Social Security and Retirement across the OECD Countries*

[JOB MARKET PAPER]

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December 3, 2009

Abstract

There are large differences in the employment to population ratio relative to the US across the OECD countries, and these differences are even larger for the old age (55-69 years). There are also large differences in various features of social security, such as the replacement rate, the entitlement age or whether it is allowed to collect social security while working. These observations suggest that they might be an important contributing factor in accounting for differences in retirement. I assess quantitatively the importance of these features using a life cycle general equilibrium model of retirement. I find that the differences in social security account for 90% of the differences in employment to population ratio at ages 60-64 in the OECD. The differences in the replacement rates and whether the system allows for collecting social security while working are the most important contributing factors to account for the differences in retirement.

Keywords: Social security, retirement, idiosyncratic labor income risk
JEL Codes: E24, H53, J14, J26

*I am deeply indebted to Richard Rogerson, Berthold Herendorf and Roozbeh Hosseini for their intellectual encouragement. I would also like to thanks Kevin Reffet, Manjira Datta, Josep Pijoan-Mas and Manuel Santos for helpful insights and the participants of the Department of Economics' Macro Seminar and Brown Bag Seminar. Special thanks to Galina Verschagina who patiently discussed my manuscript.

1 Introduction

There are large differences in employment to population ratio across OECD countries. In 2006 it ranges from 42% in Turkey to 66% in Norway. These differences are even larger for older persons: the employment to population ratio for ages 60-64 ranges from 13% in Hungary to 60% in New Zealand. At the same time there are large differences in the features of social security systems across the OECD. For example, the replacement rate ranges from 38% in Mexico to 124% in Turkey, while entitlement ages varies from 55 in Australia to 67 in Norway. Some countries (such as Denmark) do not allow collecting social security benefits while working whereas others (such as Canada) do not impose any restrictions. My paper seeks to answer two questions: Can these differences in social security account for the large differences in employment per person at old ages? What features of social security are the most important contributors in accounting for these differences? Understanding these two questions is very important for policy considerations, as demographic projections show that the population over 50 will be more than half of the working age population in 2050.

To answer to these questions I develop a life cycle general equilibrium model of retirement with a discrete labor choice, idiosyncratic labor income risk and incomplete markets. The model is calibrated to match key statistics of the US economy and its social security system. A key feature of my model is that I am able to capture the heterogeneity in employment by age that it is found in the data, which is a desirable property if we want to study cross country heterogeneity in retirement. For example, in the US more than 60% of the population is working at age 62, and 40% is still working at age 65. My model is able to capture very well the employment profile of ages 50-80.

To evaluate the effects of differences in social security across countries, I solve for the stationary equilibrium of the model with the same model parameters of the US but with the social security systems of each OECD country. My main findings are as follows. First, it turns out that the differences in social security account for a large part of the differences in retirement behavior. One way of illustrating this finding is to compare the coefficients of variation of employment to population across OECD countries observed in the data with those generated by the model. At ages 60-64 this statistic is .45 in the data and it is .42 in the model. At ages 65-69 it is .80 in the data and .70 in the model. As a matter of fact, the correlation between the data and model predictions is of .73 for ages 60-64 and .75 for ages 65-69. This means that my model captures much of the variability found in the data. For example, I account for 90% of the differences in employment to population ratio at ages 60-64 between the OECD countries and the US[1]. Second, when I ask what are the most salient characteristics of social security that account for differences in retirement, it turns out that the replacement rate and the restrictions on collecting social security while working are very important, on the other hand differences in the entitlement age are not. To assess the magnitude of each, I shut down the characteristics of social security to US levels one by one. I find that the coefficient of variation of employment to population at ages 60-64 in the model is .20 when there are differences in the replacement rate only and .22 when countries have different rules on collecting social security and working only. In contrast, it is .05 when there are just differences in the entitlement age. It follows that the replacement rate and the restrictions on collecting social security while working each account for roughly 50% of the variability in the model. I find little evidence that there are significant interactions across these three features.

My paper is most related to two streams of literature. The first one follows Prescott (2004), that sought to explain large differences in hours of work through differences in the average tax rate for G-7 economies, using a stand-in

[1]The measure of the performance is relative to the US and it is the result of averaging $\left|\frac{1-model}{1-data}\right|$.

household growth model[2]. Prescott et. al (2007) and Rogerson & Wallenius (2009) developed a life cycle model with an intensive and extensive margin in the labor choice to analyze the effect of a simple tax and transfer system on hours of work. It turns out that the results are similar to Prescott. Wallenius (2008) extends this framework to include human capital accumulation and studies differences in hours per capita of Belgium, France and Germany that are generated through differences in social security. She finds that social security has large effects on hours of work, mostly through the extensive margin. Similar to the spirit of my work Guvenen et al. (2009) examine the role of progresivity of the tax code in accounting for the evolution of wage inequality in Continental Europe relative to the US. They find that different features of the tax on income, in particular progresivity, are able to account for much of the differences in wage variance. In spite of the similarities, they use an exchange economy without market incompleteness and they abstract from retirement.

Relative to Wallenius my paper has two important characteristics. First, my model incorporates heterogeneity and it is able to match the distribution of retirement that it is found in the data whereas in her model everybody retires at the same age. Second, I compute outcomes for a much larger set of countries. While I also find large effects of social security, heterogeneity reduces the impact on employment to population. These smaller effects can be due to a smaller response of individuals to social security when there is labor income risk or to composition effects; as when there is mortality risk the weight of older individuals on the total population is smaller. To investigate the role of heterogeneity I cut the variance of the income risk by a half and recalibrate the model to match the US economy. I find that a country with a social security with twice the replacement rate of that in the US will have an employment to population ratio 3 percentage points below in a world with

[2]Many papers have studied the impact of differences in taxes on hours of work. For example: Ohanian et al. (2007), Rogerson (2007), McDaniel (2009) and Ragan (2005)

half the labor income risk, whereas the employment to population ratio will be 6 percentage points below in a world with all the idiosyncratic labor income risk. Furthermore, the employment to population ratio at ages 60-64 will be 9 percentage points below of that in the US in the former case, whereas it will be 25 percentage points below in world with the amount of idiosyncratic labor income risk found in the data. This points out to mortality risk and the implied age structure of the population in my model as the main contributor to this discrepancy[3]. To illustrate this point I shut down mortality risk, assume that each age group has the same weight and recalibrate the model. I find that a country with a social security with twice the replacement rate of that in the US would had an employment to population ratio 10 percentage points below of that in the US. An additional advantage of my model is that it can be used to study how social security impacts the ability of individuals to insure against risk and it can be used for welfare comparisons too. These applications are left for future extensions.

