of the public pension at that age as do their simulated counterparts.

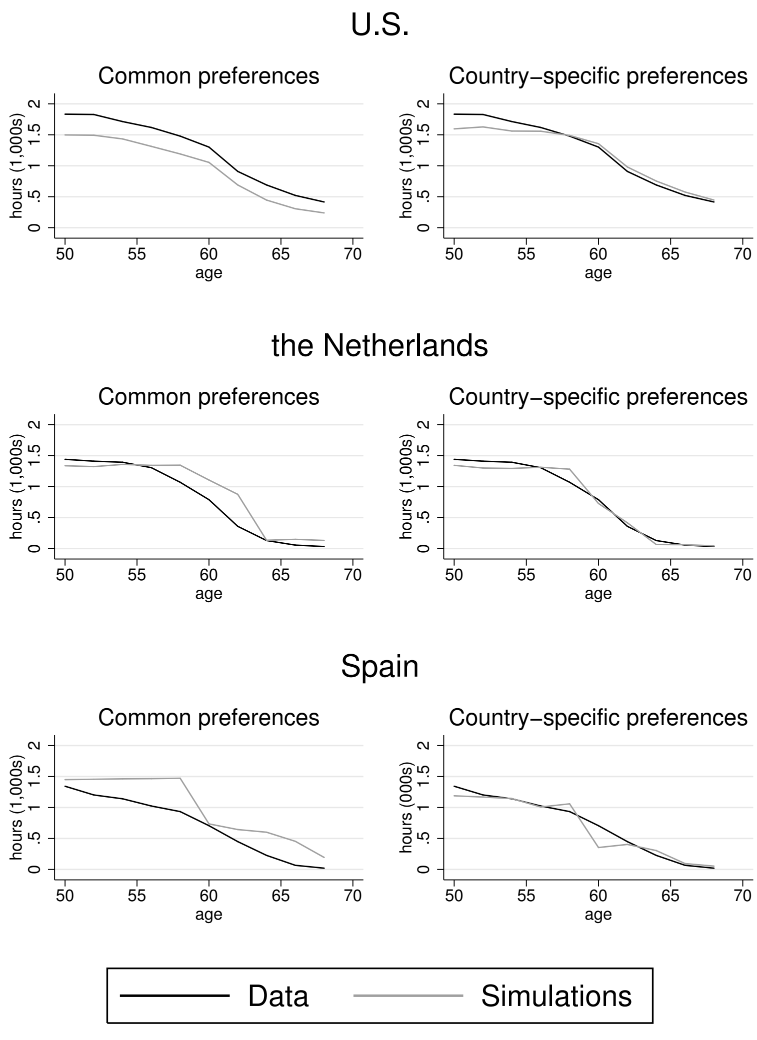

Figure 10: Data and simulated moments – hours worked

of this paper.

Though our results are preliminary, they do yield important lessons to take into account when moving forward. Firstly, we have been unable to estimate a model with common preferences that fits the data reasonably well. If this continues to be the case, that would suggest that we need more than variation in institutions to explain international differences in retirement behavior. However, before reaching that conclusion we have to improve the robustness of our optimization, to verify that our estimates correspond to a global optimum. Fortunately, we can control the robustness of the simulated annealing procedure easily by adjusting the parameters of the algorithm, trading off robustness against execution time. Secondly, we do have preference estimates for the U.S., the Netherlands and Spain that yield a reasonable fit, both in terms of wealth and labor supply.

7 Counterfactual simulations

As an illustration of the power of counterfactual experiments in an international context, we simulate the behavior of individuals from all countries if they would have the same preferences as Americans. We start from individuals from the Netherlands and Spain, using their own institutions and initial conditions, and set all preference parameters to the estimates for the U.S. We choose Americans as our baseline, because our estimates for their preferences are plausible given the previous literature and our model fits the U.S. data closely. This simulation exercise is similar to that in Laun and Wallenius (2013), with the difference that we use actual estimates for the U.S. rather than calibrated values.

Figure **??** displays the observed median wealth profiles for all countries, solid black lines, along with two sets of simulations. The dashed grey lines correspond to the case discussed in section 6.2, in which simulations are based on separate preferences estimated for each country. The graphs for the European countries also contain a dash-dotted grey profile, that shows what wealth profiles would have looked like if Europe had been inhabited by Americans. The differences with the profiles for country-specific estimates are striking: Europeans would deplete almost all of their wealth by age 60 if they had the preferences we estimate for the U.S. By removing all variation in preferences, these simulations show the importance of institutions. A given set of preferences leads to a steadily increasing wealth level in the U.S., where the risk of medical expenditures looms large and collective pension arrangements are minimal. However, the same preferences lead to very different behavior in the context of European welfare states, where out-of-pocket medical expenditures are nearly non-existent and pension income replacement rates are high. A key parameter that causes the quick depletion of wealth in the European institutional context is the high weight placed on consumption relative to leisure (κ is 0.72 for the U.S. and 0.46 and 0.57 for the Netherlands and Spain respectively). These simulations suggest that it is difficult to generate the saving behavior that we observe in the U.S. and Europe from a single utility function. The difficulty is to explain why Europeans save as much as they do, given the generosity of their welfare system. Our model implies that there would be a large intercontinental gap between the U.S. and European wealth profiles, with very little wealth in the old world, if all had the same preference for consumption and bequests as U.S. nationals.

Figure **??** shows that labor supply patterns are also difficult to match with a single set of underlying preferences. Workers with the U.S. work ethic would choose to work more hours than observed in the Netherlands and Spain, due to the much lower fixed cost of work estimated for the U.S. However, such improved work ethic does not fit the data very well: for most ages the simulated profiles are further from the observed profiles than is the case for country-specific preferences.

We find that common, U.S., preferences imply larger differences in wealth between the U.S. and Europe than observed in the data, and that the opposite is true for international differences in labor supply. This illustrates the point that international heterogeneity in preferences may lead to either *more* or *less* heterogeneity in behavior, depending on international differences in institutions. Their preferences drive Europeans to accumulate more wealth than they would have done if they would have had the same preferences as Americans. In this way preference heterogeneity *reduces* international differences in wealth holdings. On the other hand, the Dutch and Spanish work fewer hours than they would have done if they would have had U.S. preferences. Identical preferences would lead to smaller differences between labor supply profiles.

