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Equilibrium Leadership in Tax Competition: The Role of Capital-Labor Substitution/Complement

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Abstract

This paper examines endogenous leadership in tax competition using two countries with asymmetricity of population and three-input production functions, in which capital and labor are either complements or substitutes. Population size is positively (negatively) associated with marginal productivity of capital if the capital and labor are complements (substitute). Under the endogenous timing game, the simultaneous-move outcome could be realized if the productivity gap is extremely large. When capital and labor are complements, a large country tends to lead, and the strategy could be not only risk-dominant but also Pareto-dominant. In contrast, the leadership of a small country could be risk-dominant or Pareto-dominant when capital and labor are substitutes. This paper demonstrates that a large or small country leads, depending on the technological relationship between capital and labor in production.

JEL Classification: C72; H30; H87

Keywords: Endogenous timing; Tax competition; Capital-labor substitution

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1. Introduction

This paper analyzes endogenous leadership among countries and regions in tax competition with employment issues. Assuming that the governments determine their tax policies simultaneously, numerous studies have examined the economic consequences of tax competition among countries and regions.[1] However, the timing of the policy choice is crucial to winning the policy competition. Based on classical analysis of the Stackelberg leadership game, each government may attempt to make a choice proactively to obtain the first-mover advantage.

Several empirical studies found that some countries lead in tax competition (Altshuler and Goodspeed, 2002, 2015; Redoano, 2007; Chatelais and Peyrat, 2008). For instance, Altshuler and Goodspeed (2002, 2015) reported the leadership role of the United States in tax competition using data from 1968 to 2008. Kempf and Rota-Graziosi (2010) pioneeringly modeled the theoretical mechanism of leadership in tax competition, and their succeeding studies clarified the essential factors of determining leadership.[2]

Kempf and Rota-Graziosi (2010) show that two Stackelberg situations emerge, and the less productive smaller jurisdiction takes leadership in the tax competition at the risk-dominant equilibrium. Hence, they doubt a conventional approach to analyzing tax competition within a simultaneous-move game. In contrast, Ogawa (2013) points out the importance of capital ownership in the leadership in tax competition; the simultaneous-move outcome can be a unique subgame perfect equilibrium (SPE) if the residents in the countries fully own their capital.

Kemp and Rota-Graziosi (2015) demonstrate that leadership arises even if residential capital ownership is incorporated. Furthermore, Hindriks and Nishimura (2017) derive a critical value of capital ownership such that the equilibrium switches from the Stackelberg to the simultaneous-move game. More recently, Kawachi et al. (2020) considered the endogenous determination of the total amount of capital shared by countries. They show that a simultaneous-move outcome emerges for sufficiently small openness of the capital market.

These previous studies clarified the relationship between capital ownership and endogenous leadership in tax competition. However, we cannot ignore employment issues and the

[1] Zodrow (2010), Keen and Konrad (2013), and Agrawal et al. (2022) provide an excellent survey of the recent literature on tax competition.

[2] Using an infinitely repeated game framework, Itaya and Yamaguchi (2023) show that the tax union may set capital taxes sequentially in every stage if a tax union contains asymmetric countries. Apart from capital ownership, Eichner (2014) considers preferences for public goods; Kawachi et al. (2015) incorporate one more stage of public investment competition; Ogawa and Susa (2017) examine the role of heterogeneity of countries and residents; Pal and Sharma (2019) analyze political delegation.

technological relationship between capital and labor in production. National and regional governments have a keen policy aim to create employment as well as attract capital (OECD, 2017). Moreover, numerous studies found the role of the capital-labor relationship in production on factor income distribution under automation and utilizing Artificial Intelligence (AI).

Naturally, it is worthwhile to treat labor input explicitly into production to analyze endogenous leadership in tax competition. Following Kempf and Rota-Graziosi (2010) and Ogawa (2013), e develop the tax competition model of two asymmetrically populated countries with the three-inputs production function, becoming either capital-labor complement or substitute. The marginal productivity of capital increases (decreases) with an increase in the labor force if capital and labor are complements (substitutes). Hence, a larger population country has a larger (smaller) productivity than a smaller population country.

In the model, we find that which country leads or follows depends on the productivity gap and proportion of absentee ownership of capital. With some absentee owners, large and small countries are willing to move first to obtain the first mover's advantage if the extremely large productivity gap exists. Depending on the technological relationship between capital and labor, a smaller productivity gap forces one of the two to lead. Further, it generates multiple equilibria that large country leads or small leads.

When capital and labor are complements, the leadership of a large country is risk-dominant in the multiple equilibria if there is a small proportion of absentee owners. Moreover, if the productivity gap is sufficiently large, the leadership of a large country can be Pareto-dominant. However, when there is a large proportion of absentee owners, the leadership by a small country is Pareto-dominant even if the productivity gap is not large. These relationships are inversed when capital and labor are substitutes. In other words, the leadership of a small country could be risk-dominant or Pareto-dominant.

Our theoretical findings naturally include those shown by the previous studies as special cases (Kempf and Rota-Graziosi, 2010; Ogawa, 2013; Hindriks and Nishimura, 2015, 2017; Pi and Chen, 2017). Furthermore, our results reveal the importance of the technological relationship between capital and labor in production on the equilibrium outcome of tax competition between asymmetric countries, leading to the possibilities of leadership by large countries. This paper successfully provides complementary results to the previous studies and fills the gap between theoretical prospects and empirical findings.

The remainder of this paper is organized as follows: Section 2 provides the basic framework of our theoretical analysis and the main results of this paper. Section 3 extends the basic model with a perfect labor market by incorporating the labor market imperfection into the model. Section 4 delivers the conclusion of this paper.

2. Perfect labor market

2.1.The basic setup

We consider a two-countries model with capital freely mobile between the countries. Each country has a continuum of identical firms. The firm in country i ($i = L, S$) produces a homogenous good and sells it in their country. The production technology is formulated by $F_i(k_i, l_i, z_i)$, where F_i is a constant-returns-to-scale and increasing in each input, k_i is the capital input, l_i is the labor input, and z_i is the land input. We assume that the land input is fixed at $z_i = 1$.

Then, the firms maximize their rents:

$$\pi_i = f(k_i, l_i) - w_i l_i - (r + T_i)k_i, \tag{1}$$

where $f_i(k_i, l_i) \equiv F_i(k_i, l_i, 1)$, w_i is the wage rate in country i, r is the interest rate that is common with two countries, and T_i is the unit tax on capital. The first-order conditions for a firm's optimization problem are

$$r = f_{ik}(k_i, l_i) - T_i, \tag{2a}$$

$$w_i = f_{il}(k_i, l_i), \tag{2b}$$

where

$$f_{ik}(k_i, l_i) \equiv \frac{\partial f_i(k_i, l_i)}{\partial k_i}, f_{il}(k_i, l_i) \equiv \frac{\partial f_i(k_i, l_i)}{\partial l_i}.$$

The capital and labor demands can be derived from Eqs. (2a) and (2b).

The jurisdictional government taxes on capital and distributes its tax revenue among the residents in the country. Defined g_i as the lump-sum transfer from the government to the resident. The government's budget constraint becomes

$$g_i = T_i k_i. \tag{3}$$

Each resident of country i obtains capital and labor income, land rent, and government income transfer. Assume that the residents inelastically supply their fixed labor endowments. The population of a small country is normalized to unity, while that of a large country is $1+n$ $(n > 0)$. Hereafter, the large and small countries are labeled by L and S, respectively.

