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Aisa, Rosa and Larramona, Gemma and Pueyo, Fernando

University of Zaragoza, University of Zaragoza, University of Zaragoza

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Rosa Aisa[a], Gemma Larramona[b] and Fernando Pueyo[c]

[a] *Departamento de Análisis Económico, Universidad de Zaragoza.Gran Vía 2, 50005 Zaragoza (Spain). Phone number: 0034976762789. Email: raisa@unizar.es*

[b] *Departamento de Análisis Económico, Universidad de Zaragoza.Gran Vía 2, 50005 Zaragoza (Spain). Email: gemmalar@unizar.es*

[c] *Departamento de Análisis Económico, Universidad de Zaragoza.Gran Vía 2, 50005 Zaragoza (Spain). Email: fpueyo@unizar.es*

Abstract: Governments concerned with public finance are introducing reforms to push their citizens to remain in the labor market beyond the normal retirement age. We build a stylized theoretical framework in which we show that the labor supply among older workers and preventive health investment go hand in hand. In particular, those workers with the highest levels of productivity are those who remain longer in the labor market and, at the same time, who invest more in preventive health. We also find that a certain level of productivity in the health sector emerges as a prerequisite for active ageing. Furthermore, an increase in such productivity leads to growth in the effective labor supply, leading to an increase in demand for health care, while liberating additional resources for the non-health sectors.

Keywords: Active ageing, preventive health

JEL codes: I1, J2

Introduction

Since Selma Mushkin (1962) presented her seminal work, *Health as Investment,* many theoretical and empirical studies have analyzed the relationship between health and labor productivity. One consensus reached is that the effect of improvements in health on labor productivity is higher in developing countries than in developed countries (Lee, 1994), because, in developed countries, health improvements mainly benefits those who exceed the retirement age and so more health investment leads to an older population, but expands neither the labor force nor the returns on investment to education. However, the trend in developed countries towards early retirement during most of the second half of the 20th century had disappeared by the mid-1990s, giving rise to an expectation of an increase of the participation of elderly in the labor force in coming years. Thus, in this new context of delaying the retirement age, an analysis of the influence of health investment on the labor productivity of the elderly becomes interesting. The *2010 Revision* (United Nations, 2011[1]) estimated that the population aged 60 and over will rise at the fastest pace ever in the more developed regions, implying an increase from 274 million in 2011 to 418 million in 2050, and to 433 million in 2100.

There is no doubt that an increase in the retirement age alleviates public finances, and so governments are pushing the legal retirement age, and increasing the required number of years of contribution to qualify for a full pension, as well as promoting other measures such as permitting part-time work combined with a partial pension (Schirle, 2008). In any case, an adequate match to this new context of older retirement requires that individuals consider devoting resources to preventive health in order to maintain a level of health sufficiently high for individuals in their sixties and seventies to continue working. In other words, since the institutional context requires individuals to remain functional and active for a longer period of time, those individuals must decide whether to invest, or not, in preventive health measures in the face of a longer working life.

[1] http://esa.un.org/wpp/documentation/pdf/WPP2010_Volume-I_Comprehensive-Tables.pdf

Moreover, prior evidence of the relationship between the level of health at retirement age and the individual decision to shorten or lengthen the working life stresses that the connection between both elements operates in two directions[2]. In this paper, we present a theoretical framework where individuals decide jointly whether to participate in the labor market in later years, and whether to invest in preventive health to facilitate active ageing. We are interested in analyzing how *planned* health investments by an individual affect the decision to postpone, or not, an exit from the labor market, and how the desire to remain, or not, in the labor market in later years influences such investments.

To obtain a closed-form solution to a model that characterizes individual behavior with respect to preventive health and the retirement decision, we make some simplifying assumptions. First, we exclusively focus on the effect of preventive health measures on postponing the functional limitations that make participation of the elderly in the labor market feasible. We do not consider the effect of preventive health expenditures on life expectancy, nor on health care expenditures in old age. Second, we concentrate on the preventive health measures chosen by individuals, but we do not introduce public preventive health care. We are interested in *active* ageing, in the sense that the World Health Organization (WHO) Director General, Harlem Brundtland stated in 1999, the International Year of Older Persons: *there is much the individual can do to remain active and healthy in later life*[3]. In particular, we consider the preventive health measures that require an explicit economic cost, that is, secondary prevention (e.g. screening for the early detection of chronic diseases), and tertiary prevention, (e.g. appropriate clinical management of diseases)[4].