8 Conclusion

This paper sheds new light on the way institutions and preferences shape the heterogenous patterns of labor supply and wealth accumulation observed in different countries. To this end we build a lifecycle model of saving and labor supply with alternative exit routes from the labor market. Individuals derive utility from consumption and leisure and value the possibility of leaving a bequest. Workers can retire via unemployment and disability insurance and have access to public and private pension schemes. Health and longevity are uncertain. We fine-tune the model to reflect the institutions in place in the United States, the Netherlands and Spain.

In order to disentangle the roles of variation in institutions and preferences, we estimate two specifications by means of the method of simulated moments. The first specification restricts preferences to be the same for all countries, while the second allows preferences to vary internationally. We match quartiles of the wealth distributions as well as the average hours worked for two-year age bins between the ages of 50 and 68.

Our preliminary estimates suggest that it is difficult to reproduce observed wealth and labor supply profiles for the three countries considered here from a common set of underlying preferences. The model fit is satisfactory for all countries if we allow for country-specific preferences. Estimates of the utility functions vary widely across countries. The estimates obtained for the U.S. are in line with the previous literature.

We carry out counterfactual simulations to see how individuals from all countries would behave if their preferences were given by the estimates for the U.S. These simulations indicate that under U.S. preferences the difference between the wealth profile of the U.S. on the one hand and the European countries on the other would be much larger. In particular, given the generosity of European welfare states individuals from all European countries would consume all their wealth quickly. In other words: Europeans are thrifty relative to the Americans, which *reduces* international wealth differences. For labor supply we find that international differences in preferences *increase* variation in hours worked. Based on international differences in incentives alone, one would not expect such large differences in labor supply.

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Appendix A Institutional Parameters

All nominal amounts mentioned in this section are based on the institutions in place in 2004 but denoted in the local currency of 2012: nominal amounts are denoted in 2012 dollars for the U.S. and in 2012 euros for all European countries. Furthermore, income from all sources is measured on a yearly basis.

Common parameters

Only two features of the institutional landscape are shared by all three countries. The first is a wage discount for workers who are employed part-time relative to their full-time wage. This penalty on earnings from part-time employment is implemented in the earnings function:

$$earn = e^{-\pi \mathbf{I}\left\{h<h_f\right\}} \times j \times h$$

where $earn$ is earnings, π is the wage discount for working part-time, $\mathbf{I}\{.\}$ is an indicator function equal to 1 if the argument in curly braces is true and zero otherwise, h is the number of hours worked, h_f is the number of hours worked in full-time employment and j is the individual's wage. We follow French (2005) and set the penalty for part-time work to 20% ($\pi = 0.2$).

The second shared parameter is the real interest rate, which is fixed and equal to 3% for all countries.

Country-specific parameters

U.S.

The tax function for the U.S. distinguishes between taxes levied at the local, state and federal levels. Taxes are levied on income from all sources, but provisional income, social security and disability insurance, is partly exempt:

$$provinc = ssinc + diinc$$

$$taxss = \begin{cases} 0 & \text{if } provinc < 32,000 \\ 0.5 \times provinc & \text{if } 32,000 \leq provinc < 44,000 \\ 0.85 \times provinc & \text{if } 44,000 \leq provinc \end{cases}$$

Taxable provisional income $taxss$ is included in the total income measure for both federal and state taxes:

$$taxable\_fed = \max\{earn + capinc + dbinc + uiinc + taxss - 2 \times 6,650; 0\}$$

$$taxable\_state = earn + dbinc + taxss$$

where $taxable\_fed$ is income subject to federal taxes and $taxable\_state$ is income over which state taxes are levied, $earn$ is earned income, $capinc$ is capital income, $dbinc$ is income from defined benefit occupational pensions and $uiinc$ is income from unemployment insurance. Note that income from unemployment insurance and capital income are not taxable at the state level in the U.S and that the basic and personal income tax allowances are deducted from federal taxable income. Given these measures of taxable income, we apply the following function for the federal income tax:

$$fedtax = \begin{cases} 0.1 \times taxable\_fed & \text{if } taxable\_fed < 17,446 \\ ... + 0.15 \times (taxable\_fed - 17,446) & \text{if } 17,446 \leq taxable\_fed < 70,882 \\ ... + 0.25 \times (taxable\_fed - 70,882) & \text{if } 70,882 \leq taxable\_fed < 143,045 \\ ... + 0.28 \times (taxable\_fed - 143,045) & \text{if } 143,045 \leq taxable\_fed < 217,953 \\ ... + 0.33 \times (taxable\_fed - 217,953) & \text{if } 217,953 \leq taxable\_fed < 389,302 \\ ... + 0.35 \times (taxable\_fed - 389,302) & \text{if } 389,302 \leq taxable\_fed \end{cases}$$

For state taxes we apply the rules of Michigan, which are representative for the U.S.:

$$statetax = \begin{cases} 0 & \text{if } taxable\_state < 2,900 \\ 0.042 \times (taxable\_state - 2,900) & \text{if } 2,900 \leq taxable\_state \end{cases}$$

Local taxes are modeled using the rules in place in Detroit:

$$loctax = \begin{cases} 0 & \text{if } earn < 750 \\ 0.0275 \times (earn - 750) & \text{if } 750 \leq earn \end{cases}$$

In addition to these three types of income tax, we also take into account taxes levied to finance the medicare and social security programs:

$$taxable\_ss = \min\{earn; 80,400\}$$
$$sstax = 0.062 \times taxable\_ss + 0.015 \times earn$$

Net income is calculated as

$$netinc = grossinc - fedtax - statetax - loctax - sstax$$

where gross income is given by

$$grossinc = earn + capinc + ssinc + dbinc + diinc + uiinc$$

The second part of the institutional framework of the U.S. is the public pension, or social security. Social security benefits, *ssinc*, are modeled according to the rules that apply to someone born in 1939, which is the mean birth year in our estimation sample. Benefits are based on *ame*: average monthly earnings during one's working life. Based on *ame* the entitlement, primary insurance amount pia, is calculated using a piecewise linear function:

$$pia = \begin{cases} 0.9 \times ame & \text{if } ame < 761.70 \\ ... + 0.32 \times (ame - 761.70) & \text{if } 761.70 \leq ame < 4,591.60 \\ ... + 0.15 \times (ame - 4,591.60) & \text{if } 4,591.60 \leq ame \end{cases}$$

pia is then adjusted to take into account the age at which someone retires, the actuarial adjustment:

$$ssinc = 12 \times \begin{cases} pia \times e^{-0.067 \times (65 - t_c)} & \text{if } t_c < 65 \\ pia \times e^{0.07 \times (t_c - 65)} & \text{if } 65 \leq t_c < 70 \\ pia \times e^{0.07 \times (70 - 65)} & \text{if } 70 \leq t_c \end{cases}$$

where t_c is the age at which benefits are first claimed. The minimum age for claiming social security is 62.

