Life expectancy and labor supply of the elderly*

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Abstract

Most of the twentieth century saw a progressive reduction in the labor market participation of older workers but, in the nineties, there was a turning point in this trend across the developed world. Incentives to retire early have gradually been removed and, even, substituted by benefits for workers who remain active. This paper shows that these reforms will find less and less opposition from workers as a consequence of the growth in their life expectancy, as long as it has a greater positive effect on the productivity of the elderly than on the value of leisure. The higher rate of activity in the labor market of the elderly is due to those with the better levels of productivity.

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1. Introduction

In a recent report, published in 2008, the European Observatory on the Social Situation warned about the important impact that population ageing will have on the lives of European Union citizens. While, in 2007, there were four people of working age for each person over 65 in the EU27, the prevision for 2060 lowered this ratio to 2 to 1. The same scenario was anticipated in the USA where, more than ten years ago, this ratio was 3.3 to 1 and will fall to 2 to 1 in 2030 (Quinn, 1997). These demographic predictions raise many problems derived from the growing percentage of old individuals, whose principal features are low productivity and high economic needs due to health problems.

Not all countries are being equally affected by population ageing, or at the same time. Fortunately, ageing has not yet reached these worrying levels, so there is still time in which to consider the best solutions. Some measures that are being considered to correct the effects of this trend on the pension systems are a reduction in pensions and/or an increase in pension contributions during working life. However, apart from the controversial reactions of the public to these two measures, some projections carried out to assess the financial sustainability of the pension systems conclude that they may be insufficient to face all the expected difficulties (Blake and Mayhew, 2006). Immigration from less-developed countries is also considered a possible solution to population ageing in developed countries. But, as Coleman (2002) and Wallace (2001) pointed out, it cannot be a long-term solution. It could be a short-term solution while the immigrants are able to cover the shortages in the host labor markets and, obviously, as long as integration problems do not arise. But it cannot be a long-term solution because immigrants converge to the same demographic patterns as the natives of the host countries.

This is why one of the measures proposed to offset the effects of the general ageing trend that is currently receiving great support from the leaders of the most developed countries is to delay the retirement age or to increase the participation rate of old people in the labor market. There is no doubt about the positive effects that a delay in the retirement age would have on public finances or about the support that political leaders give to this policy. However, the important question is whether the citizens are really willing to extend their working life. In this paper we present a model where individuals decide whether or not to participate in the labor market at older ages, considering several factors that need to be taken into account in a full treatment of the retirement decision. The aim is to test whether the individual optimal decision about retirement coincides with the present position of institutions in favor of delaying the age of retirement. The main personal factor affecting the decision about the age of retirement that we consider is the increase in life expectancy. The other influential elements have an economic character. From an institutional point of view, our approach leads us to recommend neutral institutional setups in which agents can decide freely about when they retire.

Our theoretical framework is close, but not identical, to the one used by Matsuyama (2008). For this author, the retirement decision is endogenous, which enables the study of the interdependence between the participation rate of old people in the labor market and wage growth. Matsuyama concludes that the income effect derived from the wage growth during the active life of the workers leads most of them to choose early retirement instead of continuing to work. However, his study does not consider the effect of life expectancy, an important factor to take into consideration in the retirement decision. Introducing this element into the analysis, we find that the impact of the extension of the life span may offset the possible income effect.

More important, our approach is able to clarify a contradictory result obtained by two previous studies tackling the influence of longevity on the choice of the moment at which to retire: Bloom et al. (2007) and Ferreira and Pessôa (2007). The first authors conclude that, without institutional distortions such as those derived from the different systems of social security, a greater life expectancy has a positive effect on old people's participation rate in the labor market, while the second paper concludes the opposite. Not surprisingly, these contradictory results arise from the different key assumptions introduced into each paper, which refer to different aspects of reality.

On the one hand, focusing on the effects of longevity on national savings, Bloom et al. (2007) develop a model in which both savings and retirement decisions are endogenous. As usual, agents decide when to work and when to retire by comparing the utility gains derived from additional consumption with the disutility of additional time devoted to work. The key element for the result obtained is that the disutility of working (utility of leisure) depends exogenously on life expectancy. A higher life expectancy is assumed to reduce the disutility of working because people become healthier at all ages. They show that, in a context with no social security system and perfect capital markets, the optimal response to an improvement in life expectancy is an increase in the retirement age.

On the other hand, Ferreira and Pessôa (2007) claim that life expectancy growth explains both the increases in schooling and the trend towards an early retirement observed in the twentieth century in the USA. They introduce a specific profile of productivity during the life cycle. In particular, the mechanism that makes individuals retire earlier is the assumption that longer lives imply that productivity decreases faster at old age.

We consider jointly the link between the disutility of working, life expectancy and a profile of labor productivity. This allows us to obtain a more general framework to analyze the retirement decision. The increase in generality is due not only to the joint consideration of these two elements but also, and above all, to the endogenous character of the evolution of the disutility of working, in contrast with Bloom et al. (2007) and to the consideration that the decline in productivity associated with age is slower when life expectancy increases, in contrast with Ferreira and Pessôa (2007). This latter consideration can be explained by the fact that the enlargement of life expectancy is linked to a phenomenon known to demographists and health specialists as morbidity compression. This phenomenon implies a significant increase in the number of years free from disease, in such a way that both physical health and cognitive ability are being extended into old age faster than the increase in life expectancy (Fries, 1980; Costa, 2002; Bloom et al., 2007).

Moreover, we assume that the profile of labor productivity is not the same for all individuals. This assumption implies that, while in Bloom et al. (2007) and Ferreira and Pessôa (2007) agents are identical and, therefore, decide to retire at the same age, in our case they exhibit heterogeneous productivity profiles which generate differences in their retirement decision. This leads us to consider a two-period model (in which the decision is about whether to retire or not in the second period) instead of a continuous time specification. Thus we can maintain the model tractable and, in particular, obtain a closed-form solution, despite the increase in complexity generated by the heterogeneity of workers[1]. Two results are noteworthy. Firstly, the model identifies that the individuals who decide to prolong their participation in the labor market to older ages are those with the highest levels of productivity, a result supported by the empirical evidence. Secondly, improvements in longevity involve an increase in the utility of leisure as well as a lower fall in the productivity of older workers, two effects that work in opposite directions. Thus, a larger life expectancy leads to higher rates of activity in the labor market of older people when the latter effect dominates; otherwise, the effect of the longevity on the rate of activity of the elderly is not determinate. As it can be seen, the two key elements from Bloom et al. (2007) and Ferreira and Pessôa (2007) play their role and must be jointly considered in the results of our more general setup.

The rest of the paper is organized as follows. Section 2 extends the motivation of the paper, presenting the main facts and ideas about retirement age. Section 3 presents the household characteristics from which we deduce the first ideas about how they decide their labor supply when old. In Section 4, we extend the analysis to a general equilibrium framework, including productive considerations and market equilibria. Section 5 shows the effect of life expectancy and the productivity of old people on the participation rate. A simple social security system is included in Section 6 to analyze the influence of a policy promoting a late retirement. Finally, Section 7 concludes.

