

# Social Security Reform and Investment in Education: Is There Scope for a Pareto Improvement?

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We propose a Pareto-improving policy which reduces the overall wage tax burden in an economy with intergenerational trade in a fixed factor of production, here labelled as land. We analyse a second-best environment in which the government cannot resort to non-distortionary land taxes. Reducing the social security contribution rate encourages investment in human capital. Future efficiency gains accruing to complementary land are capitalized in its value. The capital gains may compensate land-owning pensioners for reduced benefits. We also explain why the unfunded pension system may have lost its appeal even for pensioners after its introduction.

## INTRODUCTION

In most Western countries today, participation in the pay-as-you-go (PAYG) social security system does not seem attractive to the younger generation. The expected rate of return on social security contributions is considerably lower than the expected rate of return on financial investments. Lower and even negative population growth only aggravates the burden that a PAYG system imposes on younger generations. This has stimulated a considerable interest in a social security reform in which the PAYG system would be replaced, at least partially, by a funded component taking advantage of a higher market rate of return.<sup>1</sup> In the absence of altruism, such a reform would create an intergenerational conflict. Although future generations would benefit from a transition to a fully funded system, existing pensioners would have to accept reductions in their benefits unless there were an intergenerational transfer institution through which the benefiting future generations would compensate for the benefits forfeited by the current generation of pensioners.

A natural candidate for a compensating transfer institution is public debt. If, however, the PAYG system is free from inefficiencies not related to the inherent intergenerational redistribution,<sup>2</sup> the gains of future generations will be neutralized by the higher future taxation needed to service the public debt (Fenge 1995; Brunner 1996).<sup>3</sup> The Pareto improvements identified in the literature rely on the presence of either intragenerational redistribution or externalities, neither being inherently related to a PAYG system. They can be addressed without changing the magnitude of intergenerational transfers (see Sinn 2000).

In this paper we present an alternative transfer institution through which the elderly participate in the future efficiency gains created by a decrease in the PAYG contribution rate. It relies on voluntary market transactions in a fixed factor, labelled here as land for convenience.<sup>4</sup> The part of the future efficiency gains that improves land productivity is immediately capitalized in its current

market value. If sufficiently high, the increase in land value compensates the old landowners for the cut in social security benefits. To capture the absence of lump-sum taxes in a second-best world, we assume that the government cannot resort to a land tax. We recoup the finding of previous literature that the rate-of-return differential is not in itself an inefficiency (Fenge 1995; Brunner 1996). Extending the existing literature, we show that general wage taxation is a static inefficiency sufficient to allow for a Pareto-improving social security reform. Therefore, the presence of a fixed factor of production widens the theoretical scope for a Pareto-improving PAYG reform if public expenditures have to be financed by distortionary wage taxes instead of non-distortionary land taxes.

The capitalization mechanism could equally be involved in a policy reform that entails a reduction in the level of general taxation. The induced capital gains on land value, if unexpectedly taxed away by the government, could build a fund out of which the budget balance in each future period would be restored.<sup>5</sup> Two reasons justify our focus on social security reform. First, the pension reform is feasible without widening the set of tax instruments by a capital gains tax. Second, reforming the social security system does not require the government to commit to maintaining a once-established fund in all future periods (Ramsey tax planner); neither does it require 'reputational' political mechanisms to be continuously operative in the absence of a commitment capacity.<sup>6</sup>

We also suggest alternative reasons for why a currently inefficient social security system was installed in the first place. Typically, social security systems were introduced and expanded in the nineteenth and early twentieth centuries, when other public expenditures were much smaller. Our analysis suggests that an increase in the wage tax rate collected to finance other public expenditures could alone render a social security system, which initially benefited the elderly, so costly that today even the elderly might benefit from its partial or even full dismantling. In addition, changes in demographics, productivity growth or interest rates may render a system unattractive even for the elderly, who previously had supported it.

We analyse an overlapping-generations model in which each cohort lives for three periods. During the first period of life the members of the cohort invest privately in education. In the second period they supply labour services equal to their human capital to production, and purchase land from the older generation. Social security contributions are collected. During the third period, they receive social security benefits (indexed to past contributions) as retirees and land rents as landowners, and sell the land to the next generation.

Related literature includes Laitner (2000) and İmrohoroğlu *et al.* (1999). Laitner analyses social security reform when future productivity gains are capitalized in asset prices. Since labour supply is fixed and there is no human capital formation, the allocation is intergenerationally Pareto-efficient irrespective of the size of social security; see Hange (2003) for a formal analysis. İmrohoroğlu *et al.* analyse the trade-off between the risk-sharing benefit (resulting from incomplete capital and insurance markets) and the negative effects on capital accumulation of the PAYG system. Despite incomplete insurance markets, they find that utility of steady-state generations is maximized in the absence of social security. The implications for transition generations, however, are not studied.

Intergenerational trade in land has important implications for the political process. Owing to population ageing, pensioners receive a larger representation in the political process, which tends to preserve a generous pension system rather than allow for a restrictive pension reform (Boadway and Wildasin 1989). Cooley and Soares (1999) show that the interests of the working generation nearing retirement and pensioners are sufficiently closely aligned, which gives rise to a wide political majority against privatization of social security. Hansson and Stuart (1989) even argue that social security is an implicit contract among living generations in which the elderly have veto power. Pension reform thus requires an intergenerational consensus. We show that intergenerational trade is one mechanism to moderate if not resolve intergenerational conflict among living non-altruistic generations and, interestingly, to indirectly represent future generations' interests in the contemporary political process. Relatedly, Rangel (2005) emphasizes the potential of land to act as a 'voice' mechanism of future generations in the current political process. In his paper land taxation is critical for establishing a link across generations. In our paper an intergenerational consensus may arise even without land taxes.

The paper is organized as follows. In Section I we present the model of an economy with pay-as-you-go social security. In Section II we introduce social security reform and consider the potential for Pareto improvements. In Section III possible explanations for the rise and fall of the PAYG system are considered. Section IV concludes. Proofs are relegated to the Appendix.

## I. THE MODEL

### *Production*

Production in any given period  $t$  depends on the available technology and factors of production. We assume that there are three factors of production: physical capital, human capital and land. The amount of land is normalized to unity. Aggregate human and physical capital in the economy in period  $t$  is denoted by  $H_t$  and  $K_t$ , respectively. There is no migration of human capital, while physical capital is internationally mobile. Therefore, domestic capital stock need not equal domestic aggregate saving. The production function is Cobb–Douglas with  $A_t$  reflecting the state of technology in period  $t$ . Thus,

$$(1) \quad Y_t = A_t H_t^{\alpha_H} K_t^{\alpha_K},$$

where  $0 < \alpha_H, \alpha_K \leq 1$ . Without loss of generality, capital does not depreciate. All markets are competitive, and therefore profit maximization implies that

$$(2) \quad w_t = \alpha_H A_t H_t^{\alpha_H - 1} K_t^{\alpha_K}, \quad r = \alpha_K A_t H_t^{\alpha_H} K_t^{\alpha_K - 1},$$

where  $w_t$  denotes the wage rate per unit of human capital in period  $t$  and  $r$  is the exogenous world interest rate. The land rent in period  $t$ ,  $R_t$ , is given as residual:

$$(3) \quad R_t = (1 - \alpha_H - \alpha_K) A_t H_t^{\alpha_H} K_t^{\alpha_K}.$$

The production function for human capital is

$$(4) \quad h_t = e_{t-1}^\beta,$$

where  $\beta$ ,  $0 < \beta < 1$ , is the elasticity of human capital supply with respect to investment in education. Individual human capital stock in period  $t$  depends on investment in education in the former period,  $e_{t-1}$ . The marginal productivity of education is diminishing and the unit cost of education is 1. The costs of education should be interpreted broadly in the sense that they might also include the monetarized value of effort cost. We do not consider opportunity costs explicitly, as they are effectively tax deductible with proportional taxation.<sup>7</sup> The aggregate stock of human capital is the product of the stock per worker,  $h_t$ , and the number of workers,  $N_t$ :

$$(5) \quad H_t = N_t h_t.$$

We assume a constant population growth rate, so that the size of the cohort *working* in period  $t$  is given by

$$(6) \quad N_t = N_0(1+n)^t,$$

where  $n \geq 0$  is the growth rate of the population per cohort. While our model could be solved also for  $n < 0$ , we restrict attention to non-negative growth rates. Production depends also on technology parameter

$$A_t = A_0(1+g)^t,$$

where  $g \geq 0$  denotes technological progress. We assume identical individuals, extending the results in Appendix A to the case of heterogeneous individuals. Furthermore, there is no uncertainty.

