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Labor supply and government programs: A cross-country analysis

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ABSTRACT

There are substantial cross-country differences in labor supply late in the life cycle (age 50+). A theory of labor supply and retirement decisions is developed to quantitatively assess the role of social security, disability insurance, and taxation for understanding differences in labor supply late in the life cycle across European countries and the United States. The findings support the view that government policies can go a long way towards accounting for the low labor supply late in the life cycle in the European countries relative to the United States, with social security rules accounting for the bulk of these effects.

1. Introduction

There are substantial differences in labor supply and in the design of tax and transfer programs across countries. The cross-country differences in labor supply increase dramatically late in the life cycle: using data from the Survey of Health, Ageing, and Retirement in Europe (SHARE), Fig. 1 documents that while differences in employment rates among eight European countries are in the order of 15 percentage points for the 50–54 age group, they increase to 35 percentage points for the 55–59 age group and to more than 50 percentage points for the 60–64 age group. In this paper we quantitatively assess the role of social security, disability insurance, and taxation for understanding differences in labor supply late in the life cycle (age 50+) across European countries and the United States. The paper makes three contributions to the recent literature in macroeconomics studying government policies and labor supply across countries.[1] First, we use the newly released Survey of Health, Ageing, and Retirement in Europe (SHARE), as well as the US Health and Retirement Study (HRS), to consistently document the facts on labor supply late in the life cycle (after the age of 50) across

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[1] See for example Prescott (2002, 2004), Ljungqvist and Sargent (2006), Ohanian et al. (2008), and Rogerson and Wallenius (2009).

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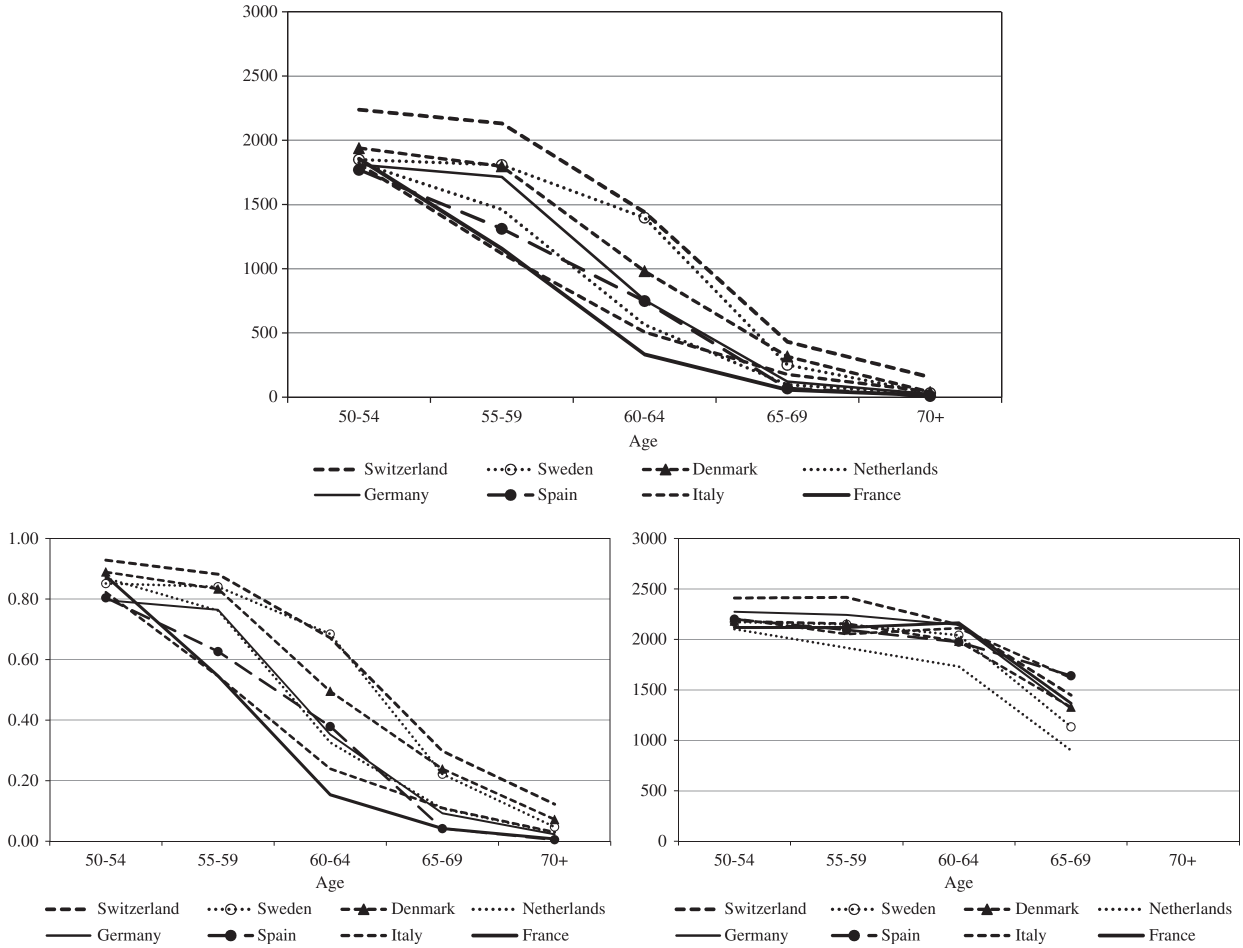

Fig. 1. Mean annual hours worked, SHARE 2006, men: all, extensive, and intensive margin.

many European countries and the US. Second, we document how the social security, disability, and taxation institutions vary across the countries in our empirical analysis. Third, we build a structural life-cycle model of labor supply and retirement decisions that explicitly models the key institutional differences across countries and use the model to assess the role of government policy in accounting for the micro-level observations documented in the empirical analysis.

While it is well known that the tax and transfer programs vary substantially across countries, there is substantial debate about their impact on labor supply decisions. A recent literature in macroeconomics has shown that tax differences can account for cross-country differences in labor supply, both in the context of the representative agent model (Prescott, 2002, 2004; Ohanian et al., 2008) and the life-cycle framework (Rogerson and Wallenius, 2009). This research has often been criticized for assuming a labor supply elasticity larger than the one typically estimated in empirical micro studies. When there is an active extensive margin on labor supply decisions and heterogeneous agents, however, aggregate labor supply responses are not driven by the preference parameter determining labor supply responses along the intensive margin (e.g., the parameter estimated in micro data as discussed in Rogerson and Wallenius, 2009; Erosa et al., 2011). The mass of agents that are close to being indifferent between working or not becomes crucial for labor supply responses (Chang and Kim, 2006). Building on these insights, we develop a theory of heterogeneous agents in which labor supply varies both along the intensive and extensive margins. Another important lesson from the literature is that aggregate labor supply responses to tax changes depend crucially on how tax revenue is spent (Prescott, 2002, 2004). Thus, we model in detail the social security system, which is arguably the most important transfer program in the OECD countries. Moreover, using data from national surveys, Gruber and Wise (2004) and Blondal and Scarpetta (1999) provide empirical evidence on the importance of social security rules in affecting retirement incentives for many countries. In addition, we model the disability insurance system since several empirical studies (Gruber and Wise, 2004) have also emphasized the potential importance of the so-called "early retirement programs" in Europe such as disability insurance. The SHARE with its harmonized cross-country methodology, allows us to document the facts on employment and participation on transfer programs consistently across several European countries.

Our life-cycle model of labor supply and retirement decisions builds on French (2005), Imrohoroglu and Kitao (2010), and Erosa et al. (2011). As in Erosa et al. (2011), we develop a neoclassical model of labor markets with non-linear wages that accounts for labor supply choices both along the intensive and the extensive margins. The key feature of the theory for delivering periods of non-participation is the non-linear mapping between hours and earnings, which is convex at low hours of work. This mapping is the competitive equilibrium outcome of an economy with a production technology in which hours of work and number of workers are imperfect substitutes (see Hornstein and Prescott, 1993; Osuna and Ríos-Rull, 2003). The social security, disability insurance, and taxation systems in the United States and European countries in the study are modelled in great detail. In particular, countries in the model economies vary in terms of (i) the social security rules—such as early and normal age of entitlement, replacement rates, adjustments for early and late withdrawal, the presence of early retirement schemes and occupational pensions, and the contributions to the social security system, (ii) the fraction of people on disability and the payments to disabled individuals, and (iii) the taxation of consumption, capital income, and labor earnings. We model two education groups – college and non-college – since we observe important differences between these two groups in the data and the fraction of men with college education varies substantially across countries. The baseline economy is calibrated to US macro data as well as US micro data from the Panel Study of Income Dynamics (PSID). The calibration methodology follows the approach in Erosa et al. (2011) in order to pin down the value of some key parameters that are important for the quantitative response of labor supply decisions to policy changes in the theory. First, the intertemporal elasticity of leisure is set to 0.5 because this value allows our model with non-linear wages to be consistent with a rich set of micro facts on labor supply (see Erosa et al., 2011). Second, the age profile and shock process of labor productivity are estimated following an indirect inference approach that explicitly controls for the selection problems that make the calibration of these parameters difficult.[2] In order to control for selection into employment, we use a Generalized Method of Moments (GMMs) procedure to estimate – for each education group – a wage profile and a wage process both in the PSID and in the model simulated data. The procedure requires simulating the model economy for different values of the parameters determining the age profile of wages and the stochastic process of wages until the GMM estimates in the simulated data recover the estimates obtained in the PSID data.

We find that the baseline economy matches very well the life-cycle patterns in hours worked for college and non-college individuals in the US, even though these patterns were not explicitly targeted by the calibration. The baseline economy is quantitatively consistent with the fact that the profile for average annual hours is relatively flat until the age of 50 and starts declining after that age. Moreover, the decline in working hours late in the life cycle is quantitatively consistent with the data both along the intensive and extensive margins underscoring the fact that the baseline economy represents a good theory of the US labor supply decisions late in the life cycle.

In a set of quantitative experiments, the US government policy is replaced with the policies of Switzerland, the Netherlands, Spain, Italy, and France. The main findings are that the model accounts fairly well for how labor supply decreases late in the life cycle for most countries. The model matches remarkably well the large decline in the aggregate labor supply after age 50 in Spain, Italy, and the Netherlands. The results support the view that government policies can go a long way towards accounting for the low labor supply late in the life cycle for these European countries relative to the United States, with social security rules accounting for the bulk of these effects and income taxation having much milder effects on labor supply. The quantitative experiments predict that, relative to the United States, the hours worked by men aged 60–64 is 43% in the Netherlands, 53% in Spain, 36% in Italy, and 37% in France. In the data, these numbers are 49% in the Netherlands, 66% in Spain, 44% in Italy, and 29% in France.

Our findings imply that labor supply is much less responsive to taxes than previous papers in the literature (Prescott, 2002, 2004). While Prescott (2002) finds that differences in taxes in France and the United States account for virtually all of the 30% difference in labor input per person between these countries, our findings only account for a 10% difference in labor supply. A more comprehensive comparison of the results should consider that Prescott (2002, 2004) assumes that all tax receipts are distributed lump-sum back to households based on the idea that public goods are good substitutes for private consumption (e.g., public schools and hospitals are good substitutes for private schools and hospitals). This assumption is crucial for generating a large response of labor supply to tax changes, as discussed by Prescott (2002, 2004). Our quantitative experiments, however, assume that apart from the social security tax receipts, which are used to finance the social security and disability systems, none of the other tax receipts are rebated back to consumers. Hence, in an experiment we simulate the French and the US policies under the assumption that all tax receipts are rebated back to households. We find that the aggregate labor supply under French policies is now 24% lower than under US policies, a result that is close to the findings in Prescott (2002, 2004) and more than twice the value of 10% that we obtained in our baseline experiment with no rebates.

A natural question is whether modelling non-linear wages is important for the quantitative effects of policies on labor supply. In order to investigate this issue, we consider a new baseline economy with linear wages and simulate the introduction of French policies into this economy. Two main findings emerge. First, aggregate hours worked in France relative to the United States are approximately the same as in the economy with non-linear wages (10% lower). Second,

[2] Given that wages are only observed for workers, the estimation of the wage process is affected by non-random selection into employment. This problem is likely to be more severe for individuals close to the retirement age. Moreover, this is a serious problem because the labor productivity process late in the life cycle plays a crucial role in determining how social security impacts on retirement decisions.

however, non-linear wages matter importantly for labor supply responses after age 60. For the age group 60–64, labor supply in France relative to the US is 0.56 with linear wages and 0.37 with non-linear wages. This result underscores that the interaction of non-linear wages with social security rules is important for understanding retirement decisions across countries.

