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ABSTRACT

The Interaction between Retirement and Job Search: A Global Approach to Older Workers Employment*

This paper presents a theoretical foundation and empirical evidence in favor of the view that the tax on continued activity not only decreases the participation rate by inducing early retirement, but also badly affects the employment rate of older workers just before early retirement age. Countries with an early retirement age at 60 also have lower employment rates for old workers aged 55-59. Based on the French Labor Force Survey, we show that the likelihood of employment is significantly affected by the distance from retirement, in addition to age and other relevant variables. We then extend McCall's (1970) job search model by explicitly integrating life-cycle features and retirement decisions. Using simulations, we show that the effective tax on continued activity caused by French social security system in conjunction with the generosity of unemployment benefits for older workers helps explain the low rate of employment just before the early retirement age. Decreasing this tax, thus bringing it closer to the actuarially-fair scheme, not only extends the retirement age, but also encourages a more intensive job-search by older unemployed workers.

JEL Classification: J22, J26, H31

Keywords: retirement, old workers, search, actuarial fairness

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1 Introduction

Ageing jeopardizes the sustainability of Pay-As-You-Go (PAYG) systems. Faced with this changing demographic trend, most developed countries have chosen to encourage the elderly to delay retirement by rewarding a longer working life with an increased pension. However, such a strategy is questioned by the fact that a significant proportion of older workers are actually unemployed or entitled to specific assistance programs far away from the current age at which benefits are first available (the early retirement age in the terminology of Gruber & Wise (1999)). One often alleged reason is that technical progress makes older workers less employable (Crépon et al. (2002), Hellerstein et al. (1999), Friedberg (2003), Aubert et al. (2004)). Hence, trying to increase the rate of employment of older workers seems to be an unattainable goal in a context where jobs available for them are scarce.

In this paper, we put forward the idea that the existence of a retirement date intrinsically creates a decrease in the employment rate just before the age of retirement. Because of strong interactions between the perspective of retirement and job search, the existence of a terminal date recursively induces disinvestment effects from unemployed workers. In this framework, the observed low employment rate of near-to-retirement people cannot be considered as a limit for postponing the age of retirement. The reasoning completely reverses, and this policy measure is likely to increase the employment rate of these workers.

More precisely, unemployed older workers may prefer waiting for their close retirement age to come, without searching for a new job. Indeed, the job value, defined as the difference between the value of employment and the value of unemployment, goes down to zero as the retirement age gets closer. The short distance from the retirement age could then play a key role in accounting for the low employment rate of older individuals. However, the existence of unemployment and disability programs for older workers, especially in Europe, could blur this judgment. These programs are often considered as an early retirement device before the official social security early retirement age (Gruber & Wise (1999)). They indeed correspond to an inactivity spell until retirement occurs. From our point of view, this situation must be distinguished from retirement stricto sensu [1] and viewed as a (non-)search decision of non-employed workers. Of course, this decision may depend on the high generosity of these programs, but we claim that it is highly influenced by the individual proximity to the retirement age.

Our paper extends Gruber and Wise's (1999) view that the pattern of social security benefit plans strongly influences the incentives to continue working. Whereas Gruber & Wise (1999) stress that in most countries the social security system discourages continued activity after the early retirement age for employed individuals, we add that it also negatively affects the search intensity of unemployed workers before this age. It is not worthwhile spending time looking for a job as the greater benefits of employment cannot be enjoyed for a long period because of the tax on continued activity. Consequently, policies introducing actuarially fair adjustments would push back the retirement age, which in

[1] In the sequel, the term "retirement" will be used with this strict meaning.

turn would boost the job value for older workers who were previously close to retirement.

Studies on older workers usually either consider the choice to retire, without taking into account a real labor market with flows between employment and unemployment, or focus on labor demand and supply specificities without considering the possibility of retirement. The originality of this paper is to take a global approach to the employment of older workers. We provide empirical evidence supporting this approach. We then propose an original theoretical setting that encompasses both search and retirement decisions. Applying the model to French data, we verify that it is able to replicate the main empirical features of older workers' employment. In addition, we show that this more general framework changes the way of thinking about social security reforms. Policies aimed at delaying the retirement age are particularly powerful to stimulate older workers' employment due to recursive effects on the labor market.

We first put forward empirical evidence suggesting that the distance from retirement age affects the employment rate of older workers. We rely as a preliminary step on Gruber and Wise's (1999) results to stress the relationship between the retirement age and the employment rate before this age in the mid-nineties. In countries with a retirement age of around 60 (Belgium, France, Italy, the Netherlands), the employment rates for 55 - 59 year old workers are the lowest in the OECD countries. In contrast, Japan, and to a lesser extent, Sweden, the US, Great Britain and Canada are characterized by the highest retirement ages and employment rates between the ages of 55-59, whereas Spain and Germany are in an intermediary position. We then estimate a logit model on individual panel data (French Labor Force Survey) that measures how the distance from retirement age affects male employment probabilities. It appears that the shorter the distance from retirement, the lower the probability of being employed.

On the theoretical side, our paper aims at uncovering some key mechanisms behind the interaction between retirement and employment decisions. If the distance from retirement matters, employment decisions must be considered in an intertemporal framework. The job search model therefore appears as a natural candidate to investigate this issue provided life cycle features are taken into account. We thus choose to extend McCall's (1970) job search model by explicitly integrating retirement decisions in order to provide theoretical foundations for our empirical findings. Our streamlined model allows economic mechanisms to become more transparent and should be considered as a first attempt to model the interaction between retirement decisions and employment issues at the end of the working life. Following Castañeda et al. (2003) and Sargent & Ljungqvist (2000), agents age stochastically. We discard saving behavior in order to preserve the tractability of the model. Other papers deal with the labor participation of older workers. Seater (1977) and Benitez Silva (2003) develop a life-cycle model which takes into account employment but not retirement decisions. Bettendorf & Broer (2003) allow agents to save. However, they introduce perfect insurance against the risk of unemployment, thereby imposing strong restrictions on unemployment dynamics.

Simulations of our theoretical model show that the social security system *in conjunction with* the generosity of unemployment benefits for older workers helps to explain the French low rate of employment of workers who are about to attain the retirement age.

Indeed, the surplus from employment cannot be enjoyed for a long period, because, due to the tax on continued activity, the old age pension does not reward a longer working life. We then investigate the impact of a social security reform, which removes the tax on continued activity by rewarding a longer working life with an actuarially-fair increase in pension. Our contribution to the literature on actuarially-fair pension is twofold. First, the computation of actuarially-fair schemes is based on an explicit welfare criterion that takes into account all labor market transitions including the probability of being fired and of being hired. This contrasts with previous studies discussing actuarial fairness, which assume full employment. Secondly, actuarial fairness is examined in an equilibrium framework as payroll taxes endogenously adjust so as to balance unemployment and social security budgets.

We show that such a policy does yield a double dividend : *(i)* workers are encouraged to delay retirement, which is the usual gain expected from this measure *(ii)* more unemployed older individuals are now willing to look for a job and accept job offers. Taking this last effect into account leads to a higher optimal pension adjustment, relative to the traditional case where the employment rate before the retirement age is considered as given. The retirement age thus appears as an efficient policy tool to meet the target set by the Stockholm European Council (2002), contradicting the widespread view that the low employment rate of older workers makes any extension of the retirement age pointless.

Our paper is organized as follows. We first investigate the empirical relevance of our intuition. In a second section, we present our theoretical framework. After careful calibration, we propose a quantitative evaluation of the tax on continued activity and its consequences on employment for near-to-retirement workers. Finally, we evaluate the effect of introducing more actuarially fair pension adjustments.

2 Some Empirical Evidence

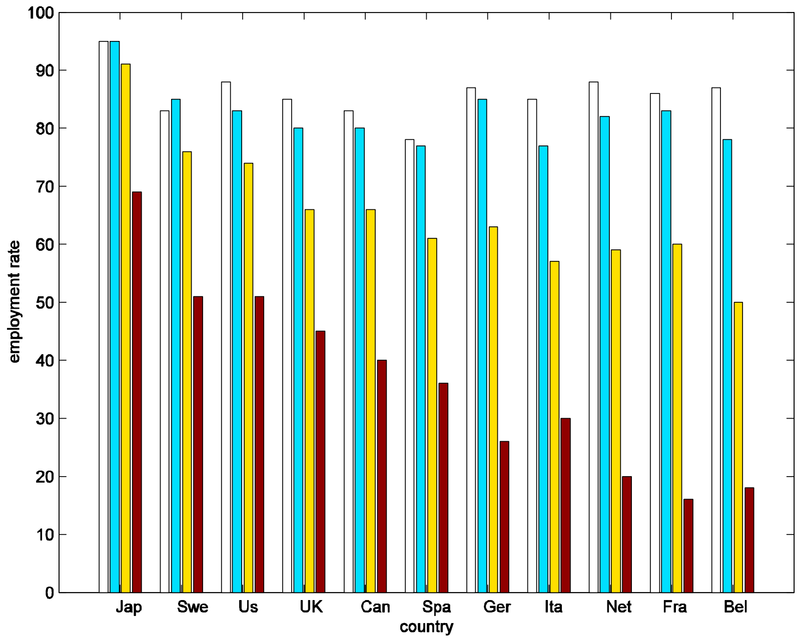
In this section we present empirical evidence in favor of the view that there is a relationship between the distance from retirement and the employment rate of older workers. This is not the biological age (its absolute level) that matters for explaining the employment rate of older workers, but what can be called the social age (the age relative to the retirement age).

2.1 Macroeconomic data on OECD countries

We first rely on OECD macroeconomic data to stress the relationship between the retirement age and the employment rate just prior to retirement. More specifically, we consider the country panel, studied in Gruber & Wise (1999), for which homogeneous information is available on the retirement age and the social security system.

