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By

Keisuke Kawachi, Hikaru Ogawa, Taiki Susa

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Endogenizing government's objectives in tax competition with capital ownership

Keisuke Kawachi* Hikaru Ogawa† Taiki Susa‡

Abstract

In this study, we extend the standard approach of horizontal tax competition by endogenizing the policy objectives that governments pursue. Following the literature on strategic delegation games, we consider a pre-play stage, where jurisdictions commit themselves to act as Leviathan or as benevolent agents. We show that the symmetric sub-game perfect equilibria correspond to three cases of tax competition among the Leviathan governments, *moderate* Leviathans, and benevolent governments, depending on the form of capital ownership. Further analysis reveals that asymmetric tax competition generates competition between the benevolent government and the (moderate) Leviathan government. The results provide grounds for benevolent or Leviathan objective of the government made in literature and explain why some governments behave as Leviathans, while others as benevolent agents in international tax competition environment.

Keywords: Tax competition; Endogenous policy objective; Leviathan; Benevolent government

JEL classification: F21, H11, H73, H77

*Faculty of Humanities, Law and Economics, Mie University, 1577 Kurimamachiya-cho, Tsu, Mie, 514-8507, Japan email: keikawachi@human.mie-u.ac.jp.

†Corresponding author. Graduate School of Economics and Graduate School of Public Policy, University of Tokyo, 7-3-1 Hongo Bunkyo-ku, Tokyo, 113-8654, Japan email: ogawa@e.u-tokyo.ac.jp.

‡College of Business Administration and Information Science, Chubu University, 1200 Matsumoto-cho, Kasugai, Aichi, 487-8501, Japan email: susa@isc.chubu.ac.jp.

1 Introduction

Drawing from the seminal work of Zodrow and Mieszkowski (1986) and Wilson (1986), numerous studies on capital tax competition clarify the effects of interregional competition for mobile capital. One standard result in the literature is that tax competition compels governments to decrease their tax rates on mobile capital. This argument is quite understandable from the inverse elasticity rule of optimal taxation, and it helps in explaining why countries in Europe decreased their corporate income tax from the 1990s onward. Contrary to the perspective of the positive theory, the normative analyses present indistinct opinions on tax competition. If the model assumes a benevolent government that aims to maximize residents' welfare, then tax competition would be regarded as problem-causing since it would reduce tax rates to an inefficient lower level. Contrarily, if the model assumes that the governments are Leviathans seeking to extend their power by increasing the scale of government, or tax-revenue-maximizing governments, then tax competition would exert downward pressure on government size, thereby improving welfare.[1]

Accordingly, the equilibrium and welfare implications of tax competition are dependent on the government objective, which has been set arbitrarily for research purposes. On the one hand, literature commonly focuses on the welfare-maximizing government as being the benevolent agent; on the other hand, the tax-revenue-maximizing (i.e., Leviathan-type) government has also been used in the literature. From the viewpoint of removing the arbitrariness, the present study contributes toward tax competition theories by studying which of the government objectives is commitment robust. Consequently, we examine the endogenous objective function of the tax decision maker in a capital tax competition.

Our study is motivated by Pal and Sharma (2013), which endogenizes objective functions of countries in a tax competition model. Following Vickers (1985), Fershtman and Judd (1987), and Sklivas (1987), Pal and Sharma (2013) consider strategic incentive delegation in the context of a two-stage tax competition. In their framework, it is assumed that the central authority, who is the true welfare-maximizer, delegates the power to decide a tax rate to a risk-neutral manager in the first stage. It can be described by the choice of parameter in the weighted sum of citizens' welfare and tax revenue. Subsequently, the manager in each region simultaneously determines a capital tax rate in the second stage.[2] The main finding of their study is that the governments can behave as if they are net tax maximizers, even when their ultimate purpose is to maximize the welfare of citizens.[3]

In this study, we extend the analysis of Pal and Sharma (2013) by focusing on the ownership of capital and regional asymmetries used for deducing the hidden equilibrium. Specifically, one of the contributions of our study is to demonstrate that Pal and Sharma's (2013) argument depends on the form of capital ownership, that is, absentee capital ownership. To facilitate our analysis, we generalize their model into two directions.

First, we formulate a general form of capital ownership to capture both absentee and non-absentee capital ownership. Within the non-absentee capital ownership model, there appears an incentive to manipulate the terms of trade in the opposite direction of the incentive which exists within the absentee capital ownership model. This shows that the introduction of capital ownership leads to significant effects

[1] See Wilson and Wildasin (2004) for the review on the advantages and disadvantages of capital tax competition.

[2] As another strand of studies of strategic delegation in tax competition, we can list Persson and Tabellini (1992), Ihori and Yang (2009), and Ogawa and Susa (2017). For instance, in Persson and Tabellini (1992), a policymaker is elected from the heterogeneous citizens through majority voting, and thus the authority to choose the capital tax rate in the country is delegated to this policymaker. This is referred to as the all-citizen-candidate model. However, the structure of the two-stage game and mathematical treatment to derive equilibrium are quite similar to the present study and the aforementioned studies under certain conditions, as the median voter theorem holds.

[3] They extend the baseline model to incorporate production asymmetries, sequential move structure, and competition in public investment and show that maximizing welfare rather than maximizing tax revenue is the dominant strategy, at least, in one country in the sequential-move game.

on the choice of policy-making objectives. When the capital is fully owned by absentee owners living outside the economy, countries in the economy prefer low-priced capital since all the returns to capital clear away from the countries. However, if the initial capital is owned by residents living in the country, then the capital exporting countries would have incentives to realize a high price for the capital, which would induce central authorities to choose the government objective differently from the results given by Pal and Sharma (2013).

Second, we clarify the effects of interregional asymmetries on the central authority's choice of policy-making objectives. The world is composed of nations with diverse characteristics, but the ultimate goal of each nation is simple—to improve the welfare of the citizens. As long as the nation is under democracy and its policymakers are representative of the citizens, the government is expected to improve the welfare of its citizens to remain sustainable. Even though countries with different characteristics pursue the same objective, the means for achieving the goals might be different. While one country may set objective other than welfare maximization, as shown in Pal and Sharma (2013), resulting in maximizing the citizen's welfare, another country may directly try to achieve its ultimate goal. Since it is essential for different governments to "manipulate" the economic factors to achieve their objectives in different ways, the target in their policy settings can be chosen strategically and will be different for each country. Our study clarifies which country tends to deviate and which country remains faithful to its ideal objective in its respective policy settings.

These extensions produce the following three patterns of possible equilibria: (i) governments act as if they are the Leviathans; (ii) they act as the benevolent agents; and (iii) they act as if they are the moderate Leviathans, who are neither entirely benevolent nor self-serving. The first case corresponds to the argument made by Pal and Sharma (2013), while the equilibria are refined in the other two cases. Specifically, cases (ii) and (iii) are more likely to prevail as residents in the countries being analyzed as owners of the capital. The case (ii) corresponds to the canonical assumption in the tax competition model (e.g., Zodrow and Mieszkowski, 1986) and case (iii) justifies the assumption made by Edwards and Keen (1996) and Wrede (1998), among others. Furthermore, our analysis on asymmetric countries shows that the governments in capital-poor countries behave as Leviathans, while the governments in capital-rich countries behave as benevolent agents. These results show that Pal and Sharma's (2013) study is relevant for economies where the capital is owned by absentee owners; however, our analysis suggests that, for economies with non-absentee capital ownership, we may expect governments to attach weight to welfare in tax competition.

