Interregional Tax Competition, Environmental Standards, and the Direction of Strategic Delegation

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Abstract

The phenomenon of strategic voting (strategic delegation) is well acknowledged in different contexts. Citizens including median voters deliberately choose a delegate with different preferences from their own to pursue strategic advantages. In the context of regions competing for mobile capital, this paper explores the outcome of non-cooperative decision making by elected politicians. The formal model is an augmented version of the conventional tax-competition framework by Zodrow and Mieszkowski (1986), Wilson (1986) and Wildasin (1988) in which regions use the environmental standards subject to the trade-off between improving the quality of life and decreasing the capital-productivity. The looser environmental standard can be used to attract mobile factor capital in addition to (or substitution to) lowering the capital taxes. Our model allows illuminating various dimensions of the political tensions and economic effects, including (i) the trade-off between tax-incentives and redistribution under endogenous wage and the return of capital and (ii) the interaction between the capital taxes, the environmental standards and interregional capital flow, where the strategic delegation through interregional dependence can result in either policy-divergence or policy-convergence. We showed the following: (i) When regions are identical, the political effect for income redistribution and the strategic delegation quantitatively dominate the force of the conventional tax-competition effect towards the lower tax rates. However, when the marginal productivity of the looser environmental standards is sufficiently high relative to the environmental damage, the strategic delegation goes towards "political race to the bottom" in which regional policies are delegated to wealthier policymakers who aim to lower the equilibrium capital taxes. (ii) We also examined various types of asymmetries across regions, such as capital productivities, impacts of environmental standards, and population sizes, as well as the median voter's types. It turns out that the extent

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of interregional divergence in capital employment crucially depends on what is asymmetric. For example, we show that the region with high capital productivity sets a higher tax rate relative to the self-representation case, aiming to gain higher tax revenue from the foreigners. The opposite is observed in the low-productivity region, so that the so-called tax-exporting effect is strengthened by the strategic delegation. We also examine the effect of interregional cooperation in environmental actions. In a situation where regions cooperatively decide on the environmental standards but taxes on capital are still decided noncooperatively, tighter environmental regulation may be complemented by more intensive tax competition under the cooperative scenario.

1 Introduction

The phenomenon of strategic delegation is well acknowledged in different contexts. Citizens including median voters deliberately choose a delegate with different preferences from their own to pursue strategic advantages. Examples include international policy coordination in the context of the capital levy problem (Kehoe, 1989; Persson and Tabellini, 1995), the provision of local public goods (Besley and Coate, 2003), and terrorism mitigation (Siqueira and Sandler, 2007). The formal model consists of the following two-stage game. In Stage 1, the delegates (*agents*) that are most preferred by the median voters (*principals*) are elected in each country. In Stage 2, two delegates choose policies in their own countries. In the context of tax competition, Ihori and Yang (2009) explored the interaction between *intra*regional political competition (Stage-1 delegation game) and *inter*regional tax competition (Stage 2). They showed a tendency towards lower tax rates through interregional tax competition is counteracted by intraregional political competition that aims higher tax rates.[1] Persson and Tabellini (1992) also studied how the political mechanism alters the economic consequences of international investment-tax competition. They showed that, when countries

[1] The skewness of capital-income distribution (median income is below mean) raises the tax rates chosen in a political equilibrium, an effect emphasized by Meltzer and Richard (1981).

are symmetric, due to strategic complementarity, the median-voters delegate policy-making to a candidate who prefers higher tax rates on capital than the median-voters themselves. They also dealt with the case of asymmetric countries but only in terms of asymmetric pivotal voters (namely, one country's income distribution is more skewed).[2]

In this paper, we adopt an augmented version of the conventional tax-competition framework by Zodrow and Mieszkowski (1986), Wilson (1986) and Wildasin (1988) in which the regions use the environmental standards subject to the trade-off between the capital productivity and the quality of life.[3] Namely, regional productivities, wages and the return of capital are endogenous, and also, the environmental standard can be used to attract mobile factor capital in addition to (or substitution to) lowering the capital taxes. The enriched structure of our model allows illuminating various dimensions of the political tensions and economic effects, including (i) the trade-off between tax-incentives and redistribution under endogenous wage and the return of capital and (ii) the interaction between the capital taxes, the environmental standards and interregional capital flow, where the strategic delegation through interregional dependence can result in either policy-divergence or policy-convergence. Also, the framework allows various types of asymmetries

[2]Persson and Tabellini's (1992) model was specifically focused on the investor's incentives where the capital may move beyond the border subject to the mobility costs. The reduction of the mobility costs by European integration alters the economic and political consequences. As such, the comparative-static property of this aspect was their main focus.

[3]In a conventional framework of the environmental-federalism literature, it is known that, even without negative technological externalities across regions, environmental policies tend to be inefficiently lax (Cumberland (1981); see Oates and Schwab (1988), Noiset (1995) and Keen and Marchand (1997) for related discussions). Under the competition for acquiring mobile capital, regions set the marginal benefit of environmental quality to residents above its marginal cost measured by the loss of output from a tighter environmental policy. A formulation originated by Oates and Schwab (1988) discussed efficiency of the decentralized environmental policy, but the effect of the strategic delegation has not been discussed yet.

across regions, such as capital productivities, impacts of environmental standards, and population sizes, as well as the median voter's types.

In an economy with heterogeneous capital ownership, we look at the strategic-delegation game in the context of competition over capital taxation and environmental standards: who would the median-capital owner in each region authorize for a strategic delegation? We will show the following. When regions are identical, the political effect for income redistribution and the strategic delegation quantitatively dominate the force of the conventional tax-competition effect towards the lower tax rates. However, when the marginal productivity of the looser environmental standards is sufficiently high relative to the environmental damage, the strategic delegation goes towards "political race to the bottom" in which regional policies are delegated to wealthier policymakers who aim to lower the equilibrium capital taxes. We also examine various types of asymmetries across regions. It turns out that the extent of interregional divergence in capital employment crucially depends on what is asymmetric. For example, we show that the region with high capital productivity sets a higher tax rate relative to the self-representation case, aiming to gain higher tax revenue from the foreigners. The opposite is observed in the low-productivity region, so that the so-called tax-exporting effect (e.g., Huizinga and Nielsen (1997), Huizinga and Nicodeme (2006)) is strengthened by the strategic delegation. Thus, our results can shed light on various countries' tax and environmental policy adoptions in an open economy.

We also examine the effect of interregional cooperation in environmental actions. Buchholz et al. (2005) showed that anticipating international negotiation affects citizens' electoral incentives and can lower the median voter's utility in comparison with the non-cooperative case. In order to treat this problem in our framework, we consider a situation where regions cooperatively decide on the environmental standards but taxes on capital are still decided noncooperatively.[4] It turns out that cooperation induces tighter environmental regulation which is preferred by the median voter. However, as citizens care environmental quality more seriously, environmental regulation is complemented by lower tax on capital more intensively under the cooperative scenario, and eventually cooperation can lower the median voter's utility in comparison with the non-cooperative case.

2 The Model

There exist two regions 1, 2. Each region is inhabited by a continuum of citizens. Each citizen supplies a unit of labor. The region is also endowed with capital. The per-capita amount of capital endowment in each region is $\bar{k}$. Residents within each region have heterogeneity with respect to the share of capital endowment, which is represented by θ, and a resident indexed by θ owns $\theta\bar{k}$ units of per-capita capital. The θ is distributed over the interval $(0, \infty)$ with a distribution function $F_i(\cdot)$ such that $\int_0^\infty \theta dF_i(\theta) = 1$.

The production of a single private good in region i requires a private mobile factor capital, a private immobile factor labor, and a public input that is paid no reward. We assume that the production per capita in region i, which is represented by y_i, is conducted by competitive firms

[4]Typically, interregional agreement is a combination of policy coordination on some issues (e.g. environmental standards) whereas other policies (e.g. taxes) are subject to regional dominion.

according to the function

$$y_i = f^i(k_i, \alpha_i) = (A_i + b_i\alpha_i)k_i - k_i^2, \tag{1}$$

where k_i is the amount of capital employment per capita in region i, and A_i and b_i represent the region-specific parameters. Also, α_i represents the amount of a public input assigned to a representative firm. The α_i serves to raise the productivity of capital but harms the local environmental quality. Oates and Schwab (1988) refer to α_i as "polluting waste emissions." It specifies the environmental standard that the firm has to abide.

The local government i provides an equal amount of lump-sum transfer γ_i, which is solely financed by taxation on capital, with each citizen. Its balanced-budget constraint is given by

$$\gamma_i = t_i k_i, \tag{2}$$

where t_i is a source-based capital tax rate.

A citizen in region i with the capital share θ receives (i) labor income $y_i - (\partial f^i/\partial k_i)k_i$ and (ii) rent from capital $r\theta\bar{k}$:

$$m_i(\theta) \equiv \left[y_i - \frac{\partial f^i}{\partial k_i}k_i\right] + r\theta\bar{k}. \tag{3}$$

In (3), $y_i - (\partial f^i/\partial k_i)k_i$ represents the citizen's income from supplying labor. It corresponds to the surplus that is equal to values of products (y_i) minus payment to the employed private mobile factor capital. In the current framework, as in Wellisch and Richter (1995), the surplus not only includes the direct factor reward on labor but also the implicit rent to local waste emissions. Implicitly we assume that citizens, by supplying an immobile factor, acquire claims on the local rent. The last term ($r\theta\bar{k}$) represents a citizen's income from holding capital endowment, which differs across citizens according to the value of θ.

The utility of a citizen in region i with the capital endowment $\theta\bar{k}$ is given by

$$u_i = m_i(\theta) + \gamma_i - D_i(\alpha_i),$$

where the last term represents the environmental damage. We assume that $D_i(\alpha_i) > 0$ takes the form of the quadratic function such that $D_i(\alpha_i) = d_i\alpha_i^2$, and the parameter $d_i > 0$ represents the assessment of the environmental damage. Namely,

$$u_i = A_i k_i + b_i \alpha_i k_i - k_i^2 - \frac{\partial f^i}{\partial k_i} k_i + r\theta\bar{k} + t_i k_i - d_i \alpha_i^2. \tag{4}$$

The current framework partially has an increasing-returns to scale through $b_i\alpha_i$ that increases the marginal productivity of k_i. On the other hand, there is a diminishing marginal utility from $d_i\alpha_i^2$. We assume that the latter is quantitatively more significant.