Three results are noteworthy. First, prolonging participation in the labor market goes parallel with investing in preventive health care; that is to say, those workers who plan to remain longer in the labor market are also those who devote more resources in advance to sustain better health when older.

[2] See, for example, Coe and Zamarro (2011)

[3] WHO (2001). Active ageing makes the difference
http://www.who.int/ageing/publications/alc_embrace2001_en.pdf

[4] World Health Organization (2002). *Active Ageing. A Policy Framework*.
http://whqlibdoc.who.int/hq/2002/WHO_NMH_NPH_02.8.pdf

Second, given that labor supply and preventive health investment go hand in hand, we find that the workers with the highest levels of productivity are those who decide to remain in the labor market longer and, at the same time, to invest more in preventive health measures. In other words, those with the highest levels of productivity will be more receptive to the idea of active ageing.

Third, the productivity of the health sector emerges as an important factor in this context. In fact, a certain minimum level of productivity in this sector is required for active ageing; otherwise, no workers would be willing to remain in the labor market in old age. Moreover, any improvement in labor productivity in the preventive health sector would make it easier to reach old age with sufficient functionality to encourage a longer working life. An increase in demand for preventive health services could take resources away from other productive activities. However, we find that the increase in labor (both in quantity and quality) as a result of a more active ageing population is sufficient not only to satisfy the demand for labor resources in the health sector, but also to allocate additional labor resources to the non-health sectors.

The rest of the paper is organized as follows. In Section 2 the model is presented and the optimal individual behavior is determined, with individual productivity appearing as an important determinant of the old age labor supply. In Section 3, the market equilibrium is solved to show the key influence of health sector productivity in active ageing, and we discuss its implications for the aggregate labor supply and its distribution between health and non-health production. Section 4 provides some concluding remarks.

1. The model and the individual optimal behavior

2.1 Individual problem

The population of any economy can, very broadly, be separated into two rough categories, the young and the old. Every individual of each generation is endowed with a different productivity level θ_i, uniformly distributed along the interval [0,1]. 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 spent on non-health goods, $c^y_{i,t-1}$,

another part is spent on health goods, $h_{i,t-1}$, and the rest is saved: $s_{i,t-1} = w_{t-1}\theta_i - c^y_{i,t-1} - q_{t-1}h_{i,t-1}$. A non-health (consumption) good is considered as the numeraire good, and *q* denotes the relative price of the health good. We interpret *h* in a broad sense, being whatever action supports *the health of tomorrow*. We consider that the higher the level of health investment in the first period, the higher the level of healthy and/or active ageing in the second period.

The longevity of an individual is uncertain. In our model, *p* is the probability of remaining alive in the second period of life. This parameter is given and, thus, life expectancy is exogenous. As usual in the economic literature on longevity, we assume the existence of actuarially fair insurance companies that redistribute income from those who do not survive to old age to those who do. Through this mechanism, the surviving elderly obtain a capital income in period *t*+1 of $\frac{1+r_t}{p} s_{i,t-1}$, where r_t is the interest rate. Survivors may supplement their capital income by remaining in the labor market, and thus earning a wage income $w_t\theta^o_{i,t}e_{i,t}$, where $e_{i,t}$ denotes their labor force participation and $\theta^o_{i,t}$ captures the productivity of the individual, the ability to continue working. Any worker retains, when old, a fraction of his youth productivity, which is positively related to the effort devoted to preventive health measures in the first stage of life: $\theta^o_{i,t} = \phi(h_{i,t-1})\theta_i$, with $\phi' > 0$ and $0 \le \phi(.) \le 1$. In particular, we assume:

$$\phi(h_{i,t-1}) = D h_{i,t-1}{}^{\delta}, \tag{1}$$

with $\delta \in (0,1)$. *D* is a scale parameter that guarantees $\phi(.) \le 1$. Thus, the old-age consumption of individual *i* in period *t* is given by $c^o_{i,t} = \frac{1+r_t}{p} s_{i,t-1} + w_t\theta^o_{i,t}e_{i,t}$. As in Matsuyama (2008), we assume that the elderly 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 remain in the labor market.

