Internal Migrations and Decentralization of Public Investment*

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Abstract

We develop a dynamic politico-economic model of public investment where decisions can be made at several levels of government: federal, state, or county. The model predicts that in the absence of internal mobility, the higher level of government would fund all investments that present positive externalities not fully internalized at lower levels. But when there are important internal migrations *unrelated to fiscal policy*, investments that are embodied — and therefore are useful to citizens if they move to other jurisdictions, like education — are more likely to be funded at the local level than investments that are physically sunk, as infrastructure. Such pattern of migrations and financing is consistent with U.S. data.

1 Introduction

Traditional theories of fiscal federalism feature a trade-off between an externality problem in the provision of public goods (favoring centralization as the desired institutional arrangement), and the cost of centralized provision in terms of a "one size fits all policy of uniform public good provision, independently of local needs and tastes (favoring, under some conditions, decentralization). Oates' (1972) Decentralization Theorem states that in the absence of spillovers (and of cost-savings from centralized provision), decentralization is preferable. This has to be read as "preferable to uniform provision." But, in a setting of perfect information, nothing will prevent a benevolent central planner to prescribe the

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right amounts for each jurisdiction. (Oates, 1999). Later work has emphasized, hence, that the case for decentralization has to be driven by political economy considerations.[1]

Among the usual arguments in favor of the decentralization of political power and public services (see, for instance World Bank, 1999), one that stands out is the famous Tiebout (1956) result that when the population is mobile and citizens can "vote with their feet, decentralization may also result in local governments competing with each other to better satisfy the wishes of citizens. In the limiting case, the Tiebout solution does indeed generate a first-best outcome that mimics a competitive market's equilibrium. Thus if there is interjurisdictional homogeneity, precluding traditional costs of centralization, and if mobility is unrelated to taxation and public good provision, the traditional theory would prescribe that public goods be provided by the central government when spillovers are present.

We introduce a novel distinction to the analysis of fiscal federalism that consists on the degree of *embodiment* of public investments. On one extreme there are physical investments that are dis-embodied in the sense that a reallocation of citizens across the country would not affect the productive possibilities in different regions. On the other extreme, public education or health provision are investments that the citizen that receives them can take with her in the event that she migrates to another region in the country, thus affecting her future productivity. This introduces a second source of *perceived* heterogeneity in the costs and benefits of public investments across levels of governments — federal, state, and local (the first one being the mentioned externalities of public investments).

At the same time, population *ageing* may also affect the the perceived costs and benefits of public investments from different levels of government. Thus in a policy game in which each level of government is choosing different instruments our model predicts that a switch in funding from the local level to the state level might take place as a consequence of the secular ageing of the population. Such change has indeed been observed in education financing in the U.S. over the previous century.

The *Serrano* ruling of 1971 was the first one to overturn a state's school finance system. It stated that the California education system was unconstitutional for discriminating students' access to education. The basis for this ruling is the fact that throughout the U.S. a substantial proportion of expenditures on public education is financed at the local level, and thus wealthier communities manage to spend more per student than poorer communities.[2] Despite the fact that this, and others, court ruling resulted in an important increase in the proportion of state financing of education relative to local financing, the relative decline in local financing of education started much earlier, around 1930. In effect, prior to the Great Depression, more than 80% of all public spending on K-12 education

[1]Besley and Coate (1998), Lockwood (2002) and Seabright (1996) present models in which potential benets of decentralization are derived through endogenous choices under alternative political aggregation mechanisms.

[2]This first ruling started a series of court battles in over forty states. Almost half of the major cases decided have resulted in an overturn of the state's school finance system, and many other states have independently initiated reforms in response to these cases. This has led research on public education to study the impact of changes in education financing systems. The main issues of interest are the extent to which different education systems reduce inequality, the effect reform has on total expenditures on education, and their impact on welfare and growth.

in the U.S. was financed by local taxes, at county and city levels. From 1930 to 1970 this proportion steadily declined to 60%, and after the above-mentioned court rulings further declined to approximately 45% nowadays.[3] Therefore the switch in school funding from the local to the state level is not a consequence of court battles, but must obey other, deeper reasons.

Building on a standard three-period overlapping generations model with physical and human capital, our framework endogenizes a number of political and economic choices. In their role as economic agents, households in the model take prices, taxes, and public investments as given when choosing consumption, savings, and labor supply. As voters, households choose among office motivated parties that offer policy platforms at the local, state or federal level comprising labor or capital income taxes as well as the expenditure shares for different types of public investments. Elections take place every period. As a consequence, the political process lacks commitment.

Fiscal policy choices are of different concern to the different cohorts. On the one hand, the exposure of agents to capital and labor income taxes changes over the life cycle. On the other hand, students and workers benefit from the effect of education spending on human capital and thus, future returns to labor and capital. When evaluating the policy platforms on offer in the political arena, the different groups of voters therefore disagree as to which platform should ideally be implemented. We model the resolution of the ensuing conflict under the assumption of probabilistic voting, representing electoral competition under the presumption that voters' support for a party is subject to a small degree of randomness. This randomness induces a continuous mapping from parties' electoral platforms to vote shares, in contrast with the discontinuous mapping that arises under the more common assumption of a pivotal median voter. As a consequence, the probabilistic-voting assumption allows to capture gradual adjustments of policy in response to changes in demographics, even in a stylized three-period-lived overlapping-generations environment.

Tax rates and spending shares do not only affect human and physical capital accumulation, factor prices, and incomes. Absent commitment, they also affect, indirectly, future policy outcomes. In addition to the "economic" repercussions of their policy choices, voters therefore have to internalize the "political" repercussions. In particular, voters must account for the equilibrium relationship between future state variables and policy choices. We assume that only fundamental state variables enter this equilibrium relationship, excluding artificial state variables of the type sustaining trigger strategy equilibria. This restriction absolves us from having to make arbitrary assumptions about the strategies being played; it also reflects our assumption that political choices suffer from a lack of commitment, including commitment to particular enforcement strategies.[4]

Under standard functional form assumptions, we are able to characterize the politico-economic equilibrium in closed form. The optimal strategy of the vote-seeking parties is to propose a policy platform maximizing a weighted average of the welfare of all voters.

[3]It is worth mentioning that federal funds were always negligible in the funding of public K-12 education, never exceeding 10% of total expenditure.

[4]For a discussion of Markov perfect equilibrium see, for example, Krusell, Quadrini and Ríos-Rull (1997).

Changes in the demographic structure affect the equilibrium allocation both directly and indirectly, by altering the balance of power and thus, policy choices. In our model students randomly change location after obtaining their education. If they move, they do so to another county that might be in the same or another state. This gives rise to different costs and benefits of education spending as perceived at different levels of governments. Reallocation of students is neutral from the perspective of the federal government, but distorts the incentives of lower levels of government.