Individuals can invest their savings in the international capital market or the national land market. Foreigners do not invest in the national land market. Even with integrated capital markets, full domestic land ownership could be guaranteed by foreigners facing a small transaction cost if they were to buy domestic land, whereas there would be no transaction cost in an international loan market. Transaction cost in foreign land acquisition might arise as a result of asymmetric information on the part of investors (Gordon and Bovenberg 1996), which tends to play a diminished role in international loan markets.<sup>8</sup> The economy produces a composite good, which is a perfect substitute for that produced abroad. By arbitrage, land value in period  $t$ ,  $V_t$ , is given by<sup>9</sup>

$$(7) \quad (1+r)V_t = R_{t+1} + V_{t+1}.$$

Recursive substitution yields

$$(8) \quad V_t = \sum_{i=1}^{\infty} \frac{R_{t+i}}{(1+r)^i}.$$

### *Individual maximization*

We analyse an overlapping-generations model in which each cohort lives for three periods. The timing of individual actions, apart from consumption, saving and borrowing, is depicted in Figure 1. In the first period of their life

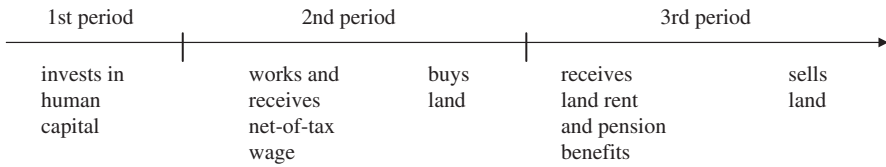


FIGURE 1. Timing of individual actions over the life-cycle.

individuals choose their education. Human capital is supplied to the labour market in the second period.<sup>10</sup>

The government collects social security contributions and wage taxes at a rate  $\tau^s$  and  $\tau^w$ , respectively, and individuals receive a net-of-tax wage income,  $[1 - (\tau^s + \tau^w)]w_t h_t$ . Social security contributions are used to finance benefits for the current old generation, whereas wage taxes finance public consumption. The middle-aged generation invests its savings by buying land from the older generation and by participating in the international financial market. In the third period individuals receive social security benefits. Formally, social security benefits in period  $t + 1$ ,  $b_{t+1}$ , depend on contributions made in period  $t$ ,  $c_t = \tau^s w_t h_t$ , according to the formula

$$(9) \quad b_{t+1} = (1 + x)c_t,$$

where  $x$  is the rate of return on contributions.<sup>11</sup> The rate of return provided by the PAYG system  $x$  is exogenous for each individual but endogenous for the economy, as shown in the next section. It is important to notice that a link between past contributions and benefits does not imply a funded social security system. In this setting a funded system is equivalent to private savings where the rate of return equals the market interest rate, while a PAYG system offers a lower rate of return, as shown below. Finally, the older generation sells land to the current middle-aged generation.

Denote by  $C_t^j$  consumption in period  $t$  by an individual living in their period  $j$ , where  $j = 1$  for the young,  $j = 2$  for the middle-aged and  $j = 3$  for the elderly. Furthermore, denote savings in the capital market of a member of age group  $j$  at the end of period  $t$  by  $S_t^j$ , and the amount of land bought when middle-aged by  $L_t^2$ . Then individual savings used for land acquisition is  $L_t^2 V_t$ . As all land is purchased by the middle-aged,  $N_t L_t^2 = 1$ . The value of land sold by old people is given by  $L_t^2 V_{t+1}$ , and land rent received in the third period of life is  $L_t^2 R_{t+1}$ .

Note that with population growth  $N_t L_t^2 = N_{t-1} L_{t-1}^2$ . In other words, population growth implies a corresponding shrinking of per capita land holdings.  $G_t$  denotes the level of the pure public good provided in period  $t$ .<sup>12</sup> We assume a well behaved utility function defined over private and public consumption. The individual lifetime utility maximization problem facing the members of a generation working in period  $t$  is

$$(10) \quad \max_{e_{t-1}, C_{t-1}^1, C_t^1, C_{t+1}^3, S_{t-1}^1, S_t^2} U(C_{t-1}^1, C_t^2, C_{t+1}^3, G_{t-1}, G_t, G_{t+1}),$$

subject to the budget constraints

$$\begin{aligned}
 -e_{t-1} - C_{t-1}^1 - S_{t-1}^1 &= 0 \\
 S_{t-1}^1(1+r) + (1-\tau^s - \tau^w)e_{t-1}^\beta w_t - C_t^2 - S_t^2 - L_t^2 V_t &= 0 \\
 S_t^2(1+r) + L_t^2 R_{t+1} + L_t^2 V_{t+1} + (1+x)\tau^s e_{t-1}^\beta w_t - C_{t+1}^3 &= 0.
 \end{aligned}$$

Notice that non-negativity of consumption and human capital investment implies that  $S_{t-1}^1 < 0$ , so that consumption and investment in human capital in the first period is financed by borrowing. All individuals can save and borrow freely at the exogenous interest rate  $r$ , determined by the international capital market, to smooth their consumption over their lifetime. Therefore, following the Fisher Separation Theorem, optimal individual choices can be characterized by a two-step optimization problem: the first where individuals choose educational investment to maximize discounted net-of-tax lifetime income, and the second where, for a given lifetime income, individuals choose their utility-maximizing intertemporal consumption profile by borrowing and lending in the perfect capital market.<sup>13</sup> As individuals rationally expect that  $(1+r)L_t^2 V_t = L_t^2 R_{t+1} + L_t^2 V_{t+1}$ , investment in the land market cancels out in the maximization of the net present value of lifetime income. Therefore, the individual maximization problem facing the members of a generation working in period  $t$  is<sup>14</sup>

$$(11) \quad \max_{e_{t-1}} \left( -e_{t-1} + \frac{1}{1+r}(1-\tau^s - \tau^w)e_{t-1}^\beta w_t + \frac{1}{(1+r)^2}[(1+x)\tau^s e_{t-1}^\beta w_t] \right).$$

The first term in large parentheses is the private cost of educational investment in period  $t-1$ , the second term is the after-tax wage income in period  $t$  discounted to period  $t-1$ , and the third term is the social security benefit in period  $t+1$ , discounted to period  $t-1$ . The first-order condition becomes

$$-1 + \frac{1}{1+r} \left( 1 - \tau^s \frac{r-x}{1+r} - \tau^w \right) \beta e_{t-1}^{\beta-1} w_t = 0,$$

which gives individually optimal educational investment in period  $t-1$  as a function of wages. Using (2)–(5) allows us to derive the level of investment in general equilibrium:

$$\begin{aligned}
 (12) \quad \hat{e}_{t-1} &= \left[ \frac{1}{1+r} \left( 1 - \tau^s \frac{r-x}{1+r} - \tau^w \right) \right. \\
 &\quad \times \left. \beta \alpha_H A_t^{1/(1-\alpha_K)} N_t^{(\alpha_H + \alpha_K - 1)/(1-\alpha_K)} \left( \frac{\alpha_K}{r} \right)^{\alpha_K/(1-\alpha_K)} \right]^{(1-\alpha_K)/(1-\alpha_K - \beta \alpha_H)}.
 \end{aligned}$$

Straightforward comparative statics yields

$$\left. \frac{\partial \hat{e}_{t-1}(\cdot)}{\partial \tau^s} \right|_{r > x} < 0.$$

The social security system discourages human capital investment if the rate of return under the PAYG system is lower than the interest rate. The rationale

for this distortion is that lending in the international capital market (as well as investment in the domestic land market) for one period yields a rate of return  $r$ , while compulsory savings under the PAYG system earn a rate of return  $x$ . If the latter falls below the former, the PAYG system imposes an implicit tax on contributions equal to

$$(13) \quad \tau^s \frac{r - x}{1 + r}.$$

Therefore, the combined tax burden imposed by the wage tax and the implicit social security tax reads  $\tau := \tau^w + \tau^s(r - x)/(1 + r)$ . Its magnitude determines the downward distortion in educational investment, and the Harberger Triangle the economy incurs.

