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Tax Competition and Fiscal Sustainability

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Abstract

By constructing a two-country endogenous growth model with a debt-financing government, this study examines the relationship between the sustainability of public finance and increases in inter-regional factor mobility. To this end, it identifies the minimum tax rate that ensures fiscal sustainability in the tax competition environment and the effects of capital tax competition on fiscal sustainability. The main findings are as follows: (i) when countries are symmetric, increasing capital flows encourages accumulation of capital through tax reduction derived from tax competition and promotes economic growth through the expansion of Romer-type knowledge spillovers, resulting in increased fiscal sustainability in all countries; and (ii) when there are significant differences between countries in initial debt outstanding, tax competition might lower fiscal sustainability in a country that has a relatively large outstanding debt.

Keywords: Tax competition; Fiscal sustainability

JEL Classification Codes: E62, F21, F62, H63

1 Introduction

The European debt crisis at the end of 2009 still has a tail. As an extreme case, the Greek debt outstanding stood at 177% of GDP in 2015. Five countries in the EU still have outstanding debt that exceeds their GDPs and 21 have been unable to keep their debt-to-GDP ratios below 60%, the threshold agreed under the Maastricht Treaty. Fiscal consolidation thus remains a policy concern for EU members, as well as other large countries such as the United States and Japan, who also face the need to pursue fiscal discipline for fiscal consolidation.[1]

Fiscal sustainability is an age-old topic in the economic literature. The classic analysis of Domar (1944) states that economic growth is necessary to avoid debt accumulation diverging, and Bohn (1998) proposes a new condition for fiscal sustainability associated with primary surplus and debt-to-GDP ratios. Recent theoretical studies have also extended their analyses to incorporate practical policy rules, such as the well-known 60% rule in the Maastricht Treaty, and examine the effects of such rules on debt sustainability. Our study also concerns fiscal sustainability, but extends the analysis in a different direction. Specifically, we construct a two-country model with a debt-financing government to focus on the relationship between the sustainability of public finance and increases in factor mobility accompanied by market integration. While experiencing a rapid increase in debt accumulation and a sovereign crisis, we also observe a consistent increase in international trade and factor mobility. In particular, triggered by the establishment of a single market in Europe, the liberalization of the financial market has fostered significant capital mobility. To capture how this increased factor mobility has affected fiscal sustainability, we assess the cross-border movement of capital, which leads to a tax-cut game among countries, known as interregional tax competition [Zodrow and Mieszkowski (1986) and Wilson (1986)].

Since the early 1990s, European countries have faced severe tax competition over mobile capital, forcing them to lower capital-related tax rates markedly. For instance, Overesch and Rincke (2011) show that the mean statutory corporate tax rate in the EU in 2006 would have been 40% in the absence of tax competition compared with the actual level of 27.5%. By comparing the data on 1983 and 1997 and using a virtual experimental technique, Devereux et al. (2008) also find that the entire fall in average statutory tax rates among 21 OECD countries can be explained by the more intense competition induced by the relaxation of capital controls. These facts arouse our interest on tax competition and fiscal sustainability. Since the interregional competition for mobile capital lowers the tax rate in each country and, thus, force countries to rely on bond-financing management, it is expected that the integration of capital markets would lead to financial deterioration. However, in fact, many countries have experiences this situation without falling into financial catastrophe. The question is why can they avoid the fiscal collapse despite the falling tax rate? In a model in which governments compete for mobile capital in a single market, which results in the familiar tax-cut competition, this study identifies the major factors that affect sustainability and suggests a rule for a minimum tax rate that ensures fiscal sustainability in the tax competition setting.

Our work is closely related to at least two studies. First, Chang (1990) presents a model of a dynamic game at an early stage to show that, in a world with internationally mobile capital, the debt issued by any government is excessive in a non-cooperative equilibrium. The author explains that, in a world in which financial capital is mobile across countries, the debt issued by any government affects global interest rates and, thus, real allocations in all countries, generating externality, which is ignored in a non-cooperative

[1]The United States recorded a government debt equivalent to 106% of its GDP in 2016 compared to about 60% ten years ago, while government debt to GDP in Japan reached 250% in 2016, an all-time high.

policy regime.[2] Second, Azzimonti et al. (2014) propose a model to show that financial liberalization and the increasing income inequality can drive an increase in government borrowing. The key mechanism behind their main result that government borrowing responds positively to the liberalization of financial markets globally is that a country on the integrated financial market faces a lower elasticity of interest rate with respect to government borrowing since, in an integrated financial market, the government can borrow not only from domestic investors but also from the international market. Hence, the interest rate is less responsive to the increase in bond issuing, which provides an incentive for governments to increase borrowing.

In contrast to our work, the two preceding studies focus on how financial capital mobility changes the optimal debt policy of each country and its efficiency, whereas we focus on the sustainability of public finance. Moreover, while they assume that government debt is sustainable no matter how high the debt outstanding is, our analysis clarifies the condition that ensures the sustainability of public finance in the presence of interregional competition for mobile capital. Furthermore, we adopt a different modeling strategy by using an endogenous growth model, whereas the effect of unilateral government borrowing on the global interest rate is central to their analyses. For instance, a larger fiscal deficit for any government implies an increase in the global interest rate, which further deters government borrowing in Azzimonti et al. (2014) and imposes a negative externality in Chang (1990). However, both analyses overlook the possibility that the rising global interest rates will increase savings and encourage economic growth through capital accumulation, thereby positively affecting fiscal sustainability. To incorporate this growth-enhancing effect pointed out by Hatfield (2015) into the analysis, our study departs from non-growth models.

While the structure of our model differs considerably from those of Chang (1990) and Azzimonti et al. (2014), it is indeed much closer to the series of debt sustainability analyses that have been presented under the endogenous growth framework.[3] However, in most of the studies examining debt sustainability using endogenous growth models, the analysis is based on a single country framework, in which the country to be analyzed has no explicit relationship with neighboring countries.[4] This is somewhat restrictive because the financial market has been highly integrated, especially in the Eurozone and, thus, a crisis in any country can subsequently spread to other countries. Contrastingly, in this study, we explore fiscal sustainability by considering cross-border capital mobility accompanied by capital market integration in a two-country model and argue that interregional competition for mobile capital may increase or decrease fiscal sustainability in each country. Indeed, in a world connected by trade and factor mobility, the fiscal policy of one country can easily affect other countries, meaning that the interdependence of fiscal policies influences fiscal sustainability.

[2]Specifically, an increase in the fiscal deficit of one country benefits the current generation but harms future generations in that country because of the increase in the taxes needed to repay government debt. When the capital market is integrated and, thus, capital is mobile across countries, the increase in the deficit of one country also imposes a heavier tax burden on the future generations of other countries because it results in a higher global interest rate, which increases the service of debt of the foreign countries.

[3]The following studies examine the effects of fiscal debt policies on stability, growth, and welfare: Saint-Paul (1992), Bruce and Turnovsky (1999), Josten (2000), Bräuninger (2005), Greiner and Semmler (2000), Ghosh and Mourmouras (2004), Greiner (2007, 2011, 2012a, 2012b), Yakita (2008), Futagami et al. (2008), Arai (2011), Kamiguchi and Tamai (2012), Minea and Villieu (2012, 2013), Teles and Mussolini (2014), and Maebayashi et al. (2017). See Greiner and Fincke (2015) for a comprehensive analysis on this approach.

