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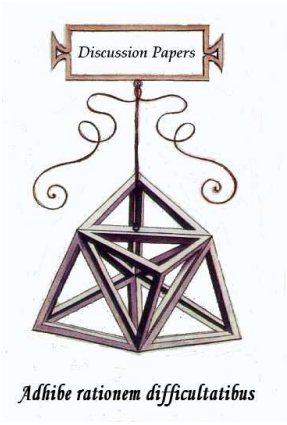

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Discussion Paper n. 149
2012

Discussion Paper n. 149, presentato: **settembre 2012**

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Si prega di citare così: Luciano Fanti (2012), "Consequences of a boost of mandatory retirement age on long run income and PAYG pensions ", Discussion Papers del Dipartimento di Scienze Economiche – Università di Pisa, n. 149 (http://www.dse.ec.unipi.it/index.php?id=52).

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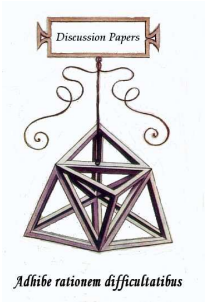

Luciano Fanti

Consequences of a boost of mandatory retirement age on long run income and PAYG pensions

Abstract

In this paper we study the effects of a boost of the mandatory retirement age, which is largely advocated in most countries facing with both the decline in the labour force participation of elderly workers and the increasing population ageing. It is shown, in the basic two-period overlapping generations model of growth (Diamond, 1965), that the postponement of the retirement age may be harmful for long run income and when the capital's share is sufficiently high even PAYG pensions are reduced. In conclusion, since it is shown that the age of retirement might be reduced obtaining a higher income and even higher pension benefits, then our results suggest that the idea that a higher mandatory age of retirement is always beneficial in the long run for income and pension payments is theoretically controversial.

Keywords Retirement age; Pensions; OLG model

JEL Classification J26; O41

1. Introduction

In the last decades it has been observed in many countries both a dramatic decrease of the labour force participation among middle-aged workers and a significant population aging.[1] Given the increasing population aging, it is a common belief that this retirement behavior contributes to increase the dependency ratio, and therefore, endangers the financial sustainability of the PAYG social security systems.

In fact it seems to be a vast consensus between politicians, economists and several international organizations - such as the European Union at the 2001 Lisbon Meetings - in advocating the increase in the effective retirement age, or - analogously - the increase in the activity rate among individuals aged above 55 years, despite the political difficulties to implement such a reform.[2] Many countries have recently increased the compulsory age of retirement in a significant way (for instance, on average, from 60 to 65 years, with proposals of further increases in the next future), under the common belief that prosperity - that is economic growth and not only more specifically the social security budget - is mined by an early retirement.

While the literature has largely developed – especially in the frame of the two-period OLG model - a normative analysis of the optimal retirement age (Hu, 1979, Marchand et al., 1996, Michel and Pestieau (1999), Crettez-Le Maitre (2002), Momota (2003), Lacomba and Lagos (2006), as well as models of political games for voting on the age of retirement (Conde-Ruiz and Galasso, 2004; Casamatta et al., 2005), what seems to be less investigated, however, is a positive analysis of the effects of the often advocated mandatory postponement of the retirement age[3] both on economic growth and the sustainability of pay-as-you-go (PAYG) pension systems.

In this paper we address in a long term perspective the following theoretical questions. Is a mandatory postponement of the retirement age really beneficial 1) for economic growth, and 2) for the sustainability of PAYG pension systems (i.e. for pension benefits paid to pensioners)? To do so, we use the neoclassical OLG growth model à la Diamond (1965), which is a standard toy-model for analysing pensions issues.

For simplicity, we mainly restrict ourselves to the case of log-linear life-cycle utility function and Cobb-Douglas production function in the textbook Diamond (1965) style

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[1] For example in the most part of OECD countries the average labour force participation of males aged between 60 and 64 has dropped by at least 25%, and in particular in the Netherlands, from 84.7% in 1960 to only 19.1% in 2000, and in France, from 68.7% in 1960 to only 17.8% in 2000 (see Conde-Ruiz and Galasso, 2004). As regards the expected population aging in developed economies it can be sufficient to say that while the age dependency ratio (over 65 in total population) was for most countries around 20 per-cent in 1995, it could be around 67 per-cent in Italy, around 57 per-cent in Japan, and around 49 per-cent in the Western Europe in 2040 (see United Nations, 1998).

[2] In order to provide other examples of this common belief, we may cite one of the policy conclusions of Maintaining Prosperity in an Ageing Society (OECD, 1998): it suggests, as noted by Lacomba and Lagos (2006), from an institutional point of view, that"...a direct way to encourage people to work longer would be to raise the pensionable age". From a theoretical point of view, Condè-Ruiz and Galasso (2004, p. 1867), among many others, note that "the prospect of retiring early - by shortening the working life - reduces the incentives to accumulate human capital, thereby decreasing economic growth."

[3] Note that in most countries, especially in Europe and Japan, retirement is compulsory (i.e. workers must retire at the age fixed by law in order to obtain a pension transfer). However, for the sake of completeness, we also note that in some countries, such as the US, old agents can contemporaneously work and receive a pension transfer.

