Capital-skill Complementarity and the Redistributive Effects of Social Security Reform*

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Abstract

This paper analyses the general equilibrium implications of reforming pay-as-you-go pension systems in an economy with heterogeneous agents, human capital investment and capital-skill complementarity. It shows that increasing funding delivers in the long run higher physical and human capital and therefore higher output, but also higher wage and income inequality. The latter affects preferences over the redistributiveness of the remaining pay-as-you-go component: despite the greater role that redistribution could perform in the new steady state, we find a lower preference for redistribution for a larger group of the population.

KEYWORDS: Capital-Skill Complementarity, Inter and Intragenerational Redistribution, Pay-As-You-Go, Fully Funded.

JEL Classification: H55, J31

1 Introduction

The discussion over the problems of traditional pay-as-you-go pension systems and on how to change them is by now a long standing one.

A considerable amount of conceptual and empirical work has been directed to identify alternative reform proposals and their impact on different economic variables[1]. Whatever the specific institutional features of these alternative proposals, most of them include some degree of funding. The claimed advantages of introducing or increasing funding

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[1]See for instance Diamond (1998 and 2002) and Sass and Triest (1997).

with respect to parametric reforms which would maintain the pay-as-you-go nature of traditional social security systems range from higher returns and higher savings to fewer labour market distortions and lower political pressure (see for instance Feldstein, 1998). Given the general attractiveness of funding, the main concerns stem from transitional[2], risk[3] and redistributive issues and from the political feasibility of such a change[4].

Although, according to Gruber and Wise (2002), to redistribute income or to maintain income redistribution is among the four economic goals which a reform should pursue[5], the economic literature on pension reform deals only marginally with *intra*generational redistribution. Namely, when considering redistributive issues, it focuses almost exclusively on the *inter*generational redistribution generated by an increase in funding either during the transition period or in the long run[6]. Redistribution within generations is sometimes taken into account by models considering the transition to a fully funded system (see for instance Brunner, 1996 and Feldstein and Liebman, 2002) but it is seldom a long run issue. The absence of an explicit theoretical analysis of the long run intragenerational redistributive implications of introducing more funding[7] is even more critical if one takes into account that, starting from the World Bank (1994) proposal of a three-pillar social security system, the funded component is almost always accompanied by a public, mandatory, pay-as-you-go pillar which should take care of redistributive concerns either via benefit floors, minimum income guarantees or flat universal benefits.

This paper tries to fill the gap by analysing the general equilibrium implications of introducing funding in an economy where there is a pay-as-you-go partially redistributive pension system. It focuses on the intragenerational conflicts that this reform generates and it studies whether the redistribution performed via the reduced pay-as-you-go pillar is subject to growing pressures for a reduction or an increase in size. The analysis sheds some light on the compatibility between (private) funding and (public) redistribution which is taken for granted by the current policy debate.

[2]When considering prefunding of social security, the transition from a pay-as-you-go to a fully funded system is a critical issue and has been the subject of substantial analysis (see for instance Breyer, 1989; Homburg, 1990; Feldstein, 1998).

[3]For references on risk issues, one has to distinguish between funding via individual accounts and via a unique trust fund. See for instance Diamond and Geanakoplos (2001) and Campbell and Feldstein (2001).

[4]See for instance Conesa and Krueger (1999), Cooley and Soares (1999), Leers et al. (2001).

[5]The others being to correct the financial imbalance, to increase national saving and to strengthen economic efficiency.

[6]Van Groezen et al. (2002) can be interpreted in this light.

[7]Casarico (1998) is an exception we are aware of. Kotlikoff et al. (2002) simulate the general equilibrium effects of privatising the US Social Security system under agents' heterogeneity. Huggett and Ventura (1999) perform steady state comparisons of the intragenerational redistributive effects of introducing a two-tier system for the US economy maintaining its pay-as-you-go structure.

We model a two-period OLG closed economy characterised by agents' heterogeneity, human capital investment and capital-skill complementarity. A standard result in the literature on social security is that, in steady state, savings are higher under a fully funded pension scheme rather than under a pay-as-you-go one (Diamond, 1965). Under the assumption that workers are perfect substitutes[8], which is common to all the literature on pension reform, an increase in funding, by driving savings up, delivers a higher level of capital stock and higher real wages for all in the new steady state, for a given ratio between the productivity of any two types of workers. The assumption of capital-skill complementarity implies that across group inequality can be influenced by policy variables affecting physical capital and therefore it brings about new issues in the analysis of pension system reforms. The inclusion of an education decision responds to the need of integrating the analysis of the long run implications of pension reform on physical capital to those on human capital and it offers an endogenous mechanism to offset changes in across group inequality.

We find that a social security reform based on an increase in funding delivers a higher steady state level of physical and human capital and a higher wage inequality. This is new to the literature on social security reform: with capital-skill complementarity not only pension gaps but also wage gaps widen, adding to the redistributional problems generated by the switch to funding. If we explicitly account for the preferences over redistribution of heterogeneous agents, we find that the cut in the payroll tax rate generates in the short run an increase in the desired amount of redistribution for people whose wage is below the average. When the effects of capital-skill complementarity kick in from time $t+1$ onwards, groups' sizes and preferences over redistribution change. Funding increases the party of those who are against redistribution in the public pay-as-you-go scheme, despite the greater role it could perform. The higher inequality observed in the long run goes with a lower preference for redistribution for a larger group of the population.