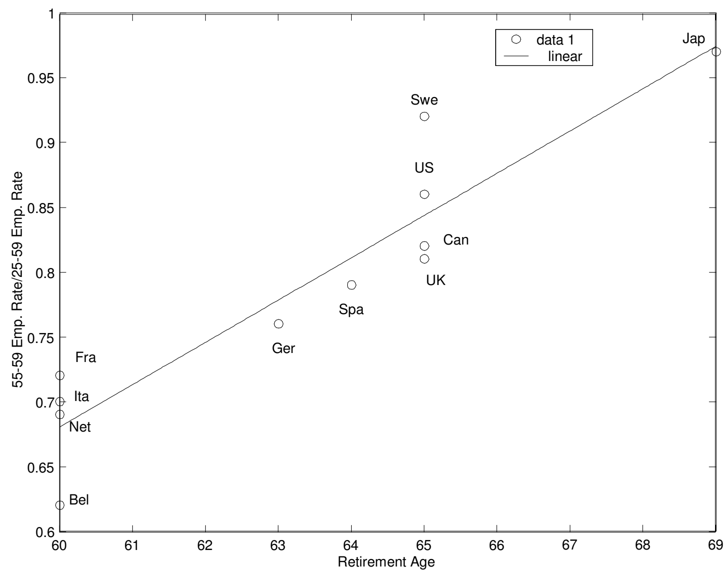
In each country, each bar refers to the employment of age groups (Figure 1): 30 - 49 (first bar on the left), 50 - 54, 55 - 59 and 60 - 64 (last bar on the right). The profile of employment rates is clearly decreasing with age. However, and more interestingly, the

Figure 1: Employment Rate by Age (Men, OECD)



speed of this decrease markedly differs across countries. Two country groups emerges very clearly: those with still high employment rates for workers aged 55-59 (Canada, Great Britain, Japan, the United States and Sweden) and those which already experience a huge decrease (around 25 points) at these ages (Belgium, France, Italy and the Netherlands). The difference from the group aged 50-54 is only of ten points on average for the former, whereas it increases by up to 25 points for the latter. How can we explain this result? Should we invoke productivity, technological bias or labor cost differentials? There are no serious reasons to believe that the 55-59 year old workers in the latter countries are more particularly sensitive to these factors. Disability and unemployment programs could be more serious candidates for explaining the observed differential, but several factors seem to invalidate this explanation. First, some countries in the first group, for instance Great Britain, have also been involved in such programs. Secondly, and more fundamentally, we think that these latter and their strength are endogenous with respect to the retirement age. The participation of individuals to these programs is largely dependent on their horizon before the retirement age. This last point will be clarified by the use of individual data, but let us first consider recent French employment history that is quite illustrative. In the seventies, when the retirement age was still at 65, specific income programs were available only to people aged 60-64. These programs refer to specific allowances given to old workers until retirement (see Blanchet & Pelé (1997) for further details). The lowering of the early retirement age to 60 in 1983 implies that their eligibility age has been decreased to 55. This is why it is possible to consider the retirement age as the crucial variable which

Figure 2: Older Worker Employment Rate and Retirement Age (Men, OECD)



explains the observed differential in the employment rate for workers aged 55-59.

As documented by Gruber & Wise (1999), the second group of countries is indeed characterized by an effective retirement age of 60 (versus 65 in the first group). The significant decrease in the employment rate would occur when the retirement age gets sufficiently close. Figure 2 plots the scattered employment rate of older workers aged (55 - 59) relative to the overall employment rate for those aged 25 - 59 against the retirement age, calculated for our country panel in Gruber & Wise (1999), in 1995. This linear regression suggests in another way that the later the retirement age, the higher the employment of older workers before 60: the employment rate of workers aged 55-59 is particularly low in countries where retirement occurs as early as 60. The retirement age heterogeneity across countries could help to explain the observed employment rate profiles by age. Where does this heterogeneity come from? Gruber & Wise (1999) stressed the differences in early retirement ages and especially, in implicit taxes on continued activity after the age. The effective retirement age is often the early retirement age[2]. In the US, the tax is essentially zero at the early retirement age, whereas it is close to 70% in France and about 40% in Germany (Gruber & Wise (1999)). This explains why in France and Germany the departure rate at the social security early retirement age is approximately 80% whereas it is only about 25% in the US.

[2]Early retirements occur when social security wealth accrual significantly gets negative implying a high tax on continued activity after a given age: this is mostly due to the fact that the pension does not reward additional working years.

2.2 Data on French workers

In this section, we measure the relationship between employment and the retirement age using the French Labor Force Survey. Our intuition is that as individuals get closer to their pension age, they are less likely to be employed. The use of individual data enables us to control for the potential influence of specific income programs, which was not allowed by macroeconomic data. The time horizon is captured by the difference between the current age and the expected retirement age.

2.2.1 Data and Empirical Strategy

The retirement age is computed by adding to the age at the first job the required number of contributive years to draw full pension. As stressed by Blanchet & Pelé (1997), in France there are no incentives to delay retirement after the full pension age as no pension adjustments are made for any additional working year[3]. However, if a person enters the job market at a very young age, she cannot retire before the early retirement age (60 years old) even though she has accumulated the required number of contributive quarters before this age. In this case, the expected retirement age is then set to 60. Finally, we take into account the fact that individuals aged 65 are forced to retire whatever their number of contributive years.

As people start working at different ages, the retirement age is an heterogenous individual characteristic, even though a large number of workers have already reached their full pension eligibility at the age of 60. Obviously, our proxy for the retirement age does not take into account incomplete careers. However, we believe that our proxy remains relevant as, in the French system, unemployment episodes are included in the number of contributive quarters[4]. In addition, non-continuous careers due to pregnancy and family matters could indeed make our proxy less accurate. To avoid this bias, we measure the impact of the retirement age only on *male* employment.

We estimate a logit model that measures how the distance from retirement age affects the chance of being employed. Estimating an unemployment duration model could be judged more appropriate. But focusing only on unemployed people is too restrictive as non-employed older people are mainly outside the labor force, entitled to specific income programs. The dependent variable is the male probability of employment. It is coded as 1 when working, 0 otherwise, meaning unemployed or inactive (but not yet retired). The estimate is based on 8 successive waves of the LFS (from 1995 through 2002). The Balladur reform in 1993 gradually increased the required number of contributive quarters to reach the full rate. The required number of contributive quarters before retirement amounts to 150 quarters for individuals born in 1933 or earlier, while the 1934 generation needs to contribute 151 quarters to Social Security, the 1935 generation 152 quarters , ... and individuals born in 1943 or later 160 quarters. This transition is taken into account when computing the retirement age.

[3] This is why the expression "full pension" is used.

[4] Even though unemployed individuals do not actually pay contributions, a state agency (Fonds Solidarité Vieillesse) actually pays the social security contributions on behalf of unemployed people.

A third of the LFS sample is replaced each year. As a consequence, the LFS allows us to follow the same individual for only 3 consecutive years. Our sample is an unbalanced panel, which allows us to check the robustness of our results against events that are specific to each year, such as macroeconomic fluctuations. We implement a random effect logit model which takes advantage of the multi-period nature of the data and controls for unobserved individual heterogeneity. Error terms then consist of random individual specific effects and unobserved individual characteristics that vary with time. A Hausman test confirms that a random effect logit is preferable to a fixed effect model.

Tables 6 - 9 in Appendix A display the descriptive statistics of our sample. We consider variables that are widely used as key determinants in the understanding of employment probabilities: age, age square, marital status, number of children, size of city, sector, citizenship and occupational group. We add to these usual characteristics the number of years left before retirement. In the descriptive statistics, to summarize the impact of expected retirement on employment probabilities, distance from retirement is presented in dummies (more than 11 years, 6 to 10 years, 3 to 5 years and less than 2 years).

Table 6 displays the expected number of years before retirement as a function of age for individuals of age 50 and older. Obviously, the vast majority of individuals of 58 and 59 (of 55-57) have to wait for less than two years (between 3 and 5 years) before retiring. These statistics are consistent with the fact that the vast majority of French workers retire at the age of 60 (see Blanchet & Pelé (1997)), but they show some heterogeneity. The first lines of table 7 suggest that the number of years before retirement does affect employment probabilities : employment odds shorten as the individual gets closer to retirement. 66% of individuals who have to wait for less 3 - 5 years before drawing full pension are still working while this proportion goes down to 39% for those who are 2 years away from retirement.

2.2.2 Estimation results

We adopt a two-step approach. First, we measure the effect of the distance from retirement by taking into account both conventional explanatory variables (age, education, sector, ...) and specific income programs. For all individuals, the distance from retirement is introduced through the number of years before retirement. Secondly, we explore the potential presence of nonlinearities in the distance effect.

Distance from retirement : the linear case. The estimated random effect logits are displayed in table 1. First, let us consider the first column which is related to a model including only traditional variables without distance from retirement (regression (1)). The reference individual is a French, blue-collar individual working in the industry, living with his spouse in the Paris area. He has no children. As far as standard characteristics are concerned, the estimates yield significant and expected results: higher skills (captured by the occupational group) and living in the Paris area increase employment probabilities. Activities in the service sector and French citizenship also improve employment odds. Family characteristics affect employment status : compared with the reference individual, not having a spouse (respectively having 6 children or more) tends to reduce employment odds by roughly 54% [5] (respectively by 19%). Notice that the coefficients on age is positive and negative on the quadratic term, thereby capturing the positive effect of age (as a proxy for experience) and the negative impact of human capital depreciation with age (quadratic term) on employment odds.

Table 1 also reports estimation results when we introduce an additional explanatory variable that is distance from retirement (regression (2)). As a preliminary step, we introduce it as a continuous variable. The positive and significant sign is consistent with our intuition : an individual closer to expected retirement age is characterized by a lower employment probability. Other estimates are barely affected by the introduction of distance from retirement, which allows us to be confident that there is little multicollinearity problem.

Our preliminary estimates suggest that as the individual gets closer to his expected retirement age, his employment probabilities fall. One might argue that this effect is likely to be due to generous specific income programs: after 55 years old, unemployed individuals are eligible for unconditional unemployment benefits schemes. Moreover, because of a special legislation that imposes a tax on firing workers over 55 years old, employers have incentives to lay off workers before they reach the age of 55. Distance from retirement would then capture the particular legislation for old workers rather than the expected retirement effect that we want to outline. In order to control for this effect, we add age dummies (one dummy for each age from 50 to 59) to our regression. Results are summarized in table 1 (regression (3)).

All age dummies appear significant and negative, thereby confirming the view that individuals of 50 and older are affected by specific legislations. Notice that, in regression (3), coefficients of age and age squared are still significant but with lower values than in regression (2): the coefficient associated with age squared shifts from -0.0037 to -0.0009. This is because age dummies capture a large fraction of the decrease in employment probability with age. However, in spite of controlling for these effects, the coefficient on the distance from retirement remains positive and significant : the longer the distance from retirement, the larger the probability of employment. Interestingly, the coefficient associated with distance from retirement increases from 0.0215 in table 1 regression (2) to 0.0327 in regression (3). This confirms our intuition that the existence of generous income programs in itself is not a sufficient explanation of the low employment rate for older workers. As the individual's horizon on the labor market gets shorter, employment probabilities fall.

