Dynamic fiscal competition: a politico-economic theory

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Abstract

I develop a politico-economic theory of dynamic fiscal competition via productive public spending and debt. With internationally mobile capital, these policies generate two cross-border externalities that voters in each country fail to internalize: (1) an increase in public spending that bolsters capital accumulation but also (2) a race to the top in public debt which crowds out capital. The relative size of these two externalities varies with the number of financially integrated countries and interacts with the domestic political conflict between young and old voters. Despite residence based taxation, capital tax rates are lower under strategic policies than under coordination. Furthermore, they may decline with financial integration. Compared to coordination, strategic policies lead to declining long run output and welfare but continue to be chosen by subsequent generations of voters unless the scale of financial integration is large enough.

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1 Introduction

The financial liberalization process that started in the mid 80s in high income democracies has far reaching yet not fully understood implications. How does international capital mobility change the politico-economic determination of fiscal policies? What is the scope for correcting cross-border externalities given electorally motivated, short-termist governments? What are the effects on welfare and growth?

The significant decline in statutory capital tax rates across OECD countries in the last decades is a well known correlate of financial liberalization.[1] Moreover, recent empirical research (e.g. Devereux and Griffith (1998), Redoano (2003), Bénassy-Quéré et al. (2007)) has shown that international capital flows respond not only to tax rate differentials but also to public spending outlays, such as infrastructure investments, research and development or public services. In this context, the simultaneous build-up of public debt in developed countries suggests strategic fiscal policies may also have persistent dynamic effects.[2]

While these stylized facts point to the importance of considering multidimensional and dynamic fiscal competition, the theoretical literature, building on the seminal work of Zodrow and Mieszkowski (1986) and Wilson (1986), has devoted little attention to the strategic use of multiple fiscal policy variables and their dynamic interactions in the presence of political frictions.

The paper provides a tractable framework to study strategic fiscal policies chosen by subsequent generations of voters through repeated elections in a world where capital is internationally mobile. Specifically, I build a multi-country dynamic general equilibrium model with productive public spending and debt and study the fiscal policy interactions arising between countries that share an integrated capital market but retain independence of their policies. Countries are assumed to be large, i.e., they take into account their effect on the interest rate. Each country is inhabited by overlapping generations of two-period lived agents. Current generations in each country elect every period a government that sets productive public spending and

[1] The average OECD statutory corporate tax rate was above 48% in the mid 80s and reached 23.6% in 2011 (Source: OECD Statistics).

[2] During the period 1980-2007, the general government consolidated gross debt as a percentage of GDP has increased from 35.5% to 60.5% in the EU15, from 43.9% to 62.2% in the US and from 45.6% to 64.2% in Canada (Source: AMECO Database).

its financing through debt, labor and capital taxes to maximize the voters' lifetime welfare. This demographic structure gives rise to intergenerational political conflict, as in, for example, Song et al. (2012).

At the same time, capital mobility generates two distinct externalities. First, seeking to attract mobile private capital, countries use productive public spending as an instrument of fiscal competition.[3] This increases the productivity of private capital and hence the output. Second, the option to partially finance this spending with debt generates a negative pecuniary externality (an increase in the interest rate) as national governments ignore the crowding out effect in other countries. This leads to higher public debt everywhere. To focus on the role of deficit financed public spending, I assume residence based capital taxation, so outright tax competition is excluded.

Importantly, both externalities arise from the common capital market inducing "beggar-thy-neighbor" behavior, hence they do not depend *qualitatively* on the government's finite time horizon. Second, these cross-border externalities are shaped by the political conflict between young and old generations with regard to domestic fiscal policy.

In this framework I derive analytic policy rules describing strategic fiscal policies implemented by elected governments and contrast them, both in the short run (i.e. conditional on previous period capital stock and debt) and the steady state, against policies implemented under the assumption that short-termist governments can credibly coordinate to maximize the joint lifetime welfare of current generations. I then analyze how fiscal externalities and equilibrium policies depend on the scale of financial integration, proxied by the number of countries participating in the common capital market. Finally, I compare the output and welfare associated with strategic and coordinated policies and study under what conditions currently living generations are made better off by international policy coordination of their respective short-termist governments.

Different from standard tax competition models, capital taxation is residence based so there is no incentive to lower tax rates to attract new capital. Nonetheless, for a given number of financially integrated countries, fiscal competition in public

[3] See Romp and de Haan (2005) for an overview on the role of public capital on productivity and growth.

spending leads in the short run to lower capital tax rates relative to coordinated policies as governments also substitute current tax revenues with debt in order to fund public spending. In turn, this increases the tax base both by attracting more capital and making it more productive. Therefore, lower tax rates under fiscal competition do not translate necessarily into lower welfare in the short run, another major difference with respect to the standard tax competition framework. In contrast to the short run results, *steady state* capital tax rates are higher and public spending is lower under strategic policies since capital accumulation is hampered by excessive public debt.

Second, following an increase in the number of financially integrated countries fiscal competition becomes more intense and both public spending and debt go up. Capital and labor taxes decline if the weight of the young generation in the political process is large. This response of taxation to an increase in the scale of financial integration sheds new light on the interaction between cross border externalities and the domestic political conflict between generations. Young agents prefer low labor taxes, high capital taxes, high public spending that increases their productivity. The current old agents would like to minimize capital tax rates by spreading the cost of public spending into the future through public debt. In contrast, the current young foresee the negative effect of the debt for their old age income and hence prefer lower levels. While similar trade-offs were also studied in Song et al. (2012), here however public debt is determined, together with the interest rate, as an equilibrium outcome of multiple strategic policies in an integrated capital market. In particular, at low initial levels, public debt increases faster with the scale of financial integration. Thus, when the political weight of the young is high, an increase in financial integration reduces the need for current tax revenues and tax rates decline.

Finally, I find that relative to coordinated policies, fiscal competition is optimal in the short run from the point of view of the current generations of voters only if the number of financially integrated economies is below some threshold. In this case, the positive effect of public spending on current output dominates the crowding out effect of debt on the next period capital stock. As explained before, the young generation has an interest to limit public debt. Thus, the better represented they are in the political process, the higher the threshold number of countries at which indebtedness is large enough to justify coordinated policies. In the steady state however, the crowding out effect of debt is always larger than the positive effect of public spending which makes coordination welfare superior.

The paper adds to the literature on policy coordination. Kehoe (1989) shows policy coordination is undesirable in the steady state when policy makers cannot commit and capital flight is possible since tax competition prevents confiscatory capital taxation. The analysis excludes externalities from productive public spending and debt which are central to this paper. In particular, here fiscal competition may be preferred in the short run when the positive effects of the former outweigh the negative effects of the latter.

Chang (1990) studies public debt under capital mobility and concludes that the debt externality is increasing in the number of countries and that policy coordination is welfare improving. The analysis focuses on the steady state and abstracts from issues of capital accumulation. It also eschews political frictions and fiscal competition, understood as bidding for mobile factors. In the current paper, these features give rise to new externalities and, as explained above, to important differences between short run and steady state welfare levels.

Moreover, the paper shares a concern for dynamics with some recent work on fiscal competition, such as Koethenbuerger and Lockwood (2010), Batina (2009), Becker and Rauscher (2013), Gross (2014) or Klein and Makris (2014). Different from all these contributions, the focus here is on residence rather than source based taxation and the simultaneous (and strategic) choice of public debt and productive public spending. Also, while many of these contributions analyze infinitely lived planners and steady state outcomes, the current paper looks at policies set by myopic governments driven by political economy concerns, both in the short run and steady state. Moreover, the paper studies how policies and welfare change with the number of financially integrated countries and compares coordinated and strategic policies.

The paper also contributes to the political economy literature on government debt. Complementing studies of closed economies (Cukierman and Meltzer (1989)), or small open economies (Song et al. (2012)), the framework presented here focuses on countries that are large enough to behave strategically. Different from previous literature, the intergenerational (domestic) political conflict leads to drastically different outcomes, in terms of welfare and growth, depending on the scale of financial integration.

The next section introduces the model. Section 3 defines and computes the equilibrium allocations under strategic and coordinated policies and section 4 compares these allocations both in the short run and the steady state. Section 5 looks at the effects of an increase in the scale of financial liberalization. Section 6 calculates and compares welfare levels attained under the two policy regimes. The final section concludes. Derivations and proofs are relegated to appendices.

2 The model economy

I consider an infinite horizon economy that consists of n countries, indexed by i, with identical technologies and initial conditions. Countries are populated by identical, immobile, two-period lived agents. In each country, population is stationary and normalized to one. Capital is perfectly mobile across the n countries. Each country has a government that taxes capital and labor and issues bonds to fund a productive public good. Competitive firms produce a unique, homogenous and costlessly tradable good whose price is normalized to one. This final good combines an endogenously determined variety of intermediate goods produced by monopolistically competitive firms using capital, labor and services stemming from the public good, provided at no cost by the government.

2.1 Households

When young, individuals supply labor inelastically, consume and save for the old age. An individual born at time t in country i maximizes the lifetime utility

$$\max_{c^y_{i,t},c^o_{i,t+1}} \ln c^y_{i,t} + \beta \ln c^o_{i,t+1} \tag{1}$$

$$\text{s.t. } c^y_{i,t} = (w_{i,t} - s_{i,t})(1-\tau^L_{i,t}),$$

$$c^o_{i,t+1} = s_{i,t}R_{t+1}(1-\tau^K_{i,t+1}),$$

where $c^y_{i,t}$, $c^o_{i,t+1}$ denote consumption flows, $s_{i,t}$ are the savings of a young individual, $w_{i,t}$ is the wage rate and $\tau^L_{i,t}$ and $\tau^K_{i,t+1}$ are the tax rates on labor and capital income, respectively.

Savings are tax deductible in the young age and the gross return R_{t+1} is taxed in the old age. The tax deduction simplifies the analysis without loss of generality. Denote the marginal product of capital with q_{t+1} and the gross return on capital with $R_{t+1} = 1 - \delta^K + q_{t+1}$ where δ^K is the depreciation rate of capital. Assuming $\delta^K = 1$, i.e. capital depreciates fully in one period, implies $R_{t+1} = q_{t+1}$.