The remainder of this paper is organized as follows. In section 2, we present a symmetric tax competition model. The equilibrium properties are presented in section 3 along with the main results. Section 4 presents the discussion of the model, which is mainly extended to the case of asymmetric tax competition. Here, the asymmetry is captured by the difference in the capital endowment or production technology between the two countries. In addition, the two-dimensional competition and Stackelberg-type competition are also examined. Section 5 offers conclusions.

2 Basic Model

Capital Endowment. There are two countries, and, in each country i ($i = 1, 2$), there are homogeneous residents normalized at 1.[4] The production of private goods requires capital and labor with constant returns to scale technology. The total amount of capital employed in the production is fixed at 2κ, which is owned by the residents of the economy and the absentee capital owners residing outside the economy. The residents of the two countries have an initial endowment of capital $2\kappa\delta$, and the rest of

[4]The basic settings, that is, preferences and technologies, follow the works of Bucovetsky (2009), Pal and Sharma (2013), and Eichner (2014), among others.

the endowment, $2\kappa(1-\delta)$, is owned by the absentee capital owners, where $\delta \in [0,1]$ characterizes the form of capital ownership. When $\delta = 0$, the capital is fully owned by absentee owners and our model reduces to the Pal and Sharma model; however, $\delta = 1$ corresponds to a non-absentee capital ownership environment, which is assumed in the canonical tax competition model.

The initially endowed capital per capita in country i is defined by $2\kappa\delta\theta_i$, where $\theta_i \in [0,1]$ is the share of capital endowment in country i ($\theta_1 + \theta_2 = 1$). To focus on the effect of the share of absentee capital ownership represented by the parameter $1-\delta$, we begin by describing the two symmetric countries in its simplest form, $\theta_1 = \theta_2 = 1/2$, deferring discussions on the case of asymmetric ownership of capital between the two countries until later. All the capital is assumed to be freely mobile between the two countries, while the high attachment of residents to their respective countries keeps them from migrating to each other's countries.

Firms. We assume that the production per capita in country i is based on the function $f(k_i) = (A_i - k_i)k_i$, where k_i stands for the capital per capita in country i and $A_i > 0$ is a parameter. Although the assumption will be relaxed later, we here assume that level of production technology captured by A_i is symmetric between the two countries or $A_1 = A_2 \equiv A$. The profit of firms in country i is yielded as $\pi_i = (A - k_i)k_i - w_i - rk_i - T_ik_i$, where w_i denotes the wage rate, r the capital price in the integrated capital market, and T_i the capital tax rate determined by the government.

From perfect mobility of capital and the capital-market clearing condition, it is implied that

$$r = A - 2k_i - T_i \text{ and } 2\kappa = k_1 + k_2. \tag{1}$$

Using (1), the amount of capital in country i and the price of capital are given as follows:

$$k_i = \kappa - \frac{T_i - T_j}{4} \text{ and } r = A - 2\kappa - \frac{T_1 + T_2}{2}. \tag{2}$$

Residents. The preference of residents in country i is defined by

$$U(c_i, G_i) = c_i + (1+\gamma)G_i, \tag{3}$$

where c_i is the consumption of a private numeraire good and G_i denotes consumption of the public good. In (3), $\gamma \in [0,1)$ is a preference parameter reflecting the strength for public goods.[5] The total amount of residents' income consists of labor income, $f(k_i) - f_k(k_i)k_i$, and the rent from the capital, $r\kappa\delta$, where $f_k(k_i) \equiv \partial f(k_i)/\partial k_i$. Hence, the budget constraint of the residents in country i becomes

$$c_i = f(k_i) - f_k(k_i)k_i + r\kappa\delta. \tag{4}$$

Government. Policy-making manager in the government of country i chooses a unit tax rate, T_i, on capital used in production within the country and provides public goods, G_i. Consequently, the budget constraint of the government of country i is

$$G_i = T_ik_i. \tag{5}$$

Following Pal and Sharma (2013), we consider a principal-agent framework in which the authorities of each government, whose ultimate goal is to maximize the welfare of citizens within its country, delegate

[5] γ can also be interpreted as the marginal costs of public funds in the country. See Cardarelli et al. (2002), Bucovetsky (2009), Keen and Konrad (2013), and Eichner (2014). If $\gamma = 0$, then the model would reduce to the one in which tax revenues will be returned to the residents in a lump sum manner.

the power to decide a capital tax rate to a risk-neutral manager.[6] The manager can be interpreted as a bureaucrat or a minister, whose objective is represented by a linear combination of resident's welfare, U_i, and the size of the government, G_i;

$$V_i = (1 - a_i)U_i + a_i G_i, \tag{6}$$

where $a_i \in [0, 1]$ is the incentive parameter chosen by the authority in country i. When $a_i = 0$, the authority of country i bids the manager to behave straightforwardly as a benevolent government. Contrarily, $a_i = 1$ means that the authority tells the manager to act as a Leviathan.[7] When a_i takes an interior solution, $a_i \in (0, 1)$, the authority orders the manager to act as a *moderate* Leviathan, who is neither entirely benevolent nor self-serving.

It must be noted that by that using (4) and (5), (3) is rewritten as $U_i = k_i^2 + r\kappa\delta + (1 + \gamma)T_i k_i$, which reduces to the *social welfare* defined in Pal and Sharma (2013) when $\delta = 0$ and $\gamma = 0$. Hence, the critical features of our analysis that differentiate our analysis from Pal and Sharma (2013) are twofold, represented by δ and γ, which can be associated with two externalities involved in the tax competition. When country i raises its capital tax rate it does not consider the capital outflow, and thereby improves the tax base and public good provision in country j. This effect, called fiscal externality, is reflected by γ. In addition, if country i raises its capital tax rate, then the net return to capital is reduced, which, in turn, changes the capital income of the resident in country j. This effect, called terms of trade externality, is captured by δ and is ignored by country i in its tax decision.

3 Equilibrium

We define the timing of the two-stage game as follows:

1. In each country, the authority chooses an incentive parameter, a_i, for the manager.

2. With a commitment to the determination in the first stage, the policy-making manager of each country simultaneously sets its tax rate, T_i.

Again, it must be noted that the ultimate goal of the authority of the government is to maximize the welfare of citizens in the country, which implies that they do not want to become a true Leviathan government, even if they bid the policy-making manager to become a Leviathan. They force the manager to act as the Leviathan to maximize the welfare at equilibrium.

Applying the concept of sub-game perfect Nash equilibrium, we solve this game backwards.

3.1 Second Stage

Given the tax rate of the other country j, the policy-making manager in country i (characterized by a_i, which is selected in the first stage) determines the tax rate, T_i, to maximize $V_i = (1 - a_i)U_i + a_i G_i$, subject to (2). The first-order condition yields the reaction function for country i, which is given by $T_i = T_i(T_j, a_i)$.[8] Solving the simultaneous equations for $i = 1, 2$, we obtain the capital tax rate of country

[6]The assumption of the ultimate goal of governments is simply justified by the fact that they are representatives elected through voting by citizens of a country that is under the regime of democracy. If they deviate from the ultimate goal, then they will not be chosen in the next election.