*Balanced growth path*

Human capital investment is independent of land price, which gives us Lemma 1.

*Lemma 1.* For any sequence of land prices  $\{V_t\}_{t=0}^\infty$ , the development in the stock of human capital is given by

$$(14) \quad \frac{h_t}{h_{t-1}} = (1 + g)^{\beta\gamma}(1 + n)^{-\beta(1-\alpha_K-\alpha_H)\gamma}, \quad \frac{H_t}{H_{t-1}} = (1 + g)^{\beta\gamma}(1 + n)^{(1-\alpha_K)(1-\beta)\gamma},$$

and the development in land rents and aggregate production is given by

$$(15) \quad \frac{R_t}{R_{t-1}} = \frac{Y_t}{Y_{t-1}} = 1 + q,$$

where

$$(16) \quad 1 + q := (1 + g)^\gamma(1 + n)^{\alpha_H(1-\beta)\gamma} \text{ and } \gamma := \frac{1}{1 - \alpha_K - \beta\alpha_H} > 0.$$

The growth rate of production,  $q$ , depends only on the parameters related to technological progress, population growth and technology for production and human capital formation. It is independent of the wage tax rate, social security contribution rate or interest rate, which affect only the level of production but not its growth rate. As given by (14), individual human capital stock increases over time if  $g \geq n$ , or if  $g$  is not much below  $n$ . If  $g \ll n$ , then  $h_t < h_{t-1}$  and human capital stock per worker would decrease over time. However, even in such an economy aggregate human capital and output would be still increasing.

Land price dynamics are captured by (7). Rearranging and using Lemma 1, all ‘price-dividend’ ratios consistent with arbitrage behavior must satisfy

$$(17) \quad \frac{1 + r}{1 + q} \frac{V_t}{R_t} = 1 + \frac{V_{t+1}}{R_{t+1}}.$$

Equation (17) defines a function  $V_{t+1}/R_{t+1} = \phi(V_t/R_t)$  with  $\phi' > 1$  if  $r > q$ . Lemma 2 summarizes the implications for the balanced growth path.

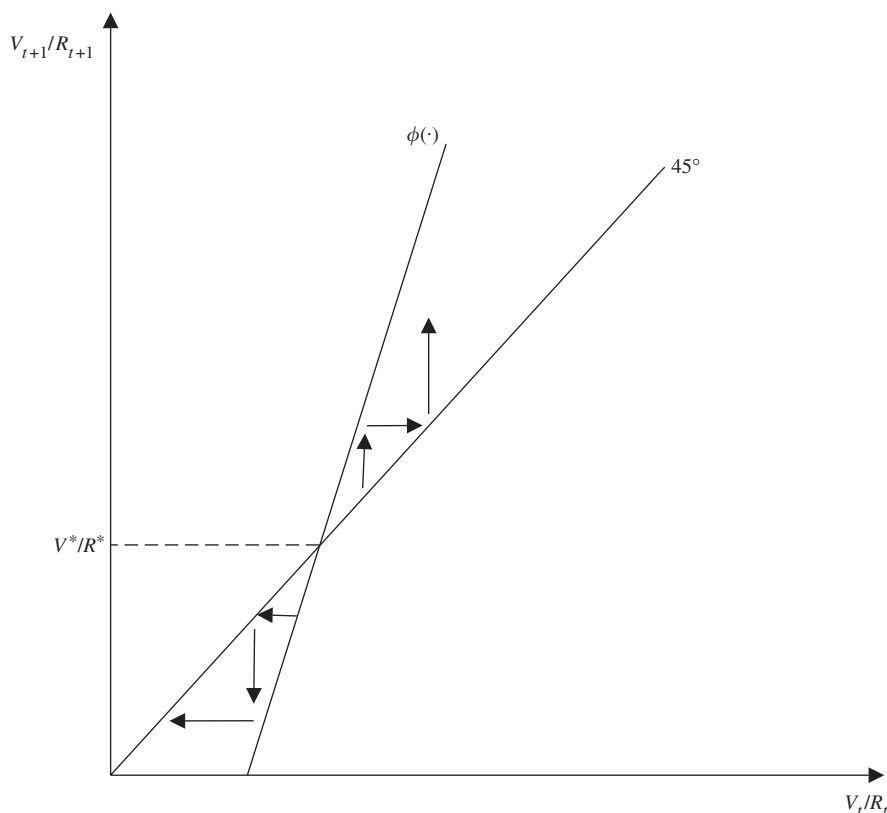


FIGURE 2. Balanced growth path for  $r > q$ .

*Lemma 2.* A unique balanced growth path exists if and only if  $r > q$ . The balanced growth path exhibits point stability.

As illustrated in Figure 2, a unique balanced growth path ratio  $V^*/R^*$  exists if and only if  $\phi' > 1$ , which holds exclusively if the interest rate exceeds the output growth rate, i.e.  $r > q$ . A positive and finite ratio of land price to land rent thus exists if the economy exhibits dynamic efficiency (Homburg 1991; Rhee 1991)<sup>15</sup>. As the economy is a price-taker in the international capital market and growth is exogenously driven, the requirement of dynamic efficiency is a necessary and sufficient assumption for a balanced growth path to exist. The balanced growth path exhibits point stability, since for any value of  $V_t/R_t \neq V^*/R^*$  the ratio  $V_t/R_t$  does not converge to  $V^*/R^*$ . Therefore, the only adjustment process consistent with perfect foresight is a jump to  $V^*/R^*$  in the period following  $V_t/R_t \neq V^*/R^*$ .

In a PAYG system  $N_{t-1}b_t = N_t c_t$ . Since  $N_t c_t = \tau^s \alpha_H Y_t$ , (9) and (15) imply that

$$\begin{aligned} x &= \frac{b_t}{c_{t-1}} - 1 \\ &= (1 + q) - 1. \end{aligned}$$

In a purely earnings-related system, the rate of return on contributions under the PAYG system equals the economy's growth rate  $q$  (Aaron 1966). Following (13) and dynamic efficiency, the earnings-related PAYG system imposes an implicit tax on contributions equal to  $\tau^s(r - q)/(1 + r) > 0$ . Given the link between  $c_{t-1}$  and  $b_t$ , only a fraction  $(r - q)/(1 + r)$  of the contribution rate  $\tau^s$  is a tax.

Using the land price equation (8) and the growth factor of land rents, the time path of land value is characterized by

$$(18) \quad V_t = R_{t+1} \frac{1}{r - q}.$$

The factor  $(r - q)^{-1}$  captures the effect of future output growth and discounting on current land value and is independent of the social security system. Any change in land value following a social security reform in period  $t$  is captured by a jump in land rents in the subsequent period.