Given policies, households' optimal allocations are:

$$c^y_{i,t} = \frac{1}{1+\beta} w_{i,t}(1 - \tau^L_{i,t+1}), \tag{2}$$

$$s_{i,t} = \frac{\beta}{1+\beta} w_{i,t}, \tag{3}$$

$$c^o_{i,t+1} = \frac{\beta}{1+\beta} w_{i,t}(1 - \tau^K_{i,t+1}) R_{t+1}. \tag{4}$$

2.2 Production

Competitive firms in country i produce the final good using an endogenously determined range of intermediate goods $x_{j,i,t}$ where $j \in (0, v_t)$:

$$Y_{i,t} = \left(\int_0^{v_{i,t}} x^{1-\sigma}_{j,i,t} dj \right)^{1/(1-\sigma)} \tag{5}$$

where $\sigma \in [0, 1]$ is the inverse of the elasticity of substitution between intermediate goods. Final good firms choose $x_{j,i,t}$ given prices $p_{j,i,t}$ to maximize profits $\Pi_{i,t} = Y_{i,t} - \int_0^{v_{i,t}} p_{j,i,t} x_{j,i,t} dj$. This yields demand functions:

$$x_{j,i,t}(p_{j,i,t}) = p^{-1/\sigma}_{j,i,t} Y_{i,t}. \tag{6}$$

The intermediate goods $x_{j,i,t}$ are produced in a monopolistically competitive sector by firms that pay a fixed cost f every period to operate. They hire capital $k_{j,i,t}$, labor $l_{j,i,t}$ and use services stemming from a public good, provided at no cost by the government:

$$x_{j,i,t} = G^{\delta}_{i,t} k^{\alpha}_{j,i,t} l^{1-\alpha}_{j,i,t}, \; 0 < \delta \leqslant \alpha < 1. \tag{7}$$

Intermediate goods producers hire private inputs at given prices $w_{i,t}$ and $q_{i,t}$ to maximize profits:

$$\max_{l_{j,i,t},k_{j,i,t}} \pi_{i,t} = p_{j,i,t}x_{j,i,t}(p_{j,i,t}) - (w_{i,t}l_{j,i,t} + q_{i,t}k_{j,i,t}) - f \text{ s.t. } (6). \tag{8}$$

The associated first order conditions are:

$$w_{i,t} = (1-\sigma)(1-\alpha)\frac{p_{j,i,t}x_{j,i,t}}{l_{j,t}}, \tag{9}$$

$$q_{i,t} = (1-\sigma)\alpha\frac{p_{j,i,t}x_{j,i,t}}{k_{j,i,t}}. \tag{10}$$

Substituting prices (9) and (10) back into the profit function (8) implies, together with the free entry condition, $f = \sigma p_{j,i,t}x_{j,i,t}$.

In a symmetric equilibrium $x_{j,i,t} = x_{i,t}$, $p_{j,i,t} = p_{i,t}$, $\forall j \in (0, v_{i,t})$ and thus:

$$Y_{i,t} = v_{i,t}^{1/(1-\sigma)}x_{i,t}, \tag{11}$$

which, combined with (6), yields $p_{i,t} = v_{i,t}^{\sigma/(1-\sigma)}$. Substituting the latter into the demand function (6) yields the equilibrium quantity of intermediate good $x_{i,t} = fv_{i,t}^{-\sigma/(1-\sigma)}/\sigma$. Using this in (11) I obtain the expression for final output $Y_{i,t} = fv_{i,t}/\sigma$.

Given aggregate labor supply has been normalized to unity, in a symmetric equilibrium $k_{j,i,t} = K_{i,t}/v_{i,t}$ and $l_{j,i,t} = 1/v_{i,t}$, where $K_{i,t}$ is the aggregate stock of capital in country i. Using these allocations in (7), the production function for $x_{i,t}$, and solving for $v_{i,t}$ yields the endogenous variety of intermediate goods:

$$v_{i,t} = \left(\sigma G_{i,t}^{\delta}K_{i,t}^{\alpha}/f\right)^{(1-\sigma)/(1-2\sigma)}.$$

Thus, denoting $z = (\sigma/f)^{\frac{\sigma}{1-2\sigma}}$, $\eta = \delta(1-\sigma)/(1-2\sigma)$, $\phi = \alpha(1-\sigma)/(1-2\sigma)$:

$$Y_{i,t} = zG_{i,t}^{\eta}K_{i,t}^{\phi}. \tag{12}$$

Prices (9) and (10) are thus given by:

$$w_{i,t} = (1-\sigma)(1-\alpha)Y_{i,t} \text{ and } q_{i,t} = (1-\sigma)\alpha Y_{i,t}/K_{i,t}. \tag{13}$$

Assumption 1. $\eta + \phi < 1$.

Assumption 1 implies overall decreasing returns to scale in reproducible inputs. Substituting the expressions for η and ϕ, it implies $\sigma < (1-\alpha-\delta)/(2-\alpha-\delta) < 1/2$, which also ensures the number of intermediate goods increases with the stock of capital. Note that in equilibrium the aggregate output elasticity with respect to public spending is higher than the firm level counterpart ($\eta > \delta$). This is due to the indirect effect of the public spending on the entry in the intermediate goods sector and hence on the variety of such goods produced in equilibrium.[4]

2.3 Government

In each country, the government uses three instruments to finance public spending: a tax on labor, a tax on capital and one period bonds, issued in the common capital market. Governments can commit to repay outstanding debt[5].

Importantly, residence based capital taxation is feasible. Thus, irrespective of where they invest their savings, the immobile households pay capital taxes only in the country of residence.

The budget constraint in period t is

$$B_{i,t+1} + \tau^L_{i,t} w_{i,t} + \tau^K_{i,t} R_t s_{i,t-1} = G_{i,t} + R_{i,t} B_{i,t}, \text{ with } B_{i,0}, G_{i,0} \text{ and } s_{i,-1} \text{ given,} \quad (14)$$

where $B_{i,t}$ is the outstanding debt at the beginning of period t. Solvency is ensured by the transversality condition $\lim_{T\to\infty} \left(\prod_{t=t_0}^{T} R_t\right)^{-1} B_{i,T} = 0$, $\forall t_0 > 0$.

These policies are selected in repeated elections where the current living generations vote. While old agents care only about their current consumption, young voters are rational and forward looking but because of repeated elections they cannot directly decide future fiscal policy. However, they can affect it through the current policy choices which in turn determine the future stock of capital and public debt.

The social welfare function obtains as the outcome of a probabilistic voting model. The mechanism is standard in the literature so I only describe it briefly.[6] Probabilistic

[4] See Chakraborty and Dabla-Norris (2011) for a more detailed discussion about the difference between the macro and the micro level output elasticity with respect to public spending.

[5] Relaxing this assumption would imply that, in equilibrium, governments are able to borrow less. However, as long as debt remains positive, introducing symmetric commitment limits does not remove the cross border externalities underlying the main results.

[6] See Persson and Tabellini (2002) for a detailed exposition of probabilistic voting models. Appli-

voting assumes the existence of a separate "ideology" dimension, orthogonal to the policy variables. With two political parties maximizing their expected vote share, the probability that a vote is cast in favor of one party is a continuous, increasing function of the relative appeal of that party's platform. In general, as shown in Persson and Tabellini (2002), the equilibrium proposed policies are identical and maximize a weighted sum of agents' welfare. In the context of this model, fiscal policy allocations are chosen every period to maximize:

$$U_{i,t} = \chi u^y_{i,t} + (1-\chi) u^o_{i,t}, \tag{15}$$

where $u^y_{i,t} = \ln c^y_{i,t} + \beta \ln c^o_{i,t+1}$ is the lifetime utility of the currently young agents and $u^o_{i,t} = \ln c^o_{i,t}$ is the utility of currently old agents. $\chi \in (0,1)$ and $1-\chi$ denote the weight of the young and old generation respectively. The old-age welfare of agents who are young in period t enters the aggregate welfare function both in period t and period $t+1$, the first occurrence being due to the forward looking behavior of young agents.

2.4 The integrated capital market

The n countries share a common capital market accessible to both firms and governments. Denote aggregate variables as $X_t = \sum_{i=1}^{n} X_{i,t}$, for $X = \{Y, K, G, c^y, c^o, s, B\}$. Every period, the common capital market clearing condition reads:

$$K_t = S_{t-1} - B_t. \tag{16}$$

2.5 The fiscal externalities

The integrated capital market yields two distinct externalities arising through: (1) government debt and (2) public spending.

The public debt externality is straightforward. In a closed economy, higher public debt crowds out capital and increases the interest rate. Thus, the cost of debt is partially internalized, even by myopic governments. When borrowing in an in-

cations to fiscal policy include Dixit and Londregan (1998), Strömberg (2004), Hassler et al. (2005), Gonzalez-Eiras and Niepelt (2008), Song et al. (2012).

ternational market, however, governments ignore the fact that an increase in the interest rate crowds out private capital and lowers output in all other countries. Thus, independently set fiscal policies rely too much on borrowing.

Importantly, this cross-border pecuniary debt externality occurs independently from the governments' finite life-spans. As shown by Chang (1990), uncoordinated benevolent governments representing current and future generations still issue excessive amounts of debt when part of a common capital market.

The second cross-border externality arises through public spending. In a closed economy public spending already generates a positive externality via entry in the intermediate goods sectors. In the following I explain how this externality is magnified in open economies.

While capital flows freely across countries, the owners are immobile. In order to focus on the interplay between public spending competition and debt, in this paper, I further assume the capital taxation is residence based, so that the direct, intraperiod, tax competition channel is shut down. Thus, capital mobility requires the marginal product of capital before tax to be equal across countries, i.e.:

$$\frac{G_{i,t}^{\eta}}{K_{i,t}^{1-\phi}} = \frac{G_{j,t}^{\eta}}{K_{j,t}^{1-\phi}}, \forall i \neq j. \tag{17}$$

Competitive capital markets and full depreciation further imply the return on assets is equal to the international marginal product of capital, $R_t = q_t$.

The presence of a publicly provided input in the production implies that the marginal product of capital can be affected by fiscal policy and that governments choose $G_{i,t}$ strategically to attract private capital, given the choices of other governments.

Thus, when the income of the old agents is taxed in the country of origin and the pre-tax returns are equalized, rewriting (17) for all countries yields the following equilibrium condition:

$$K_{i,t} = g_{i,t}K_t, \text{ where } g_{i,t}\left(G_{i,t}, G_{j\neq i,t}\right) = G_{i,t}^{\frac{\eta}{1-\phi}} \left(\sum\nolimits_{j=1}^{n} G_{j,t}^{\frac{\eta}{1-\phi}}\right)^{-1}. \tag{18}$$

where K_t is the common market aggregate stock of capital.[7] Intuitively, the stock

[7] This condition is very similar to the payoff function postulated by Bucovetsky (2005) in a model of public input competition. Here, it arises naturally from the assumptions of strategic

of physical capital that each country can attract depends on its share in total public spending and the total capital stock available in the integrated economy. This relationship summarizes the fiscal competition among countries in each period. Using (18), the production function in each country can now be expressed only in terms of the public spending *in all countries* and the aggregate capital stock

$$Y_{i,t} = zG_{i,t}^{\eta}(g_{i,t}\left(G_{i,t}, G_{j\neq i,t}\right)K_t)^{\phi}. \tag{19}$$

Given fixed costs related to entry of σY_t, the aggregate resource constraint of the n-country economy is

$$(1-\sigma)Y_t = C_t^y + C_t^o + K_{t+1} + G_t. \tag{20}$$

3 Policy regimes and equilibrium allocations

Let $\Theta_{i,t}(s_{i,t-1}, B_{it})$ denote the policy vector $(\tau_{i,t}^L, \tau_{i,t}^K, G_{i,t}, B_{i,t+1})$ as functions of the state variables in country i at time t. Given public policies, $\Theta_{i,t}$ the private sector equilibrium is given by household allocations (2), (3) and (4), firms' hiring rules (9) and (10) and the equalization of before tax returns to capital (17) implied by international capital mobility.