In addition to social security benefits, some workers in the U.S. are also entitled to a defined benefit (DB) occupational pension. The publicly available HRS data do not include information on DB entitlements, so we use the restricted-access version to estimate linear regressions of the log of entitlements on earnings and a piecewise linear specification on intervals for age relative to the earliest age at which benefits can be claimed, era_db, and the normal retirement age nra_db. Note that both era_db and nra_db vary across individuals in the restricted HRS dataset, since there exists a wide menu of DB pension arrangements. We then use the regression estimates to predict the DB entitlements based on the age at which someone retires and labor income earned while working:

$$dbinc = \begin{cases} e^{-0.5035+1.2918\log(earn)+0.1154t_c-0.05653era\_db-0.1223nra\_db} & \text{if } era\_db \leq t_c < nra\_db \\ \quad \times e^{0.5\times 0.613^2} & \\ e^{-0.5035+1.2918\log(earn)+0.1154nra\_db-0.05653era\_db-0.1223nra\_db} & \text{if } nra\_db \leq t_c < 70 \\ \quad \times e^{0.02889(t_c-nra\_db)} \times e^{0.5\times 0.613^2} & \\ e^{-0.5035+1.2918\log(earn)+0.1154nra\_db-0.05653era\_db-0.1223nra\_db} & \text{if } 70 \leq t_c \\ \quad \times e^{0.02889(70-nra\_db)} \times e^{0.5\times 0.613^2} & \end{cases}$$

We set the normal retirement age for DB pensions, nra_db, to 62 and the early retirement age era_db to 55.

The application process for disability insurance (DI) is more involved in the U.S. than it is in European countries. Bad health is a necessary condition for being entitled to DI: only individuals in bad health can apply. However, application does not yield benefits immediately (in the same year). Instead an individual has to wait one year before the application is processed, a period during which he cannot work. If his application is successful and his health has not improved, benefits start in year two and last until he leaves the state of bad health or reaches the normal retirement age for social security (age 65). Half of the applications for DI are selected at random to receive benefits. Analogously to social security benefits, the level of benefits from disability insurance depends on previous earnings. However, in contrast to social security, DI benefits are not adjusted for the age of the claimant:

$$diinc = 12 \times \begin{cases} 0.9 \times ame & \text{if } ame < 761.70 \\ ... + 0.32 \times (ame - 761.70) & \text{if } 761.70 \leq ame < 4,591.60 \\ ... + 0.15 \times (ame - 4,591.60) & \text{if } 4,591.60 \leq ame \end{cases}$$

The final exit route from employment to be modeled for the U.S. is unemployment insurance (UI). We apply a replacement rate of 20% relative to earnings from full-time employment. UI benefits are capped at 21,268 dollar, which was the average of the maximum benefits across all U.S. states in 2012:

$$uiinc = \min\{0.2 \times earn; 21,268\}$$

UI benefits are available for a maximum period of one year.

The U.S. government provides a consumption floor to ensure subsistence in case cash-on-hand, the sum of income from all sources plus wealth, is not sufficient to afford a minimum of consumption over and above out-of-pocket medical expenses. This consumption floor is set at 5,000 dollar for a household of one.

The Netherlands

The Dutch tax system groups income into three categories or "boxes": earned income, income from substantial stock ownership and returns on assets. Gross income in the first box, earned income, includes all income streams in our model, except for returns on assets:

$$grossinc = earn + ssinc + dbinc + diinc + uiinc$$

From this measure of gross income one pays contributions to the public insurance schemes that cover everybody living and working in the Netherlands. The first scheme is unemployment insurance:

$$uicontr = \begin{cases} 0 & \text{if } grossinc < 17,409 \\ 0.058 \times (grossinc - 17,409) & \text{if } 17,409 \leq grossinc < 50,115 \\ 0.058 \times (50,115 - 17,409) & \text{if } 50,115 \leq grossinc \end{cases}$$

The second scheme provides universal medical insurance:

$$medcontr = \begin{cases} 0.0125 \times grossinc + 446 & \text{if } grossinc < 33,917 \\ 0.0125 \times 33,917 + 446 & \text{if } 33,917 \leq grossinc < 37,490 \\ 0 & \text{if } 37,490 \leq grossinc \end{cases}$$

These contributions are deducted from gross income to compute taxable income:

$$taxable = \max\{grossinc - uicontr - medcontr; 0\}$$

Income tax is levied over this taxable income:

$$inctax = \begin{cases} 0.01 \times taxable & \text{if } taxable < 18,705 \\ ... + 0.0795 \times (taxable - 18,705) & \text{if } 18,705 \leq taxable < 33,974 \\ ... + 0.42 \times (taxable - 33,974) & \text{if } 33,974 \leq taxable < 58,250 \\ ... + 0.52 \times (taxable - 58,250) & \text{if } 58,250 \leq taxable \end{cases}$$

Income taxes are then lowered by two types of tax credit: the "general" and "work-related" credit. The general tax credit, *gencred*, of 2,099 euro is applied to everybody who pays income tax. Work-related credit depends on earned income and consists of two types:

$$wrkcred1 = \min\{0.01753 \times earn; 163\}$$

$$wrkcred2 = \begin{cases} 0 & \text{if } earn \leq 9,316 \\ 0.11213 \times (earn - 9,316) & \text{if } 9,316 < earn \end{cases}$$

