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Optimal linear taxation under endogenous longevity[1]

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Abstract

This paper studies the optimal linear tax-transfer policy in an economy where agents differ in productivity and in genetic background, and where longevity depends on health spending and genes. It is shown that, if agents internalize imperfectly the impact of genes and health spending on longevity, the utilitarian social optimum can be decentralized with type-specific redistributive lump sum transfers and Pigouvian taxes correcting for agents's myopia (leading to undersaving and underinvestment in health), and for their incapacity to perceive the effect of health spending on the resource constraint of the economy (causing overinvestment in health). The second-best problem is also examined under linear taxation instruments. Our main result is that it may be optimal to tax health spending, in particular under a complementarity of genes and health spending in the production of longevity.

Keywords: longevity, myopia, genetic background, social security, paternalism.

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1 Introduction

Although death is as universal as birth, all humans do not, obviously, have equal longevities. As this is well-known among demographers, there exist, even within a given cohort, significant differentials in the lifetime enjoyed by people. Demographic studies show that the determinants of longevity differentials can be of various kinds, some determinant being under the control of individuals, whereas others lie outside their control.

The causes of longevity differentials on which agents have some control are generally named the *behavioral* determinants of longevity, on the grounds that it is the agent, by his behavior, who affects his own health and longevity. Behavioral determinants of longevity are numerous, and consist of all aspects of individual decisions and lifestyles affecting survival. These include, among other things, eating (Bender *et al*, 1998), alcoholism (Peto *et al*, 1992), and smoking (Doll and Hill, 1950).[1] Individuals can also improve their longevity through health-improving efforts, which can take various forms.[2]

On the contrary, some causes of longevity differentials lie outside any control of individuals. Those causes can be classified in two broad groups: on the one hand, *environmental* factors, which include all external determinants of longevity on which agents, taken separately, have little control, and, on the other hand, *genetic* factors, on which agents have also no control, but which are here internal to each agent.[3]

From the point of view of economic policy, it is straightforward to see that whether longevity is taken as exogenous or is partly affected by agents' decisions and lifestyles makes a significant difference.

If longevity differentials are exogenous, the task of the policy-maker, which consists of comparing agents with different life expectancies, can be summarized as follows: all things being equal, should we compensate agents who have a relatively short life or, on the contrary, should we favor those who live long and happen to consume more over their lifetime? That question admits various answers, depending on the underlying ethical postulates. For instance, classical utilitarianism, if combined with assumptions such as additive lifetime welfare and expected utility, justifies a redistribution from

[1] Note that, in the presence of addiction, whether mortality factors like obesity, alcoholism and drug consumption are under the control of agents or not is questionable.

[2] Health-improving effort can be either temporal (e.g. physical activity, see Kaplan *et al.* 1987), physical (e.g. abstinence of food, see Solomon and Manson, 1997), or monetary (e.g. health services, see Poikolainen and Eskola, 1986).

[3] Environmental factors of longevity include the quality of lands (Kjellström, 1986), of waters (Sartor and Rondia, 1983), and of the air (Kinney and Oskanyak, 1991). Genetic diseases take various forms, such as the sickle-cell disease and the familial hypercholesterolemy (favouring hart attacks) (Soliani and Lucchetti, 2001).

short-lived agents to long-lived agents.[4]

But if longevity is behavioral, and can be fostered by, for instance, physical activity, health spending or an appropriate diet, the policy-maker cannot design policies without facing additional issues pertaining to individual responsibility and rationality. When one pays attention to responsibility, the mere fact that agents influence their longevities tends to question redistribution. For instance, in the hypothetical case where longevity would be chosen by agents, it is not obvious to see why a government should redistribute across agents according to their longevities. As far as rationality is concerned, it is obvious that the policy-maker cannot treat similarly a well-informed, fully rational choice of lifestyle and a badly-informed, myopic behavior. In the latter case, the government must correct individual myopia, and induce the behavior - and longevity - that is optimal from a lifetime perspective.

In reality, longevity differentials are neither exogenous to agents, nor chosen by agents, but are of mixed nature: external *and* behavioral. In addition, the difficulty to decompose longevity differentials into behavioral and external components tends to complexify the task of the policy-maker.

The goal of this paper is to examine the issue of the optimal taxation policy in an economy where individual longevity is influenced by factors of the two kinds mentioned above, i.e. by factors on which agents have some control, and by factors on which they have no control. For that purpose, we shall set up a two-period model, where the probability of survival from the first to the second period of life depends on a private monetary health effort (first-period health expenditures) and on an exogenous characteristic of agents (e.g. genetic background). Moreover, we shall consider a population of agents heterogeneous on two dimensions: on the one hand, their productivity, and, on the other hand, their genetic background.

In order to account for the - possibly limited - rationality of agents, we shall assume that, when being young, agents do not fully internalize the impact of their health investment on their life expectancy. Note that the reason why some individuals do not internalize in their behavior the causal link between financial efforts in the first period of their life and longevity can be either ignorance or myopia. But whatever the reason is, this lack of rationality legitimates the social planner into acting paternalistically. In fact, our individuals, myopic or ignorant, will be grateful to their government to have induced them into behaving rationally.

Throughout this paper, our normative analysis will rely on a particular ethical criterion: classical utilitarianism. It should be emphasized that

[4]See Bommier (2005) and Bommier *et al* (2007a,b) on that - somewhat controversial - corollary of classical utilitarianism.

this criterion suffers, in this particular context, from two main shortcomings. Firstly, utilitarianism, by relying on consequentialism, can hardly do justice to intuitions about individual responsibility. The utilitarian social planner will only consider agents's final *positions* (expressed in utilities, through individual consumptions and longevities), but will not care about how those positions have been achieved for some initial individual *conditions* (productivities and genes). Secondly, classical utilitarianism, by merely summing agents'utilities, is not fully satisfactory for discussing issues of life and death, as this presupposes that any life with a strictly positive - even infinitely low - level of utility is worth being lived.[5] Undoubtedly, those two shortcomings make classical utilitarianism a mere benchmark case, or, at most, a starting point for the study of optimal taxation policy under endogenous longevity.