Following Ogawa (2013), we consider capital ownership, which means that some part of the capital may belong to the capital owners who live abroad. Defined θ and $\bar{k}$ as the capital holding share of country i's residents to total and the capital stock respectively, the representative resident has $\theta\bar{k}$ units of capital endowment.

Hence, the representative resident's budget constraint is

$$x_i = w_i l_i + \pi_i + r\theta\bar{k} + g_i, \tag{4}$$

where x_i denotes private consumption. The resident's preference is assumed to be $u(x_i) = x_i$. Using Eqs. (1)–(4), the definition of π_i, and the representative resident's budget constraint, we have

$$u_i(x_i) = f(k_i, l_i) - \left(k_i - \theta\bar{k}\right)r. \tag{5}$$

We now consider the equilibrium conditions of factor markets. When total capital endowment is $2\bar{k}$, capital and labor market equilibrium conditions become

$$k_L + k_S = 2\bar{k}, \tag{6a}$$

$$l_L = 1 + n, l_S = 1. \tag{6b}$$

Hereafter, we specify the production function as

$$f_i(k_i, l_i) = \alpha_i k_i + \beta_i l_i - \frac{A_i k_i^2 + B_i l_i^2}{2} + \gamma_i k_i l_i,$$

where $\alpha_i > 0$, $\beta_i > 0$, $A_i > 0$, $B_i > 0$, and $\gamma_i^2 < A_i B_i$.[3] This production function is a generalized form of a quadratic production function that is widely used in the literature on tax competition (e.g., Kikuchi and Tamai, 2024).

One of the key parameters of our analysis is γ_i, which is the cross-derivative of the production function (i.e., $f_{ikl} \equiv \partial^2 f_i / \partial l_i \partial k_i = \gamma_i$). If $\gamma_i > 0$ ($\gamma_i < 0$), the capital and labor are complements (substitutes) each other. This concept corresponds to q-complements/q-substitutes introduced by Hicks (1970).[4]

Under the specified production function, Eq. (2a) can be rewritten as

$$r = a_i - b_i k_i - T_i, \tag{7}$$

where $a_i \equiv \alpha_i + \gamma_i l_i > 0$ and $b_i \equiv A_i > 0$.

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[3] It is necessary to be $F_{ikk}F_{ill} - F_{ikl}^2 = A_i B_i - \gamma_i^2 > 0$ for the concavity of f_i.

[4] Sato and Koizumi (1973) show that the sign of Hicks's elasticity of complementarity depends on the sign of the cross-derivative of production function (i.e., f_{ikl}).

The parameter a_i is one of the determinants of the marginal product of capital. When capital and labor are complements ($\gamma_i > 0$), expanding labor forces increases a_i, leading to a larger marginal product of capital; capital is more attracted to a larger country. In contrast, if the capital and labor are substitutes ($\gamma_i < 0$), a marginal product of capital decreases with increased labor forces.

To focus on the effects of labor force size and the relationship between capital and labor in production, we assume the following conditions:

Assumption 1. $\alpha_i = \alpha,\ \beta_i = \beta,\ A_i = A,\ B_i = B,$ *and* $\gamma_i = \gamma.$

Under Assumption 1, the difference in a_i characterizes the asymmetricity of the regions.

For $i = L, S$ and $i \neq j$, Eqs. (1)–(3) and (6a)–(7) yield

$$r = \frac{a_i + a_j - T_i - T_j - 2b\bar{k}}{2}, \tag{8a}$$

$$k_i = \frac{a_i - a_j - T_i + T_j + 2b\bar{k}}{2b}. \tag{8b}$$

In equilibrium, the economy-wide interest rate is a function with respect to each country's capital tax and is decreasing in them. The capital employed in country *i* is also a function of taxes. The capital employed in country *i* increases with an increase in the other country's tax, while it decreases with the own country's tax.

The next subsections examine two types of equilibria derived from different game structures: one is a simultaneous-move game, and another is a sequential-move game. To characterize these equilibria, we consider the endogenous choice of being a leader or follower by two countries.

2.2. Simultaneous-move and sequential-move games

In a simultaneous-move game, each government chooses the unit tax to maximize the resident's utility subject to the economy-wide interest rate and own country's capital demand functions for taking the other country's tax policy as given. The optimization problem of the government of country *i* is formulated as

$$\max_{T_i} u_i = f_i(k_i, l_i) - \left(k_i - \theta\bar{k}\right)r$$

subject to Eqs. (8a) and (8b) for given T_j.

The first-order condition of the government's optimization problem is

$$\frac{\partial u_i}{\partial T_i} = \frac{\partial f_i}{\partial k_i}\frac{\partial k_i}{\partial T_i} + \left(\theta\bar{k} - k_i\right)\frac{\partial r}{\partial T_i} - r\frac{\partial k_i}{\partial T_i} = 0, \tag{9}$$

where

$$\frac{\partial k_i}{\partial T_i} = -\frac{1}{2b}, \frac{\partial r}{\partial T_i} = -\frac{1}{2}.$$

Using Eq. (9), we obtain the best-response function of country *i*:

$$T_i = \frac{a_i - a_j + T_j + 2(1-\theta)b\bar{k}}{3}. \tag{10}$$

Eq. (10) implies that country *i*'s government increases the tax rate in response to increased tax by country j. Figures 1a and 1b illustrate the best response curves when $\gamma > 0$ and $\gamma < 0$, respectively.

If $\gamma > 0$, an increase in population gap (i.e., a rise in n) moves the best response curves upward: the shift from the solid lines to the dotted lines in Figure 1a. Country *L* can raise the unit tax because a larger population gap potentially attracts more capital to Country *L* through an increase in a_L. The adverse effect works for Country *S*. Hence, Country *S* reluctantly reduces the unit tax.

If $\gamma < 0$, an increase in population gap shifts the best response curves downward. In the case of $\gamma > 0$, the opposite mechanism backgrounds the movements of loci of the best response curves: the shift from the solid lines to the dotted lines in Figure 1b. The key feature is that an increase in population gap decreases a_L, leading to a decrease in the potential capital attractiveness of Country *L*.

Two equations based on Eq. (10) yield the unit tax on capital in Nash equilibrium:

$$T_i^N = \frac{a_i - a_j}{4} + (1-\theta)b\bar{k}.$$

Note that the superscript *N* denotes the value of Nash equilibrium. Inserting T_i^N into Eqs. (8) and (9) yields

$$r^N = \frac{a_i + a_j}{2} - (2-\theta)b\bar{k},$$

$$k_i^N = \bar{k} + \frac{a_i - a_j}{4b}.$$

Finally, inserting the equilibrium values into Eq. (4), the indirect utility function in country *i* is

$$u_i^N = \Omega_i + \left[a_i - \frac{bk_i^N}{2}\right]k_i^N + r^N \cdot \left(\theta\bar{k} - k_i^N\right),$$

where $\Omega_i \equiv \beta l_i - Bl_i^2/2 > 0$.