The total work credit is capped at 1,395 euro:

$$wrkcred = \min\{wrkcred1 + wrkcred2; 1,395\}$$

Income tax is then calculated as

$$inctax = inctax - gencred - wrkcred$$

Employee contributions to the public pension are also calculated from taxable income. The level of these contributions depend on whether or not the employee meets the age requirement for eligibility for the public pension:

$$sscontr = \begin{cases} t < 65 \begin{cases} 0.324 \times taxable & \text{if } taxable < 33,974 \\ 0.324 \times 33,974 & \text{if } 33,974 \leq taxable \end{cases} \\ t \geq 65 \begin{cases} 0.145 \times taxable & \text{if } taxable < 33,974 \\ 0.145 \times 33,974 & \text{if } 33,974 \leq taxable \end{cases} \end{cases}$$

t is the age of the individual. We do not take into account income from substantial stock ownership, which makes up the second box of the tax system. Assets are taxed based on a hypothetical yearly return of 4%, on which a 30% tax is levied:

$$captax = \begin{cases} 0 & \text{if } wealth < 44,280 \\ 0.012 \times (wealth - 44,280) & \text{if } 44,280 \leq wealth \end{cases}$$

Net income is the sum of gross- and capital income minus taxes and contributions to public insurance schemes:

$$netinc = grossinc + capinc - uicontr - medcontr - inctax - sscontr - captax$$

The Dutch flat-rate public pension has near universal coverage: everybody who lives and works in the Netherlands between the ages of 15 and the normal retirement age is entitled to full benefits from that age onwards. The normal retirement age in the Netherlands was 65 during the period in which the sample was collected. Benefits are cut by 2% for each year that the beneficiary did not contribute to the scheme. There are no restrictions on employment or earned income while receiving benefits, nor do people have to apply to receive them. We assume full eligibility, which results in the following function for social security (public pension) income:

$$ssinc = \begin{cases} 0 & \text{if } t < 65 \\ 12 \times 1,110 & \text{if } 65 \leq t \end{cases}$$

Yearly benefits amount to 13,320 euro, which is based on a one-person household and includes the holiday allowance. Note that the Dutch public pension scheme does not aim to maintain one's standard of living during retirement, but merely to provide a subsistence level income to all retirees.

Most retirees supplement their public pension with a mandatory occupational pension. Occupational pension schemes are predominantly defined benefit and the level of benefits depends on earnings during working life. Both final and average earnings arrangements exist, though recently the balance has shifted towards pensions that are linked to the average earnings during one's career. Ninety percent of workers are covered by an occupational pension and the replacement of income at retirement is generous with an average gross replacement rate of 70% when combined with public pension benefits (Bovenberg and Meijdam, 2002). Each year of contributions to an occupational scheme entitle the future beneficiary to an annuity equal to 1.75% of their final earnings in excess of the franchise:

$$dbinc = \max\left\{0.0175 \times yrswrk \times \left(prevearn - \frac{10}{7} \times 13,320\right); 0\right\}$$

where *dbinc* is the pension annuity, *yrswrk* is the number of years an individual worked at the time of claiming and *prevearn* is the last earned salary. The franchise is deducted from previous earnings to take into account the public pension. Claiming can start at any age between 60 and 70. As in the U.S., occupational pensions are adjusted for the age at which benefits are first claimed:

$$dbinc = \begin{cases} dbinc \times e^{-0.05\times(65-t_c)} & \text{if } t_c < 65 \\ dbinc \times e^{0.06\times(t_c-65)} & \text{if } 65 \leq t_c < 70 \\ dbinc \times e^{0.06\times(70-65)} & \text{if } 70 \leq t_c \end{cases}$$

DB pension benefits are capped at the last earned income of the retiree:

$$dbinc = \min\{dbinc; prevearn\}$$

In contrast to the U.S., there is no waiting period in the application process for disability insurance (DI) in the Netherlands. Any individual in poor health can apply for DI and receive benefits immediately until his health improves. The level of benefits is set at 70% of the final earned income and is capped at 50,396 euro:

$$diinc = \min\{0.7 \times prevearn; 50,396\}$$

Dutch workers build their entitlement to unemployment insurance (UI) by working: each year worked yields a month of UI benefits up to a maximum of 36 months. The formula for UI benefits is identical to that for DI benefits:

$$uiinc = \min\{0.7 \times prevearn; 50,396\}$$

The consumption floor is set at 13,320 euro per year for a household of one, which coincides with the generosity of welfare and the public pension.

Spain

The Spanish tax function starts with contributions to the public pension scheme. These contributions are based on earned income:

$$sscontr = \begin{cases} 0.0635 \times 8,437 & \text{if } 0 < earn < 8,437 \\ 0.0635 \times earn & \text{if } 8,437 \leq earn < 40,238 \\ 0.0635 \times 40,238 & \text{if } 40,238 \leq earn \end{cases}$$

Contributions to the public pension scheme also have to be paid from unemployment insurance benefits, albeit at a reduced rate:

$$sscontr = \begin{cases} 0.03055 \times 8,437 & \text{if } 0 < uiinc < 8,437 \\ 0.03055 \times uiinc & \text{if } 8,437 \leq uiinc < 40,238 \\ 0.03055 \times 40,238 & \text{if } 40,238 \leq uiinc \end{cases}$$

Two types of allowances are required to calculate taxable income. The first one is a general allowance, which is 4,174 euro and applies to everybody. The second allowance only benefits the employed, since it is based on earned income net of social security contributions:

$$netearn = earn - sscontr$$

$$workall = \begin{cases} 4,296 & \text{if } 0 < netearn < 10,066 \\ 4,296 - 0.2291 \times (netearn - 10,066) & \text{if } 10,066 \leq netearn < 15,958 \\ 2,946 & \text{if } 15,958 \leq netearn \end{cases}$$