For convenience, we shall also make here some other significant simplifications. Firstly, we shall allow for only a *single* influence of an agent on his health - a health expenditure - which is an obvious simplification given the various ways by which people can influence their longevity (e.g. physical effort, etc.). Secondly, we shall concentrate exclusively on the *quantity* of life - and leave aside any qualitative concerns - so that health spending can only affect individual welfare through its impact on longevity, but not otherwise.[6] Thirdly, we concentrate here on a *static* economy, and take the structure of heterogeneity in genes and productivities as fixed.[7]

Anticipating our main results, we show that, in this first-best (i.e. with full information and full availability of policy tools), the social optimum can be decentralized with type-specific Pigouvian taxes and redistributive lump-sum transfers. Pigouvian taxes correct for myopia – under-saving and under-investment in health – and for the fact that agents do not perceive the impact of health policy on revenue (as in Becker and Philipson, 1998). Moreover, as a consequence of utilitarianism, redistribution goes from high productivity to low productivity agents, and from short-lived to long-lived individuals. In the second-best problem, where policy instruments are limited to linear taxes and lump sum transfers, it is shown that the optimal taxes on labour income

[5] In other words, the critical utility level for existence is set to zero (see Broome, 2004).

[6] Our focus on longevity-enhancing spendings shall have important consequences when interpreting the results of this study. In reality, various health expenditures, which have little relationship with longevity, exhibit a strong redistributive dimension. But whether such expenditures should be taxed or subsidized lies outside the skope of this paper, which focuses on longevity-improving health expenditures.

[7] Thus, this study complements other papers, such as Zhang *et al* (2006) and Pestieau *et al* (2008), which analyse the optimal taxation policy in a dynamic framework, but without an explicit heterogeneity in longevity-enhancing characteristics. An exception is Ponthiere (2007), who studies lifestyle-based longevity in a dynamic model where lifestyles are transmitted vertically or obliqually across generations.

and health spending are affected by the sign and extent of the covariance between individual productivity and genetic endowment.

The rest of the paper is organized as follows. Section 2 presents the model and characterizes the laissez-faire. The social optimum and its decentralization are studied in Section 3. The second-best problem is analyzed in Section 4. Section 5 concludes.

2 The model and laissez-faire.

Let us consider a two-period model, where all agents live a first period (of length normalized to 1) with certainty, but enjoy a second period of life with a probability π.

The economy under study involves a population of agents who are heterogeneous in two characteristics: a longevity-affecting characteristic (e.g. genetic background), and productivity at work. Note that each of those characteristics can influence individual longevity: while the genetic background affects the survival probability *directly*, productivity can also, *indirectly*, lead to a higher probability of survival through its impact on private health expenditures.

Assuming the expected utility hypothesis and additive lifetime welfare, individual preferences can be represented by:[8]

$$u\left(c-v\left(l\right)\right)+\alpha\pi u\left(d\right) \tag{1}$$

where c and d denote first- and second- period consumption, l is the first period labour supply and $\alpha\pi$ is the perceived probability of survival. As usual, $u\left(.\right)$ denotes the temporal utility of consumption, with $u'\left(.\right)>0$ and $u''\left(.\right)<0$. Finally, the disutility of labour is denoted by $v\left(l\right)$. For simplicity, $v\left(l\right)$ is assumed here to have a quadratic form, $l^2/2$.

The perceived probability of survival to the second period has the following form:

$$\alpha\pi(e,\varepsilon) \tag{2}$$

where $\alpha\in[0,1]$ denotes the degree of rationality of the agent, that is, the extent to which the agent internalizes the impact of health spending e and genes ε on the probability of survival π.[9] No myopia occurs when α equals

[8] This expression presupposes no pure time preferences, as well as a utility from being dead normalized to zero.

[9] Note that this formalization of myopia is formally equivalent to assuming some pessimism of agents, in the sense that, under $\alpha<1$, the perceived probability of survival is always inferior to the actual probability. While this constitutes a simplification, that modelling of myopia has the virtue of analytical conveniency.

1, while α tending towards 0 involves a complete ignorance of the impact of e and ε on survival.[10]

The actual probability of survival π depends on individual characteristic ε (e.g. genetics) and on private health spending, e. We assume $\pi_e > 0$ and $\pi_{ee} < 0$. We assume also that $\pi_\varepsilon > 0$.

Agents of type i are characterized by w_i, their wage rate, and ε_i, their genetic endowment. The proportion of i in the total population is denoted by n_i. For further use, we write:

$$\pi_i(e_i) \equiv \pi(e_i, \varepsilon_i) \tag{3}$$

As the benchmark situation, we will assume both complementarity between efforts and genetics - so that the sign of the cross derivative $\pi_{e\varepsilon}$ is positive - and a positive correlation between genes and productivities.[11]

We now turn to the laissez-faire solution in an economy without government. We assume that individuals invest all their savings on a perfect annuity market. An agent with type i determines his optimal level of savings s_i as well as his optimal level of health expenditure e_i by solving the following problem:

$$\max u\left(c_i - l_i^2/2\right) + \alpha_i \pi_i(e_i)\, u(d_i)$$
$$\text{s.t.} \begin{cases} c_i = w_i l_i - s_i - e_i \\ d_i = s_i R_i \end{cases}$$

where R_i is the return of savings. First order conditions yield

$$l_i = w_i \tag{4}$$
$$u'(x_i) = u'(d_i)\, R_i \alpha_i \pi_i(e_i) \tag{5}$$
$$u'(x_i) = \alpha_i \pi_i'(e_i)\, u(d_i) \tag{6}$$

where $x_i = c_i - v(l_i)$ denotes the value of net consumption in period 1. We assume that the market for annuities is actuarially fair, so that

$$R_i = \frac{1}{\pi_i(e_i)}$$

where the interest rate is assumed to be zero for simplicity. Note that the return of the annuity depends on the true survival of the individual. Condition (5) defines the preferred level of savings. If the individual is perfectly

[10] That situation is quite unrealistic: in that case, agents would not invest in health.