We consider a game where country i chooses its tax rate first, and country j follows the choice. Since country *i* is the leader, the government takes the country *j*'s best response function into account. The optimization problem of the government of country i is

$$\max_{T_i} u_i = f_i(k_i, l_i) - \left(k_i - \theta\bar{k}\right)r$$

subject to Eqs. (8a) and (8b) with the country *j*'s best response function based on Eq. (10), which are

$$r = \frac{2a_i + a_j - 2T_i - (4-\theta)b\bar{k}}{3},$$

$$k_i = \frac{a_i - a_j - T_i + (4-\theta)b\bar{k}}{3b}.$$

The first-order condition of the government's optimization problem becomes

$$\frac{du_i}{dT_i} = \frac{\partial f_i}{\partial k_i}\frac{dk_i}{dT_i} + \left(\theta\bar{k} - k_i\right)\frac{dr}{dT_i} - r\frac{dk_i}{dT_i} = 0, \tag{11}$$

where

$$\frac{dk_i}{dT_i} = \frac{\partial k_i}{\partial T_i} + \frac{\partial k_i}{\partial T_j}\frac{\partial T_j}{\partial T_i} = -\frac{1}{3b}, \frac{dr}{dT_i} = \frac{\partial r}{\partial T_i} + \frac{\partial r}{\partial T_j}\frac{\partial T_j}{\partial T_i} = -\frac{2}{3}.$$

Using Eq. (11), we arrive at the equilibrium tax rates in the sequential-move game as

$$T_i^i = \frac{2\left(a_i - a_j\right)}{5} + \frac{8(1-\theta)b\bar{k}}{5},$$

$$T_j^i = -\frac{a_i - a_j}{5} + \frac{6(1-\theta)b\bar{k}}{5}.$$

Substituting T_i^i and T_j^i into Eqs. (8) and (9), the factor price of capital and capital inputs at equilibrium in the sequential-move game are

$$r^i = \frac{2a_i + 3a_j}{5} - \frac{(12-7\theta)b\bar{k}}{5},$$

$$k_i^i = \frac{a_i - a_j}{5b} + \frac{(4+\theta)\bar{k}}{5},$$

$$k_j^i = -\frac{a_i - a_j}{5b} + \frac{(6-\theta)\bar{k}}{5}.$$

Using these equations and Eq. (5), the indirect utility functions are

$$u_i^i = \Omega_i + \left(a_i - \frac{bk_i^i}{2}\right)k_i^i - r^i\left(k_i^i - \theta\bar{k}\right),$$

$$u_j^i = \Omega_j + \left(a_j - \frac{bk_j^i}{2}\right)k_j^i - r^i\left(k_j^i - \theta\bar{k}\right).$$

Then, the utility disparities between the equilibria become

$$u_i^i - u_i^N = I_i^i - I_i^N + \left(r^i - r^N\right)\theta\bar{k}, \tag{12a}$$

$$u_i^j - u_i^N = I_i^j - I_i^N + \left(r^j - r^N\right)\theta\bar{k}, \tag{12b}$$

where

$$I_i^i - I_i^N \equiv w_i^i + \pi_i^i + T_i^i k_i^i - w_i^N - \pi_i^N - T_i^N k_i^N = \frac{b\left(k_i^i - k_i^N\right)\left(k_i^i + k_i^N\right)}{2} + T_i^i k_i^i - T_i^N k_i^N,$$

$$I_i^j - I_i^N \equiv w_i^j + \pi_i^j + T_i^j k_i^j - w_i^N - \pi_i^N - T_i^N k_i^N = \frac{b\left(k_i^j - k_i^N\right)\left(k_i^j + k_i^N\right)}{2} + T_i^j k_i^j - T_i^N k_i^N.$$

2.3. Endogenous timing of policy choice

We examine the endogenous determination of the leadership in tax competition. Table 1 displays the games' payoff table, described in the previous subsection. All outcomes from the two-stage games are mainly characterized by the difference in the productivity parameter a_i $(i = L, S)$. We have $a_L - a_S = \gamma n$. Thus, $a_L > a_S$ $(a_L < a_S)$ holds if capital and labor are complements (substitutes).

Hereafter, we introduce the following definition:

$$\delta \equiv \frac{a_L - a_S}{b\bar{k}}.$$

Then, we obtain

$$\delta = \frac{\gamma n}{b\bar{k}} \gtreqless 0 \Leftrightarrow \gamma \gtreqless 0.$$

It is necessary to introduce the restriction of the parameter value of δ for holding the positive equilibrium values of capital (see Appendix A for the details):

Assumption 2. $-4 < \delta < 4$.

We now characterize the equilibrium outcomes such as capital price, taxes, and inputs (see Appendix B for the proof of Lemma 1):

Lemma 1. *(i) For a large country, the comparison between Nash and a large country's leadership yields*

$$r^L \gtreqless r^N \Leftrightarrow \delta \lesseqgtr -4(1-\theta),$$
$$T_L^L \gtreqless T_L^N \Leftrightarrow \delta \gtreqless 4(1-\theta),$$
$$k_L^L \gtreqless k_L^N \Leftrightarrow r^L \gtreqless r^N.$$

(ii) For a large country, the comparison between Nash and a small country's leadership yields

$$r^S \gtreqless r^N \Leftrightarrow \delta \gtreqless 4(1-\theta),$$
$$T_L^S \lesseqgtr T_L^N \Leftrightarrow \delta \gtreqless 4(1-\theta),$$
$$k_L^S \gtreqless k_L^N \Leftrightarrow r^S \lesseqgtr r^N.$$

Lemma 1 implies that the absentee ownership of capital and the relationship between capital and labor in production critically determines the magnitude relationship between key economic variables. Suppose that $\delta > 0$ and $0 < \theta < 1$ hold. A large country has a higher productivity with a larger population than a small country. A large country naturally attracts capital from a small country; therefore, a large country becomes a capital importer. The larger country is incentivized to raise the tax rate to reduce capital payment by controlling the capital price to be low if it is possible to be a leader.

On the other hand, increasing the tax rate reduces the income from other factors such as labor and land. In particular, decreased capital imports negatively affect labor income because of capital-labor complements. These negative income effects depend on the degree of capital-labor complements and the absentee ownership of capital because the former and latter determine the impact of decreasing capital on labor productivity and the size of capital import, respectively.

The benefits from decreasing capital payment overweigh the negative income effect for sufficiently large productivity gap, δ. The large country as a leader chooses a higher tax rate than that when the country is not a leader for $\delta > 4(1-\theta)$ because the benefit from reducing capital payment is more than compensated for the cost of negative income effect (i.e., $T_L^S < T_L^N < T_L^L$).

However, the large country sets a smaller tax rate (i.e., $T_L^L < T_L^N < T_L^S$) for a mild gap in productivity, $\delta < 4(1-\theta)$, because the cost of negative income effect overweighs the benefit from decreasing capital payment. The size of δ and θ mutually determines the net benefits from the leadership. Therefore, these parameter values are crucial to consider whether the country should lead or follow.

For a small country, the complete opposite results of Lemma 1 hold, based on a similar mechanism. The magnitude relationship between the utility levels of different states changes depending on δ and θ, through a change in disposable income. In other words, δ and θ determine the governments' strategies.

