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Early retirement decisions: Lessons from a dynamic structural modeling.

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ABSTRACT
Early retirement has many causes according to economic and sociological literature. These causes may be the preference for leisure, financial and health conditions, and social environment. In our paper, we aim to specify and estimate an econometric model to assess the early retirement decision-making process for aged workers. We specify a worker's utility function from which we derive worker's probability to retire earlier that depends on her health stock, estate value and preference for future. We also estimate an health production and an health consumption functions that are key factors in the individual's decision to retire earlier. Thus, we show that our model disentangles between three groups of workers: (i) those who are more likely to choose early retirement, (ii) those who are more likely not to choose early retirement and (iii) those who are uncertain about early retirement. We also show that our predicted early retirement probability is a good predictor of early retirement as it is causal for observed early retirement.

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Introduction

There is a large literature in sociology and economics that examines the decision to retire early. These studies highlight several factors that determine the retirement decision, including the preference for leisure, financial conditions, individual health, social environment, and workplace condition.

Preference for leisure at individual level is closely linked to financial conditions. Indeed, if early retirement is expected not to affect negatively individual's financial situation, then individuals will be more likely to retire earlier, especially if they have a strong preference for leisure [6]. Regarding social environment, the retirement status of a spouse, family members or neighbours, can influence an individual's decision to retire earlier [6]. Furthermore, access to post-retirement opportunities increases the likelihood to retire early. It is worth noting that these opportunities may be shaped by education level, regional unemployment rates, or the specific industry in which the individual works. In addition, health is critical for labor force participation. Individuals in poor health are less likely to continue working. Therefore, individual perceived ability to stay in the job market, along with favorable working conditions, can reduce the likelihood of early retirement.

The use of relevant microeconomics datasets to analyze the theoretical findings is a more recent development in the literature. These papers commonly use two binary measures: (i) individual intention to retire early, and (ii) the observed early retirement.

Workplace condition is the main determinant analyzed in the literature. While Quinn [25] finds no evidence effect of job characteristics and financial variables on early retirement, many studies challenge this finding. Pollak [24] shows that health status, job satisfaction and workplace condition are the major factors that explain the decision of early retirement. Debrand and Blanchet [13] and Mein et al. [22] show that job satisfaction reduces the probability to look for early retirement. Siegrist et al. [26] also show that effort reward imbalance and poor quality of work are main factors that explain that workers look for early retirement. The workload is also an important determinant of early retirement [5].

There is also empirical evidence that early retirement is related to earnings. Bazzoli [3] finds that economic variables play a more important role than health in retirement decision-making process. Workers with higher-paid jobs are more likely to retire earlier [22]. However, wage rate has a non linear effect on early retirement (Dorn and Sousa-Poza [15]); with both workers with high and low wage being more likely to keep working. In addition, eligibility to and coverage of social security play important roles in the decision to retire early ([15]; [25]).

Finally, post-retirement opportunities and economic sector also determine the decision to retire early. These opportunities are related with unemployment rate, school grade and activity sector [6] or to demographics characteristics such as marital status and spouse employment status [21]. Thirty percent of workers that retire early continue working after retirement [15], even in jobs with a degree of informality [2]. Decision to retire early is also specific to economic sectors [15]. For example, Alhawarin [2] shows that workers in army forces are more likely to retire early.

Both current and perceived future health play an important role in the decision to retire early ([5];[3]). The literature highlights that retirement has a health-preserving effect [8]. Workers are more likely to retire if they have poor health [17] or if they perceive that their future health condition will limit their ability to work [3]. Indeed, health problems, including disabilities and health shocks, increase the probability of early retirement [1] and lower the probability to participate to labour market [25] and the working hours [7]. The likelihood to retire early increases with the severity of health shock and the rate of work stoppage ([27]; [21]). In addition, the fear that health condition limits work capacity increases the likelihood of seeking early retirement [13].

Social environment of workers, including household size and partner's employment status, plays an important role in the decision of early retirement. The literature shows that increase in family size reduces the likelihood to retire early [1]. Regarding the partner employment status, it appears that because couples coordinate their retirement decision [1], workers with retired partner are more likely to retire earlier ([15]; [27]; [5]; [1]; [21]).

From the reviewed literature, it appears that individuals will retire early if (i) their health condition limits his capability to continue working, (ii) their perceived future health condition does not allow them to continue working, or (iii) they have low quality jobs. In this paper, our main goal is to assess the early retirement decision making process for aged workers. For this purpose, we take advantage of Grossman's model (1972) to specify and estimate a micro-economic model that accounts for workers financial, health, and working conditions and some socio-economics variables.

In Section 1, we present our microeconomic approach which, based on the Grossman model, provides us (i) a health production and (ii) a health consumption functions. In

Section 2, we present our dataset and some related statistics. Based on the microeconomic specification of Section 1, we estimate the different equations of our model in Section 3. This allows us to calculate a predicted retirement probability at each time period. Conclusion gives some implications of our findings.

1. The economic model

This section presents the theoretical framework of the paper. We first describe the dynamic of health stock and estate, and we end by specifying the model and its constraints. Let $\rho_{i,t}$ denotes the normalized working time of individual i at t, with $\rho_{i,t} = 1$ if individual i is retired at t and zero if full time job is observed. Let $p_{i,t}$ denotes the retirement probability.

1.1. *Health and estate equations*

Based on Grossman's theory on health capital [18], we propose a health stock dynamic equation for workers. The original model proposed by Grossman is the following:

$$H_{i,t} - H_{i,t-1} = I_{i,t-1} - \delta_{i,t-1} H_{i,t-1} \tag{1}$$

where $\delta_{i,t-1}$ denotes the health depreciation rate at time $t-1$ for individual i, $H_{i,t}$ is the health stock at t and $I_{i,t-1}$, the investment in health at $t-1$ for individual i. Since we focus on workers, it is possible to decompose health depreciation rate into three sources that are: (i) depreciation due to working condition, (ii) depreciation due to ageing, and (iii) natural depreciation due to the effects of illnesses on health. Thus, $\delta_{i,t}$ can be expressed as follows:

$$\delta_{i,t} = \alpha_1(1 - \rho_{i,t})C_{i,t} + \alpha_2 Agesq_{i,t} + \alpha_3 Age_{i,t} + \alpha_4 H_{i,t} \tag{2}$$

Where $Age_{i,t}$, $Agesq_{i,t}$ and $H_{i,t}$ are respectively age, the square of age and the health stock of individual i at the date t. Equation 2 also includes the working condition C_{it} which is a continuous variable over $[0, 1]$ ($C_{it} = 1$ if the working condition is excellent).

To adjust health stock to a desired level, worker can invest in his health stock. However, the decision to invest in health also depends on individual financial situation. Investment in health $I_{i,t}$ is a function of the amount spent in health care or prevention [20]. Let f denotes the health production function, and $h_{i,t}$ the amount that the individual i spends for his health at t. Then, we can rewrite health investment as $I_{i,t} = f(h_{i,t})$. Consequently, the health stock at $t+1$ is given by:

$$H_{i,t+1} - H_{i,t} = f(h_{i,t}) - \Bigg(\alpha_1(1 - \rho_{i,t})C_{i,t} + \alpha_2 Agesq_{i,t} + \alpha_3 Age_{i,t} + \alpha_4 H_{i,t}\Bigg) H_{i,t} \tag{3}$$

Equation 3 allows (i) to estimate how productive health expenditures are, and (ii) to disentangle the health depreciation due to job from the depreciation due to others factors.