Relative to the recent literature analyzing the role of taxation and social security on labor supply differences across countries (Prescott, 2002, 2004; Ohanian et al., 2008; Alonso-Ortiz, 2009; Wallenius, 2009), a distinguishing feature of our paper is to model the progressivity of taxes on earnings. We find that replacing the progressive tax system on earnings with a flat tax has a small effect on labor supply in the US economy (about a 2% increase) while the increase in labor supply in France is much larger—the hours worked per person aged 25–65 rise by 6.7%. This finding is explained by the fact that earnings are taxed much more progressively in France than in the US. Thus, the progressivity of the tax system matters for understanding labor supply differences across countries. French (2005) and Imrohoroglu and Kitao (2010) model, in a rich life-cycle framework, the effect of health on retirement and labor supply decisions. In the same spirit, we studied the effect of disability and evaluate its importance for labor supply differences across countries. We find that disability insurance policies do not play an important role except for the Netherlands and Spain.

This paper also builds on an important macro literature quantitatively evaluating the US social security system.[3] This basic theoretical framework with incomplete markets and life cycle has been extended by French (2005) and Imrohoroglu and Kitao (2010) to study social security and health insurance and by Low et al. (2010) to evaluate disability insurance. The contribution of our paper is to focus on how government policy (taxation, social security, disability, and other retirement programs) accounts for labor supply decisions across countries.

2. Empirical findings

The focus in this paper is on the labor supply of men late in the life cycle (after the age of 50). We use the newly released Survey of Health, Ageing, and Retirement in Europe (SHARE) as well as the US Health and Retirement Study (HRS) to document these facts. The SHARE is a European cross-national panel of micro data on health and socio-economic status which was administered in 2004, 2006, 2008, and 2010. It has data on 11 countries and more than 45,000 individuals aged 50 or older. The survey provides a balanced representation of various European regions: Scandinavia—Denmark and Sweden; Central Europe—Austria, France, Germany, Switzerland, Belgium, and the Netherlands; and Mediterranean—-Spain, Italy, and Greece. Israel, the Czech Republic, and Poland were added in the 2006 wave. The dataset provides detailed longitudinal individual data on employment, (sources of) income, (sources of) transfers, health, consumption, and assets. It is harmonized with the HRS and the English Longitudinal Study of Ageing (ELSA). The HRS surveys, over every two years, more than 20,000 Americans over the age of 50. It collects detailed longitudinal individual data on variables such as income, work, assets, pension plans, health insurance, disability, physical health and functioning, cognitive functioning, and health care expenditures.

2.1. Labor supply

Fig. 1 reports mean annual hours worked after the age of 50 for eight European countries—Switzerland, Sweden, Denmark, the Netherlands, Germany, Spain, Italy, and France. In the analysis we use data from the 2006 SHARE.[4,5] We can immediately see that the labor supply behavior of the various European countries in the sample is dramatically different for individuals aged 60–64. The differences in hours worked appear relatively small for the 50–54 age group but become quite substantial at ages 55–59 and are very large at ages 60–64. Overall, the cross-country differences in labor supply increase by a factor of 3 between the ages of 50–54 and 60–64. For the 60–64 age group, mean annual hours worked are as large as 1500 in Switzerland and Sweden, around 750 in Germany and Spain, around 500 in the Netherlands and Italy, and around 300 in France. As the bottom two panels in Fig. 1 indicate, most of the differences in labor supply are driven by the extensive margin (the fraction of workers who report positive hours worked), but there are also differences in labor hours along the intensive margin (mean hours worked for those who report positive hours worked). Table 1 summarizes the cross-country data on labor market participation, part-time work, and full time work late in the life cycle. Fig. B-2 illustrates two additional interesting findings.[6] First, in all countries individuals with college education work on average more hours than men with non-college education. Second, the cross-country differences in labor supply late in the life cycle are much more pronounced for non-college than for college individuals.[7]

[3] See, for instance, Auerbach and Kotlikoff (1987), Imrohoroglu et al. (1995), Conesa and Krueger (1999), Huggett and Ventura (1999), Fuster (1999), and Fuster et al. (2003, 2007).

[4] Online Appendix B-IV reports the same facts from the 2004 SHARE. The overall patterns are quantitatively very similar across both waves. The data from the 2008 and 2010 waves have not yet been released. Online Appendix B-I provides a detailed description of the variables from the SHARE used in the analysis.

[5] The Online Appendix B is available on the website of the *Journal of Monetary Economics*.

[6] Figs. B-1 to B-12 and Tables B-1 to B-8 can be found in the Online Appendix B.

[7] Tables B-1 and B-2 report the data on labor market participation separately for non-college and college individuals.

Table 1
Labor market participation, men, SHARE 2004.

Labor market status	Age				
	50–54	55–59	60–64	65–69	70–74
	Switzerland				
Working full time	79.4	82.1	56.0	28.1	11.5
Working part time	10.3	5.1	6.7	8.8	4.9
Not working	10.3	12.8	37.3	63.1	83.6
	Sweden				
Working full time	90.1	76.4	53.6	7.1	1.7
Working part time	2.5	4.2	10.8	11.7	68.8
Not working	7.4	19.4	35.6	81.2	91.5
	Denmark				
Working full time	79.9	69.7	46.2	7.6	0.0
Working part time	1.8	4.2	5.3	16.3	11.0
Not working	18.3	26.1	48.5	76.1	89.0
	Netherlands				
Working full time	84.6	68.7	23.3	2.0	2.1
Working part time	2.5	5.1	3.3	4.0	2.9
Not working	12.9	26.2	73.4	94.0	95.0
	Germany				
Working full time	77.1	70.9	25.9	6.5	0.7
Working part time	2.4	2.5	6.2	4.0	2.0
Not working	20.5	26.6	67.9	89.5	97.3
	Spain				
Working full time	71.2	60.4	28.0	2.5	1.8
Working part time	7.2	8.7	8.7	0.6	0.6
Not working	21.6	30.9	63.3	96.9	97.6
	Italy				
Working full time	62.4	45.8	19.2	8.3	4.0
Working part time	19.5	5.3	7.0	3.6	1.2
Not working	18.1	48.9	73.8	88.1	94.8
	France				
Working full time	76.2	54.8	11.7	2.3	0.6
Working part time	3.0	1.9	3.1	0.6	0.0
Not working	20.8	43.3	85.2	97.1	99.4
	United States				
Working full time	77.6	70.8	46.4	25.1	12.3
Working part time	3.3	4.0	9.3	10.9	11.6
Not working	19.1	25.2	44.3	64.0	76.1

Note: Authors' computations from the 2004 SHARE for the European countries and the 2004 HRS for the US.

Fig. 2 puts the documented facts on European labor supply in perspective by comparing the labor supply patterns in Switzerland, Spain, and France to those in the United States. The facts on hours worked in the United States are obtained from the 2004 HRS.[8] Fig. 2 indicates that hours worked in the United States between the ages of 50 and 74 are higher than in France and Spain but lower than in Switzerland. Indeed, hours worked are higher in the US than in all the European countries except for Switzerland and Sweden.

2.2. *Program participation late in the life cycle*

In order to get a preliminary look at the effects of various income support programs on labor market participation after the age of 50, Table 2 reports the fraction of individuals receiving the following benefits: (i) social security (SS) retired worker benefits, (ii) disability insurance (DI) benefits, (iii) unemployment insurance (UI) benefits, and (iv) private pension benefits.[9]

Three observations stand out when analyzing the evidence from Tables 1 and 2. First, in each country, older individuals have higher program participation and lower labor market participation. Second, the fraction of people not working is highly correlated with the availability of income support programs across countries—for a given age group, countries with higher program participation tend to have a lower labor market participation. Third, the relative importance of the different programs in providing income support for individuals younger than 65 varies substantially across countries. While the fraction of individuals age 65 and above receiving social security retired benefits is above 75% in all countries,

[8] Online Appendix B-II provides a detailed description of the variables from the HRS used in the analysis. Furthermore, it illustrates that the mean annual hours worked for college and non-college individuals in the 50–74 age group in the HRS are quantitatively very similar to those in the PSID.

[9] Tables B-3 and B-4 present the program participation results separately for non-college and college individuals.

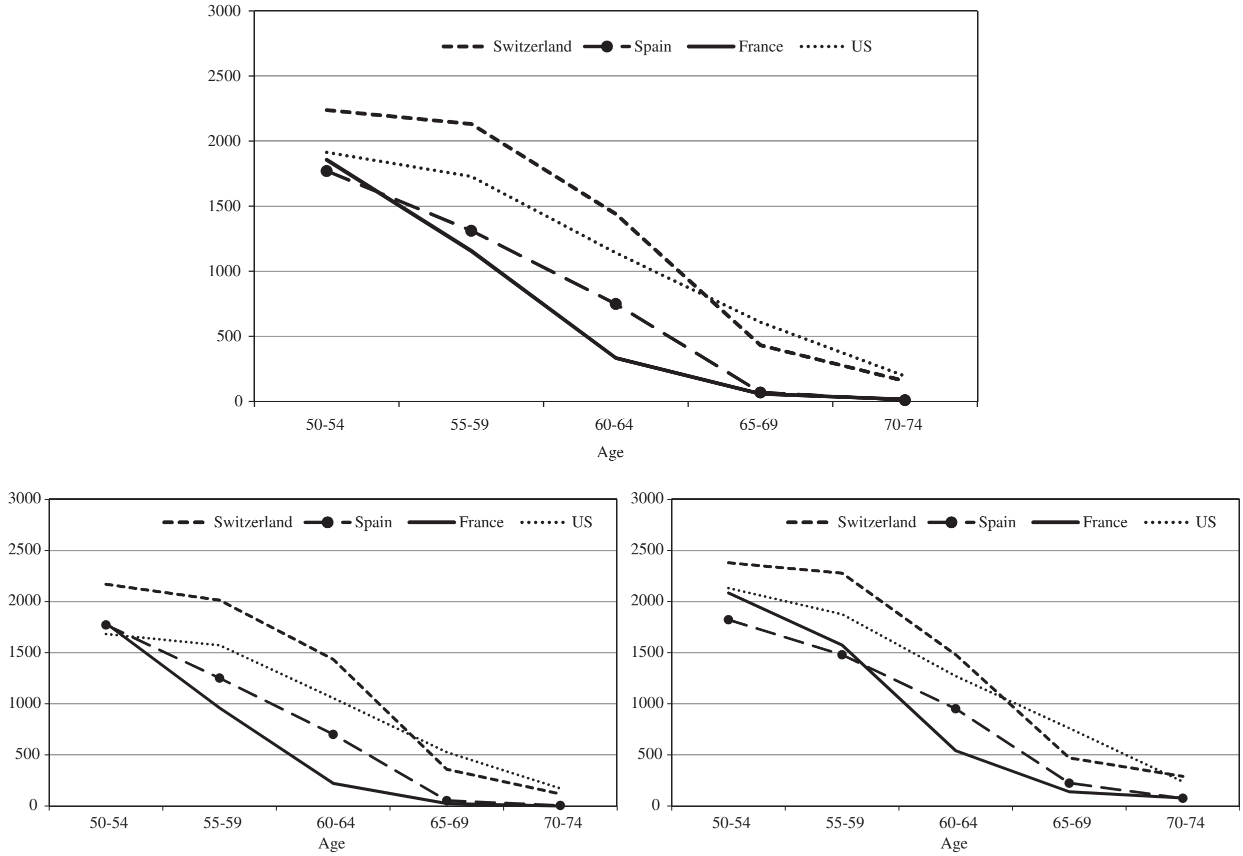

Fig. 2. Mean annual hours worked, United States vs. Europe, HRS and SHARE 2006, men: all, non-college, and college.

that fraction varies substantially for individuals younger than 65. In order to discuss the evidence in more detail, let us focus on the 60–64 age group, which is the age group for which social security rules vary more across countries. The fraction of individuals aged 60–64 receiving social security benefits is below 30% in the US, Sweden, and the Netherlands, but is as high as 66% in Italy and 70% in France. In the Netherlands, 43% of individuals aged 60–64 collect private pension benefits paid by mandatory occupational plans, which provide early retirement benefits prior to the social security retirement age of 65. The fraction of individuals aged 60–64 collecting disability insurance is important for Sweden (16%), Denmark (13%), and the Netherlands (20%). Unemployment insurance is quite important in Germany where about 10% of individuals between the ages of 50 and 64 collect unemployment benefits. Unemployment insurance is also important in France, but much less so than in Germany. Summing up, the various income support programs across the countries in the sample present individuals with alternative paths to retirement, and the relative importance of each of these programs varies substantially across all the countries.