In the following I study two policy regimes, focusing on symmetric Markov perfect equilibria. Under the first regime, termed "strategic policies" governments choose national policies independently in order to maximize the utility of domestic voters given other countries' policies. Under the second, termed "coordinated policies", fiscal policies are set to maximize the welfare of currently living generations in all countries subject to all public budget constraints. Next I define equilibrium under each of these policy regimes.

3.1 Strategic policies

Denote strategic policies by superscript s. Given states $s_{i,t-1}, B_{it}$ $i \in \{1, 2, ...n\}$, (which, through (16) define K_t), and the common interest rate given by (17), each

public investment and integrated capital markets.

country i solves:

$$V_{i,t}^{s}=\max_{\Theta_{i,t}}\left\{\chi u_{i,t}^{y}+(1-\chi)u_{i,t}^{o}\right\}, \tag{21}$$

$$\text{s.t. } B_{i,t+1}+\tau_{i,t}^{L}w_{i,t}+\tau_{i,t}^{K}R_{t}s_{i,t-1}=G_{i,t}+R_{i,t}B_{i,t}, \text{given } \Theta_{j,l}, j\neq i, l\geqslant t \tag{22}$$

knowing households' and firms' optimal decisions rules (2), (3), (4), (9), (10). Furthermore, while the government at t anticipates its effects on the government at $t+1$ in the same country, i.e. recognizes the functional dependence $\Theta_{i,t+1}(\Theta_{i,t})$, it takes as given current and future fiscal policies in other countries, $\Theta_{j,l}, j\neq i$, $l\geqslant t$. Note that welfare in country i depends on policies in the rest of the world through the capital market: the share of private capital a country can attract depends on the public investment of other countries while the interest rate depends on their public debt.

Policies depend only on current states $s_{i,t-1}, B_{i,t}$ $i\in\{1,2,...n\}$. With identical initial conditions, a symmetric equilibrium can be supported as public spending ultimately depends on the production function parameters, which are identical. Hence, *in equilibrium* public spending and the capital stock are equal across countries so $g_{i,t}=1/n$ and $K_{i,t}=K_{t}/n$.

Definition 1. *Consider the case of strategic policies with n symmetric countries characterized by $\mathbf{x}_{t}=\{s_{i,t-1},B_{i,t}\}, i\in\{1,2,...n\}$. A Markov perfect equilibrium path of this economy is a n-tuple of public policy sequences $\left\langle\left\{\Theta_{i,l}^{s}(\mathbf{x}_{l})\right\}_{l=t}^{\infty}\right\rangle$ for all i such that $\forall t>1$ national government i chooses $\Theta_{i,t}^{s}$ to solve (21) given the optimal choices of households and firms, taking into account the effects on domestic policies at $t+1$, $\Theta_{i,t+1}(\Theta_{i,t})$, and taking current and future policies in all other countries, $\Theta_{j,l}, j\neq i, l\geqslant t$, as given.*

Note that under strategic policies, while each government takes as given the other governments' policies, budget constraints hold automatically. This is because factor prices (9) and (10) adjust to maintain the common market general equilibrium.

With logarithmic utility and Cobb-Douglas production function, functional dependence on future policies can be analytically solved for. This enables a two step solution technique, similar to Klein et al. (2008) and Bonatti and Cristini (2008). First, assuming a finite horizon problem, $t=1,2,...,T$, the solution is found solving backwards. Clearly, this implies that each government at t anticipate only its effects on the *domestic* government at $t+1$. Second, iterating on this solution and letting $T \to \infty$ yields the time invariant policy rules for the infinite horizon case. Detailed derivations are relegated to Appendix A.

Given current aggregate capital $K_t^s = S_{t-1} - B_t$, symmetry implies $K_{i,t}^s = K_t^s/n$. Strategic policy rules $\Theta_{i,t}^s$, next period capital stock $K_{i,t+1}^s$ and the public budget shadow price $\mu_{i,t}^s$ are given respectively, by:

$$\begin{aligned}
\tau_{i,t}^{L,s} &= 1 - \frac{(1+\beta)\chi}{z(1-\sigma)(1-\alpha)} D^s, && (23)\\
\tau_{i,t}^{K,s} &= 1 - \frac{(1-\chi)}{z(1-\sigma)\alpha} D^s \frac{s_{i,t-1} - B_{i,t}^s}{s_{i,t-1}}, && (24)\\
G_{i,t}^s &= (c^s)^{\frac{1}{1-\eta}} \left(K_{i,t}^s\right)^{\frac{\phi}{1-\eta}}, && (25)\\
B_{i,t+1}^s &= \frac{c^s + (1-\sigma)z\left(\frac{1-\alpha}{1+\beta}\left(\frac{(1-\eta)n}{\phi\chi} - 1\right) - \alpha\right)}{1 + \frac{1-\eta}{\beta\phi\chi}n} (c^s)^{\frac{\eta}{1-\eta}} \left(K_{i,t}^s\right)^{\frac{\phi}{1-\eta}}, && (26)\\
K_{i,t+1}^s &= \frac{\chi\beta\phi}{1-\eta}\frac{D^s}{n} (c^s)^{\frac{\eta}{1-\eta}} \left(K_{i,t}^s\right)^{\frac{\phi}{1-\eta}}, && (27)\\
\mu_{i,t}^s &= (D^s)^{-1} (c^s)^{-\frac{\eta}{1-\eta}} \left(K_{i,t}^s\right)^{-\frac{\phi}{1-\eta}}, && (28)
\end{aligned}$$

where c^s and D^s are constants given by:

$$c^s = (1-\sigma)z\eta\left(\frac{1-\alpha}{1-\phi}\left(1-\frac{\phi}{n}\right) + \frac{\alpha}{n}\right) \text{ and } D^s = \frac{(1-\eta)\left(z(1-\sigma) - c^s\right)}{(1-\eta) + \chi\beta\phi/n}.$$

Assumption 1 ensures overall decreasing returns to scale and thus a unique and stable steady state, that can be solved for by setting $K_{i,t+1}^s = K_{i,t}^s$ in (27). The steady state capital stock in country i under strategic policies is then:

$$K_{i,ss}^s = (c^s)^{\frac{\eta}{1-\eta-\phi}} \left(\frac{\chi\beta\phi D^s}{n(1-\eta)}\right)^{\frac{1-\eta}{1-\eta-\phi}}. \qquad (29)$$

The term c^s captures the externality stemming from competition in public spending. Note that the cross-border spending externality depends critically on the different elasticity of public spending at firm and aggregate level ($\phi > \alpha, \eta > \delta$), i.e. on the entry enhancing effects of public spending. Moreover, it does not depend on the relative political weight of the young χ, as the marginal utility of public spending is equalized across young and old agents to the marginal cost via different tax rates. Assumption 1 ensures D^s is positive. On the one hand, higher public spending increases the tax base today and thus reduces the shadow price of the public budget $\mu^s_{i,t}$. On the other hand, the overall cost of funding the public budget is captured by the inverse of the term D^s, which depends negatively on c^s since funding public spending is distortionary. Thus, a higher D^s lowers $\mu^s_{i,t}$ as well as the tax rates and increases the capital stock next period $K^s_{i,t+1}$. At a given level of public spending, D^s increases with n as the pecuniary interest rate externality lowers the cost of debt and thus reduces tax rates. Note however that future capital depends on D^s/n therefore the public debt externality also has a direct crowding out effect on capital accumulation.

To better understand the role played by each externality in this economy, it is useful to first contrast strategic policies against those resulting from coordination among national governments.

3.2 Coordinated policies

Coordinated policies, superscripted c, are chosen by a planner that takes into account the welfare of the voting agents in all countries as well as all public budget constraints. This policy regime implicitly assumes the existence of a credible enforcement mechanism that would prevent national governments to deviate.

Note that here coordination is short-sighted, a consequence of the limited life-span of the households whose preferences are aggregated through the political process. Coordination takes into account the effects of both domestic public spending and public debt on the other countries in the economy. Coordination solves both the fiscal free-riding (through debt) and the fiscal competition (through public spending), but the long run effects of these policies are only partially internalized relative to an infinitely lived planner.

Formally, the planner solves the following problem:

$$V^c_t = \max_{\Theta_{j,t}} \sum\nolimits_{j=1}^{n} U_{j,t} \tag{30}$$

$$\text{s.t. } B_{j,t+1} + \tau^L_{j,t} w_{j,t} + \tau^K_{j,t} R_t s_{j,t-1} - T_j = G_{j,t} + R_{j,t} B_{j,t},\ j = \{1, n\}. \tag{31}$$

Definition 2. *Consider the case of coordinated policies with n symmetric countries characterized by $\mathbf{x}_t = \{s_{i,t-1}, B_{it}\}$. An equilibrium path of this economy is a n-tuple of public policy sequences $\left\langle \left\{\Theta^c_{i,v}(\mathbf{x}_v)\right\}_{v=t}^{\infty}\right\rangle$ for all i such that $\forall t > 1$, allocations solve (30) subject to (31), given the optimal choices of households and firms and taking into account the effects on domestic policies at $t+1$, $\Theta_{j,t+1}(\Theta_{i,t})$, all j.*

Solving for the coordinated policy sequences $\Theta^c_{i,t}$ (see Appendix A for details) yields:

$$\tau^{L,c}_{i,t} = 1 - \frac{(1+\beta)\chi}{z(1-\sigma)(1-\alpha)} D^c, \tag{32}$$

$$\tau^{K,c}_{i,t} = 1 - \frac{(1-\chi)}{z(1-\sigma)\alpha} D^c \frac{s_{i,t-1} - B^c_{i,t}}{s_{i,t-1}}, \tag{33}$$

$$G^c_{i,t} = \left(c^c\right)^{\frac{1}{1-\eta}} \left(K^c_{i,t}\right)^{\frac{\phi}{1-\eta}}, \tag{34}$$

$$B^c_{i,t+1} = \frac{c^c + (1-\sigma)z\left(\frac{1-\alpha}{1+\beta}\left(\frac{(1-\eta)}{\phi\chi} - 1\right) - \alpha\right)}{1 + \frac{1-\eta}{\beta\phi\chi}} \left(c^c\right)^{\frac{\eta}{1-\eta}} \left(K^c_{i,t}\right)^{\frac{\phi}{1-\eta}}, \tag{35}$$

$$K^c_{i,t+1} = \frac{\chi\beta\phi}{1-\eta} D^c \left(c^c\right)^{\frac{\eta}{1-\eta}} \left(K^c_{i,t}\right)^{\frac{\phi}{1-\eta}}, \tag{36}$$

$$\mu^c_{i,t} = \left(D^c\right)^{-1} \left(c^c\right)^{-\frac{\eta}{1-\eta}} \left(K^c_{i,t}\right)^{-\frac{\phi}{1-\eta}}, \tag{37}$$

where

$$c^c = (1-\sigma)z\eta \text{ and } D^c = \frac{(1-\eta)\left(z(1-\sigma) - c^c\right)}{(1-\eta) + \chi\beta\phi}.$$

Again, Assumption 1 guarantees overall decreasing returns to scale and the existence of a unique and stable steady state. Under coordination, the steady state aggregate capital stock is:

$$K^c_{i,ss} = \left(c^c\right)^{\frac{\eta}{1-\eta-\phi}} \left(\frac{\chi\beta\phi D^c}{1-\eta}\right)^{\frac{1-\eta}{1-\eta-\phi}}. \tag{38}$$

Analyzing the coordinated allocations, it is clear that they do not depend on n, the scale of the capital market. In fact, coordinated policies can be obtained by setting $n = 1$ in the equations that describe strategic allocations. Thus, $c^c < c^s$ as the strategic motive behind public spending is removed. $D^c > D^s$, i.e. the overall distortion from funding the public budget is lower under coordination due to both reduced financing needs ($G^c_{i,t} < G^s_{i,t}$) and to internalizing crowding out effects. The next section proceeds to compare strategic and coordinated policies more in depth. In particular, I contrast the two sets of policies in the short run, i.e. conditional on the current capital stock, as well as in the steady state.

