Equilibrium Leadership in Tax Competition for Endogenous Capital Supply

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Abstract

In this paper, we reconsider the leadership of tax competition, focusing on a situation where total amount of capital competed by countries is endogenously determined. For the purpose, we model a timing game under asymmetric tax competition, in which the capital competed among two countries is supplied not only by the residents of the two countries, but also by exogenous investors, depending on the rate of return to capital in the integrated market and how accessible it is for investors outside of the countries. As a result, it is found that, when the capital market becomes more accessible for exogenous investors, sequential-move equilibria are more likely to be realized, in which one country leads and the other follows. Contrarily, only simultaneous-move equilibrium emerges, when the openness of the market is sufficiently small.

Keywords: Tax competition; Endogenous timing; Capital supply; Market access.

JEL classification H73, H77

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1 Introduction

The issue of endogenized leadership has become an important strand in the literature on tax competition since the seminal work of Kempf and Rota-Graziosi (2010, hereafter K-RG). Their study questions the basic assumptions that traditional models of tax competition have set since the studies of Zodrow and Mieszkowski (1986) and Wilson (1986): whether regional governments are competing in a Nash manner. In other words, is the simultaneous setting of tax rates truly commitment-robust for governments if they can choose relative timing to determine tax policies? To answer this question, K-RG apply a timing game, as introduced by Hamilton and Slutsky (1990), to the model of tax competition: a pre-play stage to choose the timing is set before the stage governments determine their tax rates. As a result, they find that the simultaneous-move outcome does not emerge as a subgame perfect Nash equilibrium (SPE) of the timing game and, contrary to the assumption of canonical models of tax competition, only the sequential-move or Stackelberg outcome, emerges.

Regarding the results of K-RG, Ogawa (2013) indicates that this heavily depends on the assumption of the absence of capital ownership, and shows that only a simultaneous-move outcome emerges if it is assumed that the capital competed among countries is owned by residents, as the standard models assume. Then, the argument of endogenized leadership in tax competition evolved among researchers, with varying model settings to identify the determinant of leadership.[1] Particularly, Kemp and Rota-Graziosi (2015) and Hindriks and Nishimura (2017) describe the intermediate situation of the two polar cases of K-RG and Ogawa (2013) and provide a detailed analysis on the role of capital ownership.

However, in the models of Kempf and Rota-Graziosi (2015) and Hindriks and Nishimura (2017), the ratio of capital ownership (i.e., how much of the capital competed among countries is initially owned by residents in the economy and by non-residents) is exogenously given. This implies that the amount of capital investment from outside the market is assumed not to respond to the rate of return determined on the market. Under this assumption, the governments engaged in capital tax competition do not have an incentive to attract capital investment from outside the market, but to attract capital initially owned by residents within their economy. This points to a lack of consistency.

To fill this gap in the literature, in this paper, we reconsider the endogenized leadership of tax competition, by focusing on the role of exogenous capital supply. In other words, we assume that there exist two asymmetric countries where the residents are initially endowed with a certain amount of capital and capital is freely mobile between the countries through an integrated market. However, a capital owner can potentially reside not only within the two countries, but also outside the economy. As a feature of the model analyzed in this paper, the total amount of capital competed by the two countries is initially undetermined and depends on the return to capital investment or price of capital on the market: a higher return attracts more capital investment from the outside, while a lower return attracts less capital investment.

In addition, leadership in tax competition is not only of theoretical interest. In examining the effects of actual change in corporate tax policy, empirical research has been conducted to clarify which countries are actually taking leadership in tax competition.[2] A pioneering study is by Altshuler and Goodspeed (2002, 2015), which use the tax reform in the United Kingdom and the United States in the 1980s as a target of the analysis and examine whether the United States, the United Kingdom, and Germany lead tax

[1]For instance, Eichner (2014) focuses on the preference for public goods, which is financed by capital tax revenue, while Kemp and Rota-Graziosi (2010, 2015), Ogawa (2013), and Hindriks and Nishimura (2015, 2017) assume capital tax revenue is redistributed in a lump-sum manner. Kawachi et al. (2015) add one more stage of public investment competition to increase the productive efficiency of capital before the stage of tax competition. Ogawa and Susa (2017) consider heterogeneity of not only the countries, but also residents in a country, using the framework of majority voting. Pi and Chen (2017) present further analysis on risk-dominant equilibrium in the tax leadership game.

[2]See Leibrecht and Hochgatterer (2012) on how to identify leadership in tax competition.

competition between Europe and the United States. Their main findings were that European countries set their corporate tax rates following the United States but no policy leader exists in tax competition within EU countries. The result on leadership in European countries has been further reexamined and challenged by subsequent studies and uncovers the timing of tax competition within Europe (Redoano, 2007; Chatelais and Peyrat, 2008).[3] In verifying leadership, however, the empirical studies implicitly make an assumption that countries compete only with countries within Europe. The relationship between European countries and countries outside the region (the rest of the world) is not taken into account. Our study intends to make a contribution to empirical research by suggesting the factor that should be considered when searching empirically for the emergence of leadership in tax competition.