We are not the first ones to incorporate politics in an overlapping-generations model to analyze the choice of productive and redistributive public spending. Bellettini and Berti Ceroni (1999) and Rangel (2003) show how societies may sustain public investment (e.g., education) even if the interests of those benefiting from the investment are not represented in the political process. Glomm and Ravikumar (1992) and Perotti (1993) analyze distributive conflict in models with human capital accumulation. They focus on the political choice of public versus private education and the effect of distortive redistribution in the presence of borrowing constraints, respectively. Fernandez and Rogerson (QJE 1996 AER 1998 JPE 2003) study several issues of comparative education finance systems using a political economy approach, both in static and dynamic models. Closer in spirit to our paper, Soares (2005) evaluates the welfare benefits of a move from local to federal education funding. He emphasizes the effect this has on factor prices in the presence of an exogenous social security system. Gradstein and Kaganovich (2004) present a stylized model in which increased longevity can lead to an increase in education financing at the same time as retirees sort into communities with low taxes leading to a cross-section negative relation between the fraction of elderly residents and per-child public education spending, as found in Poterba (1997). In previous work, GE-N (2008) we found that the increase in longevity has negligible impact on the allocation of public resources and instead induces an increase in the supply of labor. It is ageing due to a decrease in fertility that leads to a decrease in the growth potential, by significantly increasing social security benefits.

In the literature on fiscal federalism, Besley and Coate (1998), Lockwood (2002) and Seabright (1996) present models in which potential benets of decentralization are derived through endogenous choices under alternative political aggregation mechanisms. Many of the papers in this literature require interjurisdictional heterogeneity a la Oates in order to derive benets of decentralization.[5] In the simplest formulation of the heterogeneity issue, decentralization can improve the efficiency of governments because local officials have better information to match the mix of services produced by the public sector and the preferences of the local population (i.e., they have the means to be responsive). One of the features of our formalization is that it does not require heterogeneity.

The remainder of the paper is structured as follows. Section 2 describes the model and characterizes the allocation conditional on policy. Section 3 solves for the politico-economic equilibrium. Section 4 contains the quantitative analysis. Section 5 concludes.

[5]Besley and Coate (1998) and Seabright (1996) are exceptions.

2 Environment

We consider an economy inhabited by three overlapping generations: students, workers, and retirees. Agents within each cohort are homogeneous. Students accumulate human capital but do not consume nor work. Workers contribute with their acquired human capital to production and the formation of new human capital, and they save for retirement. With probability p_t, workers in period $t-1$ survive to become retirees in period t. With probability $1-p_t$, workers die and the return on their savings is distributed among their surviving peers (reflecting a perfect insurance market). Retirees do not work and die at the end of the period.

The ratio of workers to retirees in period t equals ν_t/p_t which follows a deterministic process. The period-t ratio of students to workers equals ν_{t+1}. On a balanced growth path, the survival probability is constant at value p and the gross population growth rate is given by ν.

The economy is partitioned into regions (states) of equal size, each of which is itself partitioned into symmetric local communities (municipalities) with identical demographic structure. After completing their education and before taking up work, students randomly emigrate to another municipality and/or region. The parameter $\mu^l \in [0,1]$ indexes the probability of outmigration from a local community and the parameter $\mu^r \in [0,1]$ indexes the probability of outmigration from a region. By definition, $\mu^r \leq \mu^l$. At the federal level, the probability of outmigration equals zero, $\mu^f = 0$. The immigration rate in each region coincides with the emigration rate in the region, and this rate is the same across regions. A parallel statement applies for local communities.

Political decisions are taken by governmental units at the federal level, the regional level, and the local level. Decisions taken at the federal level reflect the interests of voters in the country as a whole and fully internalize the welfare consequences of policy. Decisions taken at the regional or local level reflect the interests of voters in the region or the local community, respectively; these decisions only internalize the welfare consequences of policy for voters in the respective region or local community. The political decisions at the three levels of government are taken simultaneously, to be described in more detail below.

We adopt as a convention to denote variables chosen by an individual household by a superscript i and variables corresponding to a governmental unit or jurisdiction (such as the federal government, a particular regional government, or a particular local government) by a superscript j. Economy-wide variables do not have superscripts.

2.1 Production

A continuum of competitive firms transforms capital and labor into output by means of a Cobb-Douglas technology. Since capital is fully mobile across regions and local communities, the capital-labor ratio employed by all firms is identical. As a consequence, economy-wide output per worker is given by

$$B_0 k_t^\alpha [H_t(1-x_t)]^{1-\alpha},$$

where $B_0 > 0$ and the capital share $\alpha \in (0,1)$. Capital is owned by (surviving) retirees and fully depreciates after one period. The economy-wide capital stock per worker, k_t, therefore corresponds to the economy-wide per-capita savings of workers in the previous period, s_{t-1}, normalized by ν_t. Labor is supplied by workers whose productivity is proportional to their human capital, H_t. We normalize the time-endowment of a worker to unity and denote the economy-wide leisure consumption of workers by x_t.

Due to perfect competition, production factors are paid their marginal products. Letting w_t denote the wage per unit of time and normalized by labor productivity, and letting R_t denote the gross return on physical capital, we have

$$\begin{aligned} w_t &= (1-\alpha)B_0 k_t^{\alpha}[H_t(1-x_t)]^{-\alpha}, \\ R_t &= \alpha B_0 k_t^{\alpha-1}[H_t(1-x_t)]^{1-\alpha} = w_t \frac{H_t(1-x_t)}{k_t}\alpha' \end{aligned}$$

with $\alpha' \equiv \alpha/(1-\alpha)$. The gross return on savings of a worker that survives to retirement equals $\tilde{R}_t \equiv R_t/p_t$.

2.2 Human Capital Accumulation

Human capital reflects investments in education during previous periods. Let $\mathcal{H}_{t+1}^j$ be the human capital of workers in period $t+1$ that were educated in jurisdiction j during the preceding period. This human capital is produced by combining the stock of human capital of workers *living* in the jurisdiction at time t, H_t^j, as well as the public education investment per student in that jurisdiction during period t, I_t^j:

$$\mathcal{H}_{t+1}^j = B_{1,t}(H_t^j)^{1-\delta}(I_t^j)^{\delta}, \ \delta \in (0,1).$$

Due to in- and out-migration, H_{t+1}^j reflects both the human capital of workers that were educated in the jurisdiction and did not emigrate, $\mathcal{H}_{t+1}^j$, and the human capital of workers that immigrated from other jurisdictions after completing their education there. We assume that H_{t+1}^j is given by a geometric average of these two components, $H_{t+1}^j = (\mathcal{H}_{t+1}^j)^{1-\mu^j}\bar{H}_{t+1}^{\mu^j}$ where μ^j denotes the measure of labor mobility at the level of the jurisdiction and $\bar{H}_{t+1}$ denotes the labor productivity of workers educated in other jurisdictions.

From the perspective of political decision makers in jurisdiction j, human capital accumulation is partly exogenous if $\mu^j > 0$ (that is, in all cases except for the federal government). In particular, political decision makers in jurisdiction j perceive the law of motion

$$H_{t+1}^j = (B_{1,t}(H_t^j)^{1-\delta}(I_t^j)^{\delta})^{1-\mu^j}(B_{1,t}\bar{H}_t^{1-\delta}\bar{I}_t^{\delta})^{\mu^j} \tag{1}$$

and thus, the investment elasticities $\mathrm{d}\ln(H_{t+1}^j)/\mathrm{d}\ln(I_t^j) = \delta(1-\mu^j)$ and $\mathrm{d}\ln(\mathcal{H}_{t+1}^j)/\mathrm{d}\ln(I_t^j) = \delta$. If $\mu^j > 0$, and if political decision makers are only concerned about the productivity of workers in their respective jurisdiction, then these decision makers do not fully internalize the direct benefits of public investment.[6] If, in contrast, political decision makers are concerned about the human capital formation of students in their jurisdiction, independently

[6]This point has been emphasized, see literature.

of whether these students will emigrate or not, then the decision makers will internalize all direct benefits of public education. In any case, political decision makers concerned about the welfare of currently living households will not fully internalize the dynamic externality from future stocks of human capital on further human capital formation.