2. Facts and ideas about retirement age

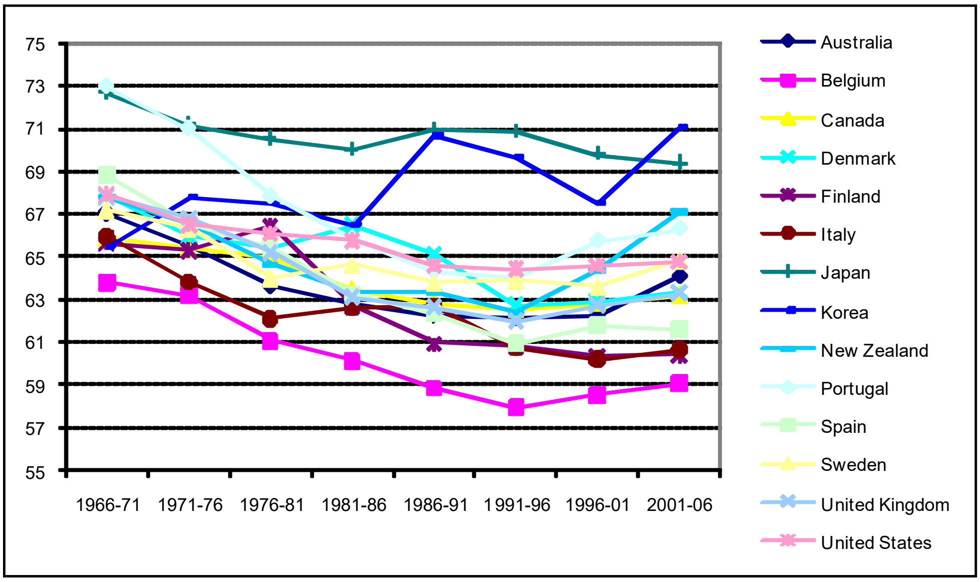
In this section, we describe the trends followed by retirement age in the recent past and review the main reasons given by the economic literature to explain early or late retirement.

During most of the second half of the twentieth century, the trend was to retire increasingly earlier. This was the rule in most countries and became a stylized fact, assumed and even promoted by governments. However, this trend was reversed in the final years of the century and, nowadays, the participation rate in the labor market of

[1] Some additional work would be required to check whether the results of our model change in a continuous time framework.

older people is increasing in most OECD countries, although not homogeneously (see Figure 1).

Figure 1. Average effective age at which men leave the labor market



Source: OECD (2006).

The figures in Table 1 illustrate this change in the case of the USA. For example, the labor force participation of men between 60 and 64 decreased by almost one third between 1955 and 1985 (from 82.6% to 55.6%) and, after a decade of slower decline, increased by 12.1% between 1994 and 2007 (from 52.8% to 59.2). The same pattern is found in the following age groups, although with lower participation rates. In the last group (mean 75 years old and over), the rates fell even more dramatically from 19.4% to 6.9% between 1955 and 1985, but reached 10% in 2007. The evolution for women is similar, although their participation rates are heavily influenced by their more recent incorporation into the labor market.

Table 1. Percentage change in labor force participation rates. USA

		Age group			
		60-64	65-69	70-74	75-
Men	1955-1985	-32.7	-57,0	-59.2	-63.9
	1985-1993	-2.7	3.7	-1.3	-1.4
	1994-2007	12.1	28.0	34.2	11.6
Women	1955-1985	15.2	-24.2	-17.4	-45.0
	1985-1993	11.1	19.3	3.9	27.3
	1994-2007	26.7	43.6	60.9	37.1

Source: Current Population Survey (Bureau of Labor Statistics), Gendel (2008).

The trend towards early retirement observed for most of the 20th century can be explained basically through four mechanisms. The first is the income effect: increments in income increase leisure demand, which leads to a reduction in the labor supply and, consequently, to a fall in the duration of active life (Matsuyama, 2008). This effect has been strengthened by a progressive reduction in the price of leisure goods (Kopecky, 2010). The second mechanism has an institutional root. Many countries implicitly punished those who continued working after the legal age of retirement through their pension systems. The more generous the pension system and the earlier the pensions could be received, the greater the proportion of individuals deciding to retire before the legal age, because the retirement option is much more attractive (Duval, 2003). Indeed, Rust and Phelan (1997) point out the incentives created by the social security rules in the presence of incomplete markets for loans, annuities and health insurance as an explanation for the peaks in retirements at ages 62 and 65 observed in the USA in the seventies. Previously, Gustman and Steinmeir (1986) had related these peaks to nonlinearities in the budget constraint of individuals created by social security and pension programs.

Closely related to the second, the third mechanism refers to the fact that some benefits conceded by the pension systems act as unemployment subsidies. As these benefits make it cheaper to lay off workers close to the legal age of retirement, firms have a clear incentive to make use of this possibility (Smith, 2006). Finally, the fourth reason for an early retirement is health or, to be more exact, bad health. Empirical evidence shows that people with bad health levels retire earlier than those who have good levels of health (McGarry, 2004). In particular, Rust and Phelan (1997) find that unhealthy individuals are more than twice as likely as healthy individuals to apply for Social Security benefits at the early retirement age of 62. However, Kalemli-Ozcan and Weil (2010) claim that the uncertainty associated with bad health and high mortality rates acts as an incentive to stay at work as long as possible.

What explains the turning point observed in the age of retirement around the mid-nineties? Institutional reforms, a change in the attitude of the employers towards older workers and, above all, improvements in health levels are the principal reasons to explain the turning point in favor of a delay in the retirement age. That is, the mechanisms which previously supported an early retirement are losing ground or even acting in the opposite direction. While, in the past, governments maintained a permissive position on early retirement, they are currently carrying out reforms directed at encouraging the extension of active life through increments in the legal age for having the right to a pension, increments in the number of years of contribution for having the right to receive the complete pension, or by means of incentives to delay the retirement age (OECD, 2007). French (2005) and Gendel (2008) emphasize the importance of the effects of these changes on the labor force participation of older workers. The attitude of the employers is also changing and some characteristics of older workers are now much better considered than previously: accumulated experience, the matching between the competences of the individual and those required by the job and the work ethic (Johnson et al., 2007a). Finally, the decrease of physically demanding jobs and, above all, the general improvement of health throughout the life span of the most recent generations explain the individuals' change of attitude towards early retirement (Johnson et al., 2007b). Although health has improved in all age groups, it is especially significant in the group around the retirement age. The morbidity compression implies an enlargement of life free from disease which supports the idea of a lower decline in productivity associated with age.

It is worth pointing out that the workers who remain longer in the labor force share certain characteristics. In their study of the determinants of the participation of European people aged 50-64, Kalwij and Vermeulen (2008) find that a higher participation rate in the labor market is positively related to both health and the level of education. Focusing on married men in the same age interval, Schirle (2008) also identifies educational attainment as an important positive determinant of the participation decision in three countries: the United States, Canada and the United Kingdom. In the same line, Haider and Loughran (2002) found that the labor supply of people over 65 in the USA is concentrated among the healthiest, wealthiest and most educated individuals. The direct relationship between higher qualifications and productivity and a longer participation in the labor market is also confirmed in a simulation exercise carried out by Fougère et al. (2009) for the case of Canada: the labor supply of the cohort that entered the labor market in 1974 remains stable until the age of 48 but declines rapidly afterwards, while the following cohorts show a progressive increase in time devoted to education and a higher labor supply at middle and advanced ages. For example, by comparing the cohorts of 1974 and 2018, they predict increases of 23.5% and 46.7% in the time devoted to work by Canadians aged 61-64 and 65-68, respectively.

