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Journal of Population Economics
Journal of the European Society for Population Economics (ESPE)

ISSN 0933-1433
Volume 24
Number 1

J Popul Econ (2010)
24:213-237
DOI 10.1007/s00148-010-0304-1


Journal of
Population Economics

Volume 24 · Number 1 · January 2011

Springer

Springer

J Popul Econ (2011) 24:213–237
DOI 10.1007/s00148-010-0304-1

ORIGINAL PAPER

Optimal linear taxation under endogenous longevity

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Received: 12 September 2008 / Accepted: 10 December 2009 /
Published online: 21 January 2010

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. If agents internalize imperfectly the impact of health spending on longevity, the utilitarian optimum can be decentralized with type-specific lump-sum transfers and Pigouvian taxes correcting for agents' myopia and for their misperception of health spending's effects on the economy's resources. The second-best problem is examined under linear taxation instruments. It may be optimal to tax health spending, especially under complementarity of genes and health spending in the production of longevity.

Keywords Longevity · Myopia · Taxation

JEL Classification H21 · I12 · I18

Responsible editor: Junsen Zhang

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1 Introduction

Although death is as universal as birth, all humans do not, obviously, have equal longevities. As it is shown by demographers, members of the same cohort can have lives of varying length, some individuals living longer than others. That empirical fact is illustrated on Fig. 1, which shows the distribution of the age at death for Swedish women born in 1900.[1] In the light of that distribution, it appears clearly that there exist significant longevity inequalities even *within* a given cohort.[2]

Regarding the causes of those inequalities, demographic studies stressed that some determinants of longevity differentials are under the control of individuals, whereas other determinants 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).[3] Agents can also improve their longevity through health-improving efforts, which take various forms, including health spending.[4] Whereas demographic studies do not generally examine the impact of health spending on longevity differentials, a brief look at the relationship between health spending and life expectancy across countries reveals that there exists a positive, but declining relationship between health expenditures and longevity prospects (see Fig. 2).[5] Hence, longevity differentials are also likely to be due to distinct levels of health spending.

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.[6] Although those external factors are

[1]Sources: The Human Mortality Database (2009).

[2]Note that longevity differentials are not here due to a selective involvement in wars: Swedish women born in 1900 did not experience any world wars.

[3]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.

[4]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 Escola 1986).

[5]Data: World Health Organization Statistical Information System (2009). The sample includes 193 countries.

[6]Environmental factors of longevity include the quality of lands (Kjellström 1986), of waters (Sartor and Rodia 1983), and of the air (Kinney and Ozkanyak 1991). Genetic diseases take various forms, such as the sickle-cell disease and the familial hypercholesterolemy (favoring heart attacks; Soliani and Lucchetti 2001).

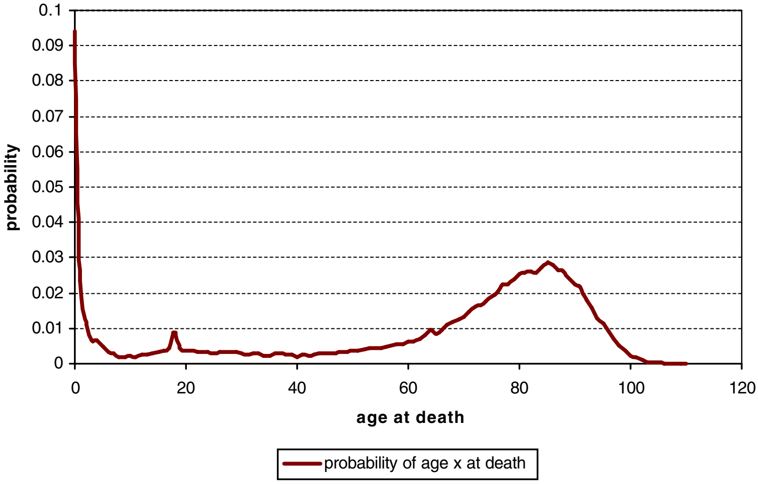

Fig. 1 Distribution of the age at death: Swedish female 1900 birth cohort

sometimes underestimated, a recent survey by Christensen et al. (2006) argues, on the basis of several studies, that genetic factors account for not less than a quarter of the variance in adult human lifespan and are thus a major source of longevity differentials. That result was derived from the comparison of longevity prospects of twins of the two kinds: monozygotic (sharing same genetic background) and dizygotic (having different genetic backgrounds). As illustrated on Fig. 3, taken from Christensen et al. (2006, p. 440), the variance