[4]Some exceptions are noteworthy. For instance, Morimoto et al. (2017) deal with debt sustainability in a small-open economy. However, they do not analyze the relationship between interregional competition for mobile factors and sustainability.

The present study is also related to the literature on the political economy of debt policies [Persson and Svensson (1989), Tabellini and Alesina (1990)] and debt policy for tax smoothing [Barro (1979)].[5] In the former context, public debt is used strategically based on political speculation, such as political turnover and budget acquisition. In the latter models, public debt is issued in response to economic fluctuations and used to minimize the distortionary effects of taxation. This study abstracts business cycles and political aspects from the model, and instead assumes a benevolent government that issues debt to fill the tax revenue shortfall resulting from the tax-cut competition. Then, it focuses on the possibility that even the benevolent government may adopt policies that lower fiscal sustainability once it engages in capital tax competition in the integrated market.

Two other studies that relate to our work should also be mentioned. Hatfield (2015) shows the positive aspect of tax competition, in which a tax cut under interregional tax competition leads to a higher net return on investment, resulting in an increase in savings and economic growth through capital accumulation. Köthenbürger and Lockwood (2010) study the effects of tax competition in an endogenous growth model with an output shock and show that the presence of such a shock in regional outputs makes households face a portfolio choice, which eases competition for mobile capital and, thus, lowers the growth-enhancing effect of tax competition. These studies examine the impact of tax competition on long-run economic growth. However, our focus is not only on economic growth, but also on the impact of tax competition on fiscal sustainability. For that reason, we account for debt financing in public finance, which is a novel contribution to the literature.

We start by identifying the minimum tax rate (MTR) that ensures sustainable fiscal management in tax competition environment. The analysis suggests how far countries with different financial conditions can reduce their tax rates. Then, we argue that the increased mobility of capital lowers the MTR, meaning that, even if the governments are forced to lower the tax rate due to the interregional competition for mobile capital and conduct fiscal management that depends more on government bonds, such management allows them to maintain the same fiscal sustainability. In short, the reasons are as follows. On one hand, capital market integration induces countries to compete for mobile capital by cutting capital tax. This increases the net return to capital investment, which leads to an increase in capital accumulation. This further leads to an increase in GDP, making repaying the debt easier. On the other hand, countries receive greater positive externalities from the integrated market. Specifically, since they can now access a single market, they increase their productivity by receiving Romer-type knowledge spillovers. This increases the production in each country and affords the repayment of debt. Our theoretical hypothesis thus explains the fact that increased mobility of capital gives countries an incentive to lower the tax related to mobile capital or firms and may thus force them to rely on bond-financing management. Nevertheless, the production in each country measured by GDP expands and fiscal sustainability is somewhat maintained.[6]

This paper further examines the effects of capital market integration, focusing on two countries with different fiscal conditions. The difference in fiscal condition is characterized by the differences in initial outstanding debt, and the analyses show that an increase in capital flows through market integration

[5] The literature on the political economy of debt policy includes Peletier et al. (1999), Battaglini and Coate (2008), and Song et al. (2012). For the tax-smoothing literature, see the classical studies by Lucas and Stokey (1983) and Aiyagari et al. (2002), which show that Barro's argument in the deterministic setting still holds, even in a stochastic environment.

[6] The increase in outstanding debt and the decline in the corporate income tax rate occur simultaneously. For instance, the EU recorded a government debt equivalent to 89.3% of its GDP in 2015 [International Monetary Fund, Government Finance Statistics Yearbook]. Given this was 38.8% in 1991, the proportion of government debt in the GDP has more than doubled over the past 25 years. The average corporate income tax rate of EU members was 39.6% in 1991, whereas this decreased to about 24.7% in 2014 [OECD Tax Database].

results in capital outflows from the country with large initial debts, suggesting that the integration of the capital market does not necessarily have a positive effect on fiscal sustainability in countries with large debt outstanding.

The remainder of the paper is organized as follows. Section 2 presents the basic model. Section 3 characterizes the equilibrium, and the condition for debt sustainability is derived. We here present the minimum tax rate that guarantees fiscal sustainability for each country. Section 4 studies how the tax competition accompanied by capital market integration affects fiscal sustainability. Section 5 concludes the paper.

2 The model

There are two symmetric countries and, in each country i ($i = 1, 2$), there are homogeneous residents normalized to one. We assume they have high attachment to their location in that they never migrate between the two countries. They own one unit of labor, which is supplied in the country of residence. The economy has a stock of capital that is perfectly mobile among countries. It is a natural argument that capital mobility leads each country's government to compete for mobile capital by using a tax/subsidy policy. This induces governments to finance their expenditure by using capital tax and government bonds.

2.1 Firms

The production of private goods in country $i(= 1, 2)$ requires capital and labor. We assume that production in country i is conducted by the function

$$Y_i = \xi K_i^{\alpha}(X_i L_i)^{1-\alpha}, \tag{1}$$

where $\xi(> 0)$ and $\alpha \in (0, 1)$ are the parameters, K_i is the amount of capital located in country i, and L_i is the amount of labor inputs. X_i denotes labor efficiency, which will be explained later.

Profit maximization in competitive markets in country i yields

$$r_i = (1 - \tau_i)\alpha \frac{Y_i}{K_i} \text{ and } w_i = (1 - \alpha)\frac{Y_i}{L_i}, \tag{2}$$

where r_i and w_i are, respectively, the after-tax interest rate and wage rate, and τ_i is the tax rate on interest income in country i.

Although labor is immobile, capital moves freely across the two countries. Hence, if we denote K as the amount of capital that exists in the world at a certain moment, $K = K_1 + K_2$ holds. Following Romer (1986), we analyze an environment in which knowledge spillovers relating to production techniques exist. In this case, labor efficiency can be assumed to depend on the level of capital in the world, K, and the number of countries, n; $X = K/n^{\nu}$, where $\nu \in [0, 1]$ and $n = 2$ in our model. Since capital markets are integrated, the knowledge spillover effect is beneficial to the two countries in the integrated market. On the contrary, if the countries wish to access knowledge, they might face congestion, which is represented by ν; if $\nu = 1$, there is no scale effect associated with knowledge spillovers because congestion simply offsets the scale effect, while there is a full-scale effect without congestion if $\nu = 0$.[7]

[7] Our specification generalizes the study of Irmen and Wigger (2006). They assume $\nu = 0$, implying that both countries have full access to the same knowledge stock at any time. Our specification allows *partial* knowledge spillover.