People above the normal retirement age for the public pension, which was 65 during the period covered by the sample, face a stronger incentive to work: their work allowance is doubled. The total allowance, to be deducted from gross income, is the sum of social security contributions, the general allowance and the work-related allowance:

$$allowance = 4,174 + sscontr + workall$$

Taxable income is calculated as gross income minus the total allowance:

$$grossinc = earn + ssinc + diinc + uiinc$$

$$taxable = \max\{grossinc - allowance; 0\}$$

where *earn* is earned income, *ssinc* is income from public pensions, *diinc* denotes income from disability insurance and *uiinc* is income generated by unemployment insurance. Note that we do not model DB pension schemes for Spain, because they are rare in that country (OECD, 2005). Both "general" and "regional" taxes are levied over taxable income:

$$gentax = \begin{cases} 0.0906 \times taxable & \text{if } taxable < 4,910 \\ ... + 0.1584 \times (taxable - 4,910) & \text{if } 4,910 \leq taxable < 16,941 \\ ... + 0.1868 \times (taxable - 16,941) & \text{if } 16,941 \leq taxable < 31,672 \\ ... + 0.2471 \times (taxable - 31,672) & \text{if } 31,672 \leq taxable < 55,242 \\ ... + 0.2916 \times (taxable - 55,242) & \text{if } 55,242 \leq taxable \end{cases}$$

$$regtax = \begin{cases} 0.0594 \times taxable & \text{if } taxable < 4,910 \\ ... + 0.0816 \times (taxable - 4,910) & \text{if } 4,910 \leq taxable < 16,941 \\ ... + 0.0932 \times (taxable - 16,941) & \text{if } 16,941 \leq taxable < 31,672 \\ ... + 0.1229 \times (taxable - 31,672) & \text{if } 31,672 \leq taxable < 55,242 \\ ... + 0.1584 \times (taxable - 55,242) & \text{if } 55,242 \leq taxable \end{cases}$$

In contrast to the Netherlands, Spain directly taxes capital income (rather than assuming some fixed hypothetical rate of return):

$$captax = \begin{cases} 0.19 \times capinc & \text{if } capinc < 7,366 \\ ... + 0.21 \times (capinc - 7,366) & \text{if } 7,366 \leq capinc \end{cases}$$

Net income is given by the sum of gross income and capital income, minus all taxes and contributions to the public pension scheme:

$$netinc = grossinc + capinc - sscontr - gentax - regtax - captax$$

The Spanish public pension resembles social security in the U.S. in that benefits depend on previous earnings and on the age at which they are claimed for the first time. Like the Dutch occupational pensions, the Spanish public pension starts from a replacement rate which depends on the number of years an individual worked:

$$RR = \begin{cases} 0 & \text{if } yrswrk < 15 \\ 0.5 + 0.03 \times (yrswrk - 15) & \text{if } 15 \leq yrswrk < 25 \\ 0.8 + 0.02 \times (yrswrk - 25) & \text{if } 25 \leq yrswrk < 35 \\ 1 & \text{if } 35 \leq yrswrk \end{cases}$$

The actuarial adjustment that provides an incentive not to retire before the normal retirement age of 65 is given by:

$$act\_adj1 = \begin{cases} yrswrk < 40 \begin{cases} 0.6 + 0.08 \times (t_c - 60) & \text{if } 60 \leq t_c < 65 \\ 1 & \text{if } 65 \leq t_c \end{cases} \\ yrswrk \geq 40 \begin{cases} 0.65 + 0.07 \times (t_c - 60) & \text{if } 60 \leq t_c < 65 \\ 1 & \text{if } 65 \leq t_c \end{cases} \end{cases}$$

where t_c is the age at which benefits are first claimed. The Spanish system also includes a bonus for delayed claiming, which is conditional on having worked at least 35 years:

$$act\_adj2 = \begin{cases} 1 & \text{if } t_c < 65 \text{ or } yrswrk < 35 \\ 1 + 0.02 \times (t_c - 65) & \text{if } 65 \leq t_c < 70 \text{ and } 35 \leq yrswrk \\ 1 + 0.02 \times (70 - 65) & \text{if } 70 \leq t_c \text{ and } 35 \leq yrswrk \end{cases}$$

Average earnings during the final 15 years of one's working life determine the earnings base with which the replacement rate and actuarial adjustments are multiplied:

$$earnbase = \begin{cases} 8,437 & \text{if } prevearn < 8,437 \\ prevearn & \text{if } 8,437 \leq prevearn < 40,238 \\ 40,238 & \text{if } 40,238 \leq prevearn \end{cases}$$

where *earnbase* is the earnings base and *prevearn* is the average earnings over the final 15 working years of one's career. Pension benefits are given by the product of the replacement rate, both actuarial adjustments and the earnings base:

$$ssinc = RR \times act\_adj1 \times act\_adj2 \times earnbase$$

The Spanish minimum public pension depends on labor income and returns on assets:

$$otherinc = earn + capinc$$

$$ssinc = \begin{cases} 8,105 & \text{if } otherinc < 5,915 \text{ and } ssinc < 8,105 \text{ and } age \geq 60 \text{ and } yrswrk \geq 15 \\ ssinc & \text{otherwise} \end{cases}$$

Finally, the public pension is capped at 40,238 euro per year:

$$ssinc = \begin{cases} 40,238 & \text{if } ssinc > 40,238 \\ ssinc & \text{otherwise} \end{cases}$$

Occupational pensions were not common in Spain during the period in which our sample was collected, so we do not model them.

In our model the application procedure for disability insurance is the same in all European countries. That is: there is no waiting period before receiving benefits, only the condition that one has to be in poor health. Benefits are based on a replacement rate of 70% relative to last earned income:

$$diinc = 0.7 \times prevearn$$

Note that income from disability insurance is not capped in Spain and that benefits last until one decides to work and/or one's health improves.

Unemployment insurance (UI) can be claimed for a maximum of two years. The level of benefits is set in reference to previous earnings and depends on the time for which benefits have been claimed:

$$uiinc = \begin{cases} 0.65 \times prevearn & \text{during first year of claiming} \\ 0.60 \times prevearn & \text{during second year of claiming} \end{cases}$$

UI benefits are subject to a minimum of 5,964 euro per year and a maximum of 13,047 euro per year.

The level of the Spanish consumption floor is set at 5,339 euro per year, which is the level of permanent, non-contributory unemployment insurance or welfare.