4 Strategic vs coordinated policies in the short run and steady state

Assuming the n-country economy is characterized at time t by $s_{i,t-1}, B_{it},\ i \in \{1, 2, ...n\}$ equations (23)-(27) and (32)-(36) describe the short run strategic and respectively the coordinated policies. Comparing the two sets of allocations, the following results can be established:

Proposition 1. ***Policy comparison in the short run.*** *Relative to coordinated policies, strategic policies imply:*

a) higher public spending $G^s_{i,t} > G^c_{i,t}$,

b) higher share of public debt in output $B^s_{i,t+1}/Y^s_{i,t} > B^c_{i,t+1}/Y^c_{i,t}$,

c) lower tax rates on labor and capital $\tau^{L,s}_{i,t} < \tau^{L,c}_{i,t}$ *and* $\tau^{K,s}_{i,t} < \tau^{K,c}_{i,t}$,

d) lower capital stock $K^s_{t+1} < K^c_{t+1}$.

Proof. See Appendix B. □

International capital mobility leads to overinvestment in public goods but also to a higher public debt share in output. Importantly, while the framework does not feature explicit tax competition, strategic tax rates are nonetheless lower than coordinated ones despite increased needs to fund public spending in order to attract capital. This arises since *i)* the higher level of productive public spending increases output and thus current tax base and *ii)* the perceived cost of public debt is too low (relative to coordination) and thus governments are willing to fund strategic public spending through public debt relative to taxation. While the public spending externality has a positive effect on capital accumulation, strategic public debt has a larger negative effect on capital hence $K^s_{t+1} < K^c_{t+1}$.

Given capital accumulation depends on the policy regime, comparing steady state outcomes becomes a natural next step. Steady state policies can be found by substituting steady state capital stocks (29) and (36) in equations (23)-(27) and (32)-(36) respectively. Comparing the two sets of policies, the following results can be established:

Proposition 2. ***Policy comparison in steady state***. *Relative to coordinated policies, strategic policies imply:*

a) lower public spending: $G^s_{i,ss} < G^c_{i,ss}$,

b) higher share of public debt in output : $B^s_{i,ss}/Y^s_{i,ss} > B^c_{i,ss}/Y^c_{i,ss}$,

c) lower tax rates on labor, $\tau^{L,s}_{i,ss} < \tau^{L,c}_{i,ss}$, *but higher capital tax rates:* $\tau^{K,s}_{i,ss} > \tau^{K,c}_{i,ss}$.

d) lower capital stock $K^s_{ss} < K^c_{ss}$.

Proof. See Appendix B. □

In stark contrast to Proposition 1, in the steady state, it is policy coordination that delivers the lower capital tax rates, as well as the higher level of public spending. Given fiscal competition under strategic policies occurs in the form of a "race to the top" in public spending, these outcomes may seem puzzling at first. They can be easily understood once capital accumulation is taken into account. While fiscal competition delivers higher public spending in the short run, i.e. for a given capital stock, this is not enough to compensate for the larger crowding out of private capital due to public debt. As capital accumulation slows down, servicing public debt requires higher tax revenues and at the same time reduces the incentives to engage in public spending competition which further slows down capital accumulation. Steady state interest rates are higher under strategic policies, while wages are lower. This explains why in the steady state capital tax rates are higher and labor tax rates are lower under fiscal competition relative to coordinated policies.

Next, I study how strategic policies are shaped by changes in the scale of financial liberalization, i.e. the number of countries participating in the common capital market.

5 An increase in the scale of financial liberalization (n)

Recall that capital accumulation depends on n, the number of countries, only under strategic policies. While changes in the scale of financial liberalization involve a transition towards a new steady state, I first focus on the short run, i.e. on the effects of an increase in n at the beginning of t, given $s_{i,t-1}, B_{it}$, $i \in \{1, 2, ...n\}$.

The higher the number of countries, the more intense the fiscal competition in public spending, i.e. $\partial G^s_{i,t}/\partial n > 0$. This follows from $\partial c^s/\partial n = z\eta(1-\sigma)(\phi-\alpha)/(n^2(1-\phi)) > 0$ and $\phi = \alpha(1-\sigma)/(1-2\sigma) > \alpha$. Thus, ceteris paribus, the larger the output and the capital stock next period. The effects on the term D^s are more involved. On the one hand, higher n increases D^s through the term in the denominator. This stems from the pecuniary interest rate externality that leads governments to underprice their debt. On the other hand, higher public spending lowers D^s and thus increases tax rates.

Proposition 3. *Assuming strategic policies, in the short run, an increase in scale of financial integration (the number of countries n) leads to:*

a) higher public spending $\partial G^s_{i,t}/\partial n > 0$,

b) higher share of public debt in output: $\partial(B^s_{i,t+1}/Y^s_{i,t})/\partial n > 0$,

c) lower tax rates: $\partial \tau^{L,s}_{i,t}/\partial n < 0$ *and* $\partial \tau^{K,s}_{i,t}/\partial n < 0$ *if* $\chi > \hat{\chi} = (1-\eta)\eta(\phi-\alpha)/(\beta\phi(1-\eta-\phi+\alpha\eta))$,

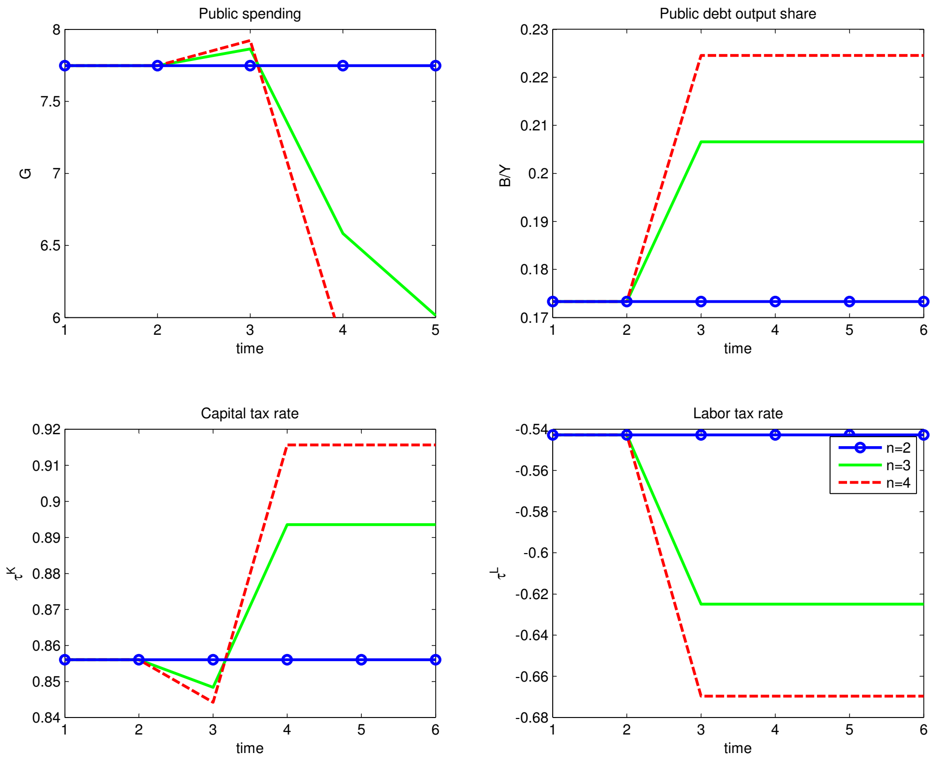
d) lower capital stock: $\partial K^s_{i,t+1}/\partial n < 0$.

Proof. See Appendix B. □

Figure 1 shows how strategic policies respond when the scale of financial integration changes from $n = 2$, assuming $\chi > \hat{\chi}$. More intense fiscal competition implies that even as they spend more, governments issue more debt and thus can set lower tax rates. The condition under which tax rates decline with n is related to the conflict of interests between young and old agents. The condition $\chi > \hat{\chi}$ implies national governments place a larger weight on the lifetime welfare of the current young.

Young agents prefer low labor taxes and high capital taxes. Moreover, similar to Song (2012), while current old would like to minimize current capital tax rates

Figure 1: Strategic policies at different levels of financial integration



The benchmark economy (circle symbol lines) has $n = 2$. The paths of public spending G_i, (upper left), debt share in output $B_{i,t+1}/Y_{i,t}$ (upper right), capital tax rate $\tau_{i,t}^K$ (bottom left) and labor tax rate $\tau_{i,t}^L$ (bottom right) are shown for different levels of financial integration n beginning with $t = 3$. The light solid lines depict policies when $n = 3$ and the dahed lines depict the case $n = 4$. The other parameters are set at $\alpha = 0.35$, $\delta = 0.2$, $\sigma = 0.1$, $\chi = 0.8$ and $\beta = 0.95$.

by spreading the cost of public spending into the future via an increase in public debt, the current young foresee the negative effect of the public debt for their old age income and hence prefer lower debt levels. However, the lower the debt level, the more it increases with the scale of financial integration as countries ignore the external effects on the interest rate. Thus, when the political weight of the young is high, i.e. $\chi > \hat{\chi}$, an increase in financial integration increases public debt more than public spending and reduces the need for current tax revenues hence both tax rates decline. In contrast, when the political weight of the young is low, $\chi \leqslant \hat{\chi}$, public debt and the interest rate are high. This implies debt is increasing less with financial integration and thus the tax rates have to increase in order to finance higher levels of public spending triggered by fiscal competition.