[7]The Leviathan-type government, first proposed by Brenann and Buchanan (1977, 1980), maximizes the fiscal surplus that consists of tax revenue minus cost for providing public goods. However, since the results do not change, we here simply follow Kanbur and Keen (1993), Ohsawa (1999), Wang (1999), and Keen and Kotsogiannis (2003) to assume that the objective of the Leviathan is tax revenue maximization.

[8]Appendix A provides details of derivations referred to throughout the text.

i in the sub-game equilibrium as $T_i^* = T_i(a_i, a_j)$. Substituting T_i^* into (2), we obtain $k_i^* = k_i(T_i^*, T_j^*)$ and $r^* = r(T_i^*, T_j^*)$, and using these, we obtain the utility level in country i as $U_i^* = U_i(T_i^*, T_j^*)$.

3.2 First Stage

In the first stage, the authority of the government maximizes the utility of residents in the country, $U_i^* = U_i(T_i^*, T_j^*)$, by choosing $a_i \in [0, 1]$. The first-order condition yields the reaction function as $a_i = a_i(a_j)$. Solving these equations for $i = 1, 2$, we finally obtain the equilibrium value of a_i as

$$a_i^* = a_j^* = \frac{(1+2\gamma)(1+\gamma-\delta)}{\gamma(1+2\gamma)+2(1-\gamma)\delta}. \tag{7}$$

(7) shows that

$$\frac{\partial a_i^*}{\partial \delta} = -\frac{(1+2\gamma)(2+\gamma)}{[\gamma(1+2\gamma)+2(1-\gamma)\delta]^2} < 0, \tag{8}$$

suggesting that as the share of capital ownership of the residents in the countries increases, the benevolent type of government objective is preferred. Since δ and γ are values between 0 and 1, when $\gamma > 0$, our main result can be summarized as follows:

Proposition. (i) When $\delta \leq (1+2\gamma)/3$, the governments choose to act as Leviathans, $a_i^* = 1$; (ii) When $\delta > (1+2\gamma)/3$, they choose to act as moderate Leviathans,

$$a_i^* = \frac{(1+2\gamma)(1+\gamma-\delta)}{\gamma(1+2\gamma)+2(1-\gamma)\delta}.$$

For reference, the equilibrium value of a_i is expressed in Figure 1.

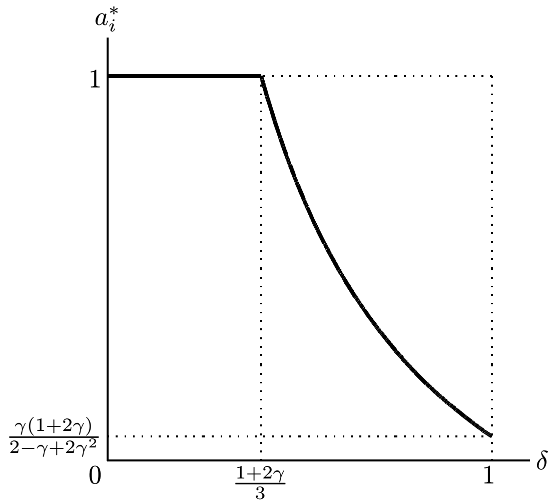

Figure 1. a_i in the equilibrium when $\gamma > 0$.

Proposition (i) corresponds to the argument made by Pal and Sharma (2013), while the equilibria are clearly refined in (ii). While the government's objective will be to act as a Leviathan, as in Pal and Sharma (2013), when δ is sufficiently small, the government puts certain weight on the utility of residents in the country when δ is sufficiently large. Specifically, there is a case wherein the government acts entirely as a benevolent agent. From (7), the conditions that facilitate the selection of the benevolent objective of the government can be summarized as follows:

Corollary. When $\gamma = 0$ and $\delta = 1$, the governments act as benevolent agents, $a_i^* = 0$.

This result is remarkable. When $\gamma = 0$, the model reduces to the case in which the tax revenue is returned to the residents in a lump sum manner, as in Pal and Sharma (2013). In this case, the sole purpose of levying capital tax is manipulation of the terms of trade. If a country is a capital importer (exporter), then it has an incentive to lower (raise) the capital price by setting a high (low) tax rate. Particularly, there are two ways of manipulating the capital price in this model, as captured by the latter part of (2); one country can manipulate the capital price through the tax rate of the country itself and *the tax rate of the other country.* If one country wants to lower capital price, then it can realize it by behaving more like a Leviathan, or tax-revenue-maximizing government, so that the country can straightforwardly set tax rate of itself higher than behaving as a benevolent government. This is the former of the two ways. However, considering that one country can recognize the type of policy-making manager that is chosen in the other country and considering that tax competition is a strategic complement, one country can induce the other country to set a higher tax rate by behaving more like a Leviathan. Hence, the capital price in the market is lowered not only by the tax increase of the country itself but also by raising tax rate of the other country.

When $\delta = 1$ or the capital is fully owned by the residents of the countries, there is no incentive to behave as a Leviathan government in order to set a higher tax rate and realize a lower capital price. This finding offers a justification for the benevolent objective of the government that is assumed to have full capital ownership in the existing literature (Itaya et al., 2008; Kempf and Rota-Graziosi, 2010; Ogawa, 2013; Hindriks and Nishimura, 2015).

In sum, the governments act as Leviathans, which reproduces the findings by Pal and Sharma (2013) when δ is sufficiently small; these findings imply that most of the capital is owned by absentee owners living outside the economy. Contrarily, when δ is sufficiently high, the argument by Pal and Sharma does not necessarily hold; the governments give attention to the utility of the residents as well as to the size of the government. Specifically, when the entire initial capital is owned by the residents of the economy ($\delta = 1$) and the tax revenue is returned to the residents in a lump sum manner ($\gamma = 0$), the governments act entirely as benevolent agents.

4 Extension

The analysis in the previous section is conducted by assuming that all countries have identical technology and an initial endowment of capital. In addition, the capital tax is assumed to be the only policy instrument, and all the decision-making are simultaneously carried out among the countries. These assumptions provide a reasonable basis to focus on the effects of the form of capital ownership on the government objective. However, some studies highlight about these effects on the equilibrium outcome of regional asymmetries in terms of preferences, technology, and initial endowments (Bucovetsky, 1991). In this section, we provide examples that are useful for examining the effects of regional asymmetries, additional policy instrument, and timing of decision making on the choice of government objectives. This is not merely a formal generalization of the basic model, but an examination to check the robustness of the results obtained. Specifically, our main concern is whether the corollary holds even in the case of asymmetric tax competition. In other words, we here examine whether a pure benevolent government prevails and what determines the country to have a benevolent objective in the case of asymmetric countries.

4.1 Asymmetric Tax Competition: Capital Endowment

The basic setup and notation of the previous sections can still be preserved here, except for the initial endowment of capital. To present our argument most clearly, we here assume $\delta = 1$ and $\gamma = 0$. With this assumption, it is shown that the governments have benevolent policy-making objective in the symmetric tax competition. Here, the regional asymmetry is captured by the initial endowment of the capital, and there is no difference in the level of production technology between the two countries—$A_1 = A_2 \equiv A$. We assume that the residents in country i own $2\kappa\theta_i$ units of capital, where $\theta_1 + \theta_2 = 1$. When $\theta_1 = 0$, the residents of country 1 have no capital endowment, but those of country 2 have a full capital endowment and vice versa when $\theta_1 = 1$.