Appendix B Data Construction

Our goal is to estimate a dynamic model of labor supply, benefit claiming and consumption on an international dataset. In order to cleanly identify the roles of preferences and institutions, we restrict the sample to be similar in all countries. Selected individuals are male; still working around age 50; and not self-employed when we first observe them. This appendix explains how we construct the datasets used to calculate moments, initial conditions and auxiliary processes needed to solve the model and estimate its parameters. We first give an outline for the United States. For Europe, we start with our general procedure for data construction, followed by country-specific discussions of the variables required to model national pension systems.

United States: HRS

The Health and Retirement Study (HRS) is a panel study administered by the University of Michigan. Its biyearly waves have been released since 1992 and follow a representative sample of over 26,000 Americans over the age of 50. The HRS focuses on the labor market participation and health transitions of individuals towards the end of their working life and after retirement. We use the RAND release of the HRS (version L).[9] The person identifier provided by RAND allows us to link observations across waves and we observe basic demographics such as the race, gender and education of respondents. Moreover, exit interviews conducted with relatives of deceased panel members tell us the age at which a respondent died.

For health we use the subjective health measure that asks respondents to rate their own health on a five-point scale. Individuals are in poor health if they rate their health as falling in the lower three categories (“poor”, “fair” or “good”). Those who rate their health as “very good” or “excellent” are classified as being in good health. Wealth is measured by total wealth as constructed by RAND, which excludes the value of a second residence. We cap wealth at 1 million dollar. We censor hourly wage to be between 5 and 100 dollar. Social

[9] http://www.rand.org/labor/aging/dataprod/hrs-data.html

security claiming status is determined by the reported age at which an individual starts claiming benefits: he is a prior claimer starting from the age after which he first claims benefits (but never before age 62). For defined benefit pensions in the U.S. we distinguish between people who do not have such pension ($db = 1$); those who are entitled but have not claimed yet ($db = 2$); and those who have already started claiming ($db = 3$). Individuals who report that they are not entitled to a DB pension make up the first group, those who are entitled but have not yet quite their main job, one with at least 20 years of tenure, constitute the second group and those who both have a DB pension and have quite their main job are the third group. Finally, the equivalence scale $n_{i,t}$ is used computed from the household size: $n_{i,t} = HH_{i,t}^{0.7}$.

Europe: SHARE

SHARE also follows a large sample of more than 85,000 individuals as they grow older and retire. It includes representative samples for the 50+ populations of over 20 European countries. SHARE contains detailed micro data on health, socio-economic status and social and family networks.Basic background data for all respondents is available from the demographics module. We use gender, year and month of birth, immigrant status and year of immigration and marital status.

The employment survey provides information on labor market status. We construct a labor force-variable to distinguish between people who are working; disabled; unemployed; and out of the labor force. Moreover, we generate an indicator for the self-employed and one for civil servants XXXX. We also observe hours worked on the main job and tenure in years in the current job. Wage are computed as labor earnings divided by hours worked, both of which are yearly.

Income and wealth variables are taken from the imputations datasets. We use imputed health on the US scale, out-of-pocket medical expenses and net worth. For the first two waves, separate imputations are available for disaggregated income components such as earned income, public pensions, private pensions, disability and unemployment insurance and capital income. For wave 3 imputations were done at a higher level of aggregation, so we compute income from public pensions, private pensions, disability insurance and unemployment insurance from the employment data directly. In this final wave no questions were asked about out-of-pocket medical expenses, so those are missing for all respondents.

Household size is available for each wave from the individual-level questionnaire on household composition.

In order to estimate the joint health/mortality process we use the mortality indicator from the dead-or-alive datasets, which were generated from exit interviews conducted with relatives of the deceased. From these datasets we construct an indicator for respondents in wave 1 who died by wave 2 and an analogous indicator for those interviewed in wave 2 who died by wave 3.

The Netherlands

In the Netherlands there are four types of income during retirement: public, occupational and private pensions and all other wealth that can be drawn down. Public pensions cover everybody who lived and worked in the country between ages 15 and 65 and provide a consumption floor that is the same for everybody starting from the normal retirement age 65. To facilitate modeling, we assume that all Dutch individuals in the sample are fully entitled to public pensions and focus on occupational pensions. Occupational pensions in the Netherlands are usually defined benefit and are mandatory for all employees of firms or industries that offer them (according to Bovenberg and Meijdam, 2002, over 90% of Dutch workers are members of an occupational pension scheme). The level of benefits depends on final or average wages during the accumulation period. SHARE distinguishes between two types of occupational pensions: normal occupational pensions and early retirement pensions. The latter type was abolished in 2006 and thus irrelevant for our sample, which did not meet the age requirement at that time. Therefore, we use the employment-module to construct an occupational pension variable db that distinguishes between those who have a defined benefit occupational pension at their current job and those who do not, ignoring the presence of an early retirement clause. In order to calculate the level of benefits, we use information on the number of years that a worker has contributed to his occupational scheme, or tenure at current job if the number of contribution years is missing. For previous earnings we use earnings from the preceding survey wave if available, otherwise we approximate previous earnings by current earnings. The final two categories of income after retirement, private pensions and other assets, are pooled in the imputed wealth measure that we use for all countries.

Workers build their entitlement to unemployment benefits at a rate of 1 month of benefits for every year worked, up to a maximum of 3 years of benefits. We use the employment spell panel dataset that was constructed from the retrospective employment data in SHARE-life to calculate each individual's entitlement in the first two survey waves and update to the third wave based on observed labor market participation. We use tenure in current job as a proxy for those individuals for whom retrospective data is not available. Since the model is specified in years, we round the unemployment insurance entitlement.

Spain

In the Spanish system private and occupational pensions do not play a large role. People rely on their public pension and on their savings for a livelihood in retirement. The level of public pension benefits is determined by a replacement rate relative to an individual's average earnings during the final 15 years of one's career. That replacement rate is determined by the number of years someone worked. For the initial conditions, we proxy previous earnings by the earnings during the first year in which we observe a worker. Note that for the initial conditions people are 50 years old and that public pensions cannot be claimed prior to age 60, so our rough approximation of previous earnings at age 50 does not affect strongly the level of benefits by the time workers become eligible for their public pension. We calculate the number of years worked at the time of the first survey wave from the retrospective life histories from SHARE-life and update to later waves by means of the employment status variables from those respective waves. For those worker without retrospective job histories, we approximate years worked with the longest job tenure reported in any of the survey waves.