Distance from retirement: the nonlinear case. In table 1, the expected number of years before retirement is represented by a continuous variable, for all individuals. This makes impossible to identify potential nonlinearities: for instance, for individuals who are far away from retirement, an additional year away from the retirement age is unlikely to influence their employment status. Another source of nonlinearity could arise from the

[5] $1 - e^{-0.7879}$

Table 1: Male employment probabilities

Variables	regression (1)	regression (2)	regression (3)
distance		0.0215***	0.0327***
age	0.2418***	0.2720***	0.0870***
age2	−0.0036***	−0.0037***	−0.0009***
Marital status (Reference : live with a spouse)			
Live alone	−0.7879***	−0.8024***	−0.8889***
Number of children (Reference : no children)			
1 to 2	0.2276***	0.2355***	0.1688***
3 to 5	0.1466***	0.1194***	0.0252
6 and more	−0.2111***	−0.3068***	−0.4325***
Size of city as the number of inhab. (Reference :Parisian Area)			
more than 200000	−0.2381***	−0.2499***	−0.2691***
20000 to 200000	−0.1419***	−0.1451***	−0.1687***
less than 20000	0.0434*	0.0619**	−0.0403
Rural town	0.2010***	0.1981***	0.1864***
Sector (Reference : Industry)			
Agriculture	−0.3647***	−0.3830***	−0.3917***
Construction	−0.3982***	−0.3873***	−0.3950***
Services	0.1868***	0.1791***	0.1876***
Occupational group (Reference : Blue collar)			
Clerk	−0.2065***	−0.2227***	−0.2193***
Middle skilled	0.3384***	0.3127***	0.3379***
Executive	0.6029***	0.5493***	0.5566***
Citizenship (Reference : French)			
Non French	−0.5366***	−0.4880***	−0.5037***
Time Dummy (Reference : 1995)			
	*yes****	*yes****	*yes****
Dummy age (Reference : less than 50 years old)			
50			−0.0748**
51			−0.1221***
52			−0.2339***
53			−0.3105***
54			−0.4565***
55			−0.6842***
56			−1.1355***
57			−1.4850***
58			−1.9950***
59			−2.5969***
Constant	−1.7253***	−3.1915***	−0.6469
Obs.	246177	246177	246177

existence of specific programs for workers over 50 years old. The distance from retirement effect would then play a significant role, but only for individuals who are, for instance, eligible to generous income programs. Both arguments prompt us to introduce interaction variables between age and distance from retirement. The variable *distk* is defined as the distance from retirement for individual of age k, with $k = \{50, 51, ..., 59\}$, 0 otherwise. Distance from retirement could affect employment odds differently at each age k. This will be shown by the difference in the coefficients of the interaction terms. We keep age dummies (after 50 years) in order to control for old age specific programs. Table 2 reports estimation results.

First, notice that the distance from retirement appears significant: this confirms the view that old individuals' employment rate is affected by their expected retirement age. However, this is true only after the age of 55 (regression (4)). 55 appears as the threshold age at which the distance from retirement begins to matter. It is interesting to note that this is the age at which generous income schemes are available to old workers, thereby suggesting a strong interaction between generous income plans and the expected retirement effect.

Secondly, the coefficient value on the distance variable increases from 0.0609 at age 55 to 0.2295 at age 59. As reported in table 6, at 55 (59), the heterogeneity of the distance from retirement ranges from 5 (1) to 10 (5) years. The remarkable increase in the coefficient associated with the distance and age interaction variable indicates that the distance effect is particularly significant when individuals are sufficiently close to retirement. For instance, for a worker aged 59, if the distance to the age of retirement is increased by one year, this raises the employment odds by 25.8% - but only by 6.8% for a worker aged 55.

Finally, we test more explicitly this source of nonlinearity by introducing dummy variables for the number of years before the retirement age (more than 10 years before retirement, 6 to 10 years before retirement, 3 to 5 years and less than 2 years) instead of the interaction variables (regression (5)). We find again that the lower the expected number of years before retirement, the lower the probability of being employed. Interestingly enough, being at 6 to 10 years to retirement is not significantly different from being at more than 10 years in terms of employment probability. What makes a difference is whether the worker is less than 5 years away from the age of retirement or more.

To sum up, the distance from retirement helps explaining the employment probability of not-yet-retired workers. The effect appears strongly nonlinear: employment odds are affected only when the distance is sufficiently close to the retirement age and only for workers between 55 and 59 years old, who are eligible to specific income programs.

3 A Structural Model

The job search model appears as a natural candidate to a global approach of older workers employment, provided life cycle features are taken into account. We choose to present a simple model in order to make the key mechanisms more transparent. This model must

Table 2: Male employment probabilities with interaction variables

Variables	regression (4)		regression (5)
dist50	−0.0024	Distance (Reference : more than 10 years)	
dist51	−0.0048	5-10 years	−0.0777
dist52	0.0621	3-5 years	−0.4079***
dist53	0.0248	0-2 years	−0.8339***
dist54	0.0402		
dist55	0.0609**		
dist56	0.0611**		
dist57	0.1165***		
dist58	0.1930***		
dist59	0.2295***		
age	0.0580***		0.0580***
age2	−0.0009***		−0.0009***
Marital status (Reference : live with a spouse)			
Live alone	−0.8878***		−0.8868***
Number of children (Reference : no children)			
1 to 2	0.1651***		0.1651***
3 to 5	0.0189		0.0189
6 and more	−0.4346***		−0.4353***
Size of city as the number of inhab. (Reference : Parisian Area)			
more than 200000	−0.2734***		−0.2742***
20000 to 200000	−0.1761***		−0.1765***
less than 20000	0.0290		0.0293
Rural town	0.1768***		0.1764***
Sector (Reference : Industry)			
Agriculture	−0.3915***		−0.3909***
Construction	−0.3970***		−0.3972***
Services	0.1873***		0.1876***
Occupational group (Reference : Blue collar)			
Clerk	−0.2128***		−0.2125***
Middle skilled	0.3539***		0.3541***
Executive	0.5812***		0.5856***
Citizenship (Reference : French)			
Non French	−0.5014***		−0.5003***
Time Dummy (Reference : 1995)			
	*yes****		*yes****
Dummy age (Reference : less than 50 years old)			
50	−0, 0448		−0.0012
51	−0.0699		−0.0445*
52	−0.7440***		−0.1529***
53	−0.4823***		−0.2268***
54	−0.6995***		−0.3701***
55	−0.9952***		−0.2975***
56	−1.3840***		−0.7393***
57	−1.8516***		−1.0800***
58	−2.4144***		−1.1956***
59	−2.8701***		−1.7832***
Constant	1.2822***		1.2810***
Obs.	246177		246177

be considered as a first step to improving our understanding of the interaction between retirement and the employment rate of older workers.

The model is a modified version of McCall's (1970) model, in which unemployed workers look for a new job and choose an optimal search intensity which will influence the average length of unemployment spells. Beyond the heterogeneity arising from wage offer distribution, life cycle features are also considered. Following here Castañeda et al. (2003) and Sargent & Ljungqvist (2000), agents age stochastically. In addition, retirement choice is endogenous. Upon death, households are replaced by other households so that the population is constant over time. Finally, we discard saving decisions in order to keep the model tractable. For each period, consumption equals income.

3.1 Population dynamics and employment opportunities

In this section, we define the exogenous stochastic variables of the model, namely the age of the households and their employment opportunities. These two stochastic processes are independent.

3.1.1 Population dynamics

In each period, some households are born and some die. We assume that the measure of the newly-born is constant over time. They are born as unemployed workers. Retirement is endogenous. Upon retirement, they can die according to a given probability.

We assume that the population can be divided into 6 age groups[6], denoted C_i for $i = 1, ..., 6$. These age groups are a stylized representation of the following life-cycle: if a worker enters the labor market at 20, his expected time in the labor market is 40 years, and his expected time as a retiree is 20 years. In order to take into account typical age-specific unemployment rates, we consider the following age groups. 20 - 34 year old individuals, in C_1, start working. Experienced individuals of age 35 - 49, in C_2, expect to be employed for a long time. People of age 50 - 54 and 55 - 59, in C_3 and C_4, expect that the duration of the job is short before retirement. Individuals in age group 60 - 64, in C_5, can choose to retire. Finally, people aged 65 and more, in C_6 are all retirees. Retirement decisions occur at age 60 (end of C_4) and 65 (end of C_5). In our policy experiments, we will then be able to measure individuals' willingness to delay retirement following changes in pension schemes.

Each individual is born young. The probability for a worker of remaining in C_i (for $i = 1, .., 6$) the next period is π_i. Conversely, the probability of aging equals $1 - \pi_i$. The matrix governing the age Markov-process is given by:

[6] More motivations are given in the calibration part.

		$t+1$					
		C_1	C_2	C_3	C_4	C_5	C_6
t	C_1	π_1	$1-\pi_1$	0	0	0	0
	C_2	0	π_2	$1-\pi_2$	0	0	0
	C_3	0	0	π_3	$1-\pi_3$	0	0
	C_4	0	0	0	π_4	$1-\pi_4$	0
	C_5	0	0	0	0	π_5	$1-\pi_5$
	C_6	$1-\pi_6$	0	0	0	0	π_6

This matrix yields the stationary distribution of workers conditionally on their age group. In each period, a fraction $1-\pi_6$ of new workers is born. They replace an equal number of dead workers, so that the measure of the population is constant.

3.1.2 Employment opportunities

An unemployed worker, each period t, chooses a job search intensity $s_t \geq 0$. We assume that individuals derive utility from consumption and leisure. Leisure refers to the time not spent on labor or the job search. Consequently, the utility of an unemployed worker at time t can be expressed as $u(b, T-s_t)$, where function u satisfies the usual Inada conditions, b denotes unemployment benefits and T the total time endowment. The incentive to increase the job search intensity is linked to the probability of getting a job offer. This probability $\phi(s_t)$ is an increasing function of s_t, and we assume that $\phi(s_t) \in [0,1]$, for $s_t \in [0, \infty[$.

According to probability $\phi(s_t)$, an unemployed worker receives a job offer in the next period. This offer is drawn from the wage offer distribution $F(w)$, which denotes the probability of receiving a wage offer between the lower wage of the distribution $\underline{w}$ and w_{t+1} ($F(w) = \text{Prob}(w_{t+1} \leq w)$). Accepting a wage offer w_{t+1} implies that the worker earns that wage in period t and thereafter for each period she has not been laid off and has not retired. The probability of being laid off at the beginning of the period is $\lambda \in [0,1]$.

3.2 Behavioral assumptions and optimal solution

An unemployed worker observes his new age at the beginning of a period before deciding to accept or reject a new wage offer and chooses a job search intensity. The preferences are given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(y_t, T-z_t) \quad \text{where } z_t \equiv I^p(As_t - (1-A)h)$$

where E_0 is the expectation operator conditional at time 0, $\beta \in [0,1]$ the subjective discount factor and y_t the after-tax income from employment, unemployment compensation or pension. If $I^p = 0$, then the agent is retired, otherwise the agent participates in the labor market. In the latter case, if $A = 0$, then the worker is at work and has a constant disutility of labor denoted by h, whereas if $A = 1$ the worker is unemployed and has an endogenous disutility of job search.