Except for the introduction of labor mobility, our human capital accumulation specification is standard in the literature (see, e.g., Boldrin and Montes, 2005). The productivity parameter $B_{1,t}$ may be constant, reflecting the assumption of non-rival human capital accumulation, or inversely related to population growth, $B_{1,t} = \tilde{B}_1 \nu_{t+1}^{-(1-\delta)}$ for some constant $\tilde{B}_1$, reflecting rivalry. The two specifications differ only with respect to the growth implications of the model.

2.3 Policy Instruments

Governmental units tax labor income and capital income. A first labor income tax, levied by jurisdiction j at rate τ_t^j, funds transfers to retirees in the jurisdiction. We denote the average transfer to retirees (per retiree) in jurisdiction j by b_t^j,

$$b_t^j = w_t H_t^j (1 - x_t^j) \tau_t^j \nu_t / p_t.$$

A second labor income tax, levied by jurisdiction j' at rate $\sigma_t^{j'}$, funds education investment in the jurisdiction. Finally, the capital income tax, levied by jurisdiction j'' at rate $\eta_t^{j''}$, funds education investment in jurisdiction j''. We then have

$$\begin{aligned} I_t^{j' \cap j''} &= w_t H_t^{j'} (1 - x_t^{j'}) \sigma_t^{j'} / \nu_{t+1} + s_{t-1}^{j''} R_t \eta_t^{j''} / (\nu_t \nu_{t+1}) \\ &= \frac{w_t H_t (1 - x_t)}{\nu_{t+1}} \left(\frac{H_t^{j'} (1 - x_t^{j'})}{H_t (1 - x_t)} \sigma_t^{j'} + \frac{s_{t-1}^{j''}}{s_{t-1}} \alpha' \eta_t^{j''} \right). \end{aligned}$$

Social security benefits are paid proportionally to private savings. If household i in jurisdiction j saves s_t^i while average savings in the jurisdiction equals s_t^j, then the household receives benefits

$$b_{t+1}^i = b_{t+1}^j \frac{s_t^i}{s_t^j}$$

in period $t + 1$. The assumption that benefits are proportional to savings rather than disposable income and social security contributions, say, simplifies the analysis of the effects of policy choices on the equilibrium allocation off the equilibrium path. More specifically, the assumption implies that the savings rate is unaffected by off-equilibrium policy choices. Along the equilibrium path, benefits are proportional to contributions, rendering the assumption irrelevant in that sense.

Our analysis in sections 3 and 4 will be concerned with the equilibrium implications of employing the three tax instruments τ, σ and η at different levels of government. Throughout the analysis, we impose that each of the three instruments can be employed at only one of these levels. Moreover, we exclude lump-sum taxes (that is, we restrict b_t^j to be positive) and impose that investment taxes may not be used for redistributive reasons (that is, we restrict $\sigma_t^{j'}$ and $\eta_t^{j''}$ to be positive):

$$\tau_t^j,\ \sigma_t^{j'},\ \eta_t^{j''} \geq 0 \ \text{ for all } t, j, j', j''. \tag{2}$$

We denote a generic combination of the three instruments in period t by κ_t, $\kappa_t \equiv (\tau_t, \sigma_t, \eta_t)$.

2.4 Household Choices

As mentioned before, students do not work nor consume. Workers value consumption during working-age, c_1, and retirement, c_2, as well as leisure. Agents discount the future at factor $\beta \in (0,1)$. Due to the risk of death, workers' effective discount factor therefore equals βp_{t+1}. For analytical tractability, we assume that the period utility function of consumption is logarithmic. Maximizing expected utility, a worker i in period t solves the following problem:

$$\begin{aligned}
\max_{s_t^i, x_t^i} \quad & \ln(c_{1,t}^i) + v(x_t^i) + \beta p_{t+1} \ln(c_{2,t+1}^i) \\
\text{s.t.} \quad & c_{1,t}^i = w_t H_t^i (1 - x_t^i)(1 - \tau_t^j - \sigma_t^{j'}) - s_t^i, \\
& c_{2,t+1}^i = s_t^i \tilde{R}_{t+1}(1 - \eta_{t+1}^{j''}) + b_{t+1}^j \frac{s_t^i}{s_t^j}.
\end{aligned}$$

The felicity function of leisure is assumed to be increasing and concave.

The Euler equation characterizing savings of household i simplifies to

$$s_t^i = z_{t+1} w_t H_t^i (1 - x_t^i)(1 - \tau_t^j - \sigma_t^{j'}),$$

where $z_{t+1} \equiv \beta p_{t+1}/(1 + \beta p_{t+1})$ denotes the savings rate out of disposable income. In turn, optimal labor supply of worker i satisfies the condition

$$v'(x_t^i) = \frac{w_t H_t^i (1 - \tau_t^j - \sigma_t^{j'})}{c_{1,t}^i} = \frac{1}{(1 - x_t^i)(1 - z_{t+1})}, \tag{3}$$

implying that $x_t^i = x_t$ where x_t is a function of the parameters β and p_{t+1}.

Note that

$$\frac{b_{t+1}^j}{s_t^j} = \frac{w_{t+1} H_{t+1}^j (1 - x_{t+1}^j) \tau_{t+1}^j \nu_{t+1}}{p_{t+1} s_t^j} = \frac{\tilde{R}_{t+1} \tau_{t+1}^j}{\alpha'} \underbrace{\frac{H_{t+1}^j s_t}{H_{t+1} s_t^j}}_{\Omega_{t+1}^j}.$$

If social security is implemented at the federal level, then the term $\Omega_{t+1}^j \equiv 1$.

We can now define the indirect utility functions of retirees, workers, and students in period t, respectively, as

$$\begin{aligned}
&\mathcal{R}_t^i(s_{t-1}^i, R_t, \tau_t^j\Omega_t^j, \eta_t^{j''}) = \ln\left(s_{t-1}^i\tilde{R}_t(1-\eta_t^{j''}+\tau_t^j\Omega_t^j/\alpha')\right),\\
&\mathcal{W}_t^i(w_t, H_t^i, R_{t+1}, \tau_t^j+\sigma_t^{j'}, \tau_{t+1}^j\Omega_{t+1}^j, \eta_{t+1}^{j''}) =\\
&\qquad(1+\beta p_{t+1})\ln\left(w_t H_t^i(1-\tau_t^j-\sigma_t^{j'})\right)+\beta p_{t+1}\ln\left(\tilde{R}_{t+1}(1-\eta_{t+1}^{j''}+\tau_{t+1}^j\Omega_{t+1}^j/\alpha')\right),\\
&\mathcal{S}_t^i(w_{t+1}, \{H_{t+1}^i\}, R_{t+2}, \{\tau_{t+1}^j+\sigma_{t+1}^{j'}\}, \{\tau_{t+2}^j\Omega_{t+2}^j\}, \{\eta_{t+2}^{j''}\})) =\\
&\qquad\beta\mathrm{E}_t\left[\mathcal{W}_{t+1}^i(w_{t+1}, H_{t+1}^i, R_{t+2}, \tau_{t+1}^j+\sigma_{t+1}^{j'}, \tau_{t+2}^j\Omega_{t+2}^j, \eta_{t+2}^{j''})\right],
\end{aligned}$$

where we have dropped additive terms that only depend on parameters. The set notation ($\{\ldots\}$) as well as the expectations operator in the indirect utility function of the student indicates that students face risk with respect to (i) their labor productivity during working age and (ii) tax rates during working age and retirement, due to their idiosyncratic migration shock.