The paper is organised as follows: Section 2 provides the basic economic set-up. Section 3 analyses the impact of the social security reform and Section 4 concludes, suggesting some policy implications of our findings.

2 The basic set-up

2.1 Consumers and government

We consider a two period overlapping generations model (OLG) of a closed economy. When young, agents consume and can either invest in education and work as skilled

[8]Once productivity differentials are adjusted.

workers (type $\mathcal{H}$ agents) or they can work as unskilled workers (type $\mathcal{L}$ agents). Agents differ in their ability to acquire skills: c_j denotes the time required to become skilled and it is distributed on the interval $[0, 1]$ with continuous density function $\varphi(\cdot)$; the more able the agent is, the less time he has to spend investing in human capital, the lower are his foregone earnings. When old, agents retire and finance their second period consumption out of their savings and pensions.

Formally, agents decide how much to consume and save solving the following maximisation problem:

$$\begin{array}{c} \max U(x_t^j) + \frac{1}{1+\beta} U(x_{t+1}^j) \\ s.t. \\ x_t^j + \frac{x_{t+1}^j}{1+r_{t+1}} = y_t^j \end{array} \tag{1}$$

where U is separable, twice differentiable, concave and increasing in x_t^j and x_{t+1}^j which represent consumption of agent j born at time t respectively when young and old; β is the rate of time preference; r_{t+1} denotes the interest rate at time $t+1$ and y_t^j represents lifetime income of agent j born at time t which we next specify.

The government operates a balanced pay-as-you-go pension scheme: it collects contributions proportional to wages at a rate τ_t and it pays per capita pensions p_{t+1}^j which are determined according to the following benefit formula:

$$p_{t+1}^j = (1+n)\tau_t w_t^j \alpha_t + \overline{p}_{t+1} \tag{2}$$

where n is the constant rate of population growth, w_t^j is the gross wage of agent j at time t, α_t is the contributory share of the scheme applying to generation t (the so-called Bismarckian factor), with $0 \leq \alpha_t \leq 1$ by assumption, and $\overline{p}_{t+1}$ is the redistributive component of the system paid out at time $t+1$ as a flat universal benefit which is determined according to the social security budget constraint. Namely:

$$\overline{p}_{t+1} = (1+n)\left[\tau_{t+1}\overline{w}_{t+1} - \alpha_t \tau_t \overline{w}_t\right] - \frac{g(\tau_t)}{2}(1-\alpha_t)^2 \tag{3}$$

The first term in square brackets represents per capita revenues collected at time $t+1$ with $\overline{w}_{t+1}$ denoting the average wage of the economy at time $t+1$ yet to be determined. The second term captures the share of per capita revenues required to finance the contributory pensions. When $\alpha_t = 0$, the pension system is only redistributive; as α_t increases, the contributory share goes up. The last term represents the cost of redistribution: we assume that the redistribution associated to the pension scheme implies a waste of resources which is quadratic in the indicator of redistribution $(1-\alpha_t)$ and which depends on the size of the scheme as measured by the contribution rate τ_t via a generic convex function $g(\cdot)$.[9]

By substituting (3) in (2), we can write the lifetime income of agent j as follows:

$$y_t^j = w_t^j(1-\tau_t) + \frac{1+n}{1+r_{t+1}}\left[\tau_t\alpha_t(w_t^j - \overline{w}_t) + \tau_{t+1}\overline{w}_{t+1}\right] - \frac{1}{1+r_{t+1}}\frac{g(\tau_t)}{2}(1-\alpha_t)^2 \quad (4)$$

with

$$w_t^j = \begin{cases} w_t^{\mathcal{H}}(1-c_t^j) & \text{if } j \in \mathcal{H} \\ w_t^{\mathcal{L}} & \text{if } j \in \mathcal{L} \end{cases}$$

where $w_t^{\mathcal{H}}$ and $w_t^{\mathcal{L}}$ represent the (gross) wage skilled and unskilled workers earn on the labour market.

From the solution to problem (1) we can derive the indirect utility functions $V_t^j(y_t^j)$ whose maximisation determines the decision to invest in human capital: it is convenient to invest in human capital if $y_t^{\mathcal{H}} \geq y_t^{\mathcal{L}}$. The last agent who finds profitable to invest is characterised by an education cost c_t^* satisfying the following condition:

$$c_t^* = \frac{w_t^{\mathcal{H}} - w_t^{\mathcal{L}}}{w_t^{\mathcal{H}}} \quad (5)$$

In order to determine w_t^j, we introduce production.

2.2 Production

To the best of our knowledge, all the existing literature on social security reform assumes that workers are perfect substitutes, once productivity differentials are adjusted. It follows that a higher (lower) level of capital stock in the economy implies higher (lower) wages for all types of workers, leaving relative wages unchanged. In fact, since the seminal work by Griliches (1969), a large body of empirical studies finds that capital - and technological progress embodied in new investments - better substitutes unskilled labour than skilled labour[10].