Assumption 1 $b_i^2/d_i < 4$ $(i = 1, 2)$.

Under Assumption 1, the first-best allocation does not yield a corner solution of $k_i = 2\bar{k}$ ($i = 1$ or 2) and $k_j = 0$ ($j \neq i$) (see Appendix A), so that, from the welfare viewpoint, we do not aim for a corner solution. It turns out that Assumption 1 guarantees the interior solution of the following tax-competition framework.

The description of the political-economic framework is standard. Events in the model unfold as follows: In Stage 1, simultaneously in both regions a policymaker (delegate) is elected under majority rule. In Stage 2, each delegate i simultaneously and independently chooses t_i and α_i. In Stage 3, having observed $(t_1, \alpha_1, t_2, \alpha_2)$, private investors in both countries make their investment decisions. We solve the game backward.

3 Equilibrium

3.1 Stage 3: Profit Maximization and Market-clearing

Given the environmental standard α_i, tax rate t_i, and a price for capital r that should be common across regions due to perfect mobility of capital, each firm maximizes the profit that is given by

$$y_i - (r + t_i)k_i \quad = \quad (A_i + b_i\alpha_i)k_i - k_i^2 - (r + t_i)k_i. \tag{5}$$

The first-order condition associated with (5) with regard to k_i is

$$\frac{\partial f^i}{\partial k_i} - r - t_i = A_i + b_i\alpha_i - 2k_i - r - t_i = 0. \tag{6}$$

Given the policy variables (t_i, α_i) for $i = 1,\ 2$, (6) should hold along with the capital market clearing condition

$$k_1 + k_2 \quad = \quad 2\bar{k}. \tag{7}$$

Thus, in the capital market equilibrium, we have[5]

$$k_i = \bar{k} + \frac{A_i - A_j}{4} + \frac{b_i\alpha_i - b_j\alpha_j}{4} + \frac{t_j - t_i}{4};\ (i = 1, 2,\ j \neq i) \tag{8}$$

$$r = -2\bar{k} + \frac{A_i + A_j}{2} + \frac{b_i\alpha_i + b_j\alpha_j}{2} - \frac{t_i + t_j}{2}. \tag{9}$$

[5] The subscript j represents region j's ($j \neq i$) parameter. The same remark applies in the following.

Denote these Stage-3 equilibrium values by $k_i(t_1, t_2, \alpha_1, \alpha_2)$ $(i = 1, 2)$ and $r(t_1, t_2, \alpha_1, \alpha_2)$. In (8) and (9), we can see that t_i and α_i work in the opposite directions:

$$\begin{aligned} \frac{\partial k_i}{\partial \alpha_i} &= -\frac{\partial^2 f^i}{\partial k_i \partial \alpha_i}\frac{\partial k_i}{\partial t_i}; \\ \frac{\partial r}{\partial \alpha_i} &= -\frac{\partial^2 f^i}{\partial k_i \partial \alpha_i}\frac{\partial r}{\partial t_i}. \end{aligned} \tag{10}$$

It may be worth noting that (10) is a general property without assuming quadratic production functions. See Appendix B.

3.2 Stage 2: Policy-maker's Choice of Tax Rate and Emission Permission

Let us represent a policy-maker in region i by θ_i. In Stage 2, given θ_i and θ_j, each delegate selects the tax and environmental policies (t_i and α_i for region i). The delegate's utility is given by u_i in (4), where the choice of the tax and environmental policies of the neighboring region (t_j, α_j) has influences on u_i through (8) and (9). The policy-maker θ_i maximizes his/her utility by choosing t_i and α_i, taking account of (8) and (9) in the subsequent stage. That is, Stage 2 is a simultaneous-move game by the two delegates represented by

$$\max_{t_i, \alpha_i} \quad A_i k_i + b_i \alpha_i k_i - k_i^2 - (r + t_i)k_i + \theta_i r\bar{k} + t_i k_i - d_i \alpha_i^2 \text{ s.t. (8) and (9)} \tag{11}$$

The associated first-order conditions are

$$\frac{\partial u_i}{\partial t_i} = t_i \frac{\partial k_i}{\partial t_i} + \frac{\partial r}{\partial t_i}(\theta_i \bar{k} - k_i) = -\frac{1}{4}t_i - \frac{1}{2}(\theta_i \bar{k} - k_i) = 0; \tag{12}$$

$$\begin{aligned} \frac{\partial u_i}{\partial \alpha_i} &= t_i \frac{\partial k_i}{\partial \alpha_i} + \frac{\partial r}{\partial \alpha_i}(\theta_i \bar{k} - k_i) + b_i k_i - 2d_i \alpha_i \\ &= -\frac{\partial^2 f^i}{\partial k_i \partial \alpha_i}\left[t_i \frac{\partial k_i}{\partial t_i} + \frac{\partial r}{\partial t_i}(\theta_i \bar{k} - k_i)\right] + b_i k_i - 2d_i \alpha_i = 0, \end{aligned} \tag{13}$$

where we used (10). We show in Appendix C that the Hessian matrix of the first-order optimum is negative definite if $b_i^2/d_i < 12$. Therefore, under Assumption 1, the second-order conditions with respect to each argument of (t_i, α_i) are satisfied.

Condition (12) is decomposed into two parts. The first term $(t_i \partial k_i/\partial t_i)$ represents the change of tax revenue generated by capital flight in response to an increased tax rate. Persson and Tabellini (1992) refer to this effect as a "tax-competition effect." As to the second term $((\partial r/\partial t_i)(\theta_i \bar{k} - k_i))$, $\theta_i \bar{k} - k_i$ is the decrease in the policy-maker's net income $(m_i(\theta_i) + \theta_i r \bar{k} + \gamma_i)$ from reducing the return of capital (r). Since $\partial r/\partial t_i < 0$ in (9), the tax increase results in a citizen with a higher proportion of capital endowment reducing a higher net income, so that a wealthier policy-maker prefers a lower tax rate on capital. The term of $(\partial r/\partial t_i)(\theta_i \bar{k} - k_i)$ is further decomposed to

$$\frac{\partial r}{\partial t_i}(\theta_i \bar{k} - k_i) = \frac{\partial r}{\partial t_i}(\theta_i \bar{k} - \bar{k}) - \frac{\partial r}{\partial t_i}(k_i - \bar{k}). \tag{14}$$

The term $\theta_i \bar{k} - \bar{k}$ is the difference between the decisive voter's capital endowment and the regional average. In effect, the structure is identical to equation (13) in Meltzer and Richard (1981) that deals with redistribution of citizens' incomes subject to the trade-off between tax-incentives and redistribution. The term of $\bar{k} - k_i$ corresponds to Persson and Tabellini's (1992) "tax-the-foreigner effect." $-(\partial r/\partial t_i)(k_i - \bar{k})$ is positive for the capital importer $(k_i > \bar{k})$ and negative for the capital exporter $(k_i < \bar{k})$. Other things being equal, the capital importer (exporter) increases (decreases) the marginal gain of the capital taxation.

Condition (13) also includes the terms associated with the environmental-policy-competition effect and the redistributive effect. However, from (10) and (12), the term in the square brackets cancels out, and it leads to

$$k_i = 2\frac{d_i}{b_i}\alpha_i. \tag{15}$$

(15) shows the relationship between the benefit of increased output ($\partial f^i/\partial\alpha_i = b_i k_i$) and the cost generated from the relaxed environmental standard ($D_i'(\alpha_i) = 2d_i\alpha_i$). As shown in Appendix A, this relationship between the environmental policy (α_i) and capital employment (k_i) is the same as in the first-best environment. This conclusion is not specific to our quadratic specification.

(12) and (13) induce a linear relationship between t_i and α_i of type θ_i ($i = 1, 2$). Taking account of such relationship, we can derive region i's reaction function as follows (see Appendix C for derivation):

$$t_i = \frac{4d_i}{12d_i - b_i^2}\left[\left(-\frac{b_j^2}{2d_j}\theta_j - \frac{8d_i - b_i^2}{2d_i}\theta_i + 4\right)\bar{k} + (A_i - A_j) + \frac{4d_j - b_j^2}{4d_j}t_j\right]. \tag{16}$$

Using (16) for regions $i = 1$, 2, we derive each decision-maker θ_i's choice of a tax rate as

$$t_i(\theta_1, \theta_2) = \frac{2\theta_i\bar{k}(b_i^2/d_i + b_j^2/d_j - 12) + 2\bar{k}(16 - 2b_j^2/d_j) - 8\theta_j\bar{k} + 4(A_i - A_j)}{16 - b_i^2/d_i - b_j^2/d_j}. \tag{17}$$

In the similar manner, we derive each region's environmental policy as

$$\alpha_i(\theta_1, \theta_2) = \frac{(b_i/d_i)(2\theta_i\bar{k} - 2\theta_j\bar{k} + \bar{k}(8 - b_j^2/d_j) + A_i - A_j)}{16 - b_i^2/d_i - b_j^2/d_j}. \tag{18}$$

3.3 Stage 1: The Median Voter's Choice of A Policy Maker

It follows from (4) that the indirect utility function of any citizen is linear in his/her type parameter θ_i which is distributed on the one-dimensional space. It thus belongs to the class of intermediate preferences, studied by Grandmont (1978) and Persson and Tabellini (2000). Then we can regard the median voters as pivotal in selecting the type of a policy maker since his/her most preferred type is a Condorcet winner.