Since one unit of labor is supplied inelastically in each country, by using $L_i = 1$ and $\phi \equiv \xi n^{(\alpha-1)\nu}$, (1) is rewritten as

$$Y_i = \phi \sigma_i^{\alpha} K, \tag{3}$$

where $\sigma_i \equiv K_i/K$ is the share of total capital in country i. In this case, (2) is rewritten as follows:

$$r_i = (1-\tau_i)\alpha\phi\sigma_i^{\alpha-1} \text{ and } w_i = (1-\alpha)\phi\sigma_i^{\alpha} K. \tag{4}$$

2.2 Capital market

Mobile capital is allocated between countries 1 and 2 to satisfy

$$\sigma_1 + \sigma_2 = 1. \tag{5}$$

If the capital market is not linked between the two countries (i.e., no cross-border capital mobility exists), the after-tax interest rate, r_i, may differ between them. However, the free mobility of capital ensures that the after-tax interest rate should be equalized between the two countries, $r_1 = r_2 = r$, which is explicitly obtained as:

$$(1-\tau_1)\sigma_1^{\alpha-1} = (1-\tau_2)\sigma_2^{\alpha-1}. \tag{6}$$

From (5) and (6), we obtain σ_i and r as a function of the tax rates:

$$\sigma_i = \frac{(1-\tau_i)^{\frac{1}{1-\alpha}}}{(1-\tau_i)^{\frac{1}{1-\alpha}} + (1-\tau_j)^{\frac{1}{1-\alpha}}} \text{ and } r = \alpha\phi\left[(1-\tau_1)^{\frac{1}{1-\alpha}} + (1-\tau_2)^{\frac{1}{1-\alpha}}\right]^{1-\alpha}.$$

The comparative statistics yield

$$\frac{\partial \sigma_i}{\partial \tau_i} = -\frac{\sigma_i\sigma_j}{(1-\tau_i)(1-\alpha)} < 0 \text{ and } \frac{\partial \sigma_i}{\partial \tau_j} = \frac{\sigma_i\sigma_j}{(1-\tau_j)(1-\alpha)} > 0,$$

which represent that the higher taxes in country i drive out capital from the country and bring capital inflows to country j. Given the tax rate in country j, an increase in the tax rate in country i lowers the after-tax interest rate in country i. This causes a capital outflow from country i and an inflow of capital to country j. In addition, the comparative statistics also yield the effect of a change in the tax rate on the after-tax interest rate:

$$\frac{\partial r}{\partial \tau_i} = -\alpha\phi\sigma_i^{\alpha} < 0.$$

The capital tax changes the after-tax interest rate through two channels. First, a change in the tax rate directly changes the after-tax interest rate: a tax increase lowers the after-tax interest rate. Second, a change in the tax rate affects the after-tax interest rate by changing the capital investment. An increase in tax involves a capital outflow, which increases the marginal product of capital under the diminishing marginal productivity of capital, which raises the after-tax interest rate. Since the former effect exceeds the second-order effect of the latter, the tax increase lowers the after-tax interest rate.

2.3 Residents

The residents in country i own financial assets and earn interest from them. They also own one unit of labor, which is supplied inelastically to receive labor income. Total income, composed of asset income

and labor income, is allocated between consumption and savings. The budget constraint of the residents in country i is given by

$$\dot{A}_i = rA_i + w_i - C_i, \tag{7}$$

where A_i is the financial asset and C_i is the consumption of the private good. The time derivative (d/dt) is denoted by the over-dot.

The utility function of the residents in country i is assumed to be given by

$$V_i = \int_0^\infty e^{-\rho t} \log C_i(t) dt, \tag{8}$$

where ρ, representing the time preference, is assumed to take a positive value. Following Bräuninger (2005), we assume that government expenditure does not affect intertemporal allocation and, consequently, it does not enter the utility function.[8] The residents of country i maximize (8) subject to (7) for the given r, w_i, and $A_i(0)$. The first-order conditions yield

$$\frac{\dot{C}_i}{C_i} = r - \rho, \tag{9}$$

$$\lim_{t\to\infty} p_i(t) A_i(t) e^{-\rho t} = 0, \tag{10}$$

where $p_i(t)$ denotes the shadow price of the financial asset in country i at time t. (9) represents the Keynes–Ramsey rule, which asserts that consumption increases or decreases over time according to whether the rate of return on investment is greater or lower than the rate of time preference. (10) is the transversality condition, requiring the present value of the asset stock to converge to zero as the horizon goes towards infinity.

2.4 Governments

The budget constraint of the government and tax revenue in country i are given by

$$\dot{B}_i = rB_i + G_i - T_i, \tag{11}$$

$$T_i = \tau_i \alpha \phi \sigma_i^\alpha K, \tag{12}$$

where B_i is the debt outstanding, G_i is the government expenditure, and T_i is the tax revenue. The government issues public bonds if tax revenues cannot cover its total expenditure, which consists of debt interest payments and government expenditure. Here, we assume that the government does not lend to residents, $B_i \geq 0$, meaning that $G_i = T_i$ holds when $B_i = 0$.

The government in country i is assumed to spend a given proportion, denoted by $\eta_i \in (0, 1)$, of GDP on its purchases:[9]

$$G_i = \eta_i Y_i. \tag{13}$$

The government issues public debt to cover revenue shortages, and the ratio of debt to GDP is defined as follows:

$$\beta_i = \frac{\dot{B}_i}{Y_i}. \tag{14}$$

[8] It is possible to formulate the case that government expenditure directly affects residents' utilities by assuming $V_i = \int_0^\infty e^{-\rho t} \left[\log C_i(t) + \theta \log G_i(t)\right] dt$, where $\theta \geq 0$. (8) corresponds to $\theta = 0$. Although the general formulation of the utility function complicates the results, the qualitative findings remain unchanged.

[9] The assumption that η_i is constant can be justified by assuming a log-linear utility function with respect to private consumption and public expenditure. The proofs are available upon request from the authors.

Note that β_i in (14) is an endogenous variable that changes over time. By using (13) and (14), (11) is rewritten as follows:

$$\beta_i = (1-\tau_i)\alpha b_i - \lambda_i, \tag{15}$$

where $b_i \equiv B_i/K_i$ and

$$\lambda_i \equiv \alpha\tau_i - \eta_i. \tag{16}$$

λ_i in (16) represents the ratio of the primary balance to GDP in country i, where $\lambda_i = 0$ when $b_i = 0$. From (15), in our model, at least one of τ_i, β_i, or η_i needs to be determined endogenously. In the following analysis, assuming that the share of government expenditure to GDP, η_i, is kept constant, the government controls the tax rate and the shortage of tax revenue is covered by issuing public debt. Furthermore, we suppose that the tax rate determined by the government remains unchanged over time.

3 Equilibrium

3.1 Long-run equilibrium

Since private capital and government debt are substitutable assets for residents, total financial assets are equal to the sum of the private capital stock and government debt outstanding at the equilibrium:

$$A_1 + A_2 = K_1 + K_2 + B_1 + B_2. \tag{17}$$

By using (3)–(7) and (11)–(17), we obtain the resource constraint in the entire economy:

$$\dot{K} = Y - C - G, \tag{18}$$

where $Y \equiv Y_1 + Y_2$, $C \equiv C_1 + C_2$, and $G \equiv G_1 + G_2$. Using (9) for $i = 1, 2$ with (3) and (18), we obtain the growth rate of consumption and capital accumulation in the economy as :

$$\frac{\dot{C}}{C} = r - \rho \ \text{ and } \ \frac{\dot{K}}{K} = \phi\sigma_1^{\alpha} + \phi\sigma_2^{\alpha} - c - g, \tag{19}$$

where $c \equiv C/K$ and $g \equiv G/K$.