Individual's estate includes financial assets, real assets and debts. Estate accumulation dynamics is given by:

$$E_{i,t} = (1+\pi)E_{i,t-1} + (1-\omega_i\rho_{i,t})W_{i,t} - h_{i,t} - c_{i,t} \tag{4}$$

where $E_{i,t}$, $W_{i,t}$, $c_{i,t}$, π, and ω_i are respectively estate, revenue from current job, total expenditures, the interest rate, and the share of last job income lost at retirement for individual i at period t.

1.2. *Model, constraints and optimal state*

There are two main factors at the period t on which individual can make a decision to maximize her utility. These controls are:

- Decision to retire: if an individual decides to work, her health stock decreases by $\alpha_1 C_{i,t} H_{i,t}$ due to health condition and her estate value increase of $\omega_i W_{i,t}$. Let g denotes the health depreciation function due to job, we can express the health depreciation saved by a retirement as $\alpha_1 C_{i,t} H_{i,t} = g\big((1-\rho_{i,t})\omega_i W_{i,t}\big)$. It is worth noting that this framework can accommodate the case where workers can decide to reduce their working time from the full time work to a partial time work in order to preserve health decrease.
- Amount invested in health: investment aims to slow down health depreciation rate by paying for care. It involves reducing estate level to earn a compensation of health stock depreciation. A unit increase in health expenditures $h_{i,t-1}$ increases the health stock by $f^{'}(h_{i,t-1})$.

We assume that worker has a utility function that only depends on consumption $c_{i,t}$ and health stock $H_{i,t}$. We assume the following separable utility function form:

$$u(c_{i,t}, H_{i,t}) = \frac{c_{i,t}^{1-\lambda}}{1-\lambda} + a\frac{H_{i,t}^{1-\gamma}}{1-\gamma} \tag{5}$$

Where a, γ, and λ are positive parameters. These coefficients are estimated at the country level, using the Hall and Jones (2007) methodology. Let r_i denotes the utility discount factor. Thus, the overall lifetime utility function is given by:

$$u_i = u(c_{i,t}, H_{i,t}) + r_i V(E_{i,t+1}, H_{i,t+1}) \tag{6}$$

where $V(E_{i,t+1}, H_{i,t+1})$ is the Bellman value function. An individual optimal state at t is a value of $h_{i,t}$ and $c_{i,t}$ that maximizes utility. Thus, the worker's program is the following:

$$u_i \quad = \quad \underset{(c_{i,t},h_{i,t})}{Max}\left\{u(c_{i,t}, H_{i,t}) + r_i V(E_{i,t+1}, H_{i,t+1})\right\} \tag{7}$$

Subject to

$$\begin{aligned} H_{i,t+\tau+1} &= f(h_{i,t+\tau}) + (1-\delta_{i,t+\tau}) * H_{i,t+\tau} \quad \forall\tau = 1,...,T \\ E_{i,t+\tau+1} &= (1+\pi)E_{i,t+\tau} + (1-\omega_i\rho_{i,t+\tau+1})W_{i,t+\tau+1} - h_{i,t+\tau+1} - c_{i,t+\tau+1} \quad \forall\tau = 1,...,T \end{aligned}$$

The first and second constraints are respectively health and estate accumulation constraints. The first order conditions of the maximization problem in Equation 7 above are given by:

$$\begin{aligned}\frac{\partial u_i}{\partial c_{i,t}} &= c_{i,t}^{-\lambda} - r_i(1+\pi)\frac{\partial V(E_{i,t+1}, H_{i,t+1})}{\partial E_{i,t+1}} = 0 \\ \frac{\partial u_i}{\partial h_{i,t}} &= -r_i(1+\pi)\frac{\partial V(E_{i,t+1}, H_{i,t+1})}{\partial E_{i,t+1}} + r_i f^{'}(h_{i,t})\frac{\partial V(E_{i,t+1}, H_{i,t+1})}{\partial H_{i,t+1}} = 0\end{aligned} \tag{8}$$

where $f^{'}(h_{i,t}) = \partial f(h_{i,t})/\partial h_{i,t}$. Using the envelop condition, the following optimal states are derived:

$$\begin{aligned}\left(c_{i,t+1}^{*}\right)^{-\lambda} &= \frac{1}{r_i(1+\pi)}\left(c_{i,t}^{*}\right)^{-\lambda} \\ \frac{1+\pi}{f^{'}(h_{i,t}^{*})} - \frac{1-\delta_{t+1}}{f^{'}(h_{i,t+1}^{*})} &= \frac{aH_{i,t+1}^{-\gamma}}{\left(c_{i,t+1}^{*}\right)^{-\lambda}}\end{aligned} \tag{9}$$

where $c_{i,t}^{*}$ and $h_{i,t}^{*}$ are function of $E_{i,t}$, $H_{i,t}$ and $\rho_{i,t}$. Then, the overall lifetime utility value at optimal state for individual i at t is given by:

$$u_{i,t}^{*} = u(c_{i,t}^{*}, H_{i,t}) + r_i V\left((1+\pi)E_{i,t} + (1-\omega_i\rho_{i,t+1})W_{i,t+1} - h_{i,t+1}^{*} - c_{i,t+1}^{*}, f(h_{i,t}^{*}) + (1-\delta_{i,t}) * H_{i,t}\right) \tag{10}$$

At period $t-1$, worker will choose $\rho_{i,t}^{*}$ that maximizes $u_{i,t}^{*}$; i.e. $\rho_{i,t}^{*} = \arg\left(\max_{\rho_{i,t}} \; u_i^{*}\left(E_{i,t}, H_{i,t}, \rho_{i,t}\right)\right)$. We also assume that working a percent of full time job grant the equivalent percent of full time revenue; i.e., the revenue from job is $(1-\rho_{i,t})\omega_i W_{i,t}$. Since the retirement decision taken for t only affect the overall utility function at this date, the worker will choose $\rho_{i,t}$ that maximizes $u_{i,t}^{*}$. Thus, the optimal condition gives $\rho_{i,t}^{*}$ fulfills:

$$\frac{g^{'}\left((1-\rho_{i,t}^{*})\omega_i W_{i,t}\right)}{1+\pi} = f^{'}\left(h_{i,t}^{*}\right) \tag{11}$$

Equation 11 implies that (i) workers are less likely to choose early retirement ($\rho_{i,t}^{*} = 0$) if the marginal productivity of the optimal health expenditure at t equates the marginal health depreciation due to the salary share lost at retirement $\omega_i W_{i,t}$; (ii) workers choose early retirement ($\rho_{i,t}^{*} = 1$) if the marginal productivity of the optimal health expenditure at t is infinite; and (iii) workers have uncertainty ($0<\rho_{i,t}^{*}<1$) if the marginal productivity of the optimal health expenditure at t is finite but upper than the marginal health depreciation due to the salary share lost at retirement.

2. Data and descriptive statistics

In this section, we first provide a brief description of the Survey on Health, Ageing and Retirement in Europe (SHARE). Second, we present the methods used for constructing health and working conditions indicators. Finally, we provide a description of workers in terms of their health condition, job characteristics and social and financial conditions.

2.1. *Dataset*

The dataset used in this paper is panel of the waves of SHARE dataset. SHARE[1] is a longitudinal survey conducted each two years in European countries. It provides information on elders' health, economic and social conditions. It also includes the individual hopes[2] in terms of retirement. Other variables collected in the survey include health conditions, health care consumption, job characteristics, working environment, social variables, and financial condition (real and financial assets, and debts).

Since our focus is on workers, we exclude from the dataset all individuals who are non-workers at their first appearance in the panel. Furthermore, we exclude individuals with only a single observation period, as we are interested in analyzing the dynamics. After this data processing, our final dataset that contains 17,568 individuals who are observed from 2 to 4 times (2.75 periods on average). The pooled dataset contains 44,331 observations.