Finally, the financial position of the country *vis-à-vis* the rest of the world must satisfy the transversality condition. When the net foreign assets of the economy in period  $t$  are denoted by  $F_t$ , the transversality condition requires that  $\lim_{T \rightarrow \infty} [1/(1 + r)]^T F_{t+T+1} = 0$  (Obstfeld and Rogoff 1996).<sup>16</sup> Here, the transversality condition is satisfied as the budget constraint is satisfied for each generation over its lifetime, and the growth rate of production as well as of land value is less than the interest rate.

## II. SOCIAL SECURITY REFORM

We assume that social security contribution rates are cut by proportion  $\omega$ ,  $\omega \in [0, 1]$ , from  $\tau^s$  to  $(1 - \omega)\tau^s$ . No reform occurs if  $\omega = 0$ , whereas  $\omega = 1$  indicates a complete transition to a fully funded system. The policy reform is announced and implemented at the beginning of period  $t^*$  before the current younger generation has decided on educational investment and the elderly have sold land to the middle-aged generation.<sup>17</sup> As we analyse a small open economy, the transition to a new steady state takes place in two periods. The investment in human capital adjusts fully to the path corresponding the new steady state after the reform has been announced, implying that the aggregate supply of labour services and the stock of physical capital adjust in the subsequent period.<sup>18</sup>

Both the young and middle-aged benefit from social security reform. While the middle-aged enjoy only a lower implicit tax on their contributions, the young also reap the benefits from less distorted educational investments. The welfare effects faced by the elderly are shaped by two conflicting forces. On the one hand, the elderly lose out because of the cut in social security benefits. On the other hand, they receive an unexpected wealth increase originating from a direct and indirect effect on educational investments. The reduced tax distortion directly increases human capital investments of the current young and future young generations, which increases land rents in all subsequent periods (starting in period  $t^* + 1$ ). Since production factors are complements, a higher stock of human capital induces an inflow of physical capital and a complementary rise in the wage rate. As an indirect effect of the reduced tax

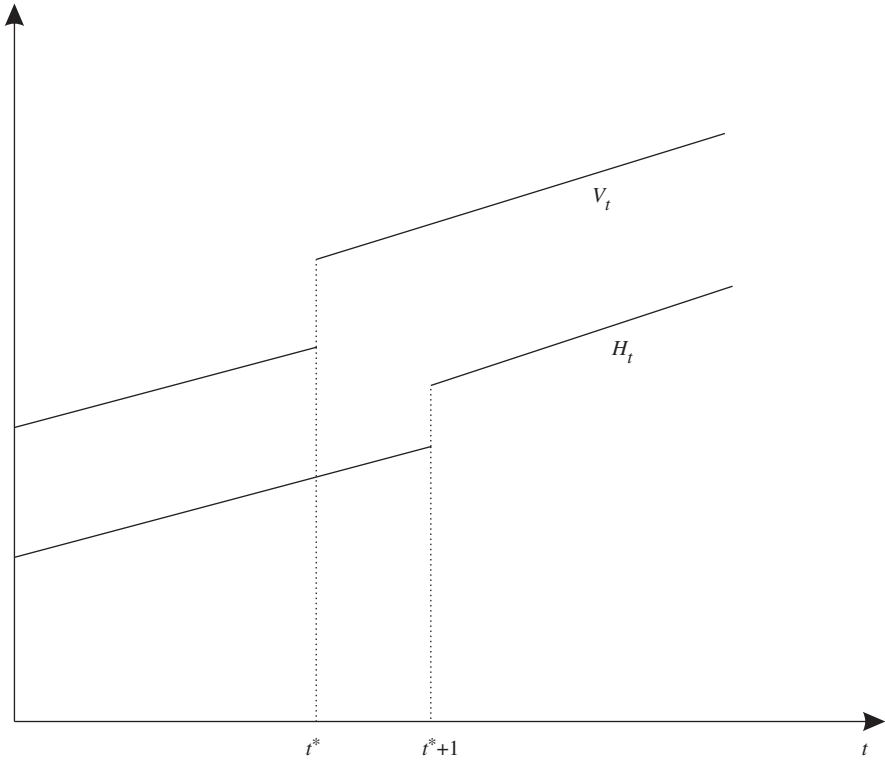


FIGURE 3. Effect of social security reform on  $H_t$  and  $V_t$ .

distortion, educational investments and land rents increase even further. Following (18), higher land rents generate an immediate jump in land value accruing to land owners; see Figure 3, assuming equal slopes of  $H_t$  and  $V_t$  for expositional simplicity. As the middle-aged have already made their investments in human capital, the value of production and wage tax revenue in the period  $t^*$  does not change, neither does the land rent accruing to the elderly before they sell the land. Denoting the social security budget in period  $t$  by  $B_t$ ,  $B_t = \tau^s \alpha_H Y_t$ , the social security reform is favoured by the older generation if and only if the increase in land value,  $\Delta V_{t^*}$ , exceeds the drop in pension benefits  $\Delta B_{t^*}$ . Measuring the changes in relation to GDP, a pension reform is Pareto-improving if and only if

$$(19) \quad \frac{\Delta B_{t^*}(\tau^s, \tau^w, \omega, \alpha_H, \alpha_K, \beta, g, n, r)}{Y_{t^*}} + \frac{\Delta V_{t^*}(\tau^s, \tau^w, \omega, \alpha_H, \alpha_K, \beta, g, n, r)}{Y_{t^*}} > 0.$$

We define

$$z := \frac{1 + q}{1 + r},$$

where  $z$  is the ratio between the gross rate of return offered by the PAYG system and the gross rate of return offered by the financial market. With dynamic efficiency ( $q < r$ ),  $z < 1$ . To understand the subsequent propositions, it is helpful to note that  $z$  depends on the output growth rate  $q$  and the interest

rate  $r$  both being exogenous. Any value  $z < 1$  can be achieved by choosing a sufficiently high value of  $r$ .

*Proposition 1.* If  $\alpha_H + \alpha_K = 1$ , there does not exist an intergenerationally Pareto-improving social security reform.

If a fixed factor is not present ( $\alpha_H + \alpha_K = 1$ ), a reform of the PAYG system is not Pareto-improving. This finding holds for any level of general wage taxation  $\tau^w \geq 0$ . The Pareto efficiency of the PAYG system holds more generally than suggested by Proposition 1. Fenge (1995) shows that even extending the set of policy instruments to include public debt would not yield a Pareto-improving pension reform.

Proposition 2 presents the main finding of the paper.

*Proposition 2.* Consider a social security reform where  $\tau^s$  is marginally reduced. For any values  $0 < \alpha_H, \alpha_K, \alpha_H + \alpha_K < 1$  and  $0 < \tau^s, \tau^w < 1$ , a sufficiently high value of  $z$ ,  $0 < z < 1$ , and an induced value of  $\beta^*(z)$ ,  $0 < \beta^*(z) < 1$ , always exists for which the reduction in benefits equals the increase in land value. Let the set of  $z$ -values that induce a  $\beta^*(z)$  be denoted by  $\Gamma$  (which is always non-empty). For all combinations of  $z \in \Gamma$  and  $\beta$ ,  $\beta^*(z) < \beta < 1$ , the social security reform is intergenerationally Pareto-improving.