[11] We will discuss the implications of those assumptions throughout this paper.

rational, $\alpha_i = 1$, and consumption is smoothed (i.e. $x_i = d_i$); on the contrary, for any $\alpha_i < 1$, first period consumption is preferred, as the individual underestimates his probability of survival.

Equation (6) determines the optimal level of health investment. Note that if $\alpha_i \to 0$, the agent does not invest in health and $e_i \to 0$.[12] Moreover, in the laissez-faire, the agent takes the return of the annuity as given and does not internalize the impact of health spending on the annuity return. As a consequence, the laissez-faire level of health expenditures will be shown to be higher than the optimal one.[13]

3 Optimum and decentralization

Let us now characterize the social optimum in the economy under study. For that purpose, we shall assume that the social planner is a standard classical utilitarian planner (i.e. a Benthamite planner), whose goal is the mere maximization of the sum of individual utilities. As this is well-known among normative philosophers, utilitarianism, by relying on the consequentialist postulate, constitutes an ethical basis that leaves aside issues of individual responsibility.[14] Moreover, the classical form of utilitarianism exhibits various limitations in the context of endogenous longevity (see Broome, 2004).[15] Hence, classical utilitarianism is used here as a mere benchmark case.

Throughout this section, it is assumed that the planner perfectly observes individuals' type. We also adopt a "paternalistic approach" in that the social planner corrects individuals self-control problems. In the following, we first study the centralized optimum and then how to implement it through a tax-and-transfer scheme.

[12] Assuming $\alpha_i = 0$ yields that $s_i = e_i = 0$ so that the results of this paper collapse.

[13] This imperfection was firstly highlighted by Becker and Philipson (1998). When choosing their longevity efforts, agents face a free rider problem, in the sense that each individual chooses his longevity effort *without* taking into account that his own effort affects the annuity price.

[14] A concern for responsibility implies that one pays attention, to some extent, to the relation between the initial conditions in which agents are and their final positions. Here the social planner has, as a unique objective, the maximization of the sum of utilities (which, under welfarism, are the unique relevant pieces of information for positions). That maximization problem is only constrained by survival functions and utility functions, and, thus, does not pay a specific attention to how conditions and positions are related.

[15] The difficulties raised by varying longevity include, among other things, the definition of a critical utility level for *existence*, making the addition of a new person with a life yielding that utility level neutral from a social point of view. In the following, we rely on classical utilitarianism, where that critical level is fixed to zero.

3.1 Centralized solution

We assume that a paternalistic government would like to correct for individuals myopia. Thus, the paternalistic government takes $\alpha_i = 1$ in its objective and chooses consumption paths as well as health spending in order to maximize

$$\sum n^i \left(u\left(c_i - l_i^2/2\right) + \pi_i\left(e_i\right) u\left(d_i\right)\right)$$

subject to the resource constraint of the economy

$$\sum n^i \left(c_i + e_i + \pi_i\left(e_i\right) d_i - w_i l_i\right) \leq 0 \tag{7}$$

First order conditions for this problem can be rearranged so that

$$l_i = w_i \tag{8}$$
$$u'(x_i) = u'(d_i) = \mu \tag{9}$$
$$\pi_i'\left(e_i\right) u(d_i) = \mu\left[1 + d_i \pi_i'\left(e_i\right)\right] \tag{10}$$

where μ is the Lagrange multiplier associated to the resource constraint. First order condition on labour results from the assumption of quadratic disutility of labor. Condition (9) indicates that consumption should be smoothed between periods and across individuals, i.e. $x_i = d_i = d$. This is a direct implication of both utilitarianism and of additivity across periods in individual lifetime utility.

We now rewrite condition (10) as

$$\pi_i'\left(e_i\right) = \frac{F}{1 - dF}$$

where $F = u'\left(d\right)/u\left(d\right)\ \forall i$ is a measure of risk aversion, called the "fear of ruin" (see Eeckhoudt and Pestieau, 2008). This function F measures the concavity of the utility of consumption, and it is generally assumed that dF is lower than 1. Comparing it with its laissez-faire counterpart, (6), where $\pi_i'\left(e_i\right) = F/\alpha_i$, this condition differs on two grounds. For ease of exposure, let us first assume that $\alpha_i = 1$; in that case, the first best FOC differs from the laissez-faire FOC (6) by a $1/1 - dF > 1$, which can be related to the impact of health effort on the budget set. This is the "Becker-Philipson effect": as opposed to the laissez-faire, the social planner takes into account that increasing health effort decreases consumption possibilities (through the budget constraint), so that the first best level of health effort is always lower than the laissez-faire one.[16] Thus, this first effect tends to lower the first best

[16] See Becker and Philipson (1998).

level of effort with respect to the laissez-faire. Yet, this first best expression also differs from the laissez-faire by $1/\alpha_i$. In the first best, the impact of effort on survival is fully internalized; this contributes to make the first best effort exceed its laissez-faire level. Since both effects (Becker-Philipson and myopia) go in opposite directions, whether the first best level of effort is superior or inferior to the laissez-faire one is not clear.

Note that in the first best, effort is differentiated according to genetic backgrounds, ε_i but not with respect to the degree of rationality of individuals, α_i. Assuming in a paternalistic way that $\alpha_i = 1$ for every type leads the social planner to redistribute only according to individuals genetic background and productivity (which individuals are not responsible for).

Our results on the first best allocation are summarized in the following proposition.

Proposition 1 *Assume two types of individuals with productivity and genetic characteristic* (w_i, ε_i)*. In the benchmark situation where* $w_1 < w_2$ *and* $\varepsilon_1 < \varepsilon_2$ *and where* e *and* ε *are complements, the first best allocation implies:*

(i) $x_i = d_i = d;\ i = 1, 2,$

(ii) $l_1 = w_1 < l_2 = w_2,$

(iii) $e_1 < e_2.$

Note that assuming substituability between efforts and genetics, one would obtain the opposite result that $e_i > e_j$ whenever $\varepsilon_i < \varepsilon_j$.