2.5 Symmetric Economic Equilibrium

In a symmetric equilibrium, all jurisdictions levy the same tax rates, implying that macroeconomic aggregates at the local, regional and federal levels coincide. In such a symmetric equilibrium, the state in period t is given by lagged per-capita savings (in any jurisdiction), s_{t-1}, as well as average current labor productivity (in any jurisdiction), H_t. These two state variables imply the equilibrium wage and interest rate (equilibrium labor supply is exogenous at level x_t) as well as, conditional on the symmetric policy choice κ_t, equilibrium saving, investment, benefits, and productivity growth and thus, the state in the following period.

Formally, s_{t-1}, H_t and κ_t recursively determine

$$\left.\begin{array}{rcl}
w_t &=& (1-\alpha)B_0[s_{t-1}/\nu_t]^\alpha[H_t(1-x_t)]^{-\alpha},\\
R_t &=& \alpha B_0[s_{t-1}/\nu_t]^{\alpha-1}[H_t(1-x_t)]^{1-\alpha} = w_t\frac{H_t(1-x_t)}{k_t}\alpha',\\
s_t &=& z_{t+1}w_tH_t(1-x_t)(1-\tau_t-\sigma_t),\\
I_t &=& \frac{w_tH_t(1-x_t)}{\nu_{t+1}}(\sigma_t+\alpha'\eta_t),\\
b_t &=& w_tH_t(1-x_t)\tau_t\nu_t/p_t,\\
H_{t+1} &=& \mathcal{H}_{t+1} = B_{1,t}H_t^{1-\delta}I_t^\delta.
\end{array}\right\} \quad (4)$$

In turn, these variables directly determine the capital stock and equilibrium consumption levels.

The investment share and the net tax shares of retirees and workers, respectively, in the symmetric equilibrium are given by

$$\begin{array}{rcl}
\mathrm{sh}_t^I &\equiv& \dfrac{I_t\nu_{t+1}}{\text{output per worker}_t} = (1-\alpha)(\sigma_t+\alpha'\eta_t),\\
\mathrm{sh}_t^R &\equiv& \dfrac{(\eta_t s_{t-1}\tilde{R}_t-b_t)\frac{p_t}{\nu_t}}{\text{output per worker}_t} = (1-\alpha)(\alpha'\eta_t-\tau_t),\\
\mathrm{sh}_t^W &\equiv& \mathrm{sh}_t^I-\mathrm{sh}_t^R = (1-\alpha)(\tau_t+\sigma_t).
\end{array}$$

Along a symmetric balanced growth path, all tax rates and demographic variables are constant, implying that per-capita labor supply is time-invariant as well. From (4), the growth rates of s_t and H_t (as well as other, implied, variables) then are equal to each other. Let this common gross balanced growth rate be denoted by γ_H. XXX here maybe some adjustments needed: For any time-invariant choice of tax rates, the first and last equation in (4) pin down the ratio H_t/s_{t-1} on the balanced growth path. Given this ratio, the same two conditions pin down γ_H:

$$\gamma_H^{1-\alpha(1-\delta)} = \left(\frac{B_0(1-\alpha)((1-x)(\sigma+\alpha'\eta))^{1-\alpha}}{\nu}\right)^{\delta} B_1^{1-\alpha}\left((1-\tau-\sigma)z(\tau,\eta)\right)^{\alpha\delta} \text{ s.t. (3).}$$

Labor income taxes depress growth because they lower disposable income of workers (the effect captured by the expression $1-\tau-\sigma$), as do expected future retirement benefits because they lower the savings rate ($z(\tau,\eta)$ is decreasing in its first argument). At the same time, education investment fosters human capital accumulation and thus, growth (the effect captured by $\sigma+\alpha'\eta$), in line with the empirical evidence (Blankenau, Simpson and Tomljanovich, 2007). Capital income taxes η have an ambiguous effect on growth because they increase education investment but lower the savings rate of workers.

Physical capital along its long-run growth path satisfies $k_{t+1} = \mathcal{L}_t(1-\tau-\sigma)\, z(\tau,\eta)/\nu$. Since k_t grows at the gross rate γ_H, it follows that

$$\begin{aligned}\left(\frac{H_t}{k_t}\right)^{1-\alpha} &= \frac{\gamma_H \nu}{B_0(1-\alpha)(1-x)^{1-\alpha}(1-\tau-\sigma)\, z(\tau,\eta)} \text{ s.t. (3),}\\ R &= \frac{\alpha\gamma_H\nu}{(1-\alpha)(1-\tau-\sigma)\, z(\tau,\eta)} \text{ s.t. (3).}\end{aligned}$$

Defining the elasticities

$$\zeta_t^{w,s} \equiv \frac{\mathrm{d}\ln(w_t^n)}{\mathrm{d}\ln(s_{t-1})},\; \zeta_t^{w,H} \equiv \frac{\mathrm{d}\ln(w_t^n)}{\mathrm{d}\ln(H_t)},\; \zeta_t^{R,s} \equiv \frac{\mathrm{d}\ln(R_t)}{\mathrm{d}\ln(s_{t-1})},\; \zeta_t^{R,H} \equiv \frac{\mathrm{d}\ln(R_t)}{\mathrm{d}\ln(H_t)},$$

we can express the laws of motion of the two "regional" endogenous state variables as

$$\begin{aligned}\begin{bmatrix}\ln(s_t)\\ \ln(H_{t+1})\end{bmatrix} &= \underbrace{\begin{bmatrix}\zeta_t^{w,s} & \zeta_t^{w,H}+1\\ \delta(1-\mu)\zeta_t^{w,s} & \delta(1-\mu)(\zeta_t^{w,H}+1)+(1-\delta)(1-\mu)\end{bmatrix}}_{M}\begin{bmatrix}\ln(s_{t-1})\\ \ln(H_t)\end{bmatrix}\\ &\quad + \underbrace{\begin{bmatrix}m_t^s(\cdot)\\ m_t^H(\cdot)\end{bmatrix}}_{m_t},\end{aligned} \tag{5}$$

where $m_t^s(\cdot)$ and $m_t^H(\cdot)$ are implicitly defined by (4).