OLG framework, extended with a compulsory age of retirement. The analysis of our simple model yields the following result: when the capital share is sufficiently high, an increase in the age of retirement reduces the neoclassical economic growth[4] and even pension benefits. Therefore, our results may constitute a policy warning suggesting that the commonly invoked boost of the mandatory retirement age could be an inappropriate policy recipe, also relaxing some concerns as regards its low popularity.[5] Finally, we note that these results are not new in the theoretical literature: for instance it has been argued (Sala-i-Martin, 1992) that a sufficiently low age of retirement may be output improving. However the novelty is in the economic channel behind the results which is at all different. In fact Sala-i-Martin postulates positive externalities in the average stock of human capital as channel for obtaining the results: "because skills depreciate with age, one implication of these externalities is that the elderly have a negative effect on the productivity of the young. When the difference between the skill level of the young and that of the old is large enough, aggregate output in an economy where the elderly do not work is higher. Retirement in this case will be a good thing" (Sala-i-Martin, 1992, p. 1). By contrast, in this paper the mechanism through which a sufficiently low mandatory age of retirement may be a good thing grounds on the intertemporal behaviours of agents in a general equilibrium context.

The paper is organised as follows. In Section 2 we develop the model and the main steady-state results on economic growth are analysed. Section 3 discusses the relationship between pensions and compulsory age of retirement in the frame of the model of the section 2. Section 4 winds up with some concluding remarks.

2. The model

2.1 Individuals

Young population N_t grows at a constant rate n and agents are assumed to belong to an overlapping generations structure with finite lifetimes. Adult life is separated among two periods: youth and old-age (Diamond, 1965). Individuals belonging to generation t have a conventional Cobb-Douglas utility function defined over young-aged and old-aged consumption, $c_{1,t}$ and $c_{2,t+1}$, respectively. Each person born at (the beginning of period) t lives for two periods and is capable of providing one unit of labour per period. In the first period t he works full time, earning a wage income of w_t while paying a Social Security tax according to the contribution rate τ. In the second period $t + 1$, he works a fraction $(1 - \lambda)$ of the time, and then retires (i.e. when $\lambda=1$ each person is retired for the whole second-period of life, which is the assumption of the conventional OLG model of Diamond (1965)). During old-age agents' earnings therefore consist of 1) the proceeds of their savings (s_t) plus the accrued interest at the rate r_{t+1}, 2) a net wage income of $(1 - \lambda)(w_{t+1}(1-\tau))$ and 3) a pension of λz_{t+1}, which is

[4] Note that in the neoclassical growth model a higher economic growth may be interpreted as a higher steady state per capita output level in that steady-state growth in per capita output is zero unless there is exogenous technical progress. Needless to say, in this model the higher the steady state per capita output level the higher the transitional average growth in per capita output is.

[5] As regards the low popularity of pension reforms also involving a boost of mandatory age of retirement, see, for instance, Boeri et al. (2002).

publicly provided and financed at balanced budget by the government. The length of the retirement period λ is mandatory (e.g. fixed by government).[6]

Thus, the representative individual born at time t is faced with the following program:

$$\max_{\{s_t\}} U_t = \ln(c_{1,t}) + \gamma \ln(c_{2,t+1}), \qquad \text{(P)}$$

subject to

$$c_{1,t} + s_t = w_t(1-\tau)$$

$$c_{2,t+1} = (1+r_{t+1})s_t + w_{t+1}(1-\tau)(1-\lambda) + \lambda z_{t+1}$$

where $0 < \gamma < 1$ is the subjective discount factor.

The maximisation of program (P) gives the following savings function:

$$s_t = \frac{1}{1+\gamma}\left[w_t(1-\tau)\gamma - \frac{w_{t+1}(1-\tau)(1-\lambda)}{(1+r_{t+1})} - \frac{\lambda z_{t+1}}{(1+r_{t+1})} \right]. \qquad (1)$$

2.2 Government

The government balances the PAYG social security scheme in every period

$$\lambda z_t N_{t-1} = \tau w_t N_t + \tau w_t N_{t-1}(1-\lambda), \qquad (2)$$

where the left-hand side represents the social security expenditure and the right-hand side the tax receipts. This scheme leads to the following formula for pension benefits[7]:

$$z_t = \tau w_t \mu \qquad (3),$$

where $\mu = \frac{2+n-\lambda}{\lambda}$.

Inserting (3) into (1) to eliminate z_{t+1}, savings function chosen optimally by individuals modifies to become:

$$s_t = \frac{1}{1+\gamma}\left[w_t(1-\tau)\gamma - \frac{w_{t+1}[1+\tau(1+n)-\lambda]}{(1+r_{t+1})} \right] \qquad (4)$$

It is of interest the investigation of the short-run effect of a reduction of the retirement period (that is a lengthening of the working period), which leads to the following result.

Result 1: *A lengthening of the working period (i.e. a mandatory increase of the retirement age) reduces savings.*

Proof: the proof follows straightforwardly from $\frac{\partial s_t}{\partial \lambda} = \frac{w_{t+1}}{(1+\gamma)(1+r_{t+1})} > 0$.