3.2 Decentralization

Let us now consider how the paternalistic optimum can be decentralized. In the following, we assume that the set of instruments available to the social planner include proportional taxes on earnings, τ_i, on health spending, θ_i, and on savings, σ_i, as well as lump sum transfers T_i. The annuity market is still assumed to be actuarially fair: $R_i = 1/\pi_i(e_i)$ at equilibrium.

The individual's problem is thus to maximize:

$$u\left(w_i(1-\tau_i)\,l_i - s_i(1+\sigma_i) - e_i(1+\theta_i) + T_i - l_i^2/2\right) + \alpha_i \pi_i(e_i)\, u(R_i s_i)$$

The first order conditions of the above problem are:

$$\begin{aligned} l_i &= w_i(1-\tau_i) \\ \frac{\alpha_i u'(d_i)}{u'(c_i)} &= 1+\sigma_i \qquad (11) \\ u'(c_i)(1+\theta_i) &= \alpha_i \pi_i'(e_i)\, u(d_i) \qquad (12) \end{aligned}$$

Comparing these FOCs with the first best FOCs, (8) − (10), we can calculate the values of our tax instruments. Let first assume that $\alpha_i = 1$. We have:

$$\begin{aligned} \tau_i &= \sigma_i = 0 \\ \theta_i &= \theta = \frac{dF}{1 - dF} > 0 \end{aligned}$$

If individuals are myopic, $\alpha_i < 1$, so that we keep $\tau_i = 0$, but now

$$\begin{aligned} \sigma_i &= \alpha_i - 1 < 0 \\ \theta_i &= \frac{\alpha_i - 1 + dF}{1 - dF} \lesseqgtr 0 \end{aligned}$$

Thus, under a myopia differing across individuals, the decentralization of the social optimum requires individualized Pigouvian subsidies on savings, and individualized Pigouvian taxes or subsidies on health spending. The intuition behind those results is the following. Since a myopic agent does not save enough in the laissez-faire, it is optimal to subsidize his savings ($\alpha_i - 1 < 0$), in order to encourage savings and to correct for the effect of myopia. Note that if individuals were all identically myopic (i.e. $\alpha_i = \alpha < 1$ $\forall i$), it would follow that the subsidy on savings would be equal for all agents (i.e. $\sigma_i = \sigma$ $\forall i$).

Concerning the sign of θ_i, it is straightforward to see that if $\alpha_i = 1$ (no myopia), $\theta_i = \theta$ is strictly positive, so that health spending is taxed uniformly on all agents. This is simply due to the correction of the Becker-Philipson effect: in order to reduce agents's health investment towards its optimal level, one has to tax health expenditures. On the contrary, in the presence of some myopia (i.e. if $\alpha_i < 1$), the optimal tax on health may turn into a subsidy, which is type-specific (as this depends on α_i). There exist two countervailing effects: on the one hand, a tax would be necessary to correct for the “free rider” problem, but, on the other hand, one needs a subsidy to correct for individual myopia. Depending on the strength of the two effects, the individualized tax on health spending θ_i is positive or negative.[17]

Regarding lump sum transfers T_i, let us first study the direction of tranfers in the benchmark case where productivities and genetic backgrounds are positively correlated, and where health efforts and genes are complementary inputs in the production of longevity. Thus, under those assumptions, we have two individuals 1 and 2 with positively correlated types such that $w_1 < w_2$ and $\varepsilon_1 < \varepsilon_2$, and a complementarity between ε_i and e_i in the production

[17]Note also that if $\alpha_i = \alpha < 1$ $\forall i$, it would follow that $\theta_i = \theta$ $\forall i$.

of longevity π_i $\forall i = 1, 2$. The net transfer T_i can be expressed as

$$T_i = c_i + \pi(e_i)\, d_i + e_i - w_i l_i$$

that is, total spending minus earning. We know that $d_1 = d_2 = d$, and that $c_1 - w_1^2/2 = c_2 - w_2^2/2 = d$.

Hence,

$$\begin{aligned} T_i &= \pi(e_i)\, d + d + \frac{w_1^2}{2} + e_1 - w_1^2 \\ &= d(1 + \pi(e_1)) + e_1 - \frac{w_1^2}{2} \end{aligned}$$

In the benchmark case, $T_1 \lesseqgtr T_2$ and the direction of transfers is ambiguous. If instead of complementarity we had substituability, then $\varepsilon_2 < \varepsilon_1$ and we would have unambiguously

$$T_1 = -T_2 > 0.$$

4 The linear tax problem

Having characterized the social optimum and its decentralization under a full set of policy instruments, let us now consider the problem of a social planner who has only a limited set of policy instruments available. As above, the planner faces a society of agents with different genetic characteristics ε_i and different productivities w_i. However, for simplicity, all agents are assumed, throughout this section, to be equally myopic ($\alpha_i = \alpha$).

The second-best framework studied here is characterized by the restricted availability of policy instruments, which, in addition, are not individualized.[18] Actually, our set of available instruments will here include: constant tax rates on earnings τ and (private) health expenditure θ, a first-period lump sum transfer T (i.e. a demogrant), and a flat rate pension benefit, P.

Furthermore, in order to be closer to reality - where annuity markets remain, for various reasons, underdeveloped -, we shall assume here that there exists no annuity market.[19] As this is well-known, the non-existence of annuities imply accidental bequests. For simplicity, it is assumed that those bequests are taxed at a 100 % rate.[20]

[18] In comparison with the instruments used in the decentralization section, we shall assume here that the tax on savings is not an available instrument.

[19] Equivalently, we assume that $R_i = 1$ $\forall i$. The absence of an annuity market consists of another major second best feature of the framework studied in this section.

[20] A rate below 100 % would complicate the analysis without affecting the qualitative results of this paper.