A household that studies in the region in period t but moves "abroad" upon taking up work supplies the same amount of labor as her co-workers (since labor supply only depends on anticipated tax rates). However, consumption of the emigrating household differs from the consumption of other households living abroad if $\mathcal{H}_{t+1}$ differs from $\bar{H}_{t+1}$ (see the derivation of equilibrium consumption and saving). Formally, we have

$$\left.\begin{array}{rcl} c^{\mu}_{1,t+1} & = & w^{n}_{t+1}\mathcal{H}_{t+1}(1-x(\bar{\tau}_{t+2},\bar{\eta}_{t+2}))\,(1-\bar{\tau}_{t+1}-\bar{\sigma}_{t+1})\,(1-z_{t+2}(\bar{\tau}_{t+2},\bar{\eta}_{t+2})), \\ c^{\mu}_{2,t+2} & = & c^{\mu}_{1,t+1}\beta p_{t+2}R_{t+2}(1-\bar{\eta}_{t+2}). \end{array}\right\} \quad (6)$$

In symmetric equilibrium, all regions impose the same policies, implying that region-specific and economy-wide variables coincide. The normalized wage and the interest rate therefore equal

$$\left.\begin{array}{rcl} w^{n}_{t} & = & (1-\alpha)B_0\left(\frac{k_t}{H_t(1-x_t)}\right)^{\alpha} = (1-\alpha)B_0\left(\frac{s_{t-1}}{\nu_t H_t(1-x_t)}\right)^{\alpha}, \\ R_t & = & w^{n}_{t}H_t\frac{(1-x_t)\nu_t}{s_{t-1}}\alpha'. \end{array}\right\} \quad (7)$$

3 Politico-Economic Equilibrium

We assume that retirees, workers and students may vote on candidates whose electoral platforms specify values for the policy instruments, κ_t. (It is straightforward to analyze the situation where only a subset of the population, e.g. only workers and retirees, participates in the vote; see below.) Voters do not only support a candidate for her policy platform, but also for other characteristics like "ideology" that are orthogonal to the fundamental policy dimensions of interest. These characteristics are permanent and cannot be credibly altered in the course of electoral competition. Moreover, their valuation differs across voters (even if voters agree about the preferred policy platform) and is subject to random aggregate shocks, realized after candidates have chosen their platforms. This "probabilistic-voting" setup renders the probability of winning a voter's support a continuous function of the competing policy platforms, implying that equilibrium policy platforms smoothly respond to changes in the demographic structure. This stands in sharp contrast to the "median-voter" setup where, in a model with only a few generations, an infinitesimal change in the demographic structure has implausibly large effects on policy outcomes if it alters the cohort the median voter is associated with.

In the Nash equilibrium of the game with two candidates choosing platforms to maximize their expected vote shares, both candidates propose the same policy platform.[7] This platform maximizes a convex combination of the objective functions of all groups of voters, where the weights reflect the groups' size and sensitivity of voting behavior to policy changes. Those groups that care the most about policy platforms rather than other candidate characteristics are the most likely to shift their support from one candidate to the other in response to small changes in the proposed platforms. In equilibrium, such groups of "swing voters" thus gain in political influence and tilt policy in their own favor. If all voters are equally responsive to changes in the policy platforms, electoral competition implements the utilitarian optimum with respect to voters.

Owing to political competition at the beginning of each period, policy makers cannot commit to future policy platforms. Voters therefore have to form expectations about the

[7]See Lindbeck and Weibull (1987) and Persson and Tabellini (2000) for discussions of probabilistic voting.

effect of current policy choices on future policy outcomes. Under the Markov assumption, future leisure and policy choices are functions of the fundamental state variables only, $x_{t+1} = \tilde{x}_{t+1}(H_{t+1}, q_{t+1})$ and $\kappa_{t+1} = \tilde{\kappa}_{t+1}(H_{t+1}, q_{t+1})$. (The state variables include demographic variables, thus the time indices of the policy functions.) If the policy functions are independent of (H, q), $\kappa_{t+1} = \tilde{\kappa}_{t+1}$, then (3) implies that the leisure function is independent of (H, q) as well, $x_{t+1} = \tilde{x}_{t+1}$, and both the aggregate savings function and the economic equilibrium conditions (4) apply (see the discussion at the end of subsection 2.4). In the following, we conjecture that the policy functions indeed are independent of (H, q). We derive the equilibrium choice of policy instruments under this conjecture and show that this choice does not depend on (H, q), thereby verifying the conjecture.

Let ω and ψ denote the per-capita political influence of retirees and students, respectively, relative to workers. The program characterizing equilibrium policy choices in period t is then given by

$$\max_{\kappa_t} W_t(H_t, q_t, \kappa_t; \tilde{\kappa}_{t+1}, \tilde{x}_{t+1}) \text{ s.t. } (2).$$

The political objective function $W_t(\cdot)$ depends on the endogenous state variables (as well as the exogenous ones, thus the time index), the contemporaneous policy instruments, and the anticipated values of policy instruments and leisure in the following period. In particular,

$$\begin{aligned} W_t(H_t, q_t, \kappa_t; \tilde{\kappa}_{t+1}, \tilde{x}_{t+1}) \;\; &\equiv \;\; \omega p_t \ln(c_{2,t}) + \nu_t[\ln(c_{1,t}) + v(x_t) + \beta p_{t+1} \ln(c_{2,t+1})] \\ & \quad + \psi \nu_t \nu_{t+1} \beta(1-\mu)[\ln(c_{1,t+1}) + v(x_{t+1}) + \beta p_{t+2} \ln(c_{2,t+2})] \\ & \quad + \psi \nu_t \nu_{t+1} \beta \mu[\ln(c^{\mu}_{1,t+1}) + v(x^{\mu}_{t+1}) + \beta p_{t+2} \ln(c^{\mu}_{2,t+2})] \\ \text{s.t.} \qquad & \quad (4), (3);\; H_t, q_t \text{ given};\; \kappa_{t+1} = \bar{\kappa}_{t+1} = \tilde{\kappa}_{t+1},\; x_{t+1} = \bar{x}_{t+1} = \tilde{x}_{t+1}. \end{aligned}$$

Here, variables with a superscript μ denote consumption or leisure of a student that emigrates after graduation. The variables $\bar{\kappa}$ and $\bar{x}$ denote policy instruments and leisure in other regions, respectively. Political equilibrium requires that for any combination of state variables (H_t, q_t), the κ_t solving this program is given by $\tilde{\kappa}_t$.

From the perspective of political decision makers at the federal level, a change in policy affects the state variables in all regions in parallel. As a consequence, political decision makers at the federal level perceive the elasticities ζ_t to be determined according to (7),

$$\zeta^{w,s}_t = \alpha,\; \zeta^{w,H}_t = -\alpha,\; \zeta^{R,s}_t = -(1-\alpha),\; \zeta^{R,H}_t = 1-\alpha.$$

From the perspective of political decision makers at the state or local level, these elasticities are smaller in absolute value or even approximately zero.