Regarding the difference in utility levels, the following equations hold for $i = L, S$:

$$u_i^i - u_i^N = \frac{[(a_j - a_i) - 4b\bar{k}(1-\theta)]^2}{160b} > 0,$$

$$u_i^N - u_i^j = \frac{3\left[9(a_i - a_j) + 44b\bar{k}(1-\theta)\right]\left[a_i - a_j - 4b\bar{k}(1-\theta)\right]}{800b}.$$

Using these equations and Lemma 1, we have the following result (see Appendix B for the proof of Lemma 2):

Lemma 2. *(i)* $u_L^L > u_L^N$ *and* $u_S^S > u_S^N$ *hold. (ii)* $u_L^N \geq u_L^S$ *and* $u_S^N > u_S^L$ *hold for* $\delta \leq -\min\{44(1-\theta)/9, 4\}$*;* $u_L^N < u_L^S$ *and* $u_S^N \geq u_S^L$ *for* $-\min\{44(1-\theta)/9, 4\} < \delta \leq -4(1-\theta)$*;* $u_L^N < u_L^S$ *and* $u_S^N < u_S^L$ *for* $-4(1-\theta) < \delta < 4(1-\theta)$*;* $u_L^N \geq u_L^S$ *and* $u_S^N < u_S^L$ *for* $4(1-\theta) \leq \delta < \min\{44(1-\theta)/9, 4\}$*;* $u_L^N > u_L^S$ *and* $u_S^N \geq u_S^L$ *for* $\min\{44(1-\theta)/9, 4\} \leq \delta$.

Based on the result (i) of Lemma 2, we have $u_L^L > u_L^N$ and $u_S^S > u_S^N$. In other words, one chooses "first move" in the best response to the rival's "second move". In contrast, each country may make a different choice in the best response to the rival's "first move", depending on δ and θ. Figure 2 illustrates the boundary lines of the utility disparities: the solid and dotted lines indicate $u_L^N - u_L^S = 0$ and $u_S^N - u_S^L = 0$, respectively. As $\theta \to 1$, the solid and dotted lines converge the same point. There is no gap between Nash and the other equilibrium if $\theta = 1$.

However, if $0 \leq \theta < 1$, the distribution of the utility disparities is more complicated. For instance, when $\delta > 0$, the set of δ and θ is divided into three regions: (a) the region below the solid line ($\delta < 4(1-\theta)$), (b) the region between the two lines ($\delta \geq 4(1-\theta)$ and $\delta <$

$44(1-\theta)/9$), (c) the region above the dotted line ($\delta \geq 44(1-\theta)/9$) in Figure 2.[5]

Within the parameters in case of (a), two countries benefit from following the other for a sufficiently small productivity gap rather than they do by Nash conjecture. In (b), a large country cannot gain as a second-mover, while a small country does as a follower. Finally, in the case of (c), neither country benefits from the second move under the rival's leadership.

We establish the following proposition as the result of choosing the timing of policy choice:

Proposition 1. *(i) If the capital and labor are complements ($\gamma > 0$), large country leads and small country follows, and vice versa for* $\delta < 4(1-\theta)$*; large country leads and small country follows for* $4(1-\theta) < \delta < \min\{44(1-\theta)/9,4\}$*; both countries move first for* $\min\{44(1-\theta)/9,4\} < \delta$*. (ii) If the capital and labor are substitutes ($\gamma < 0$), both countries move first for* $\delta < -\min\{44(1-\theta)/9,4\}$*; large country follows and small country leads for* $-\min\{44(1-\theta)/9,4\} < \delta < -4(1-\theta)$*; large country leads, and small country follows, vice versa for* $-4(1-\theta) < \delta$*.*

As mentioned in the intuition of Lemma 1, the benefit of reducing capital payment net of the negative income effect of decreasing capital and the rival's response is important for determining the government's strategy. We focus on the mechanism that large country leads; the result departs from the conventional view that small country wishes to lead.

Suppose that the capital and labor are complements ($\gamma > 0$). Then, $\delta > 0$ holds: $r^L > r^N$ and $k_L^L > k_L^N$ (Lemma 1). If $\delta > 4(1-\theta)$, we have $T_L^L > T_L^N$, $r^S > r^N$, $T_L^S < T_L^N$, and $k_L^S < k_L^N$ (Lemma 1). Hence, Eqs. (12a) and (12b) show $u_L^L > u_L^N$ and $u_L^S < u_L^N$ (Lemma 2) because factor income and transfer from the government when the country leads dominate those when the country follows; A large country wishes to lead when a large population gap exists. This result is valid for $4(1-\theta) < \delta < \min\{44(1-\theta)/9,4\}$.

The absentee ownership of capital, θ, is essential to determining the strategies of the governments. For instance, when $\theta = 0$, one of the two countries leads, and the other follows (Kempf and Rota-Graziosi, 2010). If there is no absentee owner of capital ($\theta = 1$), we have $u_L^L > u_L^N$, $u_L^N > u_L^S$, $u_S^S > u_S^N$, and $u_S^N > u_S^L$ (Ogawa, 2013). The "first move" is a dominant strategy for both countries. Hence, countries L and S move *simultaneously*. However, if $0 < \theta < 1$, the

[5] For $\delta < 0$, the signs are opposed. Hence, the solid and dotted lines switch places with each other.

situation drastically changes, depending on θ. The critical value of θ derives from $\min\{44(1-\theta)/9, 4\}$: $\theta = 2/11$.

Considering δ depends on n, the relationship between the government's strategy and the population gap is directly derived from Proposition 1: If the capital and labor are complements (substitutes), an increase in population gap causes a large country (small country) to take a leadership for $0 \leq \theta < 2/11$, while it increases the possibility of taking a lead for both countries for $2/11 < \theta < 1$. We now more precisely discuss the equilibrium selection when multiple equilibria exist. The concept of equilibrium selection is based on two criteria: payoff dominance and risk dominance.

Regarding Pareto dominance (payoff dominance), the strategy pair "*L* leads, and *S* follows" payoff dominates "*L* follows, and *S* leads" if $u_L^L > u_L^S$ and $u_S^L > u_S^S$ (one of them can be equality). In contrast, "*L* follows, and *S* leads" payoff dominates "*L* leads and *S* follows" if $u_L^L < u_L^S$ and $u_S^L < u_S^S$ (one of them can be equality).

After some calculations, we have

$$u_L^L - u_L^S = \frac{\delta^2 + 2\delta(1-\theta) - 14(1-\theta)^2}{25} b\bar{k}^2, \tag{13a}$$

$$u_S^L - u_S^S = -\frac{\delta^2 - 2\delta(1-\theta) - 14(1-\theta)^2}{25} b\bar{k}^2. \tag{13b}$$

Eqs. (13a) and (13b) show that $u_L^L > u_L^S$ ($u_L^L < u_L^S$) and $u_S^L > u_S^S$ ($u_S^L < u_S^S$) if $\delta > (\sqrt{15}-1)(1-\theta)$ for $\delta < 4(1-\theta)$ ($\delta < -(\sqrt{15}-1)(1-\theta)$ for $\delta > -4(1-\theta)$); the leadership by Country *L* (*S*) is Pareto-dominant. Therefore, if a large productivity gap exists, a country with high productivity takes the lead in the sense of Pareto dominance. Moreover, increasing the proportion of absentee owners raises the possibility that *L* leads for $\delta > 0$ while increasing the proportion of absentee owners reduces the possibility that *L* leads for $\delta < 0$.