Hence, the budget constraint of the government can be written as:

$$\sum n_i (T + \pi_i (e_i) P) = \sum n_i [\tau w_i l_i + (1 - \pi_i (e_i)) s_i + \theta e_i] \tag{13}$$

Having introduced the components of our model, the problem faced by an agent of type i is the following. In the first period, the agent works, invests in health and saves for the second period. Then, in the second period, if still alive, the agent consumes his savings and the pension benefit. Thus, the problem of an agent of type i can be written as:

$$\max_{s,e,l} u\left(c_i - l_i^2/2\right) + \alpha\pi_i (e_i) u (d_i)$$
$$\text{s.to} \begin{cases} c_i + s_i + e_i (1 + \theta) \leqslant w_i l_i (1 - \tau) + T \\ d_i \leq s_i + P \end{cases}$$

We suppose a zero interest rate. If there is no liquidity constraint, the optimality conditions are

$$u'(x_i) = \alpha\pi_i (e_i) u'(d_i) \tag{14}$$
$$l_i = w_i (1 - \tau) \tag{15}$$
$$(1 + \theta) u'(x_i) = \alpha\pi_i' (e_i) u (d_i) \tag{16}$$

Expressions (14) and (16) determine the optimal levels of savings s_i and of health expenditures e_i chosen by an agent of type i. Note that for any $\alpha \in [0, 1[$, the levels of health expenditures and of savings are *lower* than if the agent were not myopic (i.e. $\alpha = 1$). Replacing the optimal level of effort e_i^* and savings s_i^*, agent i's utility function can be rewritten as:

$$u\left(\frac{w_i^2 (1 - \tau)^2}{2} + T - s_i^* - e_i^* (1 + \theta)\right) + \alpha\pi_i (e_i^*) u (s_i^* + P)$$

As mentioned above, the social planner is assumed to be of a utilitarian - but paternalistic - type. Paternalism is justified so as to correct agents' self-control problem.

In the present context, the social planner's problem can be expressed by the following Lagrangian expression:

$$\pounds = \begin{array}{c} \sum_i n_i \left[u\left(\frac{w_i^2(1-\tau)^2}{2} - s_i^* - e_i^* (1 + \theta) + T\right) + \pi_i (e_i) u (s_i^* + P)\right. \\ \left. +\mu [(1 - \pi (e_i)) s_i + \theta e_i + w_i^2 (1 - \tau) - T - \pi_i (e_i) P]\right] \end{array}$$

where μ is the multiplier associated with the budget constraint and the variable s_i^* and e_i^* are functions of policy tools through (4)-(6).

Differentiating this expression and substituting for the FOCs describing optimal savings and optimal health expenditures yields:

$$
\begin{aligned}
\frac{\partial \pounds}{\partial \tau} &= -E\left[u'(x)\, w^2\right](1-\tau) + (1-\alpha)\, E\left[\pi(e^*)\, u'(d)\, \frac{\partial s^*}{\partial \tau} + \pi'(e)\, u(d)\, \frac{\partial e^*}{\partial \tau}\right] \\
&\quad + \mu E\left[(-\pi'(e^*)(s+P)+\theta)\, \frac{\partial e^*}{\partial \tau} + w^2(1-2\tau) + (1-\pi(e^*))\, \frac{\partial s_i^*}{\partial \tau}\right] \\
\frac{\partial \pounds}{\partial \theta} &= -E\left[u'(x)\, e^*\right] + (1-\alpha)\, E\left[\pi(e^*)\, u'(d)\, \frac{\partial s^*}{\partial \theta} + \pi'(e^*)\, u(d)\, \frac{\partial e^*}{\partial \theta}\right] \\
&\quad + \mu E\left[(-\pi'(e^*)(s+P)+\theta)\, \frac{\partial e^*}{\partial \theta} + e^* + (1-\pi(e^*))\, \frac{\partial s^*}{\partial \theta}\right] \\
\frac{\partial \pounds}{\partial T} &= Eu'(x) + (1-\alpha)\, E\left[\pi(e^*)\, u'(d)\, \frac{\partial s^*}{\partial T} + \pi'(e^*)\, u(d)\, \frac{\partial e^*}{\partial T}\right] \\
&\quad + \mu E\left[(-\pi'(e^*)(s+P)+\theta)\, \frac{\partial e^*}{\partial T} + (1-\pi(e^*))\, \frac{\partial s^*}{\partial T} - 1\right] \\
\frac{\partial \pounds}{\partial P} &= E\left[\pi(e^*)\, u'(d)\right] + (1-\alpha)\, E\left[\pi(e^*)\, u'(d)\, \frac{\partial s^*}{\partial P} + \pi'(e^*)\, u(d)\, \frac{\partial e^*}{\partial P}\right] \\
&\quad + \mu E\left[(-\pi'(e)(s^*+P)+\theta)\, \frac{\partial e^*}{\partial P} + (1-\pi(e^*))\, \frac{\partial s^*}{\partial P} - \pi(e^*)\right]
\end{aligned}
$$

where we used the expectation operator $E(.)$ to simplify notations.

Setting those expressions to zero allows us to deduce the optimal values of our policy tools. Note that the transfers T and P are closely related. Hence, to keep the analysis simple, we shall study them separately, and thus consider first the optimal values of two pairs of instruments (τ, T) and (τ, P). Then, we shall study the optimal tax-transfer θ on health spending.