2.2. *Health stock and working condition indicators estimation*

Health and working condition are described by a set of categorical variables in the dataset. To construct an index based on these categorical variables, several approaches can be used, including multiple correspondence analysis (MCA) and regression analysis. In this paper, we use the ordered probit model since we have self-reported global health condition and global work satisfaction that are respectively variables of 5 and 4 levels scales (see Cutler and Richardson, 1997 [9] for further details on this approach). In the health stock equation, we control for declared diseases[3], mental health condition[4], and some demographics variables. In the working condition equation, we control for workload and job environment[5].

The average health stock is 9.3 in the pooled dataset[6]. Furthermore, Figure 1 shows that estimated health stock declines with age. Health stock is also significantly lower for retired than workers. We find a significant difference in health stock between

[1]The SHARE data collection has been primarily funded by the European Commission through the 5th Framework Programme (project QLK6-CT-2001-00360 in the thematic programme Quality of Life), through the 6th Framework Programme (projects SHARE-I3, RII-CT-2006-062193, COMPARE, CIT5- CT-2005-028857, and SHARELIFE,CIT4-CT-2006-028812) and through the 7th Framework Programme (SHARE-PREP, N° 211909, SHARE-LEAP, N° 227822 and SHARE M4, N° 261982). Additional funding from the U.S. National Institute on Aging (U01 AG09740-13S2, P01 AG005842, P01 AG08291, P30 AG12815, R21 AG025169, Y1-AG-4553-01, IAG BSR06-11 and OGHA 04-064) and the German Ministry of Education and Research as well as from various national sources is gratefully acknowledged (see www.share-project.org for a full list of funding institutions)

[2]The question asked is: *... look for early retirement in main job ?*

[3]Answers to the question *Doctor told you had:*, and the items are: heart attack, hypertension, cholesterol, stroke, diabetes, lung disease, asthma, arthritis, osteoporosis, cancer, ulcer, Parkinson disease, cataract, hip or femoral fracture.

[4]Self-reported variables: being sad or depressed, hopes for future, felt would rather be dead, trouble sleeping, less interest in things, irritability, lost of appetite, fatigue, concentration on reading and entertainment, enjoyment, tearfulness.

[5]Variables related to: job physically demanding, time pressure due to heavy workload, little freedom to decide how work is down, opportunity to develop skills, receiving support in difficult situation, receiving recognition for work, adequate earnings or salary, poor security, and poor prospects for job advancement.

[6]See Table A1 in appendices for full statistics on health stock among waves and on overall dataset. Full estimations results are provide in Delattre and Moussa (2008) [14].

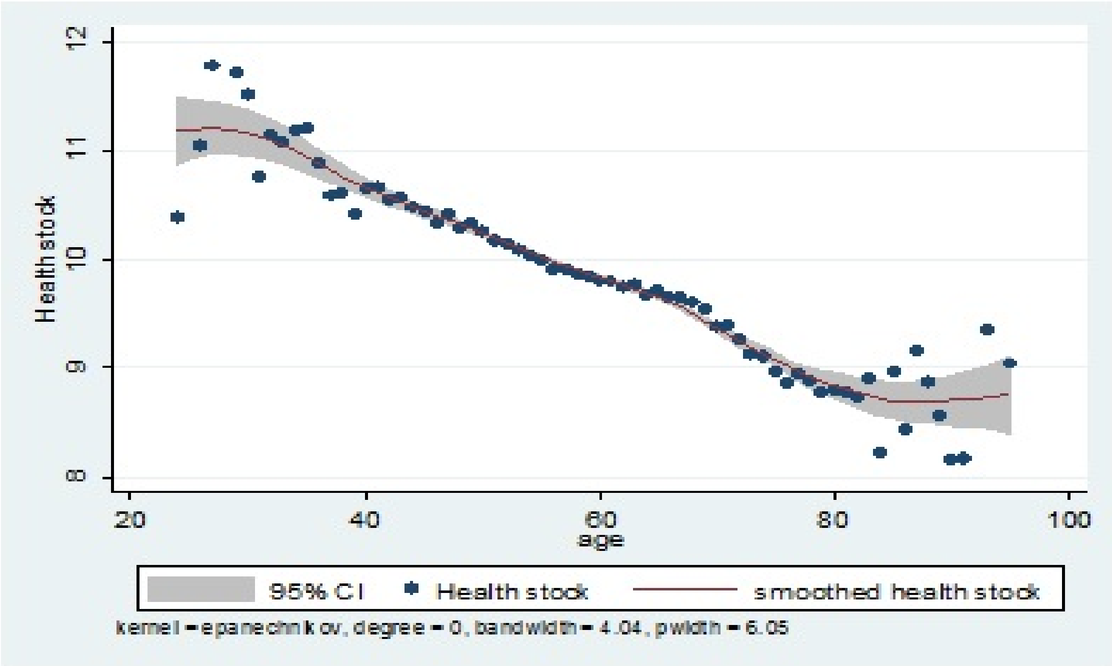

Figure 1. Evolution of health stock among age

workers looking for early retirement than those who do not. Figure A1 in appendices shows the dynamics of job satisfaction with respect age. It appears that elders are most satisfied than younger workers.

2.3. *Some determinants of early retirement in Europe*

This section aims at comparing workers that look for early retirement to those who do not with respect to key socioeconomic variables that might affect the decision to retire early. Table 1 shows that workers who are looking for early retirement (Early=Yes) are more likely to retire at the next period.

Table 1. Proportions of workers who retire among European aged workers

Early	Wave 2	Wave 4	Wave 5	Overall
Yes	0.1722 (0.0074)	0.348 (0.0098)	0.1959 (0.0059)	0.2268 (0.0043)
No	0.1342 (0.0058)	0.2676 (0.0078)	0.1579 (0.0043)	0.1774 (0.0033)
Difference	0.038*** (0.0092)	0.0804*** (0.0125)	0.038*** (0.0072)	0.0494*** (0.0053)

Early=Yes: worker looked for early retirement at last wave.
***: significant at 1% level. Standard errors are in parenthesis.

The proportion of workers looking for early retirement slightly declines from 43.3% at the first wave to 39.9% at the last wave. Table A2 in appendix 4 shows that workers who are looking for early retirement are younger than those who do not. Furthermore, workers who are looking for early retirement are less satisfied of their job and are in worst working condition. However, workers with high school level are less likely to look for early retirement.

Workers seeking early retirement are not in better financial condition than those who do not (see Table A3 in appendix 4). On average, their annual earnings and bank account balances are significantly lower. This suggests that workers with lower earnings and savings may prefer to preserving their health over continuing working. Furthermore, we find that workers looking for early retirement are those with higher (39.25% vs 32.83%) percentage of salary to be received as pension. In terms of out-of-pocket health expenditures, we find a significant difference of 26.45€ between workers who are not look for early retirement and those who are.

Post retirement opportunities are determinant for retirement ([6]; [15]). The proportion of retired who continue working among elders workers is growing (from 3.2% to 10.1%). Estonia (28.4%), Israel (21.3%), France (12.8%), and Switzerland (8.8%)[7] are the countries that are most concerned. This proportion is lower among female workers and higher among workers with higher school level.

3. Empirical models and results

In this section, we discuss the estimation of the main parameters of our model, including health depreciation due to working condition and health consumption and production functions. For this purpose, we start by estimating $I_{i,t}$ and $\delta_{i,t}$ from the Grossman model.

3.1. *Empirical estimation of Grossman's model*

Many papers have proposed reformulations for the empirical estimation of a reduced form of the demand for health and demand for health care equations based on the Grossman model given by equation 1. Wagstaff (2002) underlines consistency problems that can arise in empirical researches. These problems may result in incorrect estimates due to inappropriate assumptions when transitioning from the theoretical to the empirical model. To overcome this problem, Wagstaff (2002) assumes that the desired health stock is given by $H_t^* = \beta X_t + u_t$ where X_t is a set of exogenous variables and that individuals are not able to adjust instantaneously the health stock. Then, Wagstaff's model includes a fraction μ (between 0 and 1) to capture the instantaneous adjustment rate of the desired health stock.