Let $V_i^e(w)$ be the value of the optimization problem for a worker of age C_i and paid w, V_i^u the value of the optimization problem for an unemployed worker of age C_i, and V^r the value of a retiree. Bellman equations can be written as:

<u>for $i = 1, 2, 3$</u>

$$\begin{aligned} V_i^e(w) &= u((1-\tau_p-\tau_b)w_i, T-h) + \beta\left\{\pi_i[(1-\lambda)V_i^e(w) + \lambda V_i^u] \right. \\ &\left. +(1-\pi_i)[(1-\lambda)V_{i+1}^e(w) + \lambda V_{i+1}^u]\right\} \qquad (1) \\ V_i^u &= u(b_i, T-s_i) \\ &+\beta\left\{\pi_i\left[\phi(s_i)\int \max\{V_i^e(w), V_i^u\}dF(w) + (1-\phi(s_i))V_i^u\right]\right. \\ &\left.+(1-\pi_i)\left[\phi(s_{i+1})\int \max\{V_{i+1}^e(w), V_{i+1}^u\}dF(w) + (1-\phi(s_{i+1}))V_{i+1}^u\right]\right\} \qquad (2) \end{aligned}$$

The agent ages with probability $1 - \pi_i$. When the agent is employed, she pays taxes $\{\tau_p, \tau_b\}$ to finance non-employment incomes and retirement pensions[7]. She can lose her job with a probability λ. When the agent is non-employed, she can find a job opportunity with a probability $\phi(s)$. Each job offer is associated with a wage offer drawn from the wage distribution $F(w)$. The non-employed agent accepts a job if and only if its associated value is larger that the non-employment value $(\max\{V_{i+1}^e(w), V_{i+1}^u\})$.

<u>for $i = 4$</u>

$$\begin{aligned} V_4^e(w) &= u((1-\tau_p-\tau_b)w_4, T-h) + \beta\left\{\pi_4[(1-\lambda)V_4^e(w) + \lambda V_4^u]\right. \\ &\left.+(1-\pi_4)[(1-\lambda)\max\{V_5^e(w), V_5^r\} + \lambda V_5^r]\right\} \qquad (3) \\ V_4^u &= u(b_4, T-s_4) \\ &+\beta\left\{\pi_4\left[\phi(s_4)\int \max\{V_4^e(w), V_4^u\}dF(w) + (1-\phi(s_4))V_4^u\right]\right. \\ &\left.+(1-\pi_4)V_5^r\right\} \qquad (4) \end{aligned}$$

At age 4, workers expect with a probability $(1 - \pi_4)$ to have the right to get retired: age 5 constitutes the early retirement age, but especially the full pension age. At age 5, only employed individuals can choose to delay retirement as we assume that there is no unemployment benefit beyond 60 years old. Finally, these equations highlight an important feature of the French social security system: the pension is not lowered by an unemployment spell. The value V_5^r of getting retired in C_5 is the same for employed or non-employed workers. However, two retiree values must be distinguished in $C6$, namely the already (in C_5) retired workers value V_6^{r5} and the newly (in C_6) retired workers value V_6^{r6}.

<u>for $i = 5$</u>

$$V_5^e(w) = u((1-\tau_p-\tau_b)w_5, T-h)$$

[7] Payroll taxes endogenously adjust to balance the social security budget.

$$
\begin{aligned}
&+\beta\left\{\pi_5[(1-\lambda)V_5^e(w)+\lambda V_5^r]\right. \\
&\left.+(1-\pi_5)V_6^{r6}\right\} && (5)\\
V_5^r &= u(p_5,T)+\beta\left\{\pi_5 V_5^r+(1-\pi_5)V_6^{r5}\right\} && (6)
\end{aligned}
$$

where p_5 denotes the retiree's pension at age 5. At this age, if the agent is fired, she becomes a retiree. There is only one choice: to keep her job or to become a retiree.

for $i = 6$

$$V_6^{r5} = u(p_5,T)+\beta\left\{\pi_6 V_6^{r5}\right\} \quad (7)$$

$$V_6^{r6} = u(p_6,T)+\beta\left\{\pi_6 V_6^{r6}\right\} \quad (8)$$

In the benchmark case, we assume that the pension is not increased by additional years of working beyond the full pension rate: $p_6 = p_5$. This implies that the employment value does not increase if the agent decides to postpone retirement, leading to implicitly impose a huge tax on continued activity. In contrast, an increase in pension ($p_6 > p_5$), in return, will lead the value of employment to increase relatively to being unemployed in the age group (C_4) before the early retirement age.

Associated with equations (2) and (4) are four optimal policy rules $\overline{s}_i$, for $i = 1, ..., 4$ and four reservation wages $\overline{w}_i$. The optimal decision for search intensity is given by

$$u'_{i,2}(b_i, T-s_i) = \phi'(s_i)\beta\pi_i\left(\left[\int \max[V_i^e(w), V_i^u]dF(w)\right] - V_i^u\right) \quad (9)$$

The marginal disutility of job search activity equals its expected return, which is captured by the increase in the probability of getting a contact times the expected surplus of employment. The right hand side of equation (9) states that, as the individual ages, the gap between discounted earnings (V_i^e) and unemployment benefits (V_i^u) narrows. This is true whatever the value of discounted pensions (V^r). *A fortiori*, in a social security system paying the same pension to employed and unemployed workers, the return on the job search effort is low when the distance from retirement age decreases.

If $\max\{V_5^e(w), V_5^r\} = V_5^r$, then employed and unemployed people in C_4 has the same expected value V_5^r. Decreasing the unemployment benefit is then a traditional solution to foster job search by creating an instantaneous gap between employment and non-employment value. On the contrary, if $\max\{V_5^e(w), V_5^r\} = V_5^e(w)$, then the relative value to be employed goes up. By inspecting equation (5), it appears that this result can be reached by increasing the relative value of p_6 to p_5.

Aggregate equilibrium and wage distributions are detailed in Appendix B.

4 Investigating the relationship between retirement age and the job search

This section aims at investigating the complex interplay between the endogenous distance from retirement and individual job search decisions on the labor market. At this stage, we have two options : either to consider a theoretical setting that we could solve analytically at the expense of the robustness of our results or to calibrate a more general specification of the utility function and the wage distribution. We chose to follow the second route in order to illustrate the economic mechanisms in a more general setting, even though we do not claim to encompass all dimensions of employment and retirement decisions.

4.1 Calibration

Our calibration aims at replicating the main feature of the labor market along the life cycle. We discretize the working life cycle by choosing quite homogenous age groups. We have already provided some empirical or institutional arguments in favor of the discretization along the model exposition. In France, 60 is the early retirement age and 65 the maximum age. Between 60 and 65, agents have the choice to withdraw or not their pension. It is then particularly important to distinguish the 60-65 and the 65-and-more age groups. The expected age of death is set at 80. The working life cycle before the early retirement age is split into four age groups. The first one from 20 to 35 aims at taking into account the labor market entry process. We consider that all workers are first unemployed at 20. The employment rate is then growing with age as long as this entry process carries on. On French data, the employment rate becomes stationary from 35 on. Until 50, the employment rate exhibits a strong stationarity. From 50 on, the employment rate starts to steadily decline. It would have been useful to finely discretize these ages between 50 and 60. In order to keep a more tractable framework, we only consider two age groups, 50-54 and 55-59. The dividing age of 55 is natural as special income programs exists from this age to the early retirement age.

To sum up, the four age groups before the retirement periods are such that each individual has an expected duration of 15 years in the first class (C_1), 15 years in C_2, 5 years in C_3 and 5 years in C_4: this leads to an expected duration of 40 years in the labor market. We assume that the expected duration is 5 years for C_5 and 15 years for C_6. The life expectancy 20 is then 80 years old.

A first set of parameters are fixed according to an external information. We set the model period to a month. The discount factor β equals 0.9967, which yields an annual interest rate of 4%. We assume that the exogenous wage offer distribution $F(w)$ is a log-normal distribution. The 1998 mean of this distribution equals 9641 French Francs, with a lower bound of 5280 French Francs (minimum wage) and a dispersion measured by $\frac{D_1}{D_9}$equal to 3.1 (see Legendre (2004)). Wage offers are then included in the interval $[5280; 3.1 \times 5280]$. Finally, the variance of wage distribution amounts to 0.25, its empirical counterpart (Chéron et al. (2004)). Using the European Community Household Panel data set (ECHP), we calibrate the job destruction rates, which correspond to the average probabilities of being fired for employed workers: λ is set to 0.0111 at all ages. The model is simulated as if labor demand for all age groups were similar, which allows us to highlight how individual responses to social security pension schemes generate differential unemployment rates by age. The results are then not biased by an exogenous differential labor demand across age.

The utility function has the following form:

$$u(c, T - z) = \frac{(c^{\nu}(T - z)^{1-\nu})^{1-\sigma}}{1 - \sigma}$$

The reasons for this choice are that this function is compatible with a balanced growth path and the parameters needed for the calibration have been extensively studied in the literature relying on calibration (Auerbach & Kotlikoff (1987), Prescott (1986), Cooley & Prescott (1995), Hansen & Imrogoroglu (1992), Rios Rull (1996), Huggett & Ventura (1999)). We follow more specifically Rios Rull (1996), and Huggett & Ventura (1999) who have in common with us a life-cycle framework. ν is set to the traditional value of 0.33, σ to 2. This implies that the value of the relative risk aversion $\widetilde{\sigma} = \nu(1 - \sigma)$ is equal to 1.33. This is close to the estimates provided by Attanasio et al. (1999).

The unemployment benefits and the function that maps the job search intensity onto the probabilities of obtaining a wage offer are calibrated in order to make the model outcome consistent with stylized facts. The search function is defined as follows:

$$\phi(s) = \gamma s \quad \text{where } s \in [0; 1]$$

We choose to calibrate the parameter γ in order to replicate the elasticity of unemployment duration to the unemployment benefit. Traditionally, the estimates are run over a worker sample excluding older workers. Jackman et al. (1991) conclude that this elasticity is basically in the range of 0.2 to 0.9. We choose to replicate the median value of this interval, but only for the 35-49 age group in order to be consistent with its empirical counterpart. More precisely, we compute the unemployment duration change after a 1% increase in the benefit b_2. It turns out that the empirical requirement is then met for $\gamma = 0.3$.

The unemployment benefits could also have been calibrated on the basis of their empirical counterparts. However, many of the 55-59 non-employed workers are not registered as unemployed, but are in older workers income programs which offers a large range of benefits, in general more generous than the common unemployed benefit. As the workers distribution over these different programs and even the exact level of the different benefits are largely unknown, it is difficult to calibrate on the basis of a direct observation. The unemployment benefits profile by age is then set in accordance with the employment rates over the working life cycle. We replicate quite well the decrease in the employment rate as the retirement age stands out. The implied non-employment benefits appears quite sensible. Young unemployed workers (C_1) receive 31% of the 1998 mean value of unemployment benefits[8], C_2 and C_3 workers 40% and older workers (C_4) 56%. This is consistent with the lower eligibility rate of younger workers and the fact that there exist more generous schemes for older workers (specific income programs and less stringent conditions on eligibility for unemployment benefits).