Considering risk dominance, the strategy pair "*L* leads, and *S* follows" risk dominates "*L* follows, and *S* leads" if $(u_L^L - u_L^N)(u_S^L - u_S^N) > (u_L^S - u_L^N)(u_S^S - u_S^N)$, while "*L* follows, and *S* leads" risk dominates "*L* leads, and *S* follows" if $(u_L^L - u_L^N)(u_S^L - u_S^N) < (u_L^S - u_L^N)(u_S^S - u_S^N)$. The deviation loss from the state can be calculated as

$$(u_L^L - u_L^N)(u_S^L - u_S^N) = -\frac{3\left[(a_L - a_S) + 4b\bar{k}(1-\theta)\right]^3\left[9(a_L - a_S) - 44b\bar{k}(1-\theta)\right]}{128000b^2}, \tag{14a}$$

$$(u_L^S - u_L^N)(u_S^S - u_S^N) = -\frac{3\left[(a_L - a_S) - 4b\bar{k}(1-\theta)\right]^3\left[9(a_L - a_S) + 44b\bar{k}(1-\theta)\right]}{128000b^2}. \tag{14b}$$

Using Eqs. (14a) and (14b), we have

$$\left(u_L^L - u_L^N\right)\left(u_S^L - u_S^N\right) - \left(u_L^S - u_L^N\right)\left(u_S^S - u_S^N\right) = -\frac{3\delta(1-\theta)[\delta - 24(1-\theta)^2]}{1000} b^2 \bar{k}^4. \quad (15)$$

Eq. (15) shows that the leadership by L is risk-dominant if $\delta < 24(1-\theta)^2$ except for $\delta = 0$, while the leadership by S is risk-dominant if $\delta > 24(1-\theta)^2$. Furthermore, it also implies that small leads in the sense of risk dominance if the proportion of absentee owners is sufficiently small. If $\delta > 0$ and a small proportion of absentee owners, this result is consistent with those of Kempf and Rota-Graziosi (2010) and Hindriks and Nishimura (2015).[6]

3. Imperfect labor market

3.1. A modification of the basic setup

We consider the imperfect labor market as the extension of our basic model. The fixed wage, $\bar{w}_i$, represents the labor market imperfection in the extended model (e.g., Ogawa et al., 2006).[7] The other settings of the model are the same as those of Section 2. The most important feature of the model is an *employment externality*, which is the external effect of attracting capital through the relationship between capital and labor in production.[8]

With fixed wage and specified production function, Eq. (2b) yields

$$\bar{w}_i = \beta_i - B_i l_i + \gamma_i k_i.$$

Therefore, the labor demand becomes

$$l_i = c_i + \mu_i k_i, \quad (16)$$

where

$$c_i \equiv \frac{\beta_i - \bar{w}_i}{B_i}, \mu_i \equiv \frac{\gamma_i}{B_i}.$$

μ_i measures the degree of employment externality. Note that $\gamma_i > 0$ ($\gamma_i < 0$) leads to positive (negative) employment externality.

We assume that $n = 0$ and $l_i < 1$ hold. With unemployment, the coefficients a_i and b_i in Section 2 should be rewritten as

6 Pi and Chen (2017) further analyze risk-dominant equilibrium by jointing these two studies.
7 Several studies theoretically examined tax competition with unemployment (e.g., Sato, 2009; Eichner and Upmann, 2012; Exbrayat et al., 2012; Lee, 2021).
8 Empirical studies found that employment level is significantly affected by the corporate income tax rate (e.g., Feld and Kirchgassner, 2003; Harden and Hoyt, 2003; Bettendorf et al., 2009; Felix, 2009; Feldmann, 2011; Zirgulis and Šarapovas, 2017).

$$a_i = \alpha_i + c_i\gamma_i, b_i = A_i - \frac{\gamma_i^2}{B_i}.$$

Focusing on the difference in a_i, we introduce the following assumption instead of Assumption 1:

Assumption 3. $\alpha_i = \alpha,\ \beta_i = \beta,\ A_i = A,\ B_i = B,\ \gamma_i = \gamma$, *and* $\bar{w}_i \neq \bar{w}_j$.

Assumption 3 implies that the difference in the fixed-wage makes the asymmetricity of a_i: $a_i \neq a_j$ and $b_i = b_j = b$. Except for the new definitions of a_i and b_i and Eq. (16), all the equations that appeared in Section 2.1 still hold. We use country index *L* as the country with large fixed wages, while *S* is with small fixed wages. Hence, given the same capital input, country *L* has larger unemployment than country *S*.

We first consider the simultaneous-move games. The first-order condition of the government's optimization problem is

$$\frac{\partial u_i}{\partial T_i} = \frac{\partial f}{\partial k_i}\frac{\partial k_i}{\partial T_i} + \frac{\partial f}{\partial l_i}\frac{\partial l_i}{\partial k_i}\frac{\partial k_i}{\partial T_i} + \frac{\partial r}{\partial T_i}\left(\theta\bar{k} - k_i\right) - r\frac{\partial k_i}{\partial T_i} = 0. \tag{17}$$

The second term in the middle part of Eq. (17) differs from the first-order condition in Section 2.2. This term characterizes the employment externality found by Ogawa et al (2006).

Using Eq. (17), we obtain the best response function for the country *i* as follows:

$$T_i = \frac{a_i - a_j + T_j - 2\mu\bar{w}_i + 2b\bar{k}(1-\theta)}{3}. \tag{18}$$

The positive (negative) employment externality induces the government to reduce (raise) the unit tax on capital because attracting capital stimulates (deteriorates) employment through the complementarity (substitution) between capital and labor.

The unit tax on capital, capital amount, and the capital price at the equilibrium under a simultaneous-move game are

$$T_i^N = \frac{a_i - a_j - \mu\left(\bar{w}_j + 3\bar{w}_i\right)}{4} + b\bar{k}(1-\theta) = b\bar{k}(1-\theta) - \mu\bar{w}_i,$$

$$r^N = \frac{a_i + a_j + \left(\bar{w}_i + \bar{w}_j\right)\mu}{2} - (2-\theta)b\bar{k} = \alpha + \mu\beta - (2-\theta)b\bar{k},$$

$$k_i^N = \frac{a_i - a_j + \left(\bar{w}_i - \bar{w}_j\right)\mu}{4b} + \bar{k} = \bar{k}.$$

The equilibrium values, excluding the unit tax, are independent of the fixed-wage because of the specification of the production function and the symmetricity of its parameters. For $\theta = 1$, the unit tax on capital is negative if the capital and labor are complements ($\gamma > 0$). In contrast, the unit tax is positive if the capital and labor are substitutes.

We now consider a sequential-move game. The government's optimization problem is similar to that of Section 2.2. Some constraints are changed as Eq. (18),

$$r = \frac{2a_i + a_j - 2T_i + \mu\bar{w}_j - (4-\theta)b\bar{k}}{3},$$

$$k_i = \frac{a_i - a_j - T_i - \mu\bar{w}_j + (4-\theta)b\bar{k}}{3b}.$$

The corresponding first-order condition is

$$\frac{du_i}{dT_i} = \frac{\partial f_i}{\partial k_i}\frac{dk_i}{dT_i} + \frac{\partial f}{\partial l_i}\frac{\partial l_i}{\partial k_i}\frac{dk_i}{dT_i} + \left(\theta\bar{k} - k_i\right)\frac{dr}{dT_i} - r\frac{dk_i}{dT_i} = 0. \quad (19)$$

The second term of the middle part of Eq. (19) stands for the employment externality.

