PUBLIC EDUCATION AND PENSIONS IN DEMOCRACY: A POLITICAL ECONOMY THEORY

Francesco Lancia
University of Vienna

Alessia Russo
University of Oslo

Abstract
A dynamic political economy theory of fiscal policy is presented to explain the simultaneous existence of public education and pensions in modern democracies. The driving force of the model is the intergenerational conflict over the allocation of the public budget. Successive generations of voters choose fiscal policies through repeated elections. The political power of elderly voters creates the motive for adults to support public investment in the human capital of future generations since it expands future pension possibilities. We characterize the Markov perfect equilibrium of the voting game in a small open economy. The equilibrium reproduces salient features of intergenerational fiscal policies in modern economies. (JEL: D72, E62, H23, H30, H53)

1. Introduction

In all modern democracies, a central concern of governments is the public financing of education and pensions, each of which is targeted towards a different cohort. While public education is an investment in future generations, public pensions are a transfer to the past generation. When both programs are financed by the current generation via taxation, an intergenerational conflict arises over the financing and allocation of the public budget. In modern democracies, agents vote on fiscal policy through the election of representatives. However, future generations do not vote and the past generation is only a minority of the electorate. Therefore, the following question naturally arises. Why do democratic institutions implement both public education and pension programs?

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E-mail: francesco.lancia@univie.ac.at (Lancia); alessia.russo@econ.uio.no (Russo)

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Ever since the seminal paper of Pogue and Sgotz (1977), a vast literature has debated the link between public education and pensions. The normative approach in the literature justifies the existence of the link as a means to support complete market allocations (see, e.g., Becker and Murphy 1988; Boldrin and Montes 2005). In this approach, public education and pensions are treated as exogenous policies. However, in modern democracies, fiscal policies are endogenously set by policy makers without committing to future policies. The positive approach involves the endogenous emergence of public education and pensions. Some of the models that use this approach are motivated by altruism (see, e.g., Tabellini 1991), while others focus on reputational concerns (see, e.g., Bellettini and Berti Ceroni 1999; Rangel 2003). These models build on the idea that collective decisions are based on generosity, and transfers are linked to past contributions. In the real world, however, voters are anonymous and governments have short-term mandates. An alternative and more macro-oriented positive approach examines the endogenous emergence of policies in the absence of altruism and reputational concerns. It highlights general equilibrium effects on prices as the incentive device through which intergenerational exchanges emerge (see, e.g., Gonzalez-Eiras and Niepelt 2012). In modern economies, however, financial markets are integrated and worldwide prices are at most weakly responsive to domestic policies.

We aim to construct a positive theory according to which public education and pensions are determined through elections in the absence of altruism, commitment, reputation, and general equilibrium effects on prices. Our view of modern democracies is as follows. Governments have short-term mandates and must be attentive to the well-being of current workers and retirees since individuals in both groups can vote. Retirees are naturally motivated to support high labor taxes to finance spending on pensions. Workers dislike taxes since they reduce private consumption. Governments, therefore, will provide pensions, whose amounts will be set to balance the marginal impact on the utility of the two groups. It follows that pension transfers increase with the labor earnings of workers and in turn with their human capital. The existence of this positive link provides the motive for governments to strategically support education investments which will benefit future generations. By doing so, future workers will have higher incomes, which will give the subsequent government a reason to redistribute to future retirees. Therefore, governments will provide both public education and pensions in order to win elections by addressing the economic needs of their constituencies.[1]

The key feature of this intergenerational mechanism is the government's lack of commitment to future policies. Indeed, fiscal policies in each period are determined by the dynamic games between successive governments. Even though governments have short-term mandates, they can manipulate the human capital stock inherited by their successors through their choice of the level of education investment, which in turn affects future pensions. This strategic use of human capital allows policy makers

1. The relationship between human capital and pensions can be observed in the results of our regressions for OECD countries for the period 1995–2009. The regressions show that an increase in the level of human capital increases the generosity of pension transfers. This is the case after controlling for other factors that would be expected to influence the size of pensions. See Appendix A.1.

to buy the votes of workers without jeopardizing the votes of retirees. A government's strategic use of human capital, however, fundamentally hinges on the distribution of political power among voters. In fact, there will be no education investment if only workers or only retirees exert political power. In the former case, the incentive for workers to support investment in future generations disappears if a political rent in the form of pension benefits cannot be extracted from younger generations. In the latter case, retirees fiercely oppose spending on public education since they receive no direct benefit from it. When both groups hold political power, the existence of a political rent for retirees can stimulate public education insofar as it garners political support for growth-oriented policies.

We embed this intergenerational mechanism in a dynamic model of human capital accumulation à la Boldrin and Montes (2005). The basic structure is that of an overlapping generations world in which individuals live for three periods: young, adult, and elderly. They acquire skills during the first period, work and partially save from their income during the second period, and receive a pension benefit in addition to the return on their private savings during the last period. Apart from their age and economic role in society, agents are identical. We depart from Boldrin and Montes's setup in two main respects. First, we endogenize public education and pension policies by introducing electoral competition. In each period, adults and the elderly elect a government according to a majority rule. We model electoral competition using a probabilistic voting model (Lindbeck and Weibull 1987), in which the government maximizes a weighted sum of indirect utilities of current voters, with no concern for the well-being of future generations. The role of the policy maker is to establish fiscal budgets to finance education and pensions. The government has full commitment during its tenure, but cannot commit on behalf of its successors. Second, we focus on a small open economy, in which the interest rate is determined at the worldwide level and physical capital accumulation is independent of domestic saving, thereby excluding general equilibrium effects on prices as a possible determinant of the emergence of fiscal policies.

We restrict our attention to stationary Markov perfect equilibria of the dynamic games between successive governments. By using this equilibrium concept, we rule out equilibria in which current political outcomes are directly dependent on past ones. We believe this to be an appropriate concept for the model, in which a period is long and electoral competition among agents takes place in each period. We demonstrate the existence of a Markov perfect equilibrium characterized by public education and pensions under alternative economic scenarios. We start with the simplest case, in which human capital is the sole payoff-relevant state variable, in order to highlight the main insights of the model. We then add a private saving technology and show that the strategic role of human capital is still relevant even when the presence of private financial wealth reduces the demand for public pensions. In this context, we show that the crowding-in effect of public education on pensions prompts governments with a short-term mandate to internalize intergenerational human capital spillover, as would a Ramsey planner who weighs the utility of all future generations. Finally, we examine the case of distortionary taxation to test the robustness of the analytical results. A calibrated version of the model delivers empirically plausible values of intergenerational fiscal policies in OECD countries.[2]

The model produces results consistent with existing empirical evidence. First, the model predicts that the political power of the elderly has a negative impact on education investment as a share of GDP and a positive influence on pension transfers as a share of GDP. Second, the model predicts that a demographic transition, consisting of a baby boom followed by a baby bust, is accompanied by an initial drop in spending on education per student and in pensions per retiree and a subsequent rapid recovery of total expenditure. After such a transition, pensions per retiree eventually contract as the young cohort shrinks. This pattern resembles the post-war dynamics of public education investment and pension transfers in OECD countries.

The paper contributes to the literature on redistribution and growth. Political economy models of growth suggest that political conflict over the allocation of the public budget leads to extensive redistribution, which depresses growth (see, e.g., Alesina and Rodrick 1994; Azzimonti 2011; Battaglini and Coate 2007; Krusell, Quadrini, and Ríos-Rull 1997; Persson and Tabellini 1994). They show that governments tend to be endogenously short-sighted as long as representatives compete to retain power via the democratic process. As a result, the economy experiences underinvestment in productive assets. The current model offers a different perspective according to which intergenerational conflict over the allocation of the public budget may stimulate growth and improve welfare as long as redistribution is crucial to buying political support for growth-oriented policies.

The paper is also related to the recent literature on intergenerational conflict over the financing and allocation of the public budget, while abstracting from reputation and general equilibrium effects on prices. However, this literature looks at a different set of questions. Some authors study the relationship between taxes and transfers in the presence of private assets, including private financial wealth (see, e.g., Azariadis and Galasso 2002; Bassetto 2008; Grossman and Helpman 1998; Hassler, Storesletten, and Zilibotti 2007) or private human capital (see, e.g., Chen and Song 2014). Others examine the sustainability of redistributive fiscal policies in the presence of public assets, including public debt (see, e.g., Müller, Storesletten, and Zilibotti 2016; Song, Storesletten, and Zilibotti 2012; Song, Storesletten, and Zilibotti 2015). In contrast to these models, we study the relationship between taxes, transfers, and public investment in a setting where the government manipulates both private and public assets.[3]

2. Although the baseline model is quite stylized, the main predictions remain substantively unchanged even with the addition of more realistic features. For instance, the introduction of capital income taxation is inconsequential as long as assets can move after the tax announcement. Indeed, the tax rate in the political equilibrium would be zero. Similarly, the qualitative results are unchanged if one assumes that agents work for more than one period. Indeed, incentives for workers to support education investment before retirement in order to increase rent opportunities after retirement remain in place.

3. It is worth mentioning the literature on the determination of social security programs in a closed economy with physical capital accumulation (see, e.g., Cooley and Soares 1999; Forni 2005; Gonzalez-Eiras and Niepelt 2008; Mateos-Planas 2008). In this environment, social security reduces private savings

Methodologically, the paper is related to Klein, Krusell, and Ríos-Rull (2008), who also characterized the Markov perfect equilibrium of a dynamic game in terms of a generalized Euler equation for government expenditures. However, they focus on a redistributive economy with no productive public investment and no intergenerational conflict.

The paper proceeds as follows. Section 2 describes the model. Section 3 defines the political equilibrium concept. Section 4 presents the main results and reviews the equilibrium policy in the presence of lump-sum taxes. Section 5 introduces distortionary taxation and illustrates the quantitative experiments. Section 6 concludes. The Appendix provides additional results (not included in the text) and the proofs.

2. The Model

Time is discrete, indexed by t, and runs from zero to infinity. The model consists of a small open economy populated by overlapping generations of three-period-lived agents. Within each generation, individuals are selfish and homogeneous. Agents acquire skills in the first period, work and save in the second, and retire in the third. Every adult gives birth to n children, so that each generation is n times the size of the proceeding one.

Production. At each time t, the economy produces private goods via market and household production. Market technology employs physical capital, k_t, and effective labor as inputs in the production function $y_t = Qk_t^{\alpha}(l_t h_t)^{1-\alpha}$, where h_t and l_t are respectively the units of human capital and the units of labor supplied by each worker, and Q is the total factor productivity. Physical capital is perfectly mobile between countries and depreciates fully after one period. We denote the constant world interest rate as R. In a perfectly competitive factor market, $k_t = (\alpha Q/R)^{1/(1-\alpha)} l_t h_t$ and the wage per unit of effective labor is $w = (1-\alpha)Q(\alpha Q/R)^{\alpha/(1-\alpha)}$. To simplify the exposition, we normalize Q so that w is equal to unity. Apart from market production, workers devote the remaining share of their unitary time endowment to household production. The technology of household production is given by $F(l_t)h_t$, where $F_l < 0$, $F_{ll} \leq 0$, $F_{lll} < 0$, and $F(1) = 0$.