[8] In France, only 40% of non-employed workers are eligible for the unemployment benefit system. In 1998, the mean value of unemployment benefits equals 5896 French Francs (Legendre (2004)).

Table 3: Employment rates

Age groups	C_1	C_2	C_3	C_4	C_5
Age in years	20-34	35-49	50-54	55-59	60-64
data	0.8468	0.8931	0.8497	0.6191	0
Benchmark model	0.8466	0.8910	0.8449	0.6191	0

In our benchmark calibration, we consider an actuarially unfair social security scheme as it was the case until the 2003 reform in France[9]. We impose the pensions to be the same whatever the retirement age between 60 and 65: $p_6 = p_5$. No pension adjustment is taken into account in case of delayed retirement. We consider that all workers reach the full record of contributive years at age 60. This is not consistent with the heterogeneity we used in our microeconometric study. 82% of male individuals retired at age 60 with the full rate (DREES (2003)). Rather than a retirement age at 60, we aim at replicating the fact that French workers leave when they reach the full record of contribution years, as documented by Blanchet & Pelé (1997)[10]. Given the lack of heterogeneity in terms of careers, assumed for sake of simplicity, it implies that all individuals must be retired at age 60 in our model. We choose not to calibrate the pension level so as to replicate this stylized fact. We consider the average pension level in 1998, (6800 French Francs, COR (2001)). We then want to verify that, given the calibrated preferences, the model is able to generate a 100% rate of retirement at 60 in order to have more faith in the model's prediction. It turns out that no workers choose to delay retirement in the case of no actuarial adjustments (column C_5 in table 3).

Given the levels of non-employment incomes and pensions, the equilibrium tax rates are $\tau_b = 3.1\%$ and $\tau_p = 30.19\%$. Notice that these values are close to their empirical counterparts, respectively 6.4% and 26% in France despite the highly stylized model we consider.

4.2 The interaction between distance from retirement and the job search

In Table 3, the fall in the employment rate of older workers results from the combination of two mechanisms : a traditional one due to the upward sloping profile of unemployment benefits and the horizon effect, that is specific to the life cycle framework. This section aims at illustrating and quantifying the respective role of each element.

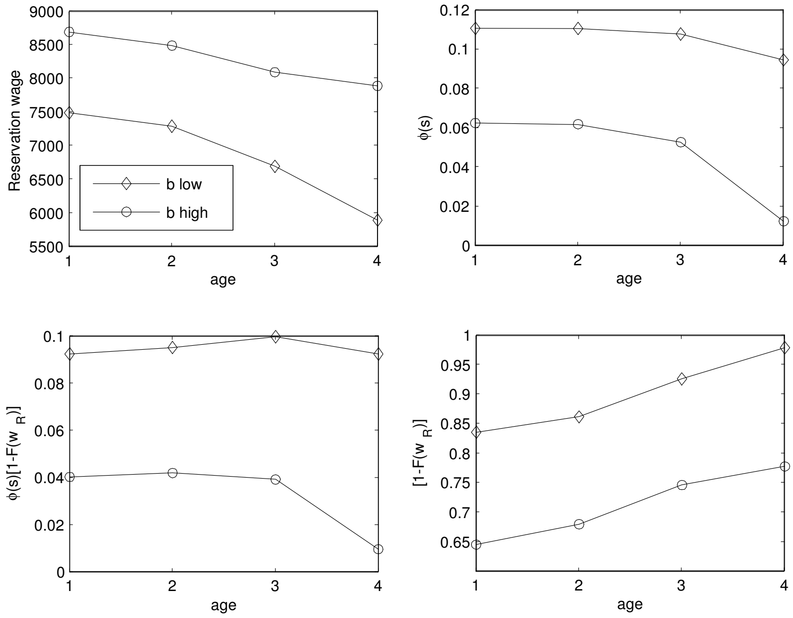
4.2.1 The retirement horizon effect

How is job search behavior altered when individuals get closer to their expected retirement age? In order to make the mechanisms at work more transparent, we first examine labor

[9] The 2003 reform introduces an actuarial flavor in the French pension scheme by giving a 3% increase in pension for any additional working year beyond the required number of contributive years.

[10] 97.6% of men retire at the full pension age.

Figure 3: Search behavior over the life-cycle



participation when non-employed incomes do not differ across ages. We can fix all the non-employed incomes at the low median age level or at the higher level of older workers. This is obvious, as equation (10) shows, that high unemployment benefits increase the elasticity of the job search effort to a variation in $\mathcal{S}$: with this utility function, given the calibration of σ, a high non-employment income implies a decrease in the marginal utility of leisure. As a result, we choose to examine the two cases : b high (the benefit level received by 55-59 year old individuals) and b low (the benefit level paid to individuals aged 30-49).

Figure 3 illustrates two main forces at work in the model at the end of the working life.

- First, the older the agent, the shorter his expected life-time duration on the labor market. Old workers will accept lower wages because impatience increases with age: the shorter the horizon, the smaller the benefit of waiting to see if a higher job offer becomes available, as the benefits of employment cannot be enjoyed for a long period. As a result, accepting a job becomes more attractive : the reservation wage decreases with age (see first panel of figure 3). This decline in the reservation wage with age implies that a larger number of job offers becomes acceptable. This is directly measured by $[1 - F(w_R)]$, where w_R denotes the reservation wage by age. Therefore, this first effect cannot account for the low employment rate of senior workers in countries such as France.

- The second effect tends to make the model more consistent with French data. Even if old unemployed workers accept lower wage offers, their incentives to search more intensively for job offer decline. After age 55, their job search intensity falls and so does the probability of getting a job offer, measured by $\phi(s)$. Given our assumptions on preferences, the optimal search intensity is given by:

$$s_i = T - \left\{ \frac{\gamma \beta \mathcal{S}}{(1-\nu)(b)^{\nu(1-\sigma)}} \right\}^{\frac{1}{(1-\nu)(1-\sigma)-1}} \quad (10)$$

$$\text{where:} \quad \mathcal{S} = \pi_i \left[\int \max[V_i^e(w), V_i^u] dF(w) - V_i^u \right]$$

First, as the individual ages, the gap between the values of an employed and an non-employed worker narrows whatever the reservation wage. The non-employed worker and the employed worker become retirees and receive the same pension: the value of employment converges to the one of non-employment. Secondly, as the reservation wage goes down with age, the convergence is reinforced. These effects are measured by $\mathcal{S}$. As the non-employment income is constant ($b_i = b$, $\forall i$), the expression of the optimal job search intensity by age implies that s_i decreases with age only because of the fall in $\mathcal{S}$ (equation (10)). This effect is magnified when non-employed income is high. It suggests that the generosity of the non-employment benefit system strongly interacts with the horizon effect.

These two economic forces move in opposite directions during the life-cycle. The decrease in the reservation wage leads to an increase in employment at the end of the life-cycle, while the decline in job search intensity, capturing the "discouraged worker effect", implies that the transition rate from unemployment-to-employment goes down at the end of the life-cycle. Our numerical example measures the combination of these two effects and shows that the "discouraged worker effect" gets the upper hand, particularly in the case where the unemployment benefit is high. Indeed, the transition rate to employment, $\phi(s)[1 - F(w_R)]$, declines.

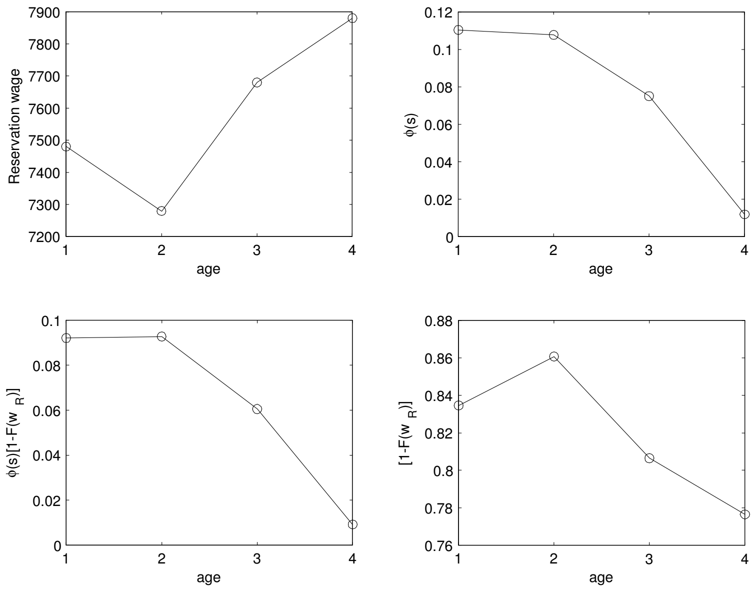
4.2.2 Adding upward sloping unemployment benefits

When unemployment benefits rise now with age, the profile of the reservation wage becomes upward sloping. Table 4 shows that the combination of the "discouraged worker effect" and the rise in the non-employment income leads to a dramatic fall in the employment rate at the end of the life cycle.

The shape of the reservation wage given by figure 4 shows three important features.

- First, at the beginning of the life cycle, the low level of non-employment income reduces the selective behavior of individuals during the job search process.
- After this first period, the increase in non-employment income leads to a parallel rise in the reservation wage: then, individuals can be more selective because their expected time spent searching for a job is long. Individuals of age C_2 and C_3 have the same behavior as when non-employment incomes are constant.

Figure 4: Search behavior over the life-cycle when b increases with age



- Finally, at the end of the life-cycle, the rise in non-employment income accounts for the evolution of the reservation wage: both economic behaviors and institutional arrangements contribute to the decline in employment rate.

4.2.3 Disentangling the retirement horizon and the unemployment benefit profile

At this stage, one could argue that the decline in older workers' labor force participation results more from high unemployment benefits rather than from the expected retirement effect identified in our econometric estimates. In order to measure the role of both elements, table 4 displays the employment rates predicted by the model with a constant but high unemployment benefit (the benefit level received by 55-59 year old individuals), and one with a constant but low unemployment benefit (set to the level of benefits paid to individuals aged 30-49). [11]

Consider line 2 of table 4: employment rates before retirement remain quite stable. With low unemployment benefits, individuals at all ages are enticed to work. Comparing with line 3 yields interesting results. Employment rates are weaker at all ages, but, more importantly, much more for the older workers. There is now a huge difference across ages. The time horizon effect alters the employment rate for older workers *only in conjunction with* generous unemployment benefits.

The joint effect of high unemployment benefits and the retirement horizon mechanism supports our cautious interpretation of the estimated logit model reported in table 1.

[11] Both experiments were carried out using the payroll tax rates computed in the benchmark scenario.