As a result, we find that the SPEs of this timing game are classified into the following situations: i) two sequential-move equilibria emerge, in which one country leads and the other country follows; ii) one sequential-move equilibrium emerges, in which the country with higher production technology leads and the country with lower production technology follows; or iii) one simultaneous-move equilibrium emerges, in which both countries determine their tax rates simultaneously. In addition, when exogenous capital investment is more responsive to the rate of return on the market, the sequential-move outcome is more likely to emerge and the simultaneous-move ones less likely.

The rest of this paper is organized as follows. Section 2 presents the model of the timing game between two asymmetric countries. In Section 3, the main results of our analysis are shown. We conclude the paper with Section 4.

2 The Model

The economy we focus on is composed of two countries, $i = H, L$. Firms in a country produce private goods using labor and capital with constant-returns-to-scale technology. Here, we assume that the market for private goods is perfectly competitive and production per capita is expressed by $f(k_i) = (A_i - k_i)k_i$, where k_i represents capital per labor, and A_i, productive efficiency or technology of the firms in country i. In this model, productive efficiency A_i is a country-specific parameter and the only factor asymmetry between the two countries. We define $A_H \equiv A + \varepsilon$ and $A_L \equiv A - \varepsilon$. Without generality loss, $A_H > A_L$, or $\varepsilon > 0$, is assumed. A firm's profit in country i is given by $\pi_i = f(k_i) - (r + T_i)k_i - w_i$, where r denotes the price of capital on the integrated market between the two countries, T_i the unit tax rate on capital imposed by the government of country i, and w_i the wage rate.

The residents in each country are homogenous with respect to the amount of labor and initial capital endowment. Particularly, a resident in either country is initially endowed with a unit of labor and 0.5κ units of capital. A resident in country i has a simple preference, $u_i(c_i) = c_i$, where c_i denotes the consumption of a numeraire private good. The total income of a resident in country i consists of wage w_i, return to capital 0.5κ, and a lump-sum transfer from the government, g_i. Therefore, the budget constraint of a resident in country i is given by

$$c_i = w_i + \frac{1}{2}r\kappa + g_i, \tag{1}$$

where $w_i = f(k_i) - [\partial f(k_i)/\partial k_i]\, k_i = k_i^2$.

The government of country i imposes unit tax T_i on the mobile capital employed by firms in the country to finance the lump-sum transfers to residents. Hence, the budget constraint of the government of country i is given by

[3] For instance, Redoano (2007) shows that small countries in Europe follow the big countries, Germany and France, while Chatelais and Peyrat (2008) point out that small countries, such as Belgium, play the role of leader in tax competition among EU countries.

$$g_i = T_i k_i. \tag{2}$$

Using this budget constraint, utility function $u_i(c_i)$ can be rewritten as

$$u_i(c_i) = (A_i - k_i)k_i + r\left(\frac{1}{2}\kappa - k_i\right), \tag{3}$$

which indicates that the utility of a resident in country i consists of its GDP per capita and the net returns from capital investment. With this formulation of utility, we can describe a situation where the manipulation of the terms of trade or capital price in the integrated market are the sole incentives to control for capital tax T_i (Peralta and Van Ypersele, 2005; Itaya et al., 2008; Ogawa, 2013).

As a feature of this model, the residents of other (outside) countries can invest their capital in the two countries (H or L). Total amount of capital supply in the market is expressed as $\kappa + b(r - r^*)$; the first term is initial capital endowment of the two countries and the second terms is the capital inflow from the outside, assuming that the amount of capital flowing into the integrated market is positively related to the capital price, r. Besides, it is natural to assume that investment decision of investors outside depends on how easy they can access to the market, captured by b, and whether the rate of return in this market is relatively higher than that of other markets, or the world capital market, r^*. It can be simply imagined that, if $r > r^*$, investors outside of the countries are likely to invest their own capital to the integrated market between the two, but its actual amount is also dependent on general investment costs; a lower (higher) b represents higher (lower) costs and induces less (more) capital investment from the outside. In the following analysis, we assume that r^* is sufficiently low, or equal to zero, so that we can clearly focus to examine how the incentive to attract more capital from outside affects the issue of endogenized leadership in tax competition.[4] Therefore, the total amount of capital in this economy is $\kappa + br$.

With the assumption that capital is freely mobile between the two countries, the market-clearing conditions are

$$r = A_i - 2k_i - T_i, \tag{4}$$

$$k_H + k_L = \kappa + br. \tag{5}$$

Under these conditions, the amount of capital in country i and the capital price on the market are respectively derived as follows:

$$k_i = \frac{(1+2b)(A_i - T_i) - (A_j - T_j) + 2\kappa}{4(1+b)}, \tag{6}$$

$$r = \frac{2(A - \kappa) - T_H - T_L}{2(1+b)}. \tag{7}$$

3 Equilibrium

3.1 Timing Game

Following K-RG, Ogawa (2013), Hindriks and Nishimura (2015, 2017), and Ogawa and Susa (2017), we consider the timing game introduced by Hamilton and Slutsky (1990). This timing game has two stages: period announcement and tax determination. In the period announcement stage, the governments of countries H and L have two possible time periods—*First* and *Second*—for the choice of a tax rate. Both

[4] The capital price in the world market, r^*, is exogenously given and constant, so this assumption does not make any substantial changes in the results obtained this analysis.