In our model, only health investment I_t and health depreciation are unobserved since a measure of health stock is constructed. As δ is assumed to be individual and time variant, the equation to estimate is the following one:

$$H_{i,t} = I_{i,t-1} + (1 - \delta_{i,t-1})H_{i,t-1} + \xi_{i,t} \tag{12}$$

Where $\xi_{i,t} = \xi_i^1 + \xi_{i,t}^2$, with the individual effects $\xi_i^1 \sim$ N$(0,\sigma_1^2)$, the idiosyncratic error $\xi_{i,t}^2 \sim$ N$(0,\sigma_2^2)$ and ξ_i^1 and $\xi_{i,t}^2$ are independent. This dynamic model with hidden factors $I_{i,t-1}$ and $\delta_{i,t-1}$ can be estimated using a space-state model (Peyrache and Rambaldi, 2012). It allows to provide estimated values of state variables (I and δ). From the specification in equation 12 above, two hidden states equations have to be defined:

[7] See Tables B1 and B2 in appendix 5 for further statistics on post retirement employment.

for the health investment $I_{i,t-1}$ and the health depreciation rate $\delta_{i,t-1}$. To achieve this goal, we make two assumptions. The first one is related to health investment. Individual health investment is assumed to have the following specification:

$$I_{i,t} = a_{1,0} + a_{1,1} I_{i,t-1} + a_{1,2}\delta_{i,t-1} + \xi^{I}_{i,t} \tag{13}$$

$$\delta_{i,t} = a_{2,0} + a_{2,1} I_{i,t-1} + a_{2,2}\delta_{i,t-1} + \xi^{\delta}_{i,t} \tag{14}$$

Where $\xi^{I}_{i,t} \sim \mathrm{N}(0,\sigma^2_I)$ and $\xi^{\delta_1}_{i} \sim \mathrm{N}(0,\sigma^2_\delta)$. A Kalman Filter algorithm[8] as developed by De Jong ([10];[11];[12]) is use to estimate the model.

Estimations results are in Table 2. We find a significant bidirectional causal link between investment and depreciation. Specifically, higher health stock depreciation is associated with lower health investment. This suggests that the older people are less likely to demand for health care when their health stock depreciation rate is high. On the other hand, higher health investment is associated with higher health stock depreciation rate. Increased demand for health care among older individuals is linked to an increase in health depreciation rate.

Table 2. Estimated coefficients of the state space model

Variable	Measurement ($H_{i,t}$) Equation 12	Investment ($I_{i,t}$) Equation 13	Depreciation ($\delta_{i,t}$) Equation 14
$I_{i,t-1}$	–	-0.8293^{***} (0.0352)	1.2696^{***} (0.1412)
$\delta_{i,t-1}$	–	-0.0448^{**} (0.0212)	0.0688 (0.0730)
Intercept	–	−0.00004 (0.0579)	−0.00004 (0.0567)
Variance covariance structure			
σ_1	0.000069	–	–
σ_2	0.00096	–	–
σ_I	–	5.4931^{***} (0.1303)	–
σ_δ	–	–	5.1494^{***} (0.1281)
$\rho_{I,\delta}$	–	0.8999^{***} (0.1082)	

***: significant at 1% level, **: significant at 5% level, Standard errors are in parenthesis.

3.2. *Health production and health consumption functions*

In this section, we estimate an health consumption and health production functions. We assume the health production function to be $\hat{I}_{i,t} = f(h_{i,t}) = A_{0,i} h^{\varphi}_{i,t}$ where $\hat{I}_{i,t}$ denotes the health stock produced by an investment $h_{i,t}$ in health expenditures, and $A_{0,i}$ denotes individual and country specifics variables that are determinant of health investment. A log-linear form of this equation is estimated by a generalized least squared approach. We control for demographic characteristics, health behaviour and medical history variables. Estimations results are in Table C1 in appendix 6. We find a positive and significant elasticity of health expenditures, suggesting that higher health expenditures results in better health.

[8] Further details on the Kalman filter derivation are given in Delattre and Moussa (2018) [14]

Most of the estimated coefficients have the expected signs. Living in couple is negatively associated with health investment, and male invests in health more than female. Contrarily to Wagstaff (2002), we find that age is positively associated with health investment. Education is not linearly associated with health investment. Individuals with no grade or undergraduate level have lower health compared to those with college and graduate levels. Contrarily to Grossman (1999) [19] and Wagstaff (2002), our specification gives an effect of education that is consistent with the original health investment model (Grossman, 1972). In addition, while alcohol consumption is not associated with health investment, smoking increases the demand for health care. Lastly, visiting a doctor or being patient increase health investment but the frequency of being patient and the total nights in hospital decrease health investment.

For the health consumption function, we assume that each worker uses health as an input in a production process to earn a wage. Thus, we assume health consumption to be a function of wage given by:

$$g\big((1-\rho_{i,t})\omega_i W_{i,t}\big) = A_{1,i}\big((1-\rho_{i,t})\omega_i W_{i,t}\big)^{\theta} \tag{15}$$

where $A_{1,i}$ includes control variables such as work and health condition, and demographic characteristics. Based on the health depreciation rate $\hat{\delta}_{i,t}$ estimated by the state-space model, we first estimate the share of this depreciation due to work. For this purpose, health depreciation rate is regressed on job status and working condition while controlling for demographic characteristics. Estimations results are in Table C2 (see appendices) . We find a strong evidence that health depreciation is higher for workers and that better working condition is associated with lower health depreciation, consistently with the literature [13]. We also find a positive and significant effect of ageing on health depreciation.

Once the health depreciation is disentangled, we can estimate a log-linear form of the health consumption function (Equation 15). Results in Table C3 (see appendices) show that health depreciation due to working condition is higher for male. Furthermore, lower pension share and lower school levels are associated with higher health depreciation.

3.3. *Estimation of retirement probabilities*

In this section, we present the estimated discount factor and early retirement probabilities computed using a separable utility function. The calculation of r_i and $\rho^*_{i,t}$ at time t requires the health stock at $t+1$ and the estate dynamics from $t+1$ until worker's death[9]. Health stock at $t+1$ is a function of individual characteristics at t. In the estate equation, post-retirement earnings are a share of annual salary received as pension. The remaining estate value after expenditures at t is assumed to grow at the country's interest rate. Regarding post-retirement expenditures, we draw on the findings of Fisher et al. (2005) to assume that consumption expenditures decrease by 2.5% at the retirement and by 1% annually thereafter.

Statistics on preferences for future are provided in Table 3. The preference for future across elder workers in Europe is highly volatile. On average, 66.56% of older

[9]The individual survival is assumed to be the life expectancy at her age in her country.

workers in Europe have a low preference for future (with an average $r_{i,t} = 0.16755$ with a standard deviation of 0.23963). However, in countries such as Germany, France, Netherlands, Spain, Greece, Israel and Poland, at least 70% of aged workers have a low preference for future while in countries such Estonia, Switzerland and Slovenia, less than 50% of aged workers have a low preference for future. Additionally, some individuals have a preference for future greater than one (for 33.44% of the estimation sample). These individuals tend to have a relatively high health stock but a low estate value. For them, the expectation of a long, healthy life leads to a high preference for future, since they anticipate, in addition to the pension they will receive, the possibility to continue working and earning additional income that will increase their estate, consequently, their utility.