2.3. Disability enrollment

In this subsection, we take a more detailed look at the disability insurance programs in Europe and the United States. We use the 2004 and 2006 waves of the SHARE to document the facts on disability insurance enrollment in the European countries in the sample. Online Appendix B-I provides a detailed description of the variables related to disability insurance payments from the SHARE used in the analysis. The questions in the 2004 and the 2006 wave differ slightly, and this partially accounts for some of the quantitative differences reported below. The qualitative message, however, is very similar.

Figs. 3 and B-6 report the fraction of individuals receiving disability insurance payments. For the year 2004, we use information on income sources last year and classify individuals as disability insurance recipients if they report having received public disability insurance, or a public invalidity or incapacity pension, or private (occupational) disability or invalidity insurance. For the year 2006, we classify individuals as disability insurance recipients if they report having received in the previous year main public disability insurance pension or sickness benefits, or secondary public disability insurance pension or sickness benefits, or occupational disability or invalidity insurance.

Table 2
Program participation, men, SHARE 2004.

Program participation	Age				
	50–54	55–59	60–64	65–69	70–74
	Switzerland				
SS retired worker benefits	0.0	1.3	2.5	88.5	98.3
DI benefits	5.9	10.1	11.3	3.3	6.8
UI benefits	7.1	1.3	2.5	1.6	1.7
Private pension benefits	0.0	6.3	25.0	37.7	55.9
	Sweden				
SS retired worker benefits	1.9	12.4	21.1	83.3	99.0
DI benefits	11.7	13.5	15.5	14.0	13.1
UI benefits	0.5	0.8	2.0	15.3	14.2
Private pension benefits	5.3	4.9	11.2	20.5	10.8
	Denmark				
SS retired worker benefits	0.0	3.6	34.1	76.1	99.0
DI benefits	12.6	14.4	13.3	7.6	0.0
UI benefits	9.0	13.7	4.4	1.1	0.0
Private pension benefits	1.2	0.7	14.1	39.1	39.0
	Netherlands				
SS retired worker benefits	0.0	1.0	2.1	83.2	99.3
DI benefits	12.3	17.1	20.0	6.4	0.0
UI benefits	3.7	6.0	5.8	1.0	0.0
Private pension benefits	0.0	5.4	43.3	73.8	79.3
	Germany				
SS retired worker benefits	1.9	5.2	46.6	91.4	96.1
DI benefits	5.4	8.0	7.6	1.1	2.0
UI benefits	11.6	9.9	8.0	0.0	0.0
Private pension benefits	0.0	1.4	10.2	22.3	28.1
	Spain				
SS retired worker benefits	2.8	9.9	34.8	88.1	91.4
DI benefits	13.4	10.6	11.0	5.0	4.3
UI benefits	6.3	4.6	8.4	0.0	0.0
Private pension benefits	1.4	0.0	3.2	0.0	0.6
	Italy				
SS retired worker benefits	6.8	35.1	66.1	81.3	86.1
DI benefits	6.9	7.5	7.0	8.9	5.8
UI benefits	0.7	1.3	1.3	0.0	0.0
Private pension benefits	0.0	2.2	5.7	5.2	6.9
	France				
SS retired worker benefits	2.1	14.3	70.6	96.5	99.0
DI benefits	6.2	7.5	0.5	4.1	3.2
UI benefits	5.2	7.5	6.4	1.2	0.0
Private pension benefits	0.7	4.5	47.1	66.1	74.2
	United States				
SS retired worker benefits	0.0	0.0	26.9	85.9	95.3
DI benefits	5.7	9.0	12.9	0.0	0.0
UI benefits	5.1	3.8	3.4	1.0	0.2
Private pension benefits	4.8	13.2	27.4	45.2	48.5

Notes: Authors' computations from the 2004 SHARE for the European countries. The evidence for the US is from Coile and Gruber (2004).

Fig. 3 shows that the fraction of individuals receiving disability insurance varies substantially across the eight European countries in the sample. In particular, the fraction of disability insurance recipients in Sweden, Denmark, and the Netherlands is higher than in Germany, Italy, and France.[10] It is clear that in order to understand the behavior of labor supply late in the life cycle it would be important to incorporate the effects of disability insurance in the analysis. Large differences in the fraction of disability insurance recipients may manifest themselves in cross-country differences in the observed participation rates as most of the disability insurance recipients do not work—for example, the 2004 SHARE reveals that the fraction of individuals on disability who report working is 15% in Spain, 26% in Italy, 23% in the

[10] The 2006 questionnaire also asks individuals about receiving public benefits since the last interview two years ago (in 2004). We use this information to construct an alternative measure of the fraction of disability insurance recipients. In particular, we classify as disability insurance recipients all those who report to have received either sickness benefits or disability insurance benefits since the previous interview in 2004 two years ago. The results, reported in Fig. B-6, reveal that the fraction of individuals receiving disability insurance payments is higher in Sweden, Denmark, and the Netherlands than in Switzerland, Italy, and France.

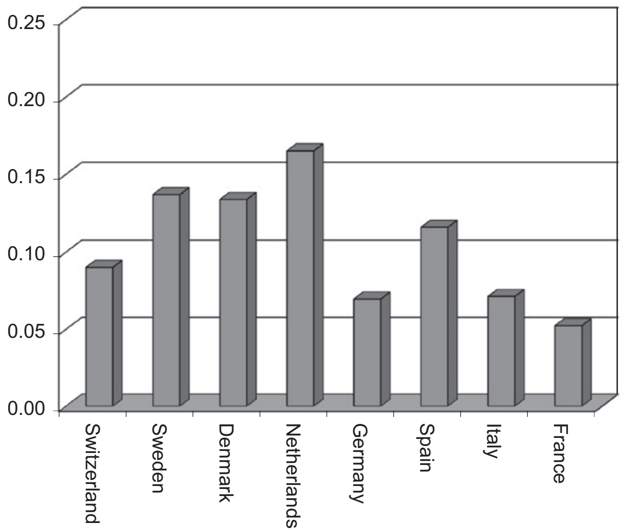

Fig. 3. Disability enrollment, SHARE 2004, men, age 50–64.

Netherlands, and 27% in Denmark. In addition, those on disability who continue to work report much lower hours worked than those who are not on disability. One major exception, however, is Sweden—in the 2004 SHARE data, 60% of the disability insurance recipients in Sweden reported positive work hours.

3. The model

We develop a life-cycle theory to evaluate how various government policies affect labor supply decisions across countries. The theory models a world of small open economies that differ in their social security, disability, and tax systems.[11] Without loss of generality, the model abstracts from cross-country differences in the level of TFP. This is because preferences and technology are chosen to be consistent with balanced growth, ensuring that the level of TFP does not affect labor supply decisions. The model economy features heterogeneous agents but, for simplicity, abstracts from the labor supply decisions of women and models only men. The baseline economy is calibrated to US micro and macro data. The calibrated model economy is then used to simulate government policies for various European countries and to quantitatively assess how the variation in government policies accounts for the cross-country variation in labor supply and retirement decisions.

3.1. Individuals: preferences, endowments, and shocks

The baseline economy is populated by overlapping generations of individuals. Individuals face uncertain lifetimes and can live, at most, J periods. They differ in terms of their education (college vs. non-college). Each period individuals face disability, mortality, and labor productivity shocks. The stochastic processes driving these shocks depend on age and education. Newborn individuals maximize their lifetime expected discounted utility

$$E\sum_{j=1}^{J}\beta^{j-1}u(c_j,1-h_j), \tag{1}$$

where c and $(1-h)$ denote consumption and leisure, respectively. An individual's time endowment in each period is one. The age-t utility function takes the form

$$u_t = u(c_j,1-h_j) = \alpha \ln c_j + (1-\alpha)\frac{(1-h_j)^{1-\sigma}}{1-\sigma}. \tag{2}$$

The utility function is consistent with balanced growth and allows for an active extensive margin on labor supply decisions. The modelling of preferences is motivated by the observation that there are no important cohort effects in the labor supply of men. It also allows the theory to be consistent with the fact that there are large permanent differences in

[11] For the purpose of this paper, the assumption of a small open economy is a better description of reality than assuming a world of small closed economies. Moreover, since the model abstracts from altruistic agents, assuming a closed economy would imply implausibly large effects of social security on the aggregate stock of capital and interest rates (Fuster, 1999; Fuster et al., 2003).

labor productivity across individuals (heterogeneity in fixed effects) but not in their lifetime labor supply (see the discussion in Erosa et al., 2011). The Frisch elasticity of leisure is given by $-1/\sigma$. Individuals enter the model at age 25, and the college decision is exogenous. The retirement decision, however, is endogenous.

3.2. Technology

There are a large number of plants and each plant is a collection of jobs. We assume that plants can operate jobs at zero cost. The production function of a job at date t is given by

$$f(K,h,Az) = h^{\varepsilon}K^{1-\theta}(Az)^{\theta} \quad \text{with } \theta \le \varepsilon \le 1, \tag{3}$$

where h denotes the workweek, K is the amount of capital for the job, and Az is effective labor in the job. Capital is assumed to depreciate at a rate δ per period. Effective labor in the job is given by the product of the worker productivity z and the level of technology A, which grows over time at an exogenous rate g. Note that, for a fixed workweek, the job technology exhibits constant returns to scale in capital and effective labor. Moreover, as discussed in Osuna and Ríos-Rull (2003), when $\varepsilon=\theta$ the job technology reduces to the standard Cobb–Douglas technology where total hours of effective labor is what matters. When $\varepsilon>\theta$ the hours and effective labor are imperfect substitutes and the composition between these two inputs matters. When $\varepsilon=1$ the technology is linear in hours and corresponds to the case where workers are not subject to fatigue.

3.3. The plant's problem

The plant's production plan is given by the choice of hours of operation h, capital K, and effective labor N, where $N=Az$. The plant takes as given the earnings schedule $\tilde{w}(h,N)$ and the rental rate of capital r. In equilibrium, the earnings schedule is a non-linear function of the workweek h and a linear function of effective labor N. To show this point, consider a plant operating h hours and hiring N units of effective labor. The optimal amount of capital K solves

$$\pi = \max_K \{h^{\varepsilon}K^{1-\theta}N^{\theta} - Kr - \tilde{w}(h,N)\}. \tag{4}$$

The solution to this problem implies that

$$\frac{K}{N} = k^*(h,r) = \left[\frac{(1-\theta)h^{\varepsilon}}{r}\right]^{1/\theta}. \tag{5}$$

Next, notice that plants will only operate if profits are non-negative. Free entry and the fact that plants can be created at zero cost imply that in equilibrium plants will make zero profits (will not extract economic rents from workers). Hence, competition for workers implies that the wage bill $\tilde{w}(h,N)$ is determined from

$$\pi = h^{\varepsilon}[Nk^*(h,r)]^{1-\theta}N^{\theta} - Nk^*(h,r)r - \tilde{w}(h,N) = 0, \tag{6}$$

which gives

$$\tilde{w}(h,N) = w(h)N, \tag{7}$$

where

$$w(h) \equiv r\frac{\theta}{1-\theta}\left[\frac{(1-\theta)h^{\varepsilon}}{r}\right]^{1/\theta}. \tag{8}$$

It follows that the earnings schedule $\tilde{w}(h,N)$ is linear in effective labor N and non-linear in hours of work h. When $\varepsilon=\theta$ earnings are also linear in h. When $\varepsilon>\theta$ the hourly wage rate increases with h. In this case, households would be better off by selling employment lotteries to firms (Hornstein and Prescott, 1993). However, we rule out this possibility by assuming that households cannot commit to work when the realization of the employment lottery implies that they should work.

3.4. Government policy: taxation, social security, and disability insurance

Government policy varies across countries along many dimensions. In order to evaluate the effects of government policy on labor supply late in the life cycle, we model the cross-country variation in the social security system, disability insurance, and tax institutions. In particular, the baseline economy is calibrated to salient features of the US tax, disability, and social security systems and is then used to evaluate the effects of replacing the US government policy with the policies pursued in various European countries. Appendix A provides a detailed description of the government policies in the countries considered in the analysis.