In order to introduce capital-skill complementarity in our model, we assume the following production technology[11]:

$$Y_t = \left[bK_t^\theta + (1-b)\,L_t^\theta\right]^{\frac{\delta}{\theta}} [H_t]^{1-\delta} \quad (6)$$

[9]For an alternative representation of the distortionary costs associated to the non-contributory part of the pay-as-you-go pension scheme which applies to a steady-state situation, see Casamatta et al. (2000).

[10]For instance, Flug and Hercowitz (2000) use data from a wide range of countries and find evidence that investment in equipment raises the relative demand for skilled labor; similar results are reported by Goldin and Katz (1998), Krusell *et al.* (2000) and Prasad (1994). For additional evidence and references on capital-skill complementarity and capital-embodied skill-biased technological change see, among others, Acemoglu (2000) and Katz and Autor (1999).

[11]See Uzawa (1988), chapter 5 for a detailed discussion.

where Y_t is production, K_t is physical capital, $L_t = \int_{c_t^*}^1 \varphi(c)dc$ is unskilled labour, $H_t = \int_0^{c_t^*}(1-c^j)\varphi(c)dc$ is the effective supply of skilled labour, all at time t; δ, b and $\theta \in (0,1)$. In (6), the Allen-Uzawa partial elasticity of substitution between capital and skilled labour $\sigma_{KH} = 1$, while the elasticity of substitution between capital and unskilled labour $\sigma_{KL} = \frac{1}{1-\theta}$. Under the condition that θ is strictly greater than zero, $\sigma_{KL} > \sigma_{KH}$ and the production function exhibits capital-skill complementarity.

Given L_t, H_t, K_t, the interest rate is:

$$r_t = \delta b \left[bK_t^\theta + (1-b)\, L_t^\theta\right]^{\frac{\delta}{\theta}-1} [H_t]^{1-\delta}\, K_t^{\theta-1} \tag{7}$$

and competitive skilled and unskilled wages are:

$$\begin{aligned} w_t^{\mathcal{H}} &= (1-\delta)\left[bK_t^\theta + (1-b)\, L_t^\theta\right]^{\frac{\delta}{\theta}} [H_t]^{-\delta} \\ w_t^{\mathcal{L}} &= \delta\,(1-b)\left[bK_t^\theta + (1-b)\, L_t^\theta\right]^{\frac{\delta}{\theta}-1} [H_t]^{1-\delta}\, L_t^{\theta-1} \end{aligned} \tag{8}$$

Note that the wage of skilled workers is unambiguously increasing in the amount of capital, while that of unskilled workers increases in capital only if δ is greater than θ -i.e. if the elasticity of substitutions σ_{KL} is not too high. Define the wage-premium as the ratio of skilled to unskilled workers' wages:

$$z_t \equiv \frac{(1-\delta)}{\delta\,(1-b)} \left[bK_t^\theta + (1-b)\, L_t^\theta\right] L^{1-\theta} H^{-1}. \tag{9}$$

An easy to verify implication of capital-skill complementarity is that $\frac{\partial z_t}{\partial K_t} > 0$, i.e. the relative productivity of skilled labour is increasing in the amount of capital and so is across group inequality in a competitive labour market. In the presence of capital-skill complementarity policy variables affecting the stock of capital do also change across group inequality. This is relevant for the analysis of the impact of social security reform.

2.3 Equilibrium

Given K_t, w_t^j and r_t, consumption, savings and investment plans must be consistent in the goods and capital markets. Focusing on the clearing condition in capital markets, the savings of the young must finance the stock of capital for the next period. In aggregate terms the equilibrium condition is:

$$K_{t+1} = \int_0^1 s_t^*(c)\varphi(c)dc = S_t^* \tag{10}$$

where $s_t^*(c)$ denotes the optimal level of savings of an agent whose cost of investing in education is given by c and S^* is aggregate saving[12]. The equilibrium of the economy is

[12] Notice that $s_t^*(c)$ is actually $s_t^*(w_t^{\mathcal{H}}, w_t^{\mathcal{L}}, r_{t+1}, c, \alpha_t, \tau_t)$. To save notation, in the text we drop all the variables but c.

therefore represented by the solution to problem (1), by factor prices (7) and (8) and by the capital market equilibrium condition (10). We now focus on the effects of a social security reform on the equilibrium of the economy, assuming that existence, uniqueness and stability are satisfied.

3 Social security reform

Using the model above, we want to study the general equilibrium effects of a reform to the social security system. The policy change we consider is represented by a reduction in the size of the pay-as-you-go pension scheme τ_t. As long as there are no liquidity constraints and mandatory saving through a fully funded scheme is a perfect substitute for private voluntary savings, a reduction in τ_t can be used to represent the introduction of some funding in the pension system. We do not deal here with transitional issues, i.e. we do not focus on alternative ways to finance the switch to more funding and the different distributions of costs and benefits they imply. We assume that the reduction in τ_t is once and for all and that it translates into lower pensions for the old at t and we concentrate on the effects of this change.