The timing of the game is unchanged. In the first stage, the authority of the government in each country chooses an incentive parameter, a_i, for the policy-making manager. Given this choice in the first stage, the policy-making managers characterized by a_i set their tax rate, T_i, in the second stage. Since the analysis is based on the model in Section 3, the description of the results will be brief.[9]

Solving the model from the backward, the reaction function of country i in the first stage is given by

$$a_i = \frac{(a_j + 1)\left[2(1-\theta_i)a_j + 1 - 2\theta_i\right]}{2(1+\theta_i)a_j + 1 + 8\theta_i}. \tag{9}$$

(9) is solved for $i = 1, 2$ to have $a_i^* = a_i(\theta_i, \theta_j)$, where $\theta_i + \theta_j = 1$:

$$(a_i^*, a_j^*) = \begin{cases} \left(\frac{1-2\theta_i}{1+8\theta_i}, 0\right) & \text{if } 0 \leq \theta_i < \frac{1}{2}, \\ (0, 0) & \text{if } \theta_i = \frac{1}{2}, \\ \left(0, \frac{2\theta_i - 1}{9-8\theta_i}\right) & \text{if } \frac{1}{2} < \theta_i \leq 1. \end{cases} \tag{10}$$

Figure 2 illustrates the equilibrium value of a_1 and a_2, where $\theta \equiv \theta_1$ and $1 - \theta \equiv \theta_2$.

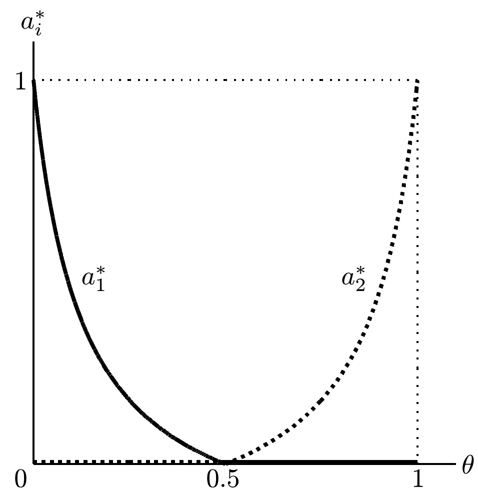

Figure 2. a_1 and a_2 when $\gamma = 0$ and $\delta = 1$

In Figure 2, the bold and dashed lines show a_1^* and a_2^*, respectively, assuming that the capital is fully owned by the residents in the two countries ($\delta = 1$), and the government's sole incentive to use capital tax is to manipulate the terms of trade ($\gamma = 0$). The symmetry in the government's objective function, i.e., $\theta = 0.5$, becomes evident, $a_i^* = 0$. Assume that the allocation of capital endowment is biased to satisfy $0 < \theta < 0.5$. In this case, the government in country 2, having a relatively large amount of initial capital, acts as the benevolent agent, $a_2^* = 0$, while country 1 acts as the moderate Leviathan, $a_1^* \in (0, 1)$. In the extreme case, in which all capital is owned by the residents in country 2, $\theta = 0$, country 1 puts no weight on the residents welfare and acts as the Leviathan, $a_1^* = 1$.

The intuitive mechanism of the equilibrium classification is the same as that explained in Section 3. Capital importing (exporting) country has an incentive to lower (raise) the capital price by raising

[9] Appendix B provides details of the derivation process of the equilibrium of this game.

(lowering) the tax rate in the country. To induce the policy-making manager to set higher (lower) tax, the authority of the government in the capital importing (exporting) country bids the policy-making manager to pursue larger tax revenue (residents' utility). Since asymmetric countries have different desirable tax rates levels, the welfare-maximizing authority of each government sets different objectives for its policy-making managers in different countries, which would explain why some countries behave as the moderate Leviathans and others are benevolent.

On the basis of the aforementioned argument, the main result indicated in corollary still holds in the capital exporting country, while a_i^* can take a value other than zero in the capital importing country.

4.2 Asymmetric Tax Competition: Technology

Similar to the analysis above, we examine the case where the countries are asymmetric in production technology. Without any loss of generality, we assume that firms in country 1 can produce goods more efficiently when compared to those in country 2, which is captured with $A_1 > A_2$. On the other hand, the initial endowment of capital is assumed to be symmetric between the two countries—$\theta_1 = \theta_2 \equiv 1/2$. Subsequently, (2) is rewritten as follows:

$$k_i = \kappa + \frac{A_i - A_j}{4} - \frac{T_i - T_j}{4} \text{ and } r = \frac{A_1 + A_2}{2} - 2\kappa - \frac{T_1 + T_2}{2}. \tag{11}$$

Other setups remain constant in the above case, or $\delta = 1$ and $\gamma = 0$. With the assumption of the technological asymmetry, we define $\Omega \equiv (A_1 - A_2)/\kappa > 0$. Then, solving this two-stage game backwards, we can derive a_i in the sub-game perfect Nash equilibrium as follows:[10]

$$a_1^* = \frac{\Omega}{20 + \Omega} \text{ and } a_2^* = 0. \tag{12}$$

We can give a straightforward intuition to the result. First, when $\Omega = 0$, the two countries are perfectly symmetric and there exist no incentive to control the price of capital in the market, since they are neither a capital importing country nor a capital exporting country. However, when $\Omega > 0$, country 1 (2) becomes a capital importing (exporting) country. In this case, two countries have an incentive to control the terms of trade. Knowing the fact that tax competition in the next stage is a strategic complement and the price of capital can be affected through the tax rate of the other country, the authority of the government in country 1, who wants a lower capital price, has an incentive to deviate from $a_1^* = 0$ and set $a_1^* > 0$, to induce country 2 to set a higher tax rate. Since this incentive becomes stronger as differences of A_i between countries increases, a_1^* increases as Ω increases, $\partial a_1^*/\partial\Omega > 0$. On the other hand, the government of country 2 has the opposite incentive, but a_2 can not be lower than zero. As a result, a_2^* is kept being zero at the equilibrium, even if there exists technological asymmetry between the two countries.

As shown in the case of the asymmetric capital endowment, the robustness of the corollary is confirmed in the capital exporting country, while a_i can take a positive value in the capital importing country.