A second stream of literature studies different aspects of social security. I will not attempt to survey it here as it is very extense[4]. The most related reference from this literature is French (2005,2007). He develops a model with labor income, health risk and incomplete markets to study the role of social security in accounting for retirement behavior in the US. He finds that market incompleteness plus social security are key to understand the retirement behavior. This provides some support to the importance of the assumptions in my model. I depart from his work in that I include general equilibrium. This is an important extension if we want to study cross country differences in retirement.

[3]More experimentation is needed to check for the importance of heterogeneity in the OECD.

[4]For example, Gustman & Steinmeier (1986), Stock & Wise (1990), Gruber & Wise (2004, 2007), Coile & Gruber (2007), Phelan & Rust (1998), French (2005,2007), Hugget & Ventura (1999) and Nishiyama & Smetters (2007) to mention a few important contributions to the study of social security

2 Employment and social security in the the OECD

This section presents empirical evidence for the OECD countries in 2006. I use labor force statistics by age and sex from the OECD on-line database[5] and social security data from "Pensions at Glance 2009" and the "Total Economy Database[6]." To study the implications of social security in cross country differences in retirement I collect the employment to population ratio[7] and the employment to population ratio at ages 55-59, 60-64, 65-69 and 70-74. Even though the employment to population ratio is not the main focus of my study it is useful as a benchmark to understand the magnitude of the differences in retirement.

There are large differences in the employment to population ratio. Turkey has the lowest employment rate at 42% whereas Norway has the highest at 66% (Figure 1 (a)). These differences are even larger for older individuals. For example, if we look at the employment rate at ages 60-64 the differences range from 13% in Hungary to 60% in New Zealand (see Figure 1 (b)) The US has an employment to population ratio of 65% and it is 51% for ages 60-64.

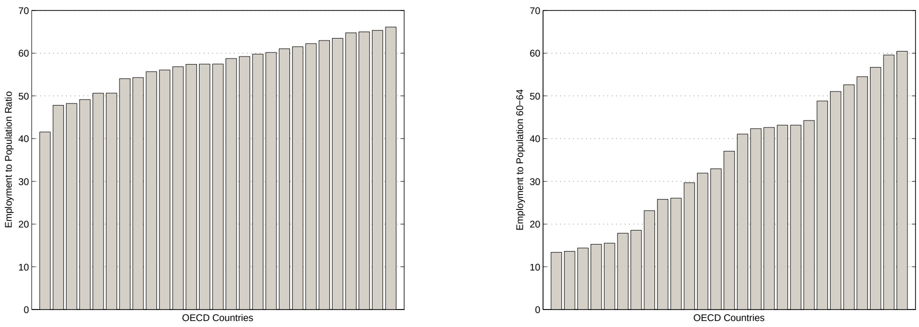
Social security systems are complex and they differ along many dimensions. For example, consider three countries: Belgium, France and the US (I could have picked any other three countries). In Belgium to qualify for full social security benefits you have to be at least 65 with no less than 45 years employed, although you may be entitled to a reduced benefit if you are at least 60 and

[5]http://stats.oecd.org/Index.aspx

[6]The Conference Board and Groningen Growth and Development Center

[7]I define employment to population ratio as the ratio of employees age 20-75 to individuals 20-75. My model economy will have an initial age of 20 and few individuals work past age 75. Also the OECD has data limitations beyond ages 70-74.

Figure 1: Employment differences in OECD



(a) 20-75 (b) 60-64

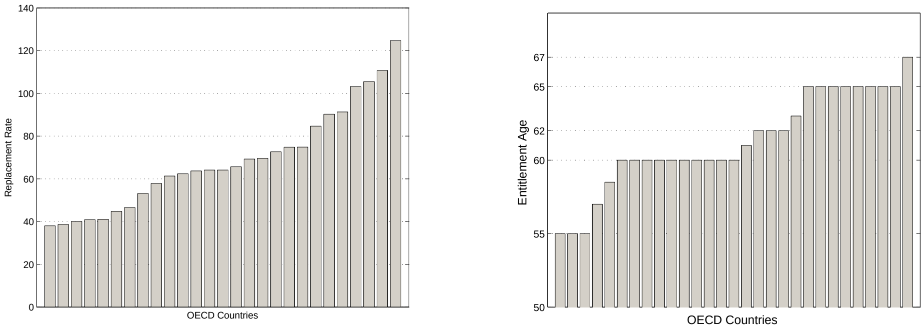
worked no less than 35 years. Social security depend on the marital status and there are means tested floor benefits and vacation allowances. In France you need to be 60 and at least have been 40 years employed to qualify for full pension but if you entered the labor force at ages 14-16 you may qualify to full benefits at ages 56-59. You may continue any gainful activity and collect social security but you have to wait 6 months from your first social security check. You may also defer social security subject to some conditions, and there are mean tested "solidarity pensions" that do not depend on earnings. Social security is based on the best 25 years and it is indexed to cost of living and it depends on marital status too. In the US social security is not simpler than in Continental Europe countries. Individuals are entitled to full benefits at age 65 but the may collect reduced benefits at age 62. This benefit reduction can be compensated if benefits are suspended later on, the compensation is roughly actuarially fair. Any individual is required to be employed at least 10 years to qualify. Dependants are also entitled to benefits and these depend on family structure.

Given these complexities I rather focus on three key dimensions that are measured by the OECD: the replacement rate, the entitlement age and whether a country allows for collecting social security while working. The definition of replacement rate that I use is the ratio of social security benefits at entitlement age to the individual average net earnings[8] at entitlement age for a single male whose individual average earnings equals the average earnings of the economy (AW hereafter) and has entered employment at age 20 with no career breaks. The assumption on the age of entry to employment is convenient to my model, as individuals will enter the economy at age 20, and the modeling assumptions make them have continuous careers until they reach age 50 at least. The entitlement age is defined by each country's social security law. There may be three different entitlement ages: early entitlement age, normal entitlement age and deferred entitlement age. The entitlement age depends sometimes on the age and the occupation. I present data on the early entitlement age for males and abstract from differences based on the occupation. More information can be found in the Appendix. Finally, to determine if a country allows for collecting social security while working I rely on the work of Duval (2003) and the thorough description of the social security systems around the world provided by the US Social Security Administration. Duval computes an implicit tax on continuing to work based on the social security rules of a sample of OECD countries. This tax is measured as the social security benefits that you loose from continuing to work the next 5 years relative to the maximum social security benefits that you could get if you retired. These three features are enough to capture the differences in social security programs across OECD members as many features of each country's social security may show up in some of these dimensions. For example, a country that requires more years employed to qualify for full benefits will have a smaller replacement rate other things being equal.

There are large differences in the replacement rate ranging from 38% in Mexico to 124% in Turkey. There are also large differences in the entitlement

[8]Net of other taxes and social security contributions. In the Appendix, I provide the values of both the gross replacement rate and net replacement rate.