Anticipating the subsequent policy-makers' choices, the median voter in region i, denoted by θ_i^m, chooses a policy maker θ_i. That is, Stage 1 is a simultaneous-move game by the two median voters. Region i's median-voter's problem is given by

$$\begin{aligned} \max_{\theta_i} \quad & A_i k_i + b_i \alpha_i k_i - k_i^2 - (r + t_i) k_i + \theta_i^m r \bar{k} + t_i k_i - d_i \alpha_i^2 \\ & \text{s.t. (8), (9) and (17) and (18) } (i = 1, 2), \end{aligned} \tag{19}$$

and similarly for the region j's median voter. The delegate of region i can be the median voter himself/herself. This case is called *self-representation* by Segendorff (1998). On the other hand, they can deliberately choose a delegate with different preferences from their own to pursue strategic advantages. The latter case is called *strategic delegation*.

Let u_i^m be the utility of region i's median voter. The first-order condition with respect to θ_i is given by[6]

$$\begin{aligned} & \frac{\partial u_i^m}{\partial t_i}\frac{\partial t_i}{\partial \theta_i} + \frac{\partial u_i^m}{\partial \alpha_i}\frac{\partial \alpha_i}{\partial \theta_i} + \frac{\partial u_i^m}{\partial t_j}\frac{\partial t_j}{\partial \theta_i} + \frac{\partial u_i^m}{\partial \alpha_j}\frac{\partial \alpha_j}{\partial \theta_i} \\ = \; & \frac{\partial r}{\partial t_i}(\theta_i^m - \theta_i)\bar{k}\frac{\partial t_i}{\partial \theta_i} + \frac{\partial r}{\partial \alpha_i}(\theta_i^m - \theta_i)\bar{k}\frac{\partial \alpha_i}{\partial \theta_i} \\ & + \left[t_i \frac{\partial k_i}{\partial t_j} + \frac{\partial r}{\partial t_j}(\theta_i^m \bar{k} - k_i)\right]\frac{\partial t_j}{\partial \theta_i} + \left[t_i \frac{\partial k_i}{\partial \alpha_j} + \frac{\partial r}{\partial \alpha_j}(\theta_i^m \bar{k} - k_i)\right]\frac{\partial \alpha_j}{\partial \theta_i} \end{aligned} \tag{20}$$

[6]The second-order condition is $\dfrac{\partial^2 u_i^m}{(\partial \theta_i)^2} = \dfrac{(8b_1^2/d_1 + 16b_2^2/d_2 - 160)\bar{k}^2}{(b_2^2/d_1 + b_1^2/d_1 - 16)^2}$, which is negative under Assumption 1. The same remarks apply to the cases in Section 4.5 and Section 5.

$$
\begin{aligned}
&= (\theta_i^m - \theta_i)\bar{k}\left(\frac{\partial r}{\partial t_i}\frac{\partial t_i}{\partial \theta_i} + \frac{\partial r}{\partial \alpha_i}\frac{\partial \alpha_i}{\partial \theta_i} + \frac{\partial r}{\partial t_j}\frac{\partial t_j}{\partial \theta_i} + \frac{\partial r}{\partial \alpha_j}\frac{\partial \alpha_j}{\partial \theta_i}\right) + 2t_i\left(\frac{\partial k_i}{\partial t_j}\frac{\partial t_j}{\partial \theta_i} + \frac{\partial k_i}{\partial \alpha_j}\frac{\partial \alpha_j}{\partial \theta_i}\right) \\
&= 0,
\end{aligned}
$$

where we made use of (12) and (13). Substituting the properties of (17) and (18)[7] into (20) and rearranging, we obtain

$$
\theta_i = \theta_i^m - t_i(\theta_1, \theta_2)\frac{b_j^2/d_j - 4}{\bar{k}(2b_j^2/d_j - 16)}. \tag{21}
$$

Under Assumption 1, (21) suggests that the direction of the strategic delegation critically depends on the sign of $t_i(\theta_1, \theta_2)$.

Further rearrangement will yield the equilibrium choice of the delegate θ_i $(i = 1, 2)$ as a function of (θ_1^m, θ_2^m), denoted by θ_i^g:

$$
\begin{aligned}
\theta_i^g \;=\;& \frac{1}{8\bar{k}(12 - b_i^2/d_i - b_j^2/d_j)}[\theta_i^m \bar{k}(b_j^4/d_j^2 + 2(b_i^2/d_i)(b_j^2/d_j) - 16b_i^2/d_i - 28b_j^2/d_j + 160) + \\
& \theta_j^m \bar{k}((b_i^2/d_i)(b_j^2/d_j) - 4b_i^2/d_i - 8b_j^2/d_j + 32) + \qquad (22) \\
& (A_i - A_j)(2b_j^2/d_j - 8) - 2\bar{k}b_j^4/d_j^2 - 2\bar{k}(b_i^2/d_i)(b_j^2/d_j) + 8\bar{k}b_i^2/d_i + 32\bar{k}b_j^2/d_j - 96\bar{k}].
\end{aligned}
$$

Substituting (22) into(17) and (18), we obtain $t_i(\theta_1^g, \theta_2^g)$ and $\alpha_i(\theta_1^g, \theta_2^g)$ $(i = 1, 2)$. Substituting these values into (8), we obtain the relationship between the policy-makers (θ_1^g, θ_2^g) and k_i $(i = 1, 2)$, which we denote $k_i(\theta_1^g, \theta_2^g)$. The comparison of these values with corresponding values under self-representation (where $\theta_i = \theta_i^m,\ i = 1, 2$) is our main interest in the following section.

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[7] $\dfrac{\partial t_i}{\partial \theta_i} = \dfrac{2\bar{k}(b_i^2/d_i + b_j^2/d_j - 12)}{16 - b_i^2/d_i - b_j^2/d_j}$, $\dfrac{\partial t_j}{\partial \theta_i} = -\dfrac{8\bar{k}}{16 - b_i^2/d_i - b_j^2/d_j}$, $\dfrac{\partial \alpha_i}{\partial \theta_i} = \dfrac{(b_i/d_i)2\bar{k}}{16 - b_i^2/d_i - b_j^2/d_j}$, $\dfrac{\partial \alpha_j}{\partial \theta_i} = -\dfrac{(b_j/d_j)2\bar{k}}{16 - b_i^2/d_i - b_j^2/d_j}$.

4 Some Special Cases

4.1 Symmetric Regions ($b_1 = b_2,\ d_1 = d_2,\ \theta_1^m = \theta_2^m,\ A_1 = A_2$)

As a benchmark, we start with the case of symmetric regions. The delegate in an economy is symmetric:

$$\theta_i^g = \frac{-4 + b_i^2/d_i + (8 - b_i^2/d_i)\theta_i^m}{4} \neq \theta_i^m, \tag{23}$$

i.e., self-representation ($\theta_i^g = \theta_i^m$) is never an equilibrium outcome unless $\theta_i^m = 1$. Under Assumption 1, the conventional situation of $\theta_i^m < 1$ (i.e., skewed income distribution) will generate a consequence of

$$\theta_i^g < \theta_i^m. \tag{24}$$

Since the equilibrium tax rate in (17) is decreasing in θ_i and θ_j, from (24), we have

$$t_i(\theta_1^g, \theta_2^g) > t_i(\theta_1^m, \theta_2^m), \tag{25}$$

which means that interregional tax competition is mitigated by strategic delegation.

We now compare the utilities of median voters with strategic delegation ($u_i^m(\theta_1^g, \theta_2^g)$) and under self-representation ($u_i^m(\theta_1^m, \theta_2^m)$). Notice that $k_1 = k_2 = \bar{k}$ both under the strategic delegation and the self-representation,[8] with (15) generating the first-best value of α_i. Since $r + t_i = \partial f^i(k_i, \alpha_i)/\partial k_i$ and the RHS is determined in its first-best level, the median voter will select a delegate who will assign a best combination of r and t_i that would maximize his/her income. Taking look at the

[8] Substituting (23) into (17), (18) (with $\theta_i = \theta_i^g$) and (8), we have $k_1 = k_2 = \bar{k}$. Also, substituting $\theta_1 = \theta_1^m = \theta_2^m = \theta_2$ into (17), (18) and (8), we have $k_1 = k_2 = \bar{k}$.

expression of (4), the difference would eventually be:

$$u_i^m(\theta_1^g, \theta_2^g) - u_i^m(\theta_1^m, \theta_2^m) = \{t_i(\theta_1^g, \theta_2^g) - t_i(\theta_1^m, \theta_2^m)\}(1 - \theta_i^m)\bar{k}. \tag{26}$$

From (25), $u_i^m(\theta_1^g, \theta_2^g) > u_i^m(\theta_1^m, \theta_2^m)$: the median voters are made better off by the strategic delegation.

As discussion in Persson and Tabellini (1992) and Ihori and Yang (2009),[9] the political effect ($\theta_i^m < 1$) and the strategic delegation ($\theta_i < \theta_i^m$) quantitatively dominate the force of the conventional tax-competition effect towards the lower tax rates. The reason is as follows. In Stage 2, the foreign delegate θ_i chooses the tax rate t_i according to (16), taking θ_j and t_j as given. Under Assumption 1 $\Big((4d_j - b_j^2)/(4d_j) > 0\Big)$, the tax rate in (16) is higher for a higher domestic tax rate t_j. This reaction by the foreign region reduces the cost of raising the domestic tax rate t_j perceived in Stage 1, and results in higher equilibrium tax rates. Namely, the choices of tax rates by two regions are strategic complements. It might be surprising that the current structure induces the first-best level of α_i even under strategic delegation as well as interregional tax competition.

Within the range of Assumption 1, the extent of the strategic delegation (the difference between θ_i^m and θ_i^g) becomes higher as b_i^2/d_i becomes lower, i.e., the more important the environmental damage is relative to the enhancement of productivity. Moreover, it would be worth noting that the violation of Assumption 1 would overturn (24), (25) and (26). If $b_i^2/d_i > 4$,[10] the structure of the

[9]Notice that, unlike Ihori and Yang (2009, Proposition 1), we do not have their issue of possible undersupply of the public-good since $t_i k_i$ is a lump-sum transfer which only causes redistribution. Also, the structure of our model is richer than Persson and Tabellini (1992) so that we will examine various dimensions of the political tensions and economic effects in the following sections.