4.3 Two-dimensional Competition: Tax and Public Investment

Here, we consider the case where the countries compete for mobile capital through the capital tax rate and public investment. Particularly, it is assumed that public investment (e.g., roads, airports, and networks, among others) in a country can enhance productive efficiency of regional firms to ensure that capital is attracted to the country. In order to describe it, production function of the basic model is rewritten as follows:

[10] Appendix C provides details of the derivation process of the equilibrium of this game.

$$f_i(k_i) = (A_i + g_i - k_i)k_i, \tag{13}$$

where g_i stands for an amount of public investment [Hindriks et al. (2008)]. In addition, an amount of capital in country i and price of capital in the market, which are derived as (2) in the basic model, are rewritten as

$$k_i = \kappa + \frac{A_i - A_j + g_i - g_j - T_i + T_j}{4} \text{ and } r = \frac{A_1 + A_2 + g_1 + g_2}{2} - 2\kappa - \frac{T_1 + T_2}{2}. \tag{14}$$

We assume that the cost function for public investment is given by $C_i(g_i) = g_i^2/2$. We also assume $\gamma = 0$ to consider lump sum transfer. Hence, the budget of the government in country i is balanced as

$$G_i = T_i k_i - \frac{g_i^2}{2}, \tag{15}$$

where G_i stands for the net tax revenue, which will be returned to the residents in a lump sum manner. To focus on the effect of this two-dimensional competition, we examine the case where the two countries are perfectly symmetric; it implies that $\theta_i = \theta_j = 1/2$ and $A_i = A_j = A$. On the basis of these setups, the utility of residents in country i is defined as

$$U_i = k_i^2 + r\kappa\delta + T_i k_i - \frac{g_i^2}{2}. \tag{16}$$

Now, we solve this game backwards. In the second stage, each policy-making manager determines a capital tax rate and an amount of public investment simultaneously, in order to maximize $V_i = (1 - a_i)U_i + a_i G_i$, considering (14). From the first-order conditions for each variables, T_i and g_i, the reaction functions, $T_i = T_i(T_j, g_i, g_j, a_i)$, and $g_i = g_i(g_j, T_i, T_j, a_i)$, are derived. Solving the simultaneous equations of these reaction functions, the values of the sub-game equilibrium, $T_i^* = T_i(a_i, a_j)$, and $g_i^* = g_i(a_i, a_j)$, are obtained. By substituting them into (14), we can derive $k_i^* = k_i(T_i^*, T_j^*, g_i^*, g_j^*)$, and $r^* = r(T_i^*, T_j^*, g_i^*, g_j^*)$. Subsequently, the utility level of residents in country i in the sub-game is obtained as $U_i^* = U_i(T_i^*, T_j^*, g_i^*, g_j^*)$.

In the first stage, the authority of the government in each country simultaneously chooses a_i to maximize the utility of residents in the country $U_i^* = U_i(T_i^*, T_j^*, g_i^*, g_j^*)$. Solving the simultaneous equations of the reaction functions derived from the first-order condition of the maximization problem, the value of a_i in the sub-game perfect equilibrium is obtained as follows:[11]

$$a_i^* = \begin{cases} 1 & \text{if } 0 \leq \delta \leq 0.2, \\ \frac{1-\delta}{4\delta} & \text{if } 0.2 < \delta \leq 1. \end{cases} \tag{17}$$

Particularly, we can easily confirm that $(1 - \delta)/4\delta$ monotonically decreases with respect to δ, and $a_i^* = 0$ when $\delta = 1$.

The result we obtain here is quite similar to that of the basic model, described in Figure 1—when the ratio of capital owned by residents in the two countries is sufficiently small or even zero, the governments choose to act as tax-revenue-maximizers or Leviathans. However, when the ratio becomes larger, the governments are more likely to choose to act as straightforward welfare-maximizers.

In the case of the two-dimensional competition, each country can raise (lower) the price of capital by decreasing (increasing) capital tax rate and increasing (decreasing) the amount of public investment, which is captured in the latter part of (14). In addition, a Leviathan government can adopt one of the following two ways to increase the net tax revenue: increase capital tax rate or decrease the amount of public investment. With these facts, we can give the following intuitive explanation to the result: when the entire (most) capital is owned by absentees of an economy, it means that countries are capital

[11] Appendix D provides details of the derivation process of the equilibrium of this game.

importers and have an incentive to lower the capital price in the market, and hence the authority of the government in each country bids its policy-making manager to act as Leviathan and increase the capital tax or to decrease the amount of public investment. The incentive is gradually weakened as more capital is owned by residents within the economy, indicating that the main arguments in Section 3 still hold, even in the case of a two-dimensional competition.

4.4 Stackelberg-type Competition

Finally, we examine the case where the capital tax rate is determined sequentially, which implies that the game is composed of the following three stages. In the first stage, the authorities of both countries choose a_i simultaneously. In the second stage, the policy-making manager of country 1 sets a capital tax rate as the first-mover. In the third stage, the policy-making manager of country 2 sets a capital tax rate as the second mover.[12] To present our arguments for this case with clarity, we assume that there are no asymmetries between the two countries ($\theta_1 = \theta_2 = 1/2$ and $A_1 = A_2 \equiv A$) and that the tax revenue of each government is redistributed to residents in a lump sum manner or $\gamma = 0$.

We solve this game backwards. In the third stage, taking the capital tax rate of country 1 as given, the policy-making manager in country 2 determines a capital tax rate to maximize $V_2 = (1 - a_2)U_2 + a_2G_2$, subject to (2). As in the case of a Stackelberg game, the capital tax rate in country 2 is derived as $T_2(T_1, a_2)$, which depends on the capital tax rate of country 1. In the second stage, with an awareness of how the capital tax rate in country 2 reacts, the policy-making manager in country 1 determines a capital tax rate, maximizing $V_1 = (1 - a_1)U_1 + a_1G_1$, subject to (2) and $T_2(T_1, a_2)$. Subsequently, we obtain the sub-game equilibrium tax rate of country 1, $T_1^* = T_1(a_1, a_2)$. Substituting it into the reaction function of country 2, the sub-game equilibrium tax rate in country 2 is derived as $T_2^* = T_2(a_1, a_2)$. With these tax rates and (2), the capital employed in each country and capital price are yielded as $k_i^* = k_i(T_i^*, T_j^*)$ and $r^* = r(T_i^*, T_j^*)$. Using these values, the utility level of the residents of country i can be also obtained as $U_i^* = U_i(T_i^*, T_j^*)$.[13] Finally, in the first stage, the authorities of each government simultaneously choose a_i to maximize the utility level of the residents. As a result, we can derive $a_1^* = 0$ in the sub-game perfect equilibrium. Figure 3 illustrates the equilibrium value of a_2. It is shown that $a_2^* = 1$ in the domain of $0 \leq \delta \leq \hat{\delta}$, while a_2^* monotonically decreases in $\hat{\delta} \leq \delta \leq 1$. Particularly, $a_2^* = 0$ holds, when $\delta = 1$.

To give an interpretation of the results obtained here, we focus on the following two extreme cases—$\delta = 0$ and $\delta = 1$. When $\delta = 0$, which means that the residents of the two countries are initially endowed with no capital, both the countries must import capital. It implies that they have an incentive to control the price of the capital and make it cheaper through their capital tax rates. As the first-mover of the tax policy determination, the policy-making manager of country 1 induces the policy-making manager of country 2 to set a higher tax rate when compared to the tax rate in country 1. Foreseeing what will happen in the following stages, the authority of government in country 2 has the incentive to induce country 1 to set as high tax rate as possible; therefore, the authority of government of country 2 chooses a_2 as high as possible and bids the policy-making manager to behave as a tax-revenue maximizer, which leads to $a_2^* = 1$. On the other hand, the authority of government in country 1 does not have any incentive to deviate from its role as the welfare-maximizer or $a_1^* = 0$, fully aware of its position as the first mover in the following tax determination stages.

When $\delta = 1$, which implies that residents of both countries are initially endowed with the entire capital employed in production by firms, both countries cease to be capital importers. In addition, we assume that there are no asymmetries between the countries, and hence they cannot be capital exporters either. It means that these countries do not possess the incentive to control the capital price through

[12] Similar results can be derived, even in the case where there are two policy instruments—capital tax and public investment.