A Pareto-improving reform with intergenerational trade is feasible. To illustrate Proposition 2 thoroughly, Figure 4 displays  $\beta^*(z)$  and the set  $\Gamma$  for three parameter combinations which involve a varying  $\tau^w$ . If, for the sake of illustration,  $\tau^w = 0.5$ , the set  $\Gamma = (0.38, 1)$ . It is only for these  $z$ -values that a  $\beta$ -value  $< 1$  exists which, in combination with the corresponding  $z$ -value, satisfies

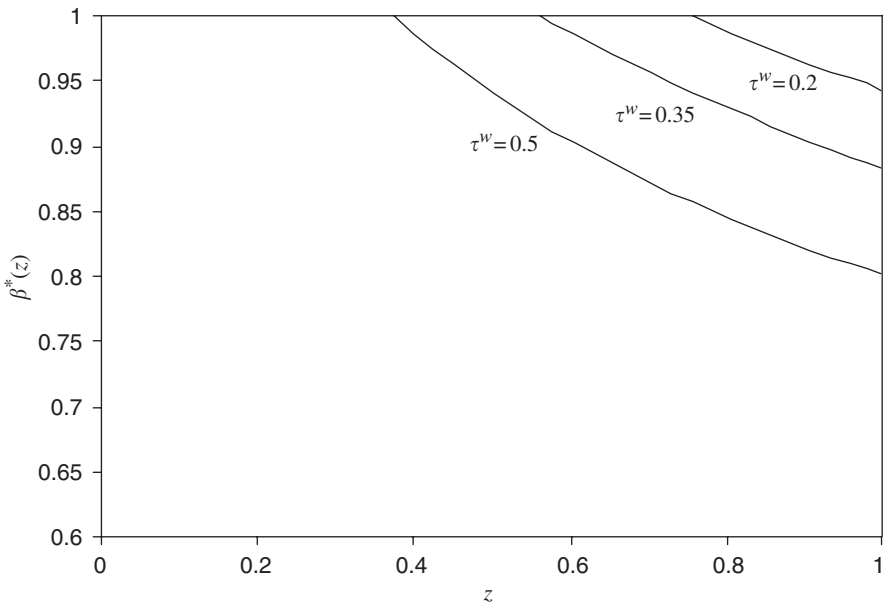


FIGURE 4.  $\beta^*(z)$  for varying values of  $\tau^w$  ( $\alpha_K = 0.2, \alpha_H = 0.6$ , and  $\tau^s = 0.2$ ).

condition (19) as an equality. Given  $z \in (0.38, 1)$ , an intergenerational Pareto improvement holds for all  $\beta > \beta^*(z)$ , as a higher elasticity of human capital supply magnifies the efficiency gains of the pension reform.

Proposition 2 and Figure 4 establish a theoretical possibility for a marginal Pareto-improving reform. From a policy perspective, an important question is whether the magnitudes of changes in land values that are implied by these reforms are reasonable. To shed further light on this question, we calculate the percentage change in land value for a cut in the social security contribution rate from 0.2 to 0.18 ( $\omega = 0.1$ ) for the values of  $\alpha_H$ ,  $\alpha_K$  and  $\tau^s$  underlying the simulation in Figure 4. We choose  $g = 0.2$ ,  $n = 0$  and  $r = 1.2$  (implying  $z = 0.9165$ ) and  $\beta = 0.9$ .<sup>19</sup> With these values, the cut in the social security contribution rate generates a Pareto improvement, and the land value increases by 0.7% if  $\tau^w = 0.5$  and by 0.5% if  $\tau^w = 0.35$ . If the PAYG reform entails a full elimination of the system ( $\omega = 1$ ), a Pareto improvement is still attainable. With  $\tau^w = 0.5$ , the associated increase in the land value would be 7.3%, and with  $\tau^w = 0.35$  it would be 5.6%.

The most stringent requirement of Proposition 2 is that the general wage tax must be strictly positive. The intuition is straightforward. The wage tax adds to the inefficiency in educational investment, owing to the implicit tax rate in the PAYG system. The distortion in educational investment is convex in the overall tax rate. Therefore, the efficiency gain of a pension reform increases over-proportionally as the initially prevailing overall tax rate rises. Figure 4 readily reveals that  $\tau^w$  is critical not only qualitatively but also quantitatively.

Proposition 2 requires that  $z$  be sufficiently high; i.e. the rate of return offered in the PAYG system and the fully funded system must be sufficiently aligned. This is a surprising finding, as it implies that a reduction in the population growth rate (lower  $q$  and thus lower  $z$ ), and therefore an increase in the dependency ratio, would actually reduce the scope for a Pareto-improving reduction in the social security contribution rate. On the other hand, reduced population growth rate may undermine the sustainability of a PAYG system since the dependency ratio goes up. Therefore, there seems to be a conflict between the implications of the demographic structure for the potential for Pareto improvements and for the sustainability of the system. The findings can be reconciled by noting that the implicit tax rate increases as  $z$  reduces, but at the same time the future productivity effects are discounted more strongly (equation (18)). The latter effect dominates, which diminishes the scope of the asset price effects to compensate the elderly.

In this framework demographic change affects asset prices in a different way from that which previous literature has focused on. Therein, the higher rate of return under a fully funded system might be partially eroded by population ageing, since future pensioners have to sell financial assets to a smaller generation of young investors when liquidating their portfolios; see Abel (2001) and Poterba (2001) for a critical evaluation of the ‘meltdown’ hypothesis. In the present paper, equilibrium land price in each period is not directly affected by a change in the ratio of the number of suppliers to demanders. Instead, negative demographic shocks reduce asset returns because of lower steady-state growth, which immediately capitalizes in asset prices.

Proposition 3 presents comparative-static results.

*Proposition 3.* (i)  $\beta^*(z)$  is decreasing in  $z$ ,  $z \in \Gamma$ .

(ii) The infimum of  $\Gamma$  is increasing in  $\alpha_K$  and decreasing in  $\alpha_H$  and  $\tau^w$ . Furthermore, keeping  $z$ ,  $z \in \Gamma$ , constant,  $\beta^*(z)$  is increasing in  $\alpha_K$  and decreasing in  $\alpha_H$  and  $\tau^w$ .

Part (i) reveals that  $z$  and  $\beta$  can be imperfectly substituted in order to sustain a Pareto improvement. Higher discounting of future productivity gains is neutralized by a higher elasticity of human capital investment, which magnifies the response of educational investment to a reduction in the implicit tax rate. The range of  $z$ -values and the critical level  $\beta^*(z)$  are influenced by the specifics of the economy.

It is *a priori* unclear how a change in  $\alpha_K$  and  $\alpha_H$  should be expected to affect the infimum of  $\Gamma$ . The first effect is that an increase in either of these shrinks the income share of land, which would suggest that the infimum of  $\Gamma$  should increase: as productivity increases accrue to a lower extent to land, it is reasonable to expect that this requires a lower discount rate  $z$  to keep the asset price adjustment at the same order of magnitude. The second effect is that an increase in either  $\alpha_K$  or  $\alpha_H$  increases the responsiveness of total production to changes in the factor whose share increases, which would suggest that the infimum of  $\Gamma$  should decrease. We find that for an increase in  $\alpha_K$  the first effect dominates, while for  $\alpha_H$  the second one is more important. This is in line with changes in adjustable physical capital stock being indirect effects, while changes in the stock of human capital are direct effects, magnified by indirectly induced effects of physical capital. A higher wage tax magnifies the distortions in educational investment which are partially eliminated by the pension reform. Discounting of productivity effects can thus be more severe—i.e. a lower value of  $z$ —and still allow for a Pareto improvement. Applying an analogous line of argument, the threshold  $\beta^*(z)$  responds similarly to the considered parameter changes as a change in  $z$  does.

At this point it is informative to relate Propositions 2 and 3 to the literature on PAYG reform using public debt to compensate the elderly. In an earnings-related PAYG system, the issuance of public debt does not yield a Pareto improvement irrespective of the pre-existing level of general wage taxation; see Fenge (1995). Intuitively, the reduction in the implicit tax rate is neutralized by the increase in wage tax necessary to service the public debt. With intergenerational trade in land, however, a lower implicit tax rate does not require adjustments in the explicit tax rate levied on future generations. The efficiency gain is permanent, and a fraction of it capitalizes in the land price. The capitalization mechanism can be interpreted as an intergenerational transfer institution which transfers part of the future efficiency gains to the elderly in a lump-sum fashion without resorting to lump-sum taxes.