4.1 Payroll taxation compensated by first period demogrant

We assume here that payroll taxation funds a first period uniform benefit T.[21] Defining the compensated Lagrangian as:

$$\frac{\partial \tilde{\pounds}}{\partial \tau} = \frac{\partial \pounds}{\partial \tau} + \frac{\partial \pounds}{\partial T}\frac{dT}{d\tau}$$

[21] To simplify the presentation, we shall assume, in this subsection, that $\theta = 0$.

one obtains,

$$\begin{aligned}\frac{\partial \tilde{\pounds}}{\partial \tau} &= -cov\left(u'(x);w^2\right)(1-\tau) - \tau E u'(x) E w^2 \\ &\quad +(1-\alpha)\left[E\pi(e)u'(d)\frac{\partial \tilde{s}}{\partial \tau} + E\pi'(e)u(d)\frac{\partial \tilde{e}}{\partial \tau}\right] \\ &\quad +\mu\left[E\left(-\pi'(e)(s+P)\right)\frac{\partial \tilde{e}}{\partial \tau} + E\left(1-\pi(e)\right)\frac{\partial \tilde{s}}{\partial \tau}\right]\end{aligned}$$

Setting that expression to zero and solving yields:

$$\frac{\tau}{1-\tau} = \frac{\begin{array}{c}-cov\left(u'(x),w^2\right) + \frac{1-\alpha}{1-\tau}\left[E\pi(e)u'(d)\frac{\partial \tilde{s}}{\partial \tau} + E\pi'(e)u(d)\frac{\partial \tilde{e}}{\partial \tau}\right] \\ +\frac{\mu}{1-\tau}\left[E\left(-\pi'(e)(s+P)\right)\frac{\partial \tilde{e}}{\partial \tau} + E\left(1-\pi(e)\right)\frac{\partial \tilde{s}}{\partial \tau}\right]\end{array}}{Eu'(x)Ew^2} \tag{17}$$

Note that if $\alpha = 1$ (individuals are perfectly rational), that expression collapses to:

$$\frac{\tau}{1-\tau} = \frac{-cov\left(u'(x);w^2\right) - \frac{\mu}{1-\tau}E\left(\pi'(e)(s+P)\right)\frac{\partial \tilde{e}}{\partial \tau} + \frac{\mu}{1-\tau}E\left(1-\pi(e)\right)\frac{\partial \tilde{s}}{\partial \tau}}{Eu'(x)Ew^2} \tag{18}$$

The denominator of (18) is the standard efficiency term. It depends on the derivative of labour supply with respect to the tax. With a quadratic labour disutility and a quasi linear utility function, the derivative of the labour supply with respect to τ is $-w_i^2(1-\tau)$.

The first term in the numerator is the standard equity term and is positive since $cov\left(u'(x);w^2\right)$ is generally negative (as the level of earnings and the marginal utility of first period consumption are negatively correlated). If $u(x)$ was linear, there would be no redistributive objective and this term would cancel out.

The second term represents the negative effect of living longer on the government's revenue. A higher effort increases aggregate pensions and decreases the number of accidental bequests (which we assumed to be taxed at 100%). This effect was first highlighted by Becker and Philipson (1998): if the payroll tax combined with a lump sum transfer leads to more health expenditures ($\partial\tilde{e}/\partial\tau > 0$), then it should be lower than in the absence of such an effect.

The third term is the effect of the tax-transfer policy on the size of savings, and, thus, on the revenue generated by accidental bequests. If $\partial\tilde{s}/\partial\tau < 0$ (as we expect), the optimal tax τ should be lower under the presence of the taxation of unintended bequests than in the absence of this ($\pi(e) = 1$).

To sum up, assuming that $\partial\tilde{s}/\partial\tau < 0$ and $\partial\tilde{e}/\partial\tau > 0$, our redistributive payroll tax will be depressed by its negative revenue effect on both total pensions to be paid [i.e. $\pi(e_i)P$], and on the number and size of accidental bequests [i.e. $(1-\pi(e_i))s$].

Let us now consider the general expression (17), where the degree of rationality α differs from 1. This equation shows that having myopic agents in this framework has non trivial consequences on the level of the optimal tax rate. Actually, with $\alpha < 1$, there are now two additional Pigouvian terms in the numerator, aimed at correcting agents's myopia. Remind that an imperfect rationality makes agents under-invest in their health and under-save. Hence, if a rise in income taxation compensated by a higher T makes people save even less (i.e. $\partial\tilde{s}/\partial\tau < 0$), this does not play in favor of a larger tax rate, as this would reinforce under-saving. However, if a rise in income taxation makes agents spend more on health (i.e. $\partial\tilde{e}/\partial\tau > 0$), this contributes to correct the under-investment in health. Given that $\partial\tilde{s}/\partial\tau < 0$ calls for a lower tax and $\partial\tilde{e}/\partial\tau > 0$ for a higher tax, the overall sign of that additional term is unknown, and depends on the absolute values of $\partial\tilde{s}/\partial\tau$ and $\partial\tilde{e}/\partial\tau$, as well as on the marginal utility gains from correcting the two effects of myopia: $\pi_i(e_i)u'(d_i)$ *versus* $\pi_i'(e_i)u(d_i)$.

In interpreting our formulae, we make here a number of assumptions concerning the sign of compensated elasticities: $\partial\tilde{s}/\partial\tau < 0$ and $\partial\tilde{e}/\partial\tau > 0$, and, below, $\partial\tilde{s}/\partial\theta > 0$ and $\partial\tilde{e}/\partial\theta < 0$. With the exception of the elasticity $\partial\tilde{e}/\partial\theta$, whose negative sign seems obvious, those assumptions should be merely regarded as *a priori* plausible postulates. We would definitely need more information about utility functions to check how realistic they are. Note also that whether payroll taxation finances T or P does matter. When a payroll tax finances pension benefits, it is expected to have a depressive effect on saving. On the contrary, when it finances first period benefit, things are less clear.

Note also that we use here a particular definition of compensation that departs from the standard definition of Slutsky effects. The compensation is here aggregate and not individual. This also should incite one to caution in interpreting our compensated elasticities.