Since coordinated policies replicate the one country case, Proposition 2 can also be used to infer the steady state impact of an increase in n. As also shown in Figure 1, in the long run labor tax rates are lower, capital tax rates are higher, the debt output share is higher but public spending declines. As a result physical capital and output are lower too.

So far, I have compared strategic and coordinated policies taking each regime as given. In the following, I assume both regimes can be implemented at time t and study the choice of national governments by comparing the social welfare levels associated with each regime, both in the short run and in the steady state.

6 Welfare analysis

The welfare of the currently living generations in country i can be expressed for each policy regime $x = \{s, c\}$, in terms of the shadow prices associated with the government budget constraints at t and $t+1$:

$$V_{i,t}^{x} = (1-\chi)\ln\left(\frac{1-\chi}{\mu_{i,t}^{x}}\right) + \chi\ln\left(\frac{(1+\beta)\chi}{\mu_{i,t}^{x}}\right) + \beta\chi\ln\left(\frac{1-\chi}{\mu_{i,t+1}^{x}}\right), \tag{39}$$

where χ is the weight of the young generation in the social welfare function.

Let $\Omega_t = V_{i,t}^{s} - V_{i,t}^{c}$ denote the welfare difference between strategic and coordinated policies, or equivalently:

$$\Omega_t = \ln \left(\frac{\mu^c_{i,t}}{\mu^s_{i,t}} \right) \left(\frac{\mu^c_{i,t+1}}{\mu^s_{i,t+1}} \right)^{\chi\beta}. \tag{40}$$

Intuitively, expression (40) links the welfare difference to the relative cost (across the two policy regimes) of funding the public budget today (this affects both young and old agents, so it has a weight of one), and tomorrow (this affects only the currently young agents, so it has a discounted weight of $\beta\chi$). Using the steady state capital stocks (29) and (38) in the expressions for $\mu^s_{i,t}$ and $\mu^c_{i,t}$, (28) and (37) respectively, yields the steady state shadow prices $\mu^s_{i,ss}$, $\mu^c_{i,ss}$ and the corresponding steady state welfare gap $\Omega_{ss} = \ln \left(\mu^c_{i,ss}/\mu^s_{i,ss}\right)^{1+\chi\beta}$.

Signing the welfare difference during transition (Ω_t) and in the steady state (Ω_{ss}) yields the following results:

Proposition 4. *In the short run, coordinated policies yield higher welfare for the currently living generations relative to strategic policies only if the number of countries is higher than some threshold. A sufficient condition for* $\Omega^s_t > \Omega^c_t$ *is* $n > \widetilde{n} = (1 + \chi\beta\phi/(1-\eta))^{1+(1-\eta)(1+\beta\chi)/(\phi\chi\beta)}$. *However, in the steady state, coordinated fiscal policies deliver the highest welfare, i.e.* $\Omega^s_{ss} > \Omega^c_{ss}, \forall n$.

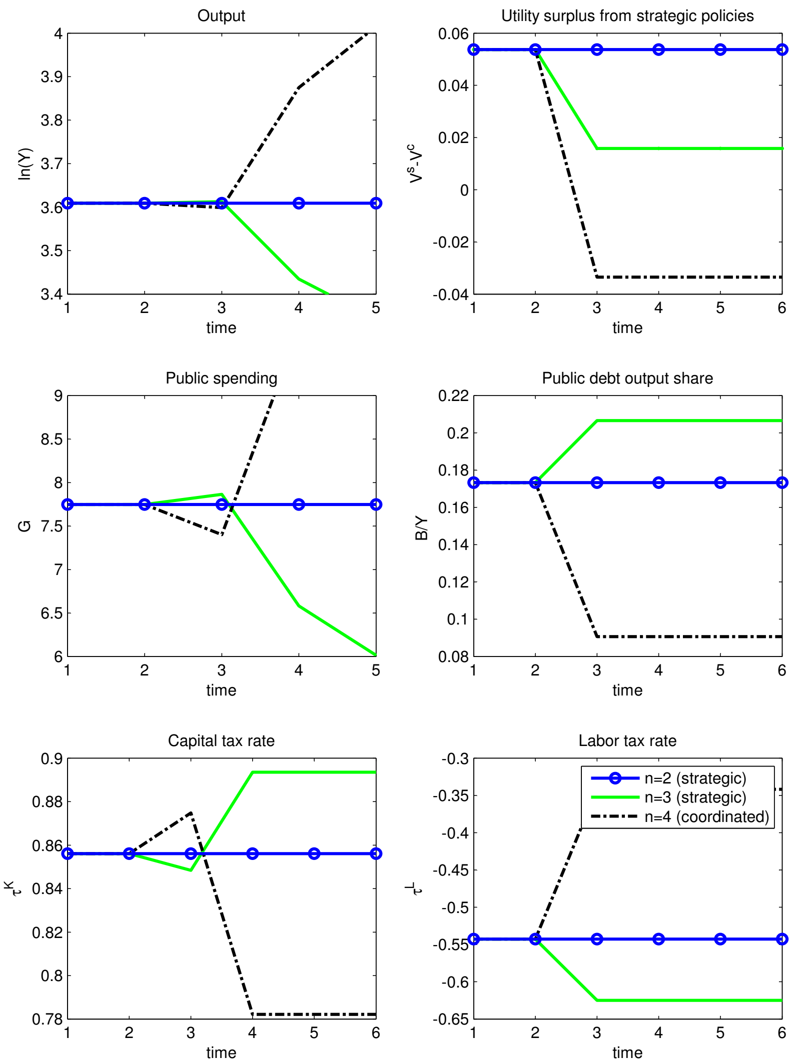
Proof. See Appendix B. □

The proposition summarizes an important result: in a world where short lived governments use deficit funded public spending to compete for mobile capital, policy coordination can be inferior in the short run and thus unenforceable despite being optimal in the steady state. In particular, given some stock of capital and public debt, if $n < \widetilde{n}$ voters prefer strategic policies while they prefer coordinated policies for $n > \widetilde{n}$.

The upper left panel of Figure 2 displays $\Omega_t = V^s_{i,t} - V^c_{i,t}$ for the benchmark case of $n = 2$ (circle symbol line) as well as for unanticipated changes to $n = 3$ (light solid line) and $n = 4$ (dash-dot line) at $t = 3$. The remaining panels display policy paths that maximize the lifetime utility of current generations at each t and n.

For the benchmark case of $n = 2$, strategic policies emerge in equilibrium. Upon the increase in the scale of financial integration to $n = 3$ tax rates drop and the public

Figure 2: Fiscal policies that maximize the lifetime welfare of current voters at different levels of financial integration



The top right panel shows the difference in lifetime utility of generations living at t between strategic and coordinated policies $V_{i,t}^s - V_{i,t}^c$. Strategic policies dominate for the benchmark $n = 2$ (circle symbol lines) and $n = 3$ (light solid lines) but coordinated policies are chosen for $n = 4$ (dash-dot lines). The other panels depict the paths of output $Y_{i,t}$ (top left, in logs), public spending $G_{i,}$ (middle left), debt share in output $B_{i,t+1}/Y_{i,t}$ (middle right), capital tax rate $\tau_{i,t}^K$ (bottom left) and labor tax rate $\tau_{i,t}^L$ (bottom right). The other parameters are set at $\alpha = 0.35$, $\delta = 0.2$, $\sigma = 0.1$, $\chi = 0.8$ and $\beta = 0.95$.

debt share in output increases. While higher debt slows down capital accumulation and lowers output in the long run, strategic policies continue to deliver higher utility to successive generations of voters relative to coordination. If $n = 4$ the debt channel is strong enough (see the dashed line in Figure 1) for strategic policies to generate a utility loss even for current generations. Thus, provided an enforceable pact to coordinate policies can be formulated, it would be supported by current generations and would lead to higher current tax rates and lower public debt. Private capital crowd in would lead to higher output growth on a transition.

So why does fiscal competition prevail if the scale of the global capital market is low? Recall that while both public spending and debt have external effects, their magnitudes change at different rates with the number of countries. The externality from productive public spending leads to higher current incomes and thus welfare. While this externality dominates initially, uncoordinated public debt increases faster with n. Eventually, crowding out of private capital becomes large enough to warrant a switch to coordinated policies even by short-lived governments.

Finally, it can be shown that $\widetilde{n}$ increases in χ. Intuitively, if young voters prefer low public debt, the higher their political weight, the lower the associated negative externality from capital mobility and since the positive spending externality is independent of χ, the higher the scale of financial integration needed to justify coordinated policies.

7 Concluding remarks

The paper develops a tractable dynamic politico-economic theory of fiscal competition via productive public spending and debt.

In this framework, while residence based taxation is feasible, fiscal competition lowers capital tax rates relative to coordination in the short run. The result is driven by the preference of the current voters to increase the tax base by funding productive public spending with debt. However, steady state capital tax rates are higher under fiscal competition as high debt levels set the world economy on a path of lower capital accumulation which in turn increases the relative cost of public debt.

Following an increase in the scale of financial liberalization, modelled as in increase in the number of countries that participate in the common capital market, capital tax rates can decline as public debt rises in all countries disproportionately. The result is relevant in the context of the long-standing policy debate on harmful tax competition. Recent agreements on automatic tax data sharing between OECD/G20 countries[8] may be seen as an attempt to restore the principle of residence based taxation with the expectation they will moderate if not revert the "race to the bottom" in capital tax rates. In contrast to conventional wisdom, this paper shows capital tax rates may continue to decline with financial liberalization as countries engage in deficit spending in order to compete more for mobile capital via public spending.

Finally, the paper points to a new link between the domestic politico-economic choice of fiscal policies and the characteristics of the global capital market. In particular, it suggests the scale of financial integration is a critical determinant of long run growth and welfare as the related cross-border externalities may help short-sighted voters select policies that deliver higher welfare both in the short and the long run.

To keep the analysis tractable, the model has been simplified along a number of dimensions. First, while fiscal free riding through public debt implies a form of tax competition as governments are able to cut current tax rates and pass the costs onto the other regions, direct tax competition is not considered. Including this channel as well as additional spending outlays, such as consumption public goods would not alter qualitatively the externalities that underpin the main results. While the paper focuses on symmetric equilibria, coordination may be harder to implement between heterogenous countries. Indeed, Kanbur and Keen (1993) find in a static model that despite added inefficiencies from size differences tax harmonization may still be suboptimal. Also, the model abstracts from other linkages, such as labor mobility, trade flows or monetary policy that may limit/amplify fiscal free riding. All these extensions are left for future research.