3. Household characteristics and decisions

Preferences

The population of the economy is made up of by individuals that can live for two periods, corresponding to young and old age. The lifetime of an individual is uncertain. Everyone lives during the first period, but dies at the end with a probability *p*. Thus, survival to old age is not assured, with $1-p$ being the probability of remaining alive in the second period of life. The young individual *i* in period *t-1* supplies θ_i units of effective labor, and earns a wage income equal to $w_{t-1}\theta_i$. A part of this income is consumed, $c^y_{i,t-1}$, and the rest is saved, $s_{i,t-1} = w_{t-1}\theta_i - c^y_{i,t-1}$. The surviving old agents obtain a capital income $R_t s_{i,t-1}$ in period *t*, where R_t is the rate of return on savings.

Any (surviving) old individuals may supplement their capital income by remaining in the labor market and, thus, earning a wage income $w_t\delta_i\theta_i e_{i,t}$, where $e_{i,t}$ denotes their labor force participation and $\delta_i\theta_i$ measures their effective labor (where δ_i captures the fraction of youth productivity maintained in the second period of life). Thus, the old-age consumption of individual *i* is given by $c^o_{i,t} = R_t s_{i,t-1} + w_t\delta_i\theta_i e_{i,t}$. We assume that the old agent's labor force participation is a zero-one decision: $e_{i,t} = 0$ if he or she decides to retire or $e_{i,t} = 1$ if he or she decides to work in his or her second period of life.

Like Ferreira and Pessôa (2007), we introduce a particular profile of productivity in which workers' productivity declines with age ($\delta_i \leq 1$), although the individuals with an early higher productivity are more able to maintain higher levels later. Additionally, given the focus of our paper on life expectancy, we consider another feature of this productivity profile which matches our model to the empirical evidence about morbidity compression: the productivity decline with age diminishes as life expectancy increases. In sum, $\delta_i = \delta(\theta_i, 1-p)$, with $\partial\delta/\partial\theta_i > 0$ and $\partial\delta/\partial(1-p) > 0$.

Every individual derives utility from youth consumption and old-age consumption conditional on survival. We also assume the existence of a gain in welfare due to the leisure time if the individual retires when old. The expected utility of an individual *i* born in *t*-1 is given by:

$$EU\left(c_{i,t-1}^{y},c_{i,t}^{o},e_{i,t}\right)=\left[1+\lambda(1-e_{i,t})\right]^{1-p}\left[\left(\frac{c_{i,t-1}^{y}}{1-\beta}\right)^{1-\beta}\left(\frac{c_{i,t}^{o}}{\beta}\right)^{\beta(1-p)}\right]. \quad (1)$$

This specification generalizes the intertemporal preferences for consumption and the retirement decision proposed by Matsuyama (2008) by incorporating the uncertainty about lifetime. In fact, it is a monotonous transformation of a standard expected logarithmic utility of the form:

$$\left(1-\beta\right)\ln\left(\frac{c_{t-1}^{y}}{1-\beta}\right)+(1-p)\left\{\beta\ln\left(\frac{c_{t}^{o}}{\beta}\right)+\ln\left[1+\lambda(1-e_{i,t})\right]\right\}.$$

Given the uncertainty about surviving the first period of life, the expected utility derived from consumption and leisure when old appears multiplied by the life expectancy, 1-*p*. Parameter $\beta\in\left(0,1\right)$ is related to the intertemporal discount rate of consumption. A positive discount rate for the future consumption requires $\beta/(1-\beta)<1$.

We normalize the size of each new generation to 1. Every individual of each generation is identified with a different value of the subindex *i*, continuously distributed along the interval $\left[0,1\right]$. Each individual is born with a different productivity θ_i, also uniformly distributed along the interval $\left[0,1\right]$. As stated before, we consider that each individual suffers a fall in productivity in old age which depends negatively on the probability of surviving to old age. We assume the following specification:

$$\delta_i=\left[(1-p)\theta_i\right]^{\gamma}, \quad (2)$$

with $\gamma\in(0,1)$. It implies that the productivity of individual *i* when old is given by $(1-p)^{\gamma}\theta_i^{1+\gamma}$, which is higher the higher the productivity when young and the life expectancy. Thus, an improvement in life expectancy reduces the decline in productivity with age.

Optimal individual decisions

The representative individual i of the cohort born in *t-1*faces the following optimization problem:

$$\underset{e_i,\{c_i\}}{Max} \quad EU\left(c_{i,t-1}^{y}, c_{i,t}^{o}, e_{i,t}\right),$$

$$\text{s.t.: } s_{i,t-1} = w_{t-1}\theta_i - c_{i,t-1}^{y}, \tag{3}$$

$$c_{it}^{o} = R_t s_{it-1} + w_t \delta_i \theta_i e_{it},$$

$$\text{given } w_{t-1},$$

where $EU\left(c_{i,t-1}^{y}, c_{i,t}^{o}, e_{i,t}\right)$ and δ_i are given by (1) and (2), respectively.

The problem can be solved in two stages. In the first one, individuals decide about their levels of consumption when young and old, $\{c_i\} = \{c_{i,t-1}^{y} \geq 0, c_{i,t}^{o} \geq 0\}$, which will depend on their decision about retirement when old. In the second stage, they decide whether to retire ($e_{it} = 0$) or not ($e_{it} = 1$) by comparing the welfare in the two situations.

The optimal consumption profile, conditional on the retirement decision, is characterized by the following values of consumption when young and old, respectively:

$$c_{i,t-1}^{y} = \frac{1-\beta}{1-\beta p}\left(w_{t-1}\theta_i + \frac{w_t\delta_i\theta_i}{R_t}e_{it}\right), \tag{4}$$

$$c_{i,t}^{o} = \frac{\beta(1-p)}{1-\beta p}R_t\left(w_{t-1}\theta_i + \frac{w_t\delta_i\theta_i}{R_t}e_{it}\right), \tag{5}$$

which imply an associate individual savings function given by:

$$s_{i,t-1} = \frac{1-p}{1-\beta p}\left[\beta w_{t-1}\theta_i - (1-\beta)\frac{w_t\delta_i\theta_i}{(1-p)R_t}e_{it}\right]. \tag{6}$$

Two important properties of the savings behavior should be emphasized here. First, ceteris paribus, a longer life expectancy increases individual savings. A higher probability of surviving into the second period implies a higher probability of enjoying the consumption derived from savings in the second period, which makes individuals reserve more income for the second period (Reinhart, 1999). Second, retirement is positively related to savings, that is to say, the individuals who remain in the labor market in the second period ($e_{it}=1$) save less than those who decide to retire. The reason is simple: the first group will earn an additional income w_t per unit of effective labor supplied in the second period, while retired individuals will perceive no income in this period and, thus, are more interested in saving when young.