Human Capital. The human capital of a working adult born at time t is $h_{t+1} = H(f_t, h_t) \equiv Ah_t^{\theta} f_t^{1-\theta}$ where f_t denotes the physical resources invested in her education when she was young and h_t is parental human capital. The implications of the human capital technology are worth mentioning. First, it emphasizes the productivity-enhancing role of education investment. Second, it suggests that the resources invested in education affect not just the labor productivity of the next generation but that of all future generations as well. Therefore, intergenerational human capital spillovers

and raises the return on capital. It turns out that the choice to implement and sustain a social security system depends crucially on these relationships.

are present.[4] We assume that markets in which young agents can borrow physical resources to finance their education do not exist. In this context, the presence of the government is justified by the need to finance the provision of public education and, in turn, sustain growth.[5]

Government. At the beginning of each period, the agents in the economy choose a government via elections (to be described in what follows). The elected government uses its fiscal authority to tax labor market earnings in order to provide education and pensions. Education investment is financed from a labor tax at the rate of $\tau_t \in [0, 1]$ and pension transfers are financed from a payroll tax at the rate of $z_t \in [0, 1]$. We assume that governments are prevented from borrowing and lending. Thus, the public sector operates under the following balanced-budget constraints:

$$\tau_t l_t h_t = n f_t \tag{1}$$

and

$$z_t l_t h_t = (1/n)\, b_t \tag{2}$$

with b_t denoting the pension paid to each retiree. Fiscal feasibility requires nonnegative education investment and pension transfers at any t.[6]

Households. Agents consume c_t^a as adults and c_{t+1}^o as retirees. We assume additively separable logarithmic preference for private consumption. Thus, the utility of an adult at time t can be written as $\log(c_t^a) + \beta \log(c_{t+1}^o)$, where $\beta \in (0, 1)$ is the discount factor.[7] Adults use their total after-tax labor income for consumption and saving, s_t, so that when they retire, they consume pension transfers and capitalized savings at the rate R. The per-period budget constraints for adults and the elderly, therefore, are respectively $c_t^a + s_t \leq (1 - \tau_t - z_t) l_t h_t + F(l_t) h_t$ and $c_{t+1}^o \leq R s_t + b_{t+1}$.[8] We

4. It is important for the analysis that education investment increases future labor productivity. The presence of intergenerational human capital spillover is, however, not essential. The qualitative results will be preserved provided that education investment and labor earnings in two successive periods are positively related.

5. In reality, credit markets to finance education investment are rare. The reasons have been widely investigated (see, e.g., Becker and Murphy 1988; Boldrin and Montes 2005). A consequence of this market restriction is that the economy immediately converges to a steady state with no human capital if f_t is not publicly provided. As we will see in what follows, this does not necessarily build in the demand for public education. In fact, it may be optimal for governments not to finance education. In Online Appendix B.2, we allow for the existence of a market for student loans and show that the main insights of the paper hold true in the presence of private education.

6. The assumption that $b_t \geq 0$ is the natural constraint in an environment with pension programs and can be motivated by incentive considerations. The elderly have no future and, if they are required to pay for transfers to younger generations, they would default on their obligations. This is reflected in the existence of active lobby groups of retirees.

7. Log utility is adopted for tractability. In a companion paper (Lancia and Russo 2012), we generalize the analysis to the CES utility function.

8. Using this formulation, we rule out any wealth effect on labor supply decisions in the spirit of Greenwood, Hercowitz, and Huffman (1988).

note that the government cannot tax household production. Hence, taxation distorts the agents' labor supply in the market. At $t = 0$, every adult owns h_0 units of human capital and every retiree has s_{-1} units of private financial wealth.

After fiscal policies have been chosen for the current period, adults allocate their time in order to maximize total after-tax labor income and allocate their savings to equalize the interest rate and the marginal rate of substitution in consumption. Logarithmic utility implies that

$$l_t = L(\tau_t, z_t) \equiv -(F_l)^{-1}(1 - \tau_t - z_t)$$

and

$$s_t = S(\tau_t, z_t, h_t, b_{t+1}) \equiv (\beta/(1+\beta))((1 - \tau_t - z_t)L(\tau_t, z_t) + F(L(\tau_t, z_t)))h_t - (1/R(1+\beta))b_{t+1}.$$

The indirect utility of adults and the elderly are given by

$$\mathcal{U}^a\left(\tau_t, z_t, h_t, b_{t+1}\right) = \log\left(C^a\left(\tau_t, z_t, h_t, b_{t+1}\right)\right) + \beta \log\left(C^o\left(\tau_t, z_t, h_t, b_{t+1}\right)\right)$$

and

$$\mathcal{U}^o\left(b_t, s_{t-1}\right) = \log\left(Rs_{t-1} + b_t\right),$$

where $c_t^a = C^a(\tau_t, z_t, h_t, b_{t+1})$ and $c_{t+1}^o = C^o(\tau_t, z_t, h_t, b_{t+1})$ are the optimal consumption allocations obtained by plugging the optimal private savings and labor supply into the per-period budget constraints.

Elections. Governments are democratically elected to office through repeated elections according to a majority rule. A government can hold office for one period and cannot commit on behalf of its successors. We model the electoral competition as a probabilistic voting model à la Lindbeck and Weibull (1987). An explicit microfoundation is provided in Online Appendix B.1.[9] In this electoral model, the equilibrium fiscal platform maximizes a weighted sum of the indirect utilities of current voters, with no concern for the well-being of unborn generations. The young have no political power.[10] Hence, the political objective function is given by $\mathcal{U}^a(\tau_t, z_t, h_t, b_{t+1}) + (\phi/n)\mathcal{U}^o(b_t, s_{t-1})$ where the weight reflects two elements: (i) the dependency ratio $1/n$ and (ii) the political power of elderly voters relative to adult voters $\phi \in [0; \infty)$. When $\phi = 0$, adult voters hold the only relevant political power. In contrast, when ϕ approaches infinity, the dominance of elderly voters determines the electoral process.

9. Probabilistic voting has been extensively studied both theoretically and empirically. By representing the interests of both age groups in society, it can adequately reproduce the political process in representative democracies. For example, Stromberg (2008) uses probabilistic voting to study presidential elections in the United States and shows that the model can explain candidates' behavior. See Persson and Tabellini (2000) for a formal discussion.

10. This assumption matches the empirical evidence that young voters have lower turnout than adults or the elderly. For example, in a study of US elections, Galasso and Profeta (2004) show the turnout rate among 60–69 year olds to be double that of 19–29 year olds.

3. Political Equilibrium

We now turn to characterizing the equilibrium policy rules. The key feature of the environment concerns the government's lack of commitment to future policies. Indeed, fiscal policies in each period are determined by the dynamic games between successive governments. Therefore, expectations of future policy outcomes are to be formed. In order to limit the set of potential equilibria, we rule out reputation mechanisms and restrict attention to stationary Markov perfect political equilibria (hereafter, MPE) where strategies are conditioned only on the current payoff-relevant state variables of the economy. For governments, the payoff-relevant state variables are the assets held by the constituencies—that is, human capital held by working, tax-paying adults and private financial wealth held by retirees. The equilibria characterized here correspond to the limits of a finite-horizon MPE (Fudenberg and Tirole 1991). The equilibrium objects of interest are the fiscal policy rules and the rules governing the evolution of the asset variables. Hereafter, unless otherwise specified, we omit t indices and use recursive notation, with primes denoting next-period variables and $s_{\_}$ the private financial wealth held by the current elderly.

DEFINITION 1. An MPE is defined as a 5-tuple $\langle \mathcal{F}, \mathcal{T}, \mathcal{B}, \mathcal{Z}, \mathcal{A} \rangle$, where $\mathcal{F} : \mathbb{R}_+ \times \mathbb{R}_+ \to \mathbb{R}_+$ is the education investment rule, $f = \mathcal{F}(h, s_{\_})$, $\mathcal{T} : \mathbb{R}_+ \times \mathbb{R}_+ \to [0, 1]$ is the labor tax rule, $\tau = \mathcal{T}(h, s_{\_})$, $\mathcal{B} : \mathbb{R}_+ \times \mathbb{R}_+ \to \mathbb{R}_+$ is the pension transfer rule, $b = \mathcal{B}(h, s_{\_})$, $\mathcal{Z} : \mathbb{R}_+ \times \mathbb{R}_+ \to [0, 1]$ is the payroll tax rule, $z = \mathcal{Z}(h, s_{\_})$, and $\mathcal{A} : \mathbb{R}_+ \times [0, 1] \times [0, 1] \times \mathbb{R}_+ \to \mathbb{R}_+$ is the optimal private saving rule, $s = \mathcal{A}(f, \tau, z, h|\mathcal{B})$, such that:

(i) for a given $\mathcal{B}$, the optimal private saving rule is the map $\mathcal{A}(f, \tau, z, h|\mathcal{B})$ that solves

$$S\left(\tau, z, h, \mathcal{B}\left(H\left(f, h\right), \mathcal{A}\left(f, \tau, z, h|\mathcal{B}\right)\right)\right) = \mathcal{A}\left(f, \tau, z, h|\mathcal{B}\right),$$

where $b' = \mathcal{B}(h', s)$ with $h' = H(f, h)$;

(ii) given the political objective function

$$\mathcal{W}\left(f, \tau, b, z, h, s_{\_}|\mathcal{B}\right) \equiv \mathcal{U}^a\left(\tau, z, h, b'\right) + (\phi/n)\, \mathcal{U}^o\left(b, s_{\_}\right),$$

where $b' = \mathcal{B}(h', s)$ with $h' = H(f, h)$ and $s = \mathcal{A}(f, \tau, z, h|\mathcal{B})$, the equilibrium fiscal policies solve

$$\left\langle \mathcal{F}\left(h, s_{\_}\right), \mathcal{T}\left(h, s_{\_}\right), \mathcal{B}\left(h, s_{\_}\right), \mathcal{Z}\left(h, s_{\_}\right) \right\rangle = \arg\max_{f,\tau,b,z} \mathcal{W}\left(f, \tau, b, z, h, s_{\_}|\mathcal{B}\right)$$

subject to the public balanced-budget constraints

$$\mathcal{T}\left(h, s_{\_}\right) L\left(\mathcal{T}\left(h, s_{\_}\right), \mathcal{Z}\left(h, s_{\_}\right)\right) h = n\mathcal{F}\left(h, s_{\_}\right)$$

and

$$\mathcal{Z}\left(h, s_{\_}\right) L\left(\mathcal{T}\left(h, s_{\_}\right), \mathcal{Z}\left(h, s_{\_}\right)\right) h = (1/n)\, \mathcal{B}\left(h, s_{\_}\right).$$

Point (i) defines a functional equation that maps current fiscal policies and human capital stock to optimal private savings, $s = \mathcal{A}(f, \tau, z, h|\mathcal{B})$. This rule describes the private sector's response to changes in f, τ, and z, under the expectation that future pensions will be set according to the equilibrium rule $\mathcal{B}(h', s)$. Point (ii) describes the government's problem. In each period, the government sets fiscal policies subject to the public balanced-budget constraints and the private sector's response, consistent with the expectation that future governments will follow the MPE rules. Even though the policy maker only holds office for one period and cannot commit to future policies, she can strategically use the fiscal authority to manipulate the decisions of future policy makers by determining the amount of human capital and private financial wealth available to her successors.

DEFINITION 2. A *Political Intergenerational State* (hereafter, PIS) is an MPE that implements both public education and pensions.

The democratic setup described here highlights the relative political pressure that each age group can exert. A PIS therefore may be politically viable in spite of the opposition from a certain sector of the population that favors the termination of the fiscal program. Elderly voters always gain from the implementation of a PIS since it awards them a pension at zero cost. Adults, however, gain if and only if the program's internal rate of return is greater than the return on private savings. The internal rate of return in a PIS is equal to the ratio of pension transfers received when one is elderly to taxes paid to finance education and pensions when one is an adult—namely,

$$\frac{b'}{(\tau + z)\, L\,(\tau, z)\, h + d\,(\tau, z)}, \tag{3}$$

where $d(\tau, z) = (L(0,0) + F(L(0,0)) - (L(\tau, z) + F(L(\tau, z))))h$ measures the earnings loss caused by the distortionary effect of taxing labor supply. In the remainder of the paper, we analyze the conditions under which a PIS is politically sustainable and discuss its implications for the welfare of constituencies.

4. Inelastic Labor Supply

In this section, we provide an analytical characterization of political equilibrium under the assumption that agents' labor supply is inelastic, implying that policy makers have access to lump-sum taxes. In particular, we set $L(\tau, z) = 1$. In order to focus on the role of the outlined democratic institution in sustaining a PIS, we first define human capital to be the sole payoff-relevant state variable (Section 4.1). We then test the robustness of the intergenerational mechanism in the presence of private financial wealth (Section 4.2).

4.1. The Strategic Role of Human Capital

An important feature of the environment concerns the non-appropriability of the benefits derived from public investment in the human capital of future generations by current taxpayers. These benefits could be accessed through two channels: the increased marginal productivity of physical capital and the growth of labor productivity. The increased productivity of labor is lost on retirement, while an increase in the marginal productivity of physical capital cannot occur in a small open economy. In this context, we show how a democratic institution that politically empowers both adult and elderly voters can render otherwise impracticable levels of human capital investment politically viable.