Figure 2: Replacement Rate and Entitlement Age

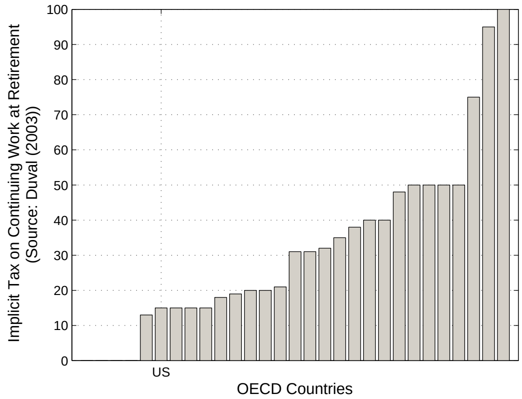


(a) Generosity

(b) Entitlement Age

age, which varies from 55 in Australia to 67 in Norway (Figure 3). Figure 4 shows Duval's implcit tax on continuing to work to illustrated the differences in the rules that allow for collecting social security while working. In the rest of the paper I assume that in each country it is either alowed to collect benefits while working or not at all. I set the following threshold: a country will allow collecting benefits while working if Duval's implicit tax on continuing to work is less than 50% and it is not explicitly said on SSA's countries description. Clearly this classification is arbitrary and a more detailed modeling of social security rules on collecting benefits while working is an exercise worth doing.

Figure 3: Implicit Taxes on Continuing to Work



3 Model Economy

This section describes assumptions about demographics, preferences and endowments, technology, policy and market structure.

3.1 Demographics

The demographic structure is stable, but the size of the population (N) grows at a constant rate n. Any given person of age a survives to the next period with probability s_a. Individuals have a maximum life length of A years. Given the population growth and the survival probabilities, each age group represents a constant fraction of the population μ_a[9].

3.2 Preferences and endowments

Every individual has identical preferences over sequences of consumption $\{c_a\}$ and leisure $\{h_a\}$. Consumption must be non negative and I assume that hours of work can take two values: zero or $\bar{h}$. Every individual is endowed with one

[9]This number is obtained with the following recursion: $\mu_{a+1} = \frac{s_{a+1}}{1+n}\mu_a$ and I normalize the weights to 1, so $\sum_a \mu_a = 1$.

unit of time each period and have preferences given by:

$$E_0 \left[\sum_{a=1}^{A} \beta^a \left(\prod_{j=1}^{a} s_j \right) u\left(c_a, 1 - h_a\right) \right] \tag{1}$$

3.3 Individual productivity

Let $z_{i,a}$ be the productivity of individual i at age a. The log of this productivity is the sum of two components: z_a^d which is a deterministic component that depends on age, and $z_{i,a}^w$ which is a random component and captures the heterogeneity within each cohort. I assume it is characterized by an AR(1) process. It can be written as

$$\log(z_{i,a}) = \log(z_a^d) + \log(z_{i,a}^w) \tag{2}$$

$$\log(z_{i,a+1}^w) = \rho \log(z_{i,a}^w) + \epsilon_{i,a+1} \tag{3}$$

where $\epsilon_{i,a}$ is the innovation that is independently and identically distributed as $N(0, \sigma_\epsilon^2)$

3.4 Technology

There is a representative firm that operates a constant returns to scale technology that transforms aggregate capital (K) and aggregate efficiency units of labor (L) into a homogeneous and perfectly divisible product (Y). Capital depreciates at a rate δ. Output can be used for either consumption or investment.

3.5 Markets

At each date there are markets for capital, labor and product. There are no insurance markets and no markets for borrowing and lending. However, as in

Aiyagari (1994) individuals accumulate precautionary savings.

3.6 Social Security

Social security is defined by two elements. The first is a payroll tax (τ) that is levied on every worker. The second is a function $\phi(\bar{e}_a, h_a, a)$ that characterizes the benefit amount and the entitlement conditions. It is a function of average earnings as the benefit amount will depend on the individual average earnings. It depends on the labor choice as social security may restrict the possibility of collecting social security while working. Finally, it depends on age as individuals are not entitle to receive social security until they reach certain age ($\hat{a}$). Further details about social security will be given in the calibration section.

3.7 Accidental Bequests

As individuals may die with positive probability they may leave some capital. I assume that the government collects all this capital and distribute it lump sum among those individuals alive. I will denote accidental bequest as B.

3.8 Recursive Steady State Representation of the Individual Decision

I represent the individual decision problem recursively. The individual state variables are: wealth (k), the idiosyncratic component of productivity (z^w), average earnings ($\bar{e}$) and age (a). Each period, individuals decide how much to consume (c), how much capital to hold (k') and employment (h).

In steady state, taking the interest rates (r), the wages (w), the payroll tax (τ), the social security system (ϕ) and the accidental bequests (B) as given, each individual solves the following Bellman equation:

$$V_a(k, z^w, \bar{e}) = \max_{c,k',h} u(c, 1-h) + \beta s_{a+1} E_{z^w}\left[V_{a+1}(k, z'^w, \bar{e}')\right]$$
$$\text{s.t. } c + k' = (1+r)k + (1-\tau)wz_a h + \phi(\bar{e}, h_a, a) + B \quad (4)$$

3.9 Aggregate State Variable

The aggregate state variable of the economy is a list of measures over the individual states $\{\Psi_a(k, z^w, \bar{e})\}$ In steady state, they are a function of the individuals' policy functions and the idiosyncratic component of productivity.

3.10 Steady State Recursive Competitive Equilibrium

To save notation I collect the individual state variables other than age in a vector $x = (k, z^w, \bar{e})$.

A stationary recursive competitive equilibrium is a list of functions and scalars: ($c_a(x)$,$k'_a(x)$,$h_a(x)$,$V_a(x)$,$\phi(\bar{e}, h_a, a)$,$\Psi_a(x)$,w,r,τ,K,L,B) such that:

1. $c_a(x)$,$k'_a(x)$,$h_a(x)$ and $V_a(x)$ solve equation (3) for every $a = 1, ..., A$
2. K and L solve the representative firm profit maximization problem, so input prices are given by the first order conditions: $r = F_K(K, L) - \delta$ and $w = F_L(K, L)$
3. Markets clear
   (a) $\sum_a \mu_a \int_X [c_a(x) + k'_a(x)]\, d\Psi_a = F(K, L) + (1-\delta)K$
   (b) $\sum_a \mu_a \int_X k'_a(x) d\Psi_a = (1+n)K$
   (c) $\sum_a \mu_a \int_X z_a h_a(x) d\Psi_a = L$
4. The aggregate state is consistent with individual behavior

5. Social security is balanced

$$\tau L = \sum_{a \geq \hat{a}} \mu_a \int_X \phi(\bar{e}, h_a(x), a) d\Psi_a$$

6. Accidental bequest are distributed evenly among individuals alive

$$\sum_a \mu_a (1 - s_{a+1}) \int_X (1 + r) k'_a(x) d\Psi_a = B(1 + n)$$

4 Calibration

I calibrate the model to key features of the US economy. Some parameters are selected individually and without solving the model, like demographics, the individual productivity process, the fraction of time working and the social security, whereas technology parameters are selected individually by solving the steady state equilibrium of the model to match a single statistic. Finally, the preference parameters are chosen jointly to minimize a function of some key statistics.