[13] Appendix E provides details of the derivation process of the equilibrium of this game.

the tax rate they set. In this case, the policy-making manager of country 1 does not optimally utilize the aforementioned first-mover advantage during the tax determination stages, and the authority of government in country 2 does not bid the policy-making manager to induce country 1 to set a high tax rate, and thereby behave as tax-revenue maximizer. Hence, both the countries fail to possess the incentive to deviate from being welfare-maximizing governments.

Considering the above discussion, the main result of this study points out $a_i^* = 0$ when $\delta = 1$ still holds, even in the case of the Stackelberg-type competition.

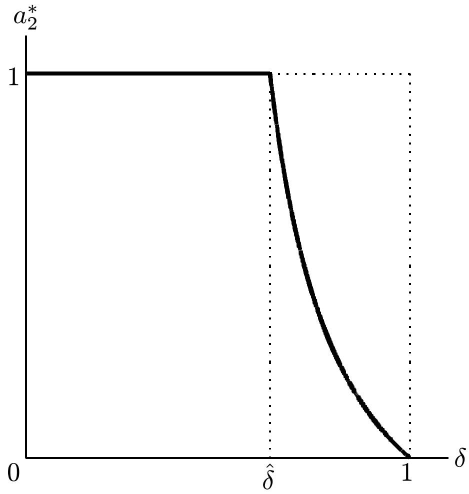

Figure 3. a_2 in the equilibrium of the Stackelberg-type competition.

Note. $\hat{\delta}$ is the solution of $46 - 73\delta + \delta^2 = 0$. The approximate solution in the domain of definition $\delta \in [0, 1]$ is 0.64.

5 Concluding Remarks

This study reexamines the issue of the endogenous objective of governments in tax competition. Pal and Sharma (2013) argue that the sub-game perfect equilibria correspond to the unique equilibrium in which governments maximize the net tax revenue, implying that the standard equilibrium under welfare-maximizing governments is not commitment robust. By generalizing the form of capital ownership, we show that the equilibrium pattern derived by Pal and Sharma prevails if most of the capital is owned by absentee capital owners. Our research further shows that if the country's residents own most of the capital, then the equilibrium outcome is reduced to tax competition among the moderate Leviathans, in which policy-makers will be neither entirely benevolent nor fully self-interested. Furthermore, in a specific situation, we suggest the possibility of governments that are entirely welfare-maximizing to prevail.

In our study, before the tax competition stage, the authority of government in each country make the policy-making manager commit to what they should pursue to maximize the residents' utility by manipulating the after-tax net return on capital investment. This approach has a possible link with studies on the timing game of tax competition, also called as leadership game, in which the timing of tax choice works as the commitment device. The studies on tax leadership have found that the form of capital ownership determines the equilibrium leadership in tax competition. For example, Kempf and Rota-Graziosi (2010) show that the sub-game perfect equilibria correspond to the sequential situations, wherein one country leads and the other follows in case that countries import capital. Elaborating Kempf and Rota-Graziosi analysis, Ogawa (2013) shows that all the countries prioritize their commitment toward setting their tax rates, and thus the sub-game perfect equilibrium corresponds to a simultaneous situation wherein capital is owned by the residents in the countries. The critical reason for the considerably different results between the two is that countries have the same incentives to lower the capital prices in the model by Kempf and Rota-Graziosi, whereas they have contrasting incentives in Ogawa's model. When both countries are capital importers, as in the model by Kempf and Rota-Graziosi, the authority of government in one country has an incentive to lower the capital price by raising the tax rate and optimally utilizing the first-mover advantage, while the authority of government in the other country can benefit from and accept it. Therefore, sequential-move equilibria prevail in sub-game perfect equilibria. However, as in Ogawa model, one country imports capital, while the other country exports it. In this case, no community of interest exists between the two countries. If the capital exporting country raises the price of the capital by lowering the tax rate, then the other country, as a capital importer, is harmed by the increase in capital price; this case shows that a conflict of interest exists. Therefore, both countries have an incentive to become the first-mover in the model with full capital ownership.

The reason that our results differ from those of Pal and Sharma (2013) can be interpreted in this context. When capital in the economy is owned by the absentee owners and the two countries being analyzed import capital, the authorities of government in the countries will choose Leviathan-type policy-making managers since they would prefer a low-interest rate, which is realized when tax rates are high. However, they choose the objective that gives more weight to the residents' welfare when capital is owned by the residents in the economy. Specifically, with full capital ownership, the authority of government in the capital exporting country will have an incentive to decrease the tax rate, namely, to increase the net of tax return on investment, and hence benevolent governments, who prefer a lower tax rate, are selected. Contrarily, the authority of government in the capital importing country will have an incentive to increase the tax rates to lower the net of tax return on the investment, and hence a Leviathan government is selected in such a country.

Although the mechanism of the leadership game and our model have similarities, there is a critical difference in the form of competition. In the leadership game, the differences between the two countries induce them to commit choosing their tax rates as the first-mover; this implies that the interregional disparity converges the timing of tax decisions. However, in this study, regional disparity drives governments to take various objectives. This provides one of the factors that explain that various types of government compete in a single international market.

The study shows that the target of policy-making manager determined by the welfare-maximizing authority, which is the representative of the citizens, depends on the form of capital ownership and is derived within the context of a model that follows the literature but depends on less general assumptions. One such assumption in the model is restricted to the case of two countries. A model with $n(> 2)$ countries can be formulated. In such a case, the governments are more likely to behave in a benevolent manner because the larger the number of countries, the less each government can manipulate the terms of trade, thereby giving lesser incentive to the authority of government to motivate the policy-making manager to deviate from welfare-maximization.

Appendix A

Solving the maximization problem in the second stage, the reaction function is obtained as

$$T_i = \frac{(1-2\gamma)a_i + 1 + 2\gamma}{(1-4\gamma)a_i + 3 + 4\gamma} T_j + 4\kappa \frac{(1-2\gamma+\delta)a_i + 1 + 2\gamma - \delta}{(1-4\gamma)a_i + 3 + 4\gamma}.$$

Solving for $i = 1, 2$, the tax rate of country i is given as

$$\begin{aligned} T_i^* = T_i(a_i, a_j) &= 4\kappa \frac{(1-3\gamma)(1-2\gamma+\delta)a_i a_j + \left[(1+2\gamma)(1-3\gamma)+3\gamma\delta\right](a_i+a_j)}{\Delta_1} \\ &+ 4\kappa \frac{(1+\delta)a_i + (2+3\gamma)(1+2\gamma-\delta)}{\Delta_1}, \end{aligned}$$

where $\Delta_1 \equiv -2\gamma(1-3\gamma)a_i a_j + (1-4\gamma-6\gamma^2)(a_i+a_j) + 2(1+\gamma)(2+3\gamma)$. Inserting this into (2), the amount of capital located in country i and the interest rate are obtained as

$$\begin{aligned} k_i^* = k_i(a_i, a_j) &= \kappa \frac{\left[2(1+\gamma)(1-3\gamma)+\delta\right](a_i+a_j) - 2\gamma(1-3\gamma)a_i a_j}{\Delta_1} \\ &+ \kappa \frac{2(1+\gamma)(2+3\gamma) - 2(1+\delta)a_i}{\Delta_1}, \\ r^* = r(a_i, a_j) &= A - 2\kappa \frac{2(1-3\gamma)(1-3\gamma+\delta)a_i a_j + \left[2(2+3\gamma)(1-3\gamma)+(1+6\gamma)\delta\right](a_i+a_j)}{\Delta_1} \\ &- 2\kappa \frac{2(2+3\gamma)(2+3\gamma-\delta)}{\Delta_1}, \end{aligned}$$

which are used to obtain $U_i^* = U_i[T_i(a_i, a_j), T_j(a_i, a_j)]$.