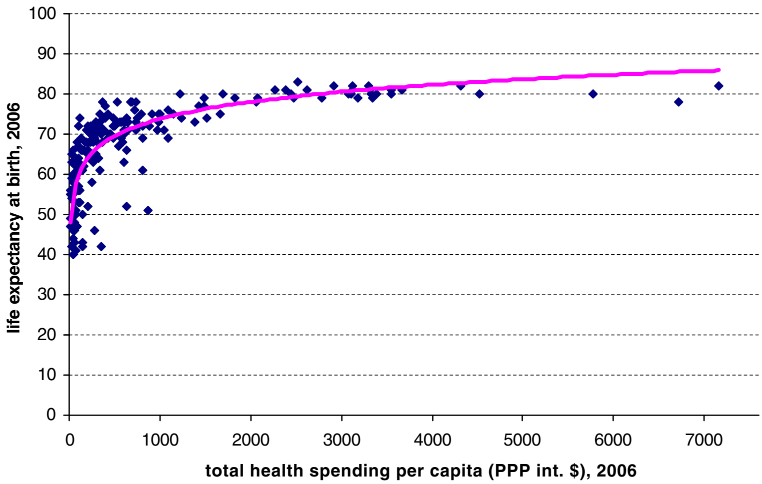

Fig. 2 Health spending and life expectancy, 2006

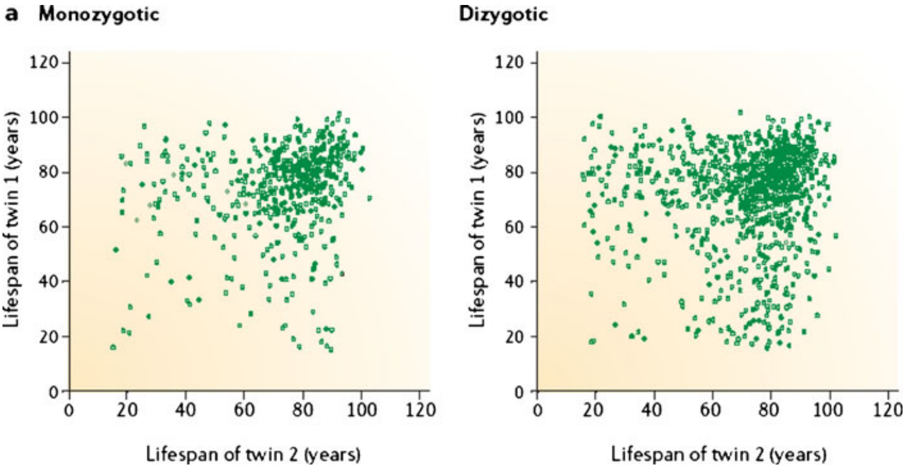

Fig. 3 Comparison of lifetimes of monozygotic and dizygotic twins

of lifespan is much reduced among monozygotic twins, revealing the role of genetic background as a source of longevity differentials.[7]

Having given some empirical clues regarding the diverse causes of longevity differentials, it should be stressed that, from the point of view of economic policy, 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 consists in comparing agents with different life expectancies: All things being equal, should we compensate agents who have a shorter 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 short-lived agents to long-lived agents.[8]

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

[7]That picture comes from the study of Herskind et al. (1996), which relies on a sample of 2,872 Danish twin pairs born between 1870 and 1900.

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

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 study 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 who are heterogeneous on two dimensions affecting survival prospects: 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.[9] 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 precise 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.[10]

Throughout this paper, our normative analysis will rely on a particular ethical criterion: classical utilitarianism. It should be stressed that 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' 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 period with a strictly positive—even infinitely low—level of utility

[9]That assumption is supported by the large empirical literature on limited rationality in the context of health-affecting behavior (see O'Donoghe and Rabbin 2000). In particular, the widespread feeling of invulnerability of young people shown by Quadrel et al. (1993) can be regarded as some myopia, i.e., an ignorance of the effects of one's actions.

[10]Note that we are not dealing here with the idea that individuals might rationally adopt a high rate of discount. In that case, government's intervention is highly questionable and has been labeled "old paternalism".

is worth being lived.[11] 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.[12] Thirdly, we concentrate here on a *static* economy and take the structure of heterogeneity in genes and productivities as fixed.[13]

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—undersaving and underinvestment 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 labor income 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

[11] Thus, the critical utility level for continuing existence is set to zero (see Broome 2004).

[12] Our focus on longevity-enhancing spending has important consequences when interpreting the results of this study. In reality, various health spending, which have little relationship with longevity, exhibit a strong redistributive dimension, or affect the quality of life periods or productivity. Whether such spending should be subsidized lies outside the scope of this paper, which focuses on longevity-improving spending.

[13] Thus, this study complements other papers, such as Zhang et al. (2006) and Pestieau et al. (2008), which analyze the optimal taxation policy in a dynamic framework, but without an explicit heterogeneity in longevity-enhancing characteristics. An exception is Ponthiere (2010), who studies lifestyle-based longevity in a dynamic model where lifestyles are transmitted vertically or obliqually across generations.

probability π. The economy under study involves a population of agents who are heterogeneous in three characteristics:

- A longevity-affecting characteristic (e.g., genes), denoted by ε_i
- A productivity at work, denoted by w_i
- A degree of rationality, denoted by α_i, reflecting the agent's knowledge of the survival process

Note that each of those characteristics can influence individual longevity: While the genetic background affects the survival probability *directly*, productivity and farsightedness can also, *indirectly*, affect the probability of survival, through their impact on the private health expenditures chosen by the agent.

In this section, we shall, for simplicity, describe the laissez-faire in general terms, i.e., by considering the decisions made by an agent of type i, who exhibits particular characteristics ε_i, w_i, and α_i, and examine how those characteristics affect his decisions and longevity prospects. The proportion of agents of type i in the total population will be denoted by n_i.