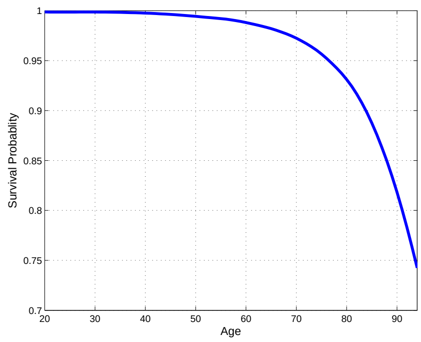
4.1 Parameters calibrated without solving the model

I need to choose the growth rate of the population (n), the age when individuals enter the economy, the life length (A), the probability of survival (s_a), the individual productivity process ($z_{i,a}$), the fraction of time working ($\bar{h}$) and the social security program.

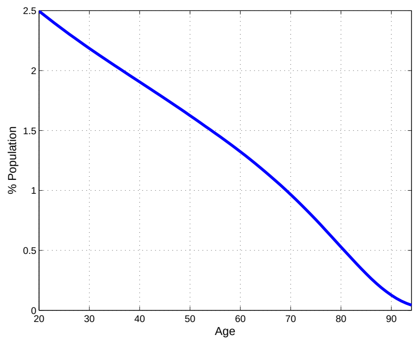
4.1.1 Demographics

I choose the population growth rate to be equal the US average of 1.2% over the period of 1960-2006. This number is taken from the US Census Bureau Statistical Abstract 2009. Individuals enter the economy at age 20 and they die with probability 1 when they are 94, implying $A = 75$. The probability of survival is taken from the actuarial tables for males provided by the US Social Security Administration in 2004. Figure 5 shows survival rates for the selected life span and the implied stationary population weights.

Figure 4: Survival and Stationary Weights



(a) Probability of Survival



(b) Weight of the Population

4.1.2 Individual productivity process

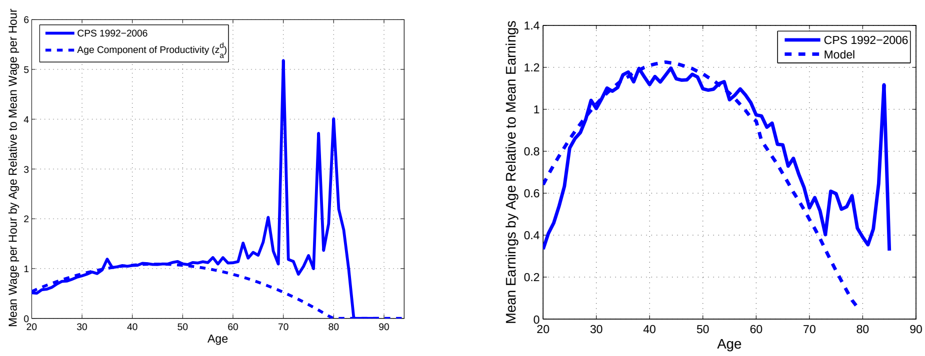
The individual productivity ($z_{i,a}$) is characterized by two components: z_a^d, a deterministic component of age and $z_{i,a}^w$, a stochastic component.

To characterize the deterministic component, I use annual earnings and annual hours worked from IPUMS-CPS[10] over the period 1992-2006. I express annual earnings in $US1982. The empirical literature usually decompose annual earnings in three different components: age, time and cohort. A well known problem in this literature is that the time and the cohort effects can not be identified separately without making strong assumptions. Hugget et al. (2009) decompose earnings under three different hypothesis: they assume that either the time effect is zero, the cohort effect is zero or the time effect and the cohort effect are orthogonal. They find that none of the assumptions affect significantly the estimation of the age component of earnings. In the

[10]http://cps.ipums.org

steady state, the time effect should be proportional to the time variable, so I assume that earnings grow at a 2% rate due to productivity gains[11]. I construct hourly wages dividing annual earnings by annual hours. I compute the ratio of mean hourly wage by age to mean hourly wage. This produces a hump-shaped profile. I use a quadratic polynomial to eliminate sample variability and I truncate the polinomial to zero when it goes below zero which happens at age 80. Estimating labor productivity is a difficult task at old age as there are very big selection effects. In the context of my model this does not seem to be crucial as it approximates relatively well the earnings profiles until age 75 and beyond this age there are few individuals working. Figure 6 (a) shows the result of the calibration of the deterministic component and Figure 6 (b) compares CPS annual earnings with the earnings profile of the calibration. The simulated earnings profile is consistent with the earning profile from the CPS for most of the life cycle.

Figure 5: Deterministic productivity (z_a^d) and earnings



(a) Wage per Hour

(b) Earnings

The stochastic component of individual productivity is characterized by an AR(1)

$$\log(z_{i,a+1}^w) = \rho \log(z_{i,a}^w) + \epsilon_{i,a+1}$$

[11]Hugget et al. (2009) document a growth of wage per hour in the PSID of 1.5% for the period 1969-1992.

with $\epsilon_{i,a+1} \overset{iid}{\rightarrow} N(0, \sigma_\epsilon^2)$ The parameters ρ and σ_ϵ^2 are taken from French (2005) and equal .977 and .0141 respectively.

Finally, the fraction of time spent working ($\bar{h}$) is set to .45 of available time in a year. To calculate the available time I assume that individuals can use 12 hours a day working which delivers 4380 hours in a year and 1971 hours spent at work.

4.1.3 Social security

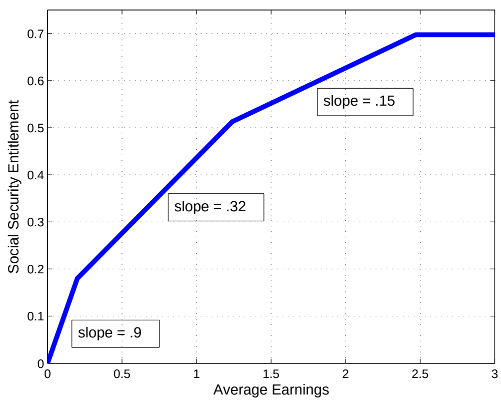
The social security system is calibrated to the US. In my model individuals start collecting social security benefits at age 62 which is the early entitlement age in the US. Ideally I should also include the normal retirement age and the choice of entitlement to benefits, but that would had made the problem more time consuming than it already is. Moreover, in the US individuals are not allowed to borrow against social security income, so the asset poor individuals want to get their benefits as soon as they are available. On the other hand, the timing of the benefit does not matter that much for the rich individuals. Thus, setting the entitlement age to 65 would had made my model to overestimate the employment rate of the asset poor individuals.