The second stage corresponds to the decision about retirement in the second period. Individuals compare the welfare derived from the two scenarios, given the optimal consumption decisions taken in the first stage. By introducing these optimal values into the utility function, we obtain that the level of welfare achieved by worker *i* who decides to remain in the labor market when old is given by:

$$EU\left(e_{it}=1\right)=\left[R_t(1-p)\right]^{\beta(1-p)}\left(\frac{w_{t-1}\theta_i+w_t\delta_i\theta_i/R_t}{1-\beta p}\right)^{1-\beta p}, \tag{7}$$

whereas the welfare if he retires is:

$$EU\left(e_{it}=0\right)=(1+\lambda)^{1-p}\left[R_t(1-p)\right]^{\beta(1-p)}\left(\frac{w_{t-1}\theta_i}{1-\beta p}\right)^{1-\beta p}. \tag{8}$$

The individual will be willing to participate in the labor market ($e_{it}=1$) when old only if the value of his utility in (7) is not lower than that in (8), that is to say, if the following condition holds:

$$\left(w_{t-1}\theta_i+\frac{w_t\delta_i\theta_i}{R_t}\right)^{1-\beta p}\geq(1+\lambda)^{1-p}\left(w_{t-1}\theta_i\right)^{1-\beta p},$$

which, taking (2) into account, can be written as:

$$\frac{w_t\theta_i^{\gamma}(1-p)^{\gamma}}{R_t}\geq\Lambda w_{t-1}, \tag{9}$$

where $\Lambda=(1+\lambda)^{\frac{1-p}{1-\beta p}}-1$. It is evident from this expression that a higher wage in the second period is a stimulus for remaining in the labor market. Similarly, the higher the fraction of young productivity maintained in the second period of life, the higher the second period labor income and, hence, the stronger the incentive for remaining in the labor market. However, the higher the term Λ, the more intense the incentive for retirement will be. The reason is that Λ measures the disutility of working, in other words, the utility of leisure. It depends negatively on the probability of dying: $\partial\Lambda/\partial p < 0$; that it is to say, a higher life expectancy increases the utility of leisure, which means that a positive evolution of life expectancy implies, from the perspective of individual preferences, a stimulus for everybody to retire early.

However, what determines individuals' decision about retirement is their productivity, which is the element that introduces heterogeneity between workers in our model. At any time *t*, there will be an individual i_t^* for whom to retire or to continue working in the second period of life will be indifferent:

$$\frac{w_t \theta_{i_t^*}^{\gamma} (1-p)^{\gamma}}{R_t} = \Lambda w_{t-1}. \tag{10}$$

According to (9), this implies that workers whose productivity exceeds the critical value $\theta_{i_t^*}$, that is to say, those from i_t^* to 1, obtain more utility working in the second period, while those with a lower productivity (those from 0 to i_t^*) decide to retire. The former, given that we have normalized the population size to 1, are 1-i_t^* in number. Let $x_t \in [0,1]$ be the activity rate of the old people, from where we have $x_t = 1 - i_t^*$. The assumption of a uniform distribution of the young productivity along the interval $[0,1]$ allows us to identify $\theta_i = i$ and, thus, we can rewrite (10) in terms of the activity rate of the old people x_t as:

$$\frac{w_t \left(1-x_t\right)^{\gamma} (1-p)^{\gamma}}{R_t} = \Lambda w_{t-1}. \tag{11}$$

This characterization fits in with the empirical evidence according to which the less productive individuals, generally those with the lowest human capital, are the ones who retire earlier while the most productive individuals are the ones who extend their active life longer.

An open economy with free mobility of inputs

Let us first analyse the above expressions from the simplest perspective of a small open economy with free mobility of inputs, in such a way that the values of wage and interest rates are exogenously given. Thus, given w_{t-1}, w_t and R_t, from expression (10), we can identify the indifferent worker as the one whose productivity when young satisfies:

$$\theta_{i_t^*} = \left[\Lambda \frac{w_{t-1}}{w_t} \frac{R_t}{(1-p)^\gamma} \right]^{\frac{1}{\gamma}},$$

whereas, from (11), the activity rate of the old people x_t is determined as:

$$x_t = 1 - \left[\Lambda \frac{w_{t-1}}{w_t} \frac{R_t}{(1-p)^\gamma} \right]^{\frac{1}{\gamma}}. \tag{12}$$

These results summarize the previous considerations about the labor supply of the old. First, the individuals with the highest productivity are those who remain in the labor market when old, whereas those with a lower productivity profile prefer to retire. Although the most productive individuals earn a higher income in the first period, which could lead to an early retirement, they are also the most productive when old, which acts as an incentive to remain active. Second, *ceteris paribus*, a higher utility of leisure, Λ, expands the set of workers who decide to retire when old. The opposite holds when a higher income is expected in the second period, either because the wage in the second period increases or the interest rate decreases. Interestingly, as longevity grows, the utility of leisure increases and the fall in the older workers' productivity slows down. The former effect leads to lower rates of activity of older people in the labor market whereas the latter works in the opposite direction, leaving the aggregate effect indeterminate. However, when the improvement in the older workers' productivity, as a result of the morbidity compression, proportionally exceeds the increase in the value of leisure, that is to say, when:

$$\frac{\partial}{\partial p} \left[\frac{\Lambda}{(1-p)^\gamma} \right] > 0, \tag{13}$$

then an increase in longevity has a positive effect on old people's participation rate in the labor market[2].

[2] Condition (13) implies that, when longevity increases, the rate of change of Λ is lower than the rate of change of $(1\text{-}p)^\gamma$: its effect on the productivity of the older workers through the compression of morbidity is proportionally greater than its effect on the utility of leisure.

In a general equilibrium framework, the wage and interest rates are determined by the availability of inputs, capital and labor, which, in turn, depends on the individuals' choices both about saving and labor supply. Thus, in the next section we move from the previous simple framework to another which incorporates the interrelationships between the retirement decision and the accumulation of capital.

4. General equilibrium

Firms

On the part of firms, we consider an aggregate technology that takes a standard Cobb-Douglas form $Y_t = AK_t^{\alpha} L_t^{1-\alpha}$, with $A>0$ and $\alpha \in (0,1)$. The supply of capital in period *t*, K_t, is the total savings made in period *t-1*. We assume a single final good which can either be consumed or invested.

Given that $1-p$ is the probability of surviving into the second period for each member of generation *t-1*, the size of the old generation in *t* will be $1-p$. The aggregate labor force in period *t*, L_t, is then given by:

$$L_t = \overline{\theta}_t + (1-p)\overline{\delta\theta}_t x_t , \quad (14)$$

with x_t being the old generation's labor force participation rate, $\overline{\theta}_t$ the average labor productivity of young people and $\overline{\delta\theta}_t$ the average labor productivity of those who decide to work in their old age.

Assuming that firms operate in a context of perfect competition, the wage and the interest rate will be given by the marginal productivities of capital and labor, respectively:

$$r_t = \alpha A k_t^{\alpha-1} , \quad (15)$$

$$w_t = (1-\alpha) A k_t^{\alpha} , \quad (16)$$

where $k_t = K_t / L_t$ denotes the capital per unit of effective labor.

We follow Blanchard (1985) in assuming a perfect annuity market, according to which the capital income unexpectedly left by agents who die at the end of their first period of life (a fraction *p* of the aggregate capital income) is shared by the agents who survive to old age (a fraction 1-*p*). Therefore, surviving agents receive a premium at a rate $p/(1-p)$, which determines a return on savings equal to

$$R_t = \frac{r_t}{1-p}. \tag{17}$$

Labor market equilibrium

By taking (17) into account and substituting the expressions of the interest and the wage rates given in (15) and (16) into (11), the following positive relationship between the participation rate of the older workers and the capital-effective labor ratio is found:

$$k_t = \frac{\alpha \Lambda A}{\left(1-p\right)^{\gamma+1}\left(1-x_t\right)^{\gamma}} k_{t-1}^{\alpha} \tag{18}$$

for any given k_{t-1}. This is the equation that represents the equilibrium in the labor market. The positive relationship comes from the fact that a higher availability of capital leads to higher wages and lower interest rates, which imply, as shown in (12), a higher incentive to remain in the labor market.