Assuming the expected utility hypothesis and additive lifetime welfare, individual preferences of an agent of type i can be represented by:[14]

$$u\left(c_i - v\left(l_i\right)\right) + \alpha_i \pi_i u\left(d_i\right) \tag{1}$$

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

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

$$\alpha_i \pi\left(e_i, \varepsilon_i\right) \tag{2}$$

where $\alpha_i \in \left]0, 1\right]$ denotes the degree of rationality of the agent, that is, the extent to which the agent internalizes the impact of health spending e_i and genes ε_i on the probability of survival π.[15] No myopia occurs when α_i equals 1, while α_i tending toward 0 involves a complete ignorance of the impact of e_i and ε_i on survival, so that agents would not invest in their health at all, which is a quite unrealistic case.

The actual probability of survival π depends on individual characteristic ε_i and on private health spending e_i. We assume $\pi_e > 0$ and $\pi_{ee} < 0$. We assume also that $\pi_\varepsilon > 0$. For further use, we write:

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

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

[15] 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 modeling of myopia has the virtue of analytical conveniency.

As the benchmark situation, we will assume both complementarity between health spending and genetics—so that the sign of the cross derivative $\pi_{e\varepsilon}$ is positive—and a positive correlation between genes and productivities.[16]

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, which yields an actuarially fair return for each risk class.[17] An agent with type i chooses his optimal level of savings s_i as well as his optimal level of health spending e_i by solving the following problem:

$$\max u\left(c_i - l_i^2/2\right) + \alpha_i \pi_i\left(e_i\right) u\left(d_i\right)$$

$$\text{s.t.} \begin{cases} c_i = w_i l_i - s_i - e_i \\ d_i = s_i R_i \end{cases}$$

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

$$l_i = w_i \tag{4}$$

$$u'\left(x_i\right) = u'\left(d_i\right) R_i \alpha_i \pi_i\left(e_i\right) \tag{5}$$

$$u'\left(x_i\right) = \alpha_i \pi_i'\left(e_i\right) u\left(d_i\right) \tag{6}$$

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

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

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.

As shown by expression 4, labor supply decisions are here independent from survival prospects: Due to the quasilinearity of utility, there is no income effect at work for the choice of labor, so that agents' labor supply does not depend on what their survival prospects are.

Condition 5 defines the preferred level of savings. If the agent is perfectly 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. Note that we focus here on the interior solution, that is, on the case where agents choose, despite their myopia, a strictly positive level of savings (and of health expenditure). This solution holds for reasonably low levels of myopia (i.e., sufficiently large levels of α_i). On the contrary, under a large myopia or under a full myopia (i.e., $\alpha_i = 0$), the first-order condition with respect to s_i would be negative and there would be no interior solution for optimal savings (i.e., $s_i = 0$).

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

[17] The assumption of a perfect annuity market, which is rather strong, is made here for analytical convenience. Actually, this study would like to abstract from tractability difficulties raised by accidental bequests, which are examined by Cremer et al. (2007). Assuming a perfect annuity market for each risk class is one way to avoid those difficulties. Another way consists in assuming that the government taxes entirely the savings of the dead (see Section 4).

Equation 6 determines the optimal level of health investment. Note that if α_i tends toward 0, the agent does not invest in health and e_i tends toward 0. 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 spending will be shown to be higher than the optimal one. This imperfection was firstly highlighted by Becker and Philipson (1998). When choosing their health spending, agents face a free rider problem in the sense that each agent chooses his health investment *without* taking into account that this reduces the annuity price. This leads to an excessive level of health spending.

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.[18] Moreover, the classical form of utilitarianism exhibits various limitations in the context of endogenous longevity (see Broome 2004).[19] 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 the sense 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.

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

[18] 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.

[19] The difficulties raised by varying longevity include, among other things, the definition of a critical utility level for *continuing existence*, making the addition of a new life-period yielding that utility level neutral. In the following, we rely on classical utilitarianism, where that critical level is fixed to zero.

function 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 labor (Eq. 8) 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, Eq. 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 (Eq. 6) by a factor $1/1 - dF > 1$, which can be related to the impact of health spending 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 spending decreases consumption possibilities, so that the first-best level of health spending is always lower than the laissez-faire one. Thus, this first effect tends to lower the first-best level of e_i 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 health spending on survival is fully internalized. This contributes to make the first-best health spending exceed its laissez-faire level. Since both effects (Becker–Philipson and myopia) go in opposite directions, whether the first-best level of health spending is superior or inferior to the laissez-faire one is not clear.

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

The differentiated treatment of agents in terms of health spending due to the differences in genetic background takes a form that depends on whether genes and health spending are complements or substitutes in the survival function. Under complementarity, the agents advantaged by nature receive more health spending: Making use of $\pi_i'(e_i) = F/1 - dF$, one obtains that $e_1 < e_2$ whenever $\varepsilon_1 < \varepsilon_2$. On the contrary, under substitutability between health spending and genes, one would obtain the opposite result (i.e., $e_1 > e_2$ whenever $\varepsilon_1 < \varepsilon_2$). Finally, we would have an equality of health spending under no genetic differences (i.e., $\varepsilon_1 = \varepsilon_2$). Thus the existence of differences in genetic backgrounds plays a crucial role, together with the assumptions on the survival function, as determinants of the social optimum. Our results are summarized in the proposition below.

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_i *and* ε_i *are complements, the first-best allocation implies:*

(a) $x_i = d_i = d$; $i = 1, 2$
(b) $l_1 = w_1 < l_2 = w_2$
(c) $e_1 < e_2$

Before studying how that social optimum can be decentralized, it should be stressed here that the optimum characterized in Proposition 1 reflects the two central features of classical utilitarianism mentioned above.

