Social security and retirement across OECD countries

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Abstract

There are large differences in the employment to population ratio relative to the US across 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

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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? Understanting 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 and Steinmeier (1986), Stock and Wise (1990), Gruber and Wise (2004, 2007), Coile and 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

The rest of the paper is organized as follows. In the next section I document the differences in retirement, employment and social security across the OECD. Section 3 presents the model. Section 4 describes the calibration procedure. Section 5 describes the counterfactual experiments and their results. Finally, section 6 concludes and outlines directions for future research.

2 Employment and social security in OECD

This section presents empirical evidence for OECD countries in 2006. I use labor force statistics by age and sex from 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 of the magnitude of the differences in retirement.

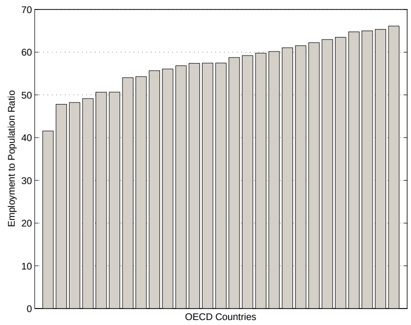
There are large differences in employment to population ratio. Turkey has the lowest employment rate at 42% whereas Norway is at 66% (Figure 1 (a)). These differences are even larger for older individuals. For example, if we look at the employment rate at ages 60-64 the differences range from 13% in 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, therefore employment to population ratio ranges from .6 to 1.02 of the US and employment to population ratio at 60-64 ranges from .2 to 1.2 of the US.

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

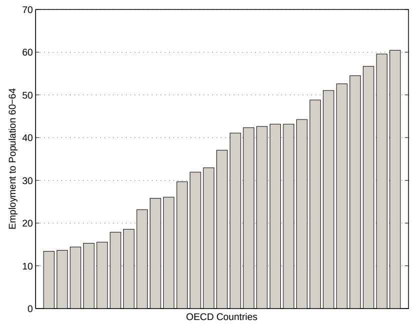
[6] The Conference Board and Groningen Growth and Development Center

[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 OECD has data limitations beyond age 70-74.

Figure 1: Employment differences in OECD



(a) 20-75

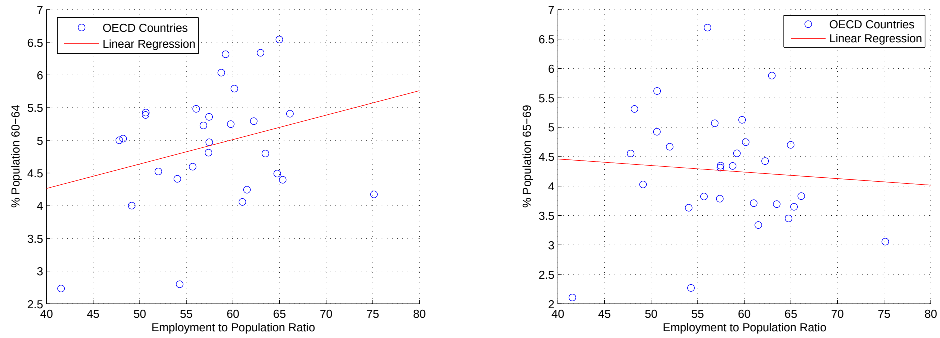


(b) 60-64

These differences are not driven by productivity, as there are countries with low employment to population ratio like Belgium (48%), Italy (50%), France (57%) or Germany (56%) that have relatively high labor productivity relative to the US (GDP per hour of 1.02, .87, .98 and .95 for each country in the same order). The correlation between employment to population ratio and GDP per employee or GDP per hour is low (.25 and .23 respectively in the whole sample). Similarly, we could argue that these differences are driven by differences in demographic structure. Figure 2 shows that the correlation between the ratio of population 60-64 and 65-69 to total population and employment to population is close to zero when both groups are considered together and it is positive for ages 60-64.