Since the tax rate chosen by the government is assumed to remain unchanged over time, from (6), σ_i is uniquely determined at a certain level, which gives the following relationship:

$$\frac{\dot{K}_i}{K_i} = \frac{\dot{K}}{K}. \tag{20}$$

By using $B \equiv B_1 + B_2$ and (14), we have

$$\frac{\dot{B}}{B} = \frac{\beta_1\phi\sigma_1^{\alpha} + \beta_2\phi\sigma_2^{\alpha}}{b}. \tag{21}$$

Then, from (20) and (21), we obtain the dynamics of b_i and $b \equiv B/K = \sigma_1 b_1 + \sigma_2 b_2$ as follows:

$$\frac{\dot{b}_i}{b_i} = \frac{\beta_i\phi\sigma_i^{\alpha-1}}{b_i} - \phi\sigma_1^{\alpha} - \phi\sigma_2^{\alpha} + c + g \ \text{ and } \ \frac{\dot{b}}{b} = \frac{\beta_1\phi\sigma_1^{\alpha} + \beta_2\phi\sigma_2^{\alpha}}{b} - \phi\sigma_1^{\alpha} - \phi\sigma_2^{\alpha} + c + g. \tag{22}$$

Furthermore, by using (19), we obtain the dynamics of c:

$$\frac{\dot{c}}{c} = r - \rho - \phi\sigma_1^{\alpha} - \phi\sigma_2^{\alpha} + c + g. \tag{23}$$

The governments determine their tax rates independently and their debt to GDP ratios are adjusted to balance the government's budget. By using (3), (13) can be rewritten as

$$g = \eta_1 \phi \sigma_1^{\alpha} + \eta_2 \phi \sigma_2^{\alpha}. \tag{24}$$

From (24), it can be confirmed that g is independent of c, b_i, and b. Therefore, the equilibrium dynamics of the economy are characterized by four variables, namely b_1, b_2, b, and c, with (22)–(23).

In the following analysis, we present the conditions to be held in the long-run equilibrium of the dynamic system. The long-run equilibrium is defined as a state in which the rate of change of each endogenous variable is constant. Under this definition, one of the long-run equilibria is that the growth rates of consumption, the capital stock, and government bonds outstanding are equalized, and the rate is constant over time. In addition, because the government may not issue bonds, the situation that the debt outstanding is constant, while consumption and the capital stock grow constantly, can also be a long-run equilibrium. Concretely, in our model, the following two cases can be the long-run equilibrium:

$$\text{(i)} \quad \frac{\dot{C}_i}{C_i} = \frac{\dot{C}}{C} = \frac{\dot{K}_i}{K_i} = \frac{\dot{K}}{K} = \frac{\dot{B}_i}{B_i} = \frac{\dot{B}}{B} > 0$$

$$\text{(ii)} \quad \frac{\dot{C}_i}{C_i} = \frac{\dot{C}}{C} = \frac{\dot{K}_i}{K_i} = \frac{\dot{K}}{K} > 0 \ \text{ and } \ \frac{\dot{B}_i}{B_i} = \frac{\dot{B}}{B} = 0 \Leftrightarrow \lambda_i = 0.$$

In either case, the growth rate of consumption and capital stock must be identical, suggesting that $\dot{c} = 0$ holds under the long-run equilibrium. In the following analysis, we focus on the former case to analyze plausible situations.

From (23), c is determined independently of b_i. Therefore, we can examine the level of c that satisfies $\dot{c} = 0$ without depending on other conditions of the dynamic equations. By substituting $\dot{c} = 0$ into (23) and solving for c, we have

$$c = \phi \sigma_1^{\alpha} + \phi \sigma_2^{\alpha} - g - \gamma = (1 - \eta_1)\phi \sigma_1^{\alpha} + (1 - \eta_2)\phi \sigma_2^{\alpha} - \gamma. \tag{25}$$

(25) suggests that a unique value of c exists and ensures $\dot{c} = 0$ holds, that is, c must satisfy (25) since it is not a predetermined variable of the residents, and c that satisfies (25) is the only level of consumption that realizes $\dot{c} = 0$ in the long run. In this case, the growth rates of consumption and capital stock are constant and they take the same positive value:

$$\gamma \equiv r - \rho. \tag{26}$$

Variables b_i and b follow (22) and (25). The dynamics of these variables are directly related to the sustainability of public debt, which is examined in the next section.

3.2 Minimum tax rate for debt sustainability

The level of β_i is crucial to study the dynamics of b_i and b , represented by (22). Since we have assumed that the government does not lend to residents directly, (15) gives

$$\beta_i = \begin{cases} (1 - \tau_i)\alpha b_i - \lambda_i & \text{if} \quad b_i > 0 \\ 0 & \text{if} \quad b_i = 0 \end{cases} \tag{27}$$

From (22), (25), and (27), we have the following equations for $b_i \neq 0$ and $b \neq 0$:

$$\dot{b}_i = \rho b_i - \lambda_i \phi \sigma_i^{\alpha - 1} \ \text{ and } \ \dot{b} = \rho b - \sum_{i=1}^{2} \lambda_i \phi \sigma_i^{\alpha}. \tag{28}$$

When $b_i(0) > 0$, we solve the dynamic equations for t to obtain

$$b_i(t) = \left[b_i(0) - \frac{\lambda_i \phi(\sigma_i)^{\alpha-1}}{\rho} \right] e^{\rho t} + \frac{\lambda_i \phi(\sigma_i)^{\alpha-1}}{\rho}, \tag{29}$$

$$b(t) = \left[b(0) - \frac{\sum_{i=1}^{2} \lambda_i \phi(\sigma_i)^{\alpha}}{\rho} \right] e^{\rho t} + \frac{\sum_{i=1}^{2} \lambda_i \phi(\sigma_i)^{\alpha}}{\rho}. \tag{30}$$

Equations (29) and (30) characterize the equilibrium dynamics of the economy.

From the transversality condition of residents, (10), and the no-Ponzi condition of the government, the following two conditions must hold: (i) households use up their assets or do not leave liabilities, and (ii) governments cannot escape the repayment of debt for the infinite future. If one of these two conditions is not satisfied, either the government or the household will collapse. These two conditions hold if we have[10]

$$0 \leq \lim_{t\to\infty} \frac{A_i}{C_i} = \lim_{t\to\infty} \left[(1 + b_i) \frac{K_i}{C_i} \right] < \infty \text{ and } 0 \leq \lim_{t\to\infty} b_i < \infty.$$

As already mentioned, C_i/K_i takes a finite value since $0 < \lim_{t\to\infty} c < \infty$, meaning that K_i/C_i also takes a finite value. Therefore, the conditions above can be summarized as $0 \leq \lim_{t\to\infty} b_i < \infty$. Noting that $b \equiv \sigma_1 b_1 + \sigma_2 b_2$, $Y \equiv Y_1 + Y_2$, and (3) hold, the conditions for the sustainability of public finance can be defined as follows.

Definition. Fiscal management is sustainable if the ratio of debt outstanding to private capital stock (b_i or b) converges to a certain level when $t \to \infty$.