Table 4: Employment rates

Age groups	C_1	C_2	C_3	C_4	C_5
Age in years	20-34	35-49	50-54	55-59	60-64
1 . Data	0.8468	0.8931	0.8497	0.6191	0
2. Model with b constant but low	0.8454	0.8922	0.8961	0.8909	0.0052
3. Model with b constant but high	0.7056	0.7821	0.7794	0.6030	0.0016
4. Benchmark model	0.8466	0.8910	0.8449	0.6191	0.0219

The theoretical model suggests that the distance from retirement discourages activity as a result of generous non-employment benefits *and* the horizon effect.

Therefore, it could be interesting to have a quantitative measure of the respective role of both elements in the decline in older workers' labor participation. First, at ages when the expected horizon effect does not affect search behavior (before the age of 54), the employment rate is more than 10% lower on line 3 than on line 2. Secondly, a high b in conjunction with the expected horizon effect yields a 30% decline in employment rate at ages just prior to retirement (a fall in labor participation from 90% to 60% at age C_4). This suggests that the generosity of non-employment income accounts for a third of the decline in the labor participation (10%) and the time horizon effect alone corresponds to a two-thirds decline in the employment rate for older workers.

This result sheds light on the empirical results we obtain in section 2. In the context of high unemployment benefits, the horizon effect may be very significant, and tends to eclipse the role of unemployment benefits. The number of years prior to retirement is crucial, since only workers close to retirement age modify their job search behavior. But this occurs only when unemployment benefits are high enough.

As expected, there are two options for dealing with the low employment rate at the end of the working life. On the one hand, decreasing the generosity of the unemployment benefit would be efficient, in particular, and unexpectedly, by dampening the horizon effect. On the other hand, delaying the retirement age could be another strategy if a high unemployment benefit for older workers is maintained: this argument reinforces the case for more actuarially fair adjustments in social security provisions.

5 A Policy Experiment

This section explores the policy implications of the retirement horizon effect. In particular, we show that the interaction between the distance from retirement and the search intensity magnifies the effects of reforms aiming at delaying retirement. We first implement a more actuarially-fair adjustment pensions scheme derived from an explicit welfare criterion maximization. Secondly, we compare this optimal scheme with a mandatory delay in retirement age. This exercise allows us to identify the magnitude of the horizon effect in the incentive scheme.

In the previous experiments, pension schemes were characterized by an extreme tax on continued activity : the pension was constant whether individuals retired at 60 or 65 years old. Let us assume that the tax on continued work is lowered: the pension increases if *employed* workers choose to retire at age 65. As we want to analyze pension reforms only, unemployment benefits are left unchanged so that non-employed individuals of age 60 and more are obliged to become retirees. Moreover, this is also the simplest way to take into account the fact that the pension adjustments are based only on working years. In France, the 2003 pension reform has introduced a 3 % annual pension adjustment for each additional working year after the statutory 40 working years. This means that the non-working years are not accounted for by pension adjustments, whereas, prior to the full rate, they are.

In the literature on the actuarially fair schemes, it is usually assumed that there is full employment in the economy, thereby neglecting the impact of social security arrangements on job search behavior.

In this section we show that, beyond the incentive to delay retirement, the decrease in the tax on continued work has sufficiently large effects to encourage unemployed older workers to find a job. This is an additional point in favor of this policy.

We choose to compute the pension adjustment Δp leading to the highest welfare. Welfare is given by

$$\begin{aligned} \mathcal{W} &= \sum_{i=1}^{5}(p_i - u_i - r_i)\sum_j u((1-\tau_p-\tau_b)w_{i,j}, T-h)dG_{i,j}(w_{i,j}) \\ &\quad + \sum_{i=1}^{4} u_i u(b_i, T-s_i) + \sum_{i=5}^{6} r_i u(p_i + \Delta p, T) \end{aligned} \tag{11}$$

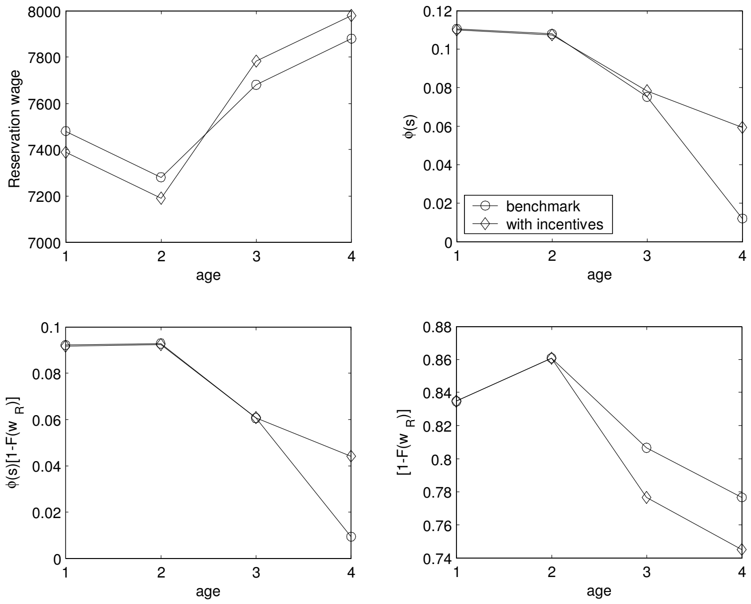
where p_i denotes the fraction of the population of age i, u_i the age i unemployment rate, r_i the rate of retired workers of age i and $dG_{i,j}(w_{i,j})$ the fraction of age i employed worker at wage w_j. Notice that the welfare criterion takes into account labor market transitions, including firing and incentives to look for a job when unemployed. Finally, we adopt an equilibrium perspective by taking into account the potential impact of unemployed workers' search behaviors on tax adjustments. Then, we measure the implications of this policy on tax rates (τ_b and τ_p) that endogenously adjust to balance the social security budget.

5.1 Identifying a double dividend

The adjustment in pensions deriving from the maximization of the welfare criterion amounts to $\Delta p = 40\%$. Let us recall that it remunerates five additional working years, and not only one. Actuarially-fair pension schemes greatly should increase the value of being employed before retirement. For unemployed workers aged 55 or more, the incentives to look for and accept a job go up. Is this uncertain return on the job search, anticipated today, large enough to reduce the "discouraged worker effect" which dominated the labor choices of older workers?

In light of figure 5, the answer to this question is a qualified *yes.* Incentives to work longer generate a double dividend : the increase in pension because of continued activity

Figure 5: Job search behavior over the life-cycle with incentive schemes



not only encourages employed workers to delay retirement but also gives incentives to non-employed workers before the early retirement age to search more intensively and accept job offers. Incentive schemes globally increase the employment rate for older workers.

- First, with incentive schemes, the implicit tax on continued activity is removed. Thus, more individuals remain at work until the maximum retirement age. In the benchmark economy, the implicit tax on continued activity results in a high reservation wage for individuals of age 60 - 64 (C_5). In contrast, incentive schemes yield a decline in the reservation wage for individuals aged 60 - 64.

- Secondly, incentive schemes not only encourage individuals to keep their jobs, but also make job offers more attractive to unemployed people because the distance from retirement age increases. In age group C_4, a more intensive job search effort, relative to the benchmark case, reduces the fall in the transition rate to employment. The employment rate of age group C_4 goes up from 60% to 80% (lines 1 and 3 in table 5), despite the high non-employment benefit.

In order to give a quantitative evaluation of the double dividend of incentive schemes, we propose to analyze the impact of this reform. In a first stage, we identify the benefits of incentive schemes traditionally underlined by those who advocate of actuarially fair schemes: incentive programs are expected to make employed workers delay retirement. We then assume that only the behaviors of employed agents between 60 and 65 are

Table 5: Incentive schemes and Employment rates

Age groups	C_1	C_2	C_3	C_4	C_5
Age in years	20-34	35-49	50-54	55-59	60-64
1. Benchmark model	0.8466	0.8910	0.8449	0.6191	0.0219
2. Exogenous labor market	0.8466	0.8910	0.8449	0.6191	**0.3721**
3. Endogenous labor market	0.8460	0.8906	0.8392	**0.8011**	**0.4840**

endogenous [12]. The behavior of agents who do not have the opportunity to retire are the same as in the economy without incentives. This first scenario enables us to compute the optimal increase in pension as if the labor market equilibrium had not changed (labor market equilibrium is exogenous). We evaluate the impact of the incentive schemes only for the older workers, who have already reached the early retirement age. In a second stage, we take into account all equilibrium adjustments when we compute the optimal increase in the pensions. We then show how the employment rate changes across ages after taking into account the endogenous response of employed workers as well as unemployed individuals.

Both experiments are carried out in a general equilibrium setting as payroll taxes endogenously adjust to balance unemployment and social security budgets. In addition, the actuarially-fair scheme maximizes welfare (equation (11)).

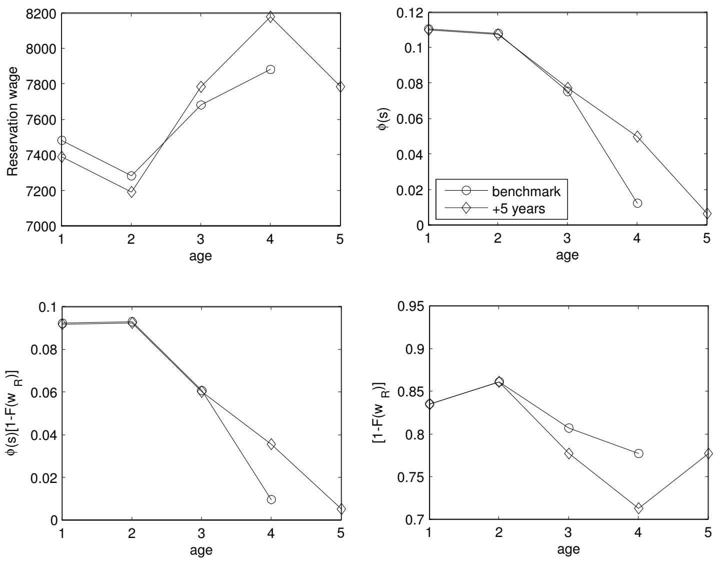
When the labor market equilibrium before the early retirement age is the same as in a economy without incentive schemes (lines 1 and 2 in table 5 are identical before 60), the optimal adjustment of pension provisions is $\Delta p = 35\%$. The impact of this policy is standard: the increase in pension if the worker retires at age 65 leads to a significant fall in the reservation wage after the age of 60 because the opportunity costs of employment are now compensated for by the heterogeneity in the pension. Then, the employment rate between age 60 and 65 significantly increases (see line 2 in table 5). As these additional workers pay a tax on their wage, at optimum, the payroll tax financing unemployment insurance decreases from 3.1% to 2.95% for all workers. In contrast, the tax rate on wages financing retirement pension increases from 30.19% to 31.44%.

