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Invest-as-you-go: Public Health Investment, Long-Term Care and Welfare

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Abstract

Better health not only boosts longevity in itself, it also postpones the initial onset of disability and chronic infirmity to a later age. In this paper we examine the effects of such 'compression of morbidity' on pensions, and introduce a health-dependent dimension to the standard pay-as-you-go (PAYG) pension scheme. Studying the implications of this 'long-term care augmented' system in an overlapping generations framework, public health investment is analytically shown to boost savings and capital accumulation in the long run. Because of this multiplier effect, a partially health-dependent PAYG scheme will outperform a regular PAYG system in terms of lifetime welfare, as indicated by our numerical calculations.

JEL Classification: H55, I15, O41.

Keywords: Public Health Investment, Overlapping Generations (OLG), Long-Term Care, PAYG Pension System, Compression of Morbidity.

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Introduction

Health care improvements have multiple effects on an increasingly ageing population, particularly when it comes to disability incidence. Indeed, having lived a healthier life, we improve our chances on postponing the inevitable slide towards disability and eventual loss of autonomy. In this paper we study this evolution, and whether it can be harnessed to design more effective pension schemes.

Whereas the ongoing debate tends to center on health improvements as a *cause* of unsustainable pension benefits, our take here will be different. True enough, healthier people will live longer, which together with decreasing fertility rates mounts the pressure on the kind of pay-as-you-go (PAYG) systems in place in most OECD countries.[1] Yet as we will show in our model, better health needn't always be a hurdle. By structurally rethinking the design of PAYG systems, health improvements can in fact take the heat off increasingly unsustainable pension liabilities, whilst adding to overall welfare at the same time.

The reason is simple, and due to what in medical terms is known as '*compression of morbidity*'. Here, a healthier lifestyle nudges up the age at which initial disability or chronic infirmity sets in, outpacing any gains in longevity which also follow from improved health (Fries et al., 2011). This results in fewer years of disability across the board, as loss of autonomy is 'compressed' into an ever smaller time frame.[2] In other words, propped up public health investment dampens disability incidence more than it boosts longevity. If pensions were then to a larger extent conditional on health, by means of e.g. disability pensions or long-term care benefits,[3] pensions could wind down even as longevity continues to rise. What is more, forward looking agents will align their saving decisions with this new pension arrangement, which could shore up capital accumulation and long-term economic growth.

To examine these dynamics, we set up a general equilibrium model where individual health and pension benefits are interlinked across time. We extend the standard overlapping generations (OLG) model introduced by Diamond (1965), and allow for two kinds of PAYG pension entitlements. A universal pension -similar to any PAYG scheme- and a *conditional* 'disability' pension which depends on individual health. The healthier the older generation in other words, the less pension benefits they will receive and vice versa. Crucially, whether the retired turn out healthier than their predecessors is endogenously determined by public health investment over earlier stages of life, in line with the 'compression of morbidity' reasoning.

[1] The reason is that for each beneficiary pensioner there are fewer working contributors, a downward trend which is projected to accelerate (Pecchenino and Pollard, 2005). See also Cigno and Werding (2007) on increasing age-dependency ratios.

[2] Fries (1989) was first to coin the term, with many empirical follow-ups providing evidence. See e.g. Vita et al. (1998), Doblhammer and Kytir (2001), Hubert et al. (2002), Fries (2003), Romeu Gordo (2011), or Andersen et al. (2012). Faria (2015) concludes that compression of morbidity 'should be upgraded from a hypothesis to a theory', given the amount of evidence at hand.

[3] We follow Cremer (2014) in defining Long-term care (LTC) as: "the provision of assistance and services to people who, because of disabling illnesses or conditions, have limited ability to perform daily activities such as bathing and preparing meals." LTC is mainly targeted at the elderly, with needs arising from various chronic diseases (mostly diabetes and -increasingly- cancer), Alzheimer or other forms of dementia (Cremer, 2014). LTC can be administered both at home, in nursing homes or in long-stay hospitals.

Our main theoretical contributions are twofold. First, we find that an increase in public health investment can brace capital accumulation and wages in the long run. Since healthier pensioners have smaller claims on the pension system, health investment encourages saving for old age. Capital levels then rise alongside wages, which in turn brings about even more health investment and savings, leading again to higher wages until a new steady state is reached. We analytically prove that this general equilibrium effect on wages -up to a certain level of taxation- always offsets the disposable income losses incurred to finance public health investment. Second, and because of this multiplier effect, combining a partially health-dependent PAYG pension scheme with health investment is numerically shown to outperform a regular PAYG system. This in lifetime utility terms and at constant levels of tax burden.

We bridge two strands of literature on intergenerational concerns to arrive at these results, both hinging on the stylised overlapping generations (OLG) framework pioneered by Diamond (1965). First, parsimonious OLG modeling has often been used to study the effectiveness of pensions. Indeed, demographic changes over the last decades have fueled this debate, and are well suited to a simple overlapping generations setup. To this end, Diamond's model has been extended in various directions to capture the effects of longevity, fertility and human capital formation on pensions.[4] Often comparing fully funded to unfunded schemes, or defined-contribution to defined-benefit systems.[5]

Second, public health investment and its long-term implications have also been sized up from a stylised OLG perspective. Chakraborty (2004) for one, adapts the model of Diamond (1965) so that *longevity* endogenously depends on public health. Raising taxes to finance public health investments then improves the survival probabilities of the elderly. Anticipating this longer lifespan, agents save more to uphold consumption at an older age, thereby boosting capital accumulation in the long run. In our model however, it's not the *length* of retired life itself that is endogenously linked to public health investment, but the *quality* of life during old age. Given any stretch of old age, to what extent does improved health investment reduce chronic infirmity and morbidity when retired? Our focus thus serves as a logical counterpart to other approaches where longevity was endogenously modelled, but health status during old-age kept constant.[6]

Studying the effects of this 'compression of morbidity' on pensions furthermore, our PAYG design can be seen as 'long-term care' augmented. Public PAYG benefits which are partially conditional on health status, indeed go a long way in capturing the main elements of most programs set up in the field.[7] First, because of shifting family patterns and a failing private market, the brunt of long-term care has come to lie with the public sector.[8] Second, long-term care benefits are assigned conditional on health status,

[4]See e.g. De La Croix and Michel (2002), Börsch-Supan et al. (2006), **?**, Pestieau and Ponthière (2012), Fanti and Gori (2012), and Cipriani (2014).

[5]See e.g. Beetsma and Bovenberg (2009), Knell (2010) or Bonenkamp and Westerhout (2014)

[6]See the pioneering work of Blackburn and Cipriani (2002), and later follow-ups by Bhattacharya and Qiao (2007), **?**, De La Croix and Ponthiere (2010), Jouvet et al. (2010), **?**, De La Croix and Licandro (2013), or Fanti and Gori (2014).