Savings-investment equality

The aggregate stock of capital, K_t, is the sum of the individual savings from all the members belonging to the cohort born in *t-1*, those who retire (from 0 to i_t^*) and those who decide to continue working (from i_t^* to 1):

$$K_t = \int_0^{i_t^*} \frac{1-p}{1-\beta p} \beta w_{t-1} \theta_i di + \int_{i_t^*}^{1} \frac{1-p}{1-\beta p} \left[\beta w_{t-1} \theta_i - \left(1-\beta\right) \frac{w_t \delta_i \theta_i}{(1-p) R_t} \right] di.$$

After some algebra, we find that the aggregate capital stock of the economy in *t* is given by:

$$K_t = \frac{1-p}{1-\beta p} \left[\frac{\beta w_{t-1}}{2} - \left(1-\beta\right)\left(1-p\right)^{\gamma-1} \frac{1-\left(1-x_t\right)^{\gamma+2}}{\gamma+2} \frac{w_t}{R_t} \right].$$

The average productivity of the individuals in the first period of their life is given by $\overline{\theta}_t = \int_0^1 i di = \frac{1}{2}$. In turn, the average productivity of the individuals that remain in the labor market in the second period of their life is given by $\overline{\delta\theta}_t = \frac{1}{1-i_t^*}\int_{i_t^*}^1 i^{\gamma+1}(1-p)^{\gamma} di = \frac{1}{x_t}(1-p)^{\gamma}\frac{1-(1-x_t)^{\gamma+2}}{\gamma+2}$, from which the effective labor supply in (14) amounts to $L_t = \frac{1}{2} + (1-p)^{\gamma}\frac{1-(1-x_t)^{\gamma+2}}{\gamma+2}$. Taking this into account, along with expressions (15), (16) and (17), the capital per unit of effective labor ($k_t = K_t / L_t$) is negatively related to the older workers' participation rate by the following equation, which captures the savings-investment equality:

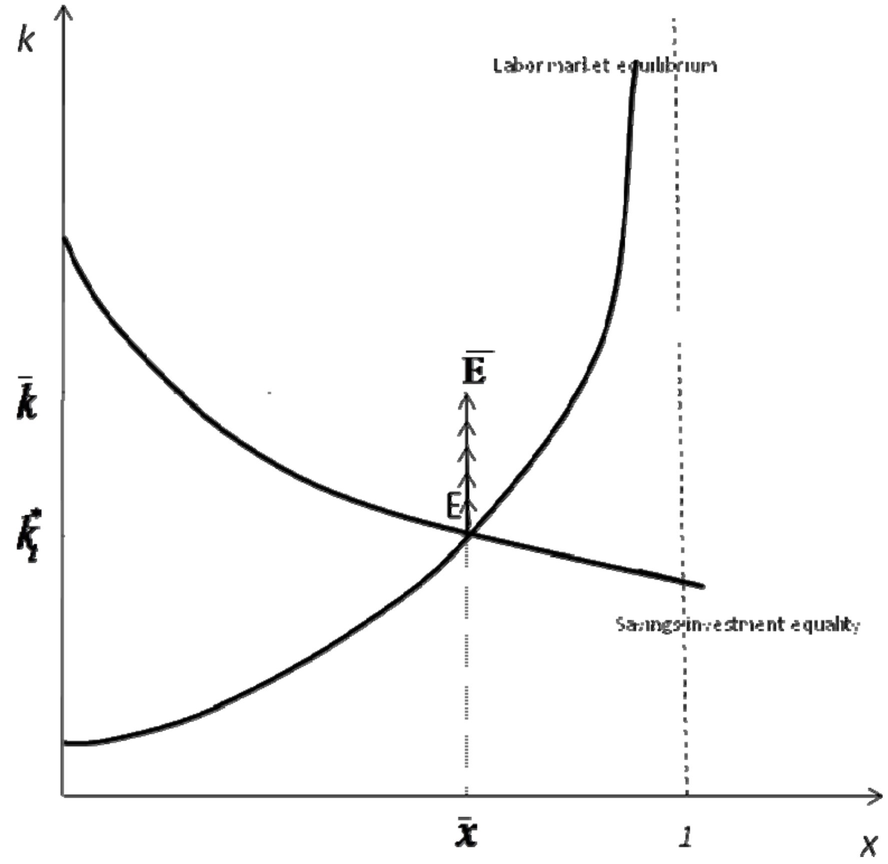
$$k_t = \frac{(1-\alpha)(1-p)\beta A}{1-\beta p + 2(1-p)^{\gamma+1}\frac{1-\beta+\alpha\beta(1-p)}{\alpha}\frac{1-(1-x_t)^{\gamma+2}}{\gamma+2}} k_{t-1}^{\alpha} = f(p, x_t) k_{t-1}^{\alpha}. \quad (19)$$

From this expression, we deduce that, given k_{t-1}, the retirement decision of the individuals affects the stock of capital per unit of effective labor through two coincident channels. The first is that the greater the number of individuals who decide to continue working during old age, the larger the workforce and the lower the capital-effective labor ratio, on the demand for capital side. The second channel corresponds to the fact that individuals who decide to continue working when old save less, which reduces the aggregate savings or, in other words, the supply of aggregate capital. As a consequence of these two influences, the capital stock per unit of effective labor is lower.

Given the wage in *t*-1, the values of the participation rate of the older workers and the capital-effective labor ratio in *t* can be deduced from the system made up of equation (18), derived from the equilibrium in the labor market, and equation (19), corresponding to the savings-investment equality. The equilibrium for period *t* is labeled as the point *E* in Figure 2.

The existence of equilibrium requires that the function representing the savings-investment equality cut the vertical axis over the point at which the function representing the labor market equilibrium does. This implies the condition:

Figure 2. Equilibrium value of the activity rate of old people



$$\frac{\Lambda}{(1-p)^{\gamma}} < \frac{(1-\alpha)(1-p)^{2}\beta}{\alpha(1-\beta p)}. \tag{20}$$

This expression establishes that the ratio between individuals' valuation of the utility of leisure, captured by Λ, and the influence of the compression of morbidity in the level of productivity in old age, captured by $(1-p)^{\gamma}$, must be bounded from above in order to make an interior equilibrium possible. In other words, given the structural characteristics of the economy, if the utility derived from leisure were too high and the compression of morbidity hardly affected the productivity over time, all the individuals would decide to retire in their second period of life. That is to say, the labor supply of the old would be zero. However, if condition (20) holds there will be people willing to extend their working life.

It is interesting to highlight that the right-hand term of (20) increases with life expectancy while, if condition (13) holds, the left-hand one diminishes. Thus, we can say that, in such a case, the existence of an interior equilibrium is always guaranteed for values of life expectancy higher than that for which expression (20) holds with equality.

According to the equilibrium point *E* for time *t* in Figure 2, given the capital-effective labor ratio in the previous period, k_{t-1}, the individuals' decision about the labor supply when old affects the current capital-effective labor ratio, which, at the same time, generates the values of the wage and interest rates that influence individuals' decisions in the future. Let us briefly analyze this dynamic behavior of the economy, described by equations (18) and (19).