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Appendix A Equilibrium policy functions

Strategic policies:

$$\max_{\Theta_{i,t}}\{U_{i,t} + \mu_{i,t}\left[B_{i,t+1} - R_t B_{i,t} - G_{i,t} + w_{i,t}\tau^L_{i,t} + s_{i,t-1}R_t\tau^K_{i,t}\right]\}$$

The solution of the non-cooperative game is found solving the game backwards.[9] Assume a terminal period of the economy T. The economy is characterized by the aggregate stock of capital K_T and the savings and bonds in each country: $s_{i,T-1}, B_{i,T}$. Since T is assumed to be the last period of the economy, no bonds are issued hence $B_{i,T+1} = 0$ and young households consume their entire income, so $s_{i,T} = 0$. Taxes in T are set to finance the repayment of outstanding debt, $R_T B_{i,T}$ and current public spending $G_{i,T.}$

Public policies are linked through the contemporaneous capital market, described by (15). Since the old age welfare of the agents that are young at T does not matter, the government's problem in country i is linked to the choices of the other governments only through the current fiscal competition in public spending.

Consumption flows at T are:

$$c_T^y = w_{i,T}(1-\tau_{i,T}^L) = \alpha Y_T(1-\tau_{i,T}^L); c_T^o = s_{i,T-1} R_T (1-\tau_{i,T}^K).$$

The government maximizes:

$$\max_{G_{i,T},\tau_{i,T}^L,\tau_{i,T}^K} \{\chi \ln[w_{i,T}(1-\tau_{i,T}^L)] + (1-\chi)\ln[s_{i,T-1}R_T(1-\tau_{i,T}^K)]$$
$$+\mu_{i,T}\left[-R_T B_{i,T} - G_{i,T} + w_{i,T}\tau_{i,T}^L + s_{i,T-1}R_T\tau_{i,T}^K\right]\},$$

given the state variables $\{K_T, B_{i,T}, s_{i,T-1}\}$, $i = \{1, 2, ...n\}$ and policies chosen by other governments. Finally, $\mu_{i,T}$ is the Lagrange multiplier associated with the budget constraint of country i.

Taking the first order conditions yields:

$$\tau_{i,T}^L : -\frac{\chi}{1-\tau_{i,T}^L} + \mu_{i,T} w_{i,T} = 0, \tag{A.1}$$

$$\tau_{i,T}^K : -\frac{1-\chi}{1-\tau_{i,T}^K} + \mu_{i,T} s_{i,T-1} R_T = 0, \tag{A.2}$$

$$G_{i,T} : \left(\frac{\chi}{w_{i,T}} + \mu_{i,T}\tau_{i,T}^L\right)\frac{\partial w_{i,T}}{\partial G_{i,T}} + \tag{A.3}$$
$$+\left(\frac{1-\chi}{R_T} - \mu_{i,T}B_{i,T} + \mu_{i,T}s_{i,T-1}\tau_{i,T}^K\right)\frac{\partial R_T}{\partial G_{i,T}} - \mu_{i,T} = 0.$$

Expression (17) can be used to rewrite prices to reflect the inter-dependency

[9] See Klein et al (2008) refered in the main text for a similar solution technique.

between national policy choices:

$$
\begin{aligned}
w_{i,T} &= (1-\sigma)(1-\alpha)Y_{i,T} = (1-\sigma)(1-\alpha)zG_{i,T}^{\frac{\eta}{1-\phi}}\left(\sum_{j=1}^{n}G_{j,T}^{\frac{\eta}{1-\phi}}\right)^{-\phi}K_T^{\phi}, && \text{(A.4)}\\
q_T &= R_T = (1-\sigma)\alpha\frac{Y_{i,T}}{K_{i,T}} = (1-\sigma)\alpha z\left(\sum_{j=1}^{n}G_{j,T}^{\frac{\eta}{1-\phi}}\right)^{1-\phi}K_T^{-1+\phi}, && \text{(A.5)}
\end{aligned}
$$

Using these expressions to compute the marginal effect of domestic public spending yields:

$$
\begin{aligned}
\frac{\partial w_{i,T}}{\partial G_{i,T}} &= \frac{(1-\sigma)(1-\alpha)z\eta}{1-\phi}\frac{G_{i,T}^{\frac{\eta}{1-\phi}-1}\left(\sum_{j=1}^{n}G_{j,T}^{\frac{\eta}{1-\phi}}-\phi G_{i,T}^{\frac{\eta}{1-\phi}}\right)}{\left(\sum_{j=1}^{n}G_{j,T}^{\frac{\eta}{1-\phi}}\right)^{\phi+1}}K_T^{\phi}, && \text{(A.6)}\\
\frac{\partial R_T}{\partial G_{i,T}} &= (1-\sigma)\alpha z\eta\frac{G_{i,T}^{\frac{\eta}{1-\phi}-1}}{K_T}\left(\sum_{j=1}^{n}G_{j,T}^{\frac{\eta}{1-\phi}}\right)^{-\phi}K_T^{\phi}. && \text{(A.7)}
\end{aligned}
$$

Under symmetry (A.6), (A.7) and (A.25) become:

$$
\begin{aligned}
\frac{\partial w_{i,T}}{\partial G_{i,T}} &= \frac{(1-\sigma)(1-\alpha)z\eta}{1-\phi}\left(\frac{K_T}{n}\right)^{\phi}G_{i,T}^{\eta-1}\left(1-\frac{\phi}{n}\right),\\
\frac{\partial R_T}{\partial G_{i,T}} &= (1-\sigma)\alpha z\eta\frac{1}{K_T}\left(\frac{K_T}{n}\right)^{\phi}G_{i,T}^{\eta-1},
\end{aligned}
$$

and $K_{i,T} = K_T/n$, $s_{i,T-1} = S_{T-1}/n$ and $B_{i,T} = B_T/n$. Using these expressions in the first order conditions (A.1)-(A.3), together with the capital market clearing condition (15) yields the optimal policies at T:

$$
\begin{aligned}
\tau_{i,T}^{L} &= 1-\frac{\chi\left(z(1-\sigma)-c^{s}\right)}{z(1-\alpha)(1-\sigma)}, && \text{(A.8)}\\
\tau_{i,T}^{K} &= 1-\frac{(1-\chi)\left(z(1-\sigma)-c^{s}\right)}{z\alpha(1-\sigma)}\frac{s_{i,T-1}-B_{i,T}}{s_{i,T-1}}, && \text{(A.9)}\\
G_{i,T} &= (c^{s})^{\frac{1}{1-\eta}}\left(\frac{K_T}{n}\right)^{\frac{\phi}{1-\eta}}, && \text{(A.10)}
\end{aligned}
$$

where

$$c^s = (1-\sigma) z\eta \left(\frac{1-\alpha}{1-\phi} \left(1 - \frac{\phi}{n} \right) + \frac{\alpha}{n} \right).$$

Then, $Y_{i,T} = z\left(c^s\right)^{\frac{\eta}{1-\eta}} \left(\frac{K_T}{n}\right)^{\frac{\phi}{1-\eta}}$. Using the above allocations in the government budget constraint yields the shadow value of relaxing the government budget constraint at T:

$$\mu_{i,T} = 1/\left(Y_{i.T}(1-\sigma) - G_{i,T}\right). \tag{A.11}$$

At time $T-1$, the government takes as given the optimal policy rules in T (i.e. anticipates the reaction of next period government to current policies) and the state of the economy at $T-1$ given by $\{K_{T-1}, s_{i,T-2}, B_{i,T-1}\}$. Now, the maximization problem includes the old-age welfare of the agents that are young at T.

$$\max_{\substack{\tau^L_{i,T-1}, \tau^K_{i,T-1} \\ G_{i,T-1}, B_{i,T}}} \left\{ \chi \ln c^y_{T-1} + \chi\beta \ln c^o_T + (1-\chi) \ln c^o_{T-1} \right\} \tag{A.12}$$

Again, prices are given by expressions (6) and (7) with the time index adjusted properly. Moreover, countries interact through the aggregate capital stock K_T :

$$K_T = \sum_{i=1}^{n} (s_{i,T-1} - B_{i,T}). \tag{A.13}$$

As opposed to the fiscal competition channel, this is a dynamic externality, due to capital accumulation. Young agents in period $T-1$ save for the old age and their welfare at T depends on the interest rate R_T which in turn depends on the (strategic) policies implemented at T and $T-1$ in all countries. The private policy function for savings is:

$$s_{i,T-1} = \frac{\beta}{1+\beta}(1-\sigma)(1-\alpha) Y_{i,T-1}$$

Also, using the terminal period capital tax policy in the utility of the old agents at T yields their consumption flow anticipated at $T-1$:

$$s_{i,T-1} R_T (1 - \tau^K_{i,T}) = (1-\chi)/\mu_{i,T}.$$

Thus, using (A.11) and (A.13) the marginal change in the future welfare of this group from a change in public spending at $T-1$ is:

$$\begin{aligned} \frac{\partial \mu_{i,T}}{\partial G_{i,T-1}} &= \frac{\partial \mu_{i,T}}{\partial K_T} \frac{\partial K_T}{\partial s_{i,T-1}} \frac{\partial s_{i,T-1}}{\partial w_{i,T-1}} \frac{\partial w_{i,T-1}}{\partial G_{i,T-1}} = \\ & \left(-\frac{\phi}{1-\eta} \right) \frac{\mu_{i,T}}{K_T} 1 \frac{\beta}{1+\beta} \frac{\partial w_{i,T-1}}{\partial G_{i,T-1}}. \end{aligned}$$

Using again (A.11) and (A.13), the corresponding change from an extra unit of public debt issued at $T-1$ is:

$$\frac{\partial \mu_{i,T}}{\partial B_{i,T}} = \frac{\partial \mu_{i,T}}{\partial K_T}\frac{\partial K_T}{\partial B_{i,T}} = \frac{\phi}{1-\eta}\frac{\mu_{i,T}}{K_T}.$$

Substituting households allocations (2)-(4), prices (13), and the optimal policies at T in (A.12) results in the Lagrangian:

$$\max_{\substack{\tau^L_{i,T-1},\tau^K_{i,T-1}\\ G_{i,T-1},B_{i,T}}} \{\chi \ln[(w_{i,T-1}-s_{i,T-1})(1-\tau^L_{i,T-1})] + (1-\chi)\ln[s_{i,T-2}R_{T-1}(1-\tau^K_{i,T-1})] +$$
$$+\chi\beta \ln\left[s_{i,T-1}R_T(1-\tau^K_{i,T})\right] +$$
$$+\mu_{i,T-1}\left[B_{i,T} - R_{T-1}B_{i,T-1} - G_{i,T-1} + (w_{i,T-1}-s_{i,T-2})\tau^L_{i,T-1} + s_{i,T-2}R_{T-1}\tau^K_{i,T-1}\right]\}.$$