[7]See Norton (2000), Cremer et al. (2012) or European Commission (2013) for an overview of the (cross-country) variety in long-term care programs. Average public spending on such programs comes in at 1.8 % of GDP for the EU27. Sweden, The Netherlands and Denmark are high-spending countries, with more than twice the EU average of their GDP devoted to long-term care.

[8]See e.g. Brown and Finkelstein (2007) on the insurance puzzle in the long-term care private insur-

usually by means of disability scales identifying various levels of dependency (e.g. the Katz scale). And last but not least, most of the public long-term care assistance of this kind is financed on a PAYG basis.

Now, since more than two out of five people aged 65 or older report having some sort of functional limitation -ranging from sensory, physical, mental, or self-care disabilities- the importance of long-term care has grown together with the number of elderly (Siciliani, 2013). In this light, our results offer some relief: long-term care brings in health status to allocate elderly benefits, so that health care coverage and medical advances are predicted to indirectly stimulate saving for old age. If the resulting multiplier effect bracing capital accumulation, wages, and consumption is set in motion, overall welfare improves. Moreover, given that public long-term care expenditures are expected to rise substantially over the next decades (Cremer et al., 2012; Siciliani, 2013), this lever of public health investment will bite all the more. Lastly, and logically, pension liabilities in a health-dependent system will partially taper off the healthier the pensioners. In a world where pensions are mainly seen as a drag on public finances, this would certainly be a welcome change.

All in all, we are first to consider the relationship between partially health-dependent pension systems and public investment in health. Shedding some light on the long-term implications of combining extended health care with conditional pensions, we cover several blind spots in the policy debate as well.

The paper proceeds as follows. Section 1 describes the characteristics of the model, and establishes equilibrium. Section 2 delves into the effect of a rise in health taxation on steady-state capital accumulation. Section 3 combines all of our findings to shed light on the potential welfare ramifications brought about by the kind of mixed pension system studied here. Section 4 concludes.

I. The Model

We consider a closed economy, populated by perfectly foresighted and identical individuals whose finite lifespan is divided up into two generations: youth (working period), and old age (retirement period).[9] During each time period t the newly born generation of N_t individuals overlaps with the previous one, growing at an exogenous rate of $n \in (-1; +\infty)$, where $N_t = (1+n)N_{t-1}$. When young, agents have one unit of labor at their disposal which they supply to firms earning the competitive wage rate w_t. As soon as they retire, agents get by on accumulated savings as well as on pension benefits provided by the government.

To finance social security, consisting *both* of pension and health care elements, the government looks to the working generation. It levies a health tax τ_h on gross labour incomes, and takes out a social security contribution rate τ_p. Health tax revenues are marked out for public investments in the health of working generations,[10] whilst the

ance market, or Pestieau and Sato (2008) on the case for public nursing.

[9]Since our focus lies with the average health effects on entire generations as a whole, abstracting from within-generation health insurance or intergenerational risk, we can safely omit uncertainty and heterogeneity from our setup.

[10]Such investments can range from building hospitals, setting up new vaccination programmes or

social security contributions are used to finance the pensions and public services of the elderly.

Public health investment

As set out in our introduction, health status during old age is to a large extent related to the degree of public health investment in earlier periods of life. Introducing these dynamics to our model, old-age health status d_{t+1} at time $t+1$ will depend on the level of public investment in health h_t at time t. Following Blackburn and Cipriani (2002), we specify this relationship as

$$d_{t+1} = \frac{d_0 + d_1 \Delta h_t^{\delta}}{1 + \Delta h_t^{\delta}} \tag{1}$$

where, like Chakraborty (2004), we focus on the simplified case where $\delta = 1$, $\Delta = 1$, $d_0 = 0$ and $0 < d_1 \leq 1$.[11] As a result, the health status function is given by the non-decreasing, concave function: $d_{t+1} = \frac{d_1 h_t}{1+h_t}$, satisfying the following properties: $d[0] = 0$, $lim_{h \to \infty} d[h] = d_1$ and $lim_{h \to 0} d^{'}[h] = d_1$. Assuming positive health investment, $h_t > 0$, old-age health status will fall between $d_{t+1} \in [0, 1]$.

Public health investments h_t at time t are financed through an exogenous tax τ_h on the labour incomes of workers at time t. For the sake of simplicity we assume a constant proportional tax on gross wages, so that $h_t = \tau_h w_t$.[12]

Health-dependent pensions and social security

The novelty of our model lies in the design of the pension system. The higher the loss of autonomy or degree of morbidity, the higher the old-age benefits, *and* vice-versa. We assume that total pension benefits at time t comprise a standard universal PAYG benefit p_t^u as well as a disability benefit p_t^d. While the former is independent from health status and universally attributed, the latter directly depends on health conditions d_t of the retired. The per pensioner benefit p_t then reads as

$$p_t = p_t^u + p_t^d[d_t] \tag{2}$$

Now, with $0 < \rho < 1$ defining the share of total social security contributions $\tau_p w_t(1+n)$ directed to universal pensions p_t^u, as opposed to revenues earmarked for other social security programs such as the disability pension p_t^d, we can reformulate (2) to obtain

$$p_t = \overbrace{\rho \tau_p w_t (1+n)}^{Universal\, pension} + \overbrace{(1-\rho)\tau_p w_t (1+n) \delta[d_t]}^{Disability\, pension} \tag{3}$$

prevention campaigns, or quite simply extending existing medical services. See e.g. Chakraborty (2004) or Fanti and Gori (2014) for a similar approach.

[11] We set d_0, the minimum health level when old, equal to zero to allow for the realistic situation of complete non-self-sufficiency during old age. Exogenous medical progress (due to e.g. scientific research) is denoted by d_1, and as such captures the efficiency of public health investments on old-age health status. Parameters δ and Δ lastly, further define the effectiveness of public health investment. Notice that setting both $\Delta = \delta = 1$ implies a tractable monotonic and concave function. By contrast, Blackburn and Cipriani (2002), study an S-shaped function, with $\delta > 1$.

[12] Chakraborty (2004), Bhattacharya and Qiao (2007), Fanti and Gori (2011) and Fanti and Gori (2014) use the exact same simplifying assumption.