Social security. Social security is financed with a payroll tax τ^{ss}. The social security system specifies an early retirement age. Once individuals attain the early retirement age, they can choose to file for social security benefits (e.g., collect pension benefits). Retired individuals can choose to work, but their earnings may be taxed at a high rate due to progressive taxation of earnings. It is assumed that individuals cannot work any longer after the age of 75 so that this is the oldest possible age of retirement in the model economy. In equilibrium, the age of retirement will differ across individuals because of heterogeneity in earnings, disability status, and assets. We carefully model the incentives for early/late retirement by modelling how pensions vary with the retirement age of individuals. In this way, the model captures how the cross-country variation in accrual rates affects the age of retirement.[12] Pensions also depend on the ability type of workers (education and fixed effects). In particular, for each ability type, pensions depend on the average lifetime earnings across workers of that ability type. This assumption considerably simplifies the computation of the model since modelling pensions as a function of the actual earnings history of individuals requires adding an extra state variable in an already difficult dynamic programming problem.[13]

We model cross-country variation in social security rules along many dimensions: (i) the normal and early retirement ages; (ii) the benefit formula determining how pensions vary with average lifetime earnings, such as the progressivity of the formula and the rules determining minimum and maximum pensions; (iii) how pensions vary with the age of workers at retirement (accrual rates); (iv) the formula used to compute average lifetime earnings such as the number of years considered in the computation and whether wages are adjusted by real wage growth or by inflation when computing lifetime average wages; (v) the formula determining the payroll taxes paid to finance pensions since the tax rate may vary with earnings; (vi) whether pensions are kept constant in real terms during retirement or increase with real wage growth; (vii) the presence of occupational pensions or early retirement programs (such as in Switzerland, the Netherlands, and France).

Disability insurance. We model the probability of becoming disabled as determined by government policy. This approach is motivated by the following evidence from the SHARE. First, Jurges (2005) documents that there are small differences in objective measures of health status across countries. Second, Borsch-Supan (2005) shows that the large cross-country differences in disability cannot be explained by differences in health or demographics and concludes that institutional differences account for the variation in disability across countries. As documented in Section 2 most of the disability insurance recipients in the SHARE do not work. Hence, the model assumes that individuals cannot work while on disability. It is also assumed that disabled individuals remain disabled for the rest of their lives and that they collect a social security payment which depends on the ability type (education and fixed effect) and the number of years since retirement because pensions may be adjusted for productivity growth during retirement.

Taxes. Following McDaniel (2007), it is assumed that the government taxes consumption (τ^c), investment expenditures (τ^I), capital income (τ^k), and labor earnings ($T(y)$). Her estimates are used to pin down the cross-country variation in the first three tax rates (τ^c, τ^I, τ^k). Differently from McDaniel (2007), we assume that labor earnings are taxed according to a progressive tax function that we estimate using OECD data. We assume that labor earnings and capital income are taxed based on the country of residency of the individual supplying the factors of production. Investment taxes are levied by the government of the country where investment is located, independently of the nationality of the owner of the factor of production. As described in McDaniel (2007), investment taxes stand for general taxes (including sales and value added taxes) paid on investment expenditures, as well as customs and import duties and taxes on the use of goods to perform investments activities (such as motor vehicle taxes and highway taxes). Taxes on consumption include property taxes paid by households, general taxes on good and services, excise taxes, customs and import duties, taxes on specific services, and taxes on the use of goods to perform activities.

Government expenditures. The tax revenue from the social security payroll tax τ^{ss} is used to finance the social security and the disability insurance programs. The government uses the rest of the tax revenue (from τ^I, τ^k, τ^c, and $T(y)$) to purchase a public good that does not provide utility to individuals or, equivalently, entering the period utility function in an additive separable fashion. Later, in a sensitivity analysis, we shall assume that these tax revenues are rebated back to individuals.

3.5. Capital markets

There are a large number of financial intermediaries that take deposits from consumers (D) and make investments in (potentially) many countries. When an intermediary purchases I_c units of capital in country c, it pays an investment tax $\tau_c^I I_c$. The purchases of capital are constrained by the amounts of deposits D as follows:

$$\sum_c I_c(1+\tau_c) = D. \tag{9}$$

Intermediaries take as given the international interest rate i, the return on capital r_c, and the tax rate τ_c^I. The present value of the return to one unit of capital invested in country c is

$$PV_c = \frac{r_c}{1+i}\left[1+\frac{1-\delta}{1+i}+\left(\frac{1-\delta}{1+i}\right)^2+\cdots\right] = \frac{r_c}{i+\delta}. \tag{10}$$

[12] The number of years since retirement may also affect pensions if pensions are not adjusted by productivity growth (mean real wage growth) during retirement. In this case, "normalized" pensions decrease during retirement at the rate of productivity growth in the economy.

[13] Our model is not convex since it features an active extensive margin (due to non-linear wages) and a retirement decision.

The investment problem faced by the representative intermediary is

$$\max_{D,I_c} \quad -D+\sum_c I_c \frac{r_c}{i+\delta}$$
$$\text{s.t.} \quad (9).$$

Profit maximization implies the following arbitrage condition

$$\frac{r_c}{1+\tau_c^I}=i+\delta \quad \text{for all } c. \tag{11}$$

In a world of open economies, differences in the investment taxes across countries are arbitraged away so that the return on capital per unit of expenditure is equated to the international (gross) interest rate.

Due to free entry in the financial industry, financial intermediaries make zero profits. Financial intermediaries sell annuity contracts to individuals so that the gross interest rate on deposits paid to an age j individual is $(1+i)/\pi_j$. The after tax gross return on deposits of an age j individual in country c is

$$R_{c,j}=1+\left(\frac{1+i}{\pi_j}-1\right)(1-\tau_c^k), \tag{12}$$

since the taxation of capital income is based on the country of residence.

3.6. The individual's problem

We use recursive language to describe the decision problem of an individual. In order to simplify the notation we abstract from the fact that the education type of an individual determines her earnings, disability, and mortality processes. The state x of an individual is given by her age j, assets a, earnings shock z, disability status d, and social security status f (age of retirement if individual has filed for social security benefits). The timing of events within each period is as follows. Individuals start the period knowing x and then decide how much to consume, work, save, and, if applicable, whether to apply for social security benefits or not. We assume that individuals with disability cannot work and that retired individuals can work as long as they are able to.

The value of state x is

$$V(x)=\underset{\{c,h,a',f'\}}{\text{Max}}\{u(c,1-h)+\beta\pi_{j+1}E[V(x')]\}$$

subject to

$$(1+\tau^c)c+(1+g)a'=R_j\ a+w(h)\ z_j\ +b(x)-T(x),$$

$$a'\geq 0,$$

where R denotes the gross interest rate (net of taxes), $T(x)$ represents the total taxes paid on labor earnings (and benefits), and $b(x)$ denotes the social security benefits received (pension and disability benefits).

4. Calibration

The baseline economy is calibrated to the US economy in the year 2004. While we consider a world of small open economies, the international interest rate is calibrated so that the net capital flows in the baseline economy are zero. Following Erosa et al. (2011), we calibrate the age profile and the shock process of labor productivity using an indirect inference approach. Moreover, the preference parameter σ is set so that the intertemporal elasticity of leisure is 0.5. Erosa et al. (2011) conclude that a Frisch elasticity of leisure of 0.5 allows this model to be consistent with a rich set of micro level facts on labor supply. This finding also applies in the current model economy with endogenous retirement.

Model period. The model period is set to be a year.

Preference parameters, time endowments, mortality rates, and disability risk. Following Prescott (2004) and Osuna and Ríos-Rull (2003), the time endowment is set at 5200 hours a year (100 hours per week) and the discount factor β is chosen to match an asset to income ratio of 3. The preference parameter α, determining the consumption weight in the utility function, is set to 0.5 so that prime age individuals work about 42% of their available time. The mortality risk for college and non-college individuals is taken from Bhattacharya and Lakdawalla (2006). The calibration of the parameters determining disability rates in the model target the fraction of men on disability by age and education in the HRS (see Online Appendix B-II). We assume that non-college individuals face a constant probability of becoming disabled from age 30 to age 40 and that after age 40 disability risk increases exponentially with age

$$p_j=\begin{cases} p_1 & \text{if } j\in[30,40), \\ p_1 e^{(j-39)p_2} & \text{if } j\in[40,75]. \end{cases} \tag{13}$$

The probability of becoming disabled for college individuals is assumed to be a constant fraction of that for non-college individuals: $p_{col,j}=p_{col}p_j$. The parameter p_{col} is pinned down so that the model is consistent with the fact that the fraction of college individuals who are disabled is about half the fraction of non-college individuals who are disabled in the HRS in the year 2004. The parameters (p_1,p_2) target the fraction of disabled individuals in the age groups 30–39 (1.5%) and 50–54 (7.3%).[14]

Technology parameters. We find that an international (pre-tax) interest rate of 4.9% achieves the target of zero net international capital flows. The rate of depreciation of capital is set at 5.3%, the labor share θ at 0.69, and the rate of labor augmenting technological progress $g=0.014$ per year, which is the average productivity growth in the US during the postwar period (Fuster et al., 2007). In order to calibrate the parameter ε, we use the fact that in equilibrium the elasticity of the hourly wage to a change in hours worked is given by $(\varepsilon/\theta)-1$ (see the discussion in Erosa et al., 2011). Aaronson and French (2004) estimate this elasticity to be 0.40 so that we set $\varepsilon = 1.4\theta$.

Tax rates on consumption, investment, capital income and labor earnings. Following McDaniel (2007), the tax rate on consumption is set to $\tau^c = 0.075$, the investment tax rate is set to $\tau^I = 0.032$, and the tax rate on capital income is fixed at $\tau^k = 0.232$. We follow Guvenen et al. (2010) in parameterizing taxes on labor earnings and fit the following effective average tax function to data from the OECD tax database

$$\overline{\tau}(y/W) = a_0 + a_1(y/W) + a_2(y/W)^{\phi}, \tag{14}$$

where $\overline{\tau}$ gives the average tax rate paid by an individual with earnings y normalized by average earnings in the economy W. We use the OECD data to compute effective labor income taxes at various points in the wage distribution and include in the calculation central government, local, and state taxes net of tax credits. Differently from Guvenen et al. (2010) we exclude social security contributions (which are modelled explicitly) and cash benefits (such as social assistance and housing assistance).[15] Table B-5 reports the regression results and the R^2s obtained for all countries which are quite close to 1.[16] Fig. 6 plots the earnings tax functions for all the countries considered in the analysis.

Social security and disability. The social security tax rate is set to $\tau^{ss} = 0.124$ with a cap $\widehat{y}$ on social security taxation fixed at 2.47 of average earnings in the economy (W). Half of the social security taxes are paid by the employer and are not subject to the personal income tax on earnings. Social security benefits depend on average lifetime earnings (adjusted by the rate of growth in the economy) according to the benefit formula in the US economy (see Fuster et al., 2007). The early and normal retirement ages are set at 62 and 65, respectively. If an individual retires before the normal retirement age of 65, her pension is reduced by 6.7% per year of early retirement. When individuals retire after the normal retirement age, the pension is increased by 6.5% per year of delayed retirement up to age 69.[17] Retired individuals of age 62–64 are subject to an earnings test—earnings above 33% of average earnings in the economy are taxed at a rate of 50% until all the pension income has been exhausted.[18]

Calibration of labor productivity. We emphasize that this is a crucial step in our calibration strategy. While the age profile of productivity and the parameterization of wage shocks have a first order effect on the retirement decisions of individuals, these objects are hard to calibrate. First, note that labor productivity is not directly observed in the data. While we do observe wages, they are observed with error since it is well known that there is measurement error in hours and, hence, in wages in the PSID data. Second, wages are only observed for individuals that work. To the extent that there is an active extensive margin late in the life cycle, the estimation of the wage process for individuals close to the retirement age is going to be affected by selection issues. This is a serious problem because the labor productivity process late in the life cycle plays a crucial role in determining how the social security system affects retirement decisions. In order to deal with these problems we follow an indirect inference approach. Building on our previous work, we use a GMM procedure to estimate, for college and non-college individuals, the following annual wage process both in the PSID and in the model-simulated data:

$$\ln \hat{w}_{ij} = x_j\kappa + \alpha_i + u_j + \lambda_j, \tag{15}$$

where $\hat{w}_{ij}$ stands for the hourly wage of individual i of age j, x_j is a quartic polynomial in age, κ is a vector of coefficients, $\alpha_i \sim N(-(\sigma_\alpha^2/2),\sigma_\alpha^2)$ is a fixed effect determined at birth, $\lambda_j \sim N(-(\sigma_\lambda^2/2),\sigma_\lambda^2)$ is an idiosyncratic transitory shock, and u_j follows a first-order autoregression

$$u_j = \rho u_{j-1} + \eta_j, \quad \eta_j \sim N\left(-\frac{\sigma_\eta^2}{2},\sigma_\eta^2\right), u_0 = 0. \tag{16}$$

[14] The target for the age group 30–39 is obtained using data from the Annual Statistical Supplement to the Social Security Bulletin (2005). The calibration sets $p_1 = 0.0029$, $p_2 = 0.054$, $p_{col} = 0.59$. For the calibrated parameters the model predicts that the fraction of individuals on disability are 1.4% and 7.3% for age groups 30–39 and 50–54, respectively.