3.1 Policy change: effects at t

A change in τ_t *has the following effects:* $\frac{\partial w_t^j(1-\tau_t)}{\partial \tau_t} < 0$; $\frac{\partial w_t^j}{\partial \tau_t} = 0$; $\frac{\partial r_t}{\partial \tau_t} = 0$; $K_t^* = K_{t-1}^*$ *and* $H_t^* = H_{t-1}^*$.

If we focus on time t, a reduction in τ_t implies higher net wages for all, while gross wages and the stock of physical and human capital are unchanged. K_t^* depends on S_{t-1}^*: the latter is not affected by the cut in payroll taxes. If the stock of physical capital is given at t, gross wages do not change and therefore the decision to invest in education mirrors that at time $t-1$, leaving the stock of human capital unaffected.

3.2 Policy change: effects at $t+1$ and in the steady state

A change in τ_t *implies:* $\frac{\partial K_{t+1}}{\partial \tau_t} < 0$; $\frac{\partial H_{t+1}}{\partial \tau_t} < 0$; $\frac{\partial Y_{t+1}}{\partial \tau_t} < 0$; $\frac{\partial r_{t+1}}{\partial \tau_t} > 0$ *and* $\frac{\partial z_{t+1}}{\partial \tau_t} < 0$. *The steady state SS after the reduction in* τ_t *is characterised by:* $K_t^* < K^{SS}$; $H_t^* < H^{SS}$; $Y_t^* < Y^{SS}$; $r_t^* > r^{SS}$ and $z_t^* < z^{SS}$.

The higher level of savings associated with a (partially) funded scheme is such that the amount of physical capital is higher than that observed before the policy change[13]. This in

[13]This is a well-known result which dates back to Diamond (1965). Given that we assume the costs of the policy change to be borne by the old, there is no issue on how the transition affects capital accumulation. By the same token, in the absence of any means-testing of the redistributive component of the scheme,

turns translates into higher output and lower interest rates. The presence of capital-skill complementarity and of an education decision adds further implications to the switch to more funding: first, the higher level of physical capital brings about an increase in the wage premium and therefore it raises across group inequality[14]. This is new to the literature on social security reform which, when allowing for agents' heterogeneity, uniformly assumes perfect substitutability among workers, once adjusted for productivity differentials. The association between more funding and more wage inequality sharpens the redistributional problems associated to this reform. Namely, the reduction in τ_t implies that the amount of resources which can potentially be devoted to redistributive purposes shrinks[15]. This is often highlighted in the policy debate where concerns are raised on how to maintain redistribution once an investment-based social security system is adopted. Indeed, the more actuarial the system is, the larger the gap between the pensions received by those who are at the top and at the bottom of the income distribution. With capital-skill complementarity not only pension gaps but also wage gaps widen, reinforcing the increase in across-group inequality. Second, the increase in the wage premium caused by the higher level of physical capital induces more people to invest in education, which in turn raises the level of human capital of the economy. The endogenous response of the education decision reduces yet not cancels the initial rise in wage inequality.

Summarising, an increase in funding delivers not only higher physical but also human capital. However, it also raises the wage premium generating higher inequality. The latter is not compensated by higher redistribution which is actually automatically reduced in size via the lower amount of resources devoted to the partially redistributive pay-as-you-go system.

If one examines the social security reform proposals advanced in the last years, one sees that most of them tend to associate higher funding -possibly via private individual accounts- with small public redistributive pay-as-you-go schemes. Maintaining the assumption that redistribution takes place via flat universal benefits and using the notation of our paper, the new system can be characterised by $\tau^{SS} = \tau^{\min}$ and $\alpha^{SS} < \alpha_t$ so as to compensate for the reduction in the total amount of resources collected by the public scheme, or in the limit $\alpha^{SS} = 0$.

In the next section we remove the assumption that the degree of redistributiveness of the pay-as-you-go scheme $(1 - \alpha_t)$ is given and study the interaction between the increase in funding and the contributory/redistributive components in the reduced pay-as-you-go

there is no saving moral hazard and therefore the Diamond's result applies.

[14] This follows immediately from the assumption of capital-skill complementarity in Section 2.2.

[15] We are not interested in cases where the inefficiency of the pay-as-you-go scheme as measured by the cost $\frac{g(\tau_t)}{2}(1 - \alpha_t)^2$ is so large as to offset the direct effect of a cut in τ_t.

scheme. The analysis throws some light on if and how distributional concerns can be taken care of in the new steady state.