First, the *consequentialist* nature of utilitarianism: The social planner cares here only about the outcomes and not about the means by which these are reached. This has the corollary that the utilitarian planning problem can hardly do justice to intuitions about individual responsibility, which require to investigate how means and ends are related. For instance, one may require that, given that agents are not responsible for genetic differentials, agents with an equal productivity should be treated equally. But this is not the case at all under utilitarianism, as we still have $e_1 < e_2$ even under $w_1 = w_2$. Thus, given that the social planner does not look at the problem in terms of relation between the initial conditions and the final positions of agents, little attention can be paid to responsibility.

Second, the above optimum, derived from classical utilitarianism, presupposes that the *critical utility level* for continuing existence is *zero*, so that any life period with a strictly positive utility level is worth being lived, whatever the utility assigned to it is. That assumption is far from neutral as far as the definition of the social optimum is concerned. To see this, let us suppose that only a life period with a utility level higher than a critical level $\bar{u}$ is worth being lived. Suppose now that the agents under study have an especially low level of productivity w_i, so that the utility of each period of life is below the critical level $\bar{u}$. Then, in that case, it is socially optimal to have no health spending: $e_1 = e_2 = 0$, in order to avoid the (welfare-reducing) survival of agents to the second period. Hence, the assumption $\bar{u} = 0$ under classical utilitarianism allows us to avoid such a corner solution.

Those remarks suggest that the classical utilitarian social optimum relies on some simplifying assumptions, which do not allow us to do justice to intuitions about responsibility or about a life period "not worth being lived". However, we shall, for simplicity, focus, in the rest of the paper, on the social optimum as described in Proposition 1.

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 includes 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 the equilibrium.

The agent's problem is thus to maximize:

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

The first-order conditions of that problem are:

$$l_i = w_i(1-\tau_i) \tag{11}$$

$$\frac{\alpha_i u'(d_i)}{u'(c_i)} = 1 + \sigma_i \tag{12}$$

$$u'(c_i)(1+\theta_i) = \alpha_i\pi_i'(e_i)u(d_i) \tag{13}$$

Comparing these FOCs with the first-best FOCs, Eqs. 8, 9, and 10, we can calculate the values of our tax instruments.

Let first assume that $\alpha_i = 1$. We have:

$$\tau_i = \sigma_i = 0$$

$$\theta_i = \theta = \frac{dF}{1-dF} > 0$$

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

$$\sigma_i = \alpha_i - 1 < 0$$

$$\theta_i = \frac{\alpha_i - 1 + dF}{1-dF} \lesseqgtr 0$$

Thus, under a myopia differing across agents, the decentralization of the social optimum requires individualized Pigouvian subsidies σ_i on savings and individualized Pigouvian taxes or subsidies θ_i on health spending.

The intuition behind those results is the following: Regarding the sign of σ_i, the justification for a subsidy on savings is straightforward: Since myopic agents do not save enough in the laissez-faire, it is optimal to subsidize their savings ($\alpha_i - 1 < 0$), in order to encourage savings and to correct for the effect of myopia. Note also that, if agents were all identically myopic (i.e., $\alpha_i = \alpha < 1$ $\forall i$), 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 across all agents. This is simply due to the correction of the Becker–Philipson effect: In order to reduce agents' health investment toward 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.[20]

Regarding lump-sum transfers T_i, let us first study the direction of transfers in the benchmark case where productivities and genetic backgrounds are positively correlated and where health spending and genes are complementary inputs in the production of longevity. Thus, under those assumptions, we have two (equal-sized) groups of agents, denoted by 1 and 2, whose characteristics are positively correlated, $w_1 < w_2$ and $\varepsilon_1 < \varepsilon_2$, and a complementarity between ε_i and e_i in the production of longevity π_i $\forall i = 1, 2$.

In that case, the net transfer can be expressed as

$$T_i - \theta_i e_i = c_i + \pi_i (e_i) d_i + e_i - w_i l_i$$

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,

$$\begin{aligned} T_i - \theta_i e_i &= d + \frac{w_i^2}{2} + \pi_i (e_i) d + e_i - w_i^2 \\ &= d (1 + \pi_i (e_i)) + e_i - \frac{w_i^2}{2} \end{aligned}$$

Thus, in the benchmark case, the direction of transfers is ambiguous. However, if the wage gap is very small (large) with respect to the genetic gap, one has $T_2 - \theta_2 e_2 >$ (resp. $<$) $T_1 - \theta_1 e_1$.

Note that, if, instead of complementarity, we had substitutability of genes ε_i and health spending e_i, we would also have an ambiguous sign of transfers, depending, among other things, on the shape of the survival function $\pi_i (e_i)$. In sum, the direction of transfers (whether an agent is net beneficiary or net recipient) cannot be identified analytically.

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

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

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 ($\alpha_i = \alpha > 0$).