[15] In the US case, the regression is run with data on taxes at 35 points in the wage distribution which, expressed as a percentage of average earnings W, are given by 10%, 20%, 30%, 40%, 50%, 75%, 100%, ..., 800% of W. For many European countries there is an initial range of income for which the average tax rate is constant and equal to a minimum level, which is often equal to 0. In this case, we only run the regression for income levels for which the tax function increases with income.

[16] The data is available online at www.oecd.org under the link to the "Tax-Benefit Calculator tool."

[17] A reform of the US social security in 1990 increased the delayed retirement credit from 3% to 8%. This change was introduced gradually. For the cohorts that were aged 66–69 in the year 2004, the delayed retirement credit was 6.5% per year, up to age 69.

[18] In 2000 the earnings test was eliminated for individuals above the normal retirement age.

Table 3
Calibration.

Parameter	Value	Target	Data	Model
W	2.9	Ratio of mean economy to mean male earnings	0.80	0.80
α	0.5	Fraction of hours worked, age 30–45	42%	42%
β	0.983	Asset to income ratio	3.0	2.93

While the parameters $(\kappa,\rho,\sigma_\alpha^2,\sigma_\lambda^2,\sigma_\eta^2)$ vary across education types, this is omitted in the notation to avoid clutter. The model economy is simulated for different parameterizations of the stochastic process for labor productivity z—it is assumed to follow the stochastic process specified in (15). In particular, we iterate on the parameters determining the age profile of wages (quartic polynomial) and the stochastic process of wages $(\rho,\sigma_\alpha^2,\sigma_\lambda^2,\sigma_\eta^2)$ until the GMM procedure in the simulated data recovers the estimates obtained in the PSID data.[19]

5. Calibration results

There are 21 parameters that are calibrated by solving the model economy. Table 3 shows the values and the calibration results for three of these parameters: average earnings in the economy W, the consumption weight α, and the discount factor β. For each education group, the indirect inference approach is used to pin down the quartic polynomial for the wage-age profile (five parameters) and the stochastic process of wages (the parameters giving the variance of fixed effects, the persistence and the variance of innovations, and the variance of the transitory shock).[20]

5.1. *Hourly wages: age profile and stochastic process*

We use an indirect inference approach to find the parameters for the trend and the stochastic process of labor productivity—the parameters are such that the same trend and stochastic process for hourly wages are obtained in the actual and model data. Fig. B-7 shows that the trend in hourly wages for college and non-college workers in the data is the same as in the model-simulated data. Similarly, Table B-6 reports that the stochastic process for hourly wages estimated in the model-simulated data is similar to the one estimated on the PSID data. In particular, the same estimates are obtained when we use a GMM estimation to estimate both in the model and in the PSID data the variance of the fixed effect component, the persistence and the variance of the innovation of the AR(1) shock, and the variance of the transitory component.

5.2. *Age profile of hours of work: performance of the model*

The calibration procedure did not explicitly target the various facts on labor supply. Nevertheless, it is important to point out that the baseline economy does an excellent job in accounting for the facts on labor supply. Fig. 4 reports mean annual hours worked over the life cycle between the ages of 25 and 65 both in the model and in the data using various cohorts from the PSID.[21] Since the PSID is a relatively small dataset, the data is grouped into age and cohort groups. Each age group consists of four ages—for instance, the age-62 group includes all individuals between the ages of 62 and 65. A cohort in a given year is comprised of all individuals who turn 18 years in that year and each cohort group consists of three cohorts—for instance, the 1976 cohort includes cohorts 1976, 1977, and 1978.

The model does very well in matching the life-cycle pattern in hours worked both for college and non-college individuals. In particular, the model is quantitatively consistent with the fact that the profile for average annual hours is relatively flat until the age of 50 and starts declining after that. This decline in working hours is steeper among non-college than college individuals, and starts at an earlier age for the former group both in the PSID and in the model data. The theory also accounts for the fact that college individuals tend to work slightly more hours than non-college types. For each of the two education categories, the decline in working hours in the PSID data is mainly driven by the extensive margin, although there is also a small decline in hours worked along the intensive margin late in the life cycle (see Figs. B-8 and B-9). The model is quantitatively consistent with these patterns in the data.

Fig. 5 reports mean annual hours for college and non-college individuals in the 50–74 age group, as this paper mostly focuses on labor supply for individuals in this age group. Since in the PSID there are not many observations for people above 60 years of age, the data is grouped across all cohorts in the PSID.[22] The model is remarkably successful in matching

[19] The transitory shock λ_j estimated in the PSID data represents both genuine transitory shocks and measurement error in wages. We pin down the measurement error in wages using the estimates in Erosa et al. (2011).

[20] When we estimate the process, both in the model-simulated and actual data, we allow the variance of the transitory shocks to vary with age according to a cubic polynomial.

[21] See Erosa et al. (2011) for a more detailed description of the facts on labor supply in the United States.

[22] For robustness, we have constructed a similar graph using data from the HRS (2004) and the picture is quantitatively quite similar to the one obtained by aggregating all cohorts in the PSID.

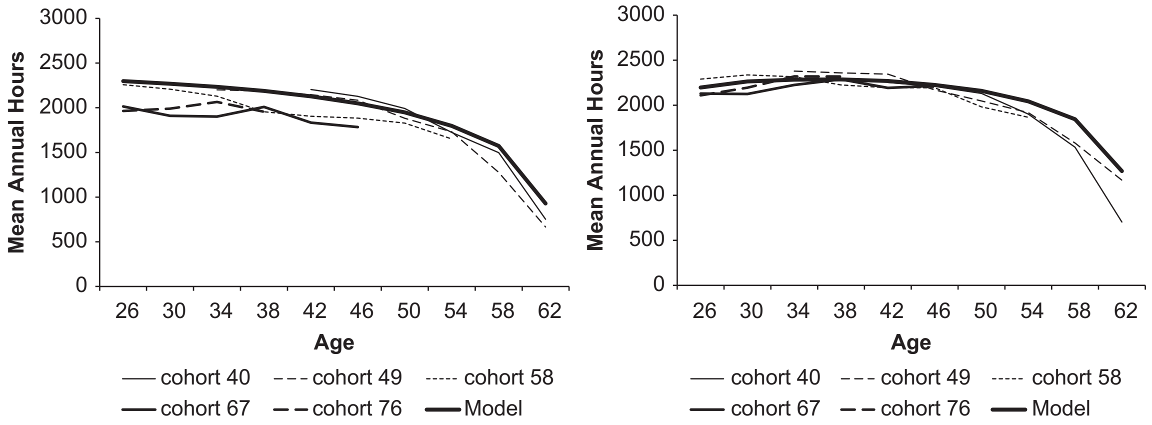

Fig. 4. Mean annual hours worked, United States, data vs. model: non-college and college.

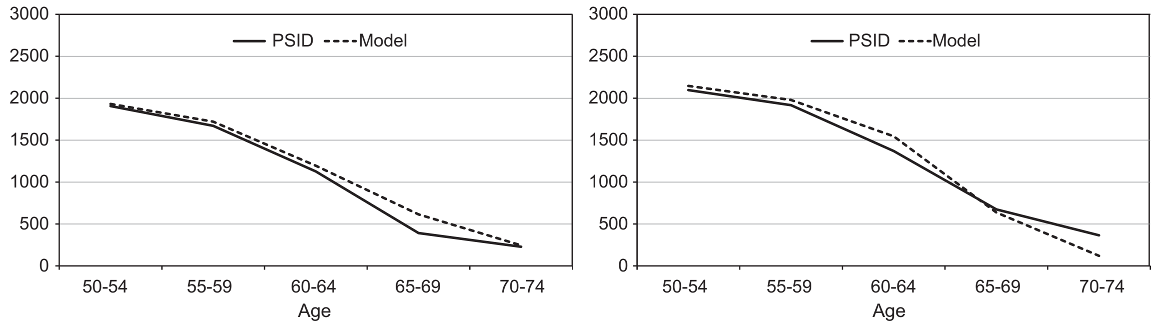

Fig. 5. Mean annual hours worked, United States, age 50–74, data vs. model: non-college and college.

quantitatively the decline in average hours worked after age 50 in the US. This observation gives us some confidence that the theory developed in this paper is an appropriate quantitative framework for assessing how the introduction of European-style policies would affect labor supply in the United States.

It is important to emphasize that incomplete markets play an important role in generating the life-cycle patterns of working hours predicted by the theory. Young individuals work long hours because they need to build a buffer stock of savings to self-insure against income risk. This mechanism explains why working hours are roughly flat during the first part of the life cycle despite the increasing age profile of wages. By age 50 the stock of assets is sufficiently large, and individuals can afford to reduce their labor supply when they receive a low temporary wage shock. This mechanism accounts for the pronounced decline in annual working hours late in the life cycle. Modelling disability provides an additional channel which contributes to the decline in working hours late in the life cycle.

6. Quantitative experiments

In order to evaluate the role of government policies in accounting for the cross-country differences in labor supply, we replace the US social security, disability, and tax systems of the baseline economy with the policies of Switzerland, the Netherlands, Spain, Italy, and France.[23] Before presenting the results, it should be emphasized that government policies vary across countries in a large number of dimensions. The taxation of earnings, capital income, and consumption varies across countries. The social security system differs substantially on many dimensions such as the contributions to the system, the pension benefit formula, the early and normal retirement ages, and the penalties and bonuses for early and late retirement. Due to the complexity of these rules, the detailed description of these institutional features for each country in

[23] We do not model the policies of Germany, Sweden, and Denmark. Recall that the empirical analysis in Section 2 revealed that unemployment insurance is an important transfer program in Germany. A proper analysis of German policies would require that the theory in this paper is extended to incorporate unemployment. Our empirical findings also showed that the Swedish disability insurance program is unique because, unlike those in the other countries, most individuals on disability in Sweden work. Given the importance of the disability program in Sweden, properly modelling Swedish policies would require extending the model economy in order to allow for disabled people to work. Furthermore, our theory abstracts from government employment and other transfer programs, something which Rogerson (2007) has argued to be important for understanding labor supply in Scandinavian countries. As a result, we do not analyze the effects of Scandinavian policies at this point.

our study is provided in Appendix A. For each country, the policy experiments set the fraction of college individuals to match the ratio of college men among the total population aged 50 and older in the 2004 SHARE.

6.1. Cross-country differences in institutional arrangements

We now document that the social security, disability, and tax systems differ importantly across countries.

6.1.1. Consumption, investment, capital income, and earnings taxes

Table 4 documents how taxation varies across countries. The US is characterized by a low consumption tax relative to the European countries. While the consumption tax is 7.5% in the US, it goes from 15.3% in Switzerland to 25.5% in France. Thus, the consumption tax generates important tax wedges that may have an effect on labor supply across countries. Investment taxes also vary across countries, but less than consumption taxes. Moreover, as previously shown, differences in investment taxes are arbitraged away with capital mobility, and they should not affect much the labor supply across countries. Capital income taxes vary in the tight range of 19.0–23.2%, with the lowest value in Spain and the highest value in the US.

Fig. 6 plots earnings taxes across countries. Two observations stand out. First, earnings taxes in the US do not appear to be low relative to those in the European countries. Second, earnings taxes are progressive in all countries. However, they are more progressive in Europe than in the United States as evidenced by the fact that in several European countries (Spain, Italy, and the Netherlands) individuals with earnings below 40% of average earnings pay zero earnings taxes.

Table 4
Consumption, investment, capital income, and earnings taxes.

Taxes	US	Spain	France	Switzerland	Netherlands	Italy
	Consumption, investment, and capital income taxes					
τ^c	0.075	0.196	0.255	0.153	0.238	0.226
τ^I	0.032	0.089	0.145	0.085	0.155	0.150
τ^k	0.232	0.190	0.193	0.216	0.202	0.216
	Earnings taxes					
Min. taxed $\left(\frac{y}{W}\right)$	0.02	0.44	0.00	0.13	0.40	0.44
Min. tax	0.0	0.0	0.076	0.0	0.0	0.0
Max. tax	0.354	0.383	0.468	0.364	0.463	0.406
$\overline{\tau}(0.5)$	0.118	0.022	0.079	0.057	0.043	0.051
$\overline{\tau}(1.0)$	0.174	0.112	0.146	0.112	0.137	0.168
$\overline{\tau}(3.0)$	0.272	0.267	0.310	0.246	0.349	0.329

Notes: The consumption, investment, and capital income taxes are taken from McDaniel (2007) while the earnings taxes are computed by the authors from OECD data. W indicates average earnings in the economy while y indicates individual earnings. $\overline{\tau}(x)$ denotes the average tax on earnings for an individual whose earnings are a fraction x of average earnings.