Eligibility for unemployment insurance is determined by the number of years someone has worked since his previous claiming episode: one year of work entitles an individual to roughly 3 months of benefits with a maximum of two years. Following the same approach as for the public pension replacement rate, we calculate the number of years worked using retrospective employment data if available and if not we substitute the longest tenure that we observe.

Sample selection

To arrive at the estimation sample for auxiliary processes we drop all female SHARE respondents, all individuals with missing year or month of birth and all those younger than 50 when first observed. The initial conditions are constructed from the first observation of each individual in that dataset, provided they were aged 50-56, working and not self-employed. Moments are calculated using all observations for the individuals that feature in the initial conditions, supplemented with older men whom the job episodes dataset shows were working at age 50.

Descriptives – labor supply

Figure 11 contains histograms of yearly hours worked for individuals in the age bracket 50-60. These are a subset of the data that we use to construct the profile of labor supply by age, the only difference being that our estimation is based on an extended age range up to and including age 68.

A few international differences stand out. Firstly, the fraction of individual-years in which labor supply is zero varies widely across the different countries, from more than 40% in Spain to XX than XX% in XXX. The U.S. and the Netherlands are in between these extremes with 30% of person-years registering zero labor supply. Secondly, part-time work, between 1,000 and 2,000 hours per year, is more prevalent in the Netherlands and Spain

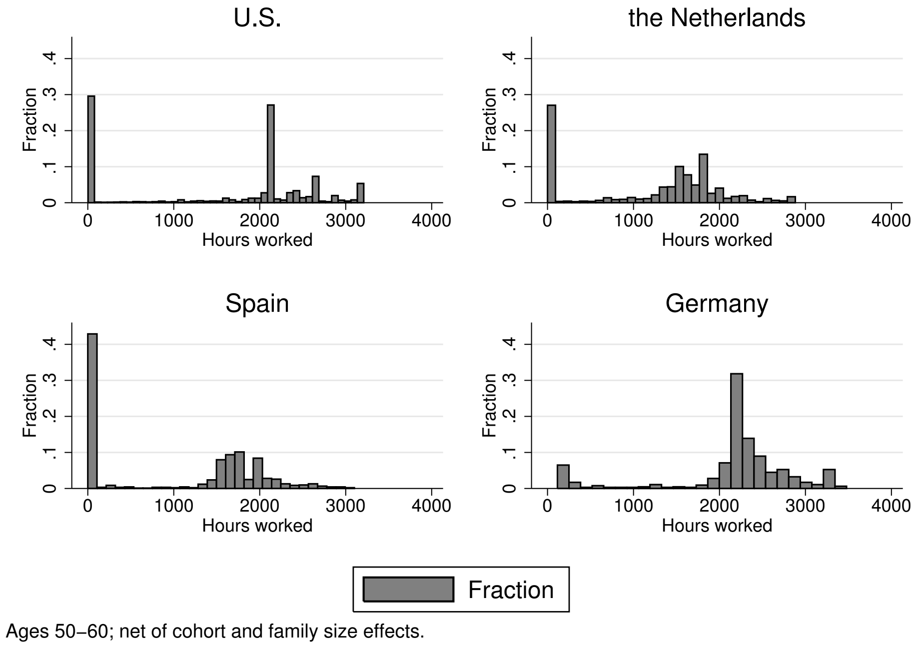

Figure 11: Histograms of hours worked

than in the U.S. These latter countries show a pronounced spike around 2,000 hours: close to 30% of the sample from those countries works around 2,000 hours per year. Very few individuals work more than 3,000 hours. All in all our discretization of labor supply into 0/1,500/2,000/2,500 hours per year seems satisfactory.

Descriptives − wealth

Histograms of wealth for the estimation sample are given in Figure 12. The distribution of wealth in all countries is clearly asymmetrical and with a long right tail. Given this shape of the wealth distributions, we match the quartiles of the distribution of wealth rather than the mean in order to estimate preference parameters.

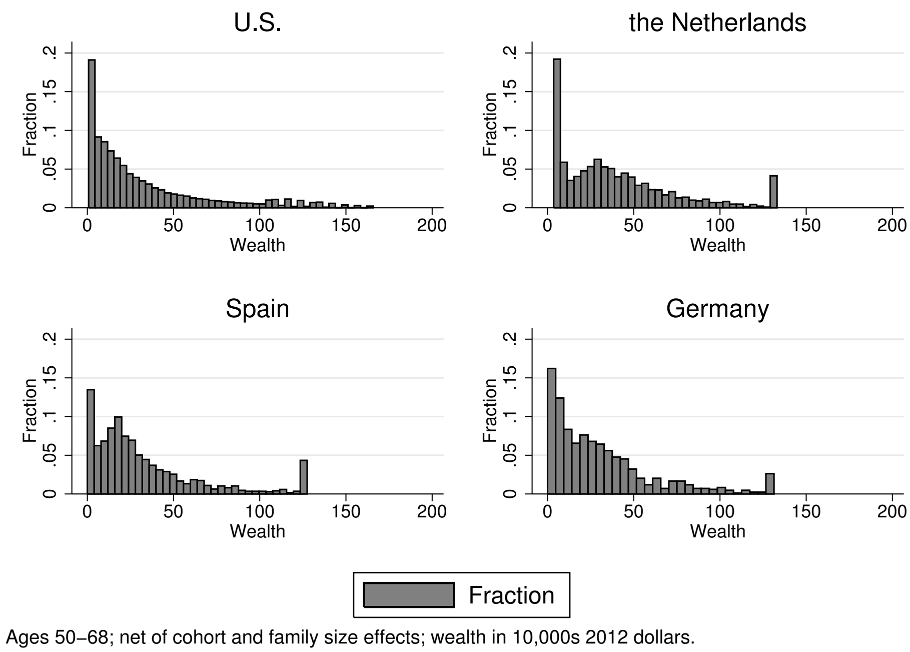

Figure 12: Histograms of wealth

Appendix C Estimation of Preference Parameters

Construction of Moment Conditions

As explained in section 5.1, we estimate six parameters of a utility function over consumption and leisure and two parameters that govern the utility of leaving a bequest. We start from a model that restricts all preference parameters to be the same for all countries and contrast its fit with that of models in which preferences are country-specific.