I assume that the US has no restrictions on collecting social security while working. I find that this is a reasonable approximation for two reasons. The first one is that the implicit tax on continuing to work obtained by Duval (2003) is one of the smallest across the OECD (12%). The second one is that in 2000 the "earning test" was repealed. The "earnings test" consisted on a tax on social security benefits for individuals that claimed entitlement before age 67 while still working. The test stablish two income thresholds: after the first threshold, $1 of social security benefits is taxed away for every $2 of labor earnings above this first threshold; and after the second threshold, $1 of social security benefits is taxed away for every $3 of labor earnings above this second threshold. On top of it, the US system includes an actuarial compensation factor that allows the individuals to compensate for some of the benefit loss later on. As a matter of fact this compensation was not actuarially fair before the reform, whereas after the repeal the "earning test" applies only before 65, and the actuarial compensation is now designed to be fair.

The social security benefit formula is taken from the US Social Security Administration. It is a piece-wise linear function of average individual earnings ($\bar{e}$) as in Hugget & Ventura (1999), French (2005) or Nishiyama & Smetters (2007). The bend-points are multiples of AW so they can be directly taken to the model economy. The US social security replaces 90% of the first $761 monthly, 32% from $761 and through $4,586, and 15% above $4,586. This is equivalent to .2,1.24 and 2.47 in multiples of annualized average earnings (AW). Therefore it writen as

$$\phi(\bar{e}_a, h_a, a) = \begin{cases} 0 & \text{if } a < 62 \\ \varphi(\bar{e}) & \text{otherwise} \end{cases}$$

Figure 6: $\varphi(\bar{e})$



Note that as I assume that there are no restrictions on collecting social security while working h_a does not play any role. I have made the following additional simplifications: the social security takes into account the 35^{st} best years of earnings while I just take the simple average over the lifetime, capped for individual earnings higher than 247% of AW. Again, this does not seem to be very important as the specification of the individual productivity process make that those highest earnings accrue early in life. I characterize individual average earnings by the following formula:

$$\bar{e}' = \begin{cases} \frac{\bar{e}\cdot(a-1)+\min(wz_{i,a}h, 2.47\cdot AW)}{a} & \text{if } a < \hat{a} \\ \bar{e} & \text{otherwise} \end{cases}$$

I abstract from the feature that US social security requires the individuals to be employed for at least 10 years. This is not an issue in my model as everybody work more than 10 years whatsoever. I also assume that there are no earnings limits on the payroll tax, while in the US earnings above $100,000 are exempt (roughly $3AW$). Still this seems a harmless assumption as the mass of individuals that earn more than $3AW$ is relatively small.

4.2 Parameters calibrated solving the model

Preferences. I assume that the utility function is separable in consumption and leisure and it takes the following form

$$u(c, 1-h) = \frac{c^{1-\sigma}}{1-\sigma} + \lambda \cdot (1-h) \tag{5}$$

this function is characterized by the relative risk aversion (σ) and the weight of leisure (λ).

Technology. I assume the technology is Cobb-Douglas, $Y = K^{\alpha}L^{1-\alpha}$. I choose α to match a labor share value from NIPA of .64. The depreciation rate is set such that the ratio of investment to output equals .20.

Objective. I choose (σ, λ, β) to match the following key statistics in the US: a capital-output ratio of 3.0, an investment-output ratio of .20, a labor share of .64 and the employment to population ratio profile from ages 50 to

80. I calculate the employment to population ratio from the same sample of the CPS that I used to calculate hourly wages. I have 33 moments and 3 parameters so I choose the parameters to minimize the square deviation of the moments from the data and the analogous moments simulated by my model. I use the Nelder-Meade algorithm to find the minimum. Even though every parameter may impact any moment, the discount factor β is related to the capital output ratio mostly. Once the algorithm finds a value of the discount factor that makes the capital-output equal 3.00, a value of α of .36 delivers a labor share of .64 and a value of δ of .066 delivers an investment output ratio of .20. The deterministic component of productivity ($\left\{z_a^d\right\}$), the weight of leisure in the utility (λ) and the relative risk aversion (σ) interact to determine the level and the shape of the employment profile. At first sight, it is not obvious why does the relative risk aversion play a role to determine the shape of the employment profile and deserves a brief comment. For a high value of σ (which implies a low elasticity of substitution), the drop in employment when individuals receive the social security benefits will be smaller than if σ is small, thus the employment profile will be steeper for smaller values of the relative risk aversion coefficient.

4.3 Calibration results

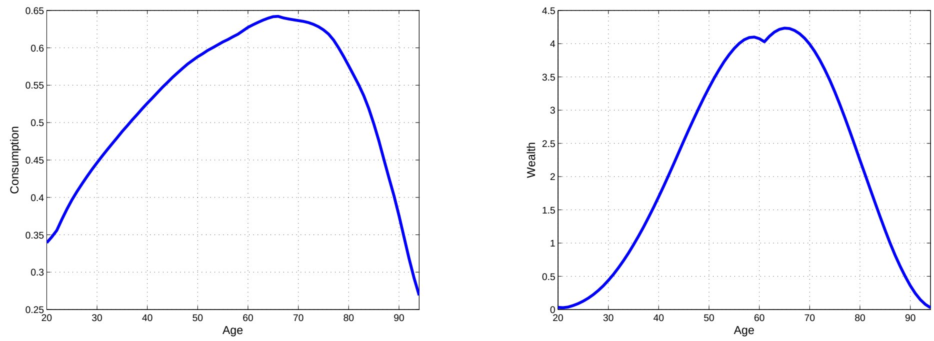
Table 1 shows the results of the calibration. Relative risk aversion (σ) is within the range of the values found in the literature which vary from 1 to 8, β is in the low range for life cycle models but I still get a hump-shaped consumption profile as it is shown in Figure 7.