Note that the ratio of debt outstanding to GDP is linearly proportional to the ratio of debt outstanding to private capital stock ($b_i = \phi B_i / Y_i$). From the definition with (29) and (30), public finance cannot be sustainable unless the primary balance is at least positive. In addition, even if the primary balance is positive, the ratio of debt outstanding to GDP or debt outstanding to the private capital stock will increase accumulatively if the initial value of debt outstanding is not below a certain level. This occurs because of an increase in interest payments, which causes the sustainability of public finance to be lost. More precisely, the following result shows the sufficient condition for debt sustainability.

Lemma 1. *Debt is not sustainable if the government manages a primary balance in deficit, $\lambda_i < 0$. If the primary balance is positive or zero, $\lambda_i \geq 0$, the condition that ensures debt sustainability is given as follows:*

$$0 \leq b_i(0) \leq \frac{\lambda_i \phi \sigma_i^{\alpha-1}}{\rho} \equiv \psi_i. \tag{31}$$

Proof. See Appendix B.

In (31), $b_i(0)$ is the debt outstanding-capital ratio at time 0 . (31) in Lemma 1 produces the following corollary.

Corollary 1. (31) *is equivalent to* $\dot{B}_i(0) \leq \gamma B_i(0)$.

Proof. See Appendix C.

[10] See Appendix A for a derivation of these conditions.

Corollary 1 shows that the sufficient condition for debt sustainability is that the issuance of debt at time 0 does not exceed the debt issuance when the growth rate of debt outstanding equals γ. This is intuitive because the government cannot absorb the interest payments in the primary balance, and thereby accumulates debt issuance without the redemption of the initial debt outstanding if that is too large compared with the scale of the primary balance. If the above conditions are satisfied in the initial stage, $b_i(\infty)$ converges to a finite level since the interest payment and redemption expenses of debt outstanding can be financed by a primary balance.

We now refer to the result derived from Lemma 1. (31) in Lemma 1 implies that there exists a minimum capital tax rate that ensures the sustainability of public finance, which can be clearly obtained by the following result.

Proposition 1. *The minimum capital tax rate to ensure debt sustainability satisfies*

$$\tau_i \geq \frac{1}{\alpha}\left[\eta_i + \rho\frac{B_i(0)}{Y_i(0)}\right]. \tag{32}$$

Proof. By inserting $\lambda_i = \alpha\tau_i - \eta_i$ into (31), we obtain the range of tax that ensures fiscal sustainability as

$$\tau_i \geq \frac{1}{\alpha}\left[\eta_i + \frac{\rho}{\phi}(\sigma_i)^{1-\alpha}b_i(0)\right]. \tag{33}$$

The ratio of debt outstanding to GDP in country i is given by

$$\frac{B_i}{Y_i} = \frac{K_i}{Y_i}\frac{B_i}{K_i} = \frac{1}{\phi}(\sigma_i)^{1-\alpha}b_i. \tag{34}$$

By substituting (34) into (33), we obtain (32). (Q.E.D.)

Corollary 2. *When the government sets the minimum tax rate, given by (32) or (33), with equality, b_i converges to the initial value, $b_i(0)$, in the long-run.*

Proof. From (16) and (33) with equality, $\lambda_i = \rho\phi^{-1}(\sigma_i)^{1-\alpha}b_i(0)$. Substituting this equation into (28), we have $\dot{b}_i = \rho b_i - \lambda_i\phi(\sigma_i)^{\alpha-1} = \rho[b_i - b_i(0)]$. (Q.E.D.)

(32) provides useful information on how far the governments competing for mobile capital can reduce the capital tax rate. Using (32) with the values of time preference (ρ), labor share (α), ratio of public expenditure to GDP (η_i), and ratio of debt outstanding to GDP ($B_i(0)/Y_i(0)$), we can obtain the minimum tax rates for each country if they covers revenues with the capital tax only. In reality, however, the government secures revenues by using not only the capital tax but also other taxes. To obtain the lower limit of the capital tax rate taking this into account, we suppose that the capital tax rate when the capital tax is used as an inclusive tax is α of the capital tax rate set in the case when public expenditure is financed only with capital tax. This is because the tax base of the capital tax is αY_i, while its tax base as an inclusive tax is Y_i.

	Govt. consumption General, Society % of GDP, 2015	Govt. debt % of GDP, 2015	Sustainable min. Tax rate %, estimated
GRC	11.42	182	16.9
JPN	7.83	234	14.9
ISR	10.59	78	12.9
PRT	8.44	149	12.9
HUN	9.91	97	12.8
ITA	7.74	157	12.5
BEL	8.30	127	12.1
USA	8.29	126	12.1
FRA	8.27	120	11.9
ESP	8.36	117	11.9
CAN	7.96	116	11.4
LVA	9.50	41	10.7
CZE	9.04	53	10.6
NLD	8.29	77	10.6
SVK	8.79	59	10.6
SVN	7.49	102	10.6
AUT	7.39	101	10.4
GBR	7.00	113	10.4
POL	8.13	69	10.2
FIN	7.83	75	10.1
TUR	8.94	27	9.8
EST	9.10	13	9.5
AUS	7.10	68	9.1
DEU	6.73	78	9.1
DNK	7.43	54	9.1
SWE	7.16	62	9.0
NOR	7.55	39	8.7
MEX	6.36	53	8.0
LUX	6.43	31	7.3
CHL	6.12	25	6.9
IRL	4.04	89	6.7
CHE	4.80	45	6.2

Table 1. Sustainable Tax Rates, Estimated.
Notes. The time preference rate (ρ) is 0.03. The countries in italics are EU countries.
Sources. OECD Data (https://data.oecd.org/)

Although the somewhat strong assumption stated above is needed, we illustrate the estimated minimum tax rate with a numerical example, shown in Table 1. This table highlights that Greece and Japan have the highest minimum corporate tax rates of 16.9% and 14.9%, respectively. Since the ratio of debt

outstanding to GDP is the highest in these two countries, the lower limit of the capital tax rate that ensures debt sustainability is higher than that in other countries. Table 1 suggests that, in countries where the expenditure-to-GDP ratio is high and countries with high debt outstanding in GDP, there is less room for lowering capital tax rates than in other countries.

4 Governments and market integration

Debt management will be sustainable if the government in tax competition sets a tax rate that exceeds the lower limit of the tax rate represented by (32). Here, we first check if the tax rate chosen by the governments is subject to the lower limit of the tax rate for debt sustainability. Second, we study the effects of capital market integration on debt sustainability by comparing the minimum tax rate under free capital mobility with that under no capital mobility.

4.1 Equilibrium tax rates

The government in each country is assumed to maximize residents' utilities. By using (8), (9), and (26), the objective function of the government is

$$V_i = \frac{1}{\rho}\left[\log C_i(0) + \frac{\gamma}{\rho}\right]. \tag{35}$$

In this model, the growth rate of capital and government bonds at time 0 is different, so that it is necessary to determine the initial portfolio. Here, we assume that the portfolio of each country stays the same, but the total assets at time 0 are different between the two countries: $A_i(0) = s_i A(0) = s_i[K(0) + B(0)]$, $K(0) > 0$, and $B_i(0) > 0$, where $s_i \in (0, 1)$ denotes the constant share of total assets in country i at time 0. In this case, the consumption levels at time 0 satisfy the following conditions (see Appendix D):

$$C_i(0) = \left\{\left[\rho + \sum_{j=1}^{2} \lambda_j \phi \sigma_j^{\alpha}\right] s_i + (1-\alpha)\phi\sigma_i^{\alpha}\right\} K(0). \tag{36}$$

Given (36), the maximization of (35) with respect to τ_i gives the tax rates chosen by the governments. The results are summarized as follows.