We consider a simple economy in which individuals are prevented from saving privately. Thus, point (i) of Definition 1 does not apply. Since taxes are not distortionary, we use $\tau = n \cdot (f/h)$ and $z = (1/n) \cdot (b/h)$, so that the consumption of adults and retirees can be written as $C^a(f, b, h) \equiv h - nf - b/n$ and $C^o(b) \equiv b$, respectively. Given the pension transfer rule $\mathcal{B}(h)$, the political objective function to be maximized with respect to the current policies b and f is

$$\mathcal{W}(f, b, h|\mathcal{B}) \equiv \log(C^a(f, b, h)) + \beta \log(b') + (\phi/n) \log(C^o(b)),$$

where $b' = \mathcal{B}(H(f, h))$. An MPE is then characterized by a system of two functional equations:

$$\frac{c^a}{c^o} = \frac{1}{\phi} \tag{4}$$

and

$$\frac{b'}{b} = \frac{\beta}{\phi n} \cdot \mathcal{B}_{h'} \cdot H_f, \tag{5}$$

where $\mathcal{B}_{h'} \cdot H_f$ denotes the total derivative of the next-period pension transfers with respect to the current investment in human capital. Equation (4) yields the intra-temporal tradeoff between the marginal cost of taxation borne by adults and the marginal benefits of pension transfers enjoyed by the elderly. This tradeoff is entirely determined by the political power of currently living constituencies and reveals a conflict of interest between adult and elderly voters. The elderly want higher taxes to finance higher retirement benefits. Thus, the more power held by the elderly relative to adults—that is, the higher ϕ is—the lower will be c^a/c^o. Equation (5) is the generalized Euler equation for education investment. Its right-hand side (and in particular $\mathcal{B}_{h'} \cdot H_f$) captures the return on an additional unit of education investment in the form of next-period pension transfers. This is the key equilibrium condition and reveals the government's motive to optimally provide both pensions and investment in education.

The intuition behind the government's optimal tradeoffs between the costs and benefits of public expenditure is straightforward. The government must be attentive to the well-being of the retired elderly and adults who work and pay taxes because both groups hold political power. Hence, pensions will be provided in equilibrium so as to balance between the marginal utility of adults and that of the elderly. It follows that pension transfers will increase with the consumption of adults and in turn with their labor earnings and human capital. Indeed, human capital will decrease the marginal utility from taxpayer consumption, which in turn will require more transfers to the elderly in the optimum. The existence of this positive link provides the motive for the current government to strategically support human capital investment for the benefit of future generations. By doing so, future taxpaying workers will have higher income, thus giving future governments a reason to redistribute to future retirees. The equilibrium is characterized by the following proposition.

PROPOSITION 1. *When $\phi > 0$, there exists a PIS characterized by:*

(i) *the following set of fiscal policy rules,*

$$\begin{aligned} f &= \mathcal{F}(h) \equiv \frac{\beta(1-\theta)}{\phi + n(1+\beta(1-\theta))} h, \\ \tau &= \mathcal{T}(h) \equiv n \cdot (\mathcal{F}(h)/h), \\ b &= \mathcal{B}(h) \equiv \frac{n\phi}{\phi + n(1+\beta(1-\theta))} h, \\ z &= \mathcal{Z}(h) \equiv (1/n) \cdot (\mathcal{B}(h)/h); \end{aligned}$$

(ii) *the following law of motion for human capital,*

$$h'/h = A(\mathcal{F}(h)/h)^{1-\theta}.$$

The education investment rule and the pension transfer rule are linear and increasing functions of adults' labor market earnings.[11] Moreover, $\mathcal{B}_\phi > 0$ and $\mathcal{F}_\phi < 0$ imply that pension transfers are more generous and education investment less so when elderly voters have relatively more political power.

The result of Proposition 1 fundamentally hinges on adults' prospect of claiming a share of the future returns on public investment via pension transfers, namely $\phi > 0$. If adults are prevented from extracting rent through the exercise of political power when they are old, the incentive to support public education disappears. The intuition behind this result is easily illustrated. Consider a finite-horizon economy and solve by backward induction. At the terminal period, adults have no future and the elderly hold no political power, namely $\phi = 0$. Thus, pensions are not provided since it is not in the government's interest. In the preceding period, the government in power anticipated that the cost of financing education borne by the adults would not be compensated for through pension transfers by its successor. Public education and pensions, therefore,

11. This result is in line with the empirical evidence appearing in Table A.1 of Appendix A.1 and contrasts with Chen and Song (2014) who predict that human capital and pensions will be negatively correlated in an environment in which individuals modify their private education decision in response to a change in the labor tax rate. These authors focus on a different political mechanism (median voter) and abstract from public education.

turn out to be politically impracticable in each period. In summary, granting political power to the elderly creates a motive for adults to publicly save for retirement by investing in the human capital of the young.[12]

Having characterized a PIS, we now turn to evaluating its implications for the welfare of adult voters. In the absence of any nonperishable private good, a PIS makes adults better off since it allows them to consume during their retirement. Moreover, the larger the internal rate of return in a PIS, the higher will be the welfare of adults. Inserting the equilibrium policy rules of Proposition 1 into equation (3) yields

$$\frac{b'}{h\left(\tau+z\right)}=\underbrace{\frac{\phi}{\phi+n\beta\left(1-\theta\right)}}_{\text{Appropriability}}\;\underbrace{n\,\frac{h'}{h}}_{\text{Growth}}. \tag{6}$$

The internal rate of return is made up of two components: growth and appropriability. As in the literature, the growth component measures the endogenous growth rate of the tax base.[13] The appropriability component, which is a distinctive feature of our model, captures the ability of retirees to exercise a political claim on the public investment they supported as adults. Equation (6) has an interesting property, which is highlighted in the following corollary.

COROLLARY 1. *The internal rate of return in a PIS is hump-shaped in ϕ.*

An increase in the political power of retirees relative to adult voters has a twofold impact on equation (6). On the one hand, it strengthens the appropriability component. On the other hand, it depresses the growth component since it reduces human capital investment. The sign of the relation between ϕ and the internal rate of return in a PIS is determined by which of these two effects is dominant. When the relative political power held by retirees is sufficiently high, the latter effect will dominate. Only when ϕ falls below a critical level does the former effect prevail since the appropriability component increases in tandem with the relative political power of the elderly at a decreasing rate and is bounded above by one. Consequently, the negative effect on the growth component starts to dominate when ϕ becomes sufficiently large. In short, the internal rate of return in a PIS may increase and in turn adults may improve their well-being by surrendering part of their political power to elderly voters if they have sufficient political power to start with.

12. It is worth noting that $\mathcal{F}(h)$ is a discontinuous map in ϕ. This is because the marginal benefits of an additional unit of education investment in terms of pension transfers tend to infinity when ϕ approaches zero. Hence, human capital investment is high when ϕ is small. However, the nonnegativity constraint of pension transfers is binding and in turn $\mathcal{F}(h)$ falls discontinuously to zero at $\phi = 0$.

13. See Feldstein and Liebman (2002) for a formal discussion of the internal rate of return in an unfunded pension system.

4.2. *Private Financial Wealth as a Substitute for Pensions*

We now extend the previous results to an economy in which individuals can save privately. Unlike human capital investment, private investment for the retirement-age period is fully appropriable by investors since it provides them with a wealth claim on investment returns. Adults are particularly reluctant to support pension programs, and instead seek to finance their retirement through private savings, especially when the interest rate is high. It is then natural to ask whether the presence of private savings jeopardizes the incentives of constituencies to endorse a PIS.

In a similar fashion to the analysis carried out in Section 4.1, we use $\tau = n \cdot (f/h)$ and $z = (1/n) \cdot (b/h)$ to deliver the first-order conditions with respect to the current fiscal policies b and f. Point (i) of Definition 1 is now added to the analysis, in order to extend the model to include private saving. Private financial wealth held by retirees is an additional payoff-relevant state variable of the economy. Hence, current public budget amendments will affect future fiscal policies through variations in the amount of both human capital and private financial wealth held by future constituencies. Given the pension transfer rule $\mathcal{B}(h, s\_)$, the optimal private saving rule can be written as $\tilde{\mathcal{A}}(f, b, h|\mathcal{B})$.[14] An MPE is then characterized by a system of two functional equations:

$$\frac{c^a}{c^o} = \frac{1}{\phi}\left(1 - \frac{n}{R} \cdot \mathcal{B}_s \cdot \tilde{\mathcal{A}}_b\right) \tag{7}$$

and

$$R = \frac{1}{n}\left(\mathcal{B}_s \cdot \tilde{\mathcal{A}}_f + \mathcal{B}_{h'} \cdot H_f\right), \tag{8}$$

where $\mathcal{B}_s \cdot \tilde{\mathcal{A}}_b$ and $\mathcal{B}_s \cdot \tilde{\mathcal{A}}_f + \mathcal{B}_{h'} \cdot H_f$ denote the total derivatives of the next-period pension transfers with respect to current pension transfers and education investment, respectively. Equation (7) yields the tradeoff between taxpayers and tax recipients. Compared to equation (4), the key difference is the term $(n/R) \cdot \mathcal{B}_s \cdot \tilde{\mathcal{A}}_b$, so that the ratio c^a/c^o now changes in tandem with fiscal policies. Agents respond to a fiscal amendment of the pension budget by altering their saving decisions. This induces a change in the private financial asset holdings of future constituencies and, in turn, affects the level of pension transfers to be set by the future government. The possibility of private saving also has an interesting implication for the generalized Euler equation for education investment. In the case of private saving, the government foresees that adults will privately smooth consumption across periods. Hence, equation (8) predicts that the policy maker will invest in human capital up to the point at which the return on an additional unit of public expenditure in the form of pension transfers is equal to

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14. The map $\tilde{\mathcal{A}}(f, b, h|\mathcal{B})$ is the optimal private saving rule that solves $S(f, b, h, \mathcal{B}(H(f, h), \tilde{\mathcal{A}}(f, b, h|\mathcal{B}))) = \tilde{\mathcal{A}}(f, b, h|\mathcal{B})$. We note that there is a direct functional relation between $\tilde{\mathcal{A}}(f, b, h|\mathcal{B})$ and the map $\mathcal{A}(f, \tau, z, h|\mathcal{B})$ as reported in Definition 1—that is, $\tilde{\mathcal{A}}_f = (n/h)\mathcal{A}_\tau + \mathcal{A}_f$ and $\tilde{\mathcal{A}}_b = (1/nh)\mathcal{A}_z$.

the return on private saving. The following proposition provides an explicit functional form for the political equilibrium.