Every individual derives utility from both youth and old-age consumption, conditional on survival. We assume the existence of a gain in utility due to the leisure time enjoyed when old. Following Aisa et al. (2012), the expected utility of an individual *i* born in *t*-1 is given by:

$$EU\left(c_{i,t-1}^{y},c_{i,t}^{o},e_{i,t}\right)=\left(\frac{c_{i,t-1}^{y}}{1-\beta}\right)^{1-\beta}\left(\frac{c_{i,t}^{o}}{\beta}\right)^{\beta p}\left[1+\lambda(1-e_{i,t})\right]^{p}, \tag{2}$$

with λ measuring the gain in utility from the leisure time in the second period of life. The presence of *p* in the exponent of the terms associated with old age *t* captures the uncertainty of remaining alive in that period.

2.2 Optimal individual decisions

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

$$\underset{e_i,h_i,\{c_i\}}{Max}\ EU\left(c_{i,t-1}^{y},c_{i,t}^{o},e_{i,t}\right)=\left(\frac{c_{i,t-1}^{y}}{1-\beta}\right)^{1-\beta}\left(\frac{c_{i,t}^{o}}{\beta}\right)^{\beta p}\left[1+\lambda(1-e_{i,t})\right]^{p},$$

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

$$c_{i,t}^{o}=\frac{1+r_t}{p}s_{i,t-1}+w_t D h_{i,t-1}^{\ \delta}\theta_i\ e_{i,t},$$

given w_{t-1}. The problem can be solved in two stages. In the first, individuals decide on their levels of non-health consumption when young and old, $\{c_i\}=\{c_{i,t-1}^{y}>0,c_{i,t}^{o}>0\}$ and their level of health goods consumption when young, $h_{i,t-1}\geq 0$, which, in turn, will depend on the decision about retirement. In the second stage, the decision to retire, or not, is taken by comparing individual welfare in both situations.

The optimal non-health and health consumption profiles, conditional on the decision to remain in the labor market when old $(e_{it}=1)$, are given by:

$$c_{i,t-1}^{y}=\frac{1-\beta}{1-\beta+p\beta}\left[w_{t-1}\theta_i+\frac{1-\delta}{\delta}q_{t-1}\left(\frac{p}{1+r_t}\frac{w_t D\delta\theta_i}{q_{t-1}}\right)^{\frac{1}{1-\delta}}\right], \tag{3a}$$

$$c_{i,t}^{o}=\frac{\beta(1+r_t)}{1-\beta+p\beta}\left[w_{t-1}\theta_i+\frac{1-\delta}{\delta}q_{t-1}\left(\frac{p}{1+r_t}\frac{w_t D\delta\theta_i}{q_{t-1}}\right)^{\frac{1}{1-\delta}}\right], \tag{4a}$$

$$h_{i,t-1} = \left(\frac{p}{1+r_t} \frac{w_t D \delta \theta_i}{q_{t-1}} \right)^{\frac{1}{1-\delta}}, \tag{5a}$$

Alternatively, the optimal decisions if the individual retires when old $\left(e_{it} = 0\right)$ are given by:

$$c_{i,t-1}^{y} = \frac{1-\beta}{1-\beta+p\beta} w_{t-1} \theta_i, \tag{3b}$$

$$c_{i,t}^{o} = \frac{\beta(1+r_t)}{1-\beta+p\beta_i} w_{t-1} \theta_i, \tag{4b}$$

$$h_{i,t-1} = 0. \tag{5b}$$

These optimal consumption profiles establish that those individuals who remain in the labor market in their second period of life choose a higher consumption path than those who decide to retire. The former earn an additional income w_t per unit of effective labor supplied in the second period, whereas retired individuals perceive no labor income in such period and, thus, are more concerned about saving when young. With respect to the health consumption profiles, equations (5a) and (5b) reveal that only those individuals who plan to remain in the labor market for longer find preventive health measures worth paying for. Note that, whereas most prior research has concentrated on the influence of individual health status on the timing of retirement, our approach emphasises that the will to extend the working life involves additional requirements of health investment in earlier stages of life.