Proposition 2. *If there is no restriction on the lower limit of the capital tax rate conditioned by (32), the governments choose a negative tax, $\tau_i^* < 0$, leading to $\lambda_i^* < 0$ holding at the equilibrium.*

Proof. See Appendix E.

Proposition 2 suggests that, if the governments are not subject to the minimum tax rate for debt sustainability given by (32), they will choose the negative tax rate, which leads them to fiscal collapse.[11] This finding means that, to make the government sustainable, the minimum tax constraint must be binding, and that the government is subject to the lower limit of the capital tax rate, leading (32) to hold with an equality. The result can be summarized as follows.

[11] Readers may have questions about the robustness of the results if governments set their tax rates cooperatively. Suppose that each country changes its tax rate uniformly so that a change in the tax rate does not generate capital mobility ($d\sigma_i = 0$). In this case, we have confirmed that both the primary balance and cooperative tax rate are still negative when the cooperative governments choose tax rates without any regard for the lower limit of tax rate that guarantees fiscal sustainability.

Corollary 3. *The capital tax rate chosen by the sustainable government is*

$$\tau_i = \frac{1}{\alpha}\left[\eta_i + \rho\frac{B_i(0)}{Y_i(0)}\right]. \tag{37}$$

With the integration of the global capital market, interregional competition for mobile capital induces governments to cut their tax rates, which leads countries towards a *race to the bottom*. The consequence in the static framework is that the tax rate is set at an inefficiently low level compared with the optimum level [Oates (1972) and Zodrow and Mieszkowski (1986)]. The consequence of the race to the bottom in the dynamic framework is more serious. Tax competition for mobile capital without considering the fiscal sustainability constraints lowers the tax rate to a negative level, which leads to fiscal collapse.[12] The policy implication is straightforward. Without letting the government consider the constraint on fiscal sustainability, to invite capital investment, it sets the tax rate at a level that cannot sustain its debt management. In order not to race to fiscal collapse, it is thus necessary for the government to impose a lower limit of the tax rate.

4.2 Capital market integration

We next study the effects of capital market integration on the minimum tax rate that ensures fiscal sustainability. If the minimum capital tax rate falls due to capital market integration, the level of tax rates that governments can set expands, which contributes to increasing fiscal sustainability. In this case, tax competition caused by capital market integration is desirable. By contrast, if market integration causes an increase in the minimum tax rate, the range of tax rates settable by governments decreases and, therefore, fiscal sustainability falls. In this case, tax competition is harmful.

In the following comparison, we assume that the capital market is integrated at $t = 0$, meaning there is no capital movement before that. In this case, the capital accumulation in each country changes the amount of capital in each country. However, since time 0, in addition to capital accumulation, the inter-regional capital flow is also a determinant of the amount of capital in each country. To compare the minimum tax rates that ensure fiscal sustainability between closed and open capital markets (or equivalently, before and after market integration), we first assume that two countries are symmetric in the amount of capital before market opening: $K_1^c = K_2^c = 0.5K(0)$. A superscript c indicates that the capital market is *closed*, that is, capital is fixed at its initial location. Then, we present the optimal and sustainable tax rates of the economy with and without capital mobility.

First, when capital does not move between the two countries, we have [13]

$$Y_i^c = 0.5\xi K^c. \tag{38}$$

Substituting (38) into (37), the sustainable tax rate in the case of the closed market is given by

$$\tau_i^c = \frac{1}{\alpha}\left[\eta_i + 2\rho\frac{B_i(0)}{\xi K(0)}\right]. \tag{39}$$

In (39), η_i, $B_i(0)$, and $K(0)$ are the predetermined variables and the right-hand side of (39) is constant.

[12] Some static studies have pointed out that the tax rates set by governments facing tax competition may not only fall below the optimal level but also take negative values. For instance, early researchers such as Coates (1993), Lee (1997), and Smith (1999) theoretically show that the government sets a negative tax on mobile capital in a static model.

[13] Substituting $X = K/n^v$ into (1), $Y_i = \xi n^{\alpha-1} v K_i^{\alpha} K^{1-\alpha} L_i^{1-\alpha}$. Since $L_i = 1$, $K_i = K$, and $n = 1$ hold in the case of a closed capital market, Y_i^c can be obtained as $Y_i^c = \xi K_i^c$. Under the symmetric equilibrium, we have $K_i(0) = K(0)/2$, which is used to obtain (39).

Next, we derive the minimum tax rate in the integrated capital market, which was already given by (37). However, the case of the open market, in which capital is free to move between countries, is different from the case of the closed market in that $Y_i(0)$ in (37) is an endogenous variable, depending on the tax rates, τ_i and τ_j . That is, in the integrated market, we have

$$Y_i(0) = 2^{(\alpha-1)v}\xi\sigma_i^{\alpha}K(0), \tag{40}$$

where $\sigma_i = \sigma_i(\tau_1, \tau_2)$.[14] The substitution of (40) into (37) yields the minimum tax rate in the integrated market:

$$\tau_i^o = \frac{1}{\alpha}\left[\eta_i + 2^{1-(1-\alpha)(1-v)}\rho\frac{B_i(0)}{\xi K(0)}\right], \tag{41}$$

where the superscript o denotes the open capital market in which capital moves between countries. Then, the comparison of (39) and (41) yields the following result.

Proposition 3. *Suppose countries are symmetric in the amount of capital before market opening: $K_1^c = K_2^c$. Then, capital market integration increases fiscal sustainability.*

Proof. For $\alpha \in (0,1)$ and $v \in [0,1]$,

$$\tau_i^o = \frac{1}{\alpha}\left[\eta_i + 2^{1-(1-\alpha)(1-v)}\rho\frac{B_i(0)}{\xi K(0)}\right] \leq \frac{1}{\alpha}\left[\eta_i + 2\rho\frac{B_i(0)}{\xi K(0)}\right] = \tau_i^c. \qquad \text{(Q.E.D.)}$$

Under Romer-type technology that assumes the knowledge stock is related to the capital stock, each country benefits from the positive externalities associated with the capital stock. This means that, once the capital market is integrated, each country can now benefit from the externality not only from the country itself but also from the capital stock of other countries. Access to a single capital market enables each country to access global knowledge, which expands production in each country and, thus, contributes to increasing fiscal sustainability.[15]

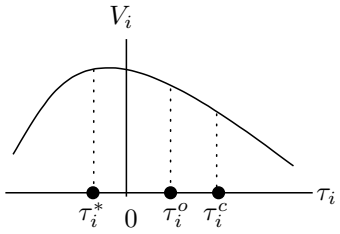


Figure 1. Tax ranking

Figure 1 illustrates our main results. If the government decides the tax rate without paying attention to the fiscal sustainability, it selects τ_i^*. This is a situation in which the government gives subsidies to capital and manages its finance, relying on the government debt issue. This is not sustainable in the long-run and leads to fiscal collapse. However, the minimum tax rate that ensures fiscal sustainability is given by τ_i^c when the capital market is not integrated, and thereby there is no capital tax competition. Once the capital market is integrated, a country benefits from interregional knowledge spillovers, which

[14] Substituting $X = K/n^v$ into (1), $Y_i = \xi n^{\alpha-1}vK_i^{\alpha}K^{1-\alpha}L_i^{1-\alpha}$. Since $L_i = 1$, $\sigma_i = K_i/K$, and $n = 2$ hold in the case of the integrated capital market, Y_i^o can be obtained as (40)

[15] It is straightforward that $\tau_i^c = \tau_i^o$ if no interregional knowledge spillover exists, $\nu = 1$.

increases the production in each country. This increases the room for having lower tax and, therefore, the minimum tax rate to ensure fiscal sustainability decreases from τ_i^c to τ_i^o. This means that tax competition accompanied by capital market integration expands the range of taxes the government can choose and therefore increases fiscal sustainability.