PROPOSITION 2. *When ϕ is strictly larger than the critical level $\underline{\phi}$, there exists a PIS characterized by:*

(i) *the following set of fiscal policy rules,*

$$\begin{aligned} f &= \mathcal{F}\left(h, s_{-}\right) \equiv \psi h, \\ \tau &= \mathcal{T}\left(h, s_{-}\right) \equiv n \cdot \left(\mathcal{F}\left(h, s_{-}\right)/h\right), \\ b &= \mathcal{B}\left(h, s_{-}\right) \equiv a_s s_{-} + a_h h, \\ z &= \mathcal{Z}\left(h, s_{-}\right) \equiv (1/n) \cdot \left(\mathcal{B}\left(h, s_{-}\right)/h\right), \end{aligned}$$

where ψ is the solution to the polynomial

$$\psi = \left(\frac{A}{R}\left((1-\theta) + n\theta\psi\right)\right)^{1/\theta},$$

$a_s \equiv -R(1+\beta)/(1+\beta+\phi/n)$, and
$a_h \equiv (\phi/(1+\beta+\phi/n))(1+n\psi\theta/(1-\theta))$;

(ii) *the following set of laws of motion for asset variables,*

$$\begin{aligned} h'/h &= A\psi^{1-\theta}, \\ s/h' &= e_s\left(s_{-}/h\right) + e_h, \end{aligned}$$

where $e_h \equiv (1-n\psi-a_h/n)\beta R/((a_s+R(1+\beta))A\psi^{1-\theta}) - a_h/(a_s + R(1+\beta))$ and $e_s \equiv -a_s\beta R/(n(a_s + R(1+\beta))A\psi^{1-\theta})$;

(iii) *the following condition for the existence of a balanced growth path,*

$$\begin{aligned} R &= R^* \equiv A\left(n+\phi/\beta\right)\left(\frac{1}{n+\phi/\left(\beta\left(1-\theta\right)\right)}\right)^{1-\theta}, \\ \psi &= \psi^* \equiv 1/\left(n+\phi/\left(\beta\left(1-\theta\right)\right)\right). \end{aligned}$$

Proposition 2 generalizes the results of Proposition 1 to an environment with private asset holdings. Points (i) and (ii) illustrate policy rules and laws of motion for assets as functions of the payoff-relevant state variables. The equilibrium policies share properties similar to those reported in the previous section. We note that both $\mathcal{F}_h$ and $\mathcal{B}_h$ are positive, which implies that education investment and pension transfers increase with the predetermined level of human capital. Hence, the presence of private financial wealth does not offset the strategic role of human capital, which is necessary for the political viability of a PIS.[15]

15. This prediction is stark in contrast to the politico-economic theory of the strategic role of public debt. For instance, Song, Storesletten, and Zilibotti (2012) show that when private and public consumption are

We next highlight the main novelties of Proposition 2 compared to the case with only human capital. First, the pension transfer rule is a linear and decreasing function of the private financial wealth held by the elderly, namely $\mathcal{B}_{s\_} < 0$. This is because a larger $s\_$ reduces the marginal utility from consumption for the elderly, which in turn reduces transfers to retirees. Thus, private savings and public pensions are substitutes. Second, $\mathcal{F}_{s\_} = 0$, which implies that the education investment rule is unaffected by changes in the private asset holdings of the elderly. This is due to the fact that education investment is set by governments to maximize the indirect utility of adults, who finance public education via taxation and reap the benefits via future pension transfers. An envelope argument implies that the government's problem is equivalent to maximizing the net present value of lifetime income for adults, which is not directly influenced by variations in private financial wealth. Therefore, $s\_$ is not a payoff-relevant state variable in the government's decision regarding public education.

While in the absence of private asset holding, a PIS is politically sustained for any strictly positive level of ϕ, this cannot hold true when adults can save privately, according to Proposition 2. Indeed, a PIS must feature $\phi > \underline{\phi}$; otherwise, the nonnegativity constraint of pension transfers would be binding.[16] The intuition behind this result is as follows. Private consumption among retirees is now guaranteed by the presence of private saving. When the relative political power of elderly voters is weak, namely $\phi \leq \underline{\phi}$, it can be optimal for the government to redistribute income from retirees to adults in order to balance marginal utilities across the two generations. Retirees, however, cannot be required to pay because of the nonnegativity constraint of pension transfers. Consequently, the lack of retirement benefits will remove the incentive to finance public education, which, in turn, will compromise the political viability of a PIS.

Finally, the third point of the proposition informs us that the economy settles on its balanced growth path when $R = R^*$.[17] Under this condition, the economy lacks transitional dynamics because it is on the balanced-growth path from the initial period onwards. All of the economy's variables grow at the constant rate $h'/h = A(\psi^*)^{1-\theta}$, which is guaranteed to be larger than 1 if the human capital technology is sufficiently productive.

Having illustrated how economic and political forces bring about and shape the government's fiscal policies, we can now discuss the impact of a PIS on the welfare of adult voters. To this end, we compare the internal rate of return in a PIS to the world interest rate.

perfect substitutes, which is a feature of our setting with pensions, the strategic role of public debt vanishes, as agents can cope better with public good impoverishment by substituting it by private savings.

16. The analytical details of obtaining $\underline{\phi}$ are provided in the proof of Proposition 2 in Appendix A.3.

17. In a world consisting of small open and homogeneous economies, there exists a unique equilibrium interest rate such that the world asset market clears. An MPE, therefore, must feature $R = R^*$. Note that there can be no $R < R^*$ since in that case all economies would accumulate an ever-increasing deficit. Analogously, it is impossible that $R > R^*$ since in that case all economies would accumulate an ever-increasing surplus. In both cases, the clearing of the world asset market would be prevented.

COROLLARY 2. *The internal rate of return in a PIS is lower than R^* when private financial wealth is a payoff-relevant state variable.*

In contrast to Section 4.1, adult voters always lose from the joint implementation of public education and pensions when they can invest their savings in the world capital market. This implies that if adults suddenly held the only relevant political power, then governments would dismantle the fiscal program in order to allow agents to pursue higher returns from private investments. While perhaps surprising at first, the result is straightforward. Consider a world in which the interest rate is smaller than the internal rate of return in a PIS. Adult investors would then have no economic motive to save privately. In this context, there would be no private financial wealth and the analysis of Section 4.1 would apply. In short, private financial wealth is a payoff-relevant state variable for the government insofar as it is economically profitable for adult investors.[18]

4.2.1. How Well Do Governments Do? This section will demonstrate that even though governments hold office for only one period and are not concerned about the well-being of future generations, they act as if they are more farsighted than the voters they represent. We contrast a PIS with the choice of a Ramsey planner who sets the fiscal policy sequence in the initial period so as to maximize the discounted utilities of current and future generations subject to the same set of constraints faced by elected governments. Taking the initial condition $\{h_0, s_{-1}\}$ as given, the sequential formulation of the planner's problem is

$$\max_{\{f_t, b_t\}_{t=0}^{\infty}} \left\{ \beta \log\left(c_0^o\right) + \sum_{t=0}^{\infty} \delta^{t+1} \left(\log\left(c_t^a\right) + \beta \log\left(c_{t+1}^o\right) \right) \right\}$$

subject to the per-period budget constraints for adults and the elderly, optimal private savings, the human capital technology, the public balanced-budget constraints, and the fiscal feasibility conditions for any t. The term δ^{t+1} with $\delta \in (0,1)$ denotes the geometrically decaying Pareto weight attached by the planner to the discounted utility of each generation t. The following proposition compares the Ramsey allocation with the PIS characterized in Proposition 2.[19]

PROPOSITION 3. *For feasible δ, the PIS coincides with the Ramsey allocation when $\phi = \beta n(1-\delta)/\delta$.*

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18. This result contrasts with the findings of Andersen and Bhattacharya (2015) who argue that a fiscal program with public education and pensions can provide a higher internal rate of return than that of an alternative asset. The authors, however, take a normative approach that disregards political economic considerations, which are the focus of the current paper.

19. The technical details of obtaining the Ramsey allocation are provided in the proof of Proposition 3 in Appendix A.3. In the absence of tax distortion, the Ramsey planner solution supports the allocation chosen by a social planner who is only bound by the economy's resource constraints. This is because the social planner's first-order condition with respect to saving is identical to the private Euler equation, which holds under the Ramsey policy.

The strategic use of human capital leads an elected government to fully internalize the intergenerational human capital spillover, as would a Ramsey planner. This result fundamentally hinges on the absence of commitment in the political process. To see the intuition behind this, consider a government that deviates from the MPE rules by providing fewer resources to finance public education. Given the positive relation between human capital stock and pensions, the government's deviation leads the subsequent government to provide smaller pension transfers to the next-period retirees. The less invested by the former government in the human capital of future generations, the larger will be the negative impact on future pensions. Adults respond to the smaller future retirement benefits by saving more privately. The private sector's response depresses the future retirement benefits even further, which in turn reduces the demand for public education in the first place. Private savings continue to adjust up to the point at which neither pensions nor education are provided. Such an allocation is not desirable for constituencies when $\phi > \underline{\phi}$. Underinvestment in public education therefore is not a profitable deviation for governments.[20]

To further appreciate the role played by lack of commitment in the political process, consider the alternative scenario in which elected governments can commit to fiscal policies over two periods. Since governments only care about current voters, they will credibly promise adults to fully expropriate the income of next-period workers in order to subsidize their consumption when old. Governments will then invest in the human capital of the next-period workers to equate the returns on public education in the form of future labor income and private savings. In this context, the economy converges to a steady state with no human capital after the first period. In short, it is the dynamic games between successive governments that empower future generations and sustain growth in the long run.

5. Elastic Labor Supply

We have so far shown how a democratic institution that confers political power on the currently living generations can simultaneously implement public education and pensions in an economy where governments can impose lump-sum taxes. In this section, we extend the baseline model to a more general setting with distortionary taxation, in order to show that similar results hold true in an environment where individuals modify their labor supply in response to changes in the labor tax rate and social security contributions.

We introduce the concept of elastic labor supply by parametrizing the technology for household production as $F(l) = (\xi/(1+\xi))X(1 - l^{1+1/\xi})$, where $\xi > 0$ is the

20. Proposition 3 differs from the result that governments fail to internalize intergenerational human capital spillover in a closed economy (Gonzalez-Eiras and Niepelt 2012). In the presence of general equilibrium effects on prices, education investment increases the return on private savings and in turn reduces the present value of pension transfers. Therefore, the implementation of pensions lowers the demand for public education.

Frisch elasticity and X is a productivity shifter. Hence, the optimal labor supply is $l = L(\tau, z) \equiv ((1-\tau-z)/X)^{\xi}$. An MPE is then characterized by a system of two functional equations:

$$\frac{c^a}{c^o} = \frac{\mu^z}{\phi}\left(1 - \frac{1}{nR}\frac{1-\mu^\tau}{\mu^\tau}\left(\mathcal{B}_s \cdot \mathcal{A}_f + \mathcal{B}_h \cdot H_f\right) - \frac{1}{RhL(\tau,z)}\left(\mathcal{B}_s \cdot \mathcal{A}_z\right)\right) \quad (9)$$

and

$$R = \frac{\mu^z + (1-\mu^z)\mu^\tau}{n\mu^\tau\mu^z}\left(\mathcal{B}_s \cdot \mathcal{A}_f + \mathcal{B}_h \cdot H_f\right) + \frac{1}{L(\tau,z)h}\left(\frac{1}{\mu^z}\mathcal{A}_\tau - \frac{1-\mu^z}{\mu^z}\mathcal{A}_z\right)\mathcal{B}_s, \quad (10)$$

where

$$\mu^z \equiv (1-\tau-z)/(1-\tau-(1+\xi)z) \text{ and } \mu^\tau \equiv (1-\tau-z)/(1-z-(1+\xi)\tau)$$

denote the marginal costs of public funds, which are increasing and convex in the corresponding tax rate and equal to unity plus the deadweight loss induced by taxation.[21] Equations (9) and (10) include the case of lump-sum taxes, namely equations (7) and (8), as a particular case, when $L(\tau, z) = 1$ and $\mu^\tau = \mu^z = 1$. There are two main differences between this case and that of an inelastic labor supply. First, the convex tax distortions increase the cost of financing b and f, as captured by μ^z and μ^τ. Second, the fiscal amendment of one budget has an adverse fiscal effect on the other since it distorts the labor supply. Specifically, an increase of the labor tax rate shrinks the pension budget, as emphasized by the presence of μ^τ in equation (9). Similarly, an increase in the payroll tax rate tightens the public investment possibilities, as captured by μ^z in equation (10). These differences have an impact on the determination of the equilibrium policy rules. Indeed, the presence of friction in the labor market exacerbates the intergenerational conflict over the allocation of the public budget. Intuitively, the convex tax distortion makes it more expensive to finance f when ϕ, and hence b, is larger.

A full analytical characterization of the MPE under elastic labor supply is not attainable and therefore we must resort to numerical analysis. The computational strategy uses a standard projection method with Chebyshev collocation in order to approximate the fiscal policy rules $\mathcal{F}(h, s_{-})$, $\mathcal{T}(h, s_{-})$, $\mathcal{B}(h, s_{-})$, and $\mathcal{Z}(h, s_{-})$ and the optimal private saving rule $\mathcal{A}(f, \tau, z, h|\mathcal{B})$, using the equilibrium conditions (9) and (10) in tandem with the Euler equation for savings and the government budget constraints (1) and (2). To simplify the exposition, we exploit the homogeneity property of the utility and human capital production functions and focus on the MPE in which strategies depend only on the level of private financial assets scaled by the human

21. The technical details of obtaining equations (9) and (10) are provided in Appendix A.2.

TABLE 1. Calibration.