Indeed, the standard PAYG system would be a particular case of our model where $\rho = 1$. Zooming in on the disability pension in (3) moreover, the relation $\delta[d_t]$ is vital. As a downwards function of health through d_t, the health-dependent feature of our pension scheme emerges here. Healthier pensioners have smaller claims on disability pension benefits, which leaves the government with a smaller bill to foot. We therefore assume $\delta[d_t]$ is inversely related to elderly health status at time t, such that: $\delta[d_t] = (1 - d_t)$. Therefore, and through $d_t[h_{t-1}]$, per pensioner benefits in time period t are endogenously determined by public health investments h_{t-1} in the previous period so that

$$p_t = \overbrace{\rho\tau_p w_t(1+n)}^{Universal\,pension} + \overbrace{(1-\rho)\tau_p w_t \tau_p(1+n)(1-d_t[h_{t-1}])}^{Disability\,pension} \quad (4)$$

Lastly, when health improves and disability pensions begin to fall, the government will have increasingly more funds at its disposal. These are expressed by $g_t[d_t] = (1 - \rho)w_t\tau_p d_t(1+n)$, and fully re-invested to compensate the elderly for incurred disposable income losses because of lower disability benefits. This could then range from spending on infrastructure (retirement homes, leisure centers geared towards the elderly,..), or non-cash benefits such as free access to public transport or university classes.[13]

Summing up, the per pensioner budget constraint faced by the government in period t is given by

$$p_t[d_t] + g_t[d_t] = \tau_p w_t(1+n) \quad (5)$$

Individuals

The lifetime utility of perfectly foresighted individuals of generation t is expressed by a homothetic and separable utility function U_t, defined over consumption and public investment as

$$U_t = ln[c_{1,t}] + \beta(ln[c_{2,t+1}] + v[g_{t+1}[d_{t+1}]]) \quad (6)$$

Where we assign index 1 to the young households and index 2 to the old households, $c_{1,t}$ denotes consumption at a young age, $c_{2,t+1}$ consumption when retired, and $g_{t+1}[d_{t+1}]$ public investment in the elderly. For reasons of simplicity, we assume sub-utility $v[.]$ to be linear so that $v[g_{t+1}[d_{t+1}]] = (1-\rho)w_{t+1}\tau_p d_{t+1}$. This is a non-restrictive assumption, since convex or concave functional forms would not change our results as long as sub-utility is positive.

Young individuals join the workforce and offer their only unit of labour to firms, receiving a competitive wage w_t per unit of labour. This salary is taxed at time t to finance both health investment and social security expenditures. Therefore, the budget constraint of the young agent at time t is given by

$$c_{1,t} + s_t = w_t(1 - \tau_h - \tau_p); \quad (7)$$

Consequently, net income at a young age is used for consumption $c_{1,t}$ and saving s_t, with the overall tax rate at $(\tau_p + \tau_h) \in [0,1]$. Savings are deposited in a mutual fund accruing at a gross return of r_{t+1}.

[13] Of course, budgetary savings can also be used to lower pension contributions or government debt, which would affect the *working* generation in period $t+1$ instead. For reasons of tractability, and because the saving behaviour of the working generation in period t comes out unaffected still, we omit this possibility here.

When old secondly, consumption is financed out of savings and social security. The budget constraint of an old agent born at time t then reads as

$$c_{2,t+1} = s_t(1 + r_{t+1}) + p_{t+1} \tag{8}$$

With p_{t+1} the pension benefit as defined by (4). Substituting equations (4), (7) and (8) into (6) and maximizing U_t w.r.t. savings s_t, the optimal saving decision of an individual born in period t can easily shown to be

$$s_t = \frac{\beta w_t(1 + r_{t+1})(1 - \tau_h - \tau_p) - (1 + n)w_{t+1}[1 - d_{t+1}(1 - \rho)]}{(1 + \beta)(1 + r_{t+1})} \tag{9}$$

Now, since we're interested in the long-term implications of public health investment, studying the savings decision in partial equilibrium is illustrative. To this end, deriving (9) with respect to health taxation τ_h yields

$$\frac{\partial s_t}{\partial \tau_h} = \frac{(1 + n)w_{t+1}\left[\frac{\partial d_{t+1}}{\partial \tau_h}\right] - \beta w_t(1 + r_{t+1})}{(1 + \beta)(1 + r_{t+1})} \gtrless 0 \tag{10}$$

What matters in (10) is the numerator, weighing up two effects on individual saving behaviour:

$$(1 + n)w_{t+1}\left[\frac{\partial d_{t+1}}{\partial \tau_h}\right] \gtrless \beta w_t(1 + r_{t+1}) \tag{11}$$

On the right hand side of (11) we find the usual income effect which hollows out savings. Indeed, a higher health tax logically reduces the amount of disposable income available for consumption as well as savings. A second effect runs counter to the first however, as captured by the left hand side of (11). Here, health taxation nudges up health investment which leads to better health d_{t+1} at old-age. Since this in turn pulls down future claims on the entitlement system, perfectly foresighted individuals have an incentive to save and uphold old-age consumption. At play here is a substitution effect from young to old-age consumption.

Which of both effects wins out in general equilibrium will depend on the steady state wage and interest rate levels, and by consequence, on the capital stock. In the following sections we introduce production of goods and services to close the model, and derive the general equilibrium features.

Firms

Final goods are produced using a Cobb Douglas technology $Y_t = AK_t^{\alpha}N_t^{1-\alpha}$, with $\alpha \in (0, 1)$. $A > 0$ represents exogenous technology productivity or total factor productivity. We define the production function in per capita terms $y = f(k_t) = Ak_t^{\alpha}$, with k_t capital per unit of labor. Assuming capital fully depreciates at the end of each period and the price of output is normalised to unity, perfect competition in the goods market implies that both capital and labor are paid their respective marginal product, that is $w_t = (1 - \alpha)Ak_t^{\alpha}$ and $r_t = \alpha Ak_t^{\alpha-1} - 1$. Given the initial capital stock k_0, competitive equilibria are characterized by a sequence of $\{k_t\}$ that satisfies equations $k_{t+1} = \frac{s_t N_t}{N_{t+1}}$.

Equilibrium

Combining the savings condition defined in (9) with (1), and after some algebraic manipulation, we obtain the following capital accumulation rule for $k_{t+1} = \frac{s_t N_t}{N_{t+1}}$:

$$k_{t+1} = \frac{\alpha k_t^\alpha (1 + \mathrm{c1} k_t^\alpha \tau_h)(1 - \tau_h - \tau_p)\beta \mathrm{c1}}{(1+n)(\mathrm{c2} - \mathrm{c1} k_t^\alpha \tau_h(\alpha(\mathrm{c3} - 1 - \beta) - \mathrm{c3}))} \tag{12}$$

With $\mathrm{c1} = (1-\alpha)A$, $\mathrm{c2} = \alpha(1+\beta) + \tau_p(1-\alpha)$ and $\mathrm{c3} = \tau_p(1 - d_1(1-\rho))$. Steady states of the above dynamic path of capital accumulation are defined by $k_{t+1} = k_t = \bar{k}^*$. Since equation (12) is a first order non-linear equation, we are not able to derive an analytical formulation for the non-trivial steady states. We can however show that the zero equilibrium of the system is unstable, and prove the existence and stability of a non-trivial steady state $\bar{k}^* > 0$.