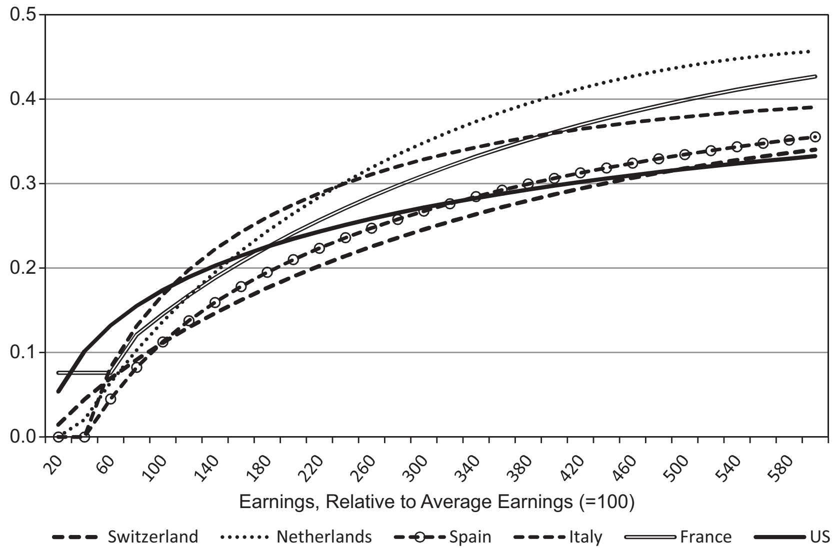

Fig. 6. Earnings taxes in the United States and Europe. *Note*: Authors' computations from OECD data.

US earnings taxes are the highest for people with earnings at 50% of mean earnings in the economy, while they are the lowest for individuals with earnings above 300% of mean earnings.

6.1.2. Social security

Social Security programs vary substantially across countries. They also vary over time as most countries have reformed their social security systems. We model social security rules as close as possible to the rules prevailing in the year 2004. However, for countries where the early retirement regulations changed substantially after a reform we model the rules that applied to individuals aged 60–64 in the 2004 SHARE when making their retirement decisions.[24] The quantitative experiments below will mostly focus on understanding labor supply differences for this age group.

Social security regulations on early retirement differ substantially across countries. While in some countries there is a minimum age requirement for collecting pensions (62 for the US, 63 for Switzerland, 60 for Spain, and 55 for the Netherlands), in other countries the age requirement is irrelevant since individuals can retire after having contributed a certain number of years to the system (40 years in France and 35 years in Italy). Switzerland and the US penalize early retirement with actuarially fair reductions. Each year of early retirement (after the early retirement age but before the normal retirement age) is penalized with a reduction of about 6.8% in the pension. Each year of retirement deferral is rewarded with a 6.5% increase in the US. In Switzerland the reward is 5.2% for 1 year of deferral, 10.8% for 2 years of deferral and up to 31.5% for 5 years of deferral. Italy (prior to the 1993 reform) provided the strongest incentives for early retirement. A worker with 40 years of contributions collects a pension with the maximum replacement rate of 80%, implying that most workers by age 60 would not see their pension increased by postponing retirement. Moreover, a worker with 35 years of contributions (and an age around 55) can retire with a replacement rate of 70%. Postponing retirement by 5 years would only increase the replacement rate by 10%, which is grossly actuarially unfair. France also provides strong incentives for early retirement. At age 60, individuals can retire with no penalty if they have contributed for 40 years to the system.[25] Each missing year of contribution is penalized by 5%, which is actuarially unfair. In the Netherlands, the early retirement schemes imply that individuals see no change in their pension benefits if they retire after age 60. In this case, the replacement rate is set at 70% regardless of the age of retirement. Individuals can retire as early as age 55 but with a replacement rate of 25%, which increases up to 55% for individuals retiring at age 60. Appendix A describes in more detail the social security rules for each of the countries considered in our analysis.

Table 5 documents that social security taxes vary significantly across countries, with taxes being the lowest in the US and Switzerland and the highest in Spain and Italy. In all countries but Italy, payroll taxes are capped at a sufficiently high level of earnings. Hence, average social security taxes tend to decrease with the level of earnings.

6.1.3. Disability pensions

We model the fraction of individuals on disability as determined by government policy. Hence, the parameters determining the probability of becoming disabled are recalibrated for each country. The calibration targets, in the 2004 SHARE, the fractions of disabled individuals in the age groups 50–54 and 55–59 and the ratio between the fractions of disabled individuals in the college and non-college categories at age 50–54. The model assumes that the government pays a disability pension to disabled individuals. The features of the various disability pensions in our analysis is pinned down using information from the "Social Security Programs Throughout the World" project administered by the US Social Security Administration.[26]

6.2. Main results

Figs. 7–9 present the main findings of the paper. The model accounts very well for the decline in labor supply late in the life cycle for most countries. In particular, it matches remarkably well the large decline in aggregate labor supply after age 50 in Spain, Italy, and the Netherlands. The results show that government policies can go a long way towards accounting for the low labor supply late in the life cycle in these countries. The main discrepancy between the quantitative experiments and the data is that the theory tends to underpredict the hours of work for individuals younger than 60 in Switzerland and overpredict the hours of work for individuals aged 55–59 in France.[27]

[24] For Italy, we model the rules prevailing before 1993 because for workers with 15 years of contributions at the end of 1992, the rules of the pre-1993 regime apply, and individuals will retire under the pre-1993 regime until the year 2015 (see Gruber and Wise, 2004). For similar reasons, in the Netherlands we model the early retirement schemes of the ABP plan for workers born after 1942 and according to the rules prevailing after 1997.

[25] For France, we assume that non-college and college individuals have 40 years of contribution by age 60 and 63, respectively. For Italy, we assume that non-college and college individuals attain 35 years of contribution by age 57 and 62, respectively.

[26] This information is available on the US Social Security Administration website at http://www.ssa.gov/policy/docs/progdesc/ssptw.

[27] The model predicts reasonably well the hours of work for college individuals in France aged 55–59, but overstates the hours of non-college individuals in that age group. One clue for why the model overpredicts the labor supply of the non-college is provided by the following observation from the SHARE—about 10% of the French non-college individuals aged 55–59 collect unemployment insurance benefits. Our model, however, abstracts from unemployment insurance.

Table 5
Social security taxes.

Countries	Public pensions		Occupational pensions	
US	0.124	if $y \in [0, 2.47W]$		
	0	if $y > 2.47W$		
Spain	0.283	if $y \in [0, 1.64W]$		
	0	if $y > 1.64W$		
France	0.1575	if $y \in [0, W]$	0.095	if $y \in [0, W]$
	0.027	if $y > W$	0.22	if $y \in (W, 8W]$
			0	if $y > 8W$
Italy	0.27			
Netherlands	0.238	if $y \in [0, 0.79W]$		
	0.0585	if $y \in (0.79W, 1.16W]$		
	0	if $y > 1.16W$		
Switzerland	0.101		0	if $y \in [0, 0.27W]$
			τ_j	if $y \in (0.27W, 1.07W]$
			0	if $y > 1.07W$

Notes: Social security taxes are computed by the authors from OECD data. W indicates average earnings in the economy while y indicates individual earnings. τ^{ss} for public pensions in Switzerland equals zero if $y < 0.27W$ and the individual is older than the normal retirement age. τ_j^{ss} for occupational pensions in Switzerland depends on the individual's age: 0.07 until 35, 0.10 for the 35–45 age group, 0.15 for the 45–55 age group, 0.18 for the 55–65 age group, and 0 for those older than 65.

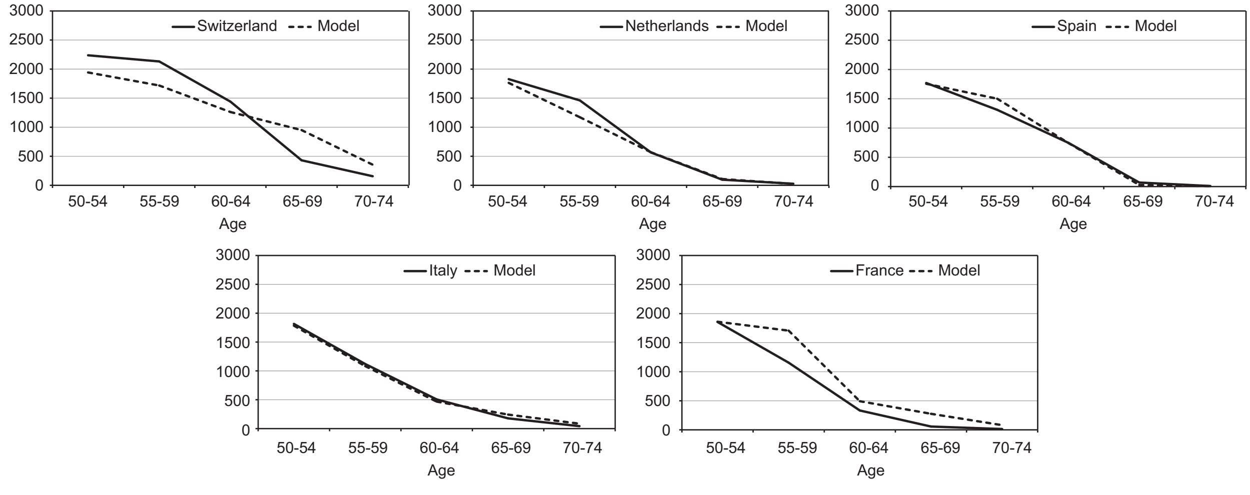

Fig. 7. Annual hours worked, all, model vs. data: SHARE 2006.

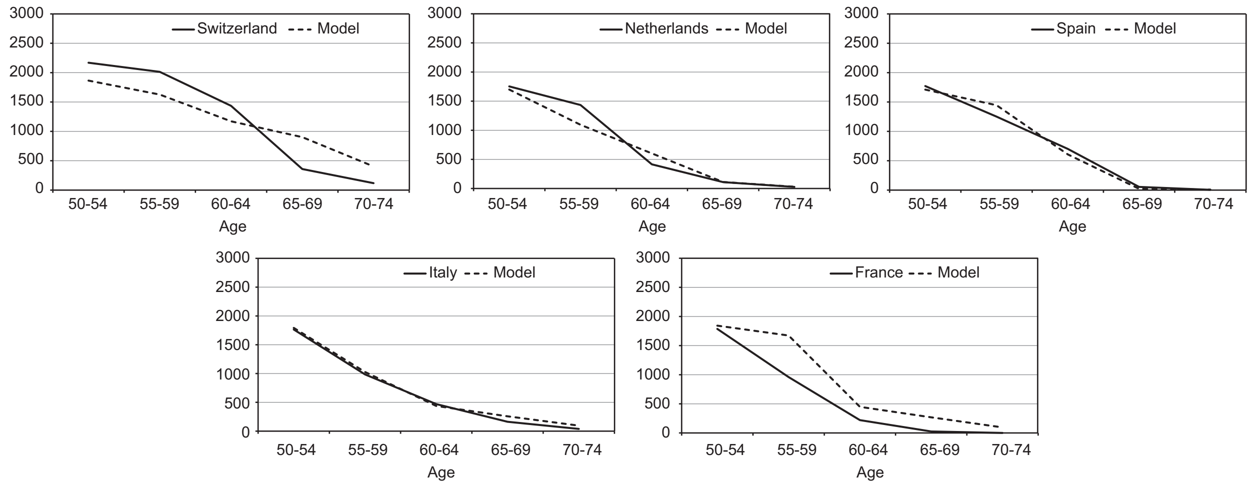

Fig. 8. Annual hours worked, non-college, model vs. data: SHARE 2006.