When we take into account all labor market equilibrium adjustments (line 3 in table 5), remember that the optimal increase in pensions amounts to 40%. It is optimal to offer an higher pension adjustment than in the usually studied case where the only choice is between work and retirement. It takes into account the additional return in terms of employment in the labor market just before the early retirement age. As in the preceding experiment, the wage tax financing unemployment benefits decreases from 3.1% to 2.3% and the wage tax financing the pensions increases from 30.19% to 31.83%. This small increase in taxes allows the government to redistribute income[13]. Most importantly, as the

[12] We assume that the decision rules of individuals under 60 are the same as in the benchmark economy. Then only individuals older than 60 modify their job search behaviors (reservation wage, search intensity) and retirement decisions.

[13] This implicit sharing rule comes from the collective objective we use in order to find the optimal fiscal system.

Figure 6: Job search behavior over the life-cycle with +5 years before eligibility for early retirement



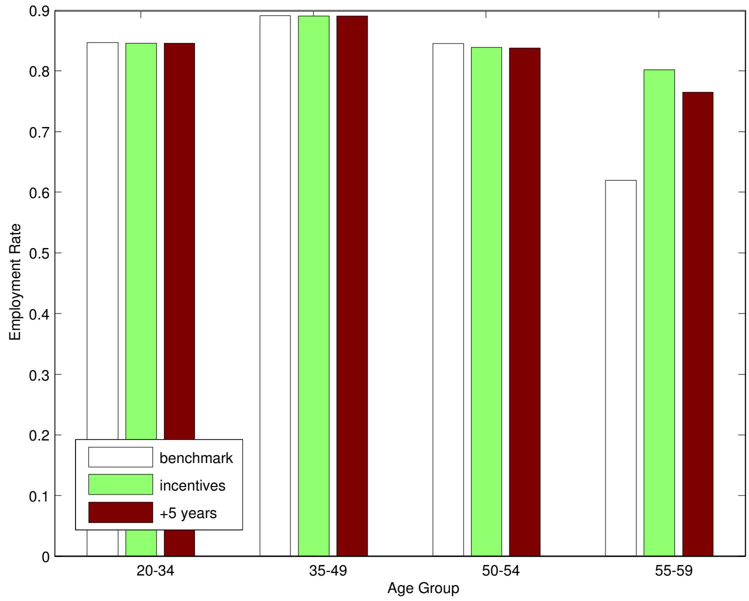
older workers intensify their job search, the increase in labor participation occurs much earlier. At age C_4, the employment rate is 80% with endogenous labor market versus 60% when the search behavior is not modified. By taking into account the behavior of workers, we show that the decrease in the tax on continued activity by increasing the employment value leads to a higher employment rate at age 55-59. This amplifies the efficiency of the reform as more people choose between the continuation of the activity and the retirement, which is an open option after 60 year old (the early retirement age). This then yields additional workers after the age of 60.

5.2 Identifying the role of the horizon effect

More actuarially fair-adjustments make the job value positive at ages for which otherwise the time horizon was too short. Firstly, they delay the retirement age, and thus the time horizon, like a mandatory lengthening of the retirement age. Secondly, the job value is boosted by restricting the opportunity of getting a higher pension to workers employed prior to the early retirement age. It takes into account the fact that pension adjustments after the normal replacement rate are based on working years. In order to identify the role of the horizon effect, we compare the actuarially fair adjustments policy to a mandatory delay in the early retirement age until the worker is 65. Generous unemployment benefits are extended to the 60-64 year old age group. As we only want to identify the role of the horizon effect, we assume that tax rates are the same as in the economy with incentives.

Figure 6 shows that a longer horizon yields large incentives *per se* for the 55-60 year old workers to find a job. First, as the impatience of this type of agent is lower, the

Figure 7: Employment rates over the life-cycle



reservation wage is higher than in the benchmark case. Nevertheless, this does not lead to a decrease in employment rates because the delay in eligibility for retirement leads to a higher value of employment and thus to a higher level of job search intensity. Figure 7 suggests that, compared with the benchmark case, the transition to employment increases for the 55-59 year old workers.

The longer horizon then explains a large part of our first results as illustrated by figure 7. In the benchmark case, the employment rate for the 55-60 year old workers is 61.91%. This rate increases to 80.11% when we introduce incentive schemes. The increase in the early retirement alone leads to an employment rate of 76.42%. This implies that the increase in the horizon explain approximately 80% of the increase in the employment rate. This result gives theoretical support to our empirical findings.[14]

6 Conclusion

This paper aimed at studying the interaction between retirement decisions and the job search on the labor market just prior to retirement. Our enlarged approach reveals a deadline effect due to retirement which recursively reduces the search intensity, hence the rate of employment, of older workers. As the expected retirement age gets closer, unemployed individuals cease to look for a job : it is not worthwhile spending time searching for a job as the benefits of employment cannot be enjoyed for a long period.

[14] Both reforms lead to very similar employment rates of older workers. However, welfare is higher in the case of incentive schemes, even after taking into account endogenous tax rates.

The expected retirement age, i.e. the time horizon before retirement, accounts for a large part of the low employment rate of older workers, which is confirmed by our empirical evidence based on macro and micro data.

We thus extend McCall's (1970) search model to allow for life cycle features and endogenous retirement. This gives theoretical grounds to the mechanisms at work on the labor market when the retirement age gets closer, in particular the strong interactions between the horizon effect and the generous unemployment benefits at the end of the working life. Calibration on the French economy confirms the major effects uncovered by the micro-econometric analysis of French panel data.

Our contribution to the literature on actuarially fair pension policy is twofold. First, the computation of actuarially fair schemes is based on an explicit welfare criterion that takes into account all labor market transitions including the probability of being fired and of looking for a job. In contrast, previous works discussed actuarial fairness assuming full employment. Secondly, actuarial fairness is examined in a general equilibrium framework as payroll taxes endogenously adjust to balance unemployment and social security budgets. The model predicts that a decrease in the tax on continued activity not only makes older workers delay retirement, but also encourages unemployed people to find a job, yielding a double dividend of incentive schemes. It provides strong support in favor of policies that reward continued activity on an actuarially-fair basis.

Overall, we think that integrating the retirement deadline into labor market analysis is a promising approach which could be undertaken to revisit other important issues such as training, labor demand and wages bargaining. This is left for further research.

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Table 6: Age and expected retirement age

Age	More than 11 years	Between 6 and 10 years	3 to 5 years	Less than 2 years	Total
50	869	5133	0	0	6002
51	623	5123	0	0	5746
52	497	5085	0	0	5582
53	311	4941	0	0	5252
54	195	4800	0	0	4995
55	0	541	4046	0	4587
56	0	397	4137	0	4534
57	0	302	4150	0	4452
58	0	155	240	3948	4343
59	0	88	199	4106	4393
Total	2495	26565	12772	8054	49886

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APPENDIX

A Empirical evidence

Table 7: Descriptive Statistics - Men (I)

	Not employed	Employed	Total
Total	41126	205051	246177
	16.71	83.29	100.00
Number of years before retirement			
More than 11 years	26150	172636	198786
	13.15	86.85	100.00
Between 6 ans 10 years	5059	21506	26565
	19.04	80.96	100.00
3 to 5 years	4725	8047	12772
	36.99	**63.01**	100.00
Less than 2 years	5192	2862	8054
	64.46	**35.54**	100.00
Marital Status			
Live with spouse	24293	153021	177314
	13.70	86.30	100.00
Live alone	16833	52030	68863
	24.44	75.56	100.00
Number of children			
No child	18801	64794	83595
	22.49	77.51	100.00
1 or 2 children	16606	109724	126330
	13.14	86.86	100.00
3 to 5 children	5251	29591	34842
	15.07	84.93	100.00
6 children and more	468	942	1410
	33.19	66.81	100.00
Size of city			
Parisean Area	5492	30273	35765
	15.36	84.64	100.00
more than 200000 inhab Outside Parisian Area	9307	38346	47653
	19.53	80.47	100.00
	9284	40671	49955
20000 to 200000 inhab	18.58	81.42	100.00
	7051	36297	43348
less than 20000 inhab	16.27	83.73	100.00
	9992	59464	69456
Rural town	14.39	85.61	100.00

Table 8: Descriptive Statistics - Men (II)

	Not employed	Employed	Total
Sector			
Industry	11848	67937	79785
	14.85	85.15	100.00
Agriculture	1416	4951	6367
	22.24	77.76	100.00
Construction	6811	23371	30182
	22.57	77.43	100.00
Services	21051	108792	129843
	16.21	83.79	100.00
Occupational Groups			
Blue Collars	24800	108045	132845
	18.67	81.33	100.00
Clerk	6286	21826	28112
	22.36	77.64	100.00
Middle skilled worker	6743	46150	52893
	12.75	87.25	100.00
Executive	3297	29030	32327
	10.20	89.80	100.00
Citizenship			
French	36905	192325	229230
	16.10	83.90	100.00
Non French	4221	12726	16947
	24.91	75.09	100.00

Table 9: Descriptive Statistics - Men (III)

	Not employed	Employed	Total
Time Dummy			
1995	5438	25954	31392
	17.32	82.68	100.00
1996	5509	26172	31681
	17.39	82.61	100.00
1997	5542	25567	31109
	17.81	82.19	100.00
1998	5356	25652	31008
	17.27	82.73	100.00
1999	5539	25875	31414
	17.63	82.37	100.00
2000	4032	22329	26361
	15.30	84.70	100.00
2001	4758	26933	31691
	15.01	84.99	100.00
2002	4952	26569	31521
	15.71	84.29	100.00
Age dummies			
Less than 50 years old	25851	170440	196291
	13.17	86.83	100.00
50	902	51	6002
	15.03	84.97	100.00
51	924	4822	5746
	16.08	83.92	100.00
52	1022	456	5582
	18.31	81.69	100.00
53	1043	4209	5252
	19.86	80.14	100.00
54	1109	3886	4995
	22.20	77.80	100.00
55	1211	3376	4587
	26.40	73.60	100.00
56	1618	2916	4534
	35.69	64.31	100.00
57	1977	2475	4452
	44.41	55.59	100.00
58	2420	1923	4343
	55.72	44.28	100.00
59	3049	1344	4393
	69.41	30.59	100.00

B Equilibrium

B.1 Equilibrium unemployment rates

Let $U_{t,i}$, $N_{t,i}$, $R_{i,t}$and $P_{t,i}$ denote respectively the number of unemployed workers of age $i$at the beginning of period t, the number of employed workers, the number of retirees, and the total labor force (note that $P_{t,i} = N_{t,i} + U_{t,i} + R_{t,i}$, $\forall t, i$). Unemployment rates at each age obey the following laws of motion:

$$U_{t,1} = \underbrace{(1-\pi_6)P_{t-1,6} + \pi_1 \lambda N_{t-1,1}}_{\text{new unemployed workers}} + \underbrace{\pi_1[\phi(\overline{s}_1)F_1(\overline{w}_1) + (1-\phi(\overline{s}_1))]U_{t-1,1}}_{\text{surviving unemployed workers}}$$

and for $i = 2, 3, 4$,

$$\begin{aligned} U_{t,i} &= \underbrace{(1-\pi_{i-1})[\phi(\overline{s}_{i-1})F_{i-1}(\overline{w}_{i-1}) + (1-\phi(\overline{s}_{i-1}))]U_{t-1,i-1}}_{\text{new unemployed workers coming from age } i-1} \\ &\quad + \underbrace{(1-\pi_{i-1})N_{t-1,i-1}[\lambda + (1-\lambda)\max\{0, G_{i-1}(\overline{w}_i) - G_{i-1}(\overline{w}_{i-1})\}]}_{\text{new unemployed workers coming from age } i-1} \\ &\quad + \underbrace{\pi_i \lambda N_{t-1,i}}_{\text{new unemployed workers}} + \underbrace{\pi_i[\phi(\overline{s}_i)F_i(\overline{w}_i) + (1-\phi(\overline{s}_i))]U_{t-1,i}}_{\text{surviving unemployed workers}} \end{aligned}$$

where $G_i(w)$denotes the fraction of age $i$employed workers at wage w or less. The right hand side of these equations is the sum of new unemployed workers of age i and the survivors at age i of workers who were unemployed at the end of the period, which correspond to the workers who reject offers that are less than the optimal reservation wage ($\overline{w}_i$).