Proposition 1 *The dynamic system described by equation (12) possesses two steady states* $\{0, \bar{k}^*\}$. *The positive steady state* $\bar{k}^* > 0$ *is the only stable steady state.*

Proof See appendix A.

II. Public health investment and capital accumulation

Having established equilibrium, we can now focus on our main point of interest: the long-term welfare implications of combining a health-dependent pension scheme with health investment. In this light, deriving the effect of a rise in health investments on the steady-state level of capital is a necessary first step. Capital accumulation influences wages, interest rates, and thus inevitably defines long-term outcomes.

Indeed, such a comparative statics exercise is far from trivial as pointed out above, and expressed by (10). Higher health investments imply higher health taxes, which take an immediate bite out of disposable income, in turn discouraging savings and eroding the capital stock. Yet the partial equilibrium effect also works in the opposite direction, as health conditions during old-age improve because of health investment, which encourages saving. What we find is that when health taxation remains below a certain threshold level and the capital stock is high, the latter effect wins out in general equilibrium.

Proposition 2 *In an economy where PAYG pension benefits are partially health-dependent, an increase in public health investment* τ_h *boosts steady state capital stock* $\bar{k}^*$ *if and only if*

1. *The health tax stays below a certain threshold* $0 < \tau_h < \bar{\tau}_h$
2. *The capital stock stays above* $\tilde{k} = \left(\frac{\tau_p + \alpha(1-\tau_p+\beta)}{A(\alpha-1)^2 d_1(1-\tau_p)\tau_p(1-\rho)}\right)^{\frac{1}{\alpha}}$

Proof See Appendix B.

When $\tau_h < \bar{\tau}_h$ and $\bar{k}^* > \tilde{k}$, the downwards pressure of health improvements on pensions induces younger generations to save more, so that capital accumulation rises. The resulting higher wages translate into even more health investment -ceteris paribus with regard to the value of the health tax τ_h- which in turn improves health conditions of the elderly. This sparks off an indirect general equilibrium feedback effect which encourages saving even more, and serves as a catalyst to accumulate capital down the line. As a result, steady-state output per worker increases.[14]

However, this multiplier effect is only triggered under certain conditions. If the government sets a tax rate $\tau_h > \bar{\tau}_h$ which is too distortive, investment in public health impedes capital accumulation in the long run. A lower capital stock $\bar{k}^* < \tilde{k}$ also plays its part. To understand these conditions, we adjust expression (11) for steady-state values and simplify, obtaining

$$(1+n)\left(\frac{\partial d[h]}{\partial \tau_h}\right) \gtrless \beta(1+r) \tag{13}$$

Now, since $d[h]$ is concave in τ_h, higher values of τ_h will lessen the chances for the substitution effect on the left of (13) to outweigh the income effect on the right. As the sign flips in favour of the latter when τ_h jumps over $\bar{\tau}_h$, individuals start saving *less* after a health tax hike. Indeed, health investment in this case only leads to minor health gains, and very small reductions in future pensions. These are readily offset by the disposable income cuts, which remain the same on the margin. Similarly, lower steady-state capital levels will also tilt expression (13) in favour of the right hand side, since smaller capital stocks generate higher interest rates and lower wages.[15]

To illustrate how the steady state level of capital responds to an increase in the health tax rate, we perform a very simple numerical analysis in Table 1.

'Table 1 here'

When $\tau_h = 0$, we get a steady state level of capital $\bar{k}^* = 2.4316$, a threshold $\tilde{k} = 0.4058$ and a threshold $\bar{\tau}_h = 0.021$. As the health tax rate edges up from 0 to this threshold of 2.1%, the steady state level of capital follows suit. For values of the tax rate larger than this threshold, our model predicts a negative impact of increased public health taxation on capital accumulation. As we can observe in Table 1, an increase of the tax rate larger than 2.1% negatively impacts the capital stocks.

III. Health, disability pensions, and welfare

Let us now look at the welfare effects of health investment in a policy context where pensions are partially health-dependent. More specifically, we're interested in maximizing steady state expected lifetime utility using both tax instruments τ_p and τ_h, but keeping the total tax burden constant.[16] Since in real life a purely PAYG system can to a certain extent always be complemented with a health-dependent dimension -and indeed in many cases already is as argued above- a budget-neutral, second-best exercise of this nature seems justified. Not in the least because raising overall tax levels is far from a feasible policy alternative in many OECD economies today.

[14] A similar mechanism where health investment bears on economic growth can be found in Chakraborty (2004), Fanti and Gori (2011) or Fanti and Gori (2014).

[15] Keeping in mind that $\frac{\partial d[h]}{\partial \tau_h} = \left(\frac{w}{1+\tau_h w} + \frac{\tau_h w^2}{(1+\tau_h w)^2}\right)$ and thus increasing in w.

[16] Since an A-Pareto improvement as defined by Golosov (2007) is ruled out because of falling interest rates in the period of reform itself, we limit ourselves to lifetime utility as a welfare indicator.

Government optimisation

Our benevolent government will set an optimal policy pair (τ_h, τ_p) as a first mover, taking into account the decision making of all agents populating the economy. Considering the optimal savings decision in (9), the government therefore knows consumption at a young age will be equal to

$$c_{1,t} = \frac{(1+r_{t+1})w_t(1-\tau_h-\tau_p)+(1+n)w_{t+1}[1-d_{t+1}(1-\rho)]}{(1+\beta)(1+r_{t+1})} \tag{14}$$

And similarly, that consumption at an older age will be

$$\begin{aligned} c_{2,t+1} = & \frac{\beta w_t(1+r_{t+1})(1-\tau_h-\tau_p)-(1+n)w_{t+1}[1-d_{t+1}(1-\rho)]}{(1+\beta)} \\ & + \frac{(1+\beta)[\rho\tau_p w_{t+1}+(1-\rho)(\tau_p(1-d_{t+1})w_{t+1})](1+n)}{(1+\beta)} \end{aligned} \tag{15}$$

Lastly, public provision in the elderly generation becomes

$$g_{t+1}[d_{t+1}] = (1-\rho)w_{t+1}\tau_p d_{t+1}(1+n) \tag{16}$$

The government then maximizes steady state indirect utility $\bar{V}[\tau_p, \tau_h]$, with $\bar{c}_1$, $\bar{c}_2$ and $\bar{g}$ the steady state values of (14), (15) and (16) above, so that

$$\underset{\tau_h}{Max}\,\bar{V}[\tau_p,\tau_h] = ln\,[\bar{c}_1[\tau_p,\tau_h]] + \beta(ln\,[\bar{c}_2[\tau_p,\tau_h]] + \bar{g}[\tau_p,\tau_h]) \tag{17}$$