Table 1: Parameters

A	n	σ	λ	β	α	δ	ρ	σ_ϵ^2
75	.012	2.50	2.50	.97	.36	.066	.977	.0141

The model matches the ratios of capital and investment to output and the labor share perfectly. It is also successful matching the employment to pop-

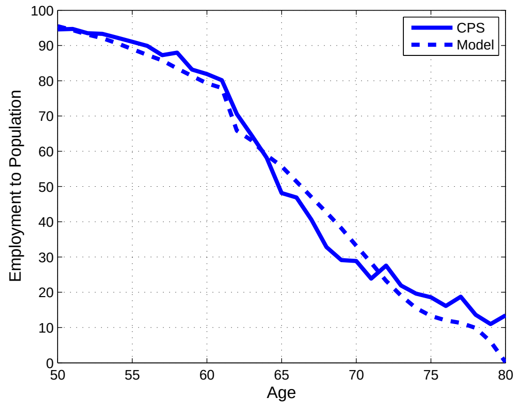
Figure 7: Consumption and wealth over the life cycle



(a) Consumption (b) Wealth

ulation ratio by age. Figure 8 shows the match of employment to population for ages 50-80[12]. This is a key feature in my model as I need an accurate

Figure 8: Employment rate fit



representation of the employment to population to do reliable cross country comparisons. French (2005) also match the employment profile but he seems to over-estimate employment by age above age 62 more than I do. That he attempts to match the wealth distribution at the same time is the most likely reason of his results. To match the accumulation of wealth in the top wealth

[12]After 80 almost nobody is working and in my model nobody is working.

quintile you need a high β but this would also induce individuals to retire early. In French (2007) he partially solves this issue introducing heterogeneous preferences.

5 Policy experiments

In this section I describe the experiments that allow me to do cross country comparisons of employment to population at older ages and what are the features of social security that affect employment the most.

5.1 Description of the Experiments

Section 2 documented large differences in employment to population and retirement across the OECD countries. It also documented large differences in social security. As I get a very good fit of the model to the US, I use the US as a benchmark and express all the employment statistics relative to it. I also express the replacement rate of the social security relative to the US replacement rate.

To account for differences in employment through differences in social security I solve the stationary equilibrium of the model for different parameterizations of social security to mimic the differences in the replacement rate, the entitlement age and the restrictions on collecting social security while working. Then I compare the results of the simulations to the OECD employment data for 2006.

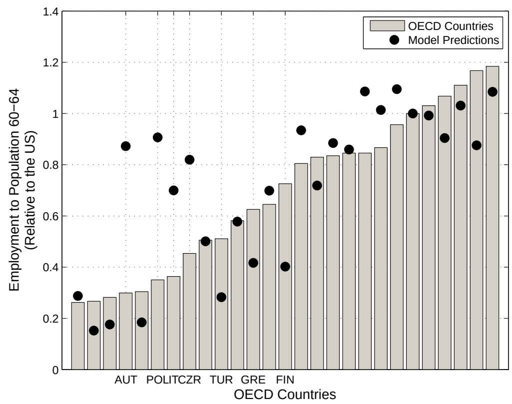
I begin with the employment to population 60-64 because it is the most common age of retirement. Still, there are some countries that have entitlement ages below 60 or above 64, so I group these countries by the entitlement age and compute the employment to population around the entitlement age. This means that if I compare to the US a country like Italy, which has entitlement age of 57, I use the employment to population for ages 55-59. Finally, I pin down the features of social security that are key to generate the large differences in employment to population found in the data by shutting down to US levels some features of social security while leaving others active. The measure of variability that I will use is the coefficient of variation.

5.2 Results

5.2.1 Retirement relative to the US

First, the differences in social security account for the large differences in retirement behavior. This is a surprising result as my model allows for differences along three dimensions of social security only. Figure 9 illustrates the ability of the model to match the retirement behavior, measured as the employment to population ratio at age 60-64 relative to the US. In Figure 9 the bars are OECD countries data and the dots are model simulations for each OECD countries. The data is sorted from low to high employment to population at ages 60-64 relative to the US.

Figure 9: Employment to population rato 60-64

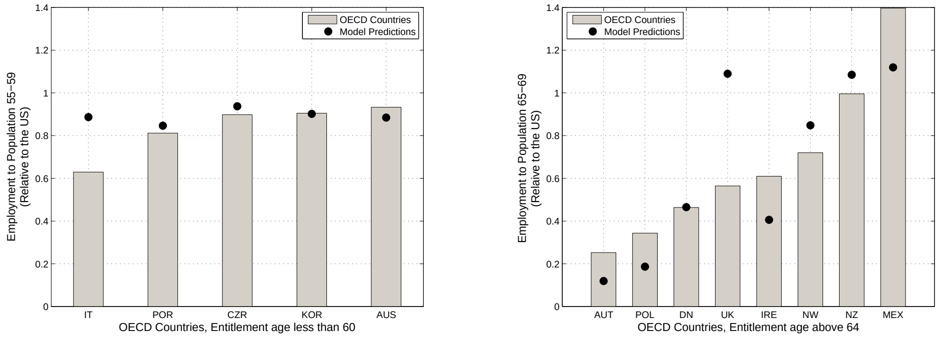


The model does a very good job matching the size of the differences and the pattern that is observed in the data and it is also able to make accurate predictions for many OECD countries. I use the following measure to summarize the predictive performance of the model: $\sum_i \left|\frac{1-sim_i}{1-data_i}\right|$. Under this measure I capture 90% of the differences in employment to population ratio at ages 60-64. The model over-predicts employment on average (the ratio of simulation to data is 1.10). Austria, Poland, Italy and Czech Republic stand out as outliers for ages 60-64. My model accounts for two thirds of the employment variability of Turkey, Greece and Finland and over-predicts employment of UK, Ireland and Mexico. Korea and Sweden are under-predicted but the model captures almost all the variability. Assuming that there are not measurement issues in the OECD data, there are a few potential reasons for these discrepancies. First, there are some countries that have retirement ages that do not fall within the ages 60-64 and my model may capture behavior at entitlement age better. All the countries mentioned above but Turkey, Greece and Finland (with entitlement ages 60,60 and 62 respectively) have entitlement ages below 60 (Italy, Czech Republic and Korea) or above 64 (Austria, Poland, UK, Ireland and Mexico)

I address this issue by computing the employment to population ratio for countries grouped by the entitlement age. Figure 10 shows the fit of employment for countries with entitlement ages less than 60 (Figure 10 (a)) and entitlement ages greater than 64 (Figure 10 (b)).

The model fit is better at the entitlement age as it is illustrated when I group countries by the entitlement age. But why does the model miss some variability in post-entitlement employment of countries with the entitlement age smaller than 60 and pre-entitlement employment in countries with the entitlement age bigger than 64. One potential weakness in my modeling choices could be the assumption about restrictions on collecting social security while working. For countries in which collecting social security while working is not explicitly forbidden in the US Social Security Administration cross country comparison assuming that it is, is a judgment call. In the real world these incentives on continuing to work are not constant after early retirement and

Figure 10: Employment to population at the entitlement age



(a) Entitlement age < 60

(b) Entitlement age > 64

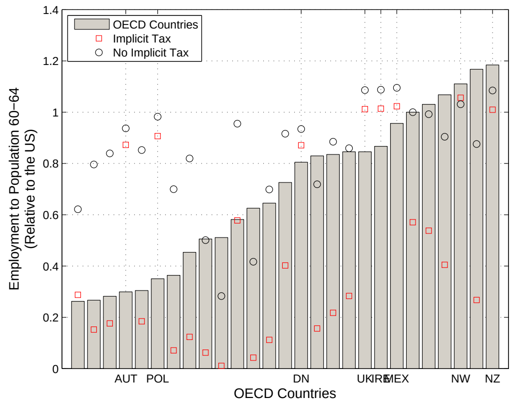
they would require a detailed modeling of normal retirement age and the entitlement choice, or an age dependent tax on social security that captured the incentives with some accuracy. I leave this as a future extension as I am already performing relatively well and it would increase the computational burden without clear advantages. Figure 11 shows the model simulations under these two different assumptions: all countries restrict collecting social security while working, and all countries do not. For most of the countries it is crucial that I make the an appropriate choice and this is why a careful modeling of social security for each country is an exercise worth pursuing.