Social security systems are a very complex set of rules that differ across countries in many dimensions related to qualifying conditions and benefit schedule. To illustrate this fact consider three countries: Belgium, France and the US. In Belgium to qualify for full social security benefits you have to be at least 65 with no less of 45 years employed but you may be entitled to a reduced benefit if you are at least 60 and worked no less than 35 years. Additionally, benefits depend on your marital status as the replacement rate

Figure 2: Demographic Composition and Employment



(a) 60-64 (b) 65-69

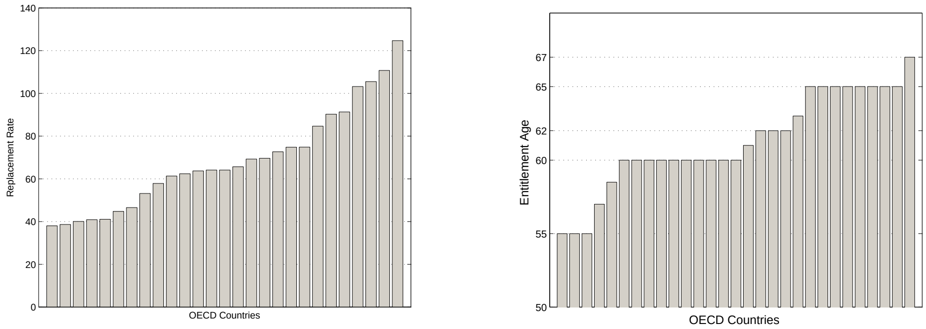
varies from single individuals to couples (60% vs 75%) and there are special minimum pensions that are means tested and vacation allowances. In France you need to be 60 and at least 40 years employed to qualify for full pension but if you entered the labor force at ages 14-16 you may qualify to full benefits at ages 56-59. You may continue a gainfull activity and collect social security but you have to wait 6 months from your first social security check. Additionally, you may defer your benefits subject to conditions and there are "solidarity pensions" that are mean tested and do not depend on earnings. Benefits are based on the best 25 years and indexed to cost of living indices. Benefits also depend on marital status. The US is not simpler than these to Continental Europe countries. Individuals are entitled to full benefits at age 65 but the may collect reduced benefits at age 62. At least 10 years employed are required to qualify. Dependants are entitled to benefits too and benefits depend on family structure.

Given that the complexity of social security I use data on three key common characteristics 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. Focusing on males is not important as the equivalent statistic for females has the same numerical value. The assumption on age of entry to employment is convenient in my model as individuals arrive to the economy at age 20 and the modeling assumptions make them have continuous careers. The entitlement age is defined by each country's social security law. There can be three different entitlement ages: early entitlement age, normal entitlement age and deferred entitlement age. The entitlement age depends sometimes on age and occupation. For the purpose of this study I present data on early entitlement age for males and abstract from differences based on 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 social security systems around the world provided by the US Social Security Administration. Duval computes an implicit tax on continuing to work based on social security rules for 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 receive in each system.

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 age, which varies from 55 in Australia to 67 in Norway (Figure 3). Figure 4 illustrates the large 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 forbiden or not forbiden at all. A country will allow collecting social security while working if the Duval's implicit tax on continuing to work

[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 3: Replacement Rate and Entitlement Age

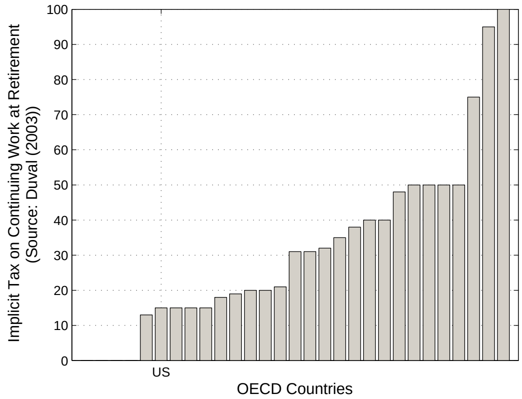


(a) Generosity

(b) Entitlement Age

is less than 50% and it is not explicitly said on SSA's countries description. As classifying countries in each group is a judgement call, I am extending my model to explicitely account for incentives in social security that may reflect in a high implicit tax on continuing to work.

Figure 4: 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 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

Individuals in my economy are endowed each period with different productivities ($z_{i,a}$), where i index each individual. These different productivities can be decomposed in two different components: a deterministic component that only depends on age and it is hump-shaped (z_a^d), and an idiosyncratic

[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 $\sum_a \mu_a = 1$.

component independent and identically distributed for each individual ($z^w_{i,a}$), characterized by an $AR(1)$.

$$\log(z_{i,a}) = \log(z^d_a) + \log(z^w_{i,a}) \tag{2}$$

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). Aggregate capital and labor are obtained by aggregating through individuals. Capital depreciates at a rate δ. Output can be used for either consumption or investment.