The second-best framework studied here is characterized by the restricted availability of policy instruments. We assume away individualized transfers or taxes and we posit that there is no way in which saving can be taxed. Specifically, our set of 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.[21] As this is well-known, the nonexistence of annuities imply accidental bequests. For simplicity, it is assumed that those bequests are taxed at a 100% rate.[22]

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

$$\sum n_i \left(T + \pi_i\left(e_i\right) P\right) = \sum n_i \left[\tau w_i l_i + \left(1 - \pi_i\left(e_i\right)\right) s_i + \theta e_i\right] \tag{14}$$

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.[23] 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:

$$\max_{s_i, e_i, l_i} u\left(c_i - l_i^2/2\right) + \alpha\pi_i\left(e_i\right) u\left(d_i\right)$$

$$\text{s.to} \begin{cases} c_i + s_i + e_i\left(1+\theta\right) \leqslant w_i l_i \left(1-\tau\right) + T \\ d_i \leq s_i + P \end{cases}$$

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

$$u'\left(x_i\right) = \alpha\pi_i\left(e_i\right) u'\left(d_i\right) \tag{15}$$

$$l_i = w_i\left(1-\tau\right) \tag{16}$$

$$\left(1+\theta\right) u'\left(x_i\right) = \alpha\pi_i'\left(e_i\right) u\left(d_i\right) \tag{17}$$

[21] 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.

[22] A rate below 100% would complicate the analysis significantly, as some agents would benefit from unintended bequests. This would be, to some extent, close to the assumption of imperfect annuity markets, discussed in Cremer et al. (2007). For simplicity, we shall abstract here from those difficulties by assuming full taxation of the saving of dead agents.

[23] It is also assumed, for simplicity, that agents cannot borrow with public pensions as collateral.

Expressions 15 and 17 determine the optimal levels of savings s_i and of health expenditures e_i chosen by an agent of type i.[24] Note that for any $\alpha \in]0,1[$, the levels of health expenditures and of savings are *lower* than if the agent was not myopic (i.e., $\alpha = 1$). Replacing the optimal level of health spending e_i^* and savings s_i^*, agent i's utility function can be rewritten as:

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

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, i.e., agents' myopia.

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

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

where μ is the multiplier associated with the budget constraint and the variable s_i^* and e_i^* are functions of policy tools through Eqs. 15–17.

Differentiating this expression and substituting for the FOCs pertaining to optimal savings and optimal health expenditures yield:

$$\frac{\partial \pounds}{\partial \tau} = -E\left[u'\left(x^*\right)w^2\right](1-\tau) + (1-\alpha)E\left[\pi\left(e^*\right)u'\left(d^*\right)\frac{\partial s^*}{\partial \tau} + \pi'\left(e^*\right)u\left(d^*\right)\frac{\partial e^*}{\partial \tau}\right]$$
$$+\mu E\left[\left(-\pi'\left(e^*\right)\left(s^* + P\right) + \theta\right)\frac{\partial e^*}{\partial \tau} + w^2(1-2\tau) + \left(1-\pi\left(e^*\right)\right)\frac{\partial s^*}{\partial \tau}\right] \tag{18}$$

$$\frac{\partial \pounds}{\partial \theta} = -E\left[u'\left(x^*\right)e^*\right] + (1-\alpha)E\left[\pi\left(e^*\right)u'\left(d^*\right)\frac{\partial s^*}{\partial \theta} + \pi'\left(e^*\right)u\left(d^*\right)\frac{\partial e^*}{\partial \theta}\right]$$
$$+\mu E\left[\left(-\pi'\left(e^*\right)\left(s^* + P\right) + \theta\right)\frac{\partial e^*}{\partial \theta} + e^* + \left(1-\pi\left(e^*\right)\right)\frac{\partial s^*}{\partial \theta}\right] \tag{19}$$

[24] Here again, we assume, for simplicity, that an interior solution exists. See Andersen and Bhattacharya (2008) on the savings of myopic agents under a PAYG system.

$$\frac{\partial \pounds}{\partial T} = Eu'\left(x^*\right) + (1-\alpha)\, E\left[\pi\left(e^*\right) u'\left(d^*\right)\frac{\partial s^*}{\partial T} + \pi'\left(e^*\right) u\left(d^*\right)\frac{\partial e^*}{\partial T}\right]$$

$$+\mu E\left[\left(-\pi'\left(e^*\right)\left(s^* + P\right) + \theta\right)\frac{\partial e^*}{\partial T} + \left(1-\pi\left(e^*\right)\right)\frac{\partial s^*}{\partial T} - 1\right] \quad (20)$$

$$\frac{\partial \pounds}{\partial P} = E\left[\pi\left(e^*\right) u'\left(d^*\right)\right] + (1-\alpha)\, E\left[\pi\left(e^*\right) u'\left(d^*\right)\frac{\partial s^*}{\partial P} + \pi'\left(e^*\right) u\left(d^*\right)\frac{\partial e^*}{\partial P}\right]$$

$$+\mu E\left[\left(-\pi'\left(e^*\right)\left(s^* + P\right) + \theta\right)\frac{\partial e^*}{\partial P} + \left(1-\pi\left(e^*\right)\right)\frac{\partial s^*}{\partial P} - \pi\left(e^*\right)\right] \quad (21)$$

where we used the expectation operator $E(.)$ to simplify notations. Throughout this paper, we consider interior solutions only, so that the above expressions are all set equal to zero.

Those optimality conditions allow us to characterize the optimal values of our policy tools τ, θ, T, and P. Note, however, that the simultaneous study of the optimal levels of the four taxation instruments would be quite laborious, as their values are all related to each others through the government's budget constraint. Hence, to keep the analysis simple, we shall proceed in three successive stages. Given that the transfers T and P are closely related, it makes sense, for conveniency, to study those policy instruments separately and thus consider first the optimal values of the two pairs of instruments (τ, T) and (τ, P). Then in a third stage, we shall study the optimal tax transfer θ on health spending.