[10]From footnote 6 and Appendix C, the relevant second-order conditions are satisfied, both under the strategic delegation and the self-representation, if $b_i^2/d_i < 160/24$. Notice that $160/24 > 4$.

stage-2 reaction function in (16) is changed to *strategic substitutes* instead of strategic complements. In turn, the strategic delegation takes the form of *political race to the bottom* in which regional policies are delegated to wealthier policy-makers ($\theta_i^g > \theta_i^m$) who aim to lower the equilibrium capital taxes. As the regions are now competing for lower taxes more intensely through the strategic delegation, consistent with (15), the environmental standards are aimed to be loosened. These results are also consistent with Proposition 1 in Nishimura and Terai (2011): under strategic substitutability (complementarity), the median voters are made worse-off (better-off) under strategic delegation than under self-representation.

4.2 Regions with Asymmetric Median Voters ($b_1 = b_2,\ d_1 = d_2,\ A_1 = A_2,\ \theta_1^m > \theta_2^m$)

Now suppose that the regions have the same economic circumstances but the type of decisive voters differs across regions.[11] The policymakers in the regions are:

$$\begin{aligned} \theta_1^g &= \frac{-4 + b_1^2/d_1}{4} + \frac{(3b_1^4/d_1^2 - 44b_1^2/d_1 + 160)\theta_1^m + (b_1^4/d_1^2 - 12b_1^2/d_1 + 32)\theta_2^m}{16(6 - b_1^2/d_1)} \\ &\equiv C_0 + C_1\theta_1^m + C_2\theta_2^m, \end{aligned} \tag{27}$$

and $\theta_2^g = C_0 + C_1\theta_2^m + C_2\theta_1^m$. We can show that $C_0 = 1 - C_1 - C_2 < 0$, $C_2 > 0$ and $C_1 - C_2 > 1$ under Assumption 1. Therefore, when $1 > \theta_1^m > \theta_2^m$, $\theta_i^g - \theta_i^m < C_0 + C_1\theta_i^m + C_2 - \theta_i^m = (1 - C_1)(1 - \theta_i^m) < 0$, so that both countries aim for a strategic delegation to a poorer agent. Also,

$$\theta_1^g - \theta_2^g = (C_1 - C_2)(\theta_1^m - \theta_2^m) > \theta_1^m - \theta_2^m, \tag{28}$$

namely, the strategic delegation increases the gap of the politicians' type than under self-representation.

[11] The different θ_i^m's may result from different distribution of the capital income, as well as different political participations across citizens in different income classes. See, e.g., Benabou (2000).

As to the rate of capital taxes, $t_i(\theta_1^g, \theta_2^g) > t_i(\theta_1^m, \theta_2^m)$ $(i = 1, 2)$ as in Section 4.1, but now $t_2(\theta_1^g, \theta_2^g) > t_1(\theta_1^g, \theta_2^g)$, $t_2(\theta_1^m, \theta_2^m) > t_1(\theta_1^m, \theta_2^m)$ (the region with a lower median-income levies the higher tax rates) and $t_2(\theta_1^g, \theta_2^g) - t_1(\theta_1^g, \theta_2^g) > t_2(\theta_1^m, \theta_2^m) - t_1(\theta_1^m, \theta_2^m)$ (the divergence is widened under the strategic delegation).[12]

As to the level of capital, as in the first subcase, $k_1^* = k_2^* = \bar{k}$. Compared with that,[13]

$$\begin{aligned} k_1(\theta_1^g, \theta_2^g) > k_1(\theta_1^m, \theta_2^m) > k_1^*, \\ k_2(\theta_1^g, \theta_2^g) < k_2(\theta_1^m, \theta_2^m) < k_2^*. \end{aligned} \tag{29}$$

Namely, the region with a higher median-income attracts higher levels of k_i. The strategic delegation in (28) increases the gap between the level of capitals k_i across regions. In turn, from (15), region 1 has higher level of the public input $(\alpha_1 > \alpha_2)$. In the current context, region 2 with a greater inequality of capital incomes adopt a more strict environmental policy.

In Persson and Tabellini (1992), the policy-maker in region 1 (a region with a more equal endowment distribution) is certainly to the left to the median voter $(\theta_1^g < \theta_1^m)$, while in region 2 (capital exporter) it can be on either side. In our case, region 2 also assigns the policy-maker with $\theta_2^g < \theta_2^m$. From (21), the median voter will elect a delegate with lower capital endowment as long as he/she is motivated for positive tax rates. The tax-the-foreigner effect is not strong enough to overturn the direction of strategic delegation for region 2, and moreover, the strategic delegation increases the gap of the politicians' type than under self-representation.[14]

[12]From (17), $t_1(\theta_1, \theta_2) - t_2(\theta_1, \theta_2) = \dfrac{2\bar{k}(b_1^2/d_1 - 4)}{8 - b_1^2/d_1}(\theta_1 - \theta_2) < 0$ if $\theta_1 > \theta_2$, and the divergence is widened with the greater $\theta_1 - \theta_2$. The result follows from (28).

[13]$k_1(\theta_1^g, \theta_2^g) - k_1(\theta_1^m, \theta_2^m) = \dfrac{(b_1^2/d_1 - 4)^2(\theta_1^m - \theta_2^m)\bar{k}}{4(b_1^2/d_1 - 6)(b_1^2/d_1 - 8)} > 0$ and $k_1(\theta_1^m, \theta_2^m) - k_1^* = \dfrac{2(\theta_1^m - \theta_2^m)\bar{k}}{8 - b_1^2/d_1} > 0$. The similar formula hold for k_2.

[14]In Persson and Tabellini (1992), policy convergence occurs by higher capital mobility. Strategic delegation can

4.3 Regions with Asymmetric Productivities ($b_1 = b_2,\ d_1 = d_2,\ \theta_1^m = \theta_2^m,\ A_1 > A_2$)

Suppose now that the regions have different region-specific factor for capital productivities. In this subsection we consider the case of $A_1 > A_2$. It turns out that region 1's median voter takes advantage of the regional rent of higher productivity and aggravates so-called tax exporting effect.

Asymmetric equilibrium is given by

$$\begin{aligned} \theta_1^g &= \frac{-4 + b_1^2/d_1 + (8 - b_1^2/d_1)\theta_1^m}{4} - \frac{(4 - b_1^2/d_1)(A_1 - A_2)}{8\bar{k}(6 - b_1^2/d_1)} < \theta_1^m, \\ \theta_2^g &= \frac{-4 + b_1^2/d_1 + (8 - b_1^2/d_1)\theta_2^m}{4} + \frac{(4 - b_1^2/d_1)(A_1 - A_2)}{8\bar{k}(6 - b_1^2/d_1)}. \end{aligned} \tag{30}$$

In addition to the effect previously mentioned, a country with high (low) productivity tends to send a low (high) capital owner. As to the relationship between θ_2^g and θ_2^m, there are offsetting effects between intraregional political competition and the tax-the-foreigner effect. Figure 1 illustrates the values of θ_2^g and θ_2^m in the case of $\theta_2^m = \theta_1^m = 0.9, b_1 = 18, d_1 = 100, A_1 = 15$. Reflecting a result in Section 4.1, $\theta_2^g < \theta_2^m$ when $A_2 = 15$. However, as the difference of the regional productivities becomes larger, the tax-the-foreigner effect becomes stronger, and eventually $\theta_2^g > \theta_2^m$ when $A_2 < 9.480$.

As to the rate of capital taxes, from (17) and (30),

$$\begin{aligned} t_1(\theta_1^g, \theta_2^g) - t_1(\theta_1^m, \theta_2^m) &= 2\bar{k}(4 - b_1^2/d_1)\left(\frac{1 - \theta_1^m}{4} + \frac{(4 - b_1^2/d_1)(A_1 - A_2)}{8\bar{k}(8 - b_1^2/d_1)(6 - b_1^2/d_1)}\right) > 0, \\ t_2(\theta_1^g, \theta_2^g) - t_2(\theta_1^m, \theta_2^m) &= 2\bar{k}(4 - b_1^2/d_1)\left(\frac{1 - \theta_2^m}{4} - \frac{(4 - b_1^2/d_1)(A_1 - A_2)}{8\bar{k}(8 - b_1^2/d_1)(6 - b_1^2/d_1)}\right). \end{aligned} \tag{31}$$

That is, the productive region levies higher taxes under the strategic delegation whereas there is an ambiguity in the unproductive region. Across regions, $t_1(\theta_1^g, \theta_2^g) > t_2(\theta_1^g, \theta_2^g)$, $t_1(\theta_1^m, \theta_2^m) >$

cause either policy convergence or policy divergence.