Country H / Country L	First	Second
First	u_H^N, u_L^N	u_H^{FS}, u_L^{FS}
Second	u_H^{SF}, u_L^{SF}	u_H^N, u_L^N

Table 1. Payoff Matrix

Note. The first (second) coordinate in each pair is the utility in country H (L).

governments simultaneously decide and announce the period in which they will choose the tax rate. Subsequently, during the tax determination stage, they have to choose their tax rates in only one of these two periods, recognizing the period in which the other government decides its tax rate.

If both governments set their tax rates in the same period, a simultaneous-move game emerges for tax competition. This game is denoted as G^N. If the governments decide to set their tax rates in different periods from each other, a sequential-move (or Stackelberg) game emerges. If country H is the first mover and country L the second, we denote this game as G^{FS}. Similarly, when country H is the second mover and country L the first, we denote this game as G^{SF}. Based on a comparison of residents' utilities, the SPEs of this timing game can be derived.

Table 1 shows the payoff matrix in the timing game. The superscripts are relevant to the game for which the variables are derived (e.g., u_H^N is the utility of a resident in country H in game G^N). These notations are also applied in the subsequent analysis.

3.2 Equilibria of the Second Stage

3.2.1 Game G^N: Simultaneous-Move Game

There are two possibilities for the simultaneous-move game: both governments choose either the first or second period. As preliminary results for the main argument of this study, we derive a lemma that shows the tax rates, the amounts of capital, and utilities of the residents in both countries:

Lemma 1. *The tax rates, when chosen simultaneously by both countries, are as follows:*

$$T_H^N = \frac{4b(1+b)(A_H-\kappa)+2\varepsilon(1+2b)}{4(1+b)(1+4b+2b^2)} \, (>0), \tag{8}$$

$$T_L^N = \frac{4b(1+b)(A_L-\kappa)-2\varepsilon(1+2b)}{4(1+b)(1+4b+2b^2)} \left(\gtrless 0 \Leftrightarrow \frac{\varepsilon}{A-\kappa} \lessgtr \frac{2b(1+b)}{1+4b+2b^2} \right). \tag{9}$$

Then, the amounts and the price of capital in the equilibrium are yielded as

$$k_H^N = \frac{\kappa}{2} + \frac{(1+2b)T_H^N}{2} \left(> \frac{\kappa}{2} \right), \tag{10}$$

$$k_L^N = \frac{\kappa}{2} + \frac{(1+2b)T_L^N}{2} \left(\gtrless \frac{\kappa}{2} \Leftrightarrow T_L^N \gtrless 0 \right), \tag{11}$$

$$r^N = \frac{(1+2b)(A-\kappa)}{1+4b+2b^2}. \tag{12}$$

Finally, the utilities of the residents in each country are obtained as

$$
\begin{aligned}
u_H^N &= \frac{(1+2b)(3+2b)(T_H^N)^2}{4} + \frac{(2A_H-\kappa)\kappa}{4}, \quad (13)\\
u_L^N &= \frac{(1+2b)(3+2b)(T_L^N)^2}{4} + \frac{(2A_L-\kappa)\kappa}{4}. \quad (14)
\end{aligned}
$$

Proof. See Appendix A.

From (8)-(9) and (10)-(11), it can be pointed out that, when $\varepsilon/(A-\kappa) < 2b(1+b)/(1+4b+2b^2)$, the both countries import capital and levy tax on capital employed in each country; $k_i^N > \kappa/2$ and $T_i^N > 0$. Contrarily, when $\varepsilon/(A-\kappa) > 2b(1+b)/(1+4b+2b^2)$, only country H imports capital and levy tax ($k_H^N > \kappa/2$ and $T_H^N > 0$), and country L exports capital and provides subsidy to capital ($k_L^N < \kappa/2$ and $T_L^N < 0$).

3.2.2 Game G^{FS}: H Leads, L Follows

There are two cases for a sequential-move game in our model: one country chooses first and the other second. First, we derive the equilibrium values in game G^{FS}, where country H moves first to choose its tax rate, and country L follows.