4.1 Payroll taxation compensated by first-period demogrant

Regarding the definition of the optimal payroll tax τ, it should be stressed that the FOC (Eq. 18) of the previous section does not allow us, on its own, to characterize the optimal level of τ, as a rise in τ must necessarily, under the government's budget constraint, imply a change in some other fiscal instruments, so that other FOCs must be considered too. In this subsection, we shall assume, as a starting point, that payroll taxation funds a first-period uniform benefit T and derive the optimal level of τ under that assumption.[25]

In order to characterize the optimal level of the payroll tax rate τ on the basis of the conditions derived in the previous section, we will use here a compensated Lagrangian expression, whose derivative with respect to the policy instrument τ gives us the effect of a variation of τ on the Lagrangian when that change is compensated by a variation of the demogrant T that keeps the aggregate households' budget constraint unchanged.

[25] To simplify the presentation, we shall assume, in this section that $\theta = P = 0$, so that changes in τ affect the demogrant T only.

Using the preceding first-order conditions 18 and 20 and reminding that, in the optimum, they are equal to zero, we obtain, as a necessary condition, that

$$\frac{\partial \tilde{\pounds}}{\partial \tau} = \frac{\partial \pounds}{\partial \tau} + \frac{\partial \pounds}{\partial T}\frac{\partial T}{\partial \tau} = 0$$

where $\tilde{\pounds}$ denotes the compensated Lagrangian and where $\partial T/\partial \tau = (1-\tau)\, Ew^2$ is computed from the aggregate households' budget constraint.[26] This approach is quite standard in public economics; it allows us to obtain tax formulas in terms of compensated tax derivatives in the Ramsey tradition.[27] Substituting for the different terms, the above condition can be rewritten as[28]

$$\begin{aligned}\frac{\partial \tilde{\pounds}}{\partial \tau} &= -cov\left(u'(x), w^2\right)(1-\tau) - \tau\, Eu'(x)\, Ew^2 \\ &\quad + (1-\alpha)\left[E\pi(e)\, u'(d)\frac{\partial \tilde{s}}{\partial \tau} + E\pi'(e)\, u(d)\frac{\partial \tilde{e}}{\partial \tau}\right] \\ &\quad + \mu\left[E\left(-\pi'(e)\, s\right)\frac{\partial \tilde{e}}{\partial \tau} + E\left(1-\pi(e)\right)\frac{\partial \tilde{s}}{\partial \tau}\right] = 0\end{aligned}$$

where $\partial \tilde{s}/\partial \tau = \partial s/\partial \tau + \partial s/\partial T \times (1-\tau)\, Ew^2$ and $\partial \tilde{e}/\partial \tau = \partial e/\partial \tau + \partial e/\partial T \times (1-\tau)\, Ew^2$ are the compensated tax derivatives of s and e. Note that we use here the concept of average compensation and not that of the standard Slutsky term, as the latter includes the individual and not the aggregate compensation. Denoting the real substitution effect by a superscript ^, we write the standard Slutsky effect of τ on e_i as

$$\frac{\partial \hat{e}_i}{\partial \tau} = \frac{\partial e_i}{\partial \tau} + \frac{\partial e_i}{\partial T}(1-\tau)\, w_i^2 = \frac{\partial \tilde{e}_i}{\partial \tau} + \frac{\partial e_i}{\partial T}\left[w_i^2 - Ew^2\right](1-\tau)$$

The two concepts differ for individuals with extreme (low or high) rates of wage. Solving the above equality, $\partial \tilde{\pounds}/\partial \tau = 0$, yields:[29]

$$\frac{\tau}{1-\tau} = \frac{\begin{array}{c}-cov\left(u'(x), w^2\right) + \frac{1-\alpha}{1-\tau}\left[E\pi(e)\, u'(d)\frac{\partial \tilde{s}}{\partial \tau} + E\pi'(e)\, u(d)\frac{\partial \tilde{e}}{\partial \tau}\right] \\ + \frac{\mu}{1-\tau}\left[E\left(-\pi'(e)\, s\right)\frac{\partial \tilde{e}}{\partial \tau} + E\left(1-\pi(e)\right)\frac{\partial \tilde{s}}{\partial \tau}\right]\end{array}}{\mu\, Ew^2} \qquad (22)$$

[26]Total differentiation of the aggregate households' budget constraint $\frac{(1-\tau)^2 Ew^2}{2} + T = 0$ leads to $(1-\tau)\, Ew^2 d\tau = dT$.

[27]On that technique, see Cremer et al. (2008). There are other ways to combine the first-order conditions. One way allows to get rid of the multiplier μ, but the expression obtained by following that alternative approach would have a more difficult interpretation.

[28]For conveniency, we shall here delete the * superscripts, but we remain at the optimum.

[29]Note that τ appears both on the LHS and on the RHS of expression 22, so that Eq. 22 consists merely of an implicit definition of the optimal τ . Moreover, the LHS is increasing in τ.