Target observation		Parameters	
GDP growth rate	2.5	A	3.347
Education–GDP ratio	5.4	θ	0.846
Pension–GDP ratio	7.16	β	0.996^{30}
Ratio of labor income to total income for adults	33/51	X	1.360
Capital–output ratio (annualized)	3	R	1.04^{30}
Tax rate corresponding to the top of the Laffer curve	0.60	ξ	2/3
Population growth rate		n	1.006^{30}
Political power of the elderly relatively to adults		ϕ	0.8

capital stock, namely $s\_/h$. The algorithm adopted to solve for the equilibrium is described in Online Appendix B.3.

5.1. Quantitative Analysis

This section illustrates the properties of the model with elastic labor supply and shows that a reasonably calibrated version of the model is consistent with key features of modern economies. We use the calibrated model to run numerical experiments, with one period in the model corresponding to 30 years in the data.

We assume an annual gross population growth rate of 1.006, corresponding to the average OECD rate during the period 1995–2009. We fix the capital share of output at $\alpha = 1/3$ and the annualized capital–output ratio at 3. These parameters imply an annual interest rate of 4%, which is standard in quantitative macroeconomics. In line with Trabandt and Uhlig (2011), we set $\xi = 2/3$ so that the top of the Laffer curve is at 60%. The literature provides no guidance on how to allocate power across generations. We set ϕ to 0.8 to reflect the political influence of the elderly, measured by voter turnout.[22] We calibrate the parameters A, θ, and β to fit the following key moments for the OECD economies during the period 1995–2009: the GDP growth rate, the GDP share of education, and pension transfers are set to the values 2.5%, 5.4%, and 7.16%, respectively. X targets the ratio of market labor earnings to total income, including the value of household production, of adults, which is set at 33/51, the ratio of market hours worked to total hours worked for US working-age households (Aguiar and Hurst 2007). Jointly matching these moments yields $A = 3.347$, $\theta = 0.846$, $\beta = 0.9016$, and $X = 1.360$.[23] Table 1 summarizes the parameters.

22. Our benchmark value of $\phi = 0.80$ corresponds to a situation in which retired voters are 30% of the overall eligible voters and working-age voters are 45%, assuming an annual gross population growth rate of 1.006. These proportions are approximately in line with the composition of the voting population by age in the United States for the period 1996–2012.

23. Despite the simplicity of the model, our calibrated political economy generates plausible values. For example, the annual discount factor corresponds to 0.996 and the calibrated value of X is consistent with Song, Storesletten, and Zilibotti (2012).

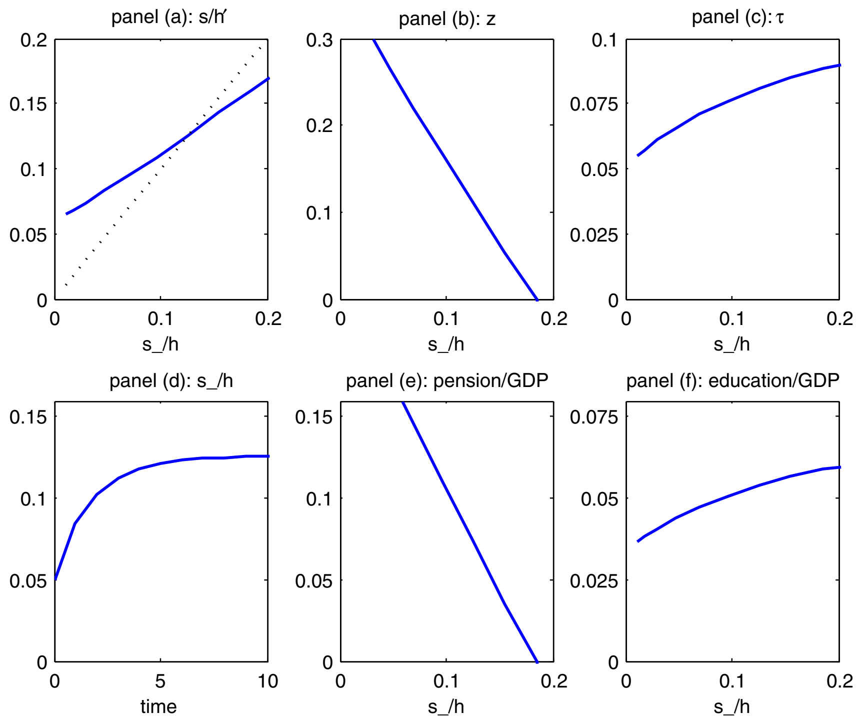

FIGURE 1. Equilibrium policy rules.

Figure 1 plots the stationary equilibrium policy rules for the calibrated economy. Consider first the optimal private saving rule. When labor is inelastic, it coincides with the 45-degree line and in that case every initial condition s_{-1}/h_0 is a steady state for the economy. As panel (a) illustrates, in the calibrated equilibrium with elastic labor supply, the optimal private saving rule scaled by the human capital stock is a concave function, which converges monotonically to the interior steady state level. Panel (d) plots the corresponding equilibrium time path. Panels (b) and (e) plot, respectively, the equilibrium payroll tax rate and pension transfers as a share of GDP. As in the case of inelastic labor supply, both policy rules are decreasing in s_-/h. We note that the steady state payroll tax rate is 10.7%, which is in line with the average rate for the OECD countries during the period 1996–2009. The financing and allocation of the public education budget, however, are qualitatively different than in the case of inelastic labor supply. Both the labor tax rate (panel (c)) and education investment as a share of GDP (panel (f)) are nonlinear and increasing functions of s_-/h. To understand the intuition behind these relationships, consider an increase in private financial wealth that reduces the payroll tax for pension financing and leads to an increase in the labor supply. Given the adverse fiscal effect of linking the two policies, the fiscal adjustment of the pension budget expands public investment possibilities and thus increases the share of GDP directed to public education. The equilibrium

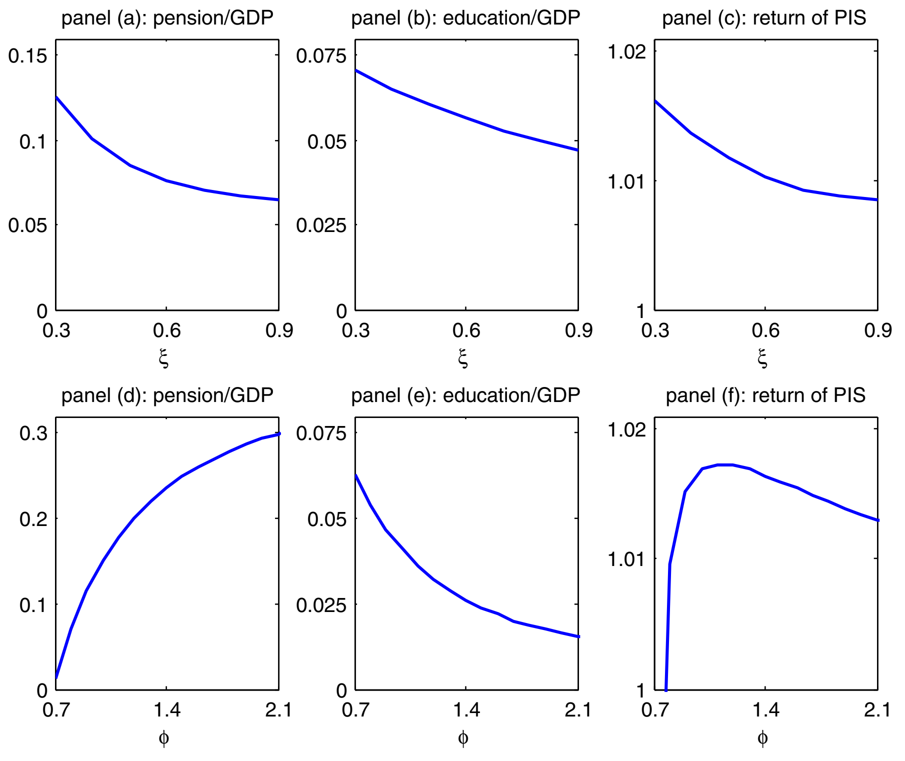

FIGURE 2. Comparative statics at the steady state.

predictions conform with evidence from developed countries that, conditioned on the same level of human capital, constituents endowed with a small amount of private financial wealth are more supportive of universal social insurance programs and less attentive to growth-oriented policies.[24]

5.2. Comparative Statics

We next examine the response of long-run equilibrium to changes in fundamental parameters of the economy. We focus on two key parameters: the Frisch elasticity of labor supply ξ in order to evaluate the impact of distortionary taxes and the balance of political power across generations ϕ in order to evaluate the effect of changes in the potential of elderly voters to extract political rent.

The upper part of Figure 2 depicts the long-run equilibrium policy rules for $\xi \in [0.3, 0.9]$ holding all other parameters at the values appearing in Table 1. As

24. Perotti and von Thadden (2006) argue theoretically and empirically that the distribution of private financial wealth influences political support for rents. They provide evidence for OECD economies which shows that political support may shift away from free markets and toward a more corporate-governance-type system in response to the loss of financial wealth.

ξ increases, the larger fiscal distortion provokes a government shirking effect associated with a fall in the GDP share of pension transfers (panel (a)) and education (panel (b)), in tandem with a reduction in the internal rate of return in a PIS (panel (c)). The result is intuitively appealing and provides an explanation of empirical findings that a shift to a tax system with higher marginal deadweight costs increases pressure from the taxpaying group and lowers total taxes and government spending (see, e.g., Becker and Mulligan 2003; Feldstein and Liebman 2002).

The lower part of Figure 2 plots the outcome of a political experiment in which the baseline ϕ is now in a range from 0.7 to 2.1.[25] A number of interesting features of the equilibrium's long-run allocations emerge. As in the case of inelastic labor, an increase in ϕ leads governments to devote a larger share of GDP to the provision of pension transfers in order to address the needs of retirees (panel (d)). This raises payroll taxes and, in turn, induces an adverse fiscal effect that reduces the share of GDP directed to public education even further when compared to the case with nondistortionary taxes (panel (e)). Finally, the internal rate of return in a PIS turns out to be hump-shaped in ϕ with a maximum at 1.15 and smaller than the world interest rate (panel (f)). Thus, the numerical solution reinforces the analytic results presented in previous sections. These predictions are consistent with evidence from other studies. For example, Mulligan and Sala-i-Martin (1999) show that the dramatic rise of social security contributions in the United States during the period 1950–1996 can be attributed to the increasing political power of the elderly as the bulk of baby boomers approached retirement age. Stromberg (2006) finds a significant relationship between the balance of political power across age groups and the composition of Swedish municipal spending. A shift of political influence toward retirees increases local expenditures that benefit the elderly and reduces those that benefit the young.

5.3. *Demographic Shocks*

The model also delivers interesting predictions of how human capital investment per student and pensions per retiree respond to demographic changes.[26] Suppose the economy experiences a temporary and unexpected baby boom, in which the fertility rate increases from its baseline value to 1.02^{30} and later returns to its original value. All other parameters remain at their baseline values, as in Table 1. The shock occurs at the beginning of the period, before the government decides on fiscal policy and before agents make their private decisions. Figure 3 plots the time path of the fiscal adjustments.

25. In line with the analytical results reported in Section 4.2, there exists a threshold level $\underline{\phi}$ such that if $\phi \leq \underline{\phi}$, then a PIS cannot be sustained as an MPE. Numerical analysis shows that this threshold corresponds approximately to 0.685 in the calibrated economy. Thus, we perform comparative statics on ϕ with 0.7 as the lower bound. No upper boundary restrictions need be imposed.