Table 3. Preference for future across European countries

Country	Population	Low ($r_{i,t} < 1$)		High ($r_{i,t} > 1$)	
	Proportion(in%)	%	*Average*	%	*Average*
Austria	4.61	2.76	0.21301 (0.25814)	1.85	464.62 (3273.347)
Germany	5.3	3.74	0.17314 (0.22755)	1.55	459.2 (3404.512)
Sweden	10.08	5.86	0.21836 (0.24735)	4.22	290.5 (2330.292)
Netherlands	8.18	7.07	0.09752 (0.19306)	1.11	699.77 (5019.927)
Spain	4.94	4.3	0.0996 (0.19075)	0.64	548.74 (3734.307)
Italy	5.08	3.02	0.21695 (0.27218)	2.06	478.17 (4380.884)
France	9.6	7.52	0.12266 (0.21442)	2.08	494.25 (3997.869)
Denmark	10.08	5.91	0.20999 (0.25577)	4.17	141.21 (1661.173)
Greece	5.54	5.13	0.06239 (0.14002)	0.41	344.96 (2921.652)
Switzerland	7.54	3.23	0.25173 (0.28794)	4.31	777.1 (5364.31)
Belgium	10.97	6.92	0.25032 (0.26481)	4.05	578.78 (4729.252)
Israel	6.37	5.63	0.0999 (0.18414)	0.74	233.66 (2226.619)
Czech Republic	4.66	2.87	0.23729 (0.26131)	1.79	301.56 (2377.2)
Poland	1.23	0.89	0.1345 (0.2069)	0.34	717.75 (4591.578)
Slovenia	1.22	0.61	0.20732 (0.2578)	0.61	132.84 (909.072)
Estonia	4.61	1.08	0.31709 (0.28705)	3.52	697.69 (4723.899)
Overall (Obs.: 20,782)	100	66.56	0.16755 (0.23963)	33.44	474.09 (3871.625)

Standard deviations are in parenthesis

From descriptive statistics presented in Table 4, significant differences are observed among groups. We consider the group of workers who are less likely to choose early retirement (probability lower than 0.15), those who are more likely to choose early retirement (probability higher than 0.85), and those who are uncertain about early retirement (probability between 0.15 and 0.85). Workers that choose early retirement have the highest health stock, and the lowest estate value and the lowest preference for future. In contrast, workers that do not choose early retirement have the lowest health stock but the highest estate value and the highest preference for future.

Table 4. Characterization of early retirement across European countries

Groups	Mean $r_{i,t}$	Mean Estate	Mean health
$\rho^*_{i,t} > 0.85$	1.4919 (0.2309)	272,366.9 (1,664.55)	10.2172 (0.0045)
$\rho^*_{i,t} < 0.15$	104.63 (6.9529)	471,223.2 (3,626.88)	10.0358 (0.0033)
Difference	-103.14^{***} (10.4074)	$-198,856.3^{***}$ (5,541.59)	0.1814^{***} (0.0058)
$\rho^*_{i,t} > 0.85$	1.4929 (0.2309)	272,366.9 (1,664.55)	10.2172 (0.0045)
$0.15 \leq \rho^*_{i,t} \leq 0.85$	66.1737 (5.2808)	325,090.7 (2,861.81)	10.0895 (0.0037)
Difference	-64.6808^{***} (6.9698)	$-52,723.85^{***}$ (3,982.18)	0.1277^{***} (0.0059)
$0.15 \leq \rho^*_{i,t} \leq 0.85$	66.1737 (5.2808)	325,090.7 (2,861.81)	10.0895 (0.0037)
$\rho^*_{i,t} < 0.15$	104.63 (6.9529)	471,223.2 (3,626.88)	10.0358 (0.0033)
Difference	-38.4548^{***} (9.1584)	$-146,132.5^{***}$ (4,825.58)	0.0537^{***} (0.005)

***: significant at 1% level. Standard errors are in parenthesis.

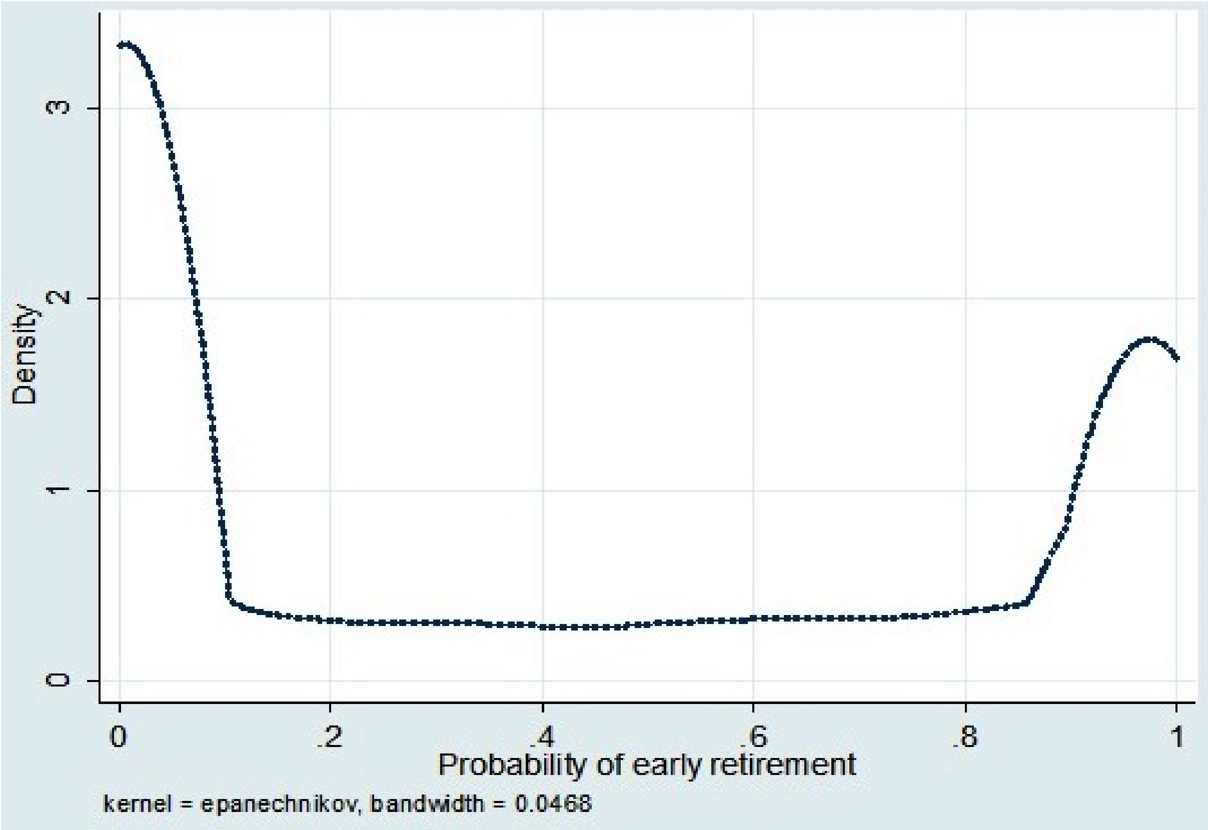

Figure 2. Density of early retirement probability

3.4. *Robustness analysis*

The robustness check for our model will consist in showing the ability of our model to distinguish between two groups of individual across workers with uncertainty about their early retirement decision. For that purpose, we plot the density of the estimated early retirement probability. The plotted density is shown in Figure 2. As we can see, the density has two peaks, the first one around the early retirement probability of 0.07 that is the higher and second one around the early retirement probability of 0.95 that is the lower peak. In addition, early retirement probability values between 0.15 and 0.85 have lower and closer to zero densities. This plot gives a first level of validation of the accuracy of our model.