The second stage corresponds to the decision to retire, or not, in the second period of life. Individuals compare the welfare derived from the two scenarios, given the optimal consumption decisions taken in the first stage. By introducing (3a)-(5a) 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:

$$EU\left(e_{it} = 1\right) = \left\{ \frac{1+r_t}{1-\beta+p\beta} \left[w_{t-1}\theta_i + \frac{1-\delta}{\delta} q_{t-1} \left(\frac{p}{1+r_t} \frac{w_t D \delta \theta_i}{q_{t-1}} \right)^{\frac{1}{1-\delta}} \right] \right\}^{1-\beta+p\beta} \left(\frac{1}{1+r_t} \right)^{1-\beta} \tag{6}$$

whereas, by using (3b)-(5b), the welfare in the case of retirement is:

$$EU\left(e_{it}=0\right)=\left(1+\lambda\right)^{p}\left[\frac{1+r_t}{1-\beta+p\beta}w_{t-1}\theta_i\right]^{1-\beta+\beta p}\left(\frac{1}{1+r_t}\right)^{1-\beta}. \quad (7)$$

In the first scenario, the labor income received in the second period of life allows for a higher consumption profile. In exchange, when the individual retires, such income disappears, but utility is derived from leisure. By comparing both scenarios, the individual will be willing to participate in the labor market when old only when his utility in (7) is not lower than that in (6), that is to say, when:

$$\left[w_{t-1}\theta_i+\frac{1-\delta}{\delta}q_{t-1}\left(\frac{p}{1+r_t}\frac{w_t D\delta\theta_i}{q_{t-1}}\right)^{\frac{1}{1-\delta}}\right]^{1-\beta+p\beta}\geq\left(1+\lambda\right)^{p}\left(w_{t-1}\theta_i\right)^{1-\beta+\beta p}$$

or, equivalently, when the individual productivity exceeds the critical value

$$\theta_{i^*t}=\Omega q_{t-1}\left(\frac{w_{t-1}^{\,1-\delta}}{w_t}\frac{1+r_t}{pD\delta}\right)^{1/\delta}, \quad (8)$$

with $\Omega=\left\{\frac{\delta}{1-\delta}\left[\left(1+\lambda\right)^{\frac{p}{1-\beta+p\beta}}-1\right]\right\}^{\frac{1-\delta}{\delta}}$ being a constant related positively to the utility that individuals derive from leisure.

Workers whose productivity exceeds the critical value in (8) - with high labor earnings - obtain more utility by continuing to work in their second period of life, whereas those with a lower productivity prefer to retire. This result conforms to the bulk of the empirical evidence. For instance, using USA data, Haider and Loughran (2002) find that the labor supply of people over 65 is concentrated among the healthiest, wealthiest, and most educated individuals. Kalwij and Vermeulen (2008) also find that a higher participation rate of Europeans aged 50-64 is positively related to both health and level of education. More recently, in the latest report on active ageing by the European Commission (Special Eurobarometer 378, 2012), the level of consent to an increase in the retirement age tends to be higher among the well-educated.

We normalize the size of each new generation to 1, in such a way that every individual of each generation is identified with a different value of the subindex *i*, continuously distributed along the interval $[0,1]$. Since we also assume a uniform distribution of productivity in the range [0,1], we can identify $\theta_i=i$. Thus, active

individuals in the second period of life are those in the range (i^*,1], that is to say, 1-i^* in number. In other words, the level of activity of the elderly is given by $x = 1 - i^*$, from which we can rewrite (8) as:

$$x_t = 1 - \Omega q_{t-1} \left(\frac{w_{t-1}^{1-\delta}}{w_t} \frac{1 + r_t}{pD\delta} \right)^{1/\delta} . \tag{9}$$

2.3. Firms

Following Hashimoto and Tabata (2010), who assume that the health sector is highly labor-intensive, the production of health goods follows a linear technology:

$$Y_t^H = A^H L_t^H , \tag{10}$$

where A^H and L^H denote the labor productivity index and the amount of labor hired in the preventive (care) health sector, respectively. The wage paid in this sector equals the value of the marginal productivity of labor: $w_t^H = q_t A^H$.