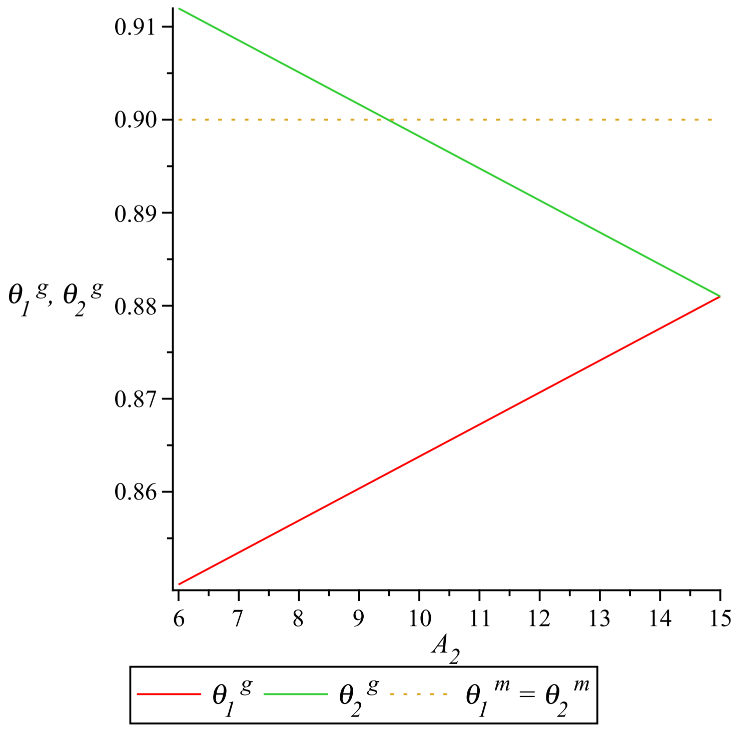

Figure 1:

$t_2(\theta_1^m, \theta_2^m)$ (the more productive region levies the higher tax rates) and $t_1(\theta_1^g, \theta_2^g) - t_2(\theta_1^g, \theta_2^g) > t_1(\theta_1^m, \theta_2^m) - t_2(\theta_1^m, \theta_2^m)$ (the divergence is widened under the strategic delegation). The reason is as follows. From (17),

$$t_1(\theta_1, \theta_2) - t_2(\theta_1, \theta_2) = \frac{2\bar{k}(b_1^2/d_1 - 4)}{8 - b_1^2/d_1}(\theta_1 - \theta_2) + \frac{4(A_1 - A_2)}{8 - b_1^2/d_1}. \tag{32}$$

The second term of the right-hand side captures the difference in region's tax incentives appearing in the last term of (17), which is present even under self-representation ($\theta_i = \theta_i^m$). In Stage 3, the divergence in two regions' productivities ($A_1 > A_2$) has direct effects in which region 1 tends to have higher capital employment. Due to the "tax-the-foreigner effect", region 1 is motivated to increase the tax rate. In the literature of tax competition, this is referred as "tax exporting"(e.g., Huizinga and Nielsen (1997), Huizinga and Nicodeme (2006)): a higher foreign ownership share will generally rationalize higher source-based capital income taxes. In contrast with the tax-competition effect that is *mitigated* under the strategic delegation, this tax-exporting effect is *strengthened* in that the tax difference in (32) is wider under the strategic delegation ($\theta_i = \theta_i^g$). The opposite force applies to the unproductive region for the competition for acquiring the mobile capital. As disparities in productivities become bigger, region 2 is ready to elect a politician who even levies subsidies on the capital ((21) and Figure 1).

As to the level of capital, compared with the first-best level of the capital $k_i^* \equiv \dfrac{A_i - A_j + (4 - b_1^2/d_1)\bar{k}}{4 - b_1^2/d_1}$, and that under self-representation $k_i(\theta_1^m, \theta_2^m)$ (induced from (17), (18), and (8)), the following holds. Substituting (30) into (17), (18), and (8) induces[15]

$$\begin{array}{l} k_1(\theta_1^g, \theta_2^g) < k_1(\theta_1^m, \theta_2^m) < k_1^*, \\ k_2(\theta_1^g, \theta_2^g) > k_2(\theta_1^m, \theta_2^m) > k_2^*, \\ k_1(\theta_1^g, \theta_2^g) > k_2(\theta_1^g, \theta_2^g). \end{array} \tag{33}$$

Namely, the tax competition and the strategic delegation will mitigate the gap between the level of capitals across regions than that of the first-best allocation and the self-representation. Since the first-best allocation implies the equal marginal productivity of capital (Appendix A), the allocation of k_i is inefficient under tax competition, and the inefficiency is worsened by the strategic delegation.

[15] $k_1(\theta_1^g, \theta_2^g) - k_1(\theta_1^m, \theta_2^m) = \dfrac{(A_1 - A_2)(b_1^2/d_1 - 4)}{2(b_1^2/d_1 - 6)(b_1^2/d_1 - 8)} < 0$ and $k_1(\theta_1^m, \theta_2^m) - k_1^* = -\dfrac{4(A_1 - A_2)}{(b_1^2/d_1 - 4)(b_1^2/d_1 - 8)} < 0$. The similar formula hold for k_2. Also, $k_1(\theta_1^g, \theta_2^g) - k_2(\theta_1^g, \theta_2^g) = \dfrac{A_1 - A_2}{6 - b_1^2/d_1} > 0$.

As to the level of emissions (α_i), from (15), the implication is parallel to (33): the tax competition and the strategic delegation will mitigate the gap between the level of public inputs across regions than that of the first-best allocation and the self-representation. For a low-productivity region (region 2), strategic delegation works to increase emissions, which creates a kind of pollution-haven.[16]

4.4 Regions with Asymmetric Impacts of the Public Input ($\theta_1^m = \theta_2^m,\ A_1 = A_2,\ b_1^2/d_1 > b_2^2/d_2$)

This section considers the case in which region 1's public input is more productive and/or region 2 is more concerned about the environment. Results are the same as those in Section 4.3, so we briefly mention the results and implications. The proofs are given in Appendix D.

In asymmetric equilibrium,

$$\begin{aligned}\theta_1^g &= \frac{1}{8(12 - b_i^2/d_i - b_j^2/d_j)}[(-2b_j^4/d_j^2 - 2(b_i^2/d_i)(b_j^2/d_j) + 8b_i^2/d_i + 32b_j^2/d_j - 96) \\ &\quad +\theta_i^m(b_j^4/d_j^2 + 3(b_i^2/d_i)(b_j^2/d_j) - 20b_i^2/d_i - 36b_j^2/d_j + 192)]. \qquad (34)\end{aligned}$$

Similar to Section 4.3, $\theta_1^m > \theta_1^g$ and $\theta_2^g > \theta_1^g$. Namely, a region with a more (less) productive public input sends a lower (higher) capital owner. Also, $\theta_2^g > \theta_2^m$ is possible when b_i^2/d_i's are sufficiently divergent.

As to the rate of capital taxes across regions, $t_1(\theta_1^g, \theta_2^g) > t_2(\theta_1^g, \theta_2^g)$, $t_1(\theta_1^m, \theta_2^m) > t_2(\theta_1^m, \theta_2^m)$ (the more productive region levies the higher tax rates) and $t_1(\theta_1^g, \theta_2^g) - t_2(\theta_1^g, \theta_2^g) > t_1(\theta_1^m, \theta_2^m) -$

[16] It has been widely believed that the stringent environmental regulation in the developed countries may induce productions and the mobile resources to shift to the developing countries, where the regulation is expected to be loose. See, for example, Levinson and Taylor (2008).

$t_2(\theta_1^m, \theta_2^m)$ (the divergence is widened under the strategic delegation). Similar to (32), region 1 (a region with a higher productivity relative to the environmental damage) has higher capital employment than region 2. The associated tax-exporting effect is reinforced by the strategic delegation.

As to k_i and α_i, the conclusion is the same as (33) in Section 4.3: the tax competition and the strategic delegation will mitigate the gap of k_i and α_i across regions than that of the first-best allocation and the self-representation. For the level of emissions (α_i), from (15), it may be worth noting that the strategic delegation increases (decreases) the level of emissions in region 2 (region 1), even under $b_2^2/d_2 < b_1^2/d_1$ (i.e., α_2 is not as useful as α_1 from the welfare point of view).

4.5 Regions with Different Populations

We now consider a framework known as asymmetric tax-competition model by Bucovetsky (1991) and Wilson (1991) in which the population is different across regions. Let $\bar{k}$ be the per-capita amount of capital endowment in the whole nation, and s_i $(i = 1, 2)$ be the share of the population in region i. Namely, $s_1 + s_2 = 1$, and we assume $s_1 > s_2 > 0$ (region 1 has higher population than region 2). The associated capital-market clearing condition is, as an extension of (7),

$$s_1 k_1 + (1 - s_1) k_2 = \bar{k}. \tag{35}$$

Namely, the average capital-labor ratio ($s_1 k_1 + (1 - s_1) k_2$) is equal to $\bar{k}$.

In the context of no intraregional heterogeneity, Bucovetsky (1991) and Wilson (1991) showed that, in the equilibrium, $t_1 > t_2$ (small region becomes a tax haven), and residents of a smaller region (region 2) are *strictly better off* than those of a bigger region (region 1). We now will investigate the implications of the strategic voting.

Replacing (7) with (35) in the equilibrium system, we obtain the following (θ_1^g, θ_2^g) under $b_1 = b_2,\ d_1 = d_2,\ \theta_1^m = \theta_2^m,\ A_1 = A_2$:[17]

$$\theta_i^g = \frac{-16(1-s_i^2) + 16\theta_i^m(1+2s_i^2) + 4b_i^2/d_i(1+s_i^2) - 4\theta_i^m b_i^2/d_i(1+3s_i^2) + b_i^4/d_i^2 s_i(-1+\theta_i^m)}{8s_i^2(6-b_i^2/d_i)}. \quad (36)$$

One can verify: (i) $\theta_1^g > \theta_2^g$ if $s_1 > 1/2$ (the big region sends a candidate that is more right in order to counteract the disadvantage from the capital-tax competition)[18] and (ii) $\theta_2^g < \theta_2^m$ (the small region sends a candidate left to the median voter).[19] As to the relationship between θ_1^g and θ_1^m, there are offsetting effects between intraregional political competition and the tax-the-foreigner effect. Figure 2 illustrates the values of θ_1^g and θ_1^m in the case of $\theta_1^m = 0.8, b_1 = 18, d_1 = 100, A_1 = 15$. Reflecting a result in Section 4.1, $\theta_1^g < \theta_1^m$ when $s_1 = 1/2$. However, as the difference of the regions becomes larger, the tax-the-foreigner effect becomes stronger, and eventually $\theta_1^g > \theta_1^m$ when $s_1 > 0.552$.