Lemma 2. *When country H leads and country L follows, the tax rates are as follows:*

$$
\begin{aligned}
T_H^{FS} &= \frac{2(1+b)\left[4b(1+b)(A_H-\kappa)+2\varepsilon(1+2b)\right]}{(1+6b+4b^2)(5+10b+4b^2)} \,(>0)\,, \quad (15)\\
T_L^{FS} &= \frac{2b(1+2b)(3+2b)(A_L-\kappa)}{(1+6b+4b^2)(5+10b+4b^2)} - \frac{2\varepsilon}{5+10b+4b^2} \quad (16)\\
&\left(\gtrless 0 \Leftrightarrow \frac{\varepsilon}{A-\kappa} \lessgtr \frac{b(1+2b)(3+2b)}{(1+b)(1+8b+4b^2)}\right).
\end{aligned}
$$

Then, the amounts and the price of capital in the equilibrium are yielded as

$$
\begin{aligned}
k_H^{FS} &= \frac{\kappa}{2} + \frac{(1+6b+4b^2)T_H^{FS}}{4(1+b)} \left(> \frac{\kappa}{2}\right), \quad (17)\\
k_L^{FS} &= \frac{\kappa}{2} + \frac{(1+2b)T_L^{FS}}{2} \left(\gtrless \frac{\kappa}{2} \Leftrightarrow T_L^{FS} \gtrless 0\right), \quad (18)\\
r^{FS} &= \frac{2(3+2b)(1+2b)^2(A-\kappa)-(A_H-\kappa)}{(1+6b+4b^2)(5+10b+4b^2)}. \quad (19)
\end{aligned}
$$

Finally, the utilities of the residents in each country are obtained as

$$
\begin{aligned}
u_H^{FS} &= \frac{(1+6b+4b^2)(5+10b+4b^2)(T_H^{FS})^2}{16(1+b)^2} + \frac{(2A_H-\kappa)\kappa}{4}, \quad (20)\\
u_L^{FS} &= \frac{(1+2b)(3+2b)(T_L^{FS})^2}{4} + \frac{(2A_L-\kappa)\kappa}{4}. \quad (21)
\end{aligned}
$$

Proof. See Appendix B.

From (15)-(16) and (17)-(18), it can be pointed out that, when $\varepsilon/(A-\kappa) < [b(1+2b)(3+2b)/(1+b)(1+8b+4b^2)]$, the both countries import capital and levy tax on capital employed in each country; $k_i^{FS} > \kappa/2$ and $T_i^{FS} > 0$. Contrarily, when $\varepsilon/(A-\kappa) > [b(1+2b)(3+2b)/(1+b)(1+8b+4b^2)]$, only country H imports capital and levy tax ($k_H^{FS} > \kappa/2$ and $T_H^{FS} > 0$), and country L exports capital and provides subsidy to capital ($k_L^{FS} < \kappa/2$ and $T_L^{FS} < 0$).

3.2.3 Game G^{SF}: H follows, L leads

Lemma 3 summarizes the results of the Stackelberg games. We derive the tax rates and utilities of residents for game G^{SF}, where country L moves first to choose its tax rate and country H follows.

Lemma 3. *When country L leads and country H follows, the tax rates and utilities of residents are as follows:*

$$
\begin{aligned}
T_H^{SF} &= \frac{2b(1+2b)(3+2b)(A_H-\kappa)}{(1+6b+4b^2)(5+10b+4b^2)} + \frac{2\varepsilon}{5+10b+4b^2}\,(>0)\,, && (22)\\
T_L^{SF} &= \frac{2(1+b)\left[4b(1+b)(A_L-\kappa)-2\varepsilon(1+2b)\right]}{(1+6b+4b^2)(5+10b+4b^2)} && (23)\\
\Big(&\gtrless 0 \Leftrightarrow \frac{\varepsilon}{A-\kappa} \lessgtr \frac{2b(1+b)}{1+4b+2b^2}\Big).
\end{aligned}
$$

Then, the amounts and the price of capital in the equilibrium are yielded as

$$
\begin{aligned}
k_H^{SF} &= \frac{\kappa}{2} + \frac{(1+2b)T_H^{SF}}{2}\left(> \frac{\kappa}{2}\right), && (24)\\
k_L^{SF} &= \frac{\kappa}{2} + \frac{(1+6b+4b^2)T_L^{SF}}{4(1+b)}\left(\gtrless \frac{\kappa}{2} \Leftrightarrow T_L^{SF} \gtrless 0\right), && (25)\\
r^{SF} &= \frac{2(3+2b)(1+2b)^2(A-\kappa)-(A_L-\kappa)}{(1+6b+4b^2)(5+10b+4b^2)}. && (26)
\end{aligned}
$$

Finally, the utilities of the residents in each country are obtained as

$$
\begin{aligned}
u_H^{SF} &= \frac{(1+2b)(3+2b)(T_H^{SF})^2}{4} + \frac{(2A_H-\kappa)\kappa}{4}, && (27)\\
u_L^{SF} &= \frac{(1+6b+4b^2)(5+10b+4b^2)(T_L^{SF})^2}{16(1+b)^2} + \frac{(2A_L-\kappa)\kappa}{4}. && (28)
\end{aligned}
$$

Proof. See Appendix C.

From (22)-(23) and (24)-(25), it can be pointed out that, when $\varepsilon/(A-\kappa) < 2b(1+b)/(1+4b+2b^2)$, the both countries import capital and levy tax on capital employed in each country; $k_i^{SF} > \kappa/2$ and $T_i^{SF} > 0$. Contrarily, when $\varepsilon/(A-\kappa) > 2b(1+b)/(1+4b+2b^2)$, only country H imports capital and levy tax ($k_H^{SF} > \kappa/2$ and $T_H^{SF} > 0$), and country L exports capital and provides subsidy to capital ($k_L^{SF} < \kappa/2$ and $T_L^{SF} < 0$).