The production of non-health care goods Y^N requires labor (in an amount L^N) as well as capital (*K*) in a constant returns to scale technology, represented by:

$$Y_t^N = F\left(K_t, A^N L_t^N\right), \tag{11}$$

where A^N denotes the labor productivity index of the non-health care sector. In terms of capital and output per effective unit of labor, that is to say, $k = K / (A^N L^N)$ and $y^N = Y^N / (A^N L^N)$, it can be written as $y_t^N = f\left(k_t\right)$.

Following the same authors, we assume a small open economy in which the interest rate is fixed at the world interest rate $\bar{r}$. This variable ties the capita per unit of effective labor in the non-health sector to the value $\bar{k}$ that verifies $f'(\bar{k}) = \bar{r}$ which, in turn, determines the wage per unit of effective labor in this sector as $\bar{w} = f(\bar{k}) - f'(\bar{k})\bar{k}$ and, thus, $w^N = A^N \bar{w}$. Labor mobility between sectors implies $w_t^N = w_t^H$, from which the relative price of health goods is given by:

$$q_t = q = \bar{w} \frac{A^N}{A^H} . \tag{12}$$

2.4. Labor market

The aggregate (effective) labor force in period *t*, L_t, is the sum of the supply of the young (L^y) and old (L^o) generations, that is to say:

$$L_t = L_t^y + L_t^o = \int_0^1 \theta_{i,t} di + p \int_{i_t^*}^1 \theta_{i,t}^o di, \tag{13}$$

where the first term measures the aggregate productivity of young people and the second the aggregate productivity of the (surviving) old people who decided to remain active. This labor force is shared by the health and non-health sectors: $L_t^H + L_t^N = L_t$.

2. The market equilibrium

From (9), the (constant) values of the wage, the interest rate, and the relative price of health determine the activity rate of the elderly to be (we drop the time subindex when unnecessary):

$$x = 1 - \frac{\Omega}{A^H}\left(\frac{1+\bar{r}}{pD\delta}\right)^{1/\delta}. \tag{14}$$

In order to guarantee that $x \in [0,1]$ in (14), the condition $\frac{\Omega}{A^H}\left(\frac{1+\bar{r}}{pD\delta}\right)^{1/\delta} \leq 1$ must hold. This condition leads us to define a critical value $\bar{A}^H = \Omega\left(\frac{1+\bar{r}}{pD\delta}\right)^{1/\delta}$, in such a way that some older individuals will remain in the labor market ($x>0$) in those economies where the productivity level of the health sector exceeds such threshold; otherwise, for values below that threshold, all individuals will be willing to retire when old ($x=0$). Thus, two market equilibria are possible: one is the corner solution in which all retire when old, and none demand preventive health goods; thus this sector remains inactive; the other, with workers involved in active ageing, corresponds to the interior solution in which a fraction of the population choose to invest in preventive health measures and work longer. Thus, active ageing will not only have a better response among more productive workers, will but also have a better response in those economies where the (preventive) health sector productivity is sufficiently.

Assuming there is no complete retirement among older individuals, we find other interesting insights. Equation (14) implies that the rate of those willing to remain in the

labor market is constant over time. By carrying the values of the wage, the interest rate, and the relative price of health to (5a), the health goods demanded by those who choose not to retire - those in the range (i*,1] - is given by:

$$h_i = \left(\frac{pA^H D\delta\theta_i}{1+\bar{r}} \right)^{\frac{1}{1-\delta}}, \tag{15}$$

from which the old-age productivity of any of these individuals amounts to:

$$\theta_i^o = D^{\frac{1}{1-\delta}} \left(\frac{pA^H \delta}{1+\bar{r}} \right)^{\frac{\delta}{1-\delta}} \theta_i^{\frac{1}{1-\delta}}. \tag{16}$$