Figure 3 illustrates t_1 and t_2. The red curves are a benchmark case of self-representation where region 1 levies higher tax $(t_1(\theta_1^m, \theta_2^m) > t_2(\theta_1^m, \theta_2^m))$ and region 2 reduces $t_2(\theta_1^m, \theta_2^m)$ as its size becomes smaller. In contrast, the blue curves show the case of the strategic delegation. Strategic delegation induces higher taxes $(t_i(\theta_1^g, \theta_2^g) > t_i(\theta_1^m, \theta_2^m),\ i = 1, 2)$. $t_2(\theta_1^g, \theta_2^g)$ is now increasing as the size becomes smaller. This is partly because the strategic delegation will make the elected

[17] As in footnote 6 and Appendix C, the second-order conditions for Stages 1 and 2 can be shown to be satisfied. Details are available upon the request to the authors.

[18] $\theta_1^g - \theta_2^g = \dfrac{(2s_1-1)(1-\theta_1^m)(b_1^4/d_1^2(s_1-s_1^2)+16-4b_1^2/d_1)}{8(6-b_1^2/d_1)(1-s_1)^2 s_1^2} > 0.$

[19] $\theta_2^g - \theta_2^m = \dfrac{(1-\theta_2^m)(32s_1 - 16s_1^2 + 4b_1^2/d_1(-s_1^2+2s_1-2) + b_1^4/d_1^2(1-s_1))}{-8(6-b_1^2/d_1)(1-s_1)^2}$. The denominator is negative. Let $G(s_1) \equiv (1-\theta_2^m)(32s_1 - 16s_1^2 + 4b_1^2/d_1(-s_1^2+2s_1-2) + b_1^4/d_1^2(1-s_1))$ be the numerator. $G(\cdot)$ is a concave function with $G(1/2) > 0$ and $G(1) > 0$, so that $G(s_1) > 0$ for all $s_1 \in [1/2, 1]$. Therefore, $\theta_2^g - \theta_2^m < 0$.

representative more left as the size becomes smaller. The difference between t_1 and t_2 is smaller under strategic delegation, so that strategic delegation works as a device to reduce the capital flight of a big country. Figure 4 shows the utility of the median voters (u_1^m and u_2^m). Reflecting a result in Section 4.1, the median voters of both countries become better-off by the strategic delegation when $s_1 = 0.5$, but the welfare improvement of the median voters do not continue under asymmetry. In the figure, strategic delegation reduces region 2's advantage of being small, so that $u_2^m(\theta_1^g, \theta_2^g) < u_2^m(\theta_1^m, \theta_2^m)$ when s_1 is sufficiently high.

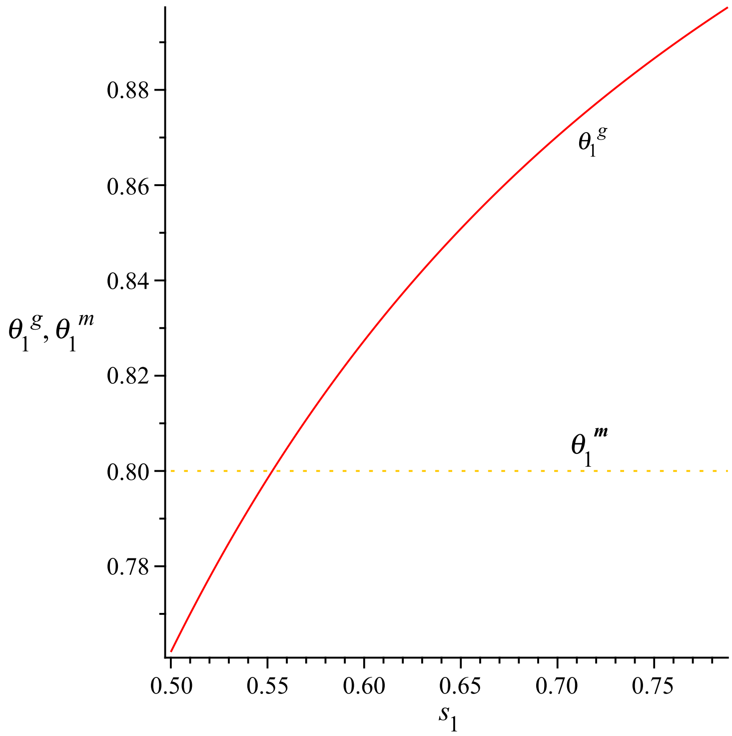

Figure 2:

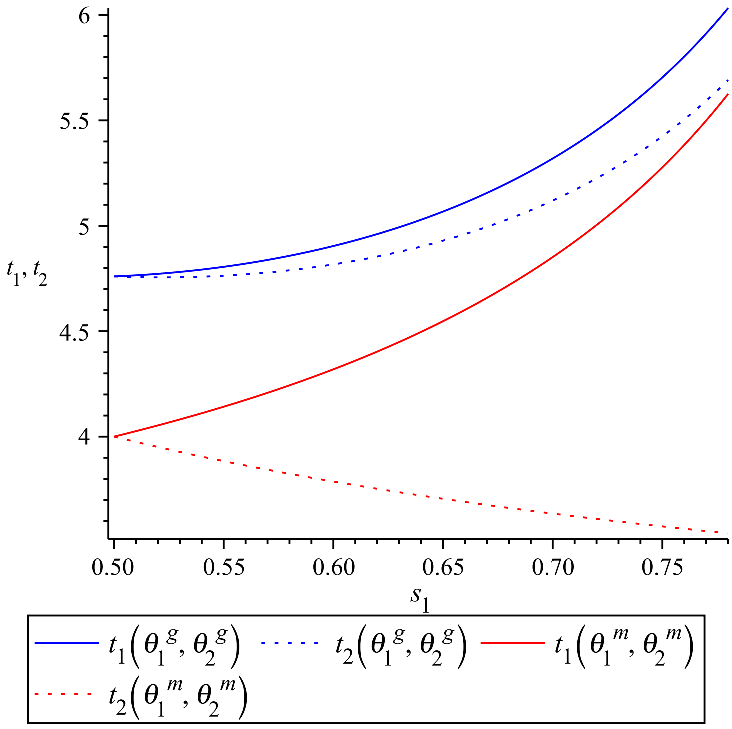

Figure 3:

5 Interregional Partial Cooperation

We examine the effect of interregional cooperation in environmental actions. We revise the timing of the game as follows. In Stage 1, simultaneously in both regions, a delegate for policy-making is elected among residents. In Stage 2, the delegate in each region decides whether to cooperate with another region. Conditional on two delegates' agreement on cooperation, in Stage 3, they set the environmental standard in each region so as to maximize their total utilities, while choosing a capital tax rate independently. If cooperation is not agreed on unanimously, two-dimensional

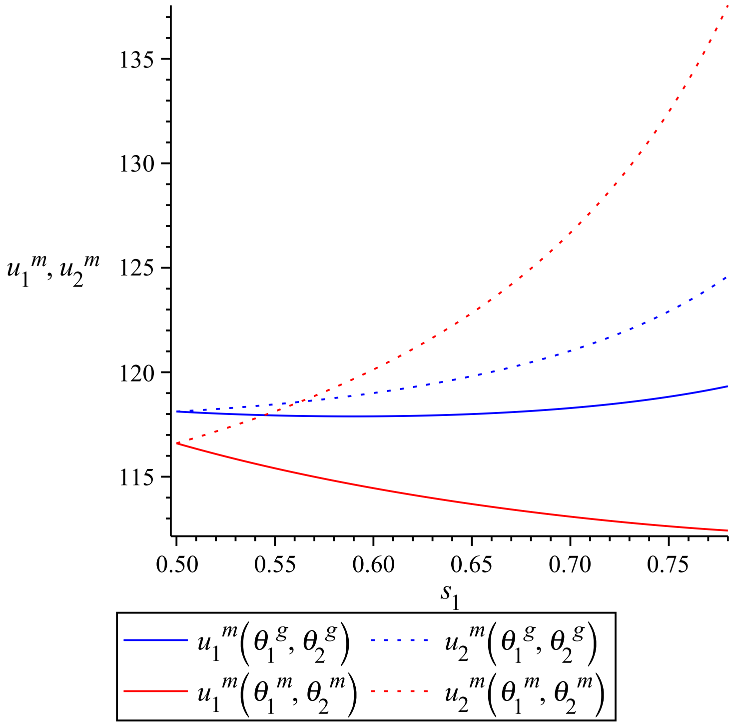

Figure 4:

policies are chosen simultaneously and independently. In Stage 4, having observed the delegates' choices, private investors in both countries make their investment decisions.

In this framework, cooperation is undertaken only in terms of α_i. Typically, interregional agreement is a combination of policy coordination on some issues (α_i in our case) whereas other policies are subject to regional dominion (t_i in our case). The interaction of cooperative and noncooperative decisions in turn reflect to Stage-1's delegation. For comparison, we go back to the benchmark case of symmetric regions ($b_1 = b_2,\ d_1 = d_2,\ \theta_1^m = \theta_2^m$, and $A_1 = A_2$).

In Stage 3, given (8) and (9), the first-order condition with ragard to a choice of tax rate by a policy-maker in region i is still represented by (12). Conditional on the policy-makers' agreement on partial cooperation, the following first-order condition holds:[20]

$$\begin{aligned}\frac{\partial}{\partial \alpha_i}(u_i + u_j) &= t_i \frac{\partial k_i}{\partial \alpha_i} + \frac{\partial r}{\partial \alpha_i}(\theta_i \bar{k} - k_i) + b_i k_i - 2d_i \alpha_i + t_j \frac{\partial k_j}{\partial \alpha_i} + \frac{\partial r}{\partial \alpha_i}\left(\theta_j \bar{k} - k_j\right) \\ &= b_i k_i - 2d_i \alpha_i - \frac{b_i t_j}{2} = 0. \end{aligned} \tag{37}$$

We can employ (13) if interregional agreement fails.

In Stage 2, in anticipation of (8), (9), (12), (13), and (37) for $i = 1, 2$, and $j \neq i$, the delegate in region i makes a decision on interregional partial cooperation. When regions are symmetric, (12) gives us the identical tax rate $2(1-\theta_i)\bar{k}$ in equilibrium with and without coordination. Coordination, with this tax rate, further enables the delegates to internalize the external effect of the looser environmental standard, and hence it improves each delegate's utility. These discussions suggest that each delegate agrees on the cooperative scheme.