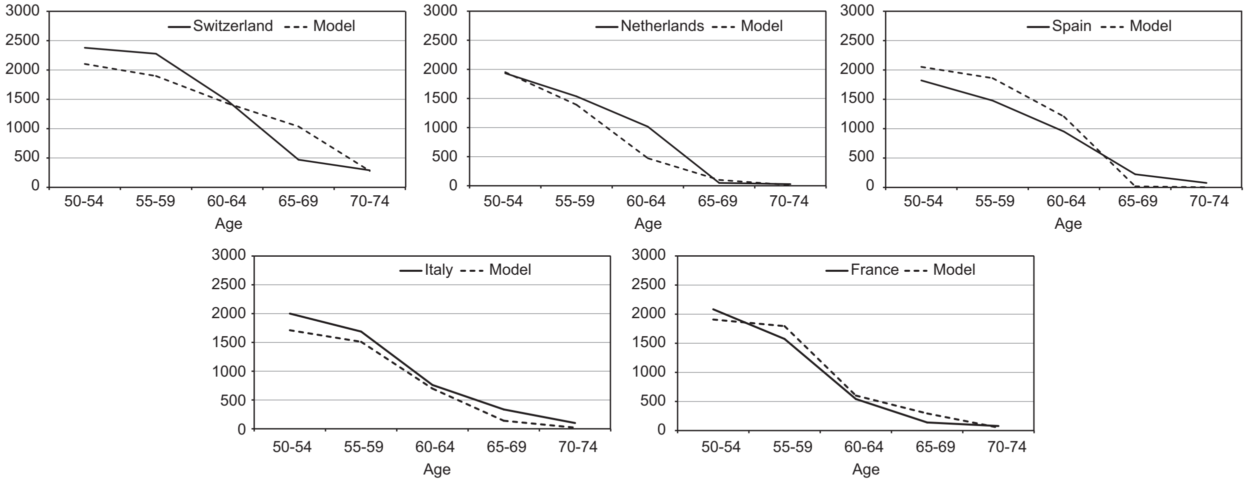

Fig. 9. Annual hours worked, college, model vs. data: SHARE 2006.

Table 6
Hours worked, by age, model vs. data (HRS and SHARE 2006): all, relative to the US.

Country	Model			Data (HRS and SHARE 2006)		
	55–59	60–64	65–69	55–59	60–64	65–69
Switzerland						
Baseline	0.95	0.96	1.53	1.23	1.26	0.71
US taxes	0.95	0.96	1.56			
US fraction of college	0.95	0.96	1.53			
Disability	0.93	0.94	1.48			
US social security	1.01	1.03	1.05			
Netherlands						
Baseline	0.65	0.43	0.17	0.84	0.49	0.16
US taxes	0.62	0.49	0.26			
US fraction of college	0.66	0.43	0.17			
Disability	0.72	0.50	0.21			
US social security	0.83	0.76	0.73			
Spain						
Baseline	0.83	0.53	0.03	0.76	0.66	0.11
US taxes	0.85	0.54	0.04			
US fraction of college	0.87	0.62	0.04			
Disability	0.94	0.63	0.04			
US social security	0.83	0.74	0.67			
Italy						
Baseline	0.60	0.36	0.39	0.65	0.44	0.29
US taxes	0.66	0.42	0.48			
US fraction of college	0.66	0.40	0.35			
Disability	0.59	0.34	0.36			
US social security	0.99	1.02	1.05			
France						
Baseline	0.94	0.37	0.44	0.67	0.29	0.09
US taxes	0.98	0.42	0.46			
US fraction of college	0.95	0.38	0.44			
Disability	0.93	0.36	0.42			
US social security	0.98	1.02	1.06			

6.3. Labor supply differences late in the life cycle: driving forces

Table 6 compares the predictions of the theory with the data on hours of work in each country relative to the US. Tables B-7 and B-8 present these facts separately for non-college and college individuals. In evaluating these predictions, it is most interesting to focus on individuals aged 60–64 since these are the ages where the variation in social security rules are likely to have a more pronounced effect on labor supply behavior. Moreover, the data reported in Table 6 shows that after age 60 there are huge differences in labor supply between the US and the European countries (except Switzerland). Relative to the United States, the hours worked by men aged 60–64 is 49% in the Netherlands, 66% in Spain, 44% in Italy, and 29% in France. The quantitative experiment predicts a value of 43% for the Netherlands, 53% for Spain, 36% for Italy, and 37% for France. On the other hand, the data show that men aged 60–64 work 26% more hours in Switzerland than in the US. The theory predicts that men in Switzerland work 4% less than in the US.

The experiment just discussed changed for each country four "primitives": (i) the social security system; (ii) the tax code (consumption, investment, earnings, and capital income taxes); the fractions of individuals with (iii) disability and with (iv) college education. We now evaluate the relative importance of these mechanisms in generating labor supply differences across countries. In a first experiment, the model economy is simulated assuming that all countries have the US tax system (consumption, investment, earnings, and capital income taxes) but differ in terms of the other country-specific policy parameters (social security system and the fraction of individuals with disability and with college education). The results from this experiment are reported in Table 6 in the row labeled "US Taxes." The results indicate that the tax system accounts for only a small part of the decline in the labor supply of men late in the life cycle in the European countries relative to the US. Focusing on the age group 60–64, replacing the Spanish tax system with the US one increases the labor supply of men in Spain relative to the United States from 53% to 54%. Thus, it accounts for only a small fraction of the overall change in labor supply predicted by the model for Spanish men aged 60–64. For the other countries, replacing their tax systems with the US tax system delivers an increase in labor supply of 0 percentage points for Switzerland, 6 for the Netherlands, 6 for Italy, and 5 for France. As in Spain, taxation accounts for a small fraction of the cross-country differences in labor supply predicted by the theory.

In a second experiment, the fraction of college individuals in the baseline economy is kept constant while all the other policy parameters vary across countries. The results are reported in the row labeled "US Fraction of College." We find that the effects of this experiment are only quantitatively important for Spain and Italy. The relative labor supply of men aged 60–64 increases by 9 percentage points (from 53% to 62%) in the case of Spain and by 4 percentage points (from 36% to 40%) in the case of Italy. Recall that the fraction of disabled individuals also varies across countries. In order to isolate how this factor matters for labor supply differences across countries, we compute the average labor supply among those individuals in the population who are not disabled (see the row labeled "Disability"). We find that disability policies matter importantly for the Netherlands and Spain. When focusing on people who are not disabled, the labor supply of individuals aged 60–64, relative to the US, increases from 0.43 to 0.50 in the Netherlands and from 0.53 to 0.63 in Spain. For all the other countries, disability policies do not play an important role in accounting for the low labor supply relative to the US.

In a third experiment, the model economy is simulated assuming that all countries have the US social security system. The results from this experiment are reported in the row labeled "US Social Security" in Table 6. Altogether, the results indicate that social security accounts for most of the variation in labor supply across countries for individuals aged 60–64. This is true even in the case of Spain where the low fraction of college people and the large number of people on disability play an important role. While these two effects account for a reduction in the Spanish labor supply of 0.19 relative to the US labor supply, the decrease due to the social security system alone amounts to 21% of the US labor supply. As a result, the social security system in Spain accounts for at least half of the differences in labor supply between individuals aged 60–64 in Spain and in the US.[28] The Dutch social security rules account for a reduction in labor supply of individuals aged 60–64 of 0.33 relative to the US, accounting for more than half of the total labor supply differences across these two countries.[29] Moreover, the social security system accounts for all of the low labor supply of aged 60–64 individuals in France and Italy relative to the US.

Social security is also important for understanding cross-country differences in labor supply late in the life cycle across education groups (Tables B-7 and B-8). With the exception of Switzerland, in all of the European countries the labor supply of individuals aged 60–64 relative to the US is lower for non-college than for college individuals. Our theory accounts well for this pattern in the data. We find that the social security rules in the European countries have a particularly strong negative effect on the labor supply of non-college individuals.

6.4. Aggregate labor supply differences: ages 25–65

Focusing on aggregate hours of work for individuals aged 25–65, the theory predicts that men in Switzerland work as much as in the United States. For all other countries, men work less than in the US with aggregate hours ratios ranging from 0.90 in France to 0.83 in Italy.[30] The theory thus implies that labor supply differences late in the life cycle are much larger than the ones observed across all age groups.

7. Discussion on taxes and labor supply

We now turn to discussing the importance of some of the features of the model environment.

[28] While the Spanish baseline economy predicts that the labor supply of individuals aged 60–64 is about 47% lower than in the US, the sum of the effects of all policies in isolation (differences in (i) taxation, (ii) fraction of college educated, (iii) fraction on disability, and (iv) social security system) account for a total reduction of 41 percentage points, with the remaining difference being accounted for by the non-linear interactions between these policies.

[29] As in Spain, the effects of all Dutch polices (in isolation) add up to a reduction in the labor supply of individuals aged 60–64 of 0.46 relative to the US, while their combined effect accounts for a decrease in labor supply of 0.57 relative to the US.

[30] The ratios of aggregate hours for the Netherlands, Spain, and France are 0.87, 0.89, and 0.90, respectively.

7.1. Rebating tax receipts with lump-sum transfers

At first sight, our findings imply that labor supply is much less responsive to taxes than previous papers in the literature (Prescott, 2002, 2004; Ohanian et al., 2008). While Prescott (2002) finds that differences in taxes in France and the United States account for virtually all of the 30% difference in labor input per person between these countries, our findings only account for a 10% difference in labor supply. A more comprehensive comparison of the results, however, should consider that Prescott (2002, 2004) assumes that all tax receipts are distributed lump-sum back to households based on the idea that public goods are good substitutes for private consumption (e.g., public schools and hospitals are good substitutes for private schools and hospitals). Prescott (2002, 2004) argues that this assumption is crucial for generating a large response of labor supply to tax changes.[31] On the other hand, our quantitative experiments assume that none of the tax receipts are rebated back to consumers. Hence, we now simulate in our baseline model economy the French and the US policies under the assumption that all tax receipts (from τ^c, τ^k, τ^l, and $T(y)$) are rebated back to the households. We find that the aggregate labor supply under French policies is now 24% lower than under US policies, a result that is close to the findings in Prescott (2002, 2004) and more than twice the value of 10% that we obtained in our baseline experiment with no rebates. Despite the similar quantitative findings, it is interesting to point that the implied Frisch elasticity of labor supply in our model is less than a fourth than the one in Prescott (2002, 2004). When there is an active extensive margin, labor supply responses to policy changes are not well approximated by the Frisch elasticity of labor supply (see Rogerson and Wallenius, 2009; Erosa et al., 2011).

7.2. Linear wages

Modelling non-linear wages allows the baseline economy to match reasonably well the decrease in labor hours after the age of 50 in the US data. A natural question is whether this feature matters for the effect of policies on labor supply. In order to investigate this issue, we now consider a new recalibrated baseline economy with linear wages. As before, β is calibrated to match the asset to income ratio, W to match average earnings, and the international interest rate is set so that the baseline economy with US policies has zero net capital flows. French policies are then introduced into the new baseline economy with linear wages. Two main findings emerge. First, aggregate hours worked in France relative to the US are approximately the same as in the economy with non-linear wages (10% lower).[32] Second, however, non-linear wages matter importantly for labor supply responses after age 60. For the age group 60–64, labor supply in France relative to the US is 0.56 with linear wages and 0.37 with non-linear wages. The larger change under non-linear wages is accounted for by labor supply responses along the extensive margin.

7.3. Proportional taxes

Relative to the literature analyzing the role of taxation on labor supply differences across countries, a distinguishing feature of our paper is to model the progressivity of taxes on earnings. In order to investigate the importance of this feature, we simulate the US and France under proportional taxes. We compute a new recalibrated US baseline economy with a flat tax on labor earnings equal to the average tax in the original US baseline economy. This procedure is then repeated for France. It is found that replacing the progressive tax system on earnings with a flat tax has small effects on labor supply in the US economy (about a 2% increase). On the other hand, the increase in labor supply is much larger in France, with an increase in the hours worked per person aged 25–65 of 6.7%. This finding is due to the fact that the progressivity of the taxation of earnings is much higher in France than in the US. It follows that the progressivity of the tax system matters for understanding labor supply differences across countries.

7.4. Closed economy

The baseline experiments consider a world of open economies. As a robustness check, it is interesting to analyze a world of closed economies. Since the international interest rate was calibrated to generate a zero net capital flows into the US, we now simulate French policies in a closed economy. We find that the aggregate labor supply and the decline in labor supply late in the life cycle under French policies do not depend significantly on whether the economy is open to international capital flows or not.

8. Concluding remarks

The role of social security, disability insurance, and taxation is analyzed for understanding differences in labor supply late in the life cycle (age 50+) across European countries and the United States. A life-cycle model of labor supply and

[31] Tax rebates offset the wealth effects of tax changes, which affect labor supply in a direction opposite to the one from the substitution effect.