[6] We may interpret $1+\lambda$ as being the retirement age as well as the total time devoted to labour over the life-cycle, while, of course, the length of retirement is $1-\lambda$. This also means that, for instance, by assuming conventionally one period of thirty years and an age of entry in the adult life (i.e. in the labour market) of thirty years, then the age of retirement would be 60 years when λ=1, 65 years when λ=0.84, 70 years when λ=0.667, and so on.

[7] This is the so-called defined contribution scheme where the contribution rate is constant and pension benefit is residually obtained through the budget constraint. Otherwise, in the so-called defined pension scheme it is the contribution rate to residually balance the budget, while the pension benefit level is kept constant.

The economic reason why this occurs is that when the working period in the old-age is reduced the saving of the young individuals is higher in order to better sustain the consumption for the retirement period: in fact the length of such a period is increased as well as the old-age wage income is reduced.

2.3 Firms

As regards the production sector, we suppose firms are identical and act competitively. The (aggregate) constant returns to scale Cobb-Douglas technology of production is $Y_t = AK_t^{\alpha} L_t^{1-\alpha}$, where Y_t and K_t are output and capital, respectively, $A > 0$ represents a scale parameter and $\alpha \in (0,1)$ is the capital's share on total output. The time- t labour input is $L_t = N_t + (1-\lambda)N_{t-1}$ which may be rewritten as $L_t = N_t \dfrac{2+n-\lambda}{1+n}$. Defining $k_t := K_t / N_t$, $y_t := Y_t / N_t$ and $l = \dfrac{L_t}{N_t} = \dfrac{2+n-\lambda}{1+n}$ as capital per-young, output per-young and the ratio between total (young and old) workers and the young workers, respectively, the intensive form production function may be written as $y_t = Ak_t^{\alpha} l^{1-\alpha}$. [8] Assuming total depreciation of physical capital at the end of each period and knowing that final output is treated at unit price, profit maximisation leads to the following marginal conditions for capital and labour, respectively:

$$1 + r_t = \alpha A k_t^{\alpha-1} l^{1-\alpha}, \tag{5}$$

$$w_t = (1-\alpha) A k_t^{\alpha} l^{-\alpha}. \tag{6}$$

2.4 Equilibrium

Given the government budget (2) and knowing that population evolves according to $N_{t+1} = (1+n)N_t$, the market-clearing condition in goods as well as in capital markets is expressed by the equality $(1+n)k_{t+1} = s_t$. Substituting out for s according to Eq. (4), exploiting (5) and (6), and assuming individuals are perfect foresighted, the dynamic equilibrium sequence of capital is determined by:

$$k_{t+1}(1+n) = \frac{1}{(1+\gamma)} \left\{ \gamma(1-\tau)(1-\alpha) A k_t^{\alpha} \left(\frac{1+n}{2+n-\lambda} \right)^{\alpha} - k_{t+1} \frac{(1-\alpha)(1+n)\left[1+\tau(1+n)-\lambda\right]}{\alpha(2+n-\lambda)} \right\} \tag{7}$$

Steady-state implies $k_{t+1} = k_t = k^*$, so that:[9]

$$k^*(\lambda) = \frac{1}{(1+n)} \left\{ \frac{\gamma(1-\tau)\alpha(1-\alpha)A(2-\lambda+n)^{1-\alpha}}{(1+\gamma)\alpha(2-\lambda+n) + (1-\alpha)(1+\tau(1+n)-\lambda)} \right\}^{\frac{1}{1-\alpha}} \tag{8}$$

[8] Note that, when population grows at the constant rate *n,* the per capita variables are simply the per-young variables multiplied for the factor *n /(1+n)*: for instance, per capita output is equal to *[y n /(1+n)]*. This means that if the population growth rate is exogenously given, only the determination of per young output matters (being per capita output only an exogenously given constant fraction of per young output). By contrast, if the fertility rate is endogenously chosen, then per capita and per young variables may significantly differ.

[9] By passing, we note that it can be easily shown that the steady-state is always stable.

2.4.1 Long run capital and retirement age

As regards the investigation of whether an early retirement age reduces or not the long-run per-young stock of capital, the following result holds:

Result 2. *The capital accumulation is always enhanced by a lengthening of the retirement period, for any value of the mandatory retirement age.*

Proof [10]: Since i) $\frac{\partial k^*}{\partial \lambda} \underset{<}{>} 0 \quad \Leftrightarrow \quad \tau \underset{>}{<} \tau^* = \frac{\alpha^2[1+\gamma(2-\lambda)]+1-\alpha\lambda}{(1-\alpha)^2}$, and ii)$1-\alpha\lambda > (1-\alpha)^2$, then τ^* is always greater than one and, as a consequence, the derivative is always positive for any $0<\tau<1$.