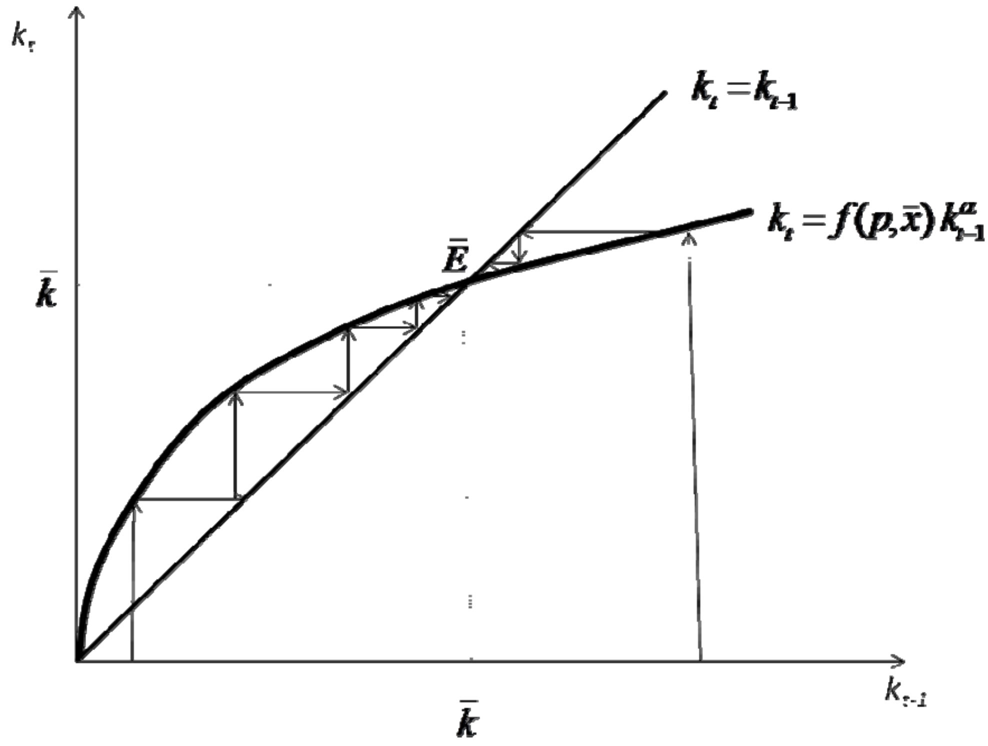
The first conclusion is that, although the capital-labor ratio evolves over time, there is no transitional dynamics in *x,* which always takes its long-run value $x_t = \bar{x}$. So, the participation rate in the second period of life of the successive generations of workers is stable over time. Only changes in the structural parameters of the economy could explain a change in this variable.

In the case of capital, given the value of $\bar{x}$, the dynamic behavior is given either by (18) or (19), which implies that the capital per effective unit of labor evolves along the transition approaching the following long-run value:

$$\bar{k} = \left[\frac{\alpha \Lambda A}{(1-p)^{\gamma+1} (1-\bar{x})^{\gamma}} \right]^{\frac{1}{1-\alpha}}, \tag{21}$$

as depicted in Figure 2. The capital per effective unit of labor increases or decreases along the transition depending on whether the initial value is below or above the long-run value $\bar{k}$, as can be seen in Figure 3. The case where the initial value is below the long-run one is represented in Figure 2.

Figure 3. Dynamics of capital per effective labor



5. The effects of an enlargement of life expectancy

Our main concern in this paper is to determine the effects of an extension of life expectancy (that is to say, a reduction in the probability of dying after the first period of life p) on the individuals' motivations to retire. Let us depart from a long-run equilibrium, which can be easily described by making $k_{t-1} = k_t = \bar{k}$ in equations (18) and (19) and is represented as the point $\bar{E}$ in Figure 4.

As stated in Section 3, an increase in life expectancy increases the utility of leisure ($\partial\Lambda / \partial p < 0$) and, simultaneously, reduces the fall in productivity due to age ($\partial\delta / \partial p < 0$), thus increasing the income for active old workers. The first effect acts as an incentive to an earlier retirement, while the second works in the opposite direction. Additionally, a lower probability of dying reduces the premium from the annuity market, which implies a lower discount for the income in the second period of life and acts as an additional stimulus to remain active.

When condition (13) holds, the second effect dominates over the first one, which implies that the critical (frontier) individual before the change in p, the one whose productivity made it indifferent to retire or not, will decide to extend his working life. And the same will occur to a set of workers with a lower (but close) productivity. That is to say, the range of individuals willing to work in the second period of life extends, which is depicted as a movement of the equation (18) to the right in Figure 4. Thus, through this channel, the increase in life expectancy acts as an incentive to remain in the labor market.

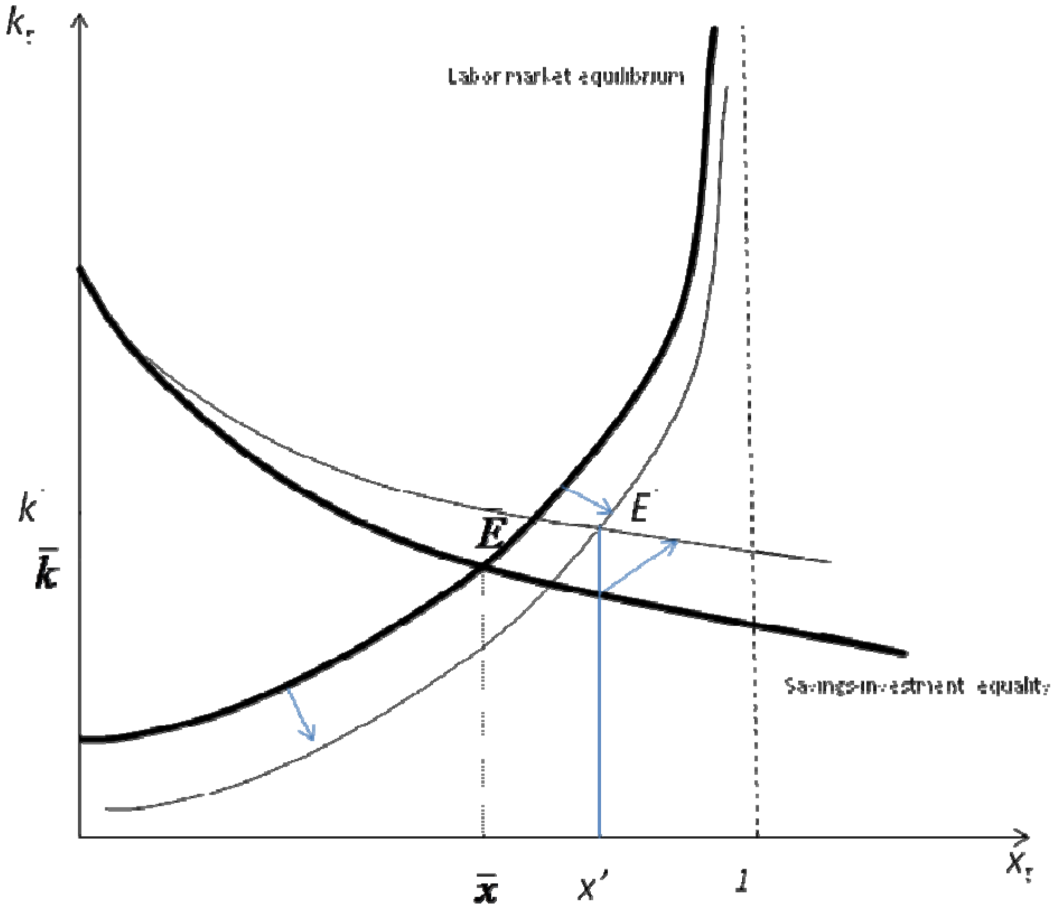
Furthermore, a higher life expectancy also modifies the saving-investment equation. It implies a different consumption profile that involves, according to (6), higher savings for every individual[3]. For a given rate of participation in the labor market, this means a wider availability of capital and a higher value of capital per effective worker. This is shown in Figure 4 as an upward movement of equation (19) that captures the equality between investment and savings. Since this trend towards a higher capital per effective worker leads to a higher discounted income in the second period (a higher wage and a lower interest rate), this channel acts as an additional incentive for individuals towards an extension of their working life.