International variation in institutions helps to identify preferences only if preferences are restricted to be the same in all countries. We ensure that the parameters are also identified for each country separately by matching moments based on wealth and labor supply for two-year age bins. For each of ten two-year age groups from age 50 to 68 we use the following four moment conditions that hold at the true parameters:

$$\begin{aligned}
\mathbb{E}\left[\mathbf{I}\left\{w_i \leq \widetilde{Q1w}_t\left(\boldsymbol{\psi}_0, \boldsymbol{\chi}_0\right)\right\} - 0.25|t\right] &= 0 \\
\mathbb{E}\left[\mathbf{I}\left\{w_i \leq \widetilde{Q2w}_t\left(\boldsymbol{\psi}_0, \boldsymbol{\chi}_0\right)\right\} - 0.50|t\right] &= 0 \\
\mathbb{E}\left[\mathbf{I}\left\{w_i \leq \widetilde{Q3w}_t\left(\boldsymbol{\psi}_0, \boldsymbol{\chi}_0\right)\right\} - 0.75|t\right] &= 0 \\
\mathbb{E}\left[hrs_i - \widetilde{hrs}_t\left(\boldsymbol{\psi}_0, \boldsymbol{\chi}_0\right)|t\right] &= 0 \\
t &= 50, 52, ..., 68
\end{aligned}$$

$\mathbf{I}\{.\}$ is an indicator function; w_i and hrs_i are the wealth stock and hours worked of individual i; $\widetilde{Qpw}_t$ is the pth quartile of the model-predicted wealth distribution at age t; $\widetilde{hrs}_t$ is the model-predicted mean hours worked at age t; $\boldsymbol{\psi}_0$ is the true vector of preference parameters; and $\boldsymbol{\chi}_0$ is the true vector of the parameters of exogenous, auxiliary processes described in section 4.2. w_i and hrs_i are net of family size and cohort effects, both of which have been removed using Fixed Effects models following the approach described by French (2005).

We use moments based on quartiles of the wealth distribution because its the mean is influenced by outliers. Moreover, we need to use information on the distribution of wealth beyond the central tendency in order to cleanly identify risk aversion, patience and the bequest motive. For each age t we construct 4 moments, for a total of 40 moments per country and 160 moments in total.

Estimator

Denote the jth moment condition involving the variable z for country c at age t by

$$\widetilde{g}_{jct}\left(\boldsymbol{\psi},\boldsymbol{\chi}\right)=\frac{1}{N_c}\sum_{i\in n_{zct}}f_j\left(z_i;\widetilde{z}_{jct}\left(\boldsymbol{\psi},\boldsymbol{\chi}\right)\right)$$

where z_i is data and $\widetilde{z}_{jct}$ is the average or a quartile of the simulated distribution of z. N_c is the number of individuals i in the sample for country c, or the *potential* number of observations if all variables were observed for all individuals at all ages. n_{zct} is the set of individuals for whom we actually observe variable z in country c at age t: the set of *actual* observations. By dividing by the potential rather than the actual sample size for each country we effectively set contributions with missing data to zero, placing more weight on moments for which more data is available (French, 2005). As an example, this is the function f_j for a moment based on the first wealth quartile:

$$f_1\left(w_i;\widetilde{w}_{1ct}\left(\boldsymbol{\psi},\boldsymbol{\chi}\right)\right)=\mathbf{I}\left\{w_i\leq\widetilde{Q1w}_{ct}\left(\boldsymbol{\psi},\boldsymbol{\chi}\right)\right\}-0.25$$

The data are by assumption generated from the model at the true value of the parameters $\boldsymbol{\psi}_0$, $\boldsymbol{\chi}_0$. Stacking the moment conditions, we obtain a vector $\widetilde{\mathbf{g}}_c\left(\boldsymbol{\psi},\boldsymbol{\chi}\right)$ for each country c which has expectation zero at $\boldsymbol{\psi}=\boldsymbol{\psi}_0$ and $\boldsymbol{\chi}=\boldsymbol{\chi}_0$. We calculate the weighted distance between the observed and simulated moments as

$$dist_c\left(\boldsymbol{\psi};\widehat{\boldsymbol{\chi}}\right)=N_c\times\widetilde{\mathbf{g}}_c\left(\boldsymbol{\psi};\widehat{\boldsymbol{\chi}}\right)'\widehat{\mathbf{W}}_c\widetilde{\mathbf{g}}_c\left(\boldsymbol{\psi};\widehat{\boldsymbol{\chi}}\right)$$

where $\widehat{\boldsymbol{\chi}}$ is a consistent estimator for the auxiliary processes and $\widehat{\mathbf{W}}_c$ is a weighting matrix that converges in probability to the inverse of the covariance matrix of the data. Assuming that the true preference parameters $\boldsymbol{\psi}_0$ are the same across countries, the Method of

Simulated Moment (MSM) estimator is given by

$$\widehat{\boldsymbol{\psi}}_{MSM} = \arg\min_{\boldsymbol{\psi}} \frac{1}{1+\tau} \sum_c dist_c \left(\boldsymbol{\psi}; \widehat{\boldsymbol{\chi}}\right)$$

where $\tau = N_{tot}/S_{tot}$, $N_{tot} = \sum_c N_c$ and $S_{tot} = 4 \times 5000$ (we simulate moments for three countries using 5000 simulated individuals per country). Given some regularity conditions, the MSM estimator is consistent for $\boldsymbol{\psi}_0$ for fixed S_{tot} when N_{tot} goes to infinity (Pakes and Pollard, 1989). It is also asymptotically normal. An estimate of the variance matrix of the estimates is given by

$$V(\theta_{MSM}) = (1+\tau) \left(G_N' W_N G_N\right)^{-1}$$

where G_N is the matrix of derivatives of the moment vector with respect to the parameters. If the model is correctly specified the value of the objective function is distributed as a χ^2 random variable with $J-K$ degrees of freedom where J denotes the number of moments and K denotes the number of parameters to be estimated.

Since the objective function is generally not smooth and has local minima, we minimize the objective by means of simulate annealing. We use the version of the algorithm presented by Goffe et al. (1994).