In Stage 1, anticipating the policy-maker's behavior, the median voter in region i delegates the authority of decision-making to the policy-maker who can maximize his/her utility. Subject to the suppositions of symmetric regions, the equilibrium policy-maker type in this cooperative scheme, which is denoted by superscript c, is

$$\theta_i^c = \frac{\left(b_i^2/d_i + 4\right)\theta_i^m - 2}{b_i^2/d_i + 2} = \theta_i^m - \frac{2(1-\theta_i^m)}{b_i^2/d_i + 2} < \theta_i^m, \; \theta_i^c - \theta_i^g = \frac{(b_i^2/d_i)(1-\theta_i^m)\left(2 - b_i^2/d_i\right)}{4\left(b_i^2/d_i + 2\right)}. \tag{38}$$

[20]The second-order conditions are verified from the differentiation of (12) with respect to t_i and the differentiation of (37) with respect to α_i and α_j. Similar to Appendix C, we can show that the second-order conditions are satisfied. Details are available upon the request to the authors.

(38) suggests that the type of the delegate induced by cooperation depends on the degree of b_i^2/d_i. In comparison with θ_i^g in (23), $\theta_i^c < \theta_i^g$ if and only if $b_i^2/d_i > 2$.

By employing (8), (9), (12), (37), and (38), we can derive the tax rate and the environmental standard outcomes:

$$t_i(\theta_1^c, \theta_2^c) = \frac{2\bar{k}(1-\theta_i^m)\left(b_i^2/d_i + 4\right)}{b_i^2/d_i + 2} > 0; \tag{39}$$

$$\alpha_i(\theta_1^c, \theta_2^c) = \frac{b_i\bar{k}\left[\left(b_i^2/d_i + 4\right)\theta_i^m - 2\right]}{2d_i\left(b_i^2/d_i + 2\right)} = \frac{b_i\bar{k}}{2d_i}\theta_i^c. \tag{40}$$

We can compare the tax rate in (39) with the one in the game with no cooperation, which we derived in Section 4.1:

$$t_i(\theta_1^c, \theta_2^c) - t_i(\theta_1^g, \theta_2^g) = \frac{(b_i^2/d_i)\bar{k}(1-\theta_i^m)\left(b_i^2/d_i - 2\right)}{2\left(b_i^2/d_i + 2\right)}. \tag{41}$$

In (41), $t_i(\theta_1^c, \theta_2^c) > t_i(\theta_1^g, \theta_2^g)$ if and only if $b_i^2/d_i > 2$. Namely, with a smaller direct effect of a looser environmental regulation on residents' utility relative to the effect on capital productivity, partial cooperation implements a higher tax rate than non-cooperation.

From (15), (38), and (40), along with $k_i(\theta_1^c, \theta_2^c) = k_i(\theta_1^g, \theta_2^g) = \bar{k}$ under the supposition of symmetric regions, we derive the following relation:

$$\alpha_i(\theta_1^c, \theta_2^c) - \alpha_i(\theta_1^g, \theta_2^g) = -\frac{b_i\bar{k}}{2d_i}(1-\theta_i^c) = -\frac{b_i\bar{k}(1-\theta_i^m)\left(b_i^2/d_i + 4\right)}{2d_i\left(b_i^2/d_i + 2\right)} < 0. \tag{42}$$

Thus cooperation implements a tighter environmental regulation.

We are now interested in comparing the median voter's utility under the partial-cooperative and non-cooperative decision-making. From (4) and (6),

$$u_i^m(\theta_1^c, \theta_2^c) - u_i^m(\theta_1^g, \theta_2^g)$$

$$
\begin{aligned}
&= \left[b_i\alpha_i(\theta_1^c,\theta_2^c)\bar{k} - (1-\theta_i^m)r(\theta_1^c,\theta_2^c)\bar{k} - d_i(\alpha_i(\theta_1^c,\theta_2^c))^2\right] \\
&\quad - \left[b_i\alpha_i(\theta_1^g,\theta_2^g)\bar{k} - (1-\theta_i^m)r(\theta_1^g,\theta_2^g)\bar{k} - d_i(\alpha_i(\theta_1^g,\theta_2^g))^2\right] \\
&= \left[b_i\alpha_i(\theta_1^c,\theta_2^c)\bar{k} + (1-\theta_i^m)(t_i(\theta_1^c,\theta_2^c) - b_i\alpha_i(\theta_1^c,\theta_2^c))\bar{k} - d_i(\alpha_i(\theta_1^c,\theta_2^c))^2\right] \\
&\quad - \left[b_i\alpha_i(\theta_1^g,\theta_2^g)\bar{k} + (1-\theta_i^m)(t_i(\theta_1^g,\theta_2^g) - b_i\alpha_i(\theta_1^g,\theta_2^g))\bar{k} - d_i(\alpha_i(\theta_1^g,\theta_2^g))^2\right],
\end{aligned}
$$

so that,

$$
\begin{aligned}
u_i^m(\theta_1^c,\theta_2^c) - u_i^m(\theta_1^g,\theta_2^g) &= \left[(\theta_i^m b_i\bar{k}\alpha_i(\theta_1^c,\theta_2^c) - d_i(\alpha_i(\theta_1^c,\theta_2^c))^2) - (\theta_i^m b_i\bar{k}\alpha_i(\theta_1^g,\theta_2^g) - (\alpha_i(\theta_1^g,\theta_2^g))^2)\right] \\
&+ (t_i(\theta_1^c,\theta_2^c) - t_i(\theta_1^g,\theta_2^g))(1-\theta_i^m)\bar{k}. \qquad (43)
\end{aligned}
$$

Intuitively, the first term in (43) captures how interregional coordination in environmental regulation improves the median voter's welfare. It follows from (38) and (42) that the first term in (43) is positive.[21] The second term resembles (26). From (41), $b_i^2/d_i \geq 2$ is a sufficient condition that the median voter's utility with partial cooperation is higher than his/her utility without cooperation. The formula can be further rearranged to yield

$$
u_i(\theta_1^c,\theta_2^c) - u_i(\theta_1^g,\theta_2^g) = \frac{(b_i^2/d_i)\bar{k}^2(1-\theta_i^m)^2}{4\left(b_i^2/d_i+2\right)^2}\left[4\left(b_i^2/d_i - 2\right) + 3\left(b_i^2/d_i\right)^2\right]. \qquad (44)
$$

Thus, we have a threshold value $\left(\hat{b_i^2/d_i}\right) < 2$ such that for b_i^2/d_i which is higher (lower) than $\left(\hat{b_i^2/d_i}\right)$, the median voter's utility under partial-cooperation is higher (lower) than his/her utility without cooperation. If $b_i^2/d_i > 2$ (indicating that the effect of the environmental standard on capital

[21] The expression of $\theta_i^m b_i k_i \alpha_i - d_i\alpha_i^2$ captures the median-voter's net benefit from α_i, taking account of the endogeneity of the return of capital, r. The first term in (43) is further rearranged to $(\alpha_i(\theta_1^c,\theta_2^c) - \alpha_i(\theta_1^g,\theta_2^g))\left[\theta_i^m b_i\bar{k} - d_i(\alpha_i(\theta_1^c,\theta_2^c) + \alpha_i(\theta_1^g,\theta_2^g))\right] = (\alpha_i(\theta_1^c,\theta_2^c) - \alpha_i(\theta_1^g,\theta_2^g))b_i\bar{k}\frac{(\theta_i^m-\theta_i^c)-(1-\theta_i^m)}{2}$. Note that $(\theta_i^m - \theta_i^c) - (1-\theta_i^m) = -(1-\theta_i^m)\frac{b_i^2/d_i}{b_i^2/d_i+2} < 0$.

productivity is more prominent), in the partial-cooperation scenario, strategic delegation appoints a poorer policy-maker who mitigates the tax-competition effect; in effect, the tax rate adopted with partial cooperation is higher than the tax rate without cooperation. On the other hand, if $b_i^2/d_i < 2$ (implying that the environmental quality seriously matters), environmental regulation is complemented by lower tax on capital more intensively under the cooperative scenario. This will reverse the sign of the second term of (43) and eventually, beyond the threshold $(\widehat{b_i^2/d_i})$, the effect of tighter environmental regulation carried out cooperatively is completely offset by the accelerated tax-competition effect.

Proposition 4 in Buchholz et al. (2005) demonstrated that strategic delegation aiming to improve the bargaining position of the country can make the median voter's utility lower than in the non-cooperation scenario. In our model, when the median voters have much concern about the deteriorated environment, the environmental regulation is tightened through interregional cooperation but the tax rate, which is independently determined, is lowered in the partial-cooperation game. Thus coordination produces the effects working on the median voter's utility in the opposite directions, and consequently, it may become ineffective.

6 Concluding Remarks

This paper examined a two-stage model that describes a political process and economic consequences of tax competition, tax exporting and environmental policy competition. Various types of asymmetries across regions are examined, such as the median voter's types, capital productivities and impacts of environmental standards. As to the rate of capital taxes, strategic delegation increases the divergence across regions. Although the tax rates tend to be increased in order to mitigate the tax-competition effect ((23), (27), the first terms of (30) and (34)), the allocations of capitals and the environmental standards are directed towards reducing allocational efficiency. The patterns are different in Section 4.5 in terms of different population. For a big country, strategic delegation of electing a representative more right works as a device to reduce the capital flight as well as increasing the median-voter's utility. We also examined the effect of interregional cooperation in environmental actions. As citizens care environmental quality more seriously, environmental regulation is complemented by lower tax on capital more intensively under the cooperative scenario.

Several extensions are possible. One can consider heterogeneity in terms of the assessment of the environmental damage (d_i). As well, one can consider the case of the transboundary externalities in which u_i is dependent on α_j ($j \neq i$). Segendorff (1998) and Buchholz et al. (2005) considered such a model, and showed that median-voters have an incentive to elect a representative who cares environment less than himself/herself. Nishimura and Terai (2011) clarified that their results are due to strategic substitutability of the regional environmental standards. On the other hand, the tax-competition game has a structure of strategic complementarity. The interaction of offsetting effects would be of interest.