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

$$\frac{\tau}{1-\tau} = \frac{-cov\left(u'(x), w^2\right) - \frac{\mu}{1-\tau} E\left(\pi'(e)\, s\right) \frac{\partial \tilde{e}}{\partial \tau} + \frac{\mu}{1-\tau} E\left(1 - \pi(e)\right) \frac{\partial \tilde{s}}{\partial \tau}}{\mu E w^2} \tag{23}$$

The denominator of Eq. 23 is the standard efficiency term. It depends on the derivative of labor supply with respect to the tax. With a quadratic labor disutility and a quasilinear utility function, the derivative of the labor 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 negative (as the level of earnings and the marginal utility of first-period consumption are negatively correlated). If $u(x)$ were 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 health spending decreases the number of accidental bequests (which we assumed to be taxed at 100%). This effect coincides with the effect that 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 this tax should, in the presence of the Becker–Philipson effect, 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 it ($\pi(e) = 1$).

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 the number and the size of accidental bequests (i.e., $(1 - \pi(e_i))\, s$).

Let us now consider the general expression 22, where the degree of rationality α differs from 1. This equation shows that having myopic agents in this framework has nontrivial 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' myopia. Remind that an imperfect rationality makes agents underinvest in their health and undersave. 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 undersaving. 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 underinvestment 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 assumptions concerning the sign of compensated elasticities: $\partial \tilde{s}/\partial \tau < 0$ and $\partial \tilde{e}/\partial \tau > 0$. It should be stressed here that 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. Moreover, whether payroll taxation finances T or P is likely to matter for the signs of those compensated elasticities. For instance, when a payroll tax finances pension benefits P, it is expected to have a depressive effect on saving (see *infra*). On the contrary, when it finances first-period benefit T (as it is the case here), things are less clear, so that $\partial\tilde{s}/\partial\tau < 0$ is a stronger assumption in that context.

Finally, it should also be reminded, when interpreting those results, 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 (see above). This also should incite one to caution in interpreting our compensated elasticities.

4.2 Income taxation compensated by a Beveridgian pension

We now do the same exercise as above, but assume that the variation of τ is compensated by a variation in the pension benefit P. Combining the expressions 18 and 21, we now have that[30]

$$\frac{\partial\tilde{\pounds}}{\partial\tau} = \frac{\partial\pounds}{\partial\tau} + \frac{\partial\pounds}{\partial P}(1-\tau)\frac{Ew^2}{\bar{\pi}}$$

where $\bar{\pi} \equiv E\pi(e)$ is the average survival probability of the population. The last term, $(1-\tau)Ew^2/\bar{\pi}$, gives the variation of P following the variation of τ so as to keep the aggregate households' budget constraint unchanged. Thus, the optimal value for the tax rate can be expressed as

$$\frac{\tau}{(1-\tau)} = \frac{\begin{bmatrix} -cov\left(\pi(e)u'(d), w^2\right) + (1-\bar{\pi}\alpha)E\left[\pi(e)u'(d)w^2\right] \\ +\frac{(1-\alpha)\bar{\pi}}{(1-\tau)}\left[E\pi(e)u'(d)\frac{\partial\tilde{s}}{\partial\tau} + E\pi'(e)u(d)\frac{\partial\tilde{e}}{\partial\tau}\right] \\ +\frac{\mu\bar{\pi}}{(1-\tau)}\left[E\left(-\pi'(e)(s+P)\right)\frac{\partial\tilde{e}}{\partial\tau} + E(1-\pi(e))\frac{\partial\tilde{s}}{\partial\tau}\right]\end{bmatrix}}{\mu\bar{\pi}Ew^2} \tag{24}$$

where $\partial\tilde{s}/\partial\tau = \partial s/\partial\tau + \partial s/\partial P \times dP/d\tau$ and $\partial\tilde{e}/\partial\tau = \partial e/\partial\tau + \partial e/\partial P \times dP/d\tau$ denote the compensated derivatives of savings and health spending.[31]

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

$$\frac{\tau}{1-\tau} = \frac{\begin{bmatrix} -cov\left(\pi(e)u'(d), w^2\right) + (1-\bar{\pi})E\left[\pi(e)u'(d)w^2\right] \\ +\frac{\mu\bar{\pi}}{(1-\tau)}\left[E\left(-\pi'(e)(s+P)\right)\frac{\partial\tilde{e}}{\partial\tau} + E(1-\pi(e))\frac{\partial\tilde{s}}{\partial\tau}\right]\end{bmatrix}}{\mu\bar{\pi}Ew^2} \tag{25}$$

When interpreting that formula, we shall assume, as above, that $\partial\tilde{e}/\partial\tau > 0$ and $\partial\tilde{s}/\partial\tau < 0$. Note, however, that the latter assumption is here much more natural than it was in the previous subsection. Actually, although a rise in τ

[30] We now assume that $\theta = T = 0$.

[31] Note that here again, these are not real substitution effects, as we consider aggregate compensation.

compensated by a rise of the demogrant T has an ambiguous effect on savings, a rise in τ compensated by a rise in the pension P is most likely to reduce savings.