Using the equilibrium expressions for consumption from (4), the objective function can be expressed as

$$
\begin{aligned}
&W_t(\cdot) = \\
&\quad \omega p_t\{\ln[(1-x_t)^{1-\alpha}(\alpha'(1-\eta_t)+\tau_t)]\} + \\
&\quad \nu_t\{\ln[(1-x_t)^{1-\alpha}(1-\tau_t-\sigma_t)] + v(x_t) + \\
&\qquad \beta p_{t+1}\ln[(1-x_t)^{(1-\alpha)(\delta(1-\alpha)(1-\mu)+\alpha)}(1-\tau_t-\sigma_t)^{\alpha} \times \\
&\qquad\qquad (\sigma_t+\alpha'\eta_t)^{\delta(1-\alpha)(1-\mu)}]\} + \\
&\quad \psi\nu_t\nu_{t+1}\beta(1-\mu)\{\ln[(1-x_t)^{(1-\alpha)(\delta(1-\alpha)(1-\mu)+\alpha)}(1-\tau_t-\sigma_t)^{\alpha} \times \\
&\qquad\qquad (\sigma_t+\alpha'\eta_t)^{\delta(1-\alpha)(1-\mu)}] + \\
&\qquad \beta p_{t+2}\ln[(1-x_t)^{(1-\alpha)(\delta 1(1-\delta)(1-\alpha)(1-\mu)^2+(\delta(1-\alpha)(1-\mu)+\alpha)^2)} \times \\
&\qquad\qquad (1-\tau_t-\sigma_t)^{\alpha(\delta(1-\alpha)(1-\mu)+\alpha)} \times \\
&\qquad\qquad (\sigma_t+\alpha'\eta_t)^{\delta(1-\alpha)(1-\mu)(1(1-\delta)(1-\mu)+\delta(1-\alpha)(1-\mu)+\alpha)}]\} + \\
&\quad \psi\nu_t\nu_{t+1}\beta\mu\{\ln(c^{\mu}_{1,t+1}) + \beta p_{t+2}\ln(c^{\mu}_{2,t+2})\} + \text{t.i.p.} \quad \text{s.t. (3)},
\end{aligned}
$$

where t.i.p. denotes terms that are unaffected by contemporaneous policy choices (under the conjecture). The wage of a student emigrating from the economy under consideration to another region with human capita $\bar{H}_{t+1}$ is given by $w^i_{t+1} = w_{t+1}\mathcal{H}_{t+1}/\bar{H}_{t+1}$. From 6, we therefore have

$$
\begin{aligned}
\frac{\partial\ln(c^{\mu}_{1,t+1})}{\partial\sigma_t} &= \frac{1}{c^{\mu}_{1,t+1}}\frac{w_{t+1}(1-x^i_{t+1})(1-\bar{\tau}_{t+1}-\bar{\sigma}_{t+1})}{(1+\beta p_{t+2})\bar{H}_{t+1}}\frac{\partial\mathcal{H}_{t+1}}{\partial\sigma_t}, \\
\frac{\partial\ln(c^{\mu}_{2,t+2})}{\partial\sigma_t} &= \frac{1}{c^{\mu}_{2,t+2}}\frac{\beta p_{t+2}w_{t+1}(1-x^i_{t+1})(1-\bar{\tau}_{t+1}-\bar{\sigma}_{t+1})}{(1+\beta p_{t+2})\bar{H}_{t+1}}\bar{\bar{R}}_{t+2}(1-\bar{\eta}_{t+2})\frac{\partial\mathcal{H}_{t+1}}{\partial\sigma_t}.
\end{aligned}
$$

Using the household's Euler equation and the human capital accumulation equation, this implies

$$
\begin{aligned}
&\frac{\partial(\ln(c^{\mu}_{1,t+1}) + \beta p_{t+2}\ln(c^{\mu}_{2,t+2}))}{\partial\sigma_t} \\
&\quad = \frac{1}{c^{\mu}_{1,t+1}}\frac{w_{t+1}(1-x^i_{t+1})(1-\bar{\tau}_{t+1}-\bar{\sigma}_{t+1})}{(1+\beta p_{t+2})\bar{H}_{t+1}}\frac{\partial\mathcal{H}_{t+1}}{\partial\sigma_t}(1+\beta p_{t+2}) \\
&\quad = \frac{1}{c^{\mu}_{1,t+1}}\frac{w_{t+1}(1-x^i_{t+1})(1-\bar{\tau}_{t+1}-\bar{\sigma}_{t+1})}{\bar{H}_{t+1}}\frac{\delta\mathcal{H}_{t+1}}{\sigma_t+\alpha'\eta_t} \\
&\quad = \frac{w_{t+1}(1-x^i_{t+1})(1-\bar{\tau}_{t+1}-\bar{\sigma}_{t+1})}{c^{\mu}_{1,t+1}}\frac{\delta}{\sigma_t+\alpha'\eta_t} \\
&\quad = \frac{1-\bar{\tau}_{t+1}-\bar{\sigma}_{t+1}}{(1-\bar{\tau}_{t+1}-\bar{\sigma}_{t+1})(1-z_{t+2}(\bar{\tau}_{t+2},\bar{\eta}_{t+2}))}\frac{\delta}{\sigma_t+\alpha'\eta_t} \\
&\quad \approx (1+\beta p_{t+2})\frac{\delta}{\sigma_t+\alpha'\eta_t}.
\end{aligned}
$$

The last two equalities use the fact that the equilibrium is symmetric across regions. The approximation in the last line is exact if $(\bar{\tau}_{t+2},\bar{\eta}_{t+2}) = (0,1)$ that is, if migrants do not expect to receive accidental bequests or social security benefits. In that case, emigrants simply consume $\mathcal{H}_{t+1}/\bar{H}_{t+1}$ times the amount consumed by native inhabitants of the other region. Parallel derivations imply that the derivative of $\ln(c^{\mu}_{1,t+1}) + \beta p_{t+2} \ln(c^{\mu}_{2,t+2})$ with respect to η_t is given by α times the above expression; the derivative with respect to τ_t equals zero.

With these results at hand, it is evident that the equilibrium choice of policy instruments, κ_t, is orthogonal to the state variables H_t and q_t, confirming the initial conjecture. (The orthogonality result relies on the logarithmic utility assumption. In related work, we analyze the sensitivity of a parallel result to changes in functional form assumptions (Gonzalez-Eiras and Niepelt, 2005). We find that, in the case of generalized CRRA preferences, state variables do affect the choice of policy instruments. However, the quantitative implications for equilibrium policies are negligible.)

In the following, we analyze politico-economic equilibrium with inelastic and elastic labor supply. We also consider the effects on political outcomes of allocating political authority to different levels of government. In particular, we model *national* political decision making (for example, at the level of a federal government) by setting μ equal to zero, implying that political decision makers fully internalize the costs and benefits of their choices on other regions. In contrast, *local* political decision making (for example, at the level of a state or community) is modeled by letting $\mu > 0$. We refer to *non-hierarchical* political decision making systems as arrangements, where authority for all policy instruments is allocated to the same level of government. In contrast, in *hierarchical* political decision making systems, authority for different policy instruments is allocated to different levels of government.