To guarantee budget neutrality, it suffices for the government to optimise with respect to the health tax rate τ_h only, as long as the contribution rate $\hat{\tau}_p$ serves as an automatic 'equaliser' keeping tax revenues constant. To this end, we choose the level of tax revenues accruing to a counterfactual, regular PAYG system (where $\rho = 1$) as a benchmark, so that: $\tau_{payg}\bar{w}_{payg}(1+n) = \hat{\tau}_p\bar{w}(1+n)+\tau_h\bar{w}$ at all times. Total public expenditures $\bar{p}_{payg}$ under this benchmark PAYG pension scheme will then always be identical to those under our the health-dependent system, $\bar{p}[\bar{d}] + \bar{g}[\bar{d}] + \bar{h}$, for any τ_h. Assumption 1 summarises:

Assumption 1 *Define with $\bar{w}$ and $\bar{w}_{payg}$ the steady-state wage rate under a health-dependent social security system and a purely PAYG pension scheme, respectively. The contribution rate under the health-dependent system $\hat{\tau}_p$ then always adjusts to guarantee budget neutrality between both systems, so that $\hat{\tau}_p \equiv \tau_p[\tau_h, \tau_{payg}] = \frac{\tau_{payg}\bar{w}_{payg}}{\bar{w}} - \frac{\tau_h}{1+n}$ $\forall$ $(\tau_h,\ \tau_{payg})$.*

Now, our optimisation exercise will depend on the general equilibrium effects of marginally increasing health taxation, both in terms of consumption and public provision as expressed by (17). These are summarised by the following total derivatives:

$$\frac{\partial\bar{c}_1[.]}{\partial\tau_h} = \overbrace{\frac{\partial\bar{c}_1}{\partial\tau_h}}^{-} + \overbrace{\frac{\partial\bar{c}_1}{\partial\hat{\tau}_p}}^{-}\overbrace{\frac{\partial\hat{\tau}_p}{\partial\tau_h}}^{-} + \overbrace{\frac{\partial\bar{c}_1}{\partial\bar{d}}}^{-}\overbrace{\frac{\partial\bar{d}}{\partial\tau_h}}^{+} + \left(\overbrace{\frac{\partial\bar{c}_1}{\partial\bar{w}}}^{+}\overbrace{\frac{\partial\bar{w}}{\partial\bar{k}^*}}^{+} + \overbrace{\frac{\partial\bar{c}_1}{\partial\bar{r}}}^{-}\overbrace{\frac{\partial\bar{r}}{\partial\bar{k}^*}}^{-}\right)\left(\overbrace{\frac{\partial\bar{k}^*}{\partial\tau_h}}^{?} + \overbrace{\frac{\partial\bar{k}^*}{\partial\hat{\tau}_p}}^{-}\overbrace{\frac{\partial\hat{\tau}_p}{\partial\tau_h}}^{-}\right) \tag{18}$$

$$\frac{\partial \bar{c}_2[.]}{\partial \tau_h} = \overbrace{\frac{\partial \bar{c}_2}{\partial \tau_h}}^{-} + \overbrace{\frac{\partial \bar{c}_2}{\partial \hat{\tau}_p}}^{+}\overbrace{\frac{\partial \hat{\tau}_p}{\partial \tau_h}}^{-} + \overbrace{\frac{\partial \bar{c}_2}{\partial \bar{d}}}^{-}\overbrace{\frac{\partial \bar{d}}{\partial \tau_h}}^{+} + \left(\overbrace{\frac{\partial \bar{c}_2}{\partial \bar{w}}}^{+}\overbrace{\frac{\partial \bar{w}}{\partial \bar{k}^*}}^{+} + \overbrace{\frac{\partial \bar{c}_2}{\partial \bar{r}}}^{+}\overbrace{\frac{\partial \bar{r}}{\partial \bar{k}^*}}^{-}\right)\left(\overbrace{\frac{\partial \bar{k}^*}{\partial \tau_h}}^{?} + \overbrace{\frac{\partial \bar{k}^*}{\partial \hat{\tau}_p}}^{-}\overbrace{\frac{\partial \hat{\tau}_p}{\partial \tau_h}}^{-}\right) \tag{19}$$

$$\frac{\partial \bar{g}[.]}{\partial \tau_h} = \overbrace{\frac{\partial \bar{g}}{\partial \bar{d}}}^{+}\overbrace{\frac{\partial \bar{d}}{\partial \tau_h}}^{+} + \overbrace{\frac{\partial \bar{c}_2}{\partial \bar{w}}}^{+}\overbrace{\frac{\partial \bar{w}}{\partial \bar{k}^*}}^{+}\left(\overbrace{\frac{\partial \bar{k}^*}{\partial \tau_h}}^{?} + \overbrace{\frac{\partial \bar{k}^*}{\partial \hat{\tau}_p}}^{-}\overbrace{\frac{\partial \hat{\tau}_p}{\partial \tau_h}}^{-}\right) \tag{20}$$

As equations (18) to (20) clearly demonstrate, the effect of a budget-neutral rise in health investment through increased health taxation is not altogether clear-cut. As pointed out before, much depends on capital accumulation. But even when $\frac{\partial \bar{k}^*}{\partial \tau_h} > 0$ under proposition 2, the outcome still crucially hinges on whether rising wages outweigh the direct impact of health taxation on consumption, both at a young and an old age. Elevated capital levels also imply a smaller interest rate which may stimulate consumption at the working age, but undercuts it when retired. The drop in pension contribution rates keeping tax revenues constant lastly, brings about the opposite.

Numerical results

Given the ambiguity of the theoretical analysis above, we resort to numerical calculations in what follows. Using the same parameter values as in section 4 and following assumption 1, we find a value of the health tax τ_h^* -and therefore of the contribution rate $\hat{\tau}_p$- which maximises steady-state lifetime indirect utility.

We illustrate this result in table 2 where, as observed in the first row, the health tax rate maximising steady-state indirect utility is given by $\tau_h^* = 0.055$. This implies a contribution rate for social security of $\hat{\tau}_p = 0.086$. Crucially, driving this outcome is the exact same multiplier effect as described in section 4. Zooming in on the second row of table 2, rising health tax rates indeed lead to higher capital levels compared to a purely PAYG system, and this keeping total tax burden constant. Wages follow suit in the third row, pushing up consumption in both periods of life in the second panel of the table, even though pension benefits decrease in the fourth panel. Also, setting the weight of the universal pension system to a more realistic value of $\rho = 0.75$ doesn't change matters. On the contrary, as table 3 demonstrates, all results carry through with a health tax rate of $\tau_h^* = 0.081$ maximising lifetime utility.