2.4.1 Long run income and retirement age

The stationary state level of the per young income is given by

$$y^* = Ak^{*\alpha} l^{1-\alpha} \tag{9}$$

How changes in the retirement age affect the economic performance is determined by the sign of the following derivative:

$$\frac{\partial y^*}{\partial \lambda} = A\left[\alpha\left(\frac{l}{k^*}\right)^{1-\alpha} - \frac{1-\alpha}{1+n}\left(\frac{k^*}{l}\right)^{\alpha}\right] \underset{<}{>} 0 \tag{10}$$

It easy to see from Eq. (10) that the effect of an increase in the retirement age may be positive if the capital share is sufficiently high. The reason why this occurs is that a high capital share is a necessary requisite for the positive effect of the increased per-young capital prevails on the negative effect of the reduced total labour supply. In other words, provided that the technology is sufficiently capital-oriented, a reduction rather than a lengthening of the age of retirement may be income-enhancing in the long run. We may ascertain more in detail the economic conditions under which a policy either of reduction or of lengthening of the age of retirement should be implemented for reaching a higher economic growth (in the neoclassical sense) by the investigation of the following inequality (again in the simplified case *n=0*):

$$\frac{\partial y^*}{\partial \lambda} \underset{<}{>} 0 \quad \Leftrightarrow \quad F = A[\alpha^2[2\gamma(\lambda-2)+\tau-1]+\alpha[2(\lambda-\tau-1)-\gamma(\lambda-2)]+1+\tau-\lambda] \underset{<}{>} 0 \tag{10}$$

Then the following result holds:

Result 3: *If the capital share is sufficiently high, then a mandatory increase of the retirement age is harmful for the long run income.*

Proof: By applying the Descartes theorem as regards the solutions of the function F and the theorem on the sign of an equation of the second degree, the determination of the effect of a lengthening of the retirement period on the neoclassical economic growth boils down to the ascertainment of the sign of the following inequality, expressed for convenience in terms of the capital share:

[10]The proof is shown (for brevity) in the simplified case in which *n=0*, which is coherent with the current situation of the developed world in which population is stationary (or even decreasing), but, of course, the proposition also holds for any value of *n* (proof disposable on request).

$$\frac{\partial y^*}{\partial \lambda} \gtrless 0 \quad \Leftrightarrow \quad \alpha \gtrless \alpha^* = \frac{\sqrt{2-\lambda}\sqrt{\gamma^2(2-\lambda)+4\gamma(1-\lambda+\tau)}+\gamma(2-\lambda)-2(-\lambda+\tau+1)}{2[2\gamma(2-\lambda)+1-\tau]} \qquad (12)$$

One way to gain further insight on the content of Result 3 is by carrying out, through numerical examples, the following sensitivity analysis, resumed in table 1.

Table 1. *Critical values of the capital share, α^* (see Eq. 12) (beyond which income is always increased by a lengthening of the retirement period), for varying length of the retirement period (λ), subjective discount factor γ (part A) and contribution rates τ (part B)*[11]*. Case of stationary population (n=0).*

(A)

λ	γ=0.10	γ=0.30
0.99	α^*=0.267	α^*=0.295
0.50	α^*=0.394	α^*=0.405
0.01	α^*=0.429	α^*=0.436

Legend: τ=0.10

(B)

λ	τ=0.05	τ=0.25
0.99	α^*=0.262	α^*=0.363
0.50	α^*=0.397	α^*=0.427
0.01	α^*=0.431	α^*=0.449

Legend: γ=0.30

As shown by table 1, the higher the existing mandatory age of retirement and the lower both the contribution rate and the subjective discount factor, the more likely the age of retirement should be reduced (instead of increased) in order to enhance the neoclassical economic growth.

Since, as shown in table 1, in the most cases the "critical" value of the capital share is included between 0.25 and 0.40, and even in the case of extremely high contribution rate (25 per-cent) and retirement age (about 75 years) such a "critical" value is below 0.43, then we feel quite confident in saying that for many countries the capital share is such that economic growth is reduced by an increase of the age of retirement.[12]

To sum up, whether governments must mandate either an early or a postponed age of retirement, it depends on several elements, such as the level of the initial age of retirement, the capital share, the degree of individual's "thriftiness", the size of the PAYG system, and therefore it is ultimately an empirical matter.

However it is possible to argue that, given the empirical observations as regards the three crucial parameters capital share, subjective discount factor and contribution rate, the present model suggests that for many countries a postponement of the mandatory retirement age is harmful for economic growth, especially when such a reform is evaluated at an existing level of the retirement age sufficiently low.

[11] Since the level of pension contributions in Europe is currently around 16% of aggregate wages (e.g. Liikanen, 2007, p. 4), we have chosen the polar cases of τ=0.05 and τ=0.25 so that the European average value is exactly included between them. .

[12] For instance, as regards US, according to Greenwood et al. (1993, p.6), the share of physical capital in market production deducted from the US national accounts could be anywhere between 0.25 and 0.43, depending on various details, such as the treatment of proprietor's income. In such a case our Result 3 certainly would hold true.

However the ascertainment that the lengthening of the retirement age is harmful for the long run income in many economies is not the end of the story. Since the accounting rules as well as the motivation for reforms lengthening of such an age would say to us that the latter always should improve the PAYG system's sustainability, then we question whether even such a common wisdom is really founded. In the next section it is examined whether and how an increase in the age of retirement favours, as commonly believed, the sustainability of PAYG pension budgets.