Current policy choices do not directly affect labor supply, see (3). Under the conjecture, they do not affect future policy choices either, implying that there is no indirect effect from κ_t on x_t either. We can therefore write

$$\begin{aligned}
&W_t(\cdot) \sim \\
&\quad \omega p_t\{\ln[(\alpha'(1-\eta_t)+\tau_t)]\} + \\
&\quad \nu_t\{\ln[(1-\tau_t-\sigma_t)] + \\
&\qquad \beta p_{t+1}\ln[(1-\tau_t-\sigma_t)^{\alpha}(\sigma_t+\alpha'\eta_t)^{\delta(1-\alpha)(1-\mu)}]\} + \\
&\quad \psi\nu_t\nu_{t+1}\beta(1-\mu)\{\ln[(1-\tau_t-\sigma_t)^{\alpha}(\sigma_t+\alpha'\eta_t)^{\delta(1-\alpha)(1-\mu)}] + \\
&\qquad \beta p_{t+2}\ln[(1-\tau_t-\sigma_t)^{\alpha(\delta(1-\alpha)(1-\mu)+\alpha)} \times \\
&\qquad\qquad (\sigma_t+\alpha'\eta_t)^{\delta(1-\alpha)(1-\mu)(1(1-\delta)(1-\mu)+\delta(1-\alpha)(1-\mu)+\alpha)}]\} + \\
&\quad \psi\nu_t\nu_{t+1}\beta\mu\{\ln(c^{\mu}_{1,t+1}) + \beta p_{t+2}\ln(c^{\mu}_{2,t+2})\}.
\end{aligned}$$

Let

$$\Delta^1_t(\mu) \equiv 1 + \alpha\beta p_{t+1} + \psi\nu_{t+1}\alpha\beta(1-\mu)[1+\beta p_{t+2}(\delta(1-\alpha)(1-\mu)+\alpha)]$$

denote the effect on the political objective function of a marginal decrease of the tax rate on labor income (this effect is normalized by the ratio between after- and pre-tax labor income and given in per-worker terms). The effect reflects increased current and future consumption of workers as well as increased future consumption by students that do not emigrate. More specifically, higher disposable income increases workers' contemporaneous consumption and, due to stronger capital accumulation, their retirement income; the associated welfare effects are proportional to $1 + \alpha\beta p_{t+1}$. Stronger capital accumulation also benefits students whose next-period labor income and savings increases, triggering (discounted) welfare effects proportional to $1+\alpha\beta p_{t+2}$. Students additionally gain because higher output in period $t+1$ translates into higher education investment and thus, higher output and income in period $t+2$; the corresponding welfare effects are proportional to $\beta p_{t+2}\delta(1-\alpha)(1-\mu)$.

Similarly, let

$$\begin{aligned}\Delta_t^2(\mu) \quad \equiv \quad & \beta\delta(1-\alpha)(1-\mu) \times \\ & \quad (p_{t+1} + \psi\nu_{t+1}(1-\mu)[1+\beta p_{t+2}(1(1-\delta)(1-\mu)+\delta(1-\alpha)(1-\mu)+\alpha)]) + \\ & \beta\delta\psi\nu_{t+1}\mu(1+\beta p_{t+2})\end{aligned}$$

denote the effect on the political objective function of a marginal increase in the fraction of labor income devoted to public education (this effect is normalized by the ratio of investment spending to labor income and given in per-worker terms). Higher investment spending increases productivity in the subsequent period, as reflected by the term $\beta\delta(1-\alpha)(1-\mu)$. Workers benefit because the productivity increase affects all their sources of income during retirement. Students not migrating benefit from increased second- and third-period consumption, both directly (the welfare effect is proportional to $1+\alpha\beta p_{t+2}$) and indirectly, through induced education investment in period $t+1$ (proportional to $\beta p_{t+2}\delta(1-\alpha)(1-\mu)$) and due to the dynamic human capital externality that pays off in period $t+2$ (proportional to $\beta p_{t+2}1(1-\delta)(1-\mu)$). Students emigrating after graduation benefit from an increase in lifetime income *proportional* to the increase in their human capital (the welfare effect is given in the last line on the right-hand side of the identity).

Using these definitions, the first-order condition with respect to τ_t can be expressed as

$$\frac{\omega p_t}{\nu_t}\frac{1}{\alpha'(1-\eta_t)+\tau_t} - \frac{\Delta_t^1(\mu)}{1-\tau_t-\sigma_t} \leq 0,$$

indicating the tradeoff between benefits from increased consumption for retirees and costs due to decreased disposable income for workers. The condition holds as an equality if τ_t is interior. The first-order condition with respect to σ_t reads

$$-\frac{\Delta_t^1(\mu)}{1-\tau_t-\sigma_t} + \frac{\Delta_t^2(\mu)}{\sigma_t+\alpha'\eta_t} \leq 0,$$

and the first-order condition with respect to η_t is given by

$$-\frac{\omega p_t}{\nu_t}\frac{\alpha'}{\alpha'(1-\eta_t)+\tau_t} + \alpha'\frac{\Delta_t^2(\mu)}{\sigma_t+\alpha'\eta_t} \leq 0.$$

3.1 Non-Hierarchical Political Decision Making

Suppose that κ_t is chosen at the local or national level. Irrespective of the value of μ, $\alpha'(\partial W_t/\partial\sigma_t - \partial W_t/\partial\tau_t) = \partial W_t/\partial\eta_t$; the effects on the political objective function of changes in the three policy instruments therefore are linearly dependent. Intuitively, this indeterminacy arises because higher social security transfers can be undone by a combination of higher capital income taxes and lower worker contributions for education.

Disregarding the inequality constraints in (2) and solving the first-order conditions with respect to σ_t and η_t for the equilibrium tax functions $\eta_t(\tau_t)$ and $\sigma_t(\tau_t)$ yields

$$\begin{aligned}\sigma_t(\tau_t) &= \frac{\omega p_t - \nu_t(\alpha'\Delta_t^1(\mu) - \Delta_t^2(\mu))}{(\omega p_t + \nu_t(\Delta_t^1(\mu) + \Delta_t^2(\mu)))} - \tau_t,\\ \eta_t(\tau_t) &= \frac{-\omega p_t + \nu_t\alpha'(\Delta_t^1(\mu) + \Delta_t^2(\mu))}{\alpha'(\omega p_t + \nu_t(\Delta_t^1(\mu) + \Delta_t^2(\mu)))} + \frac{\tau_t}{\alpha'}.\end{aligned}$$

In spite of the indeterminacy of equilibrium tax rates, the budget shares are uniquely pinned down. In particular,

$$\begin{aligned}\mathrm{sh}_t^I &= \frac{\nu_t\Delta_t^2(\mu)}{\omega p_t + \nu_t(\Delta_t^1(\mu) + \Delta_t^2(\mu))},\\ \mathrm{sh}_t^R &= (1-\alpha)\frac{-\omega p_t + \nu_t\alpha'(\Delta_t^1(\mu) + \Delta_t^2(\mu))}{\omega p_t + \nu_t(\Delta_t^1(\mu) + \Delta_t^2(\mu))},\\ \mathrm{sh}_t^W &= (1-\alpha)\frac{\omega p_t - \nu_t(\alpha'\Delta_t^1(\mu) - \Delta_t^2(\mu))}{\omega p_t + \nu_t(\Delta_t^1(\mu) + \Delta_t^2(\mu))}.\end{aligned}$$

Several observations about these shares are worth making. First, the investment share is strictly positive, except if students do not vote and $p_{t+1} = 0$ or $\mu = 1$ such that workers do not internalize any productivity enhancing effect of public education. Second, the sign of the net tax share of retirees is ambiguous and depends on the relative political influence of the different groups voting. If retirees are very influential, $\omega \to \infty$, then their net tax share approaches $-(1-\alpha)$; absent accidental bequests, retirees therefore appropriate the full labor share in that case. If the relative political weight of retirees is very low, in contrast, $\omega \to 0$, then their net tax share approaches α, corresponding to the GDP share of capital income net of accidental bequests.