'Table 2 here'

Now, since we've used a purely PAYG system as a benchmark to keep tax revenues constant in our welfare exercise, tables 2 and 3 also rhetorically answer a logical follow-up question. Can we improve welfare in the long run by making a standard PAYG pension system partially health-dependent, but when health investment τ_h is still far from its optimal level τ_h^*? As the second column of table 2 points out, we clearly can: setting a health tax of a mere 1% already improves utility considerably. An effect which holds out under higher weights ρ on the universal pension benefit as well, in table 3. This implies that even when an *optimal* budget-neutral combination of health tax and pension contribution rates is politically unfeasible -e.g. because of minimum requirements on universal pension benefits- introducing some small degree of health-dependency and health investment still pays off.

'Table 3 here'

Also, this last implication can be seen as a lower-bound outcome, since a part of the pension contributions in the purely PAYG system are turned into health tax revenues under the health-dependent system. The fact that welfare still runs higher in the health-dependent system despite such disposable income cuts in pensions, implies the same would hold in a system where the pension contribution τ_p and the health tax τ_h are held constant, and only ρ changes. Indeed, comparing table 2 with table 3, the only difference in terms of exogenous variables is this degree of health-dependency ρ. Going from a system where pension benefits are to a larger extent conditional on health-status, i.e. from table 3 to table 2, improves welfare across the board. This implies that a simple shift towards health-dependency within an existing pension system, *given* a certain level of health investment, would be Pareto improving as well.

IV. Concluding remarks

Better health not only boosts longevity in itself, it also postpones the initial onset of disability and chronic infirmity to a later age. To examine the potential impacts of such 'compression of morbidity' on pensions, we introduced a health-dependent dimension to the standard pay-as-you-go (PAYG) pension scheme studied in the literature.

Studying the long-term implications of such a system in a simple overlapping generations framework, an increase in public health investment was shown to strengthen the incentive to save. This in turn boosts capital accumulation, which comes with higher wages and consumption levels in the long run. Importantly, and because of this multiplier effect, we found that combining health investment with a partially health-dependent PAYG scheme can outperform a regular PAYG system. This in lifetime utility terms and at identical levels of tax burden.

Now, when more than two out of five people aged 65 or older report having some sort of functional limitation, these results matter. Indeed, the importance of so called *long-term care* assistance has grown together with the number of dependent elderly. Also, because of shifting family patterns -where women enter the labour market rather than caring for older relatives- and a failing private market, this challenge has come to lie with the public sector. Simply extrapolating on the basis of existing policies, public expenditures in the EU27 are already expected to increase by 115 percent on average in the coming 40 years.[17] Crucially, such public long-term care assistance is financed on a PAYG basis in most cases, and *conditionally* assigned using a disability scale identifying

[17] Cremer et al. (2012) base their conjectures on the 2009 'Aging report' of the European Commission, and underline that this projection does not capture the full scale of the policy challenge. Future changes in the number of people receiving informal or no care (which depends on family patterns) are expected to deteriorate, yet assumed constant in their analysis.

various levels of dependency (e.g. the Katz scale). Our emphasis on health-dependent 'disability' pensions then seems justified, and can be seen as extending the standard PAYG pension benefit with a long-term care dimension.

Moreover, as these kinds of health-dependent benefits are projected to rise in the future, our model lays bare the importance of public health investment. Given current health care coverage, simply extending health status as a defining factor in pension schemes would already prop up welfare. Indeed, as soon as saving incentives start shifting because of this health-dependent dimension, the multiplier effect bracing capital accumulation, wages, and consumption is set in motion. Also, budget neutral health investments could still improve welfare alongside health itself, given that health investment lies below the optimal level which we identified. Lastly, and logically, pension liabilities will partially taper off the healthier we become. In a world where pensions are mainly seen as a drag on public finances, this would certainly be a welcome change.

Appendix A: Proof of proposition 1

The proof is done in two steps. First, we prove that the trivial steady state $\bar{k}^* = 0$, the zero equilibrium of the dynamic equation (12), is unstable. Define the right-hand-side of equation (12) as $Z[k]$. Differentiating $Z[k]$ with respect to k gives:

$$Z_k^{'}[k] = \frac{\alpha^2\beta \mathrm{c1} k^{\alpha-1}(1-\tau_h-\tau_p)\left(\mathrm{c1}^2\tau_h^2 k^{2\alpha}(\alpha(\beta+1)+(1-\alpha)\mathrm{c3})+2\mathrm{c1c2}\tau_h k^a+\mathrm{c2}\right)}{(1+n)\left(\mathrm{c2}-\mathrm{c1}\tau_h k^{\alpha}(\alpha(-\beta+\mathrm{c3}-1)-\mathrm{c3})\right)^2}$$

with $c1$, $c2$ and $c3$ defined in section 3.5 of the main text. Given that $(\mathrm{c1},\mathrm{c2},\mathrm{c3}) > 0$, we observe that $Z_k^{'}[k] > 0$ for any $k > 0$. Since $Z(0) = 0$ and $\lim_{k\to 0^+} Z_k^{'}(k) = +\infty$, it follows that the steady state $\bar{k}^* = 0$ can never be stable.

Second, we prove that there exists an internal solution, $\bar{k}^* > 0$, which is a stable steady state. Rewrite the dynamic equation (12) in steady state, $k = Z[k]$, as:

$$Y_1[k] \equiv k^{1-\alpha} = \frac{\alpha(1+\mathrm{c1}k_t^{\alpha}\tau_h)(1-\tau_h-\tau_p)\beta \mathrm{c1}}{(1+n)(\mathrm{c2}-\mathrm{c1}k_t^{\alpha}\tau_h(\alpha(\mathrm{c3}-1-\beta)-\mathrm{c3}))} \equiv Y_2[k]$$

Then observe that $Y_1[0] = 0$, $Y_{1,k}^{'}[k] = (1-\alpha)k^{-\alpha} > 0$ for any $k > 0$, and that $\lim_{k\to+\infty} Y_1[k] = +\infty$. Define $Y_2[0] = \frac{\alpha \mathrm{c1}(1-\tau_h-\tau_p)\beta}{(1+n)\mathrm{c2}}$, :

$$\lim_{k\to+\infty} Y_2[k] = \frac{\alpha \mathrm{c1}(1-\tau_h-\tau_p)\beta}{(1+n)(\mathrm{c3}(1-\alpha)+\alpha(1+\beta))}$$

and

$$Y_{2,k}^{'}[k] = \frac{\alpha^2\beta \mathrm{c1}^2\tau_h k^{\alpha-1}(\tau_h+\tau_p-1)(-\mathrm{c2}+\alpha(\beta-\mathrm{c3}+1)+\mathrm{c3})}{(1+n)\left(\mathrm{c2}-\mathrm{c1}\tau_h k^{\alpha}(\alpha(-\beta+\mathrm{c3}-1)-\mathrm{c3})\right)^2}$$