3.5 Markets

There are capital, labor and product markets that open at each date and operate in perfect competition. There are no insurance markets. As in Aiyagari (1994) and individuals can not borrow, so they accumulate precautionary savings. I will characterize the stationary competitive equilibrium of these markets.

3.6 Social Security

Social security is defined by two elements. First, a payroll tax (τ) that is levied on every worker. Second, a function $\phi(\bar{e}_a, h_a, a)$ that characterizes the relation between the average of individual earnings' histories ($\bar{e}$) and the social security benefit. Note that it is a function of age as individuals do not get social security until entitlement age ($\hat{a}$) and it is also a function of the labor choice, to capture restrictions on collecting social security and working. The social security benefit will be characterized by a function of individual average earnings ($\varphi(\bar{e})$).

3.7 Accidental Bequests

As individuals may die with positive probability every period they may leave some capital. I assume that government collects this capital and distribute it lump sum among those individuals alive (B).

3.8 Recursive Stationary Representation of the Individual Decision

I represent the individual decision problem recursively. I abstract from the time dimension to save notation as I will use a stationary characterization of the equilibrium. The individual state variables of the economy 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) for every combination of the individual state variables.

Taking interest rates (r), wages (w), payroll tax (τ), social security ($\phi(\bar{e}_a, h_a, a)$) and accidental bequests (B) as given, each individual solves the following Bellman equation:

$$\begin{aligned} V_a(k, z^w, \bar{e}) &= \max\nolimits_{c,k',h} u(c, 1-h) + \beta s_{a+1} E_{z^w}\left[V_{a+1}(k, z'^w, \bar{e}')\right] \\ \text{s.t. } c + k' &= (1+r)k + (1-\tau)wz_a h + \phi(\bar{e}, h_a, a) + B \end{aligned} \tag{3}$$

3.9 Aggregate State Variable

The aggregate state variable of the economy is a list of measures over the individual states $\{\Psi_a(k, z^w, \bar{e})\}$ that can be easily obtained iterating forward by using the optimal decisions of the individuals and the idiosyncratic labor income process; and assuming that they enter the economy with zero wealth, zero average earnings, and with an initial draw from the stationary distribution of the idiosyncratic productivity shock. The aggregate state is used to integrate individual choices to get prices in the stationary equilibrium.

3.10 Stationary Recursive Competitive Equilibrium

To save notation I collect individual state variables but 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 $a = 1, ..., A-1$
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 pinned down individually from sources exogenous to the model, like demographics, the individual productivity process, the fraction of time working and social security, whereas technology is pinned down individually from solving the stationary equilibrium of the model to match a single statistic. Finally, preferences are jointly pinned down to match a set of statistics.

4.1 Parameters calibrated individually

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

4.1.1 Demographics

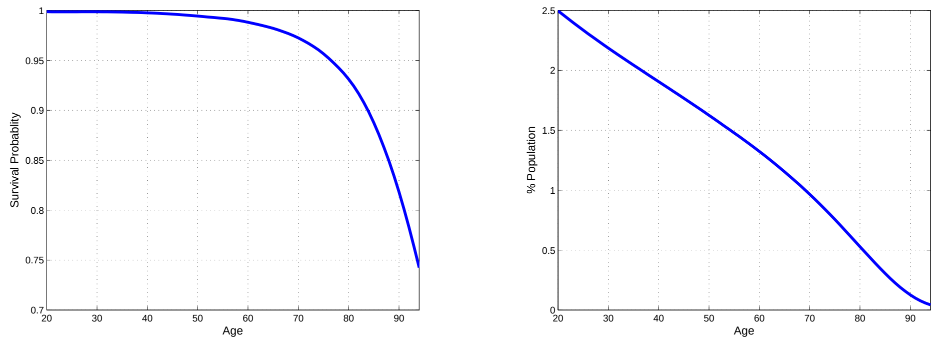
I choose population growth rate to equal the US 1960-2006 average of 1.2%. This number is taken from the US Census Bureau Statistical abstract 2009. Individuals enter the economy with 20 years and they die with probability 1 when they are 94, therefore $A = 75$. Survival rates are taken from the actuarial 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.

4.1.2 Individual productivity process

Individual productivity ($z_{i,a}$) is characterized by two components: a hump-shaped deterministic function of age (z_a^d) and a stochastic component that hits each individual every period of her life ($z_{i,a}^w$).