4.2 Income taxation compensated by a Beveridgian pension

Doing the same exercise as above but with the pension benefit P, we now express the optimal value for the tax rate as[22]

$$\frac{\tau}{(1-\tau)}=\frac{\left[\begin{array}{c}-cov\left(\pi\left(e^{*}\right)u'\left(d\right),w^{2}\right)+\left(1-\bar{\pi}\alpha\right)E\left[\pi\left(e^{*}\right)u'\left(d\right)w^{2}\right]\\+\frac{(1-\alpha)\bar{\pi}}{(1-\tau)}\left[E\pi\left(e^{*}\right)u'\left(d\right)\frac{\partial\tilde{s}^{*}}{\partial\tau}+E\pi'\left(e\right)u\left(d\right)\frac{\partial\tilde{e}^{*}}{\partial\tau}\right]\\+\frac{\mu\bar{\pi}}{(1-\tau)}\left[E\left(-\pi'\left(e^{*}\right)\left(s+P\right)\right)\frac{\partial\tilde{e}^{*}}{\partial\tau}+E\left(1-\pi\left(e^{*}\right)\right)\frac{\partial\tilde{s}^{*}}{\partial\tau}\right]\end{array}\right]}{E\left[\pi\left(e^{*}\right)u'\left(d\right)\right]Ew^{2}} \tag{19}$$

Under no myopia ($\alpha=1$), we have:

$$\frac{\tau}{1-\tau}=\frac{\left[\begin{array}{c}-cov\left(\pi\left(e^{*}\right)u'\left(d\right),w^{2}\right)+\left(1-\bar{\pi}\right)E\left[\pi\left(e^{*}\right)u'\left(d\right)w^{2}\right]\\+\frac{\mu\bar{\pi}}{(1-\tau)}\left[E\left(-\pi'\left(e^{*}\right)\left(s+P\right)\right)\frac{\partial\tilde{e}^{*}}{\partial\tau}+E\left(1-\pi\left(e^{*}\right)\right)\frac{\partial\tilde{s}^{*}}{\partial\tau}\right]\end{array}\right]}{E\left[\pi\left(e^{*}\right)u'\left(d\right)\right]Ew^{2}} \tag{20}$$

In comparison with (18), that is with the case of payroll taxation financing a uniform first-period benefit, there is here in (20) an additional term, which is the second term of the numerator. This term increases as $\bar{\pi}$ decreases, that is, as more private savings is 'wasted' as accidental bequests. It reflects the fact that the collective annuitization implicit in the pension scheme is much more attractive with a low $\bar{\pi}$ than with a high $\bar{\pi}$. Clearly, it represents an additional argument in favor of a positive τ.

Under the presence of myopia, there are two additional terms in the numerator of (19), which, as above, are of Pigouvian nature and aim at correcting agents's tendency to under-save and under-invest in health because of their myopia. Note that the term related to collective annuitization is also influenced negatively by α. Myopia and low survival probability have here the same effect: they both make collective annuitization more desirable.

4.3 Taxing or subsidizing longevity

Using the same approach as in the previous subsection, we now consider the optimal level of health taxation θ along with the first period demogrant T.[23]

Combining the FOCs of the planner's problem relative to θ and T, and defining the compensated Lagrangian as:

$$\frac{\partial\tilde{\pounds}}{\partial\theta}=\frac{\partial\pounds}{\partial\theta}+\frac{\partial\pounds}{\partial T}\bar{e}$$

[22] As in the previous subsection, we assume here $\theta=0$.

[23] For the ease of presentation, we now assume here that $\tau=0$.

It can be shown that the optimal tax on health expenditures has the following form:

$$\theta = \frac{\left[\begin{array}{c} -cov\left(u'\left(x\right),e\right) + \left(1-\alpha\right)E\left[\pi\left(e\right)u'\left(d\right)\frac{\partial\tilde{s}}{\partial\theta} + \pi'\left(e\right)u\left(d\right)\frac{\partial\tilde{e}}{\partial\theta}\right] \\ -\mu E\left(\pi'\left(e\right)\left(s+P\right)\right)\frac{\partial\tilde{e}}{\partial\theta} + \mu E\left(1-\pi\left(e\right)\right)\frac{\partial\tilde{s}}{\partial\theta} \end{array}\right]}{-\mu E\frac{\partial\tilde{e}}{\partial\theta}} \tag{21}$$

In the case where $\alpha = 1$, that expression collapses to:

$$\theta = \frac{-cov\left(u'\left(x\right),e\right) - \mu E\left(\pi'\left(e\right)\left(s+P\right)\right)\frac{\partial\tilde{e}}{\partial\theta} + \mu E\left(1-\pi\left(e\right)\right)\frac{\partial\tilde{s}}{\partial\theta}}{-\mu E\frac{\partial\tilde{e}}{\partial\theta}} \tag{22}$$

Let us first interpret expression (22), which concerns the case where agents are perfectly rational. To make the interpretation easy, we shall assume here that taxing health spendings reduces those spendings (i.e. $\partial\tilde{e}/\partial\theta < 0$), but favours savings (i.e. $\partial\tilde{s}/\partial\theta > 0$), which is quite plausible.

The denominator reflects the efficiency concerns and is positive when $\partial\tilde{e}/\partial\theta < 0$. In the numerator, the second and third terms are positive, and represent the impact of taxing health on government revenue through its impact on savings and on effort. As in the preceding section, taxing effort both increases the number of accidental bequests and decreases the number of pensions to be paid (second term); the last term represents the gain in revenue due to the increase in the size of accidental bequests. However, the covariance $cov\left(u'\left(x\right),e\right)$, which represents the redistributive objective, has an unclear sign. If $cov\left(u'\left(x\right),e\right) < 0$, it follows that $\theta > 0$, so that the agent faces a tax; but if $cov\left(u'\left(x\right),e\right) > 0$, $\theta \lesseqgtr 0$, and it might happen that agents benefit from a subsidy on health.