The first order conditions are given by:

$$\tau^L_{i,T-1} : -\frac{\chi}{1-\tau^L_{i,T-1}} + \frac{\mu_{i,T-1}}{1+\beta}w_{i,T-1} = 0, \tag{A.14}$$

$$\tau^K_{i,T-1} : -\frac{1-\chi}{1-\tau^K_{i,T-1}} + \mu_{i,T-1}s_{i,T-2}R_{T-1} = 0, \tag{A.15}$$

$$G_{i,T-1} : \left(\frac{\chi}{w_{i,T-1}} + \frac{\mu_{i,T-1}}{1+\beta}\tau^L_{i,T-1}\right)\frac{\partial w_{i,T-1}}{\partial G_{i,T-1}} + \tag{A.16}$$
$$\left(\frac{1-\chi}{R_{T-1}} - \mu_{i,T-1}B_{i,T-1} + \mu_{i,T-1}s_{i,T-2}\tau^K_{i,T-1}\right)\frac{\partial R_{T-1}}{\partial G_{i,T-1}} -$$
$$\frac{\chi\beta}{\mu_{i,T}}\frac{\partial \mu_{i,T}}{\partial G_{i,T-1}} - \mu_{i,T-1} = 0.$$

$$B_{i,T} : -\frac{\chi\beta}{\mu_{i,T}}\frac{\partial \mu_{i,T}}{\partial B_{i,T}} + \mu_{i,T-1} = 0. \tag{A.17}$$

Imposing symmetry of the states $\{s_{i,T-2}, B_{i,T-1}\}$ and using (A.14)-(A.17) together with the budget constraint yields:

$$
\begin{aligned}
G_{i,T-1} &= (c^s)^{\frac{1}{1-\eta}} \left(\frac{K_{T-1}}{n}\right)^{\frac{\phi}{1-\eta}}, \\
\tau^L_{i,T-1} &= 1 - \frac{\chi(1+\beta)}{z(1-\alpha)(1-\sigma)} D^s, \\
\tau^K_{i,T-1} &= 1 - \frac{(1-\chi)}{z\alpha(1-\sigma)} D^s \frac{s_{i,T-2} - B_{i,T-1}}{s_{i,T-2}},
\end{aligned}
$$

where c^s has been defined above,

$$
D^s = \frac{(1-\eta)\left(z(1-\sigma) - c^s\right)}{(1-\eta) + \chi\beta\phi/n},
$$

and $Y_{i,T-1} = z\,(c^s)^{\frac{\eta}{1-\eta}} \left(\frac{K_{T-1}}{n}\right)^{\frac{\phi}{1-\eta}}$.

$$
\begin{aligned}
K_{i,T} &= \frac{\beta\chi\phi}{1-\eta}\frac{D^s}{n}\,(c^s)^{\frac{\eta}{1-\eta}} \left(\frac{K_{T-1}}{n}\right)^{\frac{\phi}{1-\eta}}, && \text{(A.18)} \\
s_{i,T-1} &= \frac{z\beta}{1+\beta}(1-\sigma)(1-\alpha)\,(c^s)^{\frac{\eta}{1-\eta}} \left(\frac{K_{T-1}}{n}\right)^{\frac{\phi}{1-\eta}}, && \text{(A.19)} \\
B_{i,T} &= \frac{c^s + (1-\sigma)z\left(\frac{1-\alpha}{1+\beta}\left(\frac{(1-\eta)n}{\phi\chi} - 1\right) - \alpha\right)}{1 + \frac{1-\eta}{\beta\phi\chi}n}\,(c^s)^{\frac{\eta}{1-\eta}} \left(\frac{K_{T-1}}{n}\right)^{\frac{\phi}{1-\eta}}. && \text{(A.20)}
\end{aligned}
$$

$$
\mu_{i,T-1} = (c^s)^{-\frac{\eta}{1-\eta}} \left(\frac{K_{T-1}}{n}\right)^{-\frac{\phi}{1-\eta}} (D^s)^{-1}. \qquad \text{(A.21)}
$$

Substituting these time invariant allocations (A.18), (A.19), (A.20) and (A.21) in the set of first order conditions, one gets the equilibrium policies (19) - (22). These policies support a symmetric equilibrium given identical initial conditions. Moreover, letting $T \to \infty$ and using (A.21) repeatedly in periods $T-j$, where $j \to \infty$ yields the equilibrium policy functions, the implied capital stock (23) and the shadow price (24) in the infinite horizon setup.

Coordinated policies:

Fiscal policies under coordination are derived in a similar manner.

$$
\begin{aligned}
&\max_{G_{i,T},\tau^L_{i,T},\tau^K_{i,T}} \sum\nolimits_{i=1}^{n} \{\chi \ln[w_{i,T}(1-\tau^L_{i,T})] + (1-\chi)\ln[s_{i,T-1}R_T(1-\tau^K_{i,T})] \\
&+\mu_{i,T}\left[-R_T B_{i,T} - G_{i,T} + w_{i,T}\tau^L_{i,T} + s_{i,T-1}R_T\tau^K_{i,T}\right]\}
\end{aligned}
$$

While first order conditions for tax rates are similar to (A.8) and (A.9), the planner takes into account cross country effects of public spending on the interest rate:

$$G_{i,T}:\left(\frac{\chi}{w_{i,T}}+\mu_{i,T}\tau^{L}_{i,T}\right)\frac{\partial w_{i,T}}{\partial G_{i,T}}+\sum\nolimits_{j=1,j\neq i}^{n}\left(\frac{\chi}{w_{j,T}}+\mu_{j,T}\tau^{L}_{j,T}\right)\frac{\partial w_{j,T}}{\partial G_{i,T}} \qquad \text{(A.22)}$$
$$+\sum\nolimits_{j=1}^{n}\left(\frac{1-\chi}{R_T}-\mu_{j,T}B_{j,T}+\mu_{j,T}s_{j,T-1}\tau^{K}_{j,T}\right)\frac{\partial R_T}{\partial G_{i,T}}-\mu_{i,T}=0.$$

Imposing symmetry and solving for $G_{i,T}$ yields

$$G_{i,T}=(c^c)^{\frac{1}{1-\eta}}\left(\frac{K_T}{n}\right)^{\frac{\phi}{1-\eta}},$$

where $c^c=(1-\sigma)z\eta$. Note that $c^c=c^s$ for $n=1$. The coordinated solution mirrors indeed policy choices in a one economy world. At $T-1$ the planner solves:

$$\max_{\substack{\tau^L_{i,T-1},\tau^K_{i,T-1}\\ G_{i,T-1},B_{i,T}}}\sum\nolimits_{i=1}^{n}\{\chi\ln[(w_{i,T-1}-s_{i,T-1})(1-\tau^L_{i,T-1})]+(1-\chi)\ln[s_{i,T-2}R_{T-1}(1-\tau^K_{i,T-1})]+$$
$$+\chi\beta\ln\left[s_{i,T-1}R_T(1-\tau^K_{i,T})\right]+$$
$$+\mu_{i,T-1}\left[B_{i,T}-R_{T-1}B_{i,T-1}-G_{i,T-1}+(w_{i,T-1}-s_{i,T-2})\tau^L_{i,T-1}+s_{i,T-2}R_{T-1}\tau^K_{i,T-1}\right]\}.$$

For any $t<T$ first order conditions for tax rates are similar to (A.14) and (A.14) and the planner takes into account cross country effects of both national public spending and debt:

$$G_{i,T-1}:\left(\frac{\chi}{w_{i,T-1}}+\mu_{i,T-1}\tau^{L}_{i,T-1}\right)\frac{\partial w_{i,T-1}}{\partial G_{i,T-1}}+\sum\nolimits_{j=1,j\neq i}^{n}\left(\frac{\chi}{w_{j,T-1}}+\mu_{j,T-1}\tau^{L}_{j,T-1}\right)\frac{\partial w_{j,T-1}}{\partial G_{i,T-1}} \qquad \text{(A.23)}$$
$$+\sum\nolimits_{j=1}^{n}\left(\frac{1-\chi}{R_{T-1}}-\mu_{i,T-1}B_{i,T-1}+\mu_{i,T-1}s_{i,T-2}\tau^{K}_{i,T-1}\right)\frac{\partial R_{T-1}}{\partial G_{i,T-1}}-$$
$$\chi\beta\sum\nolimits_{j=1}^{n}\frac{1}{\mu_{j,T}}\frac{\partial\mu_{j,T}}{\partial G_{i,T-1}}-\mu_{i,T-1}=0.$$

$$B_{i,T}:-\chi\beta\sum\nolimits_{j=1}^{n}\frac{1}{\mu_{j,T}}\frac{\partial\mu_{j,T}}{\partial B_{i,T}}+\mu_{i,T-1}=0. \qquad \text{(A.24)}$$

where the effect of public debt on the cost of future public resources in all countries is internalized as is the effect of the public spending on foreign countries:

$$\frac{\partial w_{i,T}}{\partial G_{j,T}} = \frac{-\phi\eta}{1-\phi} z(1-\sigma)(1-\alpha) G_{i,T}^{\frac{\eta}{1-\phi}} \left(\sum\nolimits_{j=1}^{n} G_{j,T}^{\eta/(1-\phi)}\right)^{-\phi-1} G_{j,T}^{\frac{\eta}{1-\phi}-1} K_T^{\phi}. \tag{A.25}$$

Following similar steps as in the case of strategic policies yields the equilibrium policy functions (32)-(36).

Appendix B Proofs

Proof of Proposition 1.

a) $c^s > c^c \Rightarrow G_{i,t}^s > G_{i,t}^c, \forall n > 1$.

b) See part b) of Proposition 3. Note that $f^b(n) = B_{i,t+1}^s / Y_{i,t}^s$ and $f^b(1) = B_{i,t+1}^c / Y_{i,t}^c$. Thus, since $\partial f^b / \partial n > 0$, $\forall n > 1$, $B_{i,t+1}^s / Y_{i,t}^s > B_{i,t+1}^c / Y_{i,t}^c$.

c) Follows from $\frac{1-\tau_{i,t}^{L,s}}{1-\tau_{i,t}^{L,c}} = \frac{c^s - z(1-\sigma)}{c^c - z(1-\sigma)} \frac{1-\delta(1-\sigma)-2\sigma+\alpha\beta\chi(1-\sigma)}{1-\delta(1-\sigma)-2\sigma+\alpha\beta\chi(1-\sigma)/n} > 1$ for $n > 1$ and δ small, since $c^s > c^c$. Similarly, $\tau_{i,t}^{K,s} < \tau_{i,t}^{K,c}$.

d) The result follows from part d) of Proposition 3. Note that $f^k(1) = K_{t+1}^c$ and $g^k(1) = K_{ss}^c$.Conditional on current capital stock $K_{t+1}^s / K_{t+1}^c < 1 \Leftrightarrow K_{ss}^s / K_{ss}^c < 1$.