To characterize the deterministic component, I use annual earnings from

Figure 5: Survival and Stationary Weights



(a) Probability of Survival (b) Weight of the Population

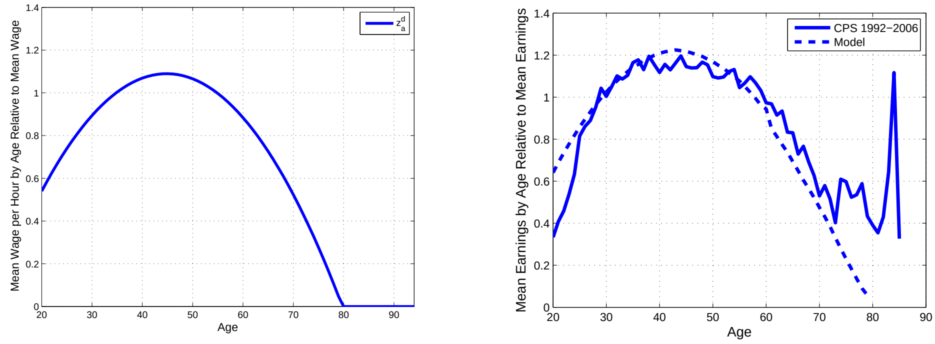
IPUMS-CPS[10] over the period 1992-2006 and annual hours worked. I express annual earnings in $US1982 and assume that they grow at a 2% rate due to productivity gains[11]. I construct hourly wages dividing annual earnings and annual hours. I compute the ratio of mean hourly wage by age to mean hourly wage. This looks like a hump-shaped profile. I adjust a quadratic polynomial to eliminate sample variability and truncate the polinomial to zero when it goes below zero (80 years) 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 70 there are few individuals working so their behavior is not quatitativaly important to my results. 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.

The stochastic component of individual productivity is characterized by an

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

[11]Therefore I assume there are time effects and abstract from cohort effects

Figure 6: Deterministic productivity (z_a^d) and earnings



(a) Wage per Hour

(b) Earnings

AR(1)

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

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 is set to 45% of available time in a year, assuming 12 hours for commuting, eating and sleeping and a year of 360 days ($\bar{h} = .45$)

4.1.3 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.

4.1.4 Social security

Social security ($\phi(a, h_a, \bar{e})$) is a a function of three elements. First, it depends on age (a) as social security is collected only after entitlement age ($\hat{a}$). I assume that individuals may get the pension when they reach the early entitlement age in the OECD. In the US it is 62 years. I abstract from the normal entitlement age and the decision to claim for benefits to keep the decision problem and the state space as small as possible as I would have to add an entitlement state and a entitlement decision at least. Usually, individuals can not borrow against social security. The poor individuals would like to get benefits as they become available and if I set the entitlement to the normal entitlement age, these would affect their employment choices. The rich individuals would not be affected by social security in any case.

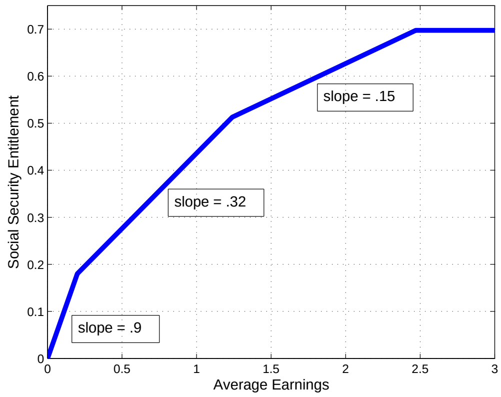
Social security is a function of the employment choices through the restrictions on collecting social security while working. I assume that if a country has such a restriction, social security will be zero if employment is positive, and a function of individual average earnings otherwise, whereas it will be only a function of the individual average earnings if the country does not have such a restriction. To determine if a country restricts collecting social security while working I use the implicit tax on continuing to work provided by Duval (2003) and details on social security systems around the world provided by the US Social Security Administration.