Therefore, when the impact on older workers' productivity is larger than on the utility of leisure -condition (13) holds[4]-, an increase in lifespan increases the participation rate of older workers in the labor market, as can be seen in the new short-run equilibrium *E'* of Figure 4. Otherwise, the result is indeterminate because, although the savings-investment relationship always encourages a higher participation rate, there is no clear effect on the part of the labor market equilibrium relationship.

[3] As mentioned in Section 1, Kalemli-Ozcan and Weil (2010) identify an element that works in the opposite direction, namely the uncertainty about the life span, which works in favour of enlarging the working period and saving. An increase in life expectancy reduces such uncertainty, thus lowering the willingness to save. However, this uncertainty effect is not present in our model because the agents insure against mortality risk through the annuities market.

[4] In this case condition (13) is sufficient.

Figure 4. Effects of an increase in life expectancy



With respect to capital, however, there is no determined effect on the short-run equilibrium capital-effective labor ratio, even in the former case. Four forces are at work. Three of them are related to the aggregate capital. First, as stated before, individual savings are higher the higher the life expectancy, enlarging aggregate capital. However, the increase in the labor market participation rate has the opposite effect, since individuals that remain in the labor market save less than those that retire in the second period. Moreover, the lower fall in productivity of old workers (and, thus, in their wage income) associated to the longer lifespan also diminishes their willingness to save. The result of these three forces makes the effect on the aggregate capital indeterminate. As a fourth force, a higher probability of surviving the first period of life increases labor supply and tends to reduce the capital-effective labor ratio. Thus, the short-run effect on *k* will depend on the relative importance of all these forces. In any case, a possible decrease in *k* never impedes the increase in *x*.

As stated before, although there is no transitional dynamics in x, the same does not hold for k. That is to say, after the short-run adjustment, the capital-labor ratio will evolve over time towards a new steady state value. The long-run effect on this variable is also indeterminate, as can be derived from expression (21). This result is consistent with the empirical evidence. For a cross-section of countries, Li et al. (2007) find that life expectancy has a positive effect on aggregate savings; however, since the effect on the participation rate in the labor market is negative, the joint effect appears to be indeterminate.

Besides the enlargement of life expectancy, the developed countries have recently been subjected to modifications in the design of their social security policy. Most modifications go in the line of punishing the earlier retirement and/or rewarding remaining in the labor market. In the rest of the paper we assess the incidence of such measures on the retirement decisions, starting by extending the previous framework to include a simple social security system.

6. Life expectancy, labor supply of the elderly and social security

In order to make the analysis straightforward, we assume a fully fund social security system. In the first period, every individual i of the cohort born in t-1 contribute to the social security system with a fraction τ of their current labor income. In the second period, he or she enjoys the return on both his private savings, $R_t s_{it-1}$, and his or her social security contribution, $R_t \tau w_{t-1} \theta_i$, and decides, as before, whether to remain or not in the labor market. That is to say, the pension benefits are received in the second period of life even when the individuals remain in the labor market. It can be easily understood that, in the extent that the contribution rate τ lies below the individual saving rate in the absence of the social security system, the above results are maintained without any change (the contribution to the social security system acts as a compulsive saving, that the individual complements until the optimal amount). In particular, the existence of the pensions system does not interfere with the agents' decision about retirement. This does not hold, however, if the system benefits include any discrimination between old individuals depending on their labor supply in the second period of life. This section explores the effects of such discrimination in a simple way.

Let us assume that the system includes a penalty η on the benefits for the individuals that leave the labor market when old, in such a way that the benefits for individual *i* of the cohort born in *t-1* amount to only $(1-\eta)R_t\tau w_{t-1}\theta_i$ in case he decides to retire. The surplus generated by this penalty is distributed by the government between all the contributors in proportion to their contribution. In this context, the budget constraint of the individual *i* in his or her first period of life becomes:

$$s_{i,t-1} = (1-\tau)w_{t-1}\theta_i - c^y_{i,t-1},$$

whereas that of the second period is given by:

$$c^o_{it} = R_t s_{it-1} + w_t\delta_i\theta_i e_{it} + R_t\left[1-\eta(1-e_{it})\right]\tau w_{t-1}\theta_i + h_{it},$$

where *h* denotes the redistributive transfer from the social security system (as in Iza and Echevarría, 2008). Note that, since the penalty paid by those that retire is shared between all the old individuals (proportionally to their contribution) a net penalty applies when the individual retires in the second period ($e_{it} = 0$), whereas he receives a premium in case of remaining active.

The new optimal consumption profile, conditional on the retirement decision, is characterized by the following values of consumption when young and old, respectively:

$$c^y_{i,t-1} = \frac{1-\beta}{1-\beta p}\left((1-\tau)w_{t-1}\theta_i + \frac{w_t\delta_i\theta_i}{R_t}e_{it} + \left[1-\eta_t(1-e_{it})\right]\tau w_{t-1}\theta_i + \frac{h_{it}}{R_t}\right),$$

$$c^o_{i,t} = \frac{\beta(1-p)}{1-\beta p}R_t\left((1-\tau)w_{t-1}\theta_i + \frac{w_t\delta_i\theta_i}{R_t}e_{it} + \left[1-\eta_t(1-e_{it})\right]\tau w_{t-1}\theta_i + \frac{h_{it}}{R_t}\right),$$

which imply an associate individual savings function given by:

$$s_{i,t-1} = \frac{1-p}{1-\beta p}\left(\beta(1-\tau)w_{t-1}\theta_i - (1-\beta)\frac{w_t\delta_i\theta_i e_{it} + h_{it}}{(1-p)R_t} - (1-\beta)\frac{\left[1-\eta_t(1-e_{it})\right]\tau w_{t-1}\theta_i}{1-p}\right).$$

Following the same steps than in Section 3, the comparison between the two alternative scenarios in the second period of life (either retiring or not) lead the individuals to remain in the labor market when the following condition holds:

$$\frac{w_t\theta_i^\gamma(1-p)^\gamma}{R_t} \geq [(1-\eta\tau)\Lambda - \eta\tau]w_{t-1} + \frac{\Lambda h_{it}/\theta_i}{R_t}, \tag{22}$$

which clearly is equivalent to (9) in the absence of a social security system.

The transfers made by the social security system correspond to the amount of the penalty from individuals that retire. Let us denote by ψ the amount of the transfer per unit contributed, that is to say, $h_{it} = \psi_t \tau w_{t-1}\theta_i$. Thus, the budget constraint of the social security system implies that $\eta R_t \int_0^{i_t^*} \tau w_{t-1}\theta_i di = \int_0^1 h_{it} di = \psi_t \int_0^1 \tau w_{t-1}\theta_i di$, from where we have $\psi_t = \eta R_t (1-x_t)^2 / 2$. Carrying this expression to (22), we deduce that the old individuals will prefer to remain active when their productivity verifies:

$$\frac{w_t \theta_i^\gamma (1-p)^\gamma}{R_t} \geq \left(\Lambda - \eta\tau\left[1 + \Lambda x_t (2 - x_t)\right]\right) w_{t-1}. \tag{23}$$

It is immediate to conclude that the higher the penalty the lower the right-hand term and, thus, the set of individuals which prefer to remain in the labor market expands, including workers of a lower productivity. That is to say, other things being equal, the policy acts, as expected, as a disincentive for an early retirement. This effect is greater the greater is x. Therefore, the above expression suggests that, for a low participation of the elderly in the labor market x, the increase in expected longevity is more able to discourage an early retirement than the penalty established by the social security system. On the opposite, the policy could have the higher effects in the case of a wide participation of the eldest in the labor market.