3.3 Preferred α

As clarified above, α_t denotes how large the contributory portion of the pension scheme is. Namely, it determines the fraction of the pension of the young at time t which depends on the contributions they have paid and therefore on their past earnings; the remaining part reflects the average contributions in the economy[16]. The higher α_t, the less the pension scheme redistributes resources across heterogeneous agents belonging to the same generation. Given agents' heterogeneity, the preferred α_t differs across agents. If we define the preferred α_t as the one maximising agents' lifetime income at time t, we find the following general expression for an internal solution which holds for any t and any j:

$$\alpha_t^{*j} = 1 + \frac{\tau_t}{g(\tau_t)} \cdot (1+n) \cdot \left(w_t^j - \overline{w}_t \right) \tag{11}$$

The preferred α_t^{*j} depend on the size of the social security scheme via $\frac{\tau_t}{g(\tau_t)}$, on the constant rate of population growth and on the difference between one's wage and the average one. The favourite α_t^{*j} can be written as follows:

$$\alpha_t^{*j} = \begin{cases} \alpha_t^{\mathcal{L}} & \text{if } c_t^j \geq c_t^{*j} \\ \alpha_t^j & \text{if } \widehat{c}_t^j < c_t^j < c_t^{*j} \\ 1 & \text{if } c_t^j \leq \widehat{c}_t^j \end{cases} \tag{12}$$

where $0 \leq \alpha_t^{\mathcal{L}} < \alpha_t^j < 1$, $\widehat{c}_t^j$ is such that $w_t^{\mathcal{H}}(1-\widehat{c}_t^j) = \overline{w}_t$ and the average wage is:

$$\overline{w}_t = w_t^{\mathcal{H}} h_t (1 - \overline{c}_t) + w_t^{\mathcal{L}} (1 - h_t) \tag{13}$$

with $h_t = \int_0^{c_t^*} \varphi(c)dc / \int_0^1 \varphi(c)dc$.

Unskilled agents belonging to group $\mathcal{L}$ prefer a lower α_t than skilled agents $\mathcal{H}$. Notice however that agents whose cost of education falls in the interval $(\widehat{c}_t^j, c_t^{*j})$, though skilled, want a positive level of redistribution: high-cost skilled agents, i.e. those whose wage is below the mean and whose group from now on we denote by $\mathcal{H}^B \in \mathcal{H}$ want $\alpha_t^j < 1$ because they benefit from redistribution.

3.3.1 Preferred α and social security reform

We now analyse how changes in the size of the pay-as-you-go scheme affect the preferred contributory/redistributive share of the benefit formula in the system itself. We focus first on what happens at time t and $t+1$ and discuss then the steady state.

[16] Notice that α_t does not affect the pension of those who are old at time t.

Differentiating equation (11) with respect to τ_t, we find the following:

$$\frac{\partial \alpha_t^{*j}}{\partial \tau_t} = (1+n) \cdot \left(w_t^j - \overline{w}_t \right) \cdot \frac{g(\tau_t) - g'(\tau_t)\tau_t}{g(\tau_t)^2} \tag{14}$$

Given that $g(\tau_t)$ is a convex function of τ_t, the last term in (14) is negative and therefore:

$$\frac{\partial \alpha_t^{*j}}{\partial \tau_t} > 0 \text{ iff } w_t^j - \overline{w}_t < 0$$

The favourite Bismarckian factor at time t decreases for those whose wage is below the average: people belonging to group $\mathcal{L}$ and $\mathcal{H}^B$ want a higher level of redistribution as τ_t goes down. People in group $\left(\mathcal{H} - \mathcal{H}^B\right)$ still want to set $\alpha_t^{*j} = 1$, i.e. the corner solution is still the optimal one[17]. In Figure 1 we represent α_t^{*j} as a function of the cost to invest in education c_t. α_t^{*j} is a linear decreasing function of c_t and it has two flat portions at 1 and at $\alpha_t^{\mathcal{L}}$, as one can see looking at (11) and (12). When τ_t decreases, α_t^{*j} moves downward from $\widehat{c}_t^j$ onwards showing an increased desire for redistribution of the low skill and the high-cost high-skill people[18]. Notice that the dotted line in Figure 1 represents the impact of a reduction in τ_t which would hold for any t in the absence of capital-skill complementarity. The presence of the latter implies that the reduction in the size of the pay-as-you-go scheme has general equilibrium implications which show up from $t+1$ onwards (and therefore also in the steady state) and cause $\alpha_t^{*j} \neq \alpha_{t+1}^{*j}$: namely, changes in τ_t affect the wage premium which in turn modifies the decision to invest in education and therefore the size of the $\mathcal{H}$, $\mathcal{H}^B$ and $\mathcal{L}$ groups.

[Insert Figure 1]

Starting from (12), it is possible to show[19] that:

$$\frac{\partial \alpha_{t+1}^{\mathcal{L}}}{\partial \tau_t} > 0, \;\; \alpha_{t+1}^{*j} = 1 \text{ with } j \in (\mathcal{H} - \mathcal{H}^B) \tag{15}$$

Moreover

$$\frac{\partial c_{t+1}^*}{\partial \tau_t} < 0, \;\; \frac{\partial \widehat{c}_{t+1}}{\partial \tau_t} < 0$$

The first inequality says that the reduction in the size of the pay-as-you-go system raises the amount of redistribution that the next generation unskilled agents want: they desire a more redistributive formula within the smaller pay-as-you-go scheme. The general equilibrium effect that the introduction of some funding has on the wage premium reinforces the direct

[17] Notice that if we had assumed $g(\tau_t) = \tau_t$, there would be no effect of changes in the size of the scheme on the degree of redistribution which maximises the lifetime income of generation t.

[18] In Figure 1 we denote by the time subscript $(t-1)$ the value of the variables before the tax decrease.