26. We describe the impact of a financial shock on the PIS in the supplementary material in Online Appendix B.4.

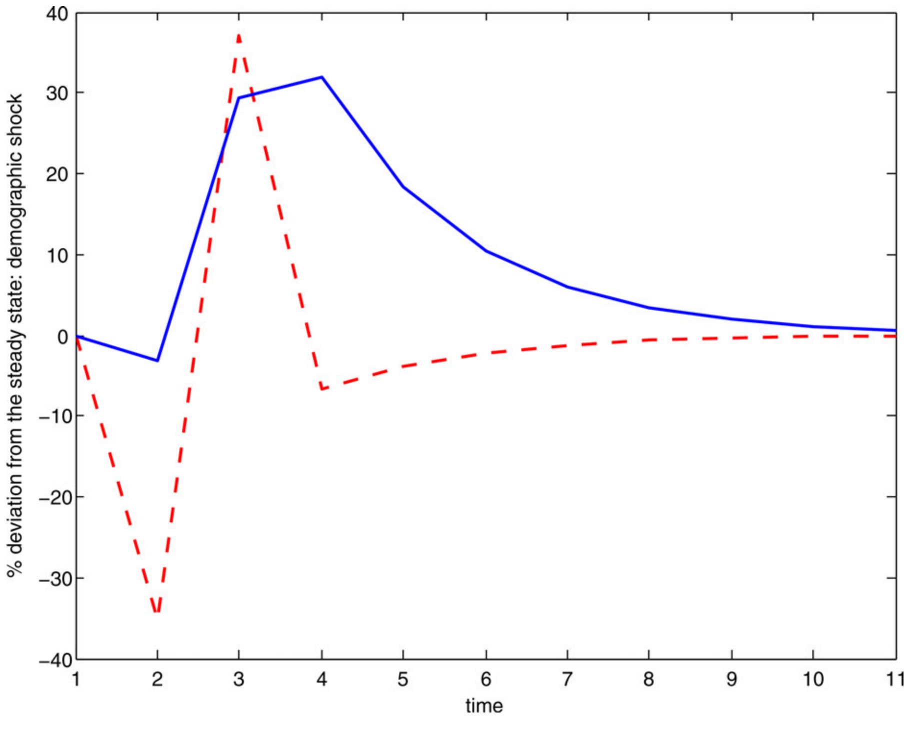

FIGURE 3. Demographic transition. The figure shows impulse–response functions for a demographic baby boom–bust shock. The solid line represents pensions per retiree and the dashed line depicts public education per student.

In the first period, the government reacts by reducing public expenditure per recipient. An unexpected baby boom is accompanied by a reduction in education spending per student and a boost in aggregate education spending, implying that a quality–quantity tradeoff is at work. The consequent increase in the labor tax rate to finance education adversely affects the pension budget and, therefore, pension benefits per retiree are also reduced. In the second period, the fertility rate reverts to its baseline value, but the policies do not yet converge back to the initial steady state. The baby boomers become workers, whereas the number of young and retirees are at their baseline levels and, as a consequence, the number of taxpayers increases. Governments rationally anticipate that tax-paying adults will form the largest and most politically influential cohort when they grow old. The future prospect of adults extracting a larger political rent then provides the government with additional motive to maintain public education spending. In the third period, the baby boomers retire. As anticipated, the government in power raises pension benefits per retiree and, in turn, payroll taxes. The resulting distortion of labor supply pushes human capital investment downward. From period $t = 4$ onward, the population reverts to its initial stationary level. Pensions per retiree fall and public investment per student grows. Eventually, both converge back to the steady state.

This pattern resembles the post-war dynamics observed in public education and social security programs in developed economies. Lindert (1996) reports the following findings for OECD countries during the period 1960–1981: (i) a growing number of children led to diluted education expenditure per child; (ii) countries with relatively more adults tended to spend more on tax-based social programs, even per recipient; (iii) the ratio of social security expenditure to GDP and the proportion of retired individuals in the population are positively correlated. Similar evidence, which is consistent with our quantitative experiment, is reported by Persson and Tabellini (2003). The results are, however, in contrast to the findings of Razin, Sadka, and Swagel (2002), who argue that the dependency ratio is negatively related to per-retiree pension transfers due to the presence of a fiscal leakage effect. In our numerical experiment, it may well be that pensions per recipient also become more generous when the number of retirees increases due to the previous period investment in education, which lowers the marginal cost for tax-paying adults.

6. Conclusions

In this paper, we attempt to explain why democratic institutions in modern economies implement public education and pensions simultaneously, without resorting to the standard explanations of altruism, commitment, reputation, and general equilibrium effects on prices. The model is one of a small open economy, in which the political power of elderly voters creates the motive for adult voters to support growth-oriented policies. The power of the theory lies in the ability of governments with short-term mandates to sustain growth and internalize intergenerational human capital spillover. Two fundamental features of the model drive the results: (i) the nature of the short-term relations between voters and representatives; and (ii) the prospect of follow-up intergenerational public programs, which serves as the incentive device for implementing current fiscal policies.

The theoretical analysis can be usefully extended in various directions. In terms of the basic model, we assume that governments maintain a balanced budget and do not have access to financial credit markets. Adding public debt under commitment to repayment would break the link between taxation and expenditure, allowing governments to shift the fiscal burden to future generations. In that case, governments could manipulate the state of the world to be inherited by their successors by means of human capital investment and public debt. These two strategic channels counteract each others. Thus, on the one hand, increasing human capital investment crowds in pensions, because it raises labor productivity and reduces the fiscal burden borne by future constituencies, as we have shown. On the other hand, increasing public debt crowds out pensions since it increases the fiscal burden borne by future generations (Song, Storesletten, and Zilibotti 2012). The strategic interaction between these two fiscal channels is an extension worth pursuing.

In terms of policy implications, our results suggest the relevance of considering the political economy of important policy choices such as public education and social security. Modern economies around the world are debating structural reforms of their social security systems. Most of the reforms entail a gradual shift from a tax-based, pay-as-you-go system to an investment-based retirement system. However, the interaction between public education and pensions is usually neglected in the debate. If this interaction is ignored, it may well be that the proposed shift has unintended negative effects on the well-being of future generations. This may occur because the destruction of economic rents enjoyed by the elderly wipes out the government's incentive to provide public education, which will affect the rate of growth. It is therefore a theoretical and empirical task to evaluate the welfare implications associated with alternative designs of social security programs by embedding the political economic consequences of each for human capital formation.

Appendix A

This appendix presents the evidence that was referred to in the Introduction (Appendix A.1), the derivation of the first-order conditions (9) and (10) (Appendix A.2), and the proofs (Appendix A.3).

A.1. Evidence

We wish to examine the empirical relationship between pensions and human capital. We show that the data are broadly consistent with the main implication of the theory (i.e. that an increase in the level of human capital increases the generosity of pension transfers). We do not provide a structural test of the theory, and therefore the empirical results should be viewed as only suggestive of the pension–human capital nexus.

We estimate social security as a function of human capital and additional control variables using the following baseline empirical specification:

$$\Delta \log b_{it} = \alpha_0 + \alpha_1 \Delta \log h_{it} + \mu_t + \delta_i + \upsilon_{it},$$

where Δ is the first-difference operator of the variable of interest, t denotes the year, i denotes the country, δ_i is a country fixed effect, and μ_t is a year fixed effect. The dependent variable b_{it} is a measure of pension generosity defined as the ratio of pension per retiree to GDP per capita. Using this proxy, we control for demographic and technological factors that can also affect pension transfers. The proxy for human capital h_{it} is defined as the percentage of the total labor force with tertiary education. Table A.1 provides the estimation results. Column (1) shows the results for the baseline regression. The following additional controls are gradually introduced into the model: private financial wealth, $wealth_{it}$, defined as total financial net household worth per capita, which is meant to capture the presence of private saving as a substitute for public pensions; total tax revenue per capita as a share of GDP, tax_{it}, which controls for the size of government; the unemployment rate, $unemp_{it}$, which is a meant to control for business cycle effects; and financial openness, $open_{it}$, which captures the adverse effect of external shocks on pensions. All variables are expressed in logarithmic form. The results are reported in columns (2)–(5).

A.2. Derivation of First-Order Conditions

In this section, we derive the first-order conditions of the politico-economic problem described by equations (9) and (10). According to Definition 1, the equilibrium fiscal policies solve

$$\left\langle \mathcal{F}\left(h, s_{\_}\right), \mathcal{T}\left(h, s_{\_}\right), \mathcal{B}\left(h, s_{\_}\right), \mathcal{Z}\left(h, s_{\_}\right)\right\rangle = \underset{f,\tau,b,z}{\arg\max}\ \mathcal{W}\left(f, \tau, b, z, h, s_{\_}|\mathcal{B}\right)$$

subject to the public budget constraints $\mathcal{T}(h, s_{\_})hL(\tau, z) \geq n\mathcal{F}(h, s_{\_})$ and $\mathcal{Z}(h, s_{\_})hL(\tau, z) \geq (1/n)\mathcal{B}(h, s_{\_})$. We denote by λ and η the Lagrangian multipliers associated with the education investment budget and the pension budget, respectively. An envelope argument implies that the first-order conditions with respect to f, τ, b,

TABLE A.1. Panel regressions.

	$\Delta\log(b_{it})$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta\log(h_{it})$	0.047**	0.042**	0.074**	0.048**	0.045**	0.074**
	(0.018)	(0.019)	(0.030)	(0.018)	(0.018)	(0.037)
$\Delta\log(wealth_{it})$		–0.021				–0.031
		(0.037)				(0.043)
$\Delta\log(tax_{it})$			0.060			0.051
			(0.066)			(0.067)
$\Delta\log(unemp_{it})$				0.043		0.026
				(0.035)		(0.048)
$\Delta\log(open_{it})$					–0.037	0.107
					(0.118)	(0.137)
Cluster	Country	Country	Country	Country	Country	Country
Observations	324	261	271	324	306	223
Countries	26	24	25	26	25	22
Adj. R^2	0.327	0.417	0.395	0.34	0.33	0.447

Notes: Data on pensions, tax revenue, and private financial wealth are from the OECD database (2013). Data on population, GDP, human capital, and unemployment rate are from the World Bank database. The index of financial openness is from the Penn World Table. Variables are expressed in constant 2005 US dollars and are for 26 countries that were OECD members during the period 1995–2009.
**Significant at 5%.

and z are

$$
\begin{aligned}
f &: 0 = \frac{1}{c^a}\frac{\mathcal{B}_s \cdot \mathcal{A}_f + \mathcal{B}_h \cdot H_f}{R} - \lambda n, \\
\tau &: 0 = \frac{1}{c^a}\left(\left((1-\tau-z)\,L_\tau - L(\tau,z) + F_l L_\tau\right)h + \frac{\mathcal{B}_s \cdot \mathcal{A}_\tau}{R}\right) \\
&\quad + \lambda\left(L(\tau,z) + \tau L_\tau\right)h + \eta z L_\tau h, \\
b &: 0 = \frac{\phi}{c^o} - \eta, \\
z &: 0 = \frac{1}{c^a}\left(\left((1-\tau-z)\,L_z - L(\tau,z) + F_l L_z\right)h + \frac{\mathcal{B}_s \cdot \mathcal{A}_z}{R}\right) \\
&\quad + \lambda \tau L_z h + \eta\left(L(\tau,z) + z L_z\right)h.
\end{aligned}
$$

Since $F(l) = (\xi/(1+\xi))X(1 - l^{1+1/\xi})$ so that $l = L(\tau, z) \equiv ((1-\tau-z)/X)^{\xi}$, we can rewrite the first-order conditions as

$$
\begin{aligned}
f &: 0 = \frac{1}{c^a}\frac{\mathcal{B}_s \cdot \mathcal{A}_f + \mathcal{B}_h \cdot H_f}{R} - \lambda n, \\
\tau &: 0 = \frac{1}{c^a}\left(-hL(\tau,z) + \frac{\mathcal{B}_s \cdot \mathcal{A}_\tau}{R}\right) + \left(\lambda\frac{1}{\mu^\tau} + \eta\frac{1-\mu^z}{\mu^z}\right)hL(\tau,z), \\
b &: 0 = \frac{\phi}{c^o} - \eta, \\
z &: 0 = \frac{1}{c^a}\left(-hL(\tau,z) + \frac{\mathcal{B}_s \cdot \mathcal{A}_z}{R}\right) + \left(\eta\frac{1}{\mu^Z} + \lambda\frac{1-\mu^\tau}{\mu^\tau}\right)hL(\tau,z),
\end{aligned}
$$

where

$$\mu^z \equiv (1-\tau-z)\,/\,(1-\tau-(1+\xi)\,z) \quad \text{and} \quad \mu^\tau \equiv (1-\tau-z)\,/\,(1-z-(1+\xi)\,\tau)$$

denote the marginal cost of public funds for z and τ, respectively. Eliminating the multipliers from the first-order conditions, namely $\eta = \phi/c^o$ and $\lambda = (1/nc^a)((\mathcal{B}_s \cdot \mathcal{A}_f + \mathcal{B}_h \cdot H_f)/R)$, the following equilibrium conditions for fiscal policies hold:

$$\frac{c^a}{c^o} = \frac{\mu^z}{\phi}\left(1 - \frac{1}{nR}\frac{1-\mu^\tau}{\mu^\tau}\left(\mathcal{B}_s \cdot \mathcal{A}_f + \mathcal{B}_h \cdot H_f\right) - \frac{1}{RhL(\tau,z)}\left(\mathcal{B}_s \cdot \mathcal{A}_z\right)\right) \tag{A.1}$$

and

$$
\begin{aligned}
R = {} & \frac{\mu^z + (1-\mu^z)\,\mu^\tau}{n\mu^\tau\mu^z}\left(\mathcal{B}_s \cdot \mathcal{A}_f + \mathcal{B}_h \cdot H_f\right) \\
& + \frac{1}{L(\tau,z)\,h}\left(\frac{1}{\mu^z}\mathcal{A}_\tau - \frac{1-\mu^z}{\mu^z}\mathcal{A}_z\right)\mathcal{B}_s,
\end{aligned} \tag{A.2}
$$

which are equations (9) and (10). Note that equations (A.1) and (A.2) include equations (7) and (8) as a particular case when $L(\tau, z) = 1$ and $\mu^{\tau} = \mu^{z} = 1$.