4.3 Asymmetric countries

We next discuss the extent to which the results change if we allow asymmetries in the amount of capital at time 0, $K_1^c \neq K_2^c$, where $K_1^c + K_2^c = K(0)$. Without any loss of generality, we define m to satisfy

$$K_2^c = mK_1^c, \tag{42}$$

where $m > 0$ denotes the ratio of K_2^c to K_1^c. In this case, $K(0) = (1+m)K_1^c = (1+m)m^{-1}K_2^c$.

In the following analysis, we focus on the case in which there is full scale effect associated with knowledge spillovers, $\nu = 0$ or, equivalently, $\phi = \xi$. This is because, as shown in Proposition 3, when countries are symmetric, market integration expands the range of tax for debt sustainability, and this positive effect associated with knowledge spillovers is largest when $\nu = 0$. Here, we show that, even in the case of $\nu = 0$, the capital market integration hinders the fiscal sustainability of either of two countries when the asymmetry across countries is significant.

Substituting $K(0) = (1+m)K_1^c = (1+m)m^{-1}K_2^c$ into (37) with (3), given K_1^c and K_2^c, we obtain the minimum tax rates in the integrated capital market as

$$\tau_1^o = \frac{1}{\alpha}\left[\eta_1 + \rho\frac{B_1(0)}{\phi K_1^c}\frac{\sigma_1^{-\alpha}}{1+m}\right] \text{ and } \tau_2^o = \frac{1}{\alpha}\left[\eta_2 + \rho\frac{B_2(0)}{\phi K_2^c}\frac{m\sigma_2^{-\alpha}}{1+m}\right]. \tag{43}$$

In (43), country i's share of capital in the integrated capital market is given by

$$\sigma_1^o = \frac{(1-\tau_1^o)^{\frac{1}{1-\alpha}}}{(1-\tau_1^o)^{\frac{1}{1-\alpha}} + (1-\tau_2^o)^{\frac{1}{1-\alpha}}} \text{ and } \sigma_2^o = \frac{(1-\tau_2^o)^{\frac{1}{1-\alpha}}}{(1-\tau_1^o)^{\frac{1}{1-\alpha}} + (1-\tau_2^o)^{\frac{1}{1-\alpha}}}. \tag{44}$$

Four variables, $\tau_1^o, \tau_2^o, \sigma_1^o$, and σ_2^o, are determined by the four equations in (43) and (44). Although we cannot obtain an explicit solution of the minimum tax rate (MRT) in each county, we see it is a function of $B_i(0)$ and K_i^c. From (43), we find that τ_i^o is likely to be large if $B_i(0)$ is large, implying there is little room for country i to lower the tax rate when the outstanding debt before market integration, denoted by $B_i(0)$, is large. Therefore, the tax rate in country i after the market integration would also be high.

Then, comparing τ_i^o and τ_i^c, we obtain the following result:

Proposition 4. *Suppose that two countries have different amounts of capital before market opening, $m \neq 1$. Market integration increases fiscal sustainability in two asymmetric countries if the following conditions hold simultaneously:*

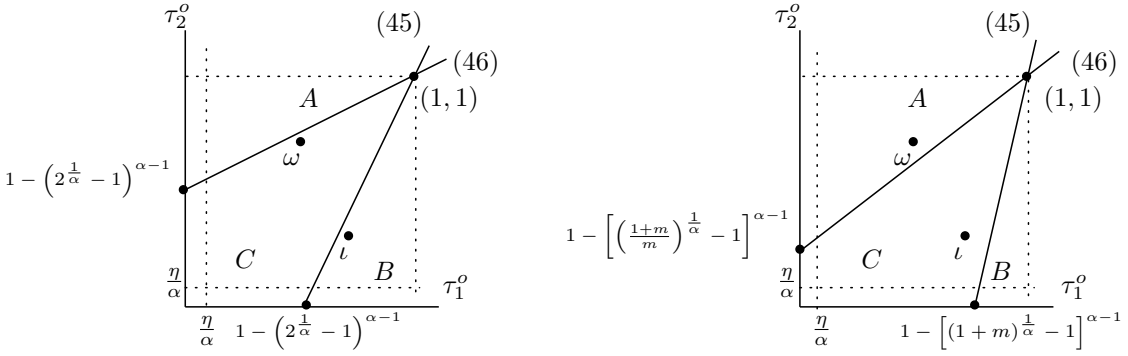
$$\tau_1^o < 1 - \frac{1-\tau_2^o}{\left[(1+m)^{1/\alpha} - 1\right]^{1-\alpha}}, \tag{45}$$

$$\tau_2^o < 1 - \frac{1-\tau_1^o}{\left[(\frac{1+m}{m})^{1/\alpha} - 1\right]^{1-\alpha}}. \tag{46}$$

Otherwise, market integration lowers fiscal sustainability in either country.

Proof. See Appendix F.

Figure 2 illustrates (45) and (46) with the equality, in which the two lines pass through (1,1). In Figure 2(i), $m = 1$ is assumed. In Figure 2(ii), without any loss of generality, $m > 1$ is assumed, meaning that country 2 has more capital than country 1 before market integration, $K_2^c > K_1^c$. The intersection of (46) and the τ_2^o-axis moves downward and the intersection of (45) and the τ_1^o-axis moves to the right as m increases in Figure 2 (ii). The valid area in Figure 2 is restricted by $\tau_i^o > \eta_i/\alpha$ since $B_i(0) > 0$ (see (39)).



(i) $m = 1$ $(K_1^c = K_2^c)$ (ii) $m > 1$ $(K_1^c < K_2^c)$

Figure 2. Effects of market integration

Notes. $\eta = \eta_i$ is assumed for simplicity. In area A, the market integration decreases (increases) the fiscal sustainability in country 2 (1). The opposite applies to area B. In area C, the market integration increases fiscal sustainability in both countries.

The combination of (τ_1^o, τ_2^o) that satisfies (45) and (46) is indicated by C in Figure 2(i) and (ii), suggesting that the market integration increases the fiscal sustainability of both countries if the difference in countries' tax rates after market integration is sufficiently small so that the tax rates are included in area C. This suggests that the integration of capital markets between similar countries improves the fiscal sustainability of all countries. This result holds if the difference between the capital positions of the two countries is small and, therefore, the tax gap in the integrated capital market between the two countries is small. In area A of Figure 2(i) and (ii), market integration decreases the sustainable (minimum) tax rate of country 1 and increases that of country 2, suggesting that fiscal sustainability in country 2 (1) is decreased (increased) after capital market integration. The opposite applies to area B of Figure 2.