Proof of Proposition 2.

a) Using the definitions of $G_{i,ss}^s$ and $G_{i,ss}^c$ together with those for the steady state capital stocks $K_{i,ss}^s$ and $K_{i,ss}^c$, for $G_{i,ss}^s / G_{i,ss}^c < 1$ it is sufficient to show:

$$x^{1-\phi} \left(\frac{1-\eta x}{1-\eta}\right)^{1-\phi} \left(\frac{1-\eta+\beta\phi\chi}{n(1-\eta)+\beta\phi\chi}\right) < 1. \tag{B.1}$$

where $x = 1 + (n-1)(\phi-\alpha)/(n(1-\phi)) > 1$. The third parenthesis is lower than one for $n > 1$ and $(1-\eta x)/(1-\eta) < 1$.

b) Denote $f^b(n) = B_{i,t+1}^s / Y_{i,t}^s = \frac{c^s + (1-\sigma) z \left(\frac{1-\alpha}{1+\beta}\left(\frac{(1-\eta)n}{\phi\chi} - 1\right) - \alpha\right)}{z(1+(1-\eta)n/(\beta\phi\chi))}$. Then

$$\frac{\partial f^b}{\partial n} = \frac{\beta\phi\chi(1-\sigma)\left[n(1-\eta)\left(n(1-(1-\alpha)\eta-\phi)+2\eta(\phi-\alpha)\right)+\beta\eta\phi\chi(\phi-\alpha)\right]}{n^2(1-\phi)\left(n(1-\eta)+\beta\phi\chi\right)^2} > 0$$

since $\phi + \eta < 1$ and $\alpha < 1 \Rightarrow 1-(1-\alpha)\eta - \phi > 0$ and $\phi = \alpha(1-\sigma)/(1-2\sigma) > \alpha$. Note that $f^b(n) = B_{i,t+1}^s / Y_{i,t}^s = B_{i,ss}^s / Y_{i,ss}^s$ and $f^b(1) = B_{i,t+1}^c / Y_{i,t}^c = B_{i,ss}^c / Y_{i,ss}^c$. Thus, since $\partial f^b / \partial n > 0$, $\forall n > 1$, $B_{i,ss}^s / Y_{i,ss}^s > B_{i,ss}^c / Y_{i,ss}^c$.

c) Labor taxes do not depend on the capital stock so part c) of Proposition 1 also implies $\tau_{i,ss}^{L,s} < \tau_{i,ss}^{L,c}$. On the other hand steady state capital taxes depend on capital stocks and saving levels. Setting equations (33) and (24) to the steady state implies, after simplifications:

$$\frac{1-\tau_{i,ss}^{K,s}}{1-\tau_{i,ss}^{K,c}} = \left(1-\frac{\eta(n-1)(\phi-\alpha)}{n(1-\phi)(1-\eta)}\right)^2 \left(1-\frac{(n-1)(1-\eta)}{n(1-\eta)+\beta\phi\chi}\right)^2 \frac{1}{n} < 1,$$

which holds $\forall n > 1$ since all the terms in parentheses are positive and subunitary.

Proof of Proposition 3.

a) Follows from $\partial c^s/\partial n = z\eta(1-\sigma)(\phi-\alpha)/(n^2(1-\phi)) > 0$ and $\phi = \alpha(1-\sigma)/(1-2\sigma) > \alpha$.

b) Denote $f^b(n) = B_{i,t+1}^s/Y_{i,t}^s = \frac{c^s+(1-\sigma)z\left(\frac{1-\alpha}{1+\beta}\left(\frac{(1-\eta)n}{\phi\chi}-1\right)-\alpha\right)}{z(1+(1-\eta)n/(\beta\phi\chi))}$. Then

$$\frac{\partial f^b}{\partial n} = \frac{\beta\phi\chi(1-\sigma)\left[n(1-\eta)\left(n(1-(1-\alpha)\eta-\phi)+2\eta(\phi-\alpha)\right)+\beta\eta\phi\chi(\phi-\alpha)\right]}{n^2(1-\phi)\left(n(1-\eta)+\beta\phi\chi\right)^2} > 0$$

since $\phi+\eta<1$ and $\alpha<1 \Rightarrow 1-(1-\alpha)\eta-\phi>0$ and $\phi=\alpha(1-\sigma)/(1-2\sigma)>\alpha$.

c) $\partial\tau_{i,t}^{K,s}/\partial n < 0 \Leftrightarrow \partial D^s/\partial n > 0 \Leftrightarrow \frac{z(1-\eta)(1-\sigma)(\beta\phi\chi(1-\eta-\phi+\alpha\eta)-(1-\eta)\eta(\phi-\alpha))}{(1-\phi)(n(1-\eta)+\beta\phi\chi)^2} > 0$. The latter inequality yields the condition $\beta\chi > (1-\eta)\eta(\phi-\alpha)/(\phi(1-\eta-\phi+\alpha\eta))$. A similar condition can be derived for labor tax rates.

d) Denote $f^k(n) = K_{t+1}^s/n$ and $g^k(n) = K_{ss}^s/n$. Conditional on current capital stock, $f^k(n) < f^k(1) \Leftrightarrow g^k(n) < g^k(1), \forall n > 1$. Thus, focusing on the latter inequality, it is sufficient to show that

$$\left(\frac{c^s}{c^c}\right)^{\eta/(1-\eta)} \frac{z(1-\sigma)-c^s}{z(1-\sigma)-c^s}\frac{1-\eta+\chi\beta\phi}{n(1-\eta)+\chi\beta\phi} < 1. \tag{B.2}$$

Substituting the expressions for c^s and c^c in (B.2) and simplifying yields:

$$\left(1+\frac{(n-1)(\phi-\alpha)}{n(1-\phi)}\right)^{\eta/(1-\eta)} \left(1-\frac{\eta(n-1)(\phi-\alpha)}{n(1-\phi)(1-\eta)}\right)\left(1-\frac{(n-1)(1-\eta)}{n(1-\eta)+\beta\phi\chi}\right) < 1.$$

First note $\eta/(1-\eta) < 1$ since $\delta \leqslant \alpha$ and $(\alpha+\delta)(1-\sigma)/(1-2\sigma) < 1$ imply $\eta < 1/2$ for the limiting case $\alpha = \delta$. Then, for $p, x < 1$ use $(1+x)^p(1-px) < (1+x)(1-x) < 1$ for $p = \eta/(1-\eta)$ and $x = (n-1)(\phi-\alpha)/n(1-\phi) < 1$. Finally, $1-(n-1)(1-\eta)/(n(1-\eta)+\beta\phi\chi) < 1$ holds for any $n > 1$.

Proof of Proposition 4.

The welfare difference at t, $\Omega_t = V_{i,t}^s - V_{i,t}^c$ is rewritten as:

$$\Omega_t = \ln\left(\frac{\mu_{i,t}^c}{\mu_{i,t}^s}\right)\left(\frac{\mu_{i,t+1}^c}{\mu_{i,t+1}^s}\right)^{\chi\beta}, \tag{B.3}$$

where

$$\frac{\mu_{i,t+1}^c}{\mu_{i,t+1}^s} = \left(\frac{\mu_{i,t}^c}{\mu_{i,t}^s}\right)^{1+\frac{\phi}{1-\eta}} n^{-\frac{1-\eta}{\phi}}, \tag{B.4}$$

$$\frac{\mu_{i,t}^c}{\mu_{i,t}^s} = n\left(1+\frac{(n-1)(\phi-\alpha)}{n(1-\phi)}\right)^{\frac{\eta}{1-\eta}}\left(1-\frac{\eta(n-1)(\phi-\alpha)}{n(1-\phi)(1-\eta)}\right)\frac{1-\eta+\chi\beta\phi}{n(1-\eta)+\chi\beta\phi} \tag{B.5}$$

Substituting (B.4) together with (37) in (B.3) and simplifying implies $\Omega_t < 0$ is equivalent to:

$$(1+\chi\beta)\ln n + \left(1+\chi\beta\left(1+\frac{\phi}{1-\eta}\right)\right)\times \tag{B.6}$$

$$\left[\frac{\eta}{1-\eta}\ln\left(1+\frac{n-1}{n}\frac{\phi-\alpha}{1-\phi}\right)+\ln\left(1-\frac{\eta}{1-\eta}\frac{n-1}{n}\frac{\phi-\alpha}{1-\phi}\right)-\right. \tag{B.7}$$

$$\left.\ln\left(\frac{n(1-\eta)+\chi\beta\phi}{1-\eta+\chi\beta\phi}\right)\right]<0. \tag{B.8}$$

Applying $x \gtrsim \ln(1+x)$ for small x to the terms on the second line above yields:

$$(1+\chi\beta)\ln n < \left(1+\chi\beta\left(1+\frac{\phi}{1-\eta}\right)\right)\ln\left(\frac{n(1-\eta)+\chi\beta\phi}{1-\eta+\chi\beta\phi}\right), \tag{B.9}$$

and using $\frac{n(1-\eta)+\chi\beta\phi}{1-\eta+\chi\beta\phi} > \frac{n(1-\eta)}{1-\eta+\chi\beta\phi}$ leads to the sufficient condition:

$$-\frac{\phi\chi\beta}{1-\eta}\ln n < \left(1+\chi\beta\left(1+\frac{\phi}{1-\eta}\right)\right)\ln\left(\frac{1-\eta}{1-\eta+\chi\beta\phi}\right). \tag{B.10}$$

This is satisfied for $n > \widetilde{n} = (1+\chi\beta\phi/(1-\eta))^{1+(1-\eta)(1+\beta\chi)/(\phi\chi\beta)}$.

Ranking of steady state welfare levels: Using capital stocks (29) and (38) in (28) and (37) respectively yields the steady state welfare difference $\Omega_{ss} = V_{i,ss}^s - V_{i,ss}^c$:

$$\Omega_{ss} = \ln\left(\frac{\mu_{i,ss}^c}{\mu_{i,ss}^s}\right)^{1+\chi\beta} = \ln\left(n^{1+\chi\beta}\right)+\ln\left(1+\frac{(n-1)(\phi-\alpha)}{n(1-\phi)}\right)^{\frac{\eta(1-\eta)(1+\chi\beta)}{(1-\eta)(1-\eta-\phi)}} +$$
$$+\ln\left[\left(1-\frac{\eta(n-1)(\phi-\alpha)}{(1-\eta)n(1-\phi)}\right)\frac{1-\eta+\chi\beta\phi}{n(1-\eta)+\chi\beta\phi}\right]^{\frac{(1-\eta)(1+\chi\beta)}{1-\eta-\phi}}.$$

Coordinated policies yield higher steady state welfare if $\Omega_{ss} < 0$. Using the log approximation to cancel the first two parentheses, after some simplifications, the inequality is equivalent with:

$$\underbrace{n^{\frac{\phi}{1-\eta}}}_{LHS(n)} > \underbrace{\frac{1-\eta+\frac{\chi\beta\phi}{n}}{1-\eta+\chi\beta\phi}}_{RHS(n)}.$$

While $LHS(1) = RHS(1) = 1$, $\partial LHS/\partial n > 0$ while $\partial RHS/\partial n < 0, \forall n > 1$. Thus $V^s_{i,ss} < V^c_{i,ss}$, $\forall n > 1$.