Using $\mathrm{c2} = \alpha(1+\beta)+\tau_p(1-\alpha)$ and $\mathrm{c3} = \tau_p(1-d_1(1-\rho))$, we observe that the denominator of $Y_{2,k}^{'}[k]$ is always positive. The numerator can be written as: $(1-\alpha)\alpha^2 c1^2 d_1 k^{\alpha-1}\tau_h\tau_p(1-\tau_h-\tau_p)\beta(1-\rho)$. This expression is positive for any $k > 0$, implying that $Y_{2,k}^{'}[k] > 0$. Moreover, notice that $Y_2(0) < \lim_{k\to+\infty} Y_2[k]$ when $(1-\alpha)d_1\tau_p(1-\rho) > 0$. Given restrictions on parameters, the latter condition is always verified. It follows that for any $k > 0$, $Y_1[k] = Y_2[k]$ only once at $\bar{k}^* > 0$, characterising the asymptotically stable steady state. ■

Appendix B: Proof of proposition 2

Define the relation between steady state of capital $\bar{k}$ and health taxation τ_h as follows: $G[\bar{k},\tau_k] = \bar{k} - Z[\bar{k},\tau_h]$ with $Z[\bar{k},\tau_h]$ defined as the right-hand-side of equation (12) in steady state, and $*$ omitted for simplicity. We apply the implicit function theorem to derive the effect of health taxation, τ_h, on capital $\bar{k}$:

$$\bar{k}_{\tau_h}^{'}[\tau_h] = -\frac{\frac{\partial G[\bar{k},\tau_h]}{\partial \tau_h}}{\frac{\partial G[\bar{k},\tau_h]}{\partial \bar{k}}} = -\frac{A}{B} \tag{21}$$

Where A in expression(21) denotes:

$$A = \alpha\beta \mathrm{c1}\bar{k}^{\alpha}\left(\mathrm{c2}\left(\mathrm{c1}\bar{k}^{\alpha}(2\tau_h+\tau_p-1)+1\right)-\mathrm{c1}\bar{k}^{\alpha}(\alpha(-\beta+\mathrm{c3}-1)-\mathrm{c3})\left(\mathrm{c1}\tau_h^2\bar{k}^{\alpha}-\tau_p+1\right)\right) \tag{22}$$

With c1, c2 and c3 defined in section 3.5 of the main text. Similarly, B is equal to:

$$B = \alpha^2\beta \mathrm{c1}\bar{k}^{\alpha-1}(\tau_h+\tau_p-1)\left(\mathrm{c1}^2\tau_h^2\bar{k}^{2\alpha}(\alpha(\beta-\mathrm{c3}+1)+\mathrm{c3})+2\mathrm{c1c2}\tau_h\bar{k}^{\alpha}+\mathrm{c2}\right)+ \\ +(1+n)\left(\mathrm{c2}-\mathrm{c1}\tau_h\bar{k}^{\alpha}(\alpha(-\beta+\mathrm{c3}-1)-\mathrm{c3})\right)^2 \tag{23}$$

The derivative $\bar{k}^{'}_{\tau_h}[\tau_h]$ is equal to zero when the numerator is equal to zero. Solving in terms of τ_h, allows us to observe that the numerator is zero if $\tau_h=\bar{\tau}_h$, with:

$$\bar{\tau}_h = \frac{\bar{k}^{-2\alpha}\left(\mathrm{c1c2}\bar{k}^{\alpha} \pm \sqrt{\mathrm{c1}^2\bar{k}^{2\alpha}(\mathrm{c2}+(\mathrm{c1}(\tau_p-1)\bar{k}^{\alpha})(\alpha(-\beta+\mathrm{c3}-1)-\mathrm{c3})\left(\alpha(-\beta+\mathrm{c3}-1)-\mathrm{c3}\right)+\mathrm{c2})}\right)}{\mathrm{c1}^2(\alpha(-\beta+\mathrm{c3}-1)-\mathrm{c3})}$$

Note that the denominator of the threshold $\bar{\tau}_h$ is always negative, so that $\bar{\tau}_h$ can be positive only when the numerator is negative. Since the term below the square root is positive and imaginary solutions are therefore ruled out, a positive threshold $\bar{\tau}_h$ can be obtained by keeping the minus sign before the square root. In this case, the threshold will be positive when: $\bar{k} > \tilde{k} \equiv \left(\frac{\tau_p+\alpha(1-\tau_p+\beta)}{\alpha(\alpha-1)^2 d_1(1-\tau_p)\tau_p(1-\rho)}\right)^{\frac{1}{\alpha}}$. Moreover, $\bar{\tau}_h$ is is also smaller than 1. To prove this statement, it is sufficient to observe that $\bar{\tau}_h < 1$ when $\beta > \tilde{\beta}$. The latter condition is always verified since $\beta > 0$ by assumption and $\tilde{\beta} \equiv \frac{\bar{k}^{-\alpha}\left(\mathrm{c1}(\alpha(\mathrm{c3}-1)-\mathrm{c3})\bar{k}^{\alpha}\left(\mathrm{c1}\bar{k}^{\alpha}-\tau_p+1\right)-\mathrm{c2}\left(\mathrm{c1}(\tau_p+1)\bar{k}^{\alpha}+1\right)\right)}{\alpha \mathrm{c1}\left(\mathrm{c1}\bar{k}^{\alpha}-\tau_p+1\right)} < 0$.

In order to prove that $\frac{\partial \bar{k}}{\partial \tau_h} > 0$ when $\tau_h < \bar{\tau}_h$, we have to consider the sign of the numerator and denominator of $\bar{k}^{'}_{\tau_h}[\tau_h]$, as expressed by (21). Solving the denominator in terms of $\bar{k}$ we derive $\tilde{\tilde{k}} \equiv \left(-\frac{c2}{c1\tau_h(c3(1-\alpha)+\alpha(1+\beta))}\right)^{\frac{1}{\alpha}} < 0$. Notice that the equation of the denominator crosses the x-axis once at $\tilde{\tilde{k}}$. Considering that at $\bar{k}=0$ the denominator of $\bar{k}^{'}_{\tau_h}[\tau_h]$ reduces to $(1+n)\mathrm{c2}^2$, the equation is necessarily increasing. It follows that the denominator is strictly increasing in $\bar{k}$ and is always positive under assumption 1. Thus, the sign of $\bar{k}^{'}_{\tau_h}[\tau_h]$ will depend on the sign of the numerator in (21).