3. Pensions and age of retirement in the long-run

A common belief suggests that a reduction of the retirement period (i.e. an increase in the age of retirement) is necessary in order to keep balanced budget of PAYG pensions systems facing with population aging (i.e. to guarantee an adequate pension benefit to retired people). This belief has motivated the recent significant prolongation of the mandatory age of retirement in many countries. However, armed with the results of the previous section, we question whether in the long run, not only the neoclassical economic growth, but even the sustainability of PAYG pension systems (i.e. the size of the pension benefit) may be harmed by an increase of the mandatory age of retirement. In what follows we investigate the relationship between pensions and age of retirement, showing that, rather surprisingly, the common belief may be reversed in the basic OLG model of growth under economic circumstances which may be realistic for a certain number of economies. First, it is worth to be noted that some evaluations of the increase of the age of retirement needed for ensuring the sustainability of the PAYG pension seems to be unfeasible even to the same proponents. For instance, Kessler (1990) argues that, as regards France, the retirement age should be increased by 13 years. Sinn (2007, p. 9), questioning how long would old people have to work to keep the contribution and the replacement rates constant, answers that, "according to the UN study it would be 77 years!". However, as noted by Crettez and LeMaitre (2002, p. 754), such increases are "unlikely to take place since mandatory retirement and pay-as-you- go transfers are beneficial for firms and society as a whole because they enhance the productivity of young workers."[13] Moreover other aspects of the meaning of the mandatory age of retirement should be considered, as noted by Diamond (2007, p. 31): "the date the earliest pension age should be based on fulfilling its social role, on seeing that pension levels are adequate and are available by the time a significant fraction of the population should sensibly be receiving them."[14]

By a basic accounting point of view (see the pension formula in Eq. (3)), benefits levels, levels of contribution rates, retirement ages and demographic patterns, should be mutually consistent. For instance, for facing with a decreased fertility, it is necessary – indisputably, according to the basic accounting rules - to response with increased contribution rates or decreased benefits or later retirement ages or a combination of

[13] Such beneficial effects of a mandatory retirement have been highlighted by, among others, Lazear (1979) and Sala-i-Martin (1992).

[14] Notice that our subsequent results are obtained abstracting from these lines of economic reasoning which stress possible positive effects of a sufficiently low age of retirement. Needless to say, our results would be strengthened by taking also account of the above mentioned points.

them. However, a part from the basic accounting effects, changes in the parameters of the pension formula also have feedback effects on agents' behaviours, which may be far more important for the sustainability of the pension system than the basic accounting effects.[15] Therefore only a full analysis may show whether the recent reforms introducing later starting ages for paying benefits are really worthwhile or not. For doing this, we begin with re-writing the long-run pension benefit (given by Eq. (3)) as a generic function of the age of retirement in the second period of life in the following way:

$$z^* = z^*\left\{\lambda, P(\lambda), w^*\left[\lambda, k^*(\lambda)\right]\right\}. \tag{13},$$

where $P = 2 + n - \lambda$ is the number of contributors (which includes both young and old generation) for each old agent. Notice that λ is the fraction of the old age period in which old age people are retired, so that it may be seen as a measure of the length of the retirement period and changes in λ as changes in the mandatory age of retirement. Therefore, the total derivative of Eq. (13) with respect to λ gives:

$$\frac{dz^*}{d\lambda} = \overbrace{\frac{\partial z^*}{\partial \lambda}}^{-} + \overbrace{\overbrace{\frac{\partial z^*}{\partial P}}^{+}\overbrace{\frac{\partial P}{\partial \lambda}}^{-}}^{-} + \underbrace{\overbrace{\frac{\partial z^*}{\partial w^*}}^{+} \cdot \left[\overbrace{\frac{\partial w^*}{\partial \lambda}}^{+} + \overbrace{\frac{\partial w^*}{\partial k^*}}^{+} \cdot \overbrace{\frac{\partial k^*}{\partial \lambda}}^{+}\right]}_{+}. \tag{14}$$

Eq. (14) reveals that the final effect of a reduction of the retirement age (that is, a lengthening o the period of retirement) on the long-run pension payment depends on three counterbalancing forces: two negative forces (the first two effects in the right side of Eq. (14)) directly channelled through a higher number of retired individuals, and one positive force (the third effect in the right side of Eq. (14)) indirectly provided by a general equilibrium feedback effect due to an induced increase of wages (recall that the higher the wage rate the higher the pension payment received by retired people).

By analysing more in detail Eq. (14), it is easy to see that the length of the retirement period plays a rather complicated role. In particular a reduction of the age of retirement has 1) a direct effect consisting in a reduction of pension benefits firstly because pensions must be paid for a longer period and secondly because the composite number of contributors (which includes both young and old generation) is reduced due to the reduced number of old workers; 2) an indirect effect due to the positive change in the wage induced by such a reduction. For what concerns the latter effect, we note that a change of the retirement period affects wages through two channels: 1) the effects on the capital stock input, 2) the effects on the labour input. As regards the former point, since savings are increased when the length of the retirement period is increased (owing to the need to sustain the second period consumption for a longer period of retirement), the capital stock will be augmented as well. As regards the latter point it is easy to see that an increased retirement period implies a lower labour supply and thus, through this channel, a tendency towards a higher wage. Therefore the overall effect on wages will be even more positive than that on the sole capital accumulation, and consequently this component of the tax base is increased.