3.3 SPEs of Timing Game

We obtain the SPEs of this timing game from the lemmas and a comparison of the residents' utilities. The main results can be summarized as follows:

Proposition 1. *In the timing game, we derive three types of equilibria based on the technological asymmetry between the two countries and magnitude of exogenous capital supply. The equilibria are classified as follows:*

(i) *When* $T_H^N - T_H^{SF} < 0$ *and* $T_L^N + T_L^{FS} > 0$*, there are two sequential-move equilibria: one country chooses its tax rate in the first period and the other in the second period,*

(ii) *When* $T_H^N - T_H^{SF} > 0$ *and* $T_L^N + T_L^{FS} > 0$*, there is one sequential-move equilibrium: country H chooses its tax rate in the first period and country L in the second period,*

(iii) *When* $T_H^N - T_H^{SF} > 0$ *and* $T_L^N + T_L^{FS} < 0$*, there is one simultaneous-move equilibrium: both countries choose their tax rates in the same (i.e., the first) period.*

Proof. See Appendix D.

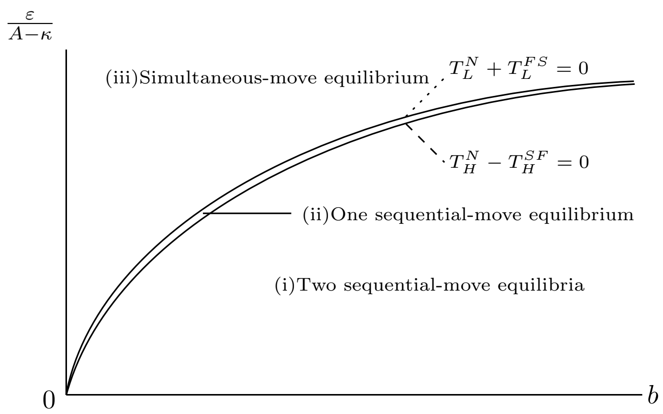

Figure 1: Equilibrium classification

Figure 1 graphically depicts our results. Areas (i) to (iii) in the figure correspond to propositions (i) to (iii). Note that (iii) corresponds to Ogawa (2013), particularly when there is no exogenous capital inflow ($b = 0$).

Overall, the simultaneous-move outcome is derived when the asymmetry between the two countries is large and b is small. However, the Stackelberg outcome is derived with little asymmetry between the countries and large b.[5]

To interpret the result in Figure 1, we need to distinguish between two types of incentive for the governments to control for tax rate T_i: I) both governments have the incentive to attract exogenous capital and achieve more domestic production by lowering the capital tax rate, and II) each government has the incentive to control for the price of capital on the market, depending on the position of the country (i.e., whether the country is a capital exporter or importer in each sub-game), which is called the terms of trade effect.[6] These are reflected in the first and second terms of the utility function, $u_i = (A_i - k_i)k_i + r(\kappa/2 - k_i)$, respectively. Additionally, the former is the factor for a community of interest, while the latter is the factor for a conflict of interest between the two countries. The type

[5] In the literature of tax competition, there are many papers in which Stackelberg game is assumed (e.g. Gordon (1992), Wang (1999), Baldwin and Krugman (2004), Konrad (2009), and so forth). However, Ogawa (2013) shows that simultaneous setting is commitment-robust, particularly when countries under tax competition are asymmetric. The result obtained in the present study implies that Stackelberg game setting could be supported when the effect of asymmetry is overwhelmed by some other factor, as the existence of capital inflow from the outside here.

[6] From (7), the capital price on the market is decreased (increased) if the tax rate in a country increases (decreases): $\partial r/\partial T_i < 0$. Hence, if a country is a capital importer (exporter), meaning that its capital endowment is lower (higher) than the capital employed per capita in the country at equilibrium, the government has an incentive to decrease (increase) the capital price by increasing (decreasing) the tax rate in that country.

of equilibrium emerging as SPE depends on whether the community or conflict of interest are more significant compared to the other.

As is well known in the literature on endogenous timing games, the emergence of the sequential-move game depends on whether the second mover can derive a benefit from and accept the choice of the first mover. If there is not much benefit (or some damage) for the second mover, it refuses to become the second mover and the simultaneous-move game emerges as SPE as a result of the timing game. As mentioned above, the first-mover advantage in this model is that it can manipulate the price of capital by changing the tax rate. On one hand, if a government wants to attract capital from other countries, it can raise the price of capital on the market by lowering the tax rate. On the other hand, if a government, as capital importer (exporter), wants to lower (raise) the price of capital, it has the incentive to set a higher (lower) tax rate.