Appendix

Appendix A: The First-best Solutions

Here, we derive the solution of the first-best case where an omniscient planner maximizes $\sum_{i=1,2}(y_i - d_i\alpha_i^2)$ subject to $k_1 \geq 0$, $k_2 \geq 0$, and $2\bar{k} \geq k_i + k_j$. The first-order condition of the interior optimum with respect to k_i and α_i yield

$$A_i + b_i\alpha_i - 2k_i = \lambda,\ \ b_ik_i - 2d_i\alpha_i = 0\ (i = 1, 2),\ \ k_1 + k_2 = 2\bar{k}, \tag{45}$$

where λ denotes the Lagrange multiplier of the constraint $k_1 + k_2 = 2\bar{k}$. The Hessian matrix formed by the above equation is negative definite if Assumption 1 is satisfied.

Solving (45), one can derive

$$k_i^* = \frac{2(A_i - A_j) + 2(4 - b_j^2/d_j)\bar{k}}{8 - b_1^2/d_1 - b_2^2/d_2}\ (i, j = 1, 2,\ i \neq j) \tag{46}$$

and

$$\alpha_i^* = \frac{b_i}{2d_i}k_i^*. \tag{47}$$

Our tax-competition game would not guarantee $k_i = k_i^*$, either under strategic delegation or self-representation. However, the *relationship* between α_i and k_i in (47) is preserved under tax competition.

Appendix B: On Equation (10)

It may be worth noting that (10) is a general property without assuming quadratic production functions. Differentiating the system of equations (6) and (7) through t_i,

$$\begin{aligned} & f^i_{kk}\frac{\partial k_i}{\partial t_i} = \frac{\partial r}{\partial t_i} + 1 \\ & f^j_{kk}\frac{\partial k_j}{\partial t_i} = \frac{\partial r}{\partial t_i} \\ & \frac{\partial k_i}{\partial t_i} + \frac{\partial k_j}{\partial t_i} = 0, \end{aligned} \tag{48}$$

where the subscript k represents the partial derivative with respect to the regional capital. The above equations yiled:

$$\frac{\partial k_i}{\partial t_i} = \frac{1}{f^i_{kk} + f^j_{kk}}, \; \frac{\partial r}{\partial t_i} = -\frac{f^j_{kk}}{f^i_{kk} + f^j_{kk}}. \tag{49}$$

Similarly,

$$\begin{aligned} & f^i_{k\alpha} + f^i_{kk}\frac{\partial k_i}{\partial \alpha_i} = \frac{\partial r}{\partial \alpha_i} \\ & f^j_{kk}\frac{\partial k_j}{\partial \alpha_i} = \frac{\partial r}{\partial \alpha_i} \\ & \frac{\partial k_i}{\partial \alpha_i} + \frac{\partial k_j}{\partial \alpha_i} = 0, \end{aligned} \tag{50}$$

where the subscript α represents the partial derivative with respect to the regional public-input. The above equations yiled:

$$\frac{\partial k_i}{\partial \alpha_i} = -\frac{f^i_{k\alpha}}{f^i_{kk} + f^j_{kk}}, \; \frac{\partial r}{\partial \alpha_i} = \frac{f^i_{k\alpha} f^j_{kk}}{f^i_{kk} + f^j_{kk}}. \tag{51}$$

(49) and (51) induce (10).

Appendix C: Second-order Condition of the Stage-2 Optimum and Derivation of (16)

From (12) and (13),

$$\begin{aligned}\frac{\partial u_i}{\partial t_i} &= -\frac{1}{4}t_i - \frac{1}{2}(\theta_i\bar{k} - k_i) \\ &= \left(\frac{(1-\theta_i)\bar{k}}{2} + \frac{A_i - A_j}{8} + \frac{b_i\alpha_i - b_j\alpha_j}{8} + \frac{t_j - 3t_i}{8}\right) = 0; \end{aligned} \tag{52}$$

$$\begin{aligned}\frac{\partial u_i}{\partial \alpha_i} &= = b_i\left(\frac{1}{4}t_i + \frac{1}{2}(\theta_i\bar{k} - k_i)\right) + b_ik_i - 2d_i\alpha_i \\ &= \left(\frac{b_i(1+\theta_i)\bar{k}}{2} + \frac{b_i(A_i - A_j)}{8} + \frac{(b_i^2 - 16d_i)\alpha_i - b_ib_j\alpha_j}{8} + \frac{b_i(t_i + t_j)}{8}\right) = 0. \end{aligned} \tag{53}$$

The associated Hessian matrix is:

$$H_i \equiv \begin{pmatrix} \frac{\partial^2 u_i}{(\partial t_i)^2} & \frac{\partial^2 u_i}{\partial t_i \partial \alpha_i} \\ \frac{\partial^2 u_i}{\partial \alpha_i \partial t_i} & \frac{\partial^2 u_i}{(\partial \alpha_i)^2} \end{pmatrix} = \begin{pmatrix} -\frac{3}{8} & \frac{b_i}{8} \\ \frac{b_i}{8} & \frac{b_i^2 - 16d_i}{8} \end{pmatrix} \tag{54}$$

$|H_i| \cdot 8^2 = -3b_i^2 + 48d_i - b_i^2 = 4(12d_i - b_i^2) > 0$ under Assumption 1. Also, $\frac{b_i^2 - 16d_i}{8} < 0$ under Assumption 1. Therefore, H_i is negative definite.

In order to see the structure of the Stage-2 reaction function clearer, we now reduce the number of policy dimensions into one, by multiplying the terms on both sides of (52) by $-b_i$ and adding them to corresponding terms on the respective sides of (53):

$$\frac{b_it_i}{2} + b_i\theta_i\bar{k} - 2d_i\alpha_i = 0,$$

i.e.,

$$\alpha_i = \frac{b_i}{4d_i}t_i + \frac{b_i}{2d_i}\theta_i\bar{k}. \tag{55}$$

By substituting (55) in (52), we derive region 1's reaction function (16) in the text.

Appendix D: Section 4.4

From (34), we have

$$\begin{aligned}\theta_i^g-\theta_i^m &= \frac{1}{8(12-b_i^2/d_i-b_j^2/d_j)}[\theta_i^m(b_j^4/d_j^2+3(b_i^2/d_i)(b_j^2/d_j)-12b_i^2/d_i-28b_j^2/d_j+96)\\ &\quad -2b_j^4/d_j^2-2(b_i^2/d_i)(b_j^2/d_j)+8b_i^2/d_i+32b_j^2/d_j-96] \end{aligned} \tag{56}$$

Let $\theta_i^g-\theta_i^m=E_{i1}\theta_i^m+E_{i0}$, with $E_{i1}=(3b_i^2/d_i+b_j^2/d_j-24)(b_j^2/d_j-4)/(8(12-b_1^2/d_1-b_2^2/d_2))>0$, $E_{11}-E_{21}=(b_1^2/d_1-b_2^2/d_2)(16-b_1^2/d_1-b_2^2/d_2)/(8(12-b_1^2/d_1-b_2^2/d_2))>0$ and $E_{10}-E_{20}=-(b_1^2/d_1-b_2^2/d_2)/4<0$. Also, $E_{11}+E_{10}=(4-b_2^2/d_2)(b_2^2/d_2-b_1^2/d_1)/(8(12-b_1^2/d_1-b_2^2/d_2))<0$ and $E_{11}+E_{10}-(E_{21}+E_{20})=(8-b_1^2/d_1-b_2^2/d_2)(b_2^2/d_2-b_1^2/d_1)/(8(12-b_1^2/d_1-b_2^2/d_2))<0$. Therefore, $\theta_1^g-\theta_1^m=E_{11}\theta_1^m+E_{10}<E_{11}+E_{10}<0$. Also, $\theta_1^g-\theta_2^g=(E_{10}-E_{20})+(E_{11}-E_{21})\theta_1^m<E_{10}-E_{20}+E_{11}-E_{21}<0$. The case for $\theta_2^g>\theta_2^m$ can be shown, for example, in the case of $\theta_1^m=0.9, b_1=18, d_1=100, A_1=15$, and $d_2>194.845$.

As to t_i, from (17), $t_1(\theta_1,\theta_2)-t_2(\theta_1,\theta_2)=\dfrac{2\bar{k}(b_1^2/d_1+b_2^2/d_2-8)}{16-b_1^2/d_1-b_2^2/d_2}(\theta_1-\theta_2)+\dfrac{4\bar{k}(b_1^2/d_1-b_2^2/d_2)}{16-b_1^2/d_1-b_2^2/d_2}$. The second term of the right-hand side represents the differences in region's tax incentives appearing in the second term of (17). Under the strategic delegation ($\theta_i=\theta_i^g$), the first term is now positive due to $\theta_2^g>\theta_1^g$ and Assumption 1.

As to k_i, $k_1(\theta_1^g,\theta_2^g)-k_1(\theta_1^m,\theta_2^m)=-\dfrac{(b_1^2/d_1-b_2^2/d_2)(24-2b_1^2/d_1-2b_2^2/d_2-(16-b_1^2/d_1-b_2^2/d_2)\theta_1^m)\bar{k}}{2(12-b_1^2/d_1-b_2^2/d_2)(16-b_1^2/d_1-b_2^2/d_2)}$ <0 and $k_1(\theta_1^m,\theta_2^m)-k_1^*=\dfrac{8(b_2^2/d_2-b_1^2/d_1)\bar{k}}{(8-b_1^2/d_1-b_2^2/d_2)(16-b_1^2/d_1-b_2^2/d_2)}<0$. The similar formula hold for k_2. Also, $k_1(\theta_1^g,\theta_2^g)-k_2(\theta_1^g,\theta_2^g)=\dfrac{(b_1^2/d_1-b_2^2/d_2)\theta_1^m\bar{k}}{12-b_1^2/d_1-b_2^2/d_2}>0$.

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