Finally, we should notice that there is a further welfare gain from increased future public expenditures; see equation (10). As the general wage tax rate is kept constant, increased human capital production implies increased wage tax revenue as a result of a decreasing social security contribution rate. If instead the revenue requirement for public expenditures were to stay constant, the implied future decrease in general wage taxation would further boost human capital investment and land value in the period a reform is announced. Additionally, private consumption would increase following a reduction in the tax burden.

### III. THE RISE AND FALL OF THE PAYG SYSTEM

Our analysis in the previous section raises a legitimate question: if the elimination of a PAYG system could be a Pareto improvement, why would such a system exist? It is not plausible that a PAYG system would have been implemented in the first place if it did not benefit the older generation at that time. The creation of a PAYG system could be explained, outside our model, by arguments such as the inability of the poor to save for their retirement in the nineteenth century. However, even our basic model captures some obvious candidates for why the PAYG system could have benefited the elderly in the first place but lost its appeal subsequently. One such candidate is unequal distribution of land ownership. The poor, older, citizens without assets would favour a PAYG system, as they are not hurt by the efficiency loss capitalized in land value. Therefore, an increasing middle class with widespread stock ownership might contribute to the eroded popularity of the PAYG system among the elderly. Another obvious candidate is the secular increase in other public expenditures. An increased tax burden implies higher distortions, and increases the cost of maintaining a PAYG system. As the increase in the welfare state during the twentieth century was not anticipated when the social security system was introduced, the elderly could have supported its introduction then but now would benefit from its abolition, even if nothing other than the general wage tax rate has changed. We summarize this argument as follows.

*Proposition 4.* If the elderly are indifferent between  $\tau^s$  and  $(1 - \omega)\tau^s$ ,  $\omega > 0$ , with a given wage tax rate  $\tilde{\tau}^w$ , then they would strictly prefer  $(1 - \omega)\tau^s$  with all  $\tau^w > \tilde{\tau}^w$ .

Proposition 4 implies:

*Corollary 1.* If the elderly are currently indifferent between maintaining the current social security system and eliminating it, they would have favoured its establishment with any given lower level of wage tax rate.

The proposed explanation for the growing concern for social security reform is supported by the steady increase in the labour tax rates (besides other taxes) in major industrialized countries over the second half of the twentieth century (see Mendoza *et al.* 1994).<sup>20</sup> Daveri and Tabellini (2000) provide empirical evidence that this increase in tax ratios has lowered economic growth and, therefore, the rate of return offered by a PAYG system, which further undermines its fiscal attractiveness. Undoubtedly, the explanation will not exclusively account for the intended or already implemented reforms in a variety of countries, but it will nevertheless complement other forces such as population ageing.

### IV. CONCLUSION

In this paper we have proposed a Pareto-improving social security reform in an economy with a fixed factor of production, labelled as land. As land value

captures future land rents, intergenerational trade in land allows the pensioners of the transition generation to participate in the benefits of reducing the social security contribution rate. In the presence of general wage taxation, the capitalization mechanism may well render a reduction in the social security contribution rate Pareto-improving.

There are important caveats when drawing policy implications. The simulations are suggestive and are not meant to be calibrated to a specific economy. Thus, the results are of a theoretical nature. The compensation mechanism that we identify may none the less constitute a part of a partial social security reform. A policy-oriented analysis should calibrate the factor shares of fixed and adjustable physical capital, as well as the production function for human capital. This would call for developing a computable general equilibrium model allowing for a policy transition, as in Conesa and Krueger (1999). As the effects of the PAYG system may depend crucially on other taxes, it would be desirable to replicate the essential features of the tax system in numerical analysis. This exercise, as well as the modelling of asset price effects through a revaluation of existing physical capital (as common in tax reform analysis—see e.g. Altig *et al.* 2001), is left to future research. As applied to social security reform, the last extension is likely to strengthen our findings, since it opens up an additional intergenerational link through which the current elderly have a stake in future productivity gains.

#### APPENDIX A: SOCIAL SECURITY REFORM WITH HETEROGENEOUS POPULATION

In this appendix we analyse the conditions under which the results from Section II hold in an economy in which people differ in their abilities and in their asset ownership. Let us divide the working population in period  $t$  into  $I$  groups ( $i = 1, \dots, I$ ), so that individuals in any group  $(t, i)$  share the same ability and asset ownership characteristics. We define ability as individual ability to absorb and effectively utilize investment in human capital. A member of group  $(t, i)$  being a worker in period  $t$  has ability  $\infty > a_{t,i} > 0$ . Instead of equation (4), the production function for human capital is now

$$h_{t,i} = a_{t,i} e_{t-1,i}^\beta,$$

in which  $e_{t-1,i}$  is investment in human capital in period  $t - 1$  by individuals belonging to the ability group  $(t, i)$ . To reflect the empirical fact that workers belonging to high-income groups often have more expensive education, we assume that the cost of creating human capital stock  $a_{t,i} e_{t-1,i}^\beta$  equals  $a_{t,i} e_{t-1,i}$ . The number of workers belonging to the ability class  $(t, i)$  is  $n_{t,i}$ . We normalize the measure of ability so that the average ability is unity in each period, implying that  $\sum_i n_{t,i} a_{t,i} = N_t$ . Replacing  $e_{t-1}$  by  $e_{t-1,i}$  and the stock of human capital  $e_{t-1}^\beta$  by  $a_{t,i} e_{t-1,i}^\beta$  in the individual maximization problem (11) and solving the first-order conditions for different ability classes  $i$  yields identical investments in human capital  $\hat{e}_{t-1,i}$ . Adoption of this normalization, translates into an aggregate stock of human capital in the economy and in factor prices, both of which are identical to the case without heterogeneity.

What remains to be analysed are the welfare effects of a social security reform for different ability classes. Subsequently, we denote the share of land held in period  $t$  by the elderly members of the ability class  $(t - 1, i)$  by  $\psi_{t-1,i}$ . Corresponding to Section II, we can now derive the condition under which social security reform benefits the members of this ability class:

$$(A1) \quad \frac{n_{t-1,i}a_{t-1,i} \Delta B_t(\tau^s, \tau^w, \omega, \alpha_H, \alpha_K, \beta, g, n, r)}{N_{t-1} Y_t} + \psi_{t-1,i} \frac{\Delta V_t(\tau^s, \tau^w, \omega, \alpha_H, \alpha_K, \beta, g, n, r)}{Y_t} > 0,$$

where  $(n_{t-1,i}a_{t-1,i})/N_{t-1}$  denotes the share of social security benefits belonging to ability class  $(t-1, i)$ . If  $(n_{t-1,i}a_{t-1,i})/N_{t-1} = \psi_{t-1,i}$ , the results from Section II can be generalized to an economy with a heterogeneous population. In this case land ownership is distributed in the same way as wage income and, importantly, social security benefits.

Therefore, what is crucial in analysing the feasibility of a Pareto improvement is  $\min_i[\psi_{t-1,i}/(n_{t-1,i}a_{t-1,i}/N_{t-1})]$ , which is the ratio of the share of land owned by the members of ability class  $(t-1, i)$  to its share of wage income in period  $t-1$ , which is again equal to its share of social security benefits in period  $t$ . Let us denote the minimum value of these ratios in period  $t$  by  $\lambda_{t-1}$ . If asset ownership is perfectly correlated with wage income, then  $\lambda_{t-1} = 1$ . If land ownership were to be distributed either less or more equally than wage income and entitlement to social security benefits, this disparity would reduce scope for a Pareto improvement in the absence of capital gains taxation above the normal rate of return on fixed asset holdings. Disparity is not allowed to be too large in order for a Pareto improvement to be achieved for each ability class. If  $\lambda_{t-1}$  drops below the threshold level, there is a demand for capital gains taxation in order to redistribute the aggregate increments in land value (exceeding the reduction in the social security budget) intragenerationally to achieve Pareto improvement for all households.