Social security 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 the economy-wide average earnings so it can be directly taken to the model economy. US social security replace 90% of the first monthly \$761, 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 social security can be writen as

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

Finally, I made some additional simplifications. Social security takes into account the 35 years of highest earnings while I just take the simple average, capped for individual earnings higher than 247% of average earnings. Therefore individual average earnings are characterize by the following law of

Figure 7: $\varphi(\bar{e})$



motion:

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

I also assume that there are not limit for taxation while in the US earnings above $100,000 roughly are exempt. My objective is to focus on three key elements common to every country in the OECD rather than many country specific details that would make harder to distinguish the main forces in action. Also, it is likely that those specifics show up in the net replacement rate.

4.2 Parameters calibrated jointly

4.2.1 Preferences

I assume that the utility is separable in consumption and leisure and it takes the following functional form

$$u(c, 1-h) = \frac{c^{1-\sigma}}{1-\sigma} + \lambda \cdot (1-h) \tag{4}$$

this function is characterized by the relative risk aversion (σ) and the weight of leisure (λ). Also, individuals discount the future at the discount rate β.

4.2.2 Calibration Objective

I assume a model period of 1 year and I choose (σ, λ, β) jointly to match the following key statistics of the US economy: a capital-output ratio of 3.0, an investment-output ratio of .20, a labor share of .64 and the employment to population ratio from ages 50 to 80. I get the employment to population ratio from the same sample of the CPS that I used to get hourly wages. As I have more moments than parameters, I choose the vector of parameters to minimize the square deviation of the moments from the data and the simulated moments. I use the Nelder-Meade algorithm to find the minimum. Intuitively, the discount factor β is related to the capital output ratio mostly. Once a capital-output of 3.00 is hit, 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 shape of the deterministic component of productivity ($\left\{z_a^d\right\}$) interacts with the weight of leisure in the utility (λ) and the relative risk aversion (σ) to determine the level and the slope of the employment profile. Given that individuals are credit constrained, it is straightforward that $\left\{z_a^d\right\}$ and λ determine the level and the slope of the employment profile, but σ also plays a role: if it is high (low elasticity of substitution) the drop in employment when individuals receive the social security benefits will be lower than if σ is small, so the employment profile will be steeper for smaller values of the relative risk aversion coefficient.

4.3 Calibration results

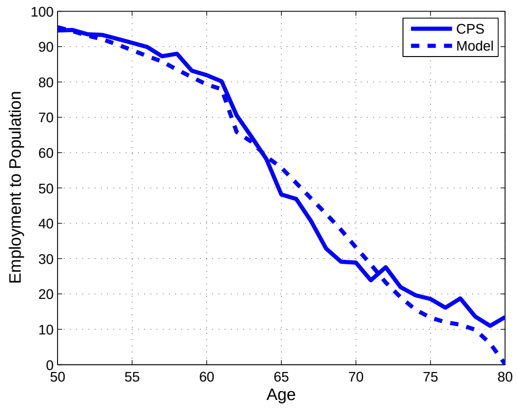
Table 1 shows the results of the calibration. Relative risk aversion (σ) is within the range of the values found in the literature which vary from 1 to 8, β is in the low range for life cycle models but I still get a hump-shaped consumption profile.

Table 1: Parameters

A	n	σ	λ	β	α	δ	ρ	σ^2_ϵ
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 population ratio by age. Figure 8 shows the match of employment to population for ages 50-80[12]. This is a key feature of 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 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.

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

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.

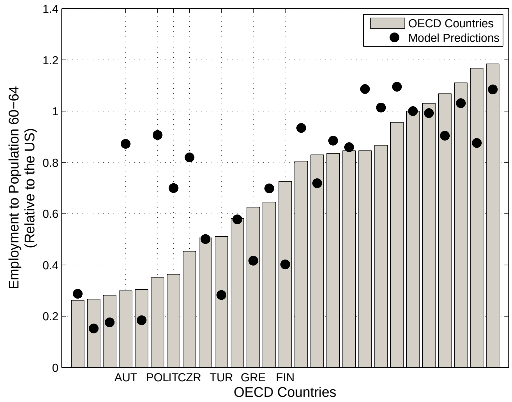
I begin with the employment to population 60-64 because it is the most common age of retirement. Still, there are some countries that have entitlement ages below 60 or above 64, so I group these countries by the entitlement age and compute the employment to population around the entitlement age. This 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.