The equilibrium values in the case where country *i* is the leader are

$$T_i^i = \frac{2\left(a_i - a_j\right) - \left(2\bar{w}_j + 3\bar{w}_i\right)\mu + 8(1-\theta)b\bar{k}}{5} = \frac{8(1-\theta)b\bar{k}}{5} - \mu\bar{w}_i,$$

$$r^i = \frac{2a_i + 3a_j + \left(2\bar{w}_i + 3\bar{w}_j\right)\mu - (12-7\theta)b\bar{k}}{5} = \alpha + \mu\beta - \frac{(12-7\theta)b\bar{k}}{5},$$

$$k_i^i = \frac{a_i - a_j + \left(\bar{w}_i - \bar{w}_j\right)\mu + (4+\theta)b\bar{k}}{5b} = \frac{(4+\theta)\bar{k}}{5}.$$

Hence, when country *j* is the leader, we obtain $r^j = r^i$,

$$T_i^j = \frac{6(1-\theta)b\bar{k}}{5} - \mu\bar{w}_i,$$

$$k_i^j = \frac{(6-\theta)\bar{k}}{5}.$$

For $\theta = 1$, $T_i^i < 0$ and $T_i^j < 0$ if the capital and labor are complements ($\gamma > 0$). Moreover, $T_i^i = T_i^j = T_i^N$, $r^i = r^j = r^N$, and $k_i^i = k_i^j = \bar{k}$ hold if $\theta = 1$. Therefore, if $\theta = 1$, Nash equilibrium is a unique equilibrium of endogenous timing of policy choice.

3.2. The effects of labor market imperfection on equilibrium leadership

We focus on the case where $0 \leq \theta < 1$ to exclude the trivial case. The following lemma characterizes the equilibrium values of capital prices, capital inputs, and unit taxes:

Lemma 3. $r^i < r^N$, $k_i^i < k_i^N < k_i^j$, *and* $T_i^N < T_i^j < T_i^i$ *for* $0 \leq \theta < 1$.

The wage differential almost offsets the difference in the parameter, a_i. The employment externality reduces unit tax on capital to raise capital price if it is a positive externality. If a negative employment externality exists, then the government raises the unit tax on capital to reduce the capital price. However, the external effect does not change the magnitude relationship bwtween the capital price, capital employed, and tax.

If the country leads, the country may benefit from increased tax revenue and decreased payment of capital interest (Lemma 3); the country is willing to lead when the rival follows. In contrast, if the country follows, the country will gain capital employed to increase total income potentially (Lemma 3); the country wishes to follow if the rival leads. Indeed, we obtain the following result concerning the difference in the utility levels:

Lemma 4. $u_i^i > u_i^N$ *and* $u_i^N < u_i^j$ *for* $0 \leq \theta < 1$.

Lemma 4 shows that the country chooses to move first in response to the rival's second move, while the country prefers to move late in response to the rival's first move. Based on Lemma 4, we establish the following result:

Proposition 2. *If* $0 \leq \theta < 1$, *a high-wage country leads, a low-wage country follows, and vice versa.*

Proposition 2 is one variation of Proposition 1 with employment externality. This result is similar to that of Kempf and Rota-Graziosi (2010). Unemployment issues are widely observed in the real economy. Therefore, considering tax competition under real economic circumstances, we should necessarily incorporate the timing of policy choice into the economic analysis.

Finally, we consider the equilibrium selection under the situation of Proposition 2. We have

$$u_L^L - u_L^S = -\frac{14k^2(AB-\gamma^2)(1-\theta)^2}{25B} < 0, \tag{20a}$$

$$u_S^L - u_S^S = \frac{14k^2(AB-\gamma^2)(1-\theta)^2}{25B} > 0. \tag{20b}$$

Since $u_L^L < u_L^S$ and $u_S^L > u_S^S$ are derived from Eqs. (20a) and (20b), there is no equilibrium in the sense of Pareto dominance. Regarding risk dominance, we have the deviation loss from some states:

$$(u_L^L - u_L^N)(u_S^L - u_S^N) = (u_L^S - u_L^N)(u_S^S - u_S^N) = \frac{33k^4(AB-\gamma^2)^2(1-\theta)^4}{500B^2} > 0.$$

Therefore, there is also no equilibrium in the sense of risk dominance.

4. Conclusion

This paper examined the role of capital input and capital-labor relationship in production to determine the endogenous leadership in tax competition. Extending the basic model presented by Kempf and Rota-Graziosi (2010) and Ogawa (2013), we modeled a timing game model of asymmetric tax competition with three inputs: capital, labor, and land in production. In the model, a combination of the relationship between capital and labor in production generates a difference between countries in their productivities, depending on labor force size. In particular, the marginal productivity of capital is positively (negatively) correlated with employment size if capital and labor are complements (substitutes).

We show that the key determinants of leadership are the productivity gap and the proportion of absentee ownership of capital. If capital and labor are complementary, the leadership of a large country could be not only risk-dominant but also Pareto-dominant for a sufficiently large productivity gap. However, the leadership of a small country could be risk-dominant or Pareto-dominant if capital and labor are substitutes. Our findings imply that the sequential move game is theoretically supported, and each of the large and small countries' leadership is reasonable.

Several empirical evidences support the significant role of labor market imperfection in tax competition. We extended the basic model of tax competition with a perfect labor market to one with an imperfect labor market by incorporating wage rigidity. The extended model shows that multiple equilibria exist. Hence, it implies that the sequential move game approaches should replace simultaneous ones

Finally, we would like to mention the extension of our model as future research. I In tax competition among regions, the fiscal transfer system plays an essential role in improving the inefficiency caused by fiscal externality. Based on our analysis, fiscal transfer may worsen or improve social welfare, depending on capital ownership and the technological relationship between capital and labor.[9] Moreover, other asymmetricities should be considered, such as asymmetric information and an asymmetric degree of capital ownership. Multiple asymmetricities interfere with each other and, therefore, may resolve inefficiencies mutually.[10]

[9] Considering the timing game of the tax competition, the fiscal transfer might be a device to generate capital misallocation by tax leaders (Haraguchi and Ogawa, 2018).
[10] Hamada (2023) shows that ex-post social welfare under asymmetric information can be larger than that under complete information because the uninformed country chooses a smaller tax rate under asymmetric information.

Appendix

A. Sufficient conditions for positive equilibrium values

For Nash equilibrium (simultaneous move game), we have

$$k_L^N = \bar{k}\left(1+\frac{\delta}{4}\right), k_S^N = \bar{k}\left(1-\frac{\delta}{4}\right).$$

Hence, $|\delta| < 4$ must hold for $\min\{k_L^N, k_S^N\} > 0$.