When $b = 0$, there is no exogenous capital investment. This implies that both governments do not have the incentive to attract exogenous capital and just compete for the initial capital owned by themselves. As a result, their positions are clearly separated and their incentives for manipulating the price of capital differ: country H becomes a capital importer due to its higher level of technology and wants to set a higher tax rate, while country L becomes a capital exporter due to its lower level of technology and wants to set a lower tax rate. Only a conflict of interest exists between the two countries; thus, one country cannot accept the action of the other as first mover. Therefore, the simultaneous-move equilibrium as the SPE of this timing game emerges only when $b = 0$.

However, if $b > 0$, as shown in Figure 1, capital can also be supplied from outside of the two countries, so both governments have a common incentive to attract capital: to increase their domestic production. In this case, there is not only a conflict of interest between the capital importer and exporter, but also a community of interest between the two governments. Particularly, in the area close to the horizontal axis, where regional asymmetry is not large, the community of interest dominates the conflict of interest: one country can accept the action of the other country as the first mover, hence the sequential-move equilibria emerge as the SPE. Nevertheless, when regional asymmetry is sufficiently large, the conflict of interest dominates the community of interest and a simultaneous-move outcome emerges.

Additionally, we examine the case when b increases or exogenous capital is more likely to respond to the rate of return on the market. The results can be summarized as follows:

Proposition 2. *As b increases, the classification of the equilibrium described changes as follows:*

(i') *Area (i) in Figure 1 widens, which implies that a two-sequential-move-equilibria is more likely to emerge as the SPEs of this timing game,*

(ii') *Area (ii) in Figure 1 is reduced, which implies that the one-sequential-move-equilibrium is less likely to emerge as the SPEs of this timing game, and eventually vanishes,*

(iii') *Area (iii) in Figure 1 is reduced, which implies that the simultaneous-move-equilibrium is less likely to emerge as the SPEs of this timing game.*

Proof. See Appendix E.

This result can be interpreted in the same manner as above. When the capital market between the two countries is more open for exogenous investment, one government, which is a potential second mover, is more likely to accept the action of the other government as first mover, because both governments have the same incentive to attract capital through manipulating the price of capital on the market.

4 Concluding Remarks

In this study, we re-examined endogenous leadership in an asymmetric tax competition model, focusing on the role of capital supply. Particularly, we modelled a situation where the capital owner resides not only in the two countries, but also potentially outside the economy, so the amount of capital competed between the two countries depends on the return to capital or the price capital on the market. This setting enables us to consider the incentives of the governments to attract capital from outside the economy.

We found that the SPEs of this timing game are classified as follows: i) two sequential-move outcomes emerge or one country leads and sets a tax policy and the other follows; ii) one sequential outcome emerges or the country with higher level of production technology leads and the country with lower level of production technology follows; or iii) one simultaneous-move outcome emerges or both governments set their tax policies at the same time. Additionally, when exogenous capital is more responsive to the return to capital on the market, an SPE of type i) is more likely to emerge.

In closing the paper, we mention the reasons and limitations of specifying functions in this paper. First is that the production function is specified as a quadratic function form. While there is a disadvantage of losing generality, this function form has been often and widely used in the tax competition literature [Keen and Konrad (2013, p.270)]. This is mainly because the marginal product of capital is obtained as a linear function of the capital labor ratio under the specific function, which enables us to solve the model analytically. Under other specific form of production functions, it is difficult to obtain a closed form solution, and therefore it is necessary to rely on analysis using simulation technique. In addition to this advantage, a linear relationship between tax rate and capital demand under the quadratic form of production function has the advantage of matching theoretical and empirical models since the estimation of the impact of tax rate on capital demand is often conducted under linear regression. Second is the specification of utility function. In our model, public goods is omitted from the analysis by assuming tax revenues are transferred to the residents in a lump manner. This setting has been also used in the literature, but it lacks a little generality. However, following Bucovetsky (2009) and Eichner (2014), our analysis can be extended to include the public goods by specifying the utility function as $u_i = c_i+(1+\gamma)g_i$, where $\gamma(\geq 0)$ denotes the preference for public goods. Then, we can expect our conclusions to be invariant even with a more general model that includes γ. The reason is as follows: The stronger the preference for public goods (compared with the private goods), i.e., the greater γ, the relatively less important the utility obtained from capital income, $r\kappa/2$ in (1) in Section 2. Therefore, the greater the preference for public goods, the lower the incentive for each country to manipulate interest rates. This lowers the incentive for the country to move first, and ultimately reduces the likelihood of having a simultaneous-move outcome. That is, in Figure 1, the generalization of the utility function by accounting for public goods has the quantitative effect of reducing the area where simultaneous-move outcome appears and instead expanding the area where sequential-move outcome occurs. At the same time, however, it means that all the qualitative results in the paper remain unchanged, with the main result that the sequential-move outcome is more likely to prevail as b increases.