## APPENDIX B: PROOFS

### *Proof of Lemma 1*

Equations (2), (4), (5) and (12) imply (14). Solving the first-order condition for  $K_t$  (equation (2)),

$$(A2) \quad K_t = \left( \frac{\alpha_K A_t H_t^{\alpha_H}}{r} \right)^{\frac{1}{1-\alpha_K}}.$$

Inserting this expression into (1) and (3) and applying (14) implies (15) and (16).  $\square$

### *Proof of Lemma 2*

By equation (17), a unique balanced growth path ratio,  $V_t/R_t = V_{t+1}/R_{t+1} = V^*/R^* \forall t$ , exists if and only if  $r > q$ . As for any  $V_t/R_t > (<) V^*/R^*$ , (17) implies that  $V_{t+1}/R_{t+1} > (<) V_t/R_t \forall t$  if  $r > q$  the balanced growth path exhibits point stability.  $\square$

### *Proof of Proposition 1*

By equations (3) and (18),

$$(A3) \quad \frac{\Delta V_t(\cdot)}{Y_t} = (1 - \alpha_H - \alpha_K) \frac{1}{Y_t} (Y_{t+1}|_{\omega > 0} - Y_{t+1}|_{\omega = 0}) \frac{1}{r - q}.$$

Following (15),

$$(A4) \quad \frac{1}{Y_t} (Y_{t+1}|_{\omega > 0} - Y_{t+1}|_{\omega = 0}) = \left( \frac{Y_{t+1}|_{\omega > 0}}{Y_{t+1}|_{\omega = 0}} - 1 \right) (1 + q).$$

Inserting (A2) into (1) and applying (5) yields

$$(A5) \quad \frac{Y_{t+1}|_{\omega>0}}{Y_{t+1}|_{\omega=0}} = \left( \frac{h_{t+1}|_{\omega>0}}{h_{t+1}|_{\omega=0}} \right)^{\alpha_H / (1 - \alpha_K)}$$

By (4), (12) and  $x = q$ , equation (A5) implies

$$(A6) \quad \frac{Y_{t+1}|_{\omega>0}}{Y_{t+1}|_{\omega=0}} = \left( \frac{\left( (1 - \tau^s(1 - \omega)) \frac{r - q}{1 + r} - \tau^w \right)^{\beta\alpha_H / (1 - \alpha_K - \beta\alpha_H)}}{(1 - \tau^s \frac{r - q}{1 + r} - \tau^w)} \right)$$

Using (A4) and (A6), (A3) becomes

$$\frac{\Delta V_t(\cdot)}{Y_t} = (1 - \alpha_H - \alpha_K) \times \left[ \left( \frac{\left( (1 - \tau^s(1 - \omega)) \frac{r - q}{1 + r} - \tau^w \right)^{\beta\alpha_H}}{(1 - \tau^s \frac{r - q}{1 + r} - \tau^w)} \right)^{\frac{\beta\alpha_H}{(1 - \alpha_K - \beta\alpha_H)}} - 1 \right] \frac{1 + q}{r - q}$$

From the definition of  $z := (1 + q)/(1 + r)$ , it follows that

$$\frac{r - q}{1 + r} = \frac{1 + r - (1 + q)}{1 + r} = 1 - z \quad \text{and} \quad \frac{1 + q}{r - q} = \frac{\frac{1 + q}{1 + r}}{\frac{r - q}{1 + r}} = \frac{z}{1 - z}$$

Introducing these terms into the expression above yields, as the change in land valuation relative to GDP,

$$(A7) \quad \frac{\Delta V_t(\cdot)}{Y_t} = (1 - \alpha_H - \alpha_K) \frac{z}{1 - z} \left[ \left( \frac{(1 - \tau^s(1 - \omega)(1 - z) - \tau^w)}{(1 - \tau^s(1 - z) - \tau^w)} \right)^{\gamma\beta\alpha_H} - 1 \right]$$

The change in benefits relative to GDP is  $\Delta B_t(\cdot)/Y_t = -\omega\tau^s\alpha_H$ . If  $\alpha_H + \alpha_K = 1$ ,  $\Delta V_t(\cdot)/Y_t = 0$ , and thus  $\Delta B_t(\cdot)/Y_t + \Delta V_t(\cdot)/Y_t \leq 0$ , violating condition (19).  $\square$

*Proof of Proposition 2*

Differentiating  $\Delta B_t(\cdot)/Y_t = -\omega\tau^s\alpha_H$  and (A7) with respect to  $\omega$  evaluated at  $\omega = 0$  gives

$$(A8) \quad \left. \frac{\partial}{\partial \omega} \frac{\Delta B_t(\cdot)}{Y_t} \right|_{\omega=0} = -\tau^s\alpha_H$$

and

$$(A9) \quad \left. \frac{\partial}{\partial \omega} \frac{\Delta V_t(\cdot)}{Y_t} \right|_{\omega=0} = (1 - \alpha_H - \alpha_K) \frac{z}{1 - z} \gamma\beta\alpha_H \frac{\tau^s(1 - z)}{1 - \tau^s(1 - z) - \tau^w}$$

where  $z := (1 + q)/(1 + r)$ . The derivative (A9) follows from

$$\left( \frac{(1 - \tau^s(1 - \omega)(1 - z) - \tau^w)}{(1 - \tau^s(1 - z) - \tau^w)} \right)^{\gamma\beta\alpha_H - 1} = 1 \quad \text{at } \omega = 0.$$

Since

$$\frac{\Delta B_t(\cdot)}{Y_t} \Big|_{\omega=0} = \frac{\Delta V_t(\cdot)}{Y_t} \Big|_{\omega=0} = 0,$$

a necessary and sufficient condition for a Pareto improvement is

$$(A10) \quad \frac{\partial}{\partial \omega} \frac{\Delta B_t(\cdot)}{Y_t} \Big|_{\omega=0} + \frac{\partial}{\partial \omega} \frac{\Delta V_t(\cdot)}{Y_t} \Big|_{\omega=0} > 0.$$

Inserting (A8) and (A9) into (A10), using  $\gamma := 1/(1 - \alpha_K - \beta\alpha_H)$  and factoring out  $\tau^s\alpha_H$  yields

$$(A11) \quad \tau^s\alpha_H \left( -1 + \beta \frac{1 - \alpha_H - \alpha_K}{1 - \alpha_K - \beta\alpha_H} \frac{z}{1 - z} \frac{1 - z}{1 - \tau^s(1 - z) - \tau^w} \right) > 0$$

$$\Leftrightarrow \beta \frac{1 - \alpha_H - \alpha_K}{1 - \alpha_K - \beta\alpha_H} \frac{z}{1 - \tau^s(1 - z) - \tau^w} > 1.$$

Note that the term on the left-hand side of (A11) is strictly increasing in  $\beta$  and  $z$ . Furthermore, observe that

$$\lim_{z \rightarrow 1} \frac{z}{1 - \tau^s(1 - z) - \tau^w} = \frac{1}{1 - \tau^w} > 1$$

and

$$\lim_{\beta \rightarrow 1} \beta \frac{1 - \alpha_H - \alpha_K}{1 - \alpha_K - \beta\alpha_H} = 1.$$

Thus,

$$(A12) \quad \lim_{z \rightarrow 1, \beta \rightarrow 1} \beta \frac{1 - \alpha_H - \alpha_K}{1 - \alpha_K - \beta\alpha_H} \frac{z}{1 - \tau^s(1 - z) - \tau^w} > 1.$$

Consequently, there is always a value of  $z$  and a sufficiently high value of  $\beta^*(z)$  such that

$$(A13) \quad \beta^*(z) \frac{1 - \alpha_H - \alpha_K}{1 - \alpha_K - \beta^*(z)\alpha_H} \frac{z}{1 - \tau^s(1 - z) - \tau^w} = 1.$$

Denote the set of  $z$ -values that induce  $\beta^*(z) \in (0,1)$  by  $\Gamma$  which is non-empty by the limes (A12). By equation (A11), for all values  $z \in \Gamma$  and  $\beta \in (\beta^*(z), 1)$  the social security reform is Pareto-improving.