[15] Indeed, for example, Fanti and Gori (2008, 2010) have shown that, in a conventional OLG growth model, an increasing longevity as well as raising contribution rates may be harmful for the sustainability of pay-as-you-go pension systems.

Since the overall effect appears to be, a priori, ambiguous, it needs to analyse ultimately which of the opposite forces dominates. For doing this, we now combine Eqs. (3), (6) and (8) to obtain the following steady-state pension benefit formula:

$$z^* = \frac{\tau(1-\alpha)A\left\{\dfrac{\gamma(1-\tau)\alpha(1-\alpha)A}{(1+\gamma)\alpha(2-\lambda+n)+(1-\alpha)(1+\tau(1+n)-\lambda)}\right\}^{\frac{\alpha}{1-\alpha}}(2-\lambda+n)}{\lambda} \qquad (15)$$

From an analytical point of view, the effect of a change in λ on z^* is in general difficult to be determined and economically interpreted. However a "natural" experiment consists in evaluating the effect of an increase of the age of retirement evaluated at the beginning of the second period of life, which, in the basic OLG model, is assumed to be a period of full retirement: for example, by supposing a length of a generation about 30 years and the entry into the adulthood at an age of about 30 years, the beginning of the second period of life would be about 60 years (implying that the maximum expected life is about 90 years). Therefore the question is: would a small postponement of the age of retirement beyond 60 years – for instance up to 65 as many recent pension reforms have deliberated - always enhance the sustainability of the pension system (that is, would always increase, ceteris paribus, the level of the pension benefit), as commonly believed? The answer is no if the production technology is sufficiently capital oriented.

Therefore, in order to obtain analytical results in closed form, we investigate the effect of a mandatory lengthening of the working life evaluated at the beginning of the second period of life (i.e. at $\lambda \cong 1$, corresponding, for instance under our conventional hypothesis, to about 60 years) and the following result holds:

Result 4. *A small increase of the age of retirement beyond the "natural" one (that is beyond the beginning of the old age period, which may correspond to, with our conventional hypothesis, 60 years) may be harmful for the pension benefit level, provided that the size of the pension system is sufficiently small and the capital share is sufficiently high. In particular this result may hold (always holds) whenever the capital share is larger than 0.5 (0.667).*

Proof: the result follows from the derivative of the pension benefit with respect to the age of retirement (assuming, again for simplicity, stationary population):[16]

$$\frac{\partial z^*}{\partial \lambda}_{|\lambda=1} \underset{<}{\overset{>}{}} 0 \quad \Leftrightarrow \quad \tau \underset{>}{\overset{<}{}} \tau^{**} = \frac{\alpha[\alpha(3\gamma+2)-(2\gamma+1)]}{2(1-\alpha)^2} \qquad (16)$$

From Eq. (16) it is possible to ascertain the conditions under which $\tau^{**}>0$ (which is the necessary condition for having a positive effect of an increase of λ on z at least for a sufficiently low value of the contribution rate) and $\tau^{**}>1$ (which is the sufficient condition for having always a positive effect of an increase of λ on z). In fact, $\tau^{**}>0 \quad \Leftrightarrow \quad \alpha > \frac{2\gamma+1}{3\gamma+2}$, and given $0<\gamma<1$, τ^{**} is larger than zero for values of α at least larger than the values included in an interval *[0.5 - 0.6]* for any values of $\gamma \in (0,1)$. Moreover $\tau^{**}>1 \quad \Leftrightarrow \quad \alpha > \frac{2}{3}$.

[16] Note that for most developed economies it would be realistic not only the case of stationary population, but also the case of below-replacement fertility, as indeed assumed in the following numerical illustration.

Result 4 says that the level of the pension payment is inversely related with the length of the retirement period if and only if the capital's share in production is low enough. On the contrary, if the capital's share is sufficiently high (i.e. an output elasticity of capital larger than that of labor), then the lower the age of the retirement, the higher the pension benefit may be.