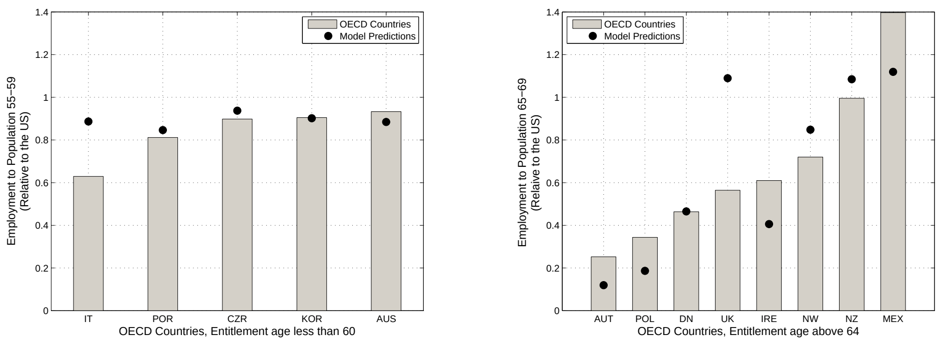
Figure 9: Employment to population rato 60-64



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)).

Figure 10: Employment to population at the entitlement age

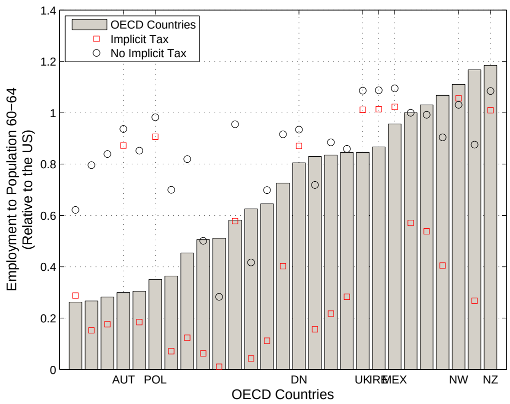


(a) Entitlement age < 60

(b) Entitlement age > 64

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 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.

Figure 11: Sensitivity of employment at ages 60-64

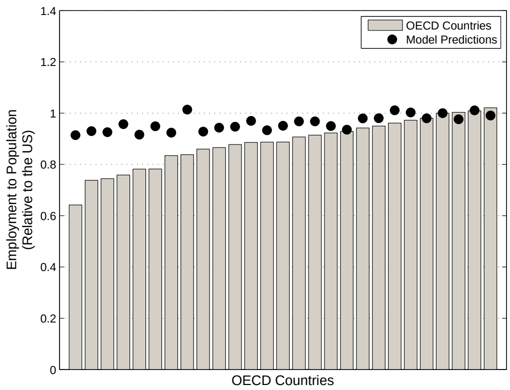


The message that we get from these experiments is that these three key features of social security are able to explain a substantial amount of retirement behavior.

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 employment 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.

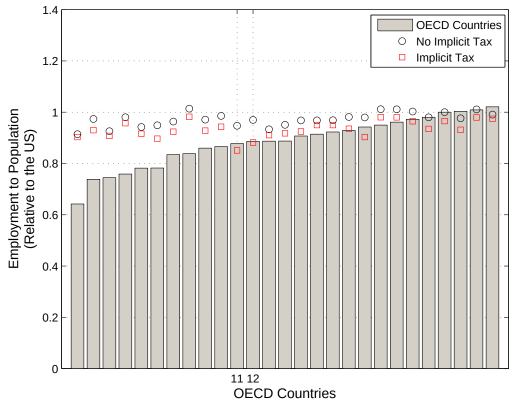
Figure 12: Employment to population



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.

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

Figure 13: Sensitivity of employment

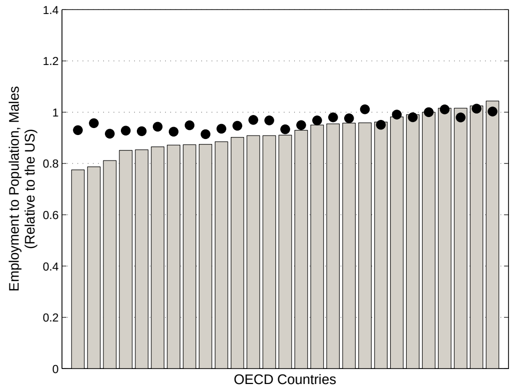


Continental European countries. Turkey, Mexico, Greece and Italy have female populations that are not as integrated into the labor force and when I look at the employment to population of males relative to the US I get a different picture. Figure 14 shows the fit of the model when I restrict the employment 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.