Carrying this value to (13), and given that $\theta_i = i$ and $x = 1 - i^*$, the labor supply of the elderly can be rewritten, in terms of their rate of activity, as:

$$L^o = \frac{1-\delta}{2-\delta} (pD)^{\frac{1}{1-\delta}} \left(\frac{\delta A^H}{1+\bar{r}} \right)^{\frac{\delta}{1-\delta}} \left[1 - (1-x)^{\frac{2-\delta}{1-\delta}} \right]. \tag{17}$$

The uniform distribution of the productivity of younger workers determines that their effective labor supply is $L^y = 1/2$. Thus, the aggregate supply of labor amounts to:

$$L = L^y + L^o = \frac{1}{2} + \frac{1-\delta}{2-\delta} (pD)^{\frac{1}{1-\delta}} \left(\frac{\delta A^H}{1+\bar{r}} \right)^{\frac{\delta}{1-\delta}} \left[1 - (1-x)^{\frac{2-\delta}{1-\delta}} \right]. \tag{18}$$

Considering now the market clearing condition for health goods, $A^H L^H = \int_{i^*}^{1} h_i di$, and introducing (14) -(18) in this market clearing condition, we obtain:

$$L^H = \frac{\delta}{1+\bar{r}} L^o, \tag{19}$$

with L^o given by (17). Observe that the labor hired in the health sector goes hand-in-hand with the labor supplied by the older generation; thus, whatever factor positively modifies the labor supply of the elderly will also increase the labor recruited by the health sector. Moreover, since the aggregate labor supply amounts to $L = \frac{1}{2} + L^o$, the amount of labor hired by the non-health sector is:

$$L^N = L - L^H = \frac{1}{2} + \frac{1+\bar{r}-\delta}{1+\bar{r}} L^o, \tag{20}$$

indicating that labor resources in the non-health sector also increase as active ageing expands in society as a whole. It is worth emphasizing this, since it diminishes the fears of those who think that *getting old costs society too much*[5].

A different question is whether, in parallel with the phenomena of active aging, the distribution of labor between health and non-health sectors changes, or not, and, if it does, what is the direction of the shift. The fraction of labor hired by the health sector is given by:

$$\frac{L^H}{L} = \frac{\delta}{1+\bar{r}} \frac{1}{1+\frac{1}{2L^o}}.$$

It is straightforward to observe that the greater the participation of the elderly in the labor market, the larger the fraction of labor devoted to the (preventive) health sector. That is to say, the labor factor demanded by the health sector increases proportionally more than the participation of the elderly in the labor market, leading to a shift of labor from the non-health sector towards the health sector. However, this does not lead to a shortage of labor resources in the non-health sector, as equation (20) shows.

What about the output? Given (19), the output of the (preventive) health sector amounts to:

$$Y^H = A^H L^H = A^H \frac{\delta}{1+\bar{r}} L^o, \tag{21}$$

whereas the non-health sector output amounts to:

$$Y^N = A^N f(\bar{k}) L^N = A^N f(\bar{k}) \left(\frac{1}{2} + \frac{1+\bar{r}-\delta}{1+\bar{r}} L^o \right). \tag{22}$$

Therefore, the aggregate output of the economy is:

$$Y^N + qY^H = A^N f(\bar{k}) \left(\frac{1}{2} + \frac{1+\bar{r}-\delta}{1+\bar{r}} L^o \right) + \bar{w} A^N \frac{\delta}{1+\bar{r}} L^o, \tag{23}$$

[5] See the article published by Paul Krugman in the New York Times Magazine, March 9, 1997, under the title, "Does Getting Old Cost Society Too Much?"

where the health services relative price in (12) has been taken into account. From (22) and (23), the weight of the production of preventive health services in aggregate GDP is given by:

$$\frac{qY^H}{Y^N + qY^H} = \frac{1}{1 + \frac{f(\bar{k})}{\delta \bar{w}}\left(1 + \bar{r} - \delta + \frac{1+\bar{r}}{2L^o}\right)},$$

which depends positively on L^o. The greater the participation of the elderly in the labor market, the greater the weight of the health sector in the economy as a whole. Active ageing affects GDP composition toward a greater weight in the health sector, a reasonable result taking into account that active ageing requires more preventive health measure investments during the course of a life.