Define for simplicity $I[\bar{k}] = \mathrm{c1}\bar{k}^{\alpha}$ and $X = -\mathrm{c3}+\alpha(\mathrm{c3}-1-\beta)$. Then, observe that the numerator of $\bar{k}^{'}_{\tau_h}[\tau_h]$ expressed by (21) is zero when the health tax rate $\tau_h = \frac{\mathrm{c2}I[\bar{k}]\pm\sqrt{I[\bar{k}]^2(\mathrm{c2}+X)(\mathrm{c2}+(\tau_p-1)XI[\bar{k}])}}{XI[\bar{k}]^2}$, that is when $\tau_h = \bar{\tau}_h$ as defined above. The fact that two solutions exist, indicates that the numerator of equation $\bar{k}^{'}_{\tau_h}[\tau_h]$ is a parabola. Rewriting the numerator of (21) as follows:

$$\alpha I[\bar{k}](\mathrm{c2}+I[\bar{k}]\mathrm{c2}(2\tau_h+\tau_p-1)-I[\bar{k}](1+I[\bar{k}]\tau_h^2-\tau_p)X)\beta \tag{24}$$

and deriving with respect to τ_h, we get:

$$2\alpha I[\bar{k}]^2(c_2-\tau_h XI[\bar{k}])\beta$$

Since $X<0$, the derivative is positive when $\tau_h > 0$ and the critical point, $\frac{\mathrm{c2}}{XI[\bar{k}]}$, negative. Finally, observe that the second derivative, $-2\alpha XI[\bar{k}]^3\beta$ is always positive. It follows that the critical point of equation (24) is a minimum and the branch of the parabola in the domain $\tau_h > 0$ always increasing, crossing the x-axis when $\tau_h = \bar{\tau}_h$.

As proved above only one of the two solutions of $\bar{k}^{'}_{\tau_h}[\tau_h] = 0$ can be positive (if $\bar{k} > \tilde{k}$) and smaller than one. Then, in the domain $\tau_h > 0$, the sign of the numerator in (21) will be negative for any $\tau_h < \bar{\tau}_h$ and positive otherwise. Since the sign of the re-worked denominator in (21) was always positive, we observe that $\bar{k}^{'}_{\tau_h}[\tau_h] = -\frac{\leq 0}{>0}$ i.e. >0 if $\tau_h < \bar{\tau}_h$ and that $\bar{k}^{'}_{\tau_h}[\tau_h] = -\frac{\geq 0}{>0}$ i.e. <0 if $\tau_h > \bar{\tau}_h$. ■

Appendix C : Tables

Table 1: The effect of a positive health shock ($\rho = 0.25$)

τ_h	$\bar{\tau}_h$	k^*	Effect on S.S. Level of Capital
0%	0.021	2.4316	
1%	0.021	2.4654	positive
1.5%	0.021	2.4727	positive
2%	0.021	2.4752	positive
2.5%	0.021	2.4738	negative
3%	0.021	2.4693	negative
3.5%	0.021	2.4621	negative
4%	0.021	2.4527	negative

Table 2: Regular vs. health-dependent PAYG system ($\rho = 0.25$)

	Health Tax Rate τ_h					
Variable	*payg*	$\tau_h = 1\%$	$\tau_h = 5\%$	$\tau_h^* = 5,5\%$	$\tau_h = 10\%$	$\tau_h = 12.5\%$
$\bar{U}$	3.332	3.432	3.559	3.560	3.510	3.456
$\bar{k}^*$	2.432	2.584	2.939	2.968	3.172	3.260
$\bar{w}$	21.402	21.929	23.085	23.178	23.805	24.067
$\bar{c}_1$	15.639	15.995	16.735	16.790	17.150	17.289
$\bar{c}_2$	18.352	18.098	17.530	17.483	17.157	17.015
$\bar{c}_1 + \bar{c}_2$	33.991	34.093	34.265	34.273	34.307	34.304
$\bar{d}$	N/A	0.171	0.509	0.532	0.669	0.713
$\hat{\tau}_p$	15%	13.69%	9.14%	8.61%	3.96%	1.43%
$\bar{h}$	0.000	0.219	1.155	1.275	2.380	3.008
$\bar{p}^u$	3.371	0.788	0.554	0.524	0.248	0.091
$\bar{p}^d$	0.000	1.960	0.816	0.735	0.246	0.078
$\bar{p}^u + \bar{p}^d$	3.371	2.748	1.370	1.259	0.494	0.169
$\bar{g}[\bar{d}]$	0.000	0.404	0.846	0.837	0.497	0.194
Total Exp.	3.371	3.371	3.371	3.371	3.371	3.371

As in Kehoe and Perri (2002) we use a capital-output elasticity of $\alpha = 0.4$ (in between common estimates for developed and developing countries), a discount factor of $\beta = 0.2$ as in Strulik (2004), and set pension contributions at $\tau_{payg} = 0.15$ (as the majority of OECD countries have rates between 10% and 20%). As in Fanti and Gori (2014) we set the efficiency of health investment at $d_1 = 0.95$, and keep an exogenous population growth rate of $n = 0.05$, being the replacement rate in a single-parent model. In line with Chakraborty (2004), we set $A = 25$.

Table 3: Regular vs. health-dependent PAYG system ($\rho = 0.75$)

	Health Tax Rate τ_h					
Variable	*payg*	$\tau_h = 1\%$	$\tau_h = 5\%$	$\tau_h^* = 8.1\%$	$\tau_h = 10\%$	$\tau_h = 12.5\%$
$\bar{U}$	3.332	3.370	3.429	3.436	3.434	3.426
$\bar{k}^*$	2.432	2.515	2.777	2.956	3.069	3.218
$\bar{w}$	21.402	21.693	22.571	23.147	23.490	23.940
$\bar{c}_1$	15.639	15.832	16.391	16.741	16.945	17.209
$\bar{c}_2$	18.352	18.206	17.760	17.467	17.294	17.069
$\bar{c}_1 + \bar{c}_2$	33.991	34.038	34.151	34.208	34.239	34.278
$\bar{d}$	N/A	0.170	0.504	0.620	0.666	0.712
$\hat{\tau}_p$	15%	13.85%	9.46%	6.15%	4.14%	1.50%
$\bar{h}$	0.000	0.218	1.129	1.875	2.349	2.992
$\bar{p}^u$	3.371	2.365	1.682	1.122	0.766	0.284
$\bar{p}^d$	0.000	0.655	0.278	0.142	0.085	0.027
$\bar{p}^u + \bar{p}^d$	3.371	3.020	1.960	1.264	0.851	0.311
$\bar{g}[\bar{d}]$	0.000	0.133	0.282	0.232	0.171	0.068
Total Exp.	3.371	3.371	3.371	3.371	3.371	3.371

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