The message that we get from these experiments is that these three key features of social security are able to explain a substantial amount of retirement behavior.

5.2.2 Employment to Population

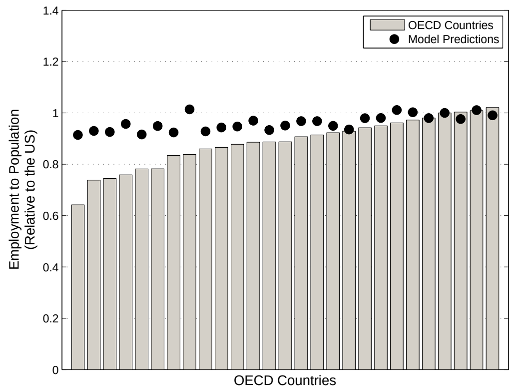
The differences in social security also account for a substantial amount of the differences in employment. My model is able to account for 68% of the differences in the employeemnt to population ratio. These differences are accounted through the retirement behavior as there is not much action in the employ-

Figure 11: Sensitivity of employment at ages 60-64



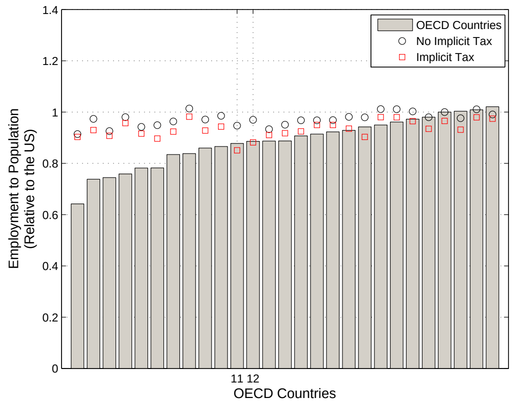
ment decisions before age 50. Figure 12 shows the fit of the employment to population ratio relative to the US. There are many factors that may affect employment behavior during a lifetime so it is remarkable that social security is able to account for such a big amount.

Figure 12: Employment to population



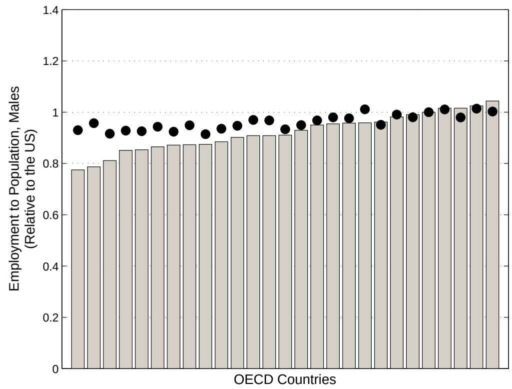
It is also worth noting the role of restrictions on collecting social security while working. Figure 13 is analogous to Figure 11 and shows how sensitive is the employment to population ratio to assuming that every country restricts collecting social security while working and that no country does.

Figure 13: Sensitivity of employment



My model misses non-European countries like Turkey and Mexico, Eastern European countries like Poland, Hungary and Slovak Republic and Belgium, Italy, France and Germany. An extension that included differences in income taxation independent of social security would fill part of what is missing on Continental European countries. Turkey, Mexico, Greece and Italy have female populations that are not as integrated into the labor force and when I look at the employment to population of males relative to the US I get a different picture. Figure 14 shows the fit of the model when I restrict the employment to males. Note that the picture for retirement will not change that much as retirement decisions are usually coordinated. Still retirement decisions of couples is an interesting topic by itself and how different treatment of social security of spouses may matter for individual and joint retirement choices.

Figure 14: Employment to population, males

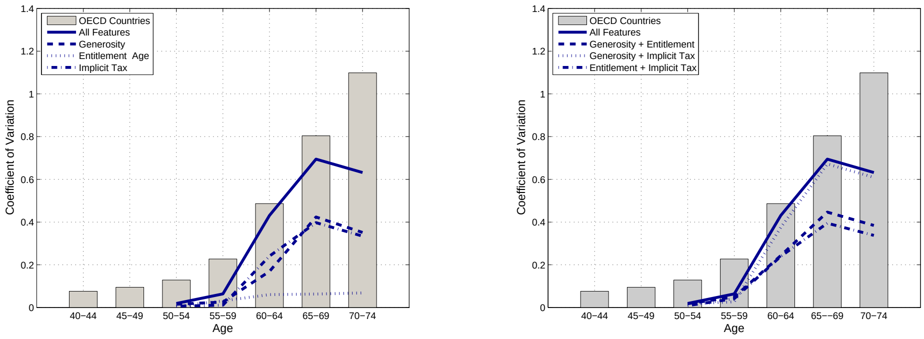


5.2.3 What features of social security are most important?

Using an eyeball measure it is possible to tell that the restrictions on collecting social security benefits while working is an important feature of social security to generate the retirement and the employment variability. To pin down rigorously what are the most important contributors into accounting for the employment variability, I use some counter-factual simulations. First, I will focus on the individual role of each feature of social security: the replacement rate, the entitlement age and whether the country restricts collecting social security while working. I let one feature active at a time and set the other features to the US levels. My measure of variability is the coefficient of variation of the data and the model. I compute the standard deviation and the mean of the employment relative to the US for different ages. The ratio of the standard deviation to the mean gives a unit-less measure of the variability. I do the same for my model simulations of the OECD countries.

Figure 15 (a) shows that the most important features individually are the restrictions on collecting social security while working and the replacement rate, whereas the entitlement age is not important. As there are potentially important interactions, I allow two features active at the same time. I find

Figure 15: Features that account for variability



(a) Individual features

(b) Interactions

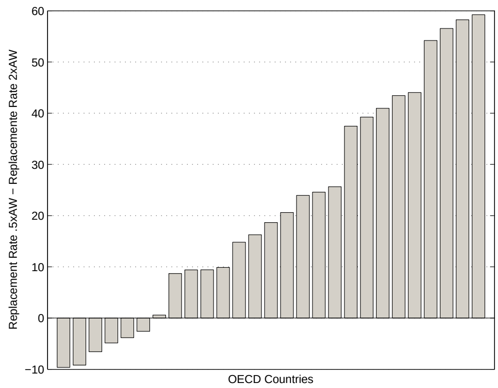
that the replacement rate and the restrictions on collecting social security while working account for almost all the variability after age 60 and the entitlement age is not an important contributor.