Given that the size of the population is a constant, denoted P, one can define stationary equilibrium unemployment rates by age. These constant levels of unemployment rates, denoted $u_i = U_i/P$, are defined by:

$$u_1 = \frac{(1-\pi_6)p_6 + \pi_1 \lambda p_1}{1 - \pi_1[\phi(\overline{s}_1)F_1(\overline{w}_1) + (1-\phi(\overline{s}_1))] + \lambda \pi_1}$$

and for $i = 2, 3, 4$,

$$\begin{aligned} & (1 - \pi_i[\phi(\overline{s}_i)F_i(\overline{w}_i) + (1-\phi(\overline{s}_i))] + \pi_i \lambda)u_i \\ = \; & (1-\pi_{i-1})[\phi(\overline{s}_{i-1})F_{i-1}(\overline{w}_{i-1}) + (1-\phi(\overline{s}_{i-1}))]u_{i-1} \\ & -[\lambda + (1-\lambda)\max\{0, G_{i-1}(\overline{w}_i) - G_{i-1}(\overline{w}_{i-1})\}]u_{i-1} \\ & +(1-\pi_{i-1})[\lambda + (1-\lambda)\max\{0, G_{i-1}(\overline{w}_i) - G_{i-1}(\overline{w}_{i-1})\}]p_{i-1} + \pi_i \lambda p_i \end{aligned}$$

where p_i denotes the fraction of population of age i in the total population. Finally, the equilibrium rates of retired workers are given by:

$$\text{if } V_5^r < V_5^u \Longrightarrow U_{5,t} > 0 \text{ and,}$$

$$
\begin{aligned}
R_{5,t} &= 0 \\
&\quad \text{if } V_5^r < V_5^u \Longrightarrow U_{5,t} = 0 \text{ and,} \\
R_{5,t} &= \pi_5[R_{5,t-1} + \lambda N_{5,t-1} \\
&\quad +(1-\pi_4)[\lambda + (1-\lambda)\max\{0, G_4(\overline{w}_5) - G_4(\overline{w}_4)\}]N_{4,t-1} \\
&\quad +(1-\pi_4)[\phi(\overline{s}_4)F_4(\overline{w}_4) + 1 - \phi(\overline{s}_4)]U_{4,t-1} \\
R_{6,t} &= \pi_6 R_{6,t-1} + (1-\pi_5)P_5
\end{aligned}
$$

At steady state, these equations imply that the rate of retired workers (R_i/P) is given by:

$$
\begin{aligned}
&\quad \text{if } V_5^r < V_5^u \\
r_5 &= 0 \\
&\quad \text{if } V_5^r > V_5^u \\
r_5 &= \frac{(1-\pi_4)[\phi(\overline{s}_4)F_4(\overline{w}_4) + (1-\phi(\overline{s}_4)) - \lambda - (1-\lambda)\max\{0, G_4(\overline{w}_5) - G_4(\overline{w}_4)\}]}{1-\pi_5(1-\lambda)} u_4 \\
&\quad + \frac{\lambda\pi_5 p_5 + (1-\pi_4)[\lambda + (1-\lambda)\max\{0, G_4(\overline{w}_5) - G_4(\overline{w}_4)\}]p_4}{1-\pi_5(1-\lambda)} \\
r_6 &= \frac{(1-\pi_5)p_5}{1-\pi_6}
\end{aligned}
$$

After solving this system of equations, one can deduce the aggregate equilibrium unemployment rates: $u = \sum_i u_i/(1-\sum_i r_i)$and the equilibrium rate of retirees $r = \sum_i r_i$. Equilibrium unemployment rates by age are defined as $\widetilde{u}_i = u_i/p_i$.

B.2 Equilibrium wage distributions

As the demographic structure affects leads to a non stationary reservation wage, we compute $G_{i,t}(w)$ the fraction of age i employed workers at wage w or less at time t in order to determine equilibrium unemployment rate. These functions are derived from the following equilibrium flows:

$$
(p_1 - u_{1,t})G_{1,t}(w) = \pi_1 \left[(1-\lambda)(p_1 - u_{1,t-1})G_{1,t-1}(w) + \phi_{1,t-1}(F_1(w) - F_1(\overline{w}_1))u_{1,t-1}\right]
$$

where $\phi_{1,t-1} \equiv \phi(\overline{s}_{1,t-1})$. At steady state, this equation implies:

$$
[1-\pi_1(1-\lambda)](p_1 - u_1)G_1(w) = \phi_1(F_1(w) - F_1(\overline{w}_1))u_1
$$

$$
\Leftrightarrow G_1(w) = \frac{\phi_1 u_1}{[1-\pi_1(1-\lambda)](p_1 - u_1)}(F_1(w) - F_1(\overline{w}_1))
$$

For age $i = 2, 3, 4$, the dynamics of the fraction of age i employed workers at wage w or less at time t is given by:

$$
(p_i - u_{i,t})G_{i,t}(w)
$$

$$
\begin{aligned}
= \; & \pi_i \left[(1-\lambda)(p_i - u_{i,t-1})G_{i,t-1}(w) + \phi_{i,t-1}(F_i(w) - F_i(\overline{w}_i))u_{i,t-1}\right] \\
& +(1-\pi_{i-1}) \left[\phi_{i-1,t-1}(F_{i-1}(w) - F_{i-1}(\overline{w}_{i-1}))u_{i-1,t-1}\right. \\
& \left. +(p_{i-1} - u_{i-1,t-1})G_{i-1,t-1}(w)[(1-\lambda)(1-\max\{0, G_{i-1}(\overline{w}_i) - G_{i-1}(\overline{w}_{i-1})\})\right]
\end{aligned}
$$

For employees, the transition between age $i-1$ and age i could lead to a voluntary quit if the wage accepted at age $i-1$ is lower than the reservation age at age i. This fraction of voluntary quits is measured by $(1-\pi_{i-1})(p_{i-1}-u_{i-1,t-1})G_{i-1,t-1}(w)(1-\lambda)\max\{0, G_{i-1}(\overline{w}_i) - G_{i-1}(\overline{w}_{i-1})\}$. At steady state, we then obtain:

$$
\begin{aligned}
& [1-\pi_i(1-\lambda)](p_i - u_i)G_i(w) \\
= \; & (1-\pi_{i-1})[(1-\lambda)(1-\max\{0, G_{i-1}(\overline{w}_i) - G_{i-1}(\overline{w}_{i-1})\})](p_{i-1} - u_{i-1})G_{i-1}(w) \\
& +u_i\pi_i\phi_i(F_i(w) - F_i(\overline{w}_i)) + u_{i-1}(1-\pi_{i-1})\phi_{i-1}(F_{i-1}(w) - F_{i-1}(\overline{w}_{i-1}))
\end{aligned}
$$

For age $i = 5$, the dynamics of the fraction of age i employed workers at wage w or less at time t is given by:

$$
\begin{aligned}
& (p_i - r_{i,t})G_{i,t}(w) \\
= \; & \pi_i(1-\lambda)(p_i - r_{i,t})G_{i,t}(w) + (1-\pi_{i-1}) \left[\phi_{i-1,t-1}(F_{i-1}(w) - F_{i-1}(\overline{w}_{i-1}))u_{i-1,t-1}\right. \\
& \left. +(p_{i-1} - u_{i-1,t-1})G_{i-1,t-1}(w)[(1-\lambda)(1-\max\{0, G_{i-1}(\overline{w}_i) - G_{i-1}(\overline{w}_{i-1})\})\right]
\end{aligned}
$$

At steady state, we then obtain:

$$
\begin{aligned}
& (1-\pi_{i-1}(1-\lambda))(p_i - r_{i,t})G_{i,t}(w) \\
= \; & (1-\pi_{i-1}) \left[\phi_{i-1}(F_{i-1}(w) - F_{i-1}(\overline{w}_{i-1}))u_{i-1}\right. \\
& \left. +(p_{i-1} - u_{i-1})G_{i-1}(w)[(1-\lambda)(1-\max\{0, G_{i-1}(\overline{w}_i) - G_{i-1}(\overline{w}_{i-1})\})\right]
\end{aligned}
$$

Notice that the equilibrium rates of unemployment by age depend on the equilibrium wage distributions, because some workers decide to quit their jobs. Moreover, the equilibrium wage distribution for a worker of age i is a function of the equilibrium wage distribution of workers of age $i-1$. Finally, one can define the aggregate equilibrium wage distribution as follows:

$$
(p-u)G(w) = \sum_i (p_i - u_i)G_i(w)
$$

where the the aggregate participation rate p is defined by $p = 1 - r$, with r the rate of retired workers.

B.3 Government budget constraints

Social security is financed by a proportional tax on labor income levied on all working people. For the sake of simplicity, we assume that pensions and non-employment incomes are not linked to individuals'earning histories. For each period, the social security budget is balanced. Then non-employment incomes are financed by levying taxes on workers:

$$
\tau_b \sum_{i=1}^{5} (p_i - u_i - r_i) \sum_j w_{i,j} dG_{i,j}(w_{i,j}) = \sum_{i=1}^{4} u_i b_i
$$

Similarly, for pensions, we have:

$$\tau_p \sum_{i=1}^{5} (p_i - u_i - r_i) \sum_j w_{i,j} dG_{i,j}(w_{i,j}) = \sum_{i=5}^{6} r_i p_i$$

The computation of the equilibrium allows us to find the tax rates τ_b and τ_p that balance both budgets.