[19] See the Appendix.

effect observed already at time t for group $\mathcal{L}$. The same holds for group $\left(\mathcal{H}-\mathcal{H}^B\right)$ whose favourite Bismarckian component is, *a fortiori*, equal to 1. It follows that the distance between the favourite degrees of redistribution for the two groups increases. Notice also that these two groups are not fixed in size: as mentioned in the previous section, the number of skilled agents goes up because the higher skilled wage provides further incentives to invest in education (second inequality); moreover, the agent whose wage coincides with the average is now less able (third inequality). This can be seen in Figure 2 where we represent the preferred α_{t-1}^{*j} and α_t^{*j} as in Figure 1 and add the preferred α_{t+1}^{*j} (thick line), which takes into account both the direct effect of the tax cut and the effect via capital-skill complementarity.

[Insert Figure 2]

Figure 2 highlights that the group that does not want any redistribution is now larger whilst the group that wants the highest level of redistribution is smaller; it also points out that the degree of redistribution desired by this last group increases. People belonging to the $\mathcal{H}^B$ group (those whose cost of education is between $\widehat{c}_{t+1}$ and c_{t+1}^*) still want some redistribution. However $\frac{\partial \alpha_{t+1}^j}{\partial \tau_t}$ is negative for some of them -those whose cost of education is close to $\widehat{c}_{t+1}$- while for some others it is positive -those whose cost of education is closer to c_{t+1}^*. The first want less while the second want more redistribution. For this last group, the effect through capital-skill complementarity reinforces the direct one while for the first group it is opposite in sign[20].

Summarising, in the short run (time t) the policy reform induces an increase in the desired amount of redistribution for people whose wage is below the average. When the effects of capital-skill complementarity start to appear (from time $t+1$ onwards), groups' sizes and preferences over redistribution change: namely, funding increases the party of those who are against redistribution in the public pay-as-you-go scheme, while worsening the relative position of those who benefitted from it and making therefore redistribution more necessary for them. The unskilled agents prefer a lower Bismarckian factor but only some of the high-cost high-skill people share their preferences: a wage below the average does not guarantee a higher preference for redistribution in the new equilibrium.

These results depend on the higher level of physical capital generated by the increase in funding and by capital-skill complementarity: given that, as shown in Section 3.2, more funding at t delivers a higher steady state level of physical capital, they hold also in the new steady state. The *higher* inequality observed in the long run goes with a *lower* preference

[20]In the Appendix we show that α_{t+1}^{j*} can intersect α_t^{j*} only in its downward sloping portion. This implies that there must always be some agent belonging to the $\mathcal{H}^B$ group who wants more redistribution than either in the initial equilibrium or at time t when only the direct effect is at work.

for redistribution for a *larger* group of the population.

As a concluding remark, notice that we here focus on a specific way to redistribute income, that is, we use a flat universal pension and we do not allow for any means-testing. Future work should be directed to analyse whether the results reached here on preferences over redistribution hold also in an environment where only those who pass a means-test are entitled to receive the state benefit. This would also require to tackle the moral hazard issues both on the saving and on the education decision which means-testing introduces.

4 Conclusions

This paper analyses the general equilibrium effects of increasing funding in an economy with heterogeneous agents, capital-skill complementarity and human capital investment. We show that more funding implies higher physical and human capital but also higher wage and income inequality. This is new to the literature on social security reform which has so far almost disregarded the long run intragenerational redistributive effects associated to a switch to funding. When preferences over redistribution are explicitly taken into account, we find that the cut in payroll taxes induces a short run increase in the desired amount of redistribution. However, when capital skill complementarity starts to bind, groups' sizes and preferences over redistribution change and we show that the higher wage and income inequality observed in the long run go with a lower preference for redistribution for a larger group of the population.

These results deliver some policy implications for the current debate on reforming partially redistributive pay-as-you-go systems. Most of the current social security reform proposals involve an increase in funding. Higher funding implies more actuarial equivalence between contributions and benefits and it raises issues on how to take care of distributional concerns in the new reformed system. Although there seems to be an agreement on defending or strengthening the redistributive portion of the smaller remaining pay-as-you-go pillar, the compatibility between (private) funding and (public) redistribution is always taken for granted and never explicitly dealt with. The results of our paper show that, indeed, a cut in the payroll tax rate increases the degree of redistribution maximising agents want, with the exception of the low-cost high-skill people who do not want any redistribution. If people were to vote over the amount of redistribution in the reformed system and if the median voter had a wage below the average, we would indeed observe higher funding accompanied by a higher degree of redistribution as the current policy debate seems to envisage. However, the results of our paper also suggest that both preferences and groups change over time due to the general equilibrium effects of the reform and that the combination of higher funding and higher redistribution in the smaller public pay-as-you-go scheme may be unstable. Public redistribution may turn out to be at odds with private funding.