6 Conclusion and Future Research

In this paper I have studied the role of three key features of social security: the replacement rate, the entitlement age and whether it restricts collecting benefits while working, using a life cycle general equilibrium model. A key feature of my model was its ability to match the heterogeneity in the retirement decisions in the US that we observe in the data. When I use my model to explain the cross country retirement decisions it is able to explain 90% of the differences in the employment to population ratio for ages 60-64. The most important contributors to account for these differences in retirement are the replacement rate and the restrictions on collecting benefits while working. There is still a feature of social security that I have not examined and it will be worth considering. Countries design social security to have different levels of progresivity. It turns out that when I define the progresivity as the difference between the replacement rate of individual earnings below $.5 \times AW$

and $2 \times AW$, there are large differences in the progresivity across the OECD. For example, in Slovak Republic the replacement rate of individuals that earn 2 times or more than AW is 10 percentage points above the replacement rate of individuals that earn .5 times or less than AW, whereas in Denmark this relationship is reverted with the lower earners having a replacement rate 60 percentage points above the highest earners. Figure 16 illustrates the large differences in the progresivity.

Figure 16: Progresivity of Social Security



In a recent paper, Guvenen et al. (2009) study the role of progresivity of the tax code in accounting for the different evolution of the wage inequality between Continental Europe and the US. Using a parsimonious representation of the income tax they are able to separate the effects of progresivity from those of generosity. An ongoing extension to my work tries to provide a parsimonious representation of social security benefits.

My model is suitable to be extended along some interesting dimensions. First, Wallenius (2009) studies the role of social security into accounting for differences in hours of work. It would be interesting to extend her model with heterogeneity to study if there are interactions between the idiosyncratic labor income risk, human capital accumulation and social security. Guvenen et al. (2009) find that differences in the tax code are able to account for 50% of the differences in hours per employee. As they use a model that shares the human capital accumulation feature of Wallenius and the presence of labor income risk as in my model, it would be interesting to investigate to what extent these features account for the differences in the extensive and the intensive margin. For example, why do some countries like Sweden and Norway have employment to population ratios that are above US levels and hours per employee below US levels, whereas countries like Czech Republic, Hungary, Greece and Ireland have employment to population ratios below the US and hours per employee above the US. Second, it is a well known fact that couples tend to retire about the same time. In addition, almost all OECD countries have a differential treatment of female spouses in social security. What is the role of social security rules by sex in shaping retirement decisions of males and females? Extending my model to family labor supply decisions would be an interesting exercise to quantify the role of differential rules in social security into accounting retirement decisions by sex and civil status.

Finally, all the space in this paper has been devoted to social security, which is the biggest tax and transfer program across the OECD. Health insurance programs are of the same order of magnitude in the GDP and they may also play an important role into shaping employment over the life cycle. Understanding how different health insurance programs affect employment across the OECD will require introducing health explicitly and it will provide an interesting insight on the current policy debate about health reform ongoing in the US.

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8 Appendix A: OECD Social Security Data

Table 2: OECD Social security

Country	GRR	NRR	ERA	WSS
AUS	1.07	1.19	55	0.00
AUT	2.07	2.02	65	1.00
BEL	1.09	1.42	60	1.00
CAN	1.15	1.29	60	0.00
CZR	1.28	1.43	58.5	0.00
DN	2.07	2.04	65	0.00
FIN	1.45	1.39	62	1.00
FR	1.38	1.47	60	1.00
DEU	1.11	1.37	63	1.00
GRE	2.47	2.47	60	0.00
HUN	1.98	2.36	62	1.00
IRE	0.88	0.90	65	1.00
IT	1.75	1.67	57	0.00
JAP	0.87	0.86	60	0.00
KOR	1.09	1.04	55	0.00
MEX	0.93	0.85	65	0.00
NDL	2.28	2.30	60	0.00
NZ	1.00	0.92	65	0.00
NW	1.53	1.55	67	0.00
POL	1.58	1.67	65	1.00
POR	1.39	1.55	55	0.00
SLV	1.46	1.62	60	1.00
SPN	2.10	1.89	60	0.00
SWD	1.59	1.43	61	0.00
TUR	2.24	2.78	60	0.00
UK	0.79	0.91	65	0.00
US	1.00	1.00	62	0.00

GRR: Gross Replacement Rate, NRR: Net Replacement Rate, ERA: Early Retirement Age, WSS: Work and Social Security (1 means it is not allowed)

9 Appendix B: Numerical Methods

The algorithm used to compute the equilibrium of the model is similar to Hugget & Ventura (1999) The following steps describe the salient features of the computation:

1. Choose an initial value of aggregate capital (K_0), aggregate labor in efficiency units (L_0), accidental bequests (B_0) and payroll tax (τ_0)

2. For these values I solve iterating backwards, starting from $V(x, A) = 0$, the Bellman's equation of the individual at each point of the individual state space $(k, z^w, \bar{e})$. As a result I get the policy functions $c(x, a)$,$k'(x, a)$,$h(x, a)$ for every $a = 1, \ldots, A$

3. I compute the distributions over the individual's state space $(\Psi_a(a))$ using Montecarlo's simulations. I start assuming that individuals start with a capital equal to accidental bequests, average earnings of zero and an initial draw of productivity belonging to the stationary distribution of z^w

4. I update K_0,L_0,B_0 and τ_0 aggregating over the simulated distributions to K_1,L_1,B_1 and τ_1

5. If aggregate variables in the previous point are close enough and product markets clear, I stop iterations. Otherwise I continue until convergence.

I choose 90 points for the individual capital, 30 points for the idiosyncratic shock and 4 points for average earnings. I have to be careful in the computations as the problem is non-standard as there is a non-convexity on the labor choice. This probably is not a problem in theory, as I am integrating the value function over a continuous distribution with no mass points. Nevertheless, in the numerical computations I am on a grid and this can be a problem. As I do not attempt to prove that the objective function is concave and differentiable, I use golden section search at each point of the individual state for each employment status (0 or $\bar{h}$) and then choose the maximum between these two numbers. Note that golden section search just require that the objective is single peaked on an interval that you choose and do not use any derivative at all. There is a trade off between reliability and computational efficiency that makes this type of problems time consuming. For example, solving for the stationary equilibrium of the model may take between 30 min to 3 hours. Calibration may take from a few days to weeks.