For subsequential move game, we obtain

$$k_L^L = \frac{(4+\delta+\theta)\bar{k}}{5}, k_S^L = \frac{(6-\delta-\theta)\bar{k}}{5}, \tag{A1}$$

$$k_S^S = \frac{\bar{k}(4-\delta+\theta)}{5}, k_L^S = \frac{\bar{k}(6+\delta-\theta)}{5}. \tag{A2}$$

Therefore, Eq. (A1) needs $4+\delta+\theta > 0$ and $6-\delta-\theta > 0$ for $\min\{k_L^L, k_S^L\} > 0$. Similarly, Eq. (A2) requires $4-\delta+\theta > 0$ and $6+\delta-\theta > 0$. If $|\delta| < 4$, $\min\{k_L^L, k_S^L\} > 0$ and $\min\{k_L^S, k_S^S\} > 0$ hold. Therefore, Assumption 2 is a sufficient condition for a positive equilibrium value of capital.

B. Proof of Lemmas 1 and 2

Proof of Lemma 1: Some calculations yield

$$r^L - r^N = -\frac{a_L - a_S}{10} - \frac{2(1-\theta)b\bar{k}}{5} \gtreqless 0 \Leftrightarrow \delta \lesseqgtr -4(1-\theta),$$

$$T_L^L - T_L^N = \frac{3(a_L - a_S)}{20} - \frac{3(1-\theta)b\bar{k}}{5} \gtreqless 0 \Leftrightarrow \delta \gtreqless 4(1-\theta),$$

$$k_L^L - k_L^N = \frac{r^L - r^N}{2b} \gtreqless 0 \Leftrightarrow r^L \gtreqless r^N.$$

$$r^S - r^N = \frac{a_L - a_S}{10} - \frac{2(1-\theta)b\bar{k}}{5} \gtreqless 0 \Leftrightarrow \delta \gtreqless 4(1-\theta),$$

$$T_L^S - T_L^N = -\frac{a_L - a_S}{20} + \frac{(1-\theta)b\bar{k}}{5} \lesseqgtr 0 \Leftrightarrow \delta \gtreqless 4(1-\theta),$$

$$k_L^S - k_L^N = \frac{r^N - r^S}{2b} \gtreqless 0 \Leftrightarrow r^S \lesseqgtr r^N.$$

Proof of Lemma 2: By easy calculations, we obtain

$$u_L^L - u_L^N = \frac{\delta^2 b\bar{k}^2}{160} - \frac{(1-\theta)\delta b\bar{k}^2}{20} + \frac{b\bar{k}^2(1-\theta)^2}{10} = \frac{[\delta - 4(1-\theta)]^2 b\bar{k}^2}{160} > 0,$$

$$u_S^S - u_S^N = \frac{\delta^2 b\bar{k}^2}{160} + \frac{(1-\theta)\delta b\bar{k}^2}{20} + \frac{b\bar{k}^2(1-\theta)^2}{10} = \frac{[\delta + 4(1-\theta)]^2 b\bar{k}^2}{160} > 0.$$

Hence, $u_i^i - u_i^N > 0$ holds for $i = L, S$.

We have

$$u_L^N - u_L^S = \frac{3b\bar{k}^2[9\delta^2 + 8(1-\theta)\delta - 176(1-\theta)^2]}{800}$$

$$= \frac{3b\bar{k}^2[9\delta + 44(1-\theta)][\delta - 4(1-\theta)]}{800} \equiv U(\delta).$$

Solving $U(\delta) = 0$ with respect to δ, we obtain

$$\delta_1 = 4(1-\theta) \equiv \overline{\delta},$$

$$\delta_2 = -\frac{44(1-\theta)}{9} \equiv \underline{\delta}.$$

Then, $0 < \delta_1 < 4$ holds for $0 < \theta < 1$. Moreover, we have

$$\delta_2 \gtreqless -4 \Leftrightarrow \theta \gtreqless \frac{2}{11}. \tag{B1}$$

We also have

$$u_S^N - u_S^L = \frac{3b\bar{k}^2[9\delta^2 - 8(1-\theta)\delta - 176(1-\theta)^2]}{800}$$

$$= \frac{3b\bar{k}^2[9\delta - 44(1-\theta)][\delta + 4(1-\theta)]}{800} \equiv V(\delta).$$

Then, $V(\delta) = 0$ leads to

$$\delta_3 = \frac{44(1-\theta)}{9} = -\delta_2,$$

$$\delta_4 = -4(1-\theta) = -\delta_1,$$

Depending on θ, the magnitude relationship between the roots of $U(\delta) = 0$ and $V(\delta) = 0$ is changed. Formally, we have

$$\delta_2 < -4 \leq \delta_4 < 0 < \delta_1 \leq 4 < \delta_3 \text{ for } 0 \leq \theta < \frac{2}{11}, \tag{B2}$$

$$-4 < \delta_2 < \delta_4 < 0 < \delta_1 < \delta_3 < 4 \text{ for } \frac{2}{11} < \theta. \tag{B3}$$

The extreme case is

$$\delta_1 = \delta_2 = \delta_3 = \delta_4 = 0 \text{ for } \theta = 1. \tag{B4}$$

Using Eqs. (B1)–(B4) with the utility disparities, we obtain all the cases of Lemma 2: When $0 \le \theta < 2/11$, $\delta_2 < -4$ and $0 < \delta_1 < 4$ hold. Hence, δ_2 and δ_3 are not valid for the critical values. For $\delta > 0$ $(\gamma > 0)$, $u_L^N < u_L^S$ and $u_S^N < u_S^L$ if $0 < \delta < \delta_1$, while $u_L^N \ge u_L^S$ and $u_S^N < u_S^L$ if $\delta_1 \le \delta$. For $\delta < 0$ $(\gamma < 0)$, $u_L^N < u_L^S$ and $u_S^N < u_S^L$ if $\delta_4 < \delta$; $u_L^N < u_L^S$ and $u_S^N \ge u_S^L$ if $\delta \le \delta_4$.

When $2/11 < \theta < 1$, we have $-4 < \delta_2 < 0$ and $0 < \delta_1 < 4$. Therefore, we must consider that both critical values are valid. For $\delta > 0$ $(\gamma > 0)$, $u_L^N \le u_L^S$ and $u_S^N < u_S^L$ if $0 < \delta \le \delta_1$; $u_L^N > u_L^S$ and $u_S^N < u_S^L$ if $\delta_1 < \delta < \delta_3$; $u_L^N > u_L^S$ and $u_S^N \ge u_S^L$ if $\delta_3 \le \delta < 4$. For $\delta < 0$ $(\gamma < 0)$, $u_L^N < u_L^S$ and $u_S^N < u_S^L$ if $\delta_4 < \delta$; $u_L^N < u_L^S$ and $u_S^N \ge u_S^L$ if $\delta_2 < \delta \le \delta_4$; $u_L^N \ge u_L^S$ and $u_S^N > u_S^L$ if $\delta \le \delta_2$.