Since Result 3 relies on a sufficiently high value of the capital share, we now restrict our attention to the empirical plausibility of such a value. Therefore, in this respect, we note, on empirical grounds, that, many countries have capital shares close to or larger than 0.50 (e.g. Italy, Spain, Japan, which, interestingly, are also among those countries showing high fertility drops). In fact, drawing, for instance, on capital's share estimates by Jones (2003) and Rodriguez and Ortega (2006), we see that 1) according to Jones, countries such as Australia, Ireland, Italy, Portugal and Spain display capitals' shares estimates higher than $1/2$ (at least according to the measure without self employment correction); 2) according to Rodrigues and Ortega, about 88% of 111 countries show (by considering UNIDO data) a capital share larger than 0.5 (while by considering OCSE/SSIS and BSC data the percentage of countries with capital shares larger than 0.5 is lower but in any case significant). Other recent works estimating capital shares with econometric techniques corroborate the high value of such shares. For instance, Senhadji (2000), as regards 10 Middle Eastern and North African countries for the period 1960-1994, estimated a value of the share of physical capital of about 0.63 when estimation is done in levels and 0.54 when the production function is estimated in first difference. Abu-Qarn and Abu-Bader (2006), reassess the conventional measure of the capital share in income by estimating the shares of inputs in income for 23 OECD countries for the period 1960-2003 utilizing panel data techniques, showing that a share of physical capital of over 0.50 is found to be robust to a variety of specifications of the production function and the econometric models used. Abu-Qarn and Abu-Bader (2007), again for 10 Middle Eastern and North African countries over the period 1960–98, estimated the long-run share of capital in income using cointegration (country- specific) and panel data (region-specific) methods, showing that the average share for the selected countries amounts to 0.54 (when Jordan and Sudan are included) while, when excluding these two Countries, the share is much higher (0.60).

Apart from the above reported empirical observations, the plausibility of sufficiently high values of the capital share may be also justified on theoretical grounds, for instance resorting to a more enlarged notion of capital, including human as well as organizational capital, as noted, for instance, by Chakraborty (2004).[17] Indeed, for instance, Barro and Sala-i-Martin (2003, p. 110) used $\alpha = 0.75$. [18]

Therefore we may conclude that for values of the capital share sufficiently high, a small increase of the retirement age may be, rather unexpectedly, pension-reducing. Furthermore, the latter result is more likely when the size of the pension system is sufficiently small and individuals are rather "spendthrift". In particular the latter result is due to the indirect general equilibrium effect of a fall in the age of retirement

[17] "Given existing estimates of α in the US, a value greater than 0.5 may be rationalized by broadening the concept of capital. By including human capital, we would expect the share to be in the range (0.6 - 0.8) as in Mankiw et al. (1992), while incorporating organizational capital gives an estimate of 0.71 as in Chari et al. (1997)."(Chakraborty, 2004, p. 124).

[18] The reason is that "values in the neighbourhood of 0.75 accord better with the empirical evidence, and these high values of α are reasonable if we take a broad view of capital to include human components" (Barro and Sala-i-Martin, 2003, p. 110).

which acts positively on wages through both an increased capital accumulation and a decreased labour supply: this twofold positive effect dominates over the negative direct effects which tends to reduce pensions owing the combined effect of a lower number of hours worked by old-aged people and a higher number of retired old individuals.
Moreover, by resorting to the numerical simulation, we show in the following sub-section that, interestingly, the effects of an increase of the age of retirement (as measured by a reduction of λ) on pension payments (z) may be negative not only when the initial retirement age is at the beginning of the second period, as analytically shown in Result 4, but also when such an age of retirement is, at the moment of its further increase, already rather high.[19]

3.1 A numerical illustration

To provide a quantitative assessment of the relative importance of the effects discussed above, we parameterize our simple model only for illustrative purposes (although it may be noted that the parameter set is coherent with some features of the Italian economy).[20]
We take the following parameter values: $A = 30$ (simply a scale parameter in the Cobb-Douglas production function), $\gamma = 0.30$ (a rather standard value as in De La Croix and Michel, 2002, p. 50), and $\tau = 0.15$. As regards the value of the capital share, we have chosen a value of α=0.60 (more or less corresponding to the more recent observations for Italy by Jones (2003) and Rodriguez and Ortega, 2006).[21]
Finally we have chosen a value of the population growth rate corresponding to the current below-replacement fertility rate observed in many advanced economies, in particular about 1.35 children for each couple recently observed for Italy (i.e. n= *-0.333*). Furthermore we note that pension reforms post-1995 have gradually increased the mandatory age of retirement up to the current level of 65 years, and proposals for further increases are on the political agenda: thus our numerical example is focused on this fact, through the comparison between the levels of benefits induced by an increase of the age of retirement from 60 years to 69 years. Therefore the following Table 2 displays the effects of a prolongation of the age of retirement, starting from the beginning of the old age (conventionally 60 years) until to 69 years, on the level of the pension benefit. Such effects, given that output elasticity of capital is sufficiently larger than that of labour, are clearly negative, in accord with the considerations of the previous section: for instance we observe that the prolongation from 60 to 65 years has induced a reduction of the pension benefit of about 4.5 %. Moreover it is shown that the mandatory age of 65 years is the most harmful for pensions in comparison with the other ages of the entire decade. In particular Table 2 reveals that the final

[19] For instance it is shown in the following numerical example that the pension benefit paid when the age of retirement is 60 years is higher not only than that paid when the age of retirement is 65 years, but even than that paid when the age of retirement is 69 years.
[20] By passing we note that the example of the Italian economy has also been used by Condè Ruiz and Galasso (2004), who consider τ=0.20 (in line with the average contribution rate prevailing in the sixties), and γ=0.46. However in their model there is no capital and thus no capital share value, and furthermore their focus is on the early retirement provision referred to the Italian legislation prior to the 1995 reform, where the early retirement age was about 57 years.
[21] According to the data provided by OECD Structural Statistics for Industry and Services (SSIS) the capital share measured as one minus the sum of wages and salaries at factor prices for Italy for the period 1990-2003 is larger than 0.59 (Rodriguez and Ortega, 2006, fig. A1). Similarly, according to Jones (2003, fig.1. p.8) the capital share (calculated on OECD national accounts data as one minus the labor share, where the labor share is employee compensation as a share of GDP) for the second part of the nineties is close to 0.60.