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Appendices

Appendix A. First, we begin with game G^N, where the two governments determine their tax rates simultaneously. The maximization problem of the government of country i is

$$\begin{aligned} \max_{T_i} \quad & u_i(c_i) = (A_i - k_i)k_i + r\left(\frac{1}{2}\kappa - k_i\right), \\ \text{s.t.} \quad & (6) \text{ and } (7). \end{aligned}$$

The tax rates for the equilibrium of this game can be derived by solving the following simultaneous equations, consisting of the reaction functions of countries H and L, which are derived from the maximization problems above, respectively:

$$T_H(T_L) = \frac{T_L + 2b(A_H - \kappa) + 2\varepsilon}{(1+2b)(3+2b)}, \tag{29}$$

$$T_L(T_H) = \frac{T_H + 2b(A_L - \kappa) - 2\varepsilon}{(1+2b)(3+2b)}. \tag{30}$$

Therefore, we obtain (8) and (9). By substituting (8) and (9) into (6) and (7), we obtain the equilibrium values as in (10)-(12).

Using (10)-(12), we derive the utilities of residents in countries H and L in the simultaneous-move game as in (13) and (14).

Appendix B. Here, we derive the sequential equilibrium in game G^{FS}, where country H leads and country L follows. The maximization problem of the government of country H is

$$\begin{aligned} \max_{T_H} \quad & u_H(c_H) = (A_H - k_H)k_H + r\left(\frac{1}{2}\kappa - k_H\right), \\ \text{s.t.} \quad & (6), \ (7), \text{ and } (30). \end{aligned}$$

The first-order condition gives the equilibrium tax rate of country H as (15). Substituting (15) into (30) gives the equilibrium tax rate of country L as (16). Similarly, using the equilibrium tax rate, we obtain the equilibrium values as in (17)-(19).

From (17)-(19), we derive the utilities of the residents of country H and L in the sequential-move game G^{FS} as in (20) and (21).

Appendix C. Finally, we derive the equilibrium of the sequential-move game G^{SF}, where country L leads and country H follows. The maximization problem of the government of country L is:

$$\begin{aligned} \max_{T_L} \quad & u_L(c_L) = (A_L - k_L)k_L + r\left(\frac{1}{2}\kappa - k_L\right), \\ \text{s.t.} \quad & (6), \ (7), \text{ and } (29). \end{aligned}$$

The first-order condition yields the equilibrium tax rate of country L as (23). Substituting (23) into (29), we obtain the equilibrium tax rate of country H as (22). The equilibrium values are derived from the equilibrium tax rates as in (24)-(26).

From (24)-(26), the utilities of the residents in countries H and L in the sequential-move game G^{SF} are (27) and (28).

Appendix D. To derive the SPEs of this timing game, we compare the utilities of residents in the two countries. First, the utilities of residents of country H can be compared as follows:

$$
\begin{aligned}
u_H^{FS} - u_H^N &= \frac{\left[4b(1+b)(A_H-\kappa)+2\varepsilon(1+2b)\right]^2}{64(1+6b+4b^2)(5+10b+4b^2)(1+b)^2(1+4b+2b^2)^2}, \\
\therefore u_H^{FS} &> u_H^N, \qquad (31)\\
u_H^N - u_H^{SF} &= \frac{(1+2b)(3+2b)(T_H^N+T_H^{SF})(T_H^N-T_H^{SF})}{4}, \\
\therefore u_H^N &\gtreqless u_H^{SF} \Leftrightarrow (T_H^N+T_H^{SF})(T_H^N-T_H^{SF}) \gtreqless 0, \qquad (32)
\end{aligned}
$$

where

$$
\begin{aligned}
T_H^N + T_H^{SF} &\equiv \frac{(A-\kappa)(9+80b+168b^2+128b^3+32b^4)}{2(1+b)(1+6b+4b^2)(5+10b+4b^2)} \\
&\quad \times \left[\frac{2b(1+b)(11+80b+168b^2+128b^3+32b^4)}{(1+4b+2b^2)(9+80b+168b^2+128b^3+32b^4)} + \frac{\varepsilon}{A-\kappa}\right], \\
T_H^N - T_H^{SF} &\equiv -\frac{A-\kappa}{2(1+b)(1+6b+4b^2)(5+10b+4b^2)} \times \left[\frac{2b(1+b)}{1+4b+2b^2} - \frac{\varepsilon}{A-\kappa}\right].
\end{aligned}
$$

Under assumption $\varepsilon > 0$ and $r^N = \frac{(1+2b)(A-\kappa)}{1+4b+2b^2} > 0$, $T_H^N + T_H^{SF} > 0$ holds. Hence, (32) can be reduced to

$$
u_H^N \gtreqless u_H^{SF} \Leftrightarrow T_H^N - T_H^{SF} \gtreqless 0. \qquad (33)
$$