5.2.3 What features of social security are most important?

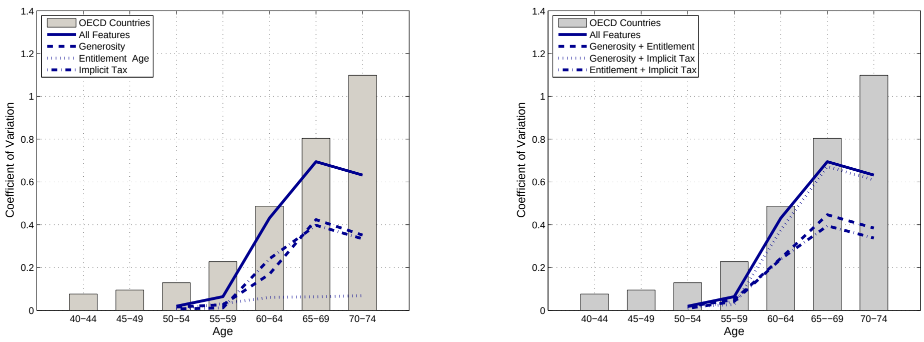
Using an eyeball measure it is possible to tell that the restrictions on collecting social security benefits while working is an important feature of social security to generate the retirement and the employment variability. To pin down rigorously what are the most important contributors into accounting 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

Figure 14: Employment to population, males



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: Features that account for variability



(a) Individual features (b) Interactions

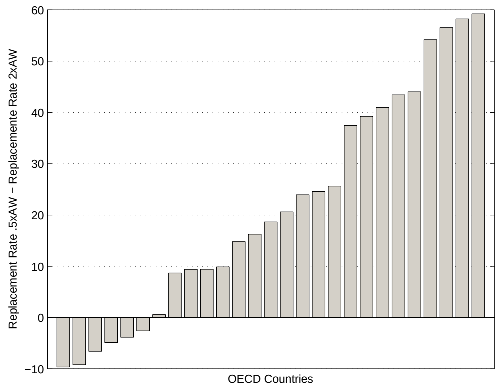
Figure 15 (a) shows that the most important features individually are the restrictions on collecting social security while working and the replacement rate, whereas the entitlement age is not important. As there are potentially important interactions, I allow two features active at the same time. I find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

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

Figure 16: Progresivity of Social Security



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.

7 References

Benitez-Silva, H. (2000) “A Dynamic Model of Labor Supply, Consumption/Saving, and Annuity Decisions Under Uncertainty.” SUNY-Stony Brook

Benitez-Silva, H. (2002) “Job Search Behavior at the End of the Life Cycle.” Center for Retirement Research Working Papers (Boston College)

Benitez-Silva, H. & Heiland, F. (2006) “The Social Security Earning Test Revisited: Information, Distortions, and Costs.” SUNY-Stony Brook & Florida State University

Blau, D.M. (2008) “Retirement and Consumption in a Life Cycle Model.” Journal of Labor Economics, 26 (1), (35-71)

Boskin, M. (1987) “Too Many Promises: The Uncertain Future of Social Security.” Dow Jones-Irwin.

Bullard, J. & Feigenbum, J. (2007) “A leisurely reading of the life-cycle consumption data." Journal of Monetary Economics 54 (2305-2320).

Chang, Y. & Kim, S. (2006) "From Individual to Aggregate Labor Supply: A Quantitative Analysis based on a Heterogeneous-Agent Macroeconomy," International Economic Review, 47 (1), (pp. 1-27)

De Nardi, M.C., Imrohoroglu, S. & Sargent, T.J. (2001) "Saving and Pension Reform in General Equilibrium Models." Oxford Review of Economic Policy, vol. 17 (1)

French, E. (2005) "The Effects of Health, Wealth, and Wages on Labour Supply and Retirement Behavior." Review of Economic Studies, 72 (395-427)

French, E. (2007) "The Effects of Health Insurance and Self-Insurance on Retirement Behavior" Federal Reserve of Chicago.

Gruber, J. & Wise, T. (2004) "Social Security and Retirement around the World." NBER

Gruber, J. & Wise, T. (2007) "Social security programs and retirement around the world: Fiscal implications of reform." NBER

Gustman, A. & Steinmeier, T. (1986) "A Structural Retirement Model" Econometrica, Vol. 54, No. 3, pages 555-584.