effect of an increase of the length of the retirement period on the pension benefit depends on the level of the existing age of retirement: when the age of retirement is fixed, for instance, in the first years of the second period of life, a further increase of the mandatory age of retirement may reduce the future pension benefit while when the existing age of retirement is high further increases of such an age will have a positive effect on the pension. In other words the example shows a U-shaped pension-age of retirement relationship with a minimum level of pension benefits when the retirement age is fixed at 65 and with levels of pension benefits always higher when the age of retirement is fixed at 60 than when it is fixed at any age included between 60 and around 70 years.

Thus, an implication of the illustrative example would be the following: since 1) only when the age of retirement is over 70 years the pension payment results higher than the level reached when the mandatory age was 60 years, 2) working after 70 years seems to be rather problematic,[22] and 3) in any case any prolongation of the mandatory retirement age over the minimum of 60 years is increasingly harmful for capital accumulation and neoclassical economic growth (as shown in section 2), then in the long run not only economic growth but even the sustainability of the PAYG pension system would be improved reducing the age of retirement rather than augmenting further it (as instead often invoked by many economists and policymakers).

Table 2. Effects of an increase of the age of retirement (λ) on pension payments (z). Ratio $q=z^*(\lambda)/\ z^*(1)$

Age of retirement (in terms of λ)	q	*Percentage change of q*
60 yrs (i.e. λ=1)	1	=
61	0.9853	- 1.47%
62	0.9675	- 3.25%
63	0.9592	- 4.08%
64	0.9559	- 4.41%
65	0.9549	- 4.51%
66	0.9577	- 4.23%
67	0.9647	- 3.53%
68	0.9753	- 2.47%
69	0.9924	- 0.76%

To sum up, this section has revealed that the effect of a boost of the retirement age on PAYG pension benefits is in any case an empirical matter, and that in economies with large capital shares the effect is, in contrast with the common belief, indisputably negative.

4. Conclusions

In this paper we investigated, by using the conventional Diamond (1965) style OLG model, whether the rather common idea that the early retirement reduces economic growth and poses a threat to the PAYG pension system viability is really warranted or not, obtaining the following results: when the capital share is sufficiently high, a reduction (rather than, as commonly believed, an increase) of the mandatory age of

[22] At least as regards the health status.

retirement may favour economic growth and, rather surprisingly, even pension payments. One policy implication is that in developed countries plagued by a strong population aging the compulsory boost of the age of retirement might not be in the long run the appropriate policy to keep balanced the PAYG pension budget.
Therefore the tendency, emerged in the recent years in many countries, towards an increase of the mandatory age of retirement may not only reduce long-run income (and the transitional rate of economic growth) but even fail the main target for which it has been often invoked, that is the sustainability of the future payments of pensions.
In conclusion, our results suggest that the idea that a higher mandatory age of retirement is always beneficial in the long run for income and PAYG pension budgets is theoretically controversial.[23]
The current article demonstrates that valuable insights can be gained by studying the effects of an element of the social security system, such as the mandatory age of retirement, in an intertemporal general economic equilibrium context such as the OLG neoclassical growth model à la Diamond. Because the complexity of the agents' intertemporal behaviours, it may be that changes in the elements of the social security system may have some economic effects merely arising from the interplay with other branches of the economy (e.g. capital and labour markets), so that they may be overlooked if the pension system is analyzed in isolation (i.e. as an accounting identity).
Beyond an attempt at generalizing our results to the case of more general preferences and technologies, straightforward extensions of this analysis should aim to introduce: *1*) young and old workers' labours which are: *1.1*) not necessarily perfect substitutes, capturing the difficulty to combine agents of different ages in the production process,[24] and *1.2*) with different productivity, reflecting the age-productivity profile[25]; *2*) an evaluation of the retirement time as leisure time which increases individuals' welfare; *3*) endogenous fertility choices and pension formulas linking benefits with the paid contributions (e.g. a Bismarckian pension scheme, which is the prevalent scheme in continental Europe); *4*) human capital investments in addition to the physical capital investments. Such extensions are left for future research.

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[23] It must be emphasised that we have obtained the result using as parsimonious a model as possible, such as the standard Diamond's (1965) OLG model of growth.
[24] For instance Crettez and Le Maitre (2002) in their normative analysis of the "optimal" retirement age found that an elasticity of substitution of old agents' labour for young agents' labour lower or higher than one is crucial for determining the relationship between "optimal" retirement age and declining population.
[25] The shape of the age-productivity profile is a rather controversial empirical issue; however it is reasonable to agree with the findings of Miles (1999) who argue for an inverted U-shaped with a rapidly declining productivity at high age.

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