This illustrates the ability of our model to create two groups: one with a strong probability at time $t-1$ to retire and one with a strong probability at time $t-1$ not to retire. Table 5 gives sizes of the corresponding populations. Around 80% of the population is within one of the two extreme groups.

Table 5. Individual probabilities of retirement

	N	%
$\rho^*_{i,t} > 0.85$	$10,213$	28.11
$0.15 \leq \rho^*_{i,t} \leq 0.85$	$8,127$	22.37
$\rho^*_{i,t} < 0.15$	$17,990$	49.52

The second robustness check test we do is to test the relationship between the calculated early retirement probability and the transition from work to early retirement. For that purpose, we estimate a dynamic probit model with the transition from work to early retirement as dependant variable. We estimate 3 models: the first one with only the last period early retirement probability as explanatory variable, the second one by including school grade that account for the post retirement opportunities, and the third one by including country dummies and school grade to account for country heterogeneities in terms of retirement policy and in terms of job opportunities after retirement. The final estimated model is given by:

$$\begin{cases} ER^*_{i,t}{=}d_0 + d_1\rho^*_{i,t} + d_2 Grade_i + d_3 Country_i + \epsilon_{i,t} \\ ER_{i,t}{=}1 \ \ if \ \ ER^*_{i,t}{>}0 \end{cases}$$

Where $ER_{i,t} = 1$ if individual i retires earlier at t. Thus, the calculated early retirement probability ρ^*_{it} is related with early retirement if d_1 is significantly different from zero. Estimate results of this model in Table 6. As we can see, in all estimated models, the calculated early retirement probability and the calculated early retirement status are related with the transition from work to early retirement. These links remain significant when we control for school level and country heterogeneity. These findings strengthen the reliability of our approach and our computed early retirement probabilities.

Table 6. Relationships between calculated early retirement probability and early retirement

Transition from work to early retirement	Model 1	Model 2	Model 3
$\rho^*_{i,t}$	0.0899*** (0.0264)	0.089*** (0.0265)	0.0857*** (0.0308)
Grade	Ref = Graduate studies		
No grade	–	−0.0203 (0.0399)	0.0769* (0.0418)
College degree	–	0.154*** (0.0277)	0.1673*** (0.0287)
Undergraduate studies	–	0.0088 (0.0385)	−0.0029 (0.0402)
Intercept	−1.1968*** (0.0172)	−1.2666*** (0.0255)	−1.0694*** (0.077)
Country fix effects	NO	NO	YES

***: significant at 1% level; *: significant at 10% level. Standard errors are in parenthesis.

Last point to consider is Table 1. There is a wide gap between the declaration of individuals which are asked if they intend to retire at the next period and the real choice of individuals. Over the three waves, only 22.7% of individuals who declare that they want to retire at the next period do retire, at the next period. For individuals who declare that they do not want to retire, the corresponding ratio is 17.7%.

It turns out that it is difficult to confront an individual predicted probability (at a given time period) to the corresponding real individual action which happens latter. This gap is due to two main factors:

- the time gap between individual interviews and the time of individual decisions.
- People can express wishes or preferences which can be very different from actions.

From Table 7, we can see that, finally, our predicted probability is quite better than the individual declaration to assess the real choice of individuals. Over the three waves, we find that 36.92% of those with retirement probability higher than 0.85 retire next period and only 5.72% of those with retirement probability lower than 0.15 retire next period.

Table 7. Individual retirement status according to past $\hat{p}_{i,t-1}$ values

	%
$\rho^*_{i,t} > 0.85$	36.92
$0.15 \leq \rho^*_{i,t} \leq 0.85$	10.74
$\rho^*_{i,t} < 0.15$	5.72

Conclusion

This paper analyzes the early retirement decision-making process among older workers in Europe. Several previous papers focus on this issue by analyzing the health effects, financial effects, or both. Some papers highlight the important roles of worker's environment and institutional regulations. However, these previous papers use a binary outcome model to assess the effects of those key variables on the probability to retire earlier. In our approach, we specify a worker's utility function depending on his or her health, estate, institutional framework by the use of the share of salary as pension, and preference for future. This specification allows us to assess the early retirement decision-making process by accounting for, not only the current health condition and estate value, but for the whole discounted lifetime utility. Estimations are done with four waves of the SHARE dataset.

Our framework is innovative. We estimate health investment and health depreciation from the Grossman's model using a space-state approach and we use these estimations to estimate a health production and health consumption function that are key in early retirement decision-making process. Contrarily to previous literature on demand for health care equation, this approach lead to expected signs for all determinants.

From our model, we predict for each individual and at each period, the probability that workers retire early with regards to their financial, health and socioeconomics conditions. These early retirement probabilities are function of (i) the marginal productivity of health expenditures, (ii) the marginal health depreciation due to working condition, and (iii) the discounted future marginal utility of estate divided by the current marginal utility of health. We show that our approach is robust as it disentangles between three categories of workers: those who will not choose early retirement, those who will choose early retirement, and those who are uncertain about early retirement. We also show that our calculated early retirement probabilities are good predictors of observed individual early retirement. Finally, this framework allows us to investigate on the effects of public policies such as (i) predicting, by simulations, the probability of early retirement with respect to health, estate value, and pension share, and (ii) predicting how public health policy or retirement policies may affect retirement behaviour.

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Appendix A. Descriptive statistics on health, financial situation and early retirement in Europe

Table A1. Health stock level

Variable	Modalities	Wave 1	Wave 2	Wave 4	Wave 5	Overall
Mean of health stock		9.599 (0.9484)	9.4627 (1.0292)	9.1703 (1.098)	9.1598 (1.0868)	9.2994 (1.0717)
Job Status	Retired	9.3158 (0.0089)	9.1792 (0.0082)	8.9038 (0.0068)	8.9254 (0.0066)	9.0207 (0.0038)
	Worker	10.1707 (0.0077)	10.1225 (0.0076)	9.7998 (0.0081)	9.8232 (0.0083)	9.9481 (0.0042)
	Difference	-0.8549^{***} (0.0118)	-0.9433^{***} (0.0112)	-0.896^{***} (0.0105)	-0.8977^{***} (0.0106)	-0.9274^{***} (0.0056)
Looking for early retirement	Yes	10.090 (0.0123)	9.9852 (0.0127)	9.7269 (0.0122)	9.7329 (0.0129)	9.8606 (0.0065)
	No	10.2361 (0.0098)	10.2231 (0.0092)	9.8512 (0.0108)	9.8837 (0.0108)	10.0113 (0.0055)
	Difference	-0.1461^{***} (0.0157)	-0.2378^{***} (0.0157)	-0.1243^{***} (0.0163)	-0.1508^{***} (0.0169)	-0.1507^{***} (0.0085)
Afraid health limits ability to work	Yes	9.9168 (0.0169)	9.8367 (0.0172)	9.5209 (0.0168)	9.5241 (0.0183)	9.6698 (0.009)
	No	10.273 (0.0082)	10.2315 (0.0079)	9.9169 (0.009)	9.9276 (0.0091)	10.0564 (0.0045)
	Difference	-0.3563^{***} (0.0187)	-0.3948^{***} (0.0189)	-0.396^{***} (0.0081)	-0.4035^{***} (0.0205)	-0.3866^{***} (0.0101)