*Proof of Proposition 3*

(i) Since  $\beta[(1 - \alpha_H - \alpha_K)/(1 - \alpha_K - \beta\alpha_H)]$  is strictly increasing in  $\beta$  and  $z/(1 - \tau^s(1 - z) - \tau^w)$  is strictly increasing in  $z$ ,  $\beta^*(z)$ , defined by (A13), is downward-sloping.

(ii)  $z/(1 - \tau^s(1 - z) - \tau^w)$  is strictly increasing in  $z$ . Furthermore,  $\beta[(1 - \alpha_H - \alpha_K)/(1 - \alpha_K - \beta\alpha_H)]$  is strictly decreasing in  $\alpha_K$  and strictly increasing in  $\alpha_H$ . Now, choose the infimum of  $\Gamma$  denoted  $z_{inf}$ . Using (A13),  $z_{inf}$  rises (falls) in response to a higher value of  $\alpha_K$  ( $\alpha_H$ ). Now keep  $z, z \in \Gamma$ , constant. The corresponding level of  $\beta^*(z)$  is increasing in  $\alpha_K$  and decreasing in  $\alpha_H$  and  $\tau^w$ . The latter results from the fact that  $z/(1 - \tau^s(1 - z) - \tau^w)$  is strictly increasing in  $\tau^w$ .

*Proof of Proposition 4*

For a given social security reform  $\omega > 0$ , let  $\tilde{\tau}^w$  be defined by

$$(1 - \alpha_H - \alpha_K) \frac{z}{1-z} \left[ \left( \frac{(1 - \tau^s(1 - \omega)(1 - z) - \tilde{\tau}^w)}{(1 - \tau^s(1 - z) - \tilde{\tau}^w)} \right)^{\gamma\beta\alpha_H} - 1 \right] - \omega\tau^s\alpha_H = 0.$$

Replace  $\tilde{\tau}^w$  by  $\tau^w$  in this equation and differentiate the left-hand side with respect to  $\tau^w$ :

$$\begin{aligned} & \gamma\beta\alpha_H(1 - \alpha_H - \alpha_K) \\ & \times \frac{z}{1-z} \left( \frac{(1 - \tau^s(1 - \omega)(1 - z) - \tau^w)}{(1 - \tau^s(1 - z) - \tau^w)} \right)^{\gamma\beta\alpha_H - 1} \frac{\tau^s\omega(1 - z)}{(1 - \tau^s(1 - z) - \tau^w)^2}. \end{aligned}$$

As the term is positive with any  $\omega > 0$ , an increase in the wage tax rate above  $\tilde{\tau}^w$  is sufficient to induce the elderly to favour a cut in the social security contribution rate.

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## NOTES

1. Most prominently, Feldstein (1996) advocates replacing a PAYG system by a funded one based on this argument. In contrast, see Diamond (1996) for a critical evaluation of the rate-of-return argument in restructuring social security.
2. Intragenerational redistribution is part of the social security system in many countries, but the implied inefficiencies cannot be attributed to the existence of a PAYG system, which inherently only induces intergenerational redistribution.
3. The Pareto efficiency of the PAYG system was first demonstrated in Breyer (1989) and Verbon (1989). In contrast to Fenge and Brunner, Breyer and Verbon assume an exogenous labour supply and a PAYG system with lump-sum contributions and pension benefits.
4. Evaluating the quantitative importance of the fixed factor, Laitner (2000) calculates the ratio of non-reproducible capital (which approximates the capitalized value of inelastically supplied factors) to reproducible capital in the United States. This centres around 15%–25% over the second half of the twentieth century. The stake that private households have in the productivity changes of these fixed factors appears to have increased as a result of at least two dramatic changes in US retirement saving during the last two decades. These are the transition from defined benefit plans to defined contribution plans, and the associated huge increase in the value of pension assets. Poterba *et al.* (2001) report that 59% of private retirement savings in 1980 were in employer-based defined benefit plans, while today 85% are defined contribution plans in which individuals decide on the level and investment of their contributions. At the same time, the ratio of all private retirement assets to wage and salary earnings quadrupled.
5. We are indebted to Clemens Fuest and Pierre Pestieau for suggesting this wider applicability of the mechanism we have identified.
6. The capitalization mechanism can also be involved in intergenerational provision of education. Poutvaara (2003) analyses the effects of the capitalization mechanism in the absence of social security, showing that non-altruistic landowners may gain by providing public education to the young even when the landowners cannot tax the young and when the latter face no credit constraints.

7. This results because, with proportional taxation, opportunity costs of lost earnings are reduced by the same proportion as benefits of higher wages resulting from educational investment.
8. Even with the presence of transaction costs faced by foreigners, equation (7) would hold as a strict inequality because any difference in the rate of return between the two assets would be eliminated by trade in land by domestic citizens, financed by international borrowing.
9. Though economic agents have a finite horizon, speculative bubbles are not considered as a component of the land price. Given the presence of a fixed factor, the economy turns out to be dynamically efficient, which rules out the existence of bubbles (Tirole 1985).
10. What is essential is that effective labour supply is endogenous in the second period of life. As an alternative to human capital formation, we could assume endogenous time allocation between work and leisure.
11. Without loss of generality, we assume that pensions are not taxed. If pensions were taxed, then  $b$  would be replaced by an after-tax pension.
12. The labour tax rate,  $\tau^w$ , is held constant throughout the analysis. However, public consumption,  $G_t$ , may change over time, e.g. owing to reform-induced adjustments in human capital investments.
13. Thus, welfare gains of a transition to a fully funded system cannot originate from capital market imperfections as is the case in, e.g. Börsch-Supan and Winter (2001).
14. To simplify the exposition, trade in land does not enter the maximization problem. This is justified by the fact that land value is exogenous from each individual's perspective, and thus does not affect educational investment. Furthermore, given the Fisher Separation Theorem, the saving decision does not have to be made explicit when analysing optimal educational investment. It serves exclusively to implement the optimal life-cycle consumption plan. The investment of savings in the international capital market and land market, in turn, follows from the arbitrage condition (7).
15. The result is not specific to Cobb–Douglas production function. With a more general production technology, land continues to preclude dynamic inefficiency if land is essential, meaning that the income share of land does not vanish asymptotically (Rhee 1991).
16. As saving and investment in the following period's capital stock take place at the end of the period, it follows that  $F_t = N_{t+1}S_t^1 + N_tS_t^2 - K_{t+1}$ .
17. It is important for our result that land is owned by the elderly at the time of policy announcement and implementation, which implies that both capital gains and reduced pension benefits accrue to current pensioners.
18. In cases where distortions would arise from labour–leisure choice, instead of distorted investment in human capital, production and land rents would adjust already in the period of reform announcement and implementation.
19. Assuming that each period is of 20 years' duration, this corresponds to an annual interest rate of 4.0% and an annual increase in the productivity parameter of 0.9%.
20. For instance, the macroeconomic US labour income tax rate rose from roughly 18% in 1965 to 29% in 1988. Over the same time span, labour income tax rates steadily increased from 15% to 26% in Japan, from 20% to nearly 27% in the UK, from almost 13% to 28% in Canada and from 30% to 41% in West Germany; see Figure 2 in Mendoza *et al.* (1994).

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