These effects of active ageing on total labor resources, and their reallocation among sectors, are valid only if the productivity of the preventive health sector is sufficiently high, as stated above. Moreover, it is straightforward to note from (17) that, once the threshold level has been reached, additional increases of A^H will increase the productivity of elderly individuals, or allow them to reach old age with a greater degree of functionality. Then, the extension of the working life becomes more attractive for a larger proportion of individuals, fostering demand for preventive health measures. Thus, the increase in health sector productivity, which expands the capacity of the sector to supply health services, also expands the demand for such services, and a non-controversial result is a greater output of the sector.

However, two opposite forces are at work when focusing on the labor requirements of the sector. The increase in productivity in the health sector not only increases its own output but, through its effect on the labor participation of the elderly, promotes the expansion of non-health output, although at a lower rate, increasing the relative weight of the former. Note that, if no labor re-allocation took place, an increase in the productivity of the health sector would increase its output, but would reduce proportionally its relative price. Specifically, it is the shift of labor towards the health services that leads to the shift in the GDP composition.

3. **Conclusions**

Active ageing is not just the participation of older individuals in the labor market; it is a much broader concept and more research is necessary. In this paper, we have focused on its implications for health system requirements, and the changing weight of this sector in the economy.

Health advances have brought an increase in life expectancy over the last one hundred years that has had an economic impact by increasing the labor supply, both quantitatively (people live longer, so they are available for longer in the labor market) and qualitatively (people are healthier and, thus, more productive). In developed countries, however, the quantitative has been exhausted once life expectancy exceeded the retirement age and, thus, the increase in longevity translates into an expansion of the retirement years, without significant changes in labor supply. Just this situation, and the possible financial challenge involved, has led to a debate about the convenience of delaying retirement, with the result that many countries are increasing the legal retirement age. The challenge now is not to increase life expectancy, but to extend the period of the healthy and productive life. In other words, the focus is qualitative, on a healthy life expectancy.

With the new scenario in mind, we have developed a theoretical model that takes life expectancy as given, and focuses on the incidence of investments in the health status of the elderly. From an economic point of view, this is important because health status is a significant determinant of worker productivity and has implications both at the individual and at the aggregate levels: on the one hand, it conditions retirement decisions; on the other, it involves a demand pressure on the health sector, to the detriment of alternative activities. The consideration of differences in productivity between workers introduces an additional dimension to the analysis, since it can give rise to heterogeneous individual behavior facing both retirement and health demand decisions.

Our results show clearly that individual productivity is a main determinant of the length of the active period of workers' lives. Those more productive stay longer in the labor market, whereas those with lower productivity retire sooner. The longer the active period, the greater the demand for preventive health measures, to extend the years of a healthy status. This implies that more productive individuals are not only those who remain in the labor market longer, but those who put pressure on the health services

production. We have deduced that, as the labor supply of the elderly expands, so does the demand for health services and, in parallel, the amount of labor hired by this sector. The latter conclusion has implications at an aggregate level, since it suggests a shift towards the health sector that may give rise to a labor shortage in the rest of the economy. However, we find that the greater demand for labor in the health sector, as a result of greater pressure from those who decide to prolong their working lives, can be met with the increase in labor supply both in quantity (people retire later) and in quality (they remain productive longer). Indeed, although the health sector in equilibrium incorporates a larger fraction of the labor supply, the amount of labor available in non-health activities also expands. The positive message of this theoretical analysis is that, as active ageing expands in the society as a whole, the weight of the health sector in the composition of GDP increases, without diminishing labor resources from non-health sectors.

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Highlights (maximum 85 characters, including spaces, per bullet point)

- Prolonging working life requires lifetime preventive health measures.
- High-productivity entails more involvement in preventive health and active ageing.
- Active ageing requires a minimum productivity level in the preventive health sector.
- Active ageing moves labor to health without taking resources from other sectors.