Guvenen, F., Kurusku, B., Ozcan, S. (2009) "Taxation of Human Capital and Wage Inequality: A Cross-Country Analysis." Working paper.

Hansen, G. (1993) "The Cyclical and Secular Behaviour of the Labour Input: Comparing Efficiency Units and Hours Worked," Journal of Applied Econometrics, vol. 8 (1), (pp. 71-80)

Hotchkiss, J.L. (1991) "The definition of Part-Time Employment: A Switching Regression Model with Unknown Sample Selection." International Economic Review, 32 (4) (pp. 899-917)

Hugget, M & Ventura, G. (1999) "On the Distributional Effects of Social Security Reform." Review of Economic Dynamics 2 (498-531).

Imrohoroglu, A., Imrohoroglu, S. & Joines D. H. (1995) "A life cycle analysis of social security." Economic Theory 6 (83-114)

Kotlicoff, L. & Auerbach, A. (1987) "Dynamic Fiscal Policy." Cambridge University Press.

Kopecky, K. A. (2009) "The Trend in Retirement." International Economic Review (Forthcoming)

Krussel, P. & Smith, A. (1998) "Income and Wealth Heterogeneity in the Macroeconomy." Journal of Political Economy, 106 (5)

Manoli, D. & Wagner, M. (2007) "Pension Benefits & Retirement Decisions: Income vs. Price Effects." (Job Market Paper) Berkeley University.

McDaniel, C. (2009) "Hours worked in the OECD 1960-2003: Driving forces and propagation mechanisms" Kenyon College

Miriam King, Steven Ruggles, Trent Alexander, Donna Leicach, and Matthew Sobek. Integrated Public Use Microdata Series, Current Population Survey: Version 2.0. [Machine-readable database]. Minneapolis, MN: Minnesota Population Center [producer and distributor], 2009.

McDaniel, C. (2009) "Hours worked in the OECD 1960-2003: Driving forces and propagation mechanisms" Kenyon College

Munnell, A.H. & Sass S.A. (2007) "The Labor Supply of Older Americans." Center for Retirement Research Working Papers (Boston College)

Nishiyama, S. & Smetters, K. (2007) " Does Social Security Privatization Produce Efficiency Gains?" The Quarterly Journal of Economics, November (1677-1719)

Ohanian, L., Raffo, A. & Rogerson, R. (2008) "Long-term changes in labor supply and taxes: Evidence from OECD countries, 1956-2004", Journal of Monetary Economics, Elsevier, vol. 55(8), pages 1353-1362, November.

Prescott (2004) "Why do Americans Work so much Longer than Europeans?" Quarterly Review, Federal Reserve Bank of Minneapolis, issue Jul, pages 2-13.

Prescott, Rogerson & Wallenius (2009) "Lifetime Aggregate Labor Supply with Endogenous Workweek Length", Review of Economic Dynamics, Elsevier for the Society for Economic Dynamics, vol. 12(1), pages 23-36, January.

Ragan, K (2005) "Taxes, Transfers and Time use: Fiscal Policy in a Household Production Model," November 2005.

Rogerson (2007) "Taxation and Market Work: Is Scandinavia an Outlier?"

Economic Theory, Springer, vol. 32(1), pages 59-85, July.

Rogerson & Wallenius (2007) “Micro and Macro Elasticities in a Life Cycle Model With Taxes” NBER Working Paper No. 13017, April.

Wallenius (2009) “Social Security and Cross-Country Hours: A General Equilibrium Analysis”. Job Market Paper.

Stock & Wise (1990) “The Option Value of Work and Retirement.” Econometrica, Vol. 58, No. 5, pages 1151-1180.

Rust, J & Pheland, C. (1997) “How Social Security and Medicare Affect Retirement Behavior In a World of Incomplete Markets.” Econometrica, Vol. 65, No. 4. (781-831)

Rust, J. (1999) “Strategies for Incorporating Risk, Uncertainty, and Private Insurance Mechanisms in Models of Social Security.” Yale University.

Skirbekk, V. (2004) “Age and Individual Productivity: A Literature Survey” Vienna Yearbook of Population Research, Vienna : Austrian Academy of Sciences Press: 133-153.

Storesletten, K., Telmer, C.I., Yaaron, A. (1999) “The risk-sharing implications of alternative social security arrangements.” Carnegie-Rochester Conference Series on Public Policy. Volume 50 (June) (213-259)

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.