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5 Appendix

Proof that $\frac{\partial \alpha_{t+1}^{\mathcal{L}}}{\partial \tau_t} > 0$

Consider equation (11), (13) and (5) all at time $t+1$. Substituting (13) in (11) and using (5) for $j \in \mathcal{L}$ we have:

$$\alpha_{t+1}^{\mathcal{L}} = 1 - \frac{\tau_{t+1}}{g(\tau_{t+1})} \cdot (1+n) \cdot h_{t+1} \cdot \left(c_{t+1}^{*} - \bar{c}_{t+1}\right) w_{t+1}^{\mathcal{H}} \tag{16}$$

Recalling that the change in the payroll tax rate is once and for all -i.e. $\tau_{t+1} = \tau_t$, we find:

$$\begin{aligned} \frac{\partial \alpha_{t+1}^{\mathcal{L}}}{\partial \tau_t} = & \left\{ \frac{-(1+n)\,\tau_{t+1}}{g(\tau_{t+1})} \cdot \left[\overbrace{\frac{\partial h_{t+1}}{\partial \tau_t}}^{-} \overbrace{\left(c_{t+1}^{*} - \bar{c}_{t+1}\right)}^{+} w_{t+1}^{\mathcal{H}} + h_{t+1} w_{t+1}^{\mathcal{H}} \overbrace{\left(\frac{\partial c_{t+1}^{*}}{\partial \tau_t} - \frac{\partial \bar{c}_{t+1}}{\partial \tau_t} \right)}^{-} + \right. \right. \\ & \left. \left. + h_{t+1} \cdot \overbrace{\left(c_{t+1}^{*} - \bar{c}_{t+1}\right)}^{+} \overbrace{\frac{\partial w_{t+1}^{\mathcal{H}}}{\partial \tau_t}}^{-} \right] \right\} + \\ & - \left\{ (1+n) \cdot h_{t+1} \cdot \overbrace{\left(c_{t+1}^{*} - \bar{c}_{t+1}\right)}^{+} w_{t+1}^{\mathcal{H}} \cdot \overbrace{\left[\frac{g(\tau_{t+1}) - \tau_{t+1} g^{'}(\tau_{t+1})}{g(\tau_{t+1})^2} \right]}^{-} \right\} \end{aligned}$$

It follows that $\frac{\partial \alpha_{t+1}^{\mathcal{L}}}{\partial \tau_t} \geq 0$. Note that a change in τ_t affects $\alpha_{t+1}^{\mathcal{L}}$ through two channels. The first curly bracket captures the effect of a change in K_{t+1}: a decrease in τ_t rises the amount of physical capital at period $t+1$ and it affects wages and, through capital-skill complementarity, the wage premium and the skill composition of workers. The second curly bracket is analogous to (14). If the cost function $g(\cdot)$ were linear, the second curly bracket would disappear. In this case the reduction in $\alpha_{t+1}^{\mathcal{L}}$ due to a cut in the payroll tax rate is exclusively due to changes in K_{t+1} and to the presence of capital-skill complementarity.

Proof that $\alpha_{t+1}^{*j} = 1$ **with** $j \in (H - H^B)$

Looking at the agent whose education cost is $\widehat{c}_{t+1}$, (11) becomes $\alpha^{*j}_{t+1} = 1$; it follows that for all $c^j_{t+1} \leq \widehat{c}^j_{t+1}$, $\alpha^{*j}_{t+1} = 1$.

Intersection between α^{*j}_{t+1} and α^{*j}_t

We prove by contradiction that α^{*j}_{t+1} cannot intersect α^{*j}_t in its flat portion. Define $\widetilde{c}$ the cost of investing in education of the agent for which $\alpha^{*j}_{t+1} = \alpha^{*j}_t$. Assume that α^{*j}_{t+1} intersects α^{*j}_t in its flat portion $\alpha^{\mathcal{L}}_t$ -i.e. $\widetilde{c} > c^*_t$. Substituting the expressions for α^{*j}_{t+1} and $\alpha^{\mathcal{L}}_t$ and rearranging terms, we have:

$$\widetilde{c} = 1 - \frac{\overline{w}_{t+1} - \overline{w}_t}{w^{\mathcal{H}}_{t+1}} - \frac{w^{\mathcal{L}}_t}{w^{\mathcal{H}}_{t+1}}$$

Using (5), $\widetilde{c} - c^*_t > 0$ if $\left[\frac{w^{\mathcal{L}}_t}{w^{\mathcal{H}}_t} - \frac{w^{\mathcal{L}}_t}{w^{\mathcal{H}}_{t+1}}\right] > \left[\frac{\overline{w}_{t+1} - \overline{w}_t}{w^{\mathcal{H}}_{t+1}}\right]$. The term on the left hand side of the inequality is always negative, while the right hand side is always non negative; therefore we can conclude that it cannot be the case that $\widetilde{c} > c^*_t$.