Then, the utilities of residents of country L can be compared as follows:

$$
\begin{aligned}
u_L^{SF} - u_L^N &= \frac{\left[4b(1+b)(A_L-\kappa)-2\varepsilon(1+2b)\right]^2}{64(1+6b+4b^2)(5+10b+4b^2)(1+b)^2(1+4b+2b^2)^2}, \\
\therefore u_L^{SF} &> u_L^N, \qquad (34)\\
u_L^N - u_L^{FS} &= \frac{(1+2b)(3+2b)(T_L^N+T_L^{FS})(T_L^N-T_L^{FS})}{4}, \\
\therefore u_L^N &\gtreqless u_L^{FS} \Leftrightarrow (T_L^N+T_L^{FS})(T_L^N-T_L^{FS}) \gtreqless 0, \qquad (35)
\end{aligned}
$$

where

$$
\begin{aligned}
T_L^N + T_L^{FS} &\equiv \frac{(A-\kappa)(9+80b+168b^2+128b^3+32b^4)}{2(1+b)(1+6b+4b^2)(5+10b+4b^2)} \\
&\quad \times \left[\frac{2b(1+b)(11+80b+168b^2+128b^3+32b^4)}{(1+4b+2b^2)(9+80b+168b^2+128b^3+32b^4)} - \frac{\varepsilon}{A-\kappa}\right], \\
T_L^N - T_L^{FS} &\equiv -\frac{A-\kappa}{2(1+b)(1+6b+4b^2)(5+10b+4b^2)} \times \left[\frac{2b(1+b)}{1+4b+2b^2} + \frac{\varepsilon}{A-\kappa}\right].
\end{aligned}
$$

Similarly, under assumption $\varepsilon > 0$ and $r^N = \frac{(1+2b)(A-\kappa)}{1+4b+2b^2} > 0$, $T_L^N - T_L^{FS} < 0$ holds. Hence, (35) can be reduced to

$$
u_L^N \gtreqless u_L^{FS} \Leftrightarrow T_L^N + T_L^{FS} \lesseqgtr 0. \qquad (36)
$$

Therefore, in the domain of definition, we have three areas of the SPEs of this timing game: i) when $T_H^N - T_H^{SF} < 0 \Leftrightarrow u_H^N < u_H^{SF}$ and $T_L^N + T_L^{FS} > 0 \Leftrightarrow u_L^N < u_L^{FS}$, there exist two sequential-move equilibria, where one country leads and the other follows; ii)when $T_H^N - T_H^{SF} > 0 \Leftrightarrow u_H^N > u_H^{SF}$ and $T_L^N + T_L^{FS} > 0 \Leftrightarrow u_L^N < u_L^{FS}$, there exists one sequential-move equilibrium, where country H leads and country L follows; and iii) when $T_H^N - T_H^{SF} > 0 \Leftrightarrow u_H^N > u_H^{SF}$ and $T_L^N + T_L^{FS} < 0 \Leftrightarrow u_L^N > u_L^{FS}$, there exists one simultaneous-move equilibrium, where the two countries determine their tax rates in the first period.

In particular, when $b = 0$, $u_H^N - u_H^{SF} = u_L^N - u_L^{FS} = 27\varepsilon^2/400 > 0$. Considering the fact that (31) and (34) always hold, it can be pointed out that only the simultaneous-move equilibrium emerges in the domain of definition.

Appendix E. As shown in Figure 1, line $T_H^N - T_H^{SF} = 0$ on the b and $\varepsilon/(A-\kappa)$ plane can be expressed as:

$$\frac{\varepsilon}{A-\kappa} = \frac{2b(1+b)}{1+4b+2b^2}.$$

Then, we examine the changes in its slope as b increases:

$$\frac{d}{db}\left(\frac{2b(1+b)}{1+4b+2b^2}\right) > 0 \text{ and } \frac{d^2}{db^2}\left(\frac{2b(1+b)}{1+4b+2b^2}\right) < 0,$$

which indicates that the slope of line $T_H^N - T_H^{SF} = 0$ becomes less steep. To identify the value when b is sufficiently large, we take the limit as:

$$\lim_{b\to\infty}\left(\frac{2b(1+b)}{1+4b+2b^2}\right) = 1.$$

Hence, line $T_H^N - T_H^{SF} = 0$ eventually converges to 1.

Similarly, line $T_L^N + T_L^{FS} = 0$ on the b and $\varepsilon/(A-\kappa)$ plane is expressed as:

$$\frac{\varepsilon}{A-\kappa} = \frac{2b(1+b)(11+80b+168b^2+128b^3+32b^4)}{(1+4b+2b^2)(9+80b+168b^2+128b^3+32b^4)}.$$

Then, we examine the changes in its slope as b increases:

$$\frac{d}{db}\left(\frac{2b(1+b)(11+80b+168b^2+128b^3+32b^4)}{(1+4b+2b^2)(9+80b+168b^2+128b^3+32b^4)}\right) > 0,$$
$$\frac{d^2}{db^2}\left(\frac{2b(1+b)(11+80b+168b^2+128b^3+32b^4)}{(1+4b+2b^2)(9+80b+168b^2+128b^3+32b^4)}\right) < 0,$$

which indicates that the slope of line $T_L^N + T_L^{FS} = 0$ becomes less steep. To determine the value when b is sufficiently large, we consider the limit as:

$$\lim_{b\to\infty}\left(\frac{2b(1+b)(11+80b+168b^2+128b^3+32b^4)}{(1+4b+2b^2)(9+80b+168b^2+128b^3+32b^4)}\right) = 1.$$

Hence, line $T_L^N + T_L^{FS} = 0$ eventually converges to 1.

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