In the first stage, the authority of government in country i maximizes $U_i^* = U_i[T_i(a_i, a_j), T_j(a_i, a_j)]$, with respect to a_i. The reaction function is obtained as follows:

$$a_i = \frac{\left[(1-2\gamma)a_j + 1 + 2\gamma\right]\left[(2-2\gamma-10\gamma^2+5\gamma\delta-6\gamma^3+6\gamma^2\delta)a_j + 2(1+\gamma)(2+3\gamma)(1+\gamma-\delta)\right]}{\Delta_2},$$

where

$$\begin{aligned} \Delta_2 &\equiv 2\gamma(1-3\gamma)(-\gamma-2\delta-2\gamma^2+2\gamma\delta)a_j^2 \\ &+ (2-2\gamma+4\delta-10\gamma^2-17\gamma\delta-28\gamma^3-10\gamma^2\delta-24\gamma^4+24\gamma^3\delta)a_j \\ &+ 4+14\gamma+6\delta+24\gamma^2+11\gamma\delta+26\gamma^3-6\gamma^2\delta+12\gamma^4-12\gamma^3\delta. \end{aligned}$$

Solving for $i = 1, 2$, the effective value of $a_i = a_j \in [0, 1]$ in the symmetric equilibrium can be solved as (7).

Appendix B

Solving the maximization problem in the second stage, the reaction function is obtained as

$$T_i = \frac{a_i+1}{a_i+3}T_j + 4\kappa \frac{(1+2\theta_i)a_i + 1 - 2\theta_i}{a_i+3}.$$

Solving for $i = 1, 2$, the tax rate of country i is given as

$$T_i^* = T_i(a_i, a_j) = 4\kappa \frac{2a_i a_j + (1+4\theta_i)a_i + 2(1-\theta_i)a_j + 1 - 2\theta_i}{a_i + a_j + 4}.$$

Inserting this into (2), the amount of capital located in country i and the interest rate are obtained as

$$\begin{aligned} k_i^* = k_i(a_i, a_j) &= 2\kappa \frac{1 + 2\theta_i - \theta_i a_i + (2-\theta_i)a_j}{a_i + a_j + 4}, \\ r^* = r(a_i, a_j) &= A - 4\kappa \frac{2a_i a_j + (1+3\theta_i)a_i + (1+3\theta_j)a_j + 2}{a_i + a_j + 4}. \end{aligned}$$

which are used to obtain $U_i^* = U_i[T_i(a_i, a_j), T_j(a_i, a_j)]$.

In the first stage, the authority of government in country i maximizes $U_i^* = U_i[T_i(a_i, a_j), T_j(a_i, a_j)]$, with respect to a_i. The reaction functions are obtained as:

$$
\begin{aligned}
a_i &= \frac{(a_j+1)\left[2(1-\theta_i)a_j+1-2\theta_i\right]}{2(1+\theta_i)a_j+1+8\theta_i}, \qquad (18)\\
a_j &= \frac{(a_i+1)(2\theta_i a_i-1+2\theta_i)}{2(2-\theta_i)a_i+9-8\theta_i}. \qquad (19)
\end{aligned}
$$

From (18) and (19), we obtain

$$
\begin{aligned}
a_i \leq 0 \quad &\Leftrightarrow \quad \theta_i \geq \frac{2a_j+1}{2(a_j+1)}, \qquad (20)\\
a_j \leq 0 \quad &\Leftrightarrow \quad \theta_i \leq \frac{1}{2(a_i+1)}, \qquad (21)
\end{aligned}
$$

respectively. When $a_i \leq 0$, the equilibrium (a_i^*, a_j^*) is $(0, \frac{2\theta_i-1}{9-8\theta_i})$. Substituting a_j^* into the latter inequality of (20), we can derive the domain of θ_i supporting the equilibrium as

$$
(2\theta_i-1)(6\theta_i-7) \leq 0 \;\Leftrightarrow\; \frac{1}{2} \leq \theta_i \leq \frac{7}{6},
$$

which is reduced to $1/2 \leq \theta_i \leq 1$ from the domain of definition of θ_i.

Similarly, when $a_j \leq 0$, the equilibrium (a_i^*, a_j^*) is $(\frac{1-2\theta_i}{1+8\theta_i}, 0)$. Substituting a_i^* into the latter inequality of (21), we can derive the domain of θ_i supporting the equilibrium as

$$
(6\theta_i+1)(2\theta_i-1) \leq 0 \;\Leftrightarrow\; -\frac{1}{6} \leq \theta_i \leq \frac{1}{2},
$$

which is reduced to $0 \leq \theta_i \leq 1/2$ from the domain of definition of θ_i.

Both of the domains derived above do not overlap with each other, except $\theta_i = 1/2$, where the equilibrium (a_i^*, a_j^*) is $(0,0)$. Therefore, we can obtain the equilibrium as (10).

Appendix C

Solving the maximization problem in the second stage, the reaction function is obtained as

$$
T_i = \frac{a_i+1}{a_i+3}T_j + \frac{(A_i-A_j+8\kappa)a_i+A_i-A_j}{a_i+3}.
$$

Solving for $i = 1, 2$, the tax rate of country i is given as

$$
T_i^* = T_i(a_i, a_j) = \frac{8\kappa a_i a_j + (A_i-A_j+12\kappa)a_i + 4\kappa a_j + A_i - A_j}{a_i+a_j+4}.
$$

Inserting this into (11), the amount of capital located in country i and the interest rate are obtained as

$$
\begin{aligned}
k_i^* = k_i(a_i, a_j) &= \frac{8\kappa - 2\kappa a_i + 6\kappa a_j + A_i - A_j}{2(a_i+a_j+4)},\\
r^* = r(a_i, a_j) &= \frac{A_i+A_j}{2} - \frac{16\kappa a_i a_j + (A_i-A_j+20\kappa)a_i + (A_j-A_i+20\kappa)a_j + 16\kappa}{2(a_i+a_j+4)},
\end{aligned}
$$

which are used to obtain $U_i^* = U_i[T_i(a_i, a_j), T_j(a_i, a_j)]$.

In the first stage, the authority of government in country i maximizes $U_i^* = U_i[T_i(a_i, a_j), T_j(a_i, a_j)]$, with respect to a_i. The first order condition of country 1 is yielded as

$$\frac{\partial U_1^*}{\partial a_1} = \frac{\kappa^2(8a_2+16+\Omega)R_1}{2\left(a_1+a_2+4\right)^3} = 0,$$

where $\Omega \equiv (A_1 - A_2)/\kappa$ and $R_1 \equiv 4a_2^2 - 12a_1a_2 - (20+\Omega)a_1 + (4+\Omega)a_2 + \Omega$. Without loss of generality, we assume that the level of production technology in country 1 is higher than that in country 2, so $\Omega > 0$. In addition, we put an assumption on upper limit of Ω as $\Omega < 2(3a_1 - a_2 + 4)$. If this assumption is violated, all capital flows to country 1 and production in country 2 becomes inactive.