In comparison with Eq. 23, that is with the case of payroll taxation financing a uniform first-period benefit, there is here in Eq. 25 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 Eq. 24, which, as above, are of Pigouvian nature and aim at correcting agents' tendency to undersave and underinvest 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 subsections, we now consider the optimal level of health taxation θ along with the first-period demogrant T.[32] Combining the FOCs of the planner's problem relative to θ and T, we now have that

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

where, as before, $\partial \tilde{\pounds}/\partial \theta$ is the derivative of the compensated Lagrangian with respect to θ. This is equal to the sum of the derivative of the Lagrangian with respect to θ *plus* the derivative of the Lagrangian with respect to the demogrant T, i.e., $\partial \pounds/\partial T$, multiplied by the variation of the demogrant induced by the change of θ, i.e., $dT/d\theta = \bar{e}$, in order to keep the aggregate households' budget constraint unchanged.[33]

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

$$\theta = \frac{\left[\begin{array}{c} -cov\left(u'(x), e\right) + (1-\alpha)\, E\left[\pi(e)\, u'(d)\, \frac{\partial \tilde{s}}{\partial \theta} + \pi'(e)\, u(d)\, \frac{\partial \tilde{e}}{\partial \theta}\right] \\ -\mu E\left(\pi'(e)\, s\right) \frac{\partial \tilde{e}}{\partial \theta} + \mu E\left(1-\pi(e)\right) \frac{\partial \tilde{s}}{\partial \theta} \end{array}\right]}{-\mu E \frac{\partial \tilde{e}}{\partial \theta}} \tag{26}$$

where $\partial \tilde{s}/\partial \theta = \partial s/\partial \theta + \partial s/\partial T \times dT/d\theta$ and $\partial \tilde{e}/\partial \theta = \partial e/\partial \theta + \partial e/\partial T \times dT/d\theta$ are the compensated tax derivatives of s and e with respect to θ.

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

[33] The term $\bar{e}$ denotes the average level of health spending in the population.

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

$$\theta = \frac{-cov\left(u'(x), e\right) - \mu E\left(\pi'(e)\, s\right)\frac{\partial \tilde{e}}{\partial \theta} + \mu E\left(1 - \pi(e)\right)\frac{\partial \tilde{s}}{\partial \theta}}{-\mu E\frac{\partial \tilde{e}}{\partial \theta}} \tag{27}$$

Let us first interpret expression 27, which concerns the case where agents are perfectly rational. To make the interpretation easy, we shall assume here that taxing health spendings reduce those spendings (i.e., $\partial\tilde{e}/\partial\theta < 0$), but favors 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 health spending. As in the preceding subsection, taxing health spending increases the number of accidental bequests (second term); the last term represents the gain in revenue due to the increase in the size of accidental bequests. However, the covariance $cov\left(u'(x), e\right)$, which represents the redistributive objective, has an unclear sign. If $cov\left(u'(x), e\right) < 0$, it follows that $\theta > 0$, so that the agent faces a tax; but if $cov\left(u'(x), e\right) > 0$, $\theta \lesseqgtr 0$, and it might happen that agents benefit from a subsidy on health.

The sign of $cov\left(u'(x), e\right)$ depends on the correlation between w and ε and on the functional relation between e and ε in $\pi(e, \varepsilon)$. In the benchmark situation where w and ε are positively correlated and e and ε are complements, we expect the covariance $cov\left(u'(x), e\right)$ 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 be substitutes, it is possible, if $\pi(e, \varepsilon)$ exhibits decreasing returns to scale, that a higher ε makes more productive agents choose a lower health spending e, so that e is here negatively correlated to w, implying that the covariance $cov\left(u'(x), e\right)$ is positive.[34]

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 directions. If taxing health spending enhances savings, $\partial\tilde{s}/\partial\theta > 0$, then the presence of myopia leading to undersaving is an additional motive for taxing health expenditures. On the contrary, if taxing health spending reduces these (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: $cov\left(u'(x), w^2\right) < 0$, $\partial\tilde{s}/\partial\tau < 0$, $\partial\tilde{e}/\partial\tau > 0$, $\partial\tilde{s}/\partial\theta > 0$, and $\partial\tilde{e}/\partial\theta < 0$ and under $cov\left(u'(x), e\right) \gtreqless 0$. 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

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

the covariance terms, and, in the benchmark situation, we get positive taxes on earnings and on health.[35]

Note that substitutability between genetics and health spending is important, but the relative weight 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 saving promotion. 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.[36]

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' myopia—undersaving and underinvestment 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 devoted to an optimal income tax financing a first-period lump-sum transfer, it was shown that the redistributive motive supporting income taxation tends to be mitigated by its negative revenue effect 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 an optimal income tax financing a 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 (size and sign) depends on the covariance between the marginal utility of consumption and health spending and, thus, on the complementarity (and the relative importance) of genes and health spending as inputs in the survival process, as well as on the correlation between genetic background and productivity.

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

[36] Clearly, if only e 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 spending in longevity terms.

In sum, our tax policy analysis reveals the crucial role played by determinants that are usually absent in a setting with fixed longevities: the roles of genes and health spending (and their interactions) in the production of longevity and the correlation between genetic background and productivity. Those determinants are generally absent in the optimal taxation literature, but this paper shows that if one wants to characterize the optimal taxation policy in a society with large longevity differentials (as shown on Fig. 1), which depend on both genes and health spending, one can hardly ignore those determinants. However, given the imperfect knowledge of those crucial pieces of information, it cannot be overemphasized here 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, as this does not allow us to do justice to intuitions about individual responsibility or about a life period "not worth being lived". 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 and productivity unchanged. Undoubtedly, this restriction leaves aside various motives for subsidizing health care.

Acknowledgements The authors are most grateful to Dirk Van de gaer for his comments and suggestions on this paper. We would like also to thank two anonymous referees for their helpful remarks on this paper.

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