*** significant at 1% level. Standard errors are in parenthesis.

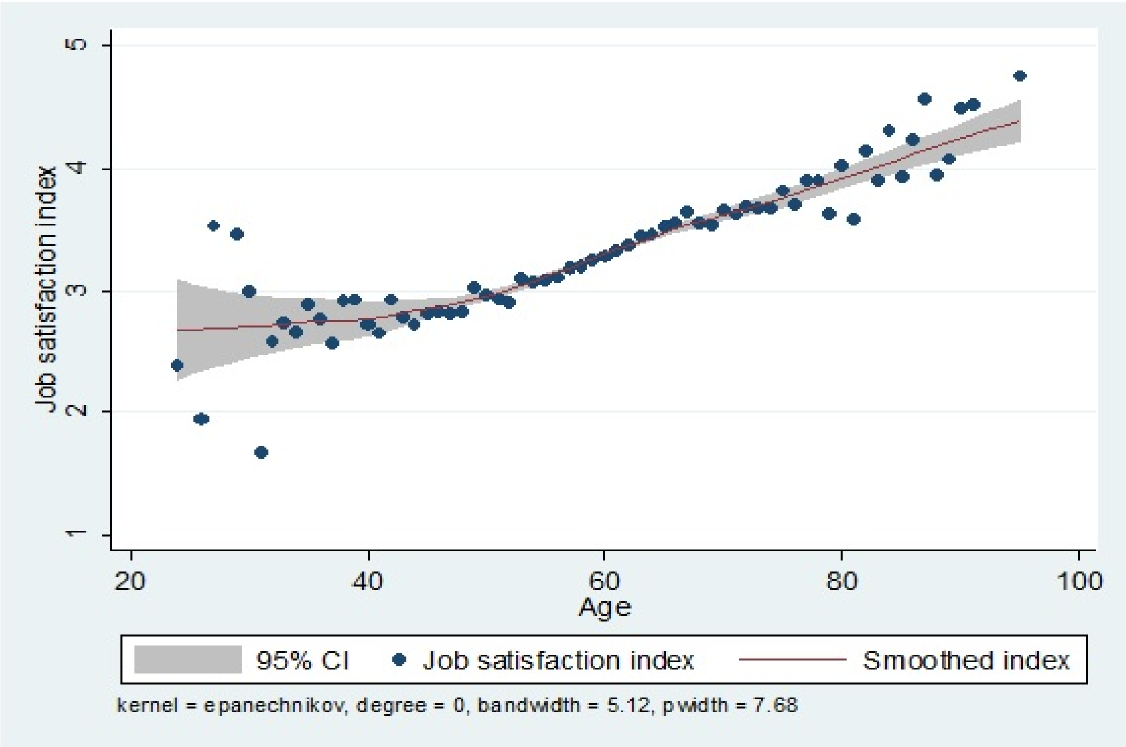

Figure A1. Evolution of job satisfaction indicator among age

Table A2. Characterization of early retirement in Europe: Part 1

Variable	Early+	Wave 1	Wave 2	Wave 4	Wave 5	Overall
Proportion of worker	in %	43.26	41.85	39, 94	38.88	40.7
looking for early retirement	Obs.	6, 840	8, 105	11, 428	9, 886	36, 259
Proportion of smoker	Yes	0.2815	0.2621	0.2397	0.1964	0.242
		(0.0083)	(0.0076)	(0.0063)	(0.0064)	(0.0035)
	No	0.2363	0.2166	0.2073	0.1802	0.207
		(0.0068)	(0.006)	(0.0049)	(0.0049)	(0.0028)
	Difference	0.0452***	0.0454***	0.0324***	0.0162**	0.035***
		(0.0106)	(0.0096)	(0.0079)	(0.008)	(0.0044)
Proportion of male	Yes	0.5465	0.5139	0.4748	0.4737	0.4979
		(0.0092)	(0.0086)	(0.0074)	(0.008)	(0.0041)
	No	0.4945	0.4963	0.4599	0.4547	0.4727
		(0.008)	(0.0073)	(0.006)	(0.0064)	(0.0034)
	Difference	0.052***	0.0176	0.0149	0.0191*	0.0252***
		(0.0122)	(0.0113)	(0.0095)	(0.0103)	(0.0053)
Proportion of worker that	Yes	0.3721	0.3721	0.3935	0.373	0.379
		(0.0089)	(0.0083)	(0.0072)	(0.0078)	(0.004)
are afraid that health limits	No	0.1927	0.1842	0.1916	0.1592	0.1811
		(0.0063)	(0.0056)	(0.0047)	(0.0047)	(0.0026)
ability to work	Difference	0.1794***	0.1879***	0.2019***	0.2138***	0.1979***
		(0.0108)	(0.0099)	(0.0085)	(0.0088)	(0.0048)
Proportion of worker	Yes	0.8364	0.8275	0.7627	0.7575	0.791
		(0.0068)	(0.0065)	(0.0063)	(0.0069)	(0.0033)
in couple	No	0.8093	0.8088	0.748	0.7458	0.7718
		(0.0063)	(0.0057)	(0.0052)	(0.0056)	(0.0029)
	Difference	0.0271***	0.0187**	0.0147*	0.0118	0.0193***
		(0.0094)	(0.0087)	(0.0082)	(0.0089)	(0.0044)
Mean of age in year	Yes	55.61	55.84	55.96	57.3	56.21
		(0.0814)	(0.0766)	(0.0664)	(0.0711)	(0.037)
	No	56.18	56.74	57.37	58.78	57.42
		(0.0861)	(0.0768)	(0.0699)	(0.0718)	(0.0383)
	Difference	−0.57***	−0.91***	−1.42***	−1.48***	−1.21***
		(0.1185)	(0.1084)	(0.0964)	(0.101)	(0.0533)
Proportion of workers that	Yes	0.8628	0.8567	0.8718	0.8574	0.6692
		(0.0063)	(0.006)	(0.0049)	(0.0155)	(0.0039)
are satisfy of their job	No	0.9531	0.9635	0.9672	0.9626	0.7292
		(0.0034)	(0.0027)	(0.0021)	(0.0066)	(0.003)
	Difference	−0.0903***	−0.1068***	−0.0954***	−0.1052	−0.0599***
		(0.0068)	(0.0061)	(0.0049)	(0.015)	(0.0049)

+: looking for early retirement. Standard errors are in parenthesis. ***: significant at 1% level.
**: significant at 5% level, *: significant at 10% level

Table A3. Characterization of early retirement in Europe: Part 2

Variable	Early$^+$	Wave 1	Wave 2	Wave 4	Wave 5	Overall
Mean of annual	Yes	25,565.87	17,885.61	19,502.44	21,209.61	20,913.96
		(180.83)	(138.73)	(130.43)	(144.76)	(74.83)
earnings from	No	28,305.94	20,288.7	22,479.46	24,145.13	23,628.62
		(187.18)	(136.21)	(128.97)	(139.52)	(73.79)
employment in €	Diff.	$-2,740.09^{***}$	$-2,403.09^{***}$	$-2,977.02^{***}$	$-2,935.52^{***}$	$-2,714.66^{***}$
		(265.63)	(199.28)	(190.29)	(208.60)	(108.33)
Amount in bank	Yes	12,336.73	15,486.33	17,082.53	15,111.29	15,238.72
		(198.78)	(252.69)	(303.44)	(243.92)	(133.67)
account in €	No	15253.45	23,741.11	24,741.46	23,644.07	22,445.74
		(208.16)	(313.56)	(311.09)	(283.19)	(149.55)
	Diff.	$-2,916.72^{***}$	$-8,254.77^{***}$	$-7,658.93^{***}$	$-8,532.79^{***}$	$-7,207.03^{***}$
		(294.52)	(425.84)	(453.93)	(402.79)	(211.12)
Out-of-pocket	Yes	293.96	269.03	-	435.79	344.46
		(4.90)	(5.14)		(6.71)	(3.48)
health expenditures	No	312.22	279.44	-	463.96	370.91
		(5.00)	(3.59)		(5.53)	(3.02)
in €	Diff.	-18.26^{**}	-10.41^{*}	-	-28.17^{***}	-26.45^{***}
		(7.13)	(6.07)		(8.76)	(4.64)
Proportion of	Yes	0.2406	0.2565	0.1933	0.2734	0.2382
		(0.0079)	(0.0075)	(0.0058)	(0.0072)	(0.0035)
undergraduate	No	0.3187	0.366	0.2880	0.3805	0.3367
		(0.0075)	(0.007)	(0.0055)	(0.0062)	(0.0032)
studies at least	Diff.	-0.0781^{***}	-0.1095^{***}	-0.0948^{***}	-0.1071^{***}	-0.0985^{***}
		(0.011)	(0.0105)	(0.0083)	(0.0098)	(0.0049)
Percentage of	Yes	33.3586	36.3031	41.5433	43.7965	39.251
		(0.7757)	(0.672)	(0.5732)	(0.6365)	(0.329)
salary to be	No	28.5844	29.7371	33.6839	37.5918	32.8254
		(0.634)	(0.5162)	(0.4709)	(0.4963)	(0.2615)
received as pension	Diff.	4.7742^{***}	6.566^{***}	7.8594^{***}	6.2047^{***}	6.4256^{***}
		(1.0018)	(0.8474)	(0.7418)	(0.8071)	(0.4203)
Mean of job	Yes	2.7745	2.6746	2.6664	3.6753	2.9527
		(0.0133)	(0.0126)	(0.0113)	(0.0079)	(0.0067)
satisfaction and	No	3.1979	3.1496	3.1138	3.7612	3.3341
		(0.0105)	(0.0092)	(0.0082)	(0.0051)	(0.0046)
condition indicator	Diff.	-0.4234^{***}	-0.475^{***}	-0.4474^{***}	-0.1406^{***}	-0.3814^{***}
		(0.017)	(0.0156)	(0.0139)	(0.0094)	(0.0081)