The sign of $cov\left(u'\left(x\right),e\right)$ depends on the correlation between w and ε and on the functional relation between e and ε in $\pi\left(e,\varepsilon\right)$. In the benchmark situation where w and ε are positively correlated and e and ε are complements, we can expect the covariance $cov\left(u'\left(x\right),e\right)$ to be negative: more productive agents will spend more on health, so that $u'(x)$ and e are negatively correlated. Alternatively, if we allow e and ε to close substitutes, it is possible, if $\pi(e,\varepsilon)$ exhibits decreasing returns to scale, that a higher ε makes more productive agents choose a lower effort e, so that the chosen e is here negatively correlated to w, implying that the covariance $cov\left(u'\left(x\right),e\right)$ is positive.[24]

Turning now to the general formula with $\alpha < 1$, there are two additional Pigouvian terms, which, if $\partial\tilde{e}/\partial\theta < 0$ and $\partial\tilde{s}/\partial\theta > 0$, play in opposite

[24] Take the case of 2 agents $(w_2 > w_1 > 0, \varepsilon_2 > \varepsilon_1 = 0)$ and assume $\pi\left(\varepsilon_i + e_i\right)$. Assume further that $\pi_1\left(0\right) = 0$, $\pi_1'\left(0\right) = \infty, \pi_2(\varepsilon_2) = 1$, $\pi_2'(\varepsilon_2) = 0$. One expects $e_1 > 0$ and $e_2 = 0$.

directions. If taxing effort enhances savings, $\partial\tilde{s}/\partial\theta > 0$, then the presence of myopia leading to under-saving is an additional motive for taxing health expenditures. On the contrary, if taxing efforts reduces effort (i.e. $\partial\tilde{e}/\partial\theta < 0$), then such a tax would not correct at all the myopia, but reinforce it. Hence, the overall impact of myopia on the optimal level of the tax on health spending is ambiguous.

To sum up, let us compare the tax on earnings with the tax on health expenditures under the assumptions: $cov\left(u'\left(x\right), w^2\right) < 0$, $\partial\tilde{s}/\partial\tau < 0$, $\partial\tilde{e}/\partial\tau > 0$, $\partial\tilde{s}/\partial\theta > 0$ and $\partial\tilde{e}/\partial\theta < 0$, and under $cov\left(u'\left(x\right), e\right) \gtrless 0$. If all agents are identical, that is, if there is no redistributive concern, we expect a tax on health and a subsidy on earnings. However, as soon as agents differ, we reintroduce the covariance terms, and, in the benchmark situation, we get positive taxes on earnings and on health.[25]

Note that substitutability between genetics and effort is important; but the relative importance of these two factors in the production of π matters also. To see that, let us take two extreme examples: $\pi_e = 0$ and $\pi_\varepsilon = 0$. In the first case, π is exogenous but differs across agents. Hence, in that case, $e = 0$, and tax policy is restricted to redistribution and to stimulating saving. In the second case, where genetics plays no role, most results obtained above remain true, but it becomes impossible for the $cov\left(u'\left(x\right), e\right)$ to be positive.[26]

5 Conclusions

The goal of this paper was to study the optimal tax-transfer policy in an economy where longevity depends on individual behavior when being young and on an exogenous characteristic (e.g. genetic background). For that purpose, we considered a two-period model, where the population differs in productivity and genes, and where the probability of survival to the second period depends on first-period health spending and on inherited genes.

We showed that, under Benthamite utilitarianism, the social optimum can be decentralized by means of redistributive lump sum transfers and Pigouvian taxes correcting for agents's myopia - under-saving and under-investment in health - and for their incapacity to perceive the effect of health spending on the resource constraint.

The second-best problem was studied in three stages. In a first stage

[25] If e and ε are substituables, $cov\left(u'\left(x\right), e\right) > 0$, and we have a positive or a negative tax on health.

[26] Clearly, if only effort can enhance longevity, more productive agents do not spend less on health than less productive agent, as there exists, under $\pi_\varepsilon = 0$, no way to 'compensate' low health effort in longevity terms.

devoted to the optimal income taxation compensated by first-period lump sum transfer, it was shown that the redistributive motive supporting income taxation tends to be depressed by its negative revenue effect on both total pensions to be paid and on the amount of accidental bequests. Moreover, myopia has here an ambiguous effect on the optimal tax level, as a rise in income tax may well raise the (too low) health expenditures, but may also lower the (already too low) savings even more. The second stage, devoted to optimal income taxation compensated by second-period pension, allowed us to identify an additional determinant of optimal income tax, reflecting the fact that the collective annuitization implicit in the pension scheme is more attractive with a low average longevity than with a high average longevity. Finally, it was shown that the optimal tax on health spending depends on the covariance between the marginal utility of consumption and health spending, and, thus, on the complementarity between genes and effort in the production of longevity, on their importance as inputs in that production process, as well as on the correlation between genetic background and productivity.

In sum, our tax policy analysis reveals the crucial role played by determinants that are usually absent in the context of economies with fixed longevities: the roles of genes and effort (and their interactions) in the production of longevity, and the correlation between genetic background and productivity. Given the imperfect knowledge of those crucial pieces of information, it cannot be overemphasized that this study gives us only a - purely theoretical - clue regarding the design of the optimal taxation policy in the environment under study.

Moreover, even on the theoretical side, this study suffers from several weaknesses, which invite further research and, at least, much caution. First, on the ethical side, this study relied on the standard utilitarian approach, which should only be regarded as a first approximation in the context of endogenous longevity. Second, when considering the second-best problem, we assumed that all agents are equally myopic, which is a strong assumption, as we may expect more productive agents to be also more informed on the survival function. Third, this study focused on a static economy with a fixed heterogeneity, whereas the heterogeneity of the population is likely to evolve over time. Given that the social planner would like to internalize the 'composition effects' of agents' decisions on the composition of future cohorts, the optimal long-run policy may depend on the dynamics of transmission of genes and productivities, and might thus differ from the optimal policy under a fixed partition.

Those few remarks suffice to show that much work remains to be done, in the future, to have a better idea of the optimal fiscal policy in an economy where longevity is influenced by factors on which agents have some control, and by factors on which they have no control at all.

To conclude, one might find shocking the likely conclusion that health spendings should be taxed and not subsidized. This is at odds with the usual recommendation that health care should be subsidized for various reasons: redistribution, paternalism, externalities, etc. Nonetheless, this result can be explained by the fact that here most redistribution is implemented by the income taxation. Moreover, it should be kept in mind that health expenditures are, in our model, pure longevity-enhancing spendings, which affect welfare *only through* increasing the length of life, while leaving the quality of each period lived unchanged. Undoubtedly, this restriction leaves aside various motives for subsidizing health care.

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