Since $\sigma_t(\tau_t) + \alpha'\eta_t(\tau_t) > 0$ and $\eta_t{}'(\tau_t) > 0$, a sufficient increase of τ_t always allows to satisfy all inequality constraints in (2). For any parameter constellation, a continuum of policies κ_t therefore satisfies the constraints (2) as well as the first-order conditions of the political program. We eliminate this policy indeterminacy by focusing on the policy that minimizes τ_t and $\eta_t(\tau_t)$ and thus, maximizes the savings rate conditional on satisfying (2). This refinement can be motivated by the observation that any mechanism suggesting/implementaing such policy choices ex ante would happily be followed by government ex post since then indifferent. The equilibrium tax rates thus are given by

$$\kappa_t = (\tau_t, \sigma_t, \eta_t),\ \ \tau_t = \max[0, \tau_t(0)],\ \ \eta_t = \max[0, \eta_t(0)],\ \ \sigma_t = \sigma_t(\tau_t)$$

with $\tau_t(\cdot)$ denoting the inverse of the function $\eta_t(\tau_t)$.

Subject to the refinement, the equilibrium policy functions are unique in the limit of the finite horizon economy. To see this, note that the consumption of workers and retirees in the final period, T, is given by

$$\begin{aligned} c_{1,T} &= \mathcal{L}_T(1-\tau_T-\sigma_T), \\ c_{2,T} &= \mathcal{L}_T\frac{\nu_T}{p_T}(\alpha'(1-\eta_T)+\tau_T), \end{aligned}$$

respectively. Tax rates are set to achieve $\omega = \frac{c_{2,T}}{c_{1,T}}$ (if possible). Under the refinement, this equation has a unique solution with κ_T independent of (H_T, q_T). Moving to period $T-1$, the policy functions for σ_{T-1}, τ_{T-1}, and η_{T-1} therefore are independent of (H_{T-1}, q_{T-1}) as well. The result then follows by induction.

3.2 Hierarchical Political Decision Making

Suppose now that τ_t is chosen nationally while σ_t is chosen at the level of the state and η_t is chosen locally. We assume instruments are chosen simultaneously. The political equilibrium conditions then read

$$\begin{aligned} \frac{\omega p_t}{\nu_t}\frac{1}{\alpha'(1-\eta_t)+\tau_t} - \frac{\Delta_t^1(\mu^F)}{1-\tau_t-\sigma_t} &\leq 0, \\ -\frac{\Delta_t^1(\mu^S)}{1-\tau_t-\sigma_t} + \frac{\Delta_t^2(\mu^S)}{\sigma_t+\alpha'\eta_t} &\leq 0, \\ -\frac{\omega p_t}{\nu_t}\frac{\alpha'}{\alpha'(1-\eta_t)+\tau_t} + \alpha'\frac{\Delta_t^2(\mu^L)}{\sigma_t+\alpha'\eta_t} &\leq 0. \end{aligned}$$

were $\mu^L \geq \mu^S \geq \mu^F$. Since investment spending must be larger than zero for the economy not to collapse, either σ_t or η_t must be strictly positive. Multiplying the first-order conditions with respect to σ_t and η_t by α' and -1, respectively, and combining the resulting conditions therefore yields

$$\frac{\omega p_t}{\nu_t}\frac{1}{\alpha'(1-\eta_t)+\tau_t} - \frac{\Delta_t^1(\mu)}{1-\tau_t-\sigma_t}\begin{cases} < 0 \text{ if } \sigma_t = 0, \eta_t > 0 \\ = 0 \text{ if } \sigma_t \geq 0, \eta_t \geq 0 \\ > 0 \text{ if } \sigma_t > 0, \eta_t = 0 \end{cases}.$$

Comparing this finding with the first-order condition with respect to τ_t and using the fact that $\Delta_t^1(\mu^F) > \Delta_t^1(\mu^S) > 0$ leads to the conclusions that at least one instrument is in a corner.

In the case that σ is in a corner we get

$$\begin{aligned} \tau_t &= \frac{\frac{\omega p_t}{\nu_t} + \Delta_t^2(\mu^L) - \alpha'\Delta_t^1(\mu^F)}{\frac{\omega p_t}{\nu_t} + \Delta_t^2(\mu^L) + \alpha'\Delta_t^1(\mu^F)}, \\ \eta_t &= \frac{\Delta_t^2(\mu^L)}{\frac{\omega p_t}{\nu_t} + \Delta_t^2(\mu^L)}(1+\frac{\tau_t}{\alpha'}. \end{aligned}$$

And if η is in corner the solution is

$$\tau_t = \frac{\frac{\omega p_t}{\nu_t} - \alpha' \Delta_t^1(\mu^F) - \alpha' \Delta_t^1(\mu^F)\frac{\Delta_t^2(\mu^S)}{\Delta_t^1(\mu^S)}}{\frac{\omega p_t}{\nu_t} + \Delta_t^1(\mu^F) + \Delta_t^1(\mu^F)\frac{\Delta_t^2(\mu^S)}{\Delta_t^1(\mu^S)}},$$

$$\sigma_t = \Delta_t^1(\mu^F)\frac{\Delta_t^2(\mu^S)}{\Delta_t^1(\mu^S)}(\frac{\tau_t + \alpha'}{\frac{\omega p_t}{\nu_t}}).$$

Inspection of these formulas shows that τ decreases discontinuously when parameters, such as fertility and longevity, change leading to a shift from σ being in a corner to η being in corner. We illustrate this in graphs in the next section, together with the possibility that there is a transition region for which $\tau = 0$ as a result of this discontinuous reduction hitting the feasibility constraint on social security transfers.

4 Quantitative Implications

We now turn to a quantitative assessment of our framework. We calibrate the model to match stylized features of the U.S. economy, in particular the GDP shares flowing into retirement benefits on the one hand and public education on the other. We then analyze how the forecasted changes in the demographic structure affect equilibrium tax rates, budget shares and per-capita growth. We also compare the politico-economic equilibrium along a balanced growth path with the corresponding Ramsey allocation (under the assumption that $\rho = \beta\nu$) and assess consumption and production efficiency of the equilibrium. One period in the model corresponds to 25 years in the data.

Using NIPA data, Piketty and Saez (2003) compute a time series for the capital share in post-war U.S. data. We use the average of that series for the period 1970–2003: $\alpha = 0.2815$. In the model, the elasticity of earnings with respect to education spending equals δ (holding aggregate human capital and labor supply fixed).[8] Card and Krueger (1995) and Betts (1996) report various estimates of this elasticity, ranging from close to zero up to 0.55. We use $\delta = 0.12$, the median of the more recent estimates reported by both Card and Krueger (1995) and Betts (1996) as our baseline value, but also consider $\delta = 0.155$, the value Card and Krueger (1995) infer from their own earlier work, as a ro

To be completed.

5 Concluding Remarks

To be written.

[8] Letting h_t and i_{t-1} denote human capital and lagged education of an individual worker, earnings are given by

$$\frac{w_t}{H_t} h_t(1-x_t) = (1-\alpha)B_0 s_{t-1}^{\alpha}[H_t\nu(1-x_t)]^{-\alpha} h_t(1-x_t) \;\; \text{s.t. } h_t = B_{1,t}H_{t-1}^{1(1-\delta)}(\nu_t\nu_{t+1}i_{t-1})^{\delta}.$$

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