A.3. Proofs

Proof of Proposition 1. Since $\tau_t = n(f_t/h_t)$ and $z_t = (1/n)(b_t/h_t)$ so that $c_t^a = h_t - nf_t - (1/n)b_t$ and $c_t^o = b_t$, we can rewrite the government's objective as

$$\langle \mathcal{F}(h_t), \mathcal{B}(h_t) \rangle = \arg\max_{f_t, b_t} \log(h_t - nf_t - (1/n)\, b_t) + \beta \log(b_{t+1}) + \left(\frac{\phi}{n}\right) \log(b_t),$$

where $b_{t+1} = \mathcal{B}(H(f_t, h_t))$ with $d\mathcal{B}(h_{t+1})/df_t \equiv \mathcal{B}_{h_{t+1}} \cdot H_{f_t}$. We consider a T-period economy with a sufficiently large and finite T. First, we compute the equilibrium fiscal policy rules $\mathcal{F}_{T-j}(h_{T-j})$ and $\mathcal{B}_{T-j}(h_{T-j})$ by solving backward for every $T - j$, with $j = 0, 1, \ldots, T$, subject to the fiscal policy rules implemented by successive governments. Second, we take the limit of the finite-horizon political equilibrium for T that tends to infinity to show that as the time horizon expands, the equilibrium fiscal policy rules converge to a limit.

At the terminal date T, adults have no future. Hence, the political objective function reduces to $\log(h_T - nf_T - (1/n)b_T) + (\phi/n)\log(b_T)$. The first-order conditions with respect to f_T and b_T are $-n/c_T^a < 0$ and $c_T^a/c_T^o = 1/\phi$, respectively. This implies that $f_T = \mathcal{F}_T(h_T) \equiv 0$ and $b_T = \mathcal{B}_T(h_T) \equiv (n\phi/(\phi + n))h_T$. At time $T - 1$, adults have a two-period temporal horizon. Hence, the political objective function is $\log(h_{T-1} - nf_{T-1} - (1/n)b_{T-1}) + \beta \log(b_T) + (\phi/n) \log(b_{T-1})$. The first-order conditions with respect to f_{T-1} and b_{T-1} are, respectively, $n/c_{T-1}^a = \beta(1/b_T)(d\mathcal{B}_T(h_T)/df_{T-1})$ and $c_{T-1}^a/c_{T-1}^o = 1/\phi$ where

$$d\mathcal{B}_T(h_T)/df_{T-1} = (n\phi/(\phi + n))A(1 - \theta)(h_{T-1}/f_{T-1})^{\theta}.$$

Combining these two conditions, we obtain $b_T/b_{T-1} = (\beta/n\phi)(d\mathcal{B}_T(h_T)/df_{T-1})$, which is structurally equivalent to equation (5). Using b_T and the human capital technology, algebraic manipulation yields

$$f_{T-1} = \mathcal{F}_{T-1}(h_{T-1}) \equiv (\beta(1 - \theta)/(\phi + n(1 + \beta(1 - \theta))))h_{T-1}$$

and

$$b_{T-1} = \mathcal{B}_{T-1}(h_{T-1}) \equiv (n\phi/(\phi + n(1 + \beta(1 - \theta))))h_{T-1}.$$

Iterating the maximization program for period $T - 2$, we find that the fiscal policy rules are structurally equivalent to those of period $T - 1$. Thus, we can conclude that for every t

$$f_t = \mathcal{F}(h_t) \equiv \frac{\beta(1 - \theta)}{\phi + n(1 + \beta(1 - \theta))} h_t \tag{A.3}$$

and

$$b_t = \mathcal{B}(h_t) \equiv \frac{n\phi}{\phi + n(1 + \beta(1 - \theta))} h_t. \tag{A.4}$$

Substituting equations (A.3) and (A.4) into the constraints (1) and (2) yields

$$\tau_t = \mathcal{T}(h_t) \equiv n\beta(1-\theta)/(\phi + n(1+\beta(1-\theta)))$$

and

$$z_t = \mathcal{Z}(h_t) \equiv \phi/(\phi + n(1+\beta(1-\theta))).$$

Finally,

$$h_{t+1}/h_t = A\left(\beta\left(1-\theta\right)/\left(\phi + n\left(1+\beta\left(1-\theta\right)\right)\right)\right)^{1-\theta}$$

is obtained by inserting equation (A.3) into the human capital technology.

Proof of Corollary 1. Let $\rho(\phi) \equiv b'/(nf + (1/n)b)$. Using the fiscal policies reported in Proposition 1, we obtain equation (6). It is straightforward to show that $\lim_{\phi\to 0}\rho(\phi) = \lim_{\phi\to\infty}\rho(\phi) = 0$. There is a unique

$$\bar{\phi} \equiv (n/2)\left(\beta\theta + \sqrt{\beta(\beta\theta^2 + 4(1+\beta(1-\theta)))}\right)$$

such that $\rho_\phi(\bar{\phi}) = 0$ and

$$\rho_{\phi\phi}(\bar{\phi}) \propto -n\sqrt{\beta\left(4+\beta(\theta-2)^2\right)}$$

is negative for any parameter value. Therefore, we conclude that $\rho(\phi)$ is hump-shaped in ϕ.

Proof of Proposition 2. The resolution strategy involves three steps. First, we consider a T-period economy and solve by backward induction. Second, we determine the condition for the existence of an MPE that corresponds to the limit of the finite-horizon equilibrium for T approaching infinity. Third, we determine the condition for the existence of the balanced growth path. Using $\tau_t = n(f_t/h_t)$ and $z_t = (1/n)(b_t/h_t)$ such that

$$s_t = S(f_t, b_t, h_t, b_{t+1}) \equiv (\beta/(1+\beta))(h_t - nf_t - (1/n)b_t) - (1/R(1+\beta))b_{t+1},$$

we rewrite

$$c_t^a = C^a(f_t, b_t, h_t, b_{t+1}) \equiv (1/(1+\beta))(h_t - nf_t - (1/n)b_t + b_{t+1}/R)$$

and $c_{t+1}^o = R\beta c_t^a$. Ignoring irrelevant terms, the government's objective can be expressed as

$$\begin{aligned}&\left\langle \mathcal{F}\left(h_t, s_{t-1}\right), \mathcal{B}\left(h_t, s_{t-1}\right)\right\rangle \\ &\quad = \arg\max_{f_t, b_t}\ (1+\beta)\log\left(C^a\left(f_t, b_t, h_t, b_{t+1}\right)\right) + (\phi/n)\log\left(Rs_{t-1} + b_t\right),\end{aligned}$$

where $b_{t+1} = \mathcal{B}(h_{t+1}, s_t)$, with $h_{t+1} = H(f_t, h_t)$ and $s_t = \tilde{\mathcal{A}}(f_t, b_t, h_t|\mathcal{B})$, which solves $\tilde{\mathcal{A}}(f_t, b_t, h_t|\mathcal{B}) = S(f_t, b_t, h_t, \mathcal{B}(H(f_t, h_t), \tilde{\mathcal{A}}(f_t, b_t, h_t|\mathcal{B})))$. To simplify the exposition, let $d\mathcal{B}(h_{t+1}, s_t)/df_t \equiv \mathcal{B}_{s_t} \cdot \tilde{\mathcal{A}}_{f_t} + \mathcal{B}_{h_{t+1}} \cdot H_{f_t}$ and $d\mathcal{B}(h_{t+1}, s_t)/db_t \equiv \mathcal{B}_{s_t} \cdot \tilde{\mathcal{A}}_{b_t}$.

First Step (Backward Induction). At the terminal date T, adults have no future. Hence, $s_T = 0$. The political objective function is

$$\log(C^a(f_T, b_T, h_T)) + (\phi/n)\log(Rs_{T-1} + b_T),$$

where

$$C^a(f_T, b_T, h_T) \equiv (1/(1+\beta))(h_T - nf_T - (1/n)b_T).$$

The first-order conditions with respect to f_T and b_T are $-n/c^a_T < 0$ and $c^a_T/c^o_T = 1/\phi$, respectively. This implies that $f_T = \mathcal{F}_T(h_T, s_{T-1}) \equiv 0$ and

$$b_T = \mathcal{B}_T\left(h_T, s_{T-1}\right) \equiv -\frac{R}{1+\phi/n}s_{T-1} + \frac{\phi}{1+\phi/n}h_T. \tag{A.5}$$

At $T-1$, adults have a two-period temporal horizon. Hence, the political objective function is $(1+\beta)\log(C^a(f_{T-1}, b_{T-1}, h_{T-1}, b_T)) + (\phi/n)\ \log(Rs_{T-1} + b_{T-1})$. Using equation (A.5) to eliminate b_T, we rewrite the optimal private saving as

$$\begin{aligned} s_{T-1} &= \tilde{\mathcal{A}}\left(f_{T-1}, b_{T-1}, h_{T-1}|\mathcal{B}_T\right) \\ &\equiv \frac{\beta\left(1+\phi/n\right)}{\phi/n + \beta\left(1+\phi/n\right)}\left(h_{T-1} - nf_{T-1} - (1/n)\, b_{T-1}\right) \\ &\quad - \frac{\phi}{R\left(\phi/n + \beta\left(1+\phi/n\right)\right)}h_T, \end{aligned}$$

where $h_T = Ah^{\theta}_{T-1}f^{1-\theta}_{T-1}$. The first-order conditions with respect to f_{T-1} and b_{T-1} are respectively

$$nR = d\mathcal{B}_T\left(h_T, s_{T-1}\right)/df_{T-1}$$

and

$$c^a_{T-1}/c^o_{T-1} = (1/\phi)\left(1 - (n/R)\left(d\mathcal{B}_T\left(h_T, s_{T-1}\right)/db_{T-1}\right)\right),$$

where

$$\begin{aligned} &d\mathcal{B}_T\left(h_T, s_{T-1}\right)/df_{T-1} = \\ &\qquad n\beta R/(\phi/n + \beta\left(1+\phi/n\right)) + \left(\phi\left(1+\beta\right)/\left(\phi/n + \beta\left(1+\phi/n\right)\right)\right)H_{f_{T-1}} \end{aligned}$$

and

$$d\mathcal{B}_T(h_T, s_{T-1})/db_{T-1} = \left(R\beta/n\right)/\left(\phi/n + \beta\left(1+\phi/n\right)\right).$$