$^+$: looking for early retirement. Standard errors are in parenthesis. ***: significant at 1% level.
**: significant at 5% level, *: significant at 10% level

Appendix B. Descriptive statistics on post retirement employment

Table B1. Proportion of retired workers among aged worker per country, school grade and sex

	Wave 1			Wave 2			Wave 4			Wave 5			Overall		
Country	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Per country															
Austria	0,8	6,7	3,4	0	7,3	3,4	3,3	10,3	6,9	1,6	7,8	4,8	2,1	8,8	5,5
Germany	5,3	2,6	4	3,3	1,7	2,5	8	4,4	5,9	7,4	3,6	5,2	5,4	2,9	4,1
Sweden	1,5	0,4	0,9	4	1	2,3	5,9	2,5	4,1	12,1	1,8	6,7	4,7	1,1	2,8
Netherlands	1,7	1	1,3	1,2	1,7	1,4	1,5	1	1,2	4,4	1,9	3,1	2,1	1,4	1,7
Spain	2,6	4,4	3,3	1,3	1,9	1,5	2,2	2,2	2,2	3,2	2,5	2,8	2,3	2,6	2,4
Italy	3,8	2,6	3,3	4,6	1	3	6,4	1,3	4,1	3,3	2,3	2,8	4,7	1,7	3,3
France	4,5	6,2	5,5	6,8	7,7	7,3	10,2	8,9	9,5	15,5	10,7	12,8	9,7	8,6	9,1
Denmark	3,3	2,8	3	4	1,8	2,9	6,3	2,3	4,3	8,1	3,8	5,9	5,6	2,6	4,1
Greece	3,4	0,8	2,4	6	2	4,5	–	–	–	–	–	–	4,7	1,4	3,4
Switzerland	9,1	5,6	7,4	6,9	3,7	5,3	7,7	6	6,8	10,8	7	8,8	8,8	5,9	7,3
Belgium	0,9	1,1	1	1,8	0,3	1,1	1,9	1,1	1,5	2	0,9	1,4	1,7	0,9	1,3
Israel	8,3	5,1	6,6	11,3	7	9,1	0	0	0	21,8	20,8	21,3	12,7	9,4	11,1
Czech Republic	–	–	–	4,5	3,4	4	3,4	4,9	4,2	5	4,7	4,8	4,2	4,5	4,4
Poland	–	–	–	0	2,2	1	2	4,7	3,3	–	–	–	0,8	3,1	1,9
Slovenia	–	–	–	–	–	–	0,5	0	0,3	2,9	0	1,4	1,6	0	0,8
Estonia	–	–	–	–	–	–	24,6	28,2	26,7	25,1	30,6	28,4	24,8	29,3	27,5
Total	3,6	2,9	3,2	4,4	2,9	3,7	7,8	8,6	8,2	10,2	10	10,1	6,8	6,8	6,8

Table B2. Proportion of retired workers among aged worker per country and school grade

	Wave 1			Wave 2			Wave 4			Wave 5			Overall		
Country	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Per school grade															
No grade	7,1	5,8	6,3	12,5	3,3	6,5	–	–	–	3,8	12,8	9,2	8	6,5	7,1
College degree	2,6	2,9	2,7	4	3,4	3,7	8	8,2	8,1	7,9	8,9	8,4	5,8	6,3	6
Undergraduate studies	6,5	4	5,2	3,8	2,4	3,1	6,4	9,1	7,9	14,2	18,1	16,4	7,3	9,6	8,6
Graduate studies	3,5	1,7	2,6	5,1	2,2	3,6	9	8,7	8,8	13,6	10,2	11,7	8,3	6,4	7,3
Total	3,1	2,6	2,8	4,4	2,9	3,7	7,8	8,6	8,2	10,2	10	10,1	6,7	6,8	6,8

Appendix C. Health production and consumption functions

Table C1. Health production function estimation

Variable	Coefficients
Log of health expenditures	0.000057^{***} (0.00002)
Age	0.00011^{***} ($6.46e{-}6$)
Male	0.00013^{*} (0.00007)
Couple	-0.0003^{***} (0.000089)
Ever smoke	0.00016^{**} (0.00007)
Drink alcohol	0.00012 (0.00009)
Doctor	0.00006^{***} ($5.05e{-}6$)
Be patient	0.00043^{**} (0.00018)
Times being patient	-0.00042^{***} (0.00009)
Nights in hospital	-0.00002^{**} ($9.42e{-}6$)
Grade	ref: graduate studies
no grade	-0.00025^{*} (0.00013)
college degree	0.00028^{***} (0.00008)
undergraduate studies	-0.00014 (0.00017)
Intercept	-0.00667^{***} (0.00042)
$\sigma_\mu = 3.5e-5$, $\sigma_e = 0.0124$	
Country dummies	Yes

***: significant at 1% level, **: significant at 5% level, *: significant at 10% level, Standard errors are in parenthesis.

Table C2. Health depreciation explanatory factors

Variable	Coefficient
Work	0.0037*** (0.00064)
Work*Condition	−0.00097*** (0.00017)
Age	0.00009*** (0.00002)
Health stock	0.00557*** (0.00016)
Intercept	−0.05446*** (00215)
Country dummies	Yes
$\sigma_\mu = 0.7e-5$, $\sigma_e = 0.0138$	

***: significant at 1% level, **: significant at 5% level
Standard errors are in parenthesis.

Table C3. Health consumption function

Variable	Coefficient
Wage: $log\left[(1-\omega)W_{i,t}\right]$	0.00015*** ($3.89e{-6}$)
Age	−0.00052*** ($2.6e{-6}$)
male	0.00091*** (0.00003)
Grade	ref: graduate studies
No grade	0.00288*** (0.00005)
College degree	0.00165*** (0.00003)
Undergraduate studies	0.00274*** (0.00005)
Intercept	0.0326*** (0.00017)
Country dummies	Yes
$\sigma_\mu = 0.0229$, $\sigma_e = 0.0054$, $\rho = 0.1524$	

***: significant at 1% level, **: significant at 5% level, Standard errors are in parenthesis.