C. Proof of Lemmas 3 and 4

Proof of Lemma 3: Some calculations lead to

$$r^N - r^i = \frac{2(1-\theta)b\bar{k}}{5} > 0,$$

$$T_i^N - T_i^j = -\frac{b\bar{k}(1-\theta)}{5} < 0,$$

$$T_i^N - T_i^i = -\frac{3b\bar{k}(1-\theta)}{5} < 0.$$

Proof of Lemma 4: After some manipulations, we obtain

$$u_i^i - u_i^N = \frac{k^2(AB-\gamma^2)(1-\theta)^2}{10B} > 0,$$

$$u_i^N - u_i^j = -\frac{33k^2(AB-\gamma^2)(1-\theta)^2}{50B} < 0.$$

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Figures

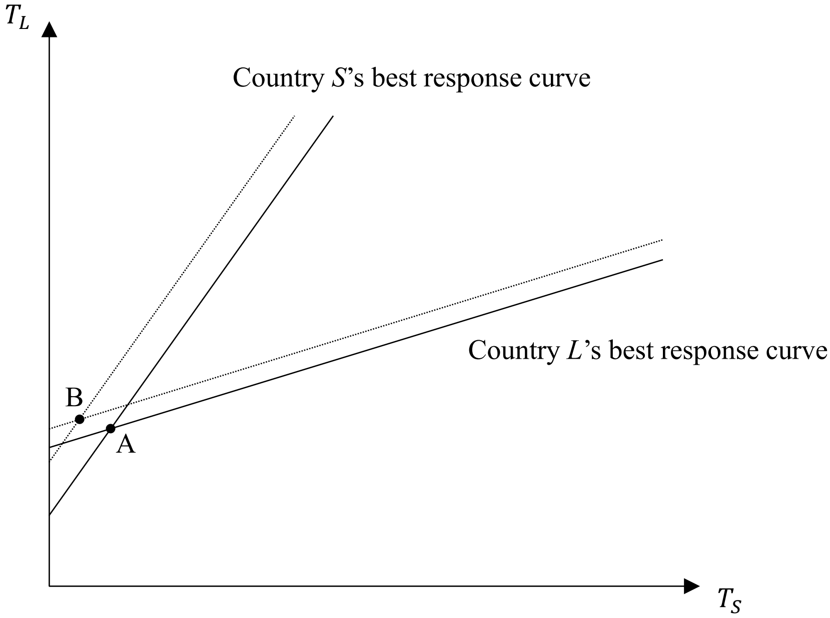

Figure 1a. Best response curves when $\gamma > 0$

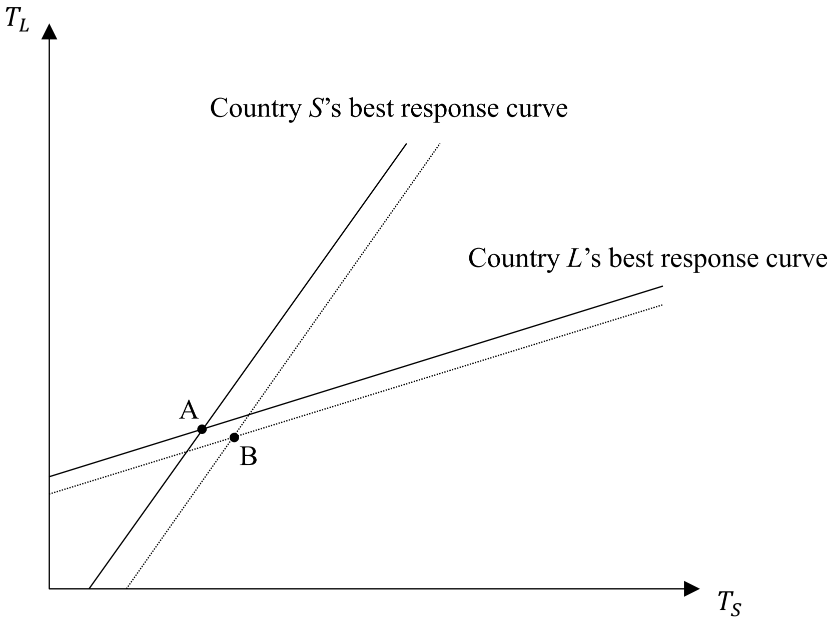

Figure 1b. Best response curves when $\gamma < 0$

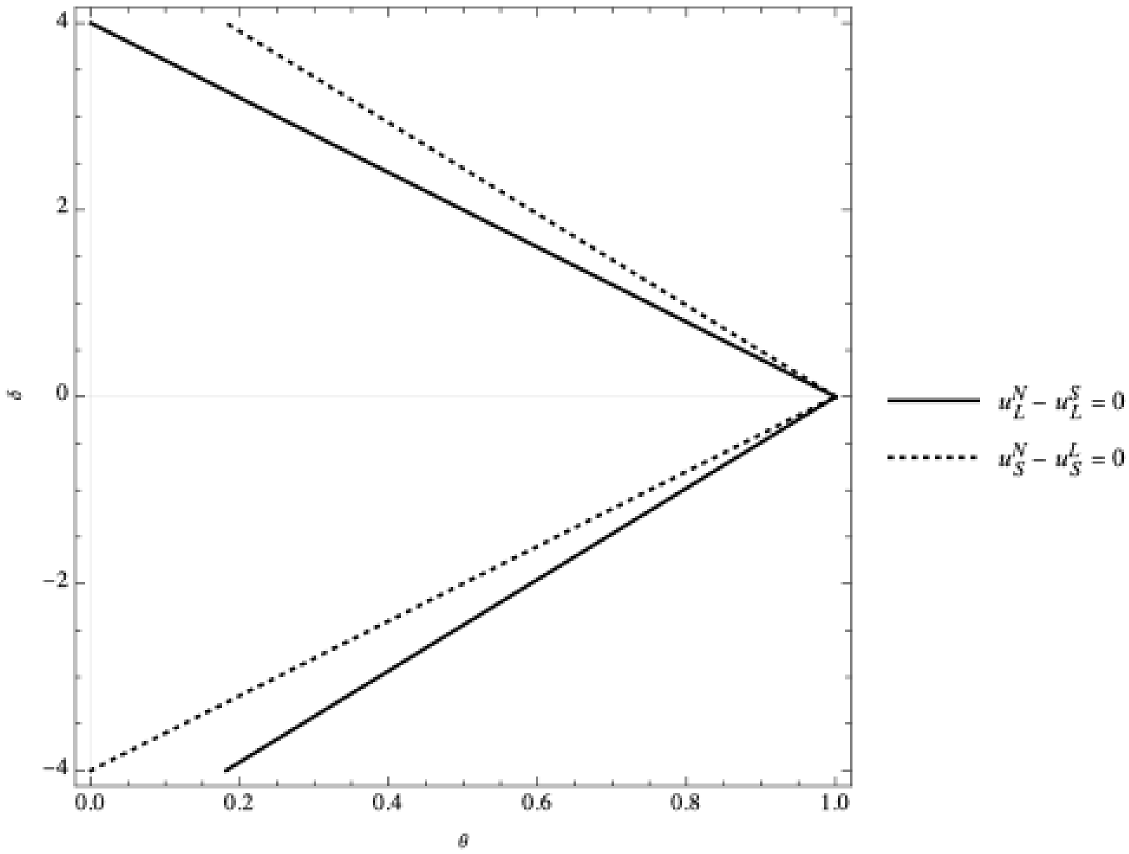

Figure 2. Boundary lines of utility disparities

Tables

Table 1. Payoff table

Country *L*/Country *S*	Early Period	Late Period
Early Period	u_L^N, u_S^N	u_L^L, u_S^L
Late Period	u_L^S, u_S^S	u_L^N, u_S^N