These conditions are structurally equivalent to equations (7) and (8). Let $\psi_{(1)} \equiv (A(1-\theta)/R)^{1/\theta}$ where the subscript in parentheses represents the number of iterations. Algebraic manipulation yields $f_{T-1} = \mathcal{F}_{T-1}(h_{T-1}, s_{T-2}) \equiv \psi_{(1)} h_{T-1}$ and

$$\begin{aligned} b_{T-1} &= \mathcal{B}_{T-1}\left(h_{T-1}, s_{T-2}\right) \\ &\equiv -\frac{(1+\beta)R}{1+\beta+\phi/n} s_{T-2} + \frac{n\phi}{1+\beta+\phi/n}\left(\frac{1}{n}\frac{\theta}{1-\theta}\psi_{(1)}\right) h_{T-1}. \end{aligned} \tag{A.6}$$

Next, consider period $T-2$. The government's objective function is equivalent to that of $T-1$. Using equation (A.6), optimal private saving is given by

$$\begin{aligned} s_{T-2} &= \tilde{\mathcal{A}}\left(f_{T-2}, b_{T-2}, h_{T-2} | \mathcal{B}_{T-1}\right) \\ &\equiv \frac{\beta(1+\beta+\phi/n)}{(1+\beta)(\beta+\phi/n)}\left(h_{T-2} - n f_{T-2} - (1/n) b_{T-2}\right) \\ &\quad - \frac{n\phi}{R(1+\beta)(\beta+\phi/n)}\left(\frac{1}{n} + \frac{\theta}{1-\theta}\psi_{(1)}\right) h_{T-1}, \end{aligned}$$

where $h_{T-1} = A h_{T-2}^{\theta} f_{T-2}^{1-\theta}$. The first-order conditions with respect to f_{T-2} and b_{T-2} coincide with those of period $T-1$, where

$$\begin{aligned} & d\mathcal{B}_{T-1}\left(h_{T-1}, s_{T-2}\right)/df_{T-2} = \\ & \qquad n\beta R/(\beta+\phi/n) + (n\phi/(\beta+\phi/n))(1/n + (\theta/(1-\theta))\psi_{(1)}) H_{f_{T-2}} \end{aligned}$$

and

$$d\mathcal{B}_{T-1}\left(h_{T-1}, s_{T-2}\right)/db_{T-2} = \beta R/(n\beta+\phi).$$

Let $\psi_{(2)} \equiv (A((1-\theta) + n\theta\psi_{(1)})/R)^{1/\theta}$. Algebraic manipulation yields $f_{T-2} = \mathcal{F}_{T-2}(h_{T-2}, s_{T-3}) \equiv \psi_{(2)} h_{T-2}$ and

$$\begin{aligned} b_{T-2} &= \mathcal{B}_{T-2}\left(h_{T-2}, s_{T-3}\right) \\ &\equiv -\frac{(1+\beta)R}{1+\beta+\phi/n} s_{T-3} + \frac{n\phi}{1+\beta+\phi/n}\left(\frac{1}{n} + \frac{\theta}{1-\theta}\psi_{(2)}\right) h_{T-2}. \end{aligned}$$

Iterating the problem at $T-j$ for any $j > 2$, we find that the equilibrium policy rules are structurally equivalent to those of $j = 2$.

Second Step (Fixed Point). An MPE that corresponds to the limit of the finite-horizon equilibrium for T approaching infinity exists if and only if $\lim_{j\to\infty} \psi_{(j)}$ exists and is finite where

$$\psi_{(j)} = m(\psi_{(j-1)}) \equiv \left(A\left((1-\theta) + n\theta\psi_{(j-1)}\right)/R\right)^{1/\theta}$$

with $\psi_{(1)}$ as the initial condition. Note that the mapping $m(\psi_{(j-1)})$ is twice continuously differentiable with $m(0) > 0$, $m_\psi > 0$, and $m_{\psi\psi} > 0$. Moreover, denoting $\bar{\psi} \equiv (1/\theta)((R/nA)^{1/(1-\theta)} - (1-\theta)/n)$ as the value of $\psi_{(j)}$ such that $m_\psi(\bar{\psi}) = 1$, we obtain $m(\bar{\psi}) = (R/nA)^{1/(1-\theta)}$. Only if $R > An^\theta$, then $m(\bar{\psi}) < \bar{\psi}$. This implies that the first-order difference equation $\psi_{(j)} = m(\psi_{(j-1)})$ admits a unique locally stable fixed-point ψ, which solves the following nonlinear equation:

$$\psi = \left(\frac{A}{R}\left((1-\theta) + n\theta\psi\right)\right)^{1/\theta}. \tag{A.7}$$

At every t, therefore, the equilibrium policy rules are

$$f_t = \mathcal{F}\left(h_t, s_{t-1}\right) \equiv \psi h_t \tag{A.8}$$

and

$$b_t = \mathcal{B}\left(h_t, s_{t-1}\right) \equiv a_s s_{t-1} + a_h h_t, \tag{A.9}$$

where $a_h \equiv (\phi n/(1+\beta+\phi/n))(1/n + (\theta/(1-\theta))\psi)$ and $a_s \equiv -R(1+\beta)/(1+\beta+\phi/n)$. Substituting equations (A.8) and (A.9) into the constraints (1) and (2), we obtain $\tau_t = \mathcal{T}(h_t, s_{t-1}) \equiv n\psi$ and $z_t = \mathcal{Z}(h_t, s_{t-1}) \equiv (1/n)(a_s(s_{t-1}/h_t) + a_h)$.

Third Step (Balanced Growth). Inserting equations (A.8) and (A.9) into the human capital technology and equilibrium private saving yields $h_{t+1}/h_t = A\psi^{1-\theta}$ and $s_t/h_{t+1} = e_s(s_{t-1}/h_t) + e_h$, where

$$e_h \equiv \left(R\beta/\left(\left(a_s + R\left(1+\beta\right)\right)A\psi^{1-\theta}\right)\right)\left(1 - n\psi - a_h/n\right) - \left(a_h/\left(a_s + R\left(1+\beta\right)\right)\right)$$

and $e_s \equiv -a_s\beta R/(n(a_s + R(1+\beta))A\psi^{1-\theta})$. It is straightforward to show that the economy settles on its balanced growth path where all variables grow at the constant rate $A\psi^{1-\theta}$ when

$$R = (n + \phi/\beta)\,A\psi^{1-\theta}. \tag{A.10}$$

Solving equations (A.7) and (A.10) simultaneously yields

$$\psi = \psi^* \equiv 1/\left(n + \phi/\left(\beta\left(1-\theta\right)\right)\right)$$

and

$$R = R^* \equiv (n + \phi/\beta)\,A\left(1/\left(n + \phi/\left(\beta\left(1-\theta\right)\right)\right)\right)^{1-\theta}.$$

Note that $R^* > An^\theta$ for any $\theta \in (0, 1)$. Thus, a solution of (A.7) always exists. Inserting ψ^* and R^* into equation (A.9) yields the restriction on ϕ, which guarantees that $b_t > 0$, namely

$$\phi > A\left(1+\beta\right)\left(1-\theta\right)^{1-\theta}\left(n\left(1-\theta\right) + \phi/\beta\right)^{\theta}\left(s_{-1}/h_0\right). \tag{A.11}$$

The right-hand side of equation (A.11) is increasing and concave in ϕ, and larger than zero for $\phi = 0$. This implies that a unique $\underline{\phi}$ exists, such that if $\phi > \underline{\phi}$, the inequality (A.11) is satisfied.

Proof of Corollary 2. Inserting the equilibrium fiscal policies of Proposition 2 into equation (3) yields

$$\frac{b'}{h\left(\tau+z\right)} = \frac{a_s\left(s_{-1}/h_0\right)+a_h}{n^2\psi+\left(a_s\left(s_{-1}/h_0\right)+a_h\right)} nA(\psi^*)^{1-\theta}. \tag{A.12}$$

For the purpose of contradiction, let equation (A.12) be larger than R^*. Given that equation (A.12) is monotonically decreasing in s_{-1}/h_0, this implies that $b'/h(\tau+z)$ must necessarily be larger than R^* when $s_{-1}/h_0 = 0$. Using equation (A.10), the inequality holds only if $a_h/(n\psi^* + (1/n)a_h) > n + \phi/\beta$. Algebraic manipulation shows that this condition is never satisfied, which proves the contradiction. We conclude that the internal rate of return in a PIS must necessarily be smaller than R^*.

Proof of Proposition 3. Given the initial condition $\left\{h_0, s_{-1}\right\}$, the sequential formulation of the Ramsey planner's problem is

$$\max_{\{f_t,b_t\}_{t=0}^{\infty}} \left\{\beta\log\left(c_0^o\right) + \sum_{t=0}^{\infty}\delta^{t+1}\left(\log\left(c_t^a\right)+\beta\log\left(c_{t+1}^o\right)\right)\right\}$$

subject to the per-period budget constraints $c_t^a + s_t \leq h_t - nf_t - (1/n)b_t$ and $c_{t+1}^o \leq Rs_t + b_{t+1}$, optimal private savings

$$s_t = (\beta/(1+\beta))(h_t - nf_t - (1/n)b_t) - (1/R(1+\beta))b_{t+1},$$

the human capital technology $h_{t+1} = H(f_t, h_t) = Ah_t^{\theta} f_t^{1-\theta}$, and the fiscal feasibility conditions $f_t \geq 0$ and $b_t \geq 0$. Applying the envelope condition based on the Euler equation for saving $R\beta c_t^a = c_{t+1}^o$ yields the following first-order conditions with respect to b_t and f_t:

$$\frac{c_t^a}{c_t^o} = \frac{\delta}{\beta n} \tag{A.13}$$

and

$$H_{f_t} = R\left(1 + \frac{n}{R}H_{h_{t+1}}\left(1 + \sum_{j=1}^{\infty}\left(\frac{n}{R}\right)^j \prod_{i=1}^{j} H_{h_{t+1+i}}\right)\right). \tag{A.14}$$

Replicating the derivation for f_{t+1} yields

$$1 + \sum_{j=1}^{\infty}\left(\frac{n}{R}\right)^j \prod_{i=1}^{j} H_{h_{t+1+i}} = \frac{R}{H_{f_{t+1}}}.$$

Thus, we can rewrite equation (A.14) as follows:

$$R = \left(1 + n\frac{H_{h_{t+1}}\left(h_{t+1}, f_{t+1}\right)}{H_{f_{t+1}}\left(h_{t+1}, f_{t+1}\right)}\right) H_{f_t}\left(h_t, f_t\right). \quad \text{(A.15)}$$

Next, we guess and verify whether the optimal education investment chosen by the Ramsey planner is $f_t = \hat{\psi} h_t$. Inserting the guess into equation (A.15) and rearranging the terms, we obtain

$$\hat{\psi} = \left(\frac{A}{R}\left((1-\theta) + n\theta\hat{\psi}\right)\right)^{1/\theta}. \quad \text{(A.16)}$$

Given R, equation (A.16) is identical to (A.7) and in turn $\hat{\psi} = \psi$. Combining equation (A.13) and the Euler equation for private savings, the planner's economy settles on its balanced growth path where all variables grow at the rate $h_{t+1}/h_t = A\hat{\psi}^{1-\theta}$ if and only if

$$R = \hat{R}^* \equiv A\hat{\psi}^{1-\theta}(n/\delta). \quad \text{(A.17)}$$

Hence, human capital investment implemented by elected governments coincides with the Ramsey allocation when $\hat{R}^* = R^*$. Using equations (A.10) and (A.17), it is straightforward to show that the two interest rates are equal when $\phi = \beta n(1-\delta)/\delta$. Under this parametric configuration with $\phi > \underline{\phi}$, equation (A.13) coincides with equation (7) where we use

$$\mathcal{B}_s = R(1+\beta)/(1+\beta+n^2\beta(1-\delta)/\delta)$$

and

$$\tilde{\mathcal{A}}_b = \beta(1/n)(1+\beta+n^2\beta(1-\delta)/\delta)/((1+\beta)(\beta+n^2\beta(1-\delta)/\delta))$$

from Proposition 2. We can therefore conclude that the level of pension transfers implemented by elected governments is identical to the Ramsey allocation. It is worth noting that the Ramsey planner supports the allocation chosen by a social planner who is only bounded by the economy's resource constraint. Indeed, the social planner will balance the marginal utility of adults and of the elderly, as in equation (A.13), and will yield the optimal human capital accumulation as implied by equation (A.15).

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