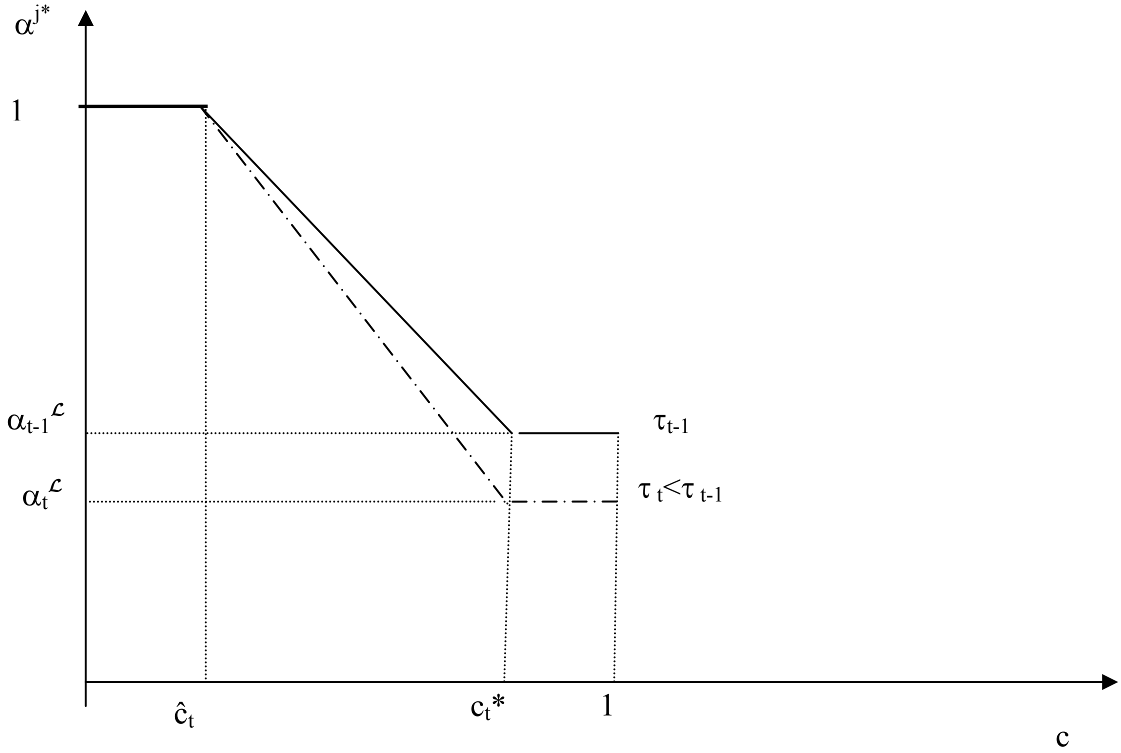

Figure 1: Favourite Bismarckian factor at time *t*

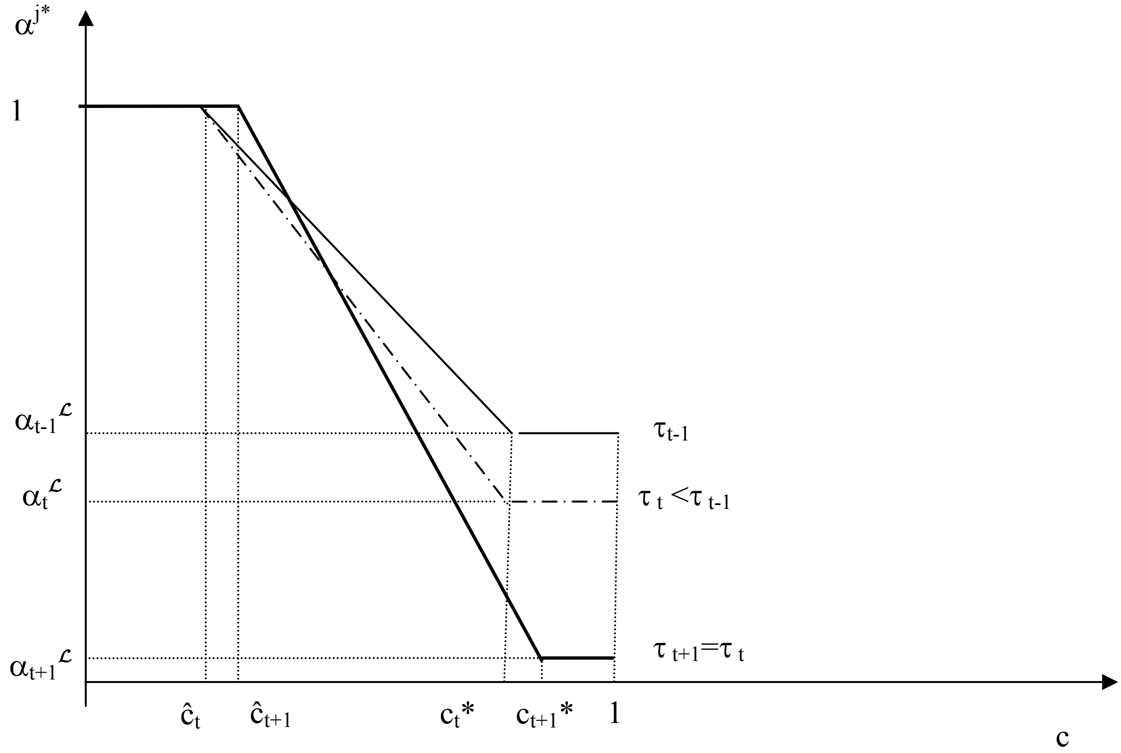

Figure 2: Favourite Bismarckian factor at time *t+1*