After some algebra, the labor market equilibrium condition in this context becomes:

$$k_t = \frac{\alpha A}{(1-p)^{\gamma+1}(1-x_t)^\gamma}\left\{\Lambda - \eta\tau\left[1 + \Lambda x_t (2 - x_t)\right]\right\} k_{t-1}^\alpha. \tag{24}$$

Compared with (18), this expression relates every value of $x \in [0,1]$ with a lower value of capital per unit of effective labor, with the drop being higher the higher the penalty for the early retirees η. This means that the penalty shifts down the curve representing the labor market equilibrium in Figure 2.

The second function needed for the equilibrium, the available stock of capital, comes from the aggregation of the individual savings of all the young individuals, whether they are willing to retire when old or not, as well as from their payroll taxes.

Proceeding as in Section 4, the savings-investment equality remains invariant to the introduction of the social security system and, thus, is again given by (19).

From Figure 2, it is clear that a shift down of the labor market equilibrium function without any movement in the savings-investment function generates a new equilibrium with a higher labor supply of the older workers and a lower capital/labor ratio. The first effect was clear from the analysis of the expression (23) above. The second is a consequence of the lower savings of individuals that remain active when old. These effects are more intense the higher the penalty imposed by the social security system to the early retirees.

In Section 5, we found the condition under which the progressive enlargement of life expectancy increased the labor supply of the elderly (in particular, of the most productive) in a fully decentralized context. Of course, this is not the context in real countries, in which the individuals' decisions about retirement are deeply influenced by the regulation of the public system of pensions. As indicated in Section 2, a possible explanation for the recent change in trends towards a later retirement could be explained by the changes in the public incentives to remain or leave the labor market. Whether these institutional changes are more important than other non-institutional ones (as the enlargement in life prospects) is subject to controversy.

Some authors find that the design of the social security system explains most of the changes in the labor supply of older workers, as Gruber and Wise (1999) for a cross-country sample of OECD countries. On the opposite, others conclude that it has a minor influence: less than one sixth of the changes in Krueger and Pischke (1992) or below a quarter in Anderson et al. (1992). In this line, Kalemli-Ozcan and Weil (2010) find an important effect of the reduction in uncertainty due to the falling in mortality, while Kopecky (2010) identifies the rising real wages and the declining prices of leisure goods as the main explanations or recent trends in retirement. Our results suggest that, conditionally to the simple scheme of policy introduced, the effect of an increasing longevity would be the greatest in economies with a low participation rate of the elderly in the labor market.

7. Conclusions

During the 20th century, the labor market participation of the elderly has been deeply influenced by the institutional framework regulating the legal age of retirement and the conditions in which workers could receive the benefits of the public pension systems when leaving the labor market before or after that legal age. There is a general consensus in identifying incentives to an early retirement as the main reason behind the progressive reduction in the labor market participation of older workers over most of the last century.

However, in the nineties, it started to become evident that regulation on retirement conditions should take into account some slow but important demographical changes: the reduction in the birth rate and the growth of life expectancy progressively increased the dependency rate and raised important financial concerns about the public pension systems. Meanwhile, labor markets evolved in many aspects, among which the decrease in the importance of physically demanding workplaces and the improvement in the health level of the oldest workers are possibly the most closely related to retirement decisions.

This context of financial pressures and demographical and labor changes has recently raised a debate about the convenience of redesigning the retirement regulation. One of the main guidelines for this redesign should be to make the public regulation compatible with the interest of the workers, especially if this contributes to relaxing the financial pressures on the public pension systems. In this paper, we have examined how the demographical and labor changes influence the unconstrained decisions of workers, that is to say, in a deregulated environment, with the idea that the trends observed in this context should inspire the main guidelines for future reforms.

Our focus of interest has been the extension of longevity. The workers' desire to retire obviously depends on the perspectives of being alive after leaving the labor market. A greater life expectancy makes it possible to enjoy retirement longer but also increases the need for resources to maintain the quality of life over a longer period. Our analysis concludes that, as long as the increase in longevity improves the old workers' productivity more than the utility of leisure, the trade-off between these two forces is solved by workers, on average, by distributing the additional time of life expectancy between work and retirement, so more workers find incentives to leave the labor market later.

This contribution clarifies a previous contradictory result in Bloom et al. (2007) and Ferreira and Pessôa (2007). The first found a positive effect of life expectancy on old people's participation rate in the labor market, while the second found the opposite. From the former we consider the link "disutility of working/life expectancy" and from the later we introduce a profile of labor productivity. However, in our case, the link between disutility of working and life expectancy becomes endogenous and the fall in productivity over time lowers with age as a result of the compression of morbidity. Our more general approach highlights the importance of the two factors, in such a way that the effect of longevity on the old workers' productivity must dominate the effect on the utility of leisure in order to have a positive effect on the labor supply of the elderly.

It is clear that the response of individuals to the increase in life expectancy poses no additional financial problems to the public pension systems. On the contrary, the delay in the retirement age increases the ratio of contributors to beneficiaries and so contributes to the sustainability of the system. In this sense, the interests of workers and governments coincide.

In fact, the recent changes in the public pension systems have followed this direction. The incentives to an early retirement, before the legal age, during most of the past century have gradually been removed and even substituted by additional benefits for workers that remain longer in the labor market. We have shown that, in the context of a funded pension system, the introduction of a very simple incentive scheme to continuing at work has a clear positive effect in the labor supply of the elderly. What this paper shows is that such reforms should find less and less opposition from workers because, in the context of a proportionally greater positive effect of the improvements in health and life expectancy on the old workers' productivity than on the utility of leisure, more and more of them will increase their welfare with later retirement.

This conclusion indicates the general trend, but allows for different behaviors depending on workers' own characteristics or those of their workplace. Our analysis also identifies the types of workers who are more favourable to working longer and they match the usual findings of the empirical literature. The more productive a worker is, the higher his interest in extending his working life.

This general conclusion has many implications. For example, it implies an earlier retirement of individuals with lower levels of education and/or working in the less human capital-intensive sectors, while workers with higher skills will stay longer in the labor market. This has an evident counterpart: higher wages are positively related to a higher participation of the oldest workers. On the other hand, workers would abandon workplaces that require important physical effort earlier because this type of work would quickly deteriorate their health status. The mechanization of the most physically demanding tasks and the progressive reduction of the weight of industrial activities in favor of services (in general, less physically demanding) is, thus, another element that spurs a longer working life. The morbidity compression at advanced ages, due to health care progress, goes also in the same direction.

All these results indicate that, from a macroeconomic perspective, establishing a common retirement age for all workers may be a source of inefficiencies: the more productive workers are crowded out of the labor market while the less productive are forced to remain working longer than they desire. The possibility of introducing flexibility into the legal retirement age not only suits the interests of the workers but also leads to increases in productivity.

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