[32] This finding is consistent with the message in Erosa et al. (2011) who show that non-linear wages do not affect the quantitative response of labor supply to a permanent tax change, although they do amplify substantially the response to temporary wage and tax variations.

retirement decisions that accounts well for key regularities of labor supply in the US is first built. The quantitative framework is then used to replace US government policies (social security, taxation, and disability insurance) with European style policies. The main finding is that the model accounts well for the decline in labor supply late in the life cycle for most European countries in the study, supporting the view that government policies can go a long way towards accounting for labor supply differences across countries. Social security rules account for the bulk of cross-country differences in labor supply late in the life cycle (with its contribution varying from 50% to 100%), but other policies also matter. In accounting for the low labor supply relative to the US at ages 60–64, taxes matter importantly in the Netherlands (6%), Italy (6%), and France (5%); disability insurance policies are important for the Netherlands (7%) and Spain (10%); and the low fraction of college individuals is a contributing factor in Italy (4%) and Spain (9%). When we simulate tax policies under the assumption that all tax revenues are rebated, the effect of taxes is as large as in Prescott (2002, 2004), despite the fact that our parameterization of the utility function implies a much lower elasticity of labor supply (about one-fourth of the one in Prescott, 2002, 2004). In our framework, due to an active extensive margin, labor supply responses to policy changes are not well approximated by the Frisch elasticity of labor supply (Rogerson and Wallenius, 2009; Erosa et al., 2011).

Our paper is a first step towards developing a quantitative life-cycle theory to evaluate tax and transfer programs across countries. In future research, we plan to incorporate unemployment and medical expenditures in order to evaluate the effects of unemployment insurance and health policies across countries. The main finding in this paper, that government policies matter importantly for the large differences in labor supply of men across countries, should be even more important for women. Hence, it would be interesting to extend the framework in this paper and, following the work of Guner et al. (2008), model both males and females.

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Appendix A. Details of the social security systems

A.1. Spain

The Spanish public pension system is of a defined benefit type and is organized in three regimes: the General Regime, the Special Regimes (for a few occupations), and the Regime for Civil Servants. We model the General Regime (Régimen General de la Seguridad Social) after the 1997 reform, which applies to more than 70% of workers.[33] The early and normal retirement ages are 60 and 65 years. The initial pension is proportional to individuals' average earnings in the last 15 years of work (the earnings base). In computing the earnings base, individuals' monthly earnings are indexed to inflation (but not to real wage growth) except for the earnings in the last 24 months. The model assumes that an individual that retires at age 65 collects a pension with a replacement rate of 90% of base earnings.[34] Moreover, pensions decrease by 8% per year of early retirement and increase by 2% per year of late retirement. There are minimum and maximum pensions equal to 37% and 90% of the economy's average earnings. Pensions are financed with a payroll tax of 28.3%. Contributions into the system are capped at an earnings' ceiling of 1.64 of average earnings in the economy. The Spanish Social Security considers three degrees of disability: incapacity to work in the usual occupation (IPT), incapacity to do any kind of job (IPA), inability to do any kind of job plus requiring assistance to carry the basic vital functions (GI). Since the model assumes that individuals cannot work when disabled, we model the disability pension of the IPA-GI degree of disability, which has the same replacement rate as regular pensions. Since pension benefits in Spain are indexed to inflation, in the model pensions are kept constant as individuals age.

[33] See Boldrin et al. (2004) for a very detailed description of the Spanish Social Security System.

[34] This replacement rate is obtained by assuming that individuals have 30 years of contribution at age 65, which is the average years of contribution at retirement in Spain, as reported in Boldrin et al. (2004). The replacement rate for an individual retiring at age 65 is 50% for the first 15 years of contributions, increases by 3% for each additional year of contribution between 15 and 25 years, and increases by 2% per year of additional contribution between 25 and 35 years. There is a maximum replacement rate of 100%.

A.2. Italy

There were important reforms in the Italian public pension system in 1992 and 1995. However, the rules of the pre-1993 regime apply to workers with at least 15 years of contribution at the end of 1992. Since people will retire under the pre-1993 system until about the year 2015 (Brugiavini and Peracchi, 2004), we consider the social security rules prevailing before 1993 to be consistent with the data in the 2004 and 2006 SHARE. About 2/3 of the work force in Italy is insured with the National Institute of Social Security, whose most important fund covers the private sector employees (Fondo Pensioni Lavoratori Dipendenti or FPLD). For these workers, the pension benefit is computed as the product of three terms: pensionable earnings (average of 5 years before retirement), number of years of contributions (up to 40 years), and a 2% factor per year of contribution. The normal retirement age is 60 for males but individuals can retire at any age if they have contributed at least 35 years to the system. In modelling the Italian social security system, we assume that individuals reach 35 years of contributions at age 57 for non-college and at age 62 for college types. The minimum pension is about 22% of the economy's average earnings (5300 Euros in 2004). The payroll tax in 1992 was 27.17% of which the worker paid 8.34%. The entitlement to a permanent disability pension is based on the absence of all other forms of income. We model disability pensions as equal to regular pensions (including the penalties for early retirement). The model also incorporates a minimum disability pension of 4700 Euros in 2004.

A.3. The Netherlands

The Dutch pension system has two pillars: a flat-rate public pension and a mandatory occupational pension scheme. In addition, there is a separate scheme to finance early retirement pensions. The normal retirement age is 65 years and early retirement is allowed from age 55. From age 65 on, residents in the Netherlands (for at least 50 years) receive a flat-rate pension benefit which is related to the minimum wage and which is financed in a pay-as-you go fashion (old-age pension). This flat pension benefit is about 30% of the average earnings in the Netherlands (OECD, 2009). Since the benefit value is linked to the minimum wage (updated biannually), we assume in the model that the flat-rate pension grows at the same rate as real wages.

Most employees are entitled to a supplementary occupational pension. Occupational pensions are earnings-related and part of collective labor agreements covering 90% of the labor force (see Bovenberg and Gradus, 2008). Approximately 94% of employees are covered by defined benefit pension funds and 77% of them received a pension related to their lifetime average earnings while the rest receive a pension related to their final salary (see OECD, 2009). Consequently, occupational pensions are modelled as depending on the lifetime average earnings of the individual type (education and fixed effect). In computing the lifetime average earnings, annual earnings are indexed with real wage growth. The replacement rate is 70% and benefits are reduced by a franchise amount which varies with the pension fund. In the paper, we assume a franchise of 40% of average earnings which is the value that applies for most workers (see Table 2.2 in Euwals et al., 2010). We also assume that occupational pensions grow at the same rate as wages.

Early retirement schemes allow individuals to retire before age 65. Participation in these schemes is mandatory for employees. Early retirement schemes were introduced in the 1970s (VUT) and operated as a pay-as-you-go system. These schemes were gradually replaced by the capital funded pre-pension (PP) schemes that try to create more incentives to work. According to Euwals et al. (2010, page 6), transitional arrangements were introduced in order to smooth the transition from the flat rate VUT scheme to the PP scheme. In practice, however, it turned out that most older workers continued to face early retirement arrangements that were close to the old schemes. An exception was the ABP, the pension fund for civil servants and individuals working in the educational sector. This pension fund started reforming relatively early and introduced some actuarial adjustments into its schemes from 1997 on. We model the early retirement scheme following the rules of the ABP fund applied since 1997 for individuals born in 1942 and after (Table 2.1 in Euwals et al., 2010). These individuals were age 60 in 2002 so our SHARE data may observed some of them. The replacement rate determining the early retirement pension depends on the age of the individual at retirement and equals 0.7 for ages 61–64, 0.55 for age 60, 0.45 for age 59, 0.38 for age 58, 0.32 for age 57, 0.28 for age 56, and 0.25 for age 55.

The payroll tax is 0.238 (0.179 is paid by the employee) for earnings up to 80% of the economy's average earnings in 2006. Above this earnings level and up to earnings equal to 116% of average earnings, the employer pays a payroll tax of 0.0656 to finance disability pensions. The disability pension is set equal to the pension benefit the individual would have received at the normal retirement age.

A.4. Switzerland

The Swiss pension system has two pillars: an earnings related public pension and a mandatory occupational pension. The normal retirement age is 65 years, and a full pension is received if individuals have contributed for 44 years to the system. The public pension depends on the individual's average lifetime earnings, and the pension formula is progressive. If lifetime average earnings are below 0.535 of the average economy's earnings, the pension equals 13.2% of the economy's average earnings plus 26% of the individual's earnings. For individuals' earnings above 0.535 of the economy's average earnings, the pension equals 18.55% of the economy's average earnings plus 16% on the individual's lifetime average earnings. There is also a minimum pension (17.8% the economy's average earnings) and a maximum pension equal to twice the level of the minimum pension. Pensions are indexed 50% to prices and 50% to nominal earnings (see OECD, 2009). In the paper, we assume that pensions are constant as individuals age. Individuals can retire as early as at age 63 but the pension is reduced by 6.8% for each year of early retirement (until age 65). Late retirement (after age 65) increases the public pension by 5.2% for 1 year of deferral, by 10.8% for 2 years, 17.1% for 3 years, 24% for 4 years, and 31.5% for 5 years of deferral. It is possible to claim the public pension at age 65 and continue working but no additional pension entitlements can be earned. Public pensions are financed by a payroll tax of 10.1%, half of which is paid by the employer.

The coverage of mandatory occupational pensions is nearly universal (OECD, 2009). Occupational pensions are related to the individual's contributions. The contribution rate varies between 7% and 18% depending on age (7% for ages 25–35, 10% for ages 35–45, 15% for ages 45–55, 18% for ages 55–65, and 0% for individuals older than 65). For an individual retiring at age 65, the occupational pension equals the product of the sum of contributions and the factor 0.071. In general, early retirement is allowed up to 5 years before the normal retirement age. If the individual retires early, the statutory annuity rate is reduced from the 7.1% by 0.2% per year of early retirement. Similarly, the annuity rate is increased by 0.2% per year of late retirement up to 5 years.

Regarding disability pensions, the full pension is paid if the insured is assessed at least 70%. In the paper, we assume that disabled individuals receive the full pension but we apply the penalties for early retirement.

A.5. France

The French pension system has two tiers: an earnings related public pension and a mandatory occupational pension based on a points scheme (OECD, 2009). A full-pension in the public system requires 40 years of contributions but before 2003 it was granted with 37.5 years of contributions. In the paper, we assume that a non-college individual can receive a full pension at age 60, while a college individual can receive a full pension at age 63. The replacement rate of a full pension is 50%. The pension rate is reduced by 5% per year of early retirement. If people have reached the qualifying conditions for full pension and work, each additional year of work increases the public pensions by 3% (this incentive changes from 2007, see page 196 in OECD, 2009). Pensions are indexed to inflation. There is a minimum pension equal to 23% of the economy's average earnings if the individual has contributed 40 years or is older than 65. The maximum pension equals 50% of the economy's average earnings.

Average earnings are computed over 23 years and they are only adjusted by inflation. There is a ceiling on eligible earnings equal to the economy's average earnings. The payroll tax is 0.1475 (0.082 paid by the employer) on the insured earnings while the tax rate above that earnings level is 0.017. In addition, a tax rate of 1% is applied on total earnings to finance disability pensions.

Occupational schemes provide 40% of the pensions for workers in the private sector and contribution to these complementary schemes became compulsory in 1972 (see Mahieu and Blanchet, 2004). They consist of 180 schemes that are divided in two main organisms: AGIRC for executive workers and ARRCO for other workers. In the paper, we model the rules of the ARCCO scheme that apply to wage earners in the private sector (we do not model the rules for civil servants). The normal retirement age is 65 and there is a quasi-actuarial adjustment for early retirement (full retirement pension is possible at 37.5 years of contributions after the 1983 reform). The pension is calculated based on a point system so that it is a defined contribution system. Individuals accumulate points during their career and at the retirement year a point value is applied to compute the benefit. For earnings below the economy's average earnings a contribution rate of 6% is applied. Above that earnings level and up to three times the economy's average earnings a contribution of 16% applies (OECD, 2009). The number of points earned in a particular year are computed dividing the contributions by the cost of the pension point that year (13.027 Euros in 2006). The total accumulated points are multiplied by the point value (1.1241 Euros in 2006) to compute the pension benefit at retirement.

Regarding disability pensions, the benefit equals 50% of the average earnings in the best 10 years if incapable of any professional activity up to a maximum of 48% of average earnings in the economy. There is a minimum pension of 9% of the economy's average earnings. In the paper, we assume that the average earnings are computed over the full career of the individual type (education and fixed effect) and we apply a replacement rate of 50%. We apply a reduction for early retirement as in the regular pensions.

Appendix B. Supplementary data

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jmoneco.2011.10.006.

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