Then, the first order condition is satisfied, if and only if

$$R_1 = 4a_2^2 - 12a_1a_2 - (20+\Omega)a_1 + (4+\Omega)a_2 + \Omega = 0$$

holds. From this condition, the reaction function of country 1 is obtained as

$$a_1 = \frac{(a_2+1)(4a_2+\Omega)}{12a_2+20+\Omega}.$$

In turn, we solve the maximization problem of country 2. Differentiating U_2^* with respect to a_2, we obtain

$$\frac{\partial U_2^*}{\partial a_2} = \frac{\kappa^2(8a_1+16-\Omega)R_2}{2\left(a_1+a_2+4\right)^3},$$

where $R_2 \equiv 4a_1^2 - 12a_1a_2 - (20-\Omega)a_2 + (4-\Omega)a_1 - \Omega$. From the assumption $0 < \Omega < 2(3a_1 - a_2 + 4)$, we can easily confirm $8a_1 - \Omega + 16 > 0$, and it implies

$$\frac{\partial U_2^*}{\partial a_2} \gtreqless 0 \;\Leftrightarrow\; R_2 \gtreqless 0.$$

Substituting the reaction function of country 1 into R_2, it is shown that

$$R_2 = -\frac{2(8a_2+16+\Omega)\left[32a_2^3 + 192a_2^2 + 12(20+\Omega)a_2 + \Omega(10+\Omega)\right]}{(12a_2+20+\Omega)^2} < 0.$$

Therefore, $\partial U_2^*/\partial a_2 < 0$ always holds, which implies that $a_2^* = 0$ in the equilibrium as the corner solution. Substituting $a_2^* = 0$ into the reaction function of country 1, we obtain

$$a_1^* = \frac{\Omega}{20+\Omega}.$$

Appendix D

Solving the maximization problem, with respect to T_i and g_i, in the second stage, the reaction functions are obtained as

$$\begin{aligned} T_i &= \frac{a_i+1}{a_i+3}T_j + \frac{(a_i+1)(g_i-g_j) + 4\kappa(1+\delta)a_i + 4\kappa(1-\delta)}{a_i+3}, \\ g_i &= -\frac{1-a_i}{a_i+7}g_j + \frac{(a_i+1)T_i + (1-a_i)T_j + 4\kappa(1+\delta)(1-a_i)}{a_i+7}. \end{aligned}$$

Solving for $i = 1, 2$, the tax rate and the amount of public investment of country i are given as

$$\begin{aligned} T_i^* = T_i(a_i, a_j) &= 2\kappa\frac{2(1+\delta)a_ia_j + (3+\delta)a_i + 2a_j + 3(1-\delta)}{a_i+a_j+3}, \\ g_i^* = g_i(a_i, a_j) &= \kappa\frac{3-\delta a_i + (2+\delta)a_j}{a_i+a_j+3}. \end{aligned}$$

Inserting this into (14), the amount of capital located in country i and the interest rate are obtained as

$$\begin{aligned} k_i^* = k_i(a_i, a_j) &= \kappa\frac{3 - \delta a_i + (2+\delta)a_j}{a_i + a_j + 3}, \\ r^* = r(a_i, a_j) &= A - \kappa\frac{4(1+\delta)a_i a_j + (6+\delta)(a_i + a_j) + 3(3-2\delta)}{a_i + a_j + 3}, \end{aligned}$$

which are used to obtain $U_i^* = U_i[T_i(a_i, a_j), T_j(a_i, a_j), g_i(a_i, a_j), g_j(a_i, a_j)]$.

In the first stage, the authority of government in country i maximizes $U_i^* = U_i(T_i^*, T_j^*, g_i^*, g_j^*)$, with respect to a_i. The first order condition is yielded as

$$4(1+2\delta)a_i a_j - 4a_j^2 + 2(3+4\delta)a_i - 2(4-3\delta)a_j - 3(1-\delta) = 0.$$

To derive the equilibrium, we substitute $a_i = a_j$ from the assumption of symmetry of the countries. Subsequently, we obtain the equilibrium as (17).

Appendix E

In the third stage, taking T_1 as given, we solve the maximization problem of the policy-making manager in country 2, with respect to T_2, and obtain the reaction function as

$$T_2 = \frac{a_2 + 1}{a_2 + 3}T_1 + 4\kappa\frac{(1+\delta)a_2 + 1 - \delta}{a_2 + 3}. \tag{22}$$

Taking (22) into consideration, the policy-making manager in country 1 maximizes the objective function and determines the tax rate as

$$T_1^* = T_1(a_1, a_2) = 2\kappa\frac{\delta a_1 a_2^2 + 2(1+3\delta)a_1 a_2 + 2a_2^2 + (4+5\delta)a_1 + 4(2-\delta)a_2 + 8(1-\delta)}{a_1 + 2a_2 + 5}. \tag{23}$$

Substituting (23) into (22), we obtain the tax rate in country 2 as

$$T_2^* = T_2(a_1, a_2) = 2\kappa\frac{\delta a_1 a_2^2 + 2(1+2\delta)a_1 a_2 + 2a_2^2 + (2+\delta)a_1 + 8a_2 + 6(1-\delta)}{a_1 + 2a_2 + 5}.$$

Inserting this into (2), the amount of capital located in each country and the interest rate are obtained as

$$\begin{aligned} k_1^* = k_1(a_1, a_2) &= \kappa\frac{4 + \delta - \delta a_1 a_2 - 2\delta a_1 + 2(1+\delta)a_2}{a_1 + 2a_2 + 5}, \\ k_2^* = k_2(a_1, a_2) &= \kappa\frac{6 - \delta + \delta a_1 a_2 + 2(1+\delta)a_1 + 2(1-\delta)a_2}{a_1 + 2a_2 + 5}, \\ r^* = r(a_1, a_2) &= A - 2\kappa\frac{\delta a_1 a_2^2 + (2+5\delta)a_1 a_2 + 2a_2^2 + (4+3\delta)a_1 + 2(5-\delta)a_2 + 12 - 7\delta}{a_1 + 2a_2 + 5}, \end{aligned}$$

which are used to obtain $U_i^* = U_i[T_i(a_i, a_j), T_j(a_i, a_j)]$.

In the first stage, the authority of government in country i maximizes $U_i^* = U_i[T_i(a_i, a_j), T_j(a_i, a_j)]$, with respect to a_i. The first-order condition of country 1 is yielded as

$$\frac{\partial U_1^*}{\partial a_1} = -\frac{2\kappa^2 a_1\left[2\delta a_2^2 + (2+11\delta)a_2 + 4 + 11\delta\right]^2}{(a_1 + 2a_2 + 5)^3} < 0,$$

which implies that the corner solution $a_1^* = 0$ is derived. Substituting it into the first order condition of country 2, we obtain

$$4(1-2\delta)(2a_2 + 15)a_2^2 + 4(39 - 70\delta - 4\delta^2)a_2 + 24(1-\delta)(6-\delta) = 0.$$

With the equilibrium value satisfying this equation in the domain of definition, Figure 3 is yielded.

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