To understand the intuition of this classification, let us look at point ι in Figure 2(i), where the amount of capital before market integration is the same in both countries but the tax rate is different. At point ι, the outstanding debt before the market integration is larger in country 1 than in country 2, $B_1(0) > B_2(0)$. Consequently, country 1 has less room to lower the tax rate, so the tax rate of country 1 after market integration is higher than that of country 2. After market integration, the two countries can access the knowledge stock, and they equally benefit from knowledge spillovers, since $K_1^c = K_2^c$. Although the knowledge spillover accompanied by capital market integration is brought equally to both countries, the impacts of capital movements are different between countries. Since the tax rate of country 1 is relatively high, once the capital market is integrated, capital moves from country 1 to country 2. This is good for country 2. The capital inflow leads to the expansion of production and enhances fiscal sustainability.

Conversely, in country 1, production decreases with the capital outflow, so market integration works to lower fiscal sustainability.

In sum, at point ι, market integration brings a positive effect to country 2 from two routes:, knowledge spillover and capital inflow, which enhance fiscal sustainability. On the other hand, it causes a negative impact on country 1, since production is decreased due to the capital outflow, while it has a positive effect through the spillover of knowledge. At point ι, since the tax gap is sufficiently large, a large amount of capital flows out from country 1. Therefore, the negative effect is greater than the positive effect, and that market integration decreases the fiscal sustainability in country 1.

Next, we look at point ι in Figure 2(ii), where the capital of country 1 is smaller than that of country 2 before market integration, $K_1^c < K_2^c$. Again, market integration increases the fiscal sustainability of country 2 because it brings two positive effects: spillover and capital inflow. Market integration also has a positive spillover effect and a negative effect in country 1. However, at point ι in Figure 2(ii), the positive impact exceeds the negative one in country 1. This is because country 1 is small, in the sense that it has less capital. The smaller the country is, the greater the merit of having access to the knowledge of other major countries. Therefore, at point ι in Figure 2(ii), market integration increases fiscal sustainability not only in country 2 but also in country 1.

A similar explanation can be applied to interpret the situation of point ω. When $K_1^c = K_2^c$, the market integration generates equivalent benefits to both countries, associated with knowledge spillovers. This is the positive aspect of market integration. While it adds the additional benefit of capital inflow into country 1 since the tax rate in this country is relatively small, it has a negative impact on country 2, since it causes capital outflow from this country. At point ω in Figure 2(i), since the tax gap after market integration is sufficiently small, the positive effect of market integration enables the two countries to lower the minimum tax rate for debt sustainability. In Figure 2(ii), the results will be changed. At point ω of Figure 2(ii), country 2 can receive small benefits from knowledge spillovers accompanied by market integration, since this country has more capital than country 1, $K_1^c < K_2^c$. Although country 1, with little capital, receives significant benefits from market integration, country 2, with lots of capital, suffers from the disadvantage of capital outflow instead of benefitting from market integration. Consequently, for the large country 2, market integration has a negative impact on fiscal sustainability.

5 Conclusion

This study presents a model of fiscal sustainability under the endogenous growth framework, focusing on the relationship between interregional competition for mobile factors and fiscal sustainability. It clarifies the factors that decrease the sustainability of public finance and identifies a simple condition to estimate what extent of a tax rate reduction is necessary to sustain the fiscal budget.

The capital market integration induces governments to compete for mobile capital and the tax rate in each country is reduced. This seems to lead to financial deterioration. In fact, our paper shows that capital market integration induces two factors that increase fiscal sustainability. The first is that the falling tax rate increases the after-tax interest rate, which enhances capital accumulation. This leads to an increase in GDP, making repaying the debt easier. The second is that countries receive greater positive externalities from an integrated market. Specifically, they can increase their productivities by receiving Romer-type knowledge spillovers in a single capital market. This increases the production in each country and allows the repayment of debt. In the first part of the paper, we show that these positive

effects outweigh the demerit of tax competition and bring benefits to all countries when the differences between countries are sufficiently small. Our theoretical hypothesis thus explains the fact that fiscal sustainability is somewhat maintained, while countries are forced to reduce their capital tax rates in the integrated capital market and thus rely on bond-financing management.

However, market integration may not provide equal benefits to all countries if heterogeneity among countries competing in a single market is large. In the second part of the paper, we show that countries with high outstanding debt have little room to lower their tax rates. Once the capital is free to move across countries after market integration, this leads to capital outflows from such countries, resulting in a decline in GDP. This suggests that market integration does not necessarily increase the fiscal sustainability of countries with high outstanding debt. In addition, capital rich countries do not receive much of the benefits of knowledge spillover from other countries arising from market integration, while capital poor countries can use the knowledge of countries with abundant capital. Therefore, we find that, in capital rich countries, there is no guarantee that fiscal sustainability increases through market integration.

Finally, we should mention the limitations and possible future research directions of our study. The former relate to demographic changes. To formulate a solvable model of interregional tax competition, we have not focused on the problems caused by the falling birthrate and aging population. It is clear that demographic pressures continue to mount and add to the concerns about fiscal sustainability and, therefore, numerous researchers have clarified the relationships between them (Jensen and Nielsen, 1995; Castro et al., 2017). In this paper, we identify the influence of interregional tax competition on fiscal sustainability by excluding the influence of aging from the model. However, the reality is more complex. With the decline of the tax rate caused by globalization, policy recommendations should be made in consideration of the changes in demographic structure. Future research directions relate to other tax instruments and the political aspect. To focus on interregional competition for mobile factors using capital-related tax, other tax measures were excluded from our analysis. This enables us to single out the impact of capital tax competition on the fiscal sustainability. In fact, it is also possible to make fiscal reconstruction by increasing other taxes, including VAT and labor income tax. When applying our theoretical hypothesis to policy practice, consideration for other tax measures is also necessary. Furthermore, in this paper we did not consider the political process of policy decision-making and assumed a benevolent government. By doing so, we have shown that even "good" governments aiming to maximize residents' utilities are exposed to financial crises once they engage in capital tax competition. However, the characteristics and objectives of policy makers also change with globalization [Persson and Tabellini (1992) and Ogawa and Susa (2017)]. When analyzing globalization and fiscal sustainability, it may also be necessary to consider how the objectives of policy makers are determined through the political process.

Appendices

Appendix A

The transversality condition of the residents, (10), and the no-Ponzi condition of the government are

$$\lim_{t\to\infty} p_i A_i e^{-\rho t} = \lim_{t\to\infty} \frac{A_i}{C_i} e^{-\rho t} = 0, \tag{47}$$

$$\lim_{t\to\infty} B_i e^{-rt} = 0. \tag{48}$$

Specifically, (48) can be rewritten, by using $K(t) = K(0)e^{\gamma t}$, as follows:

$$\lim_{t\to\infty} B_i e^{-rt} = \lim_{t\to\infty} \frac{B_i}{K_i}\frac{K_i}{K} K e^{-rt} = \lim_{t\to\infty} b_i \sigma_i e^{-\rho t} = 0. \tag{49}$$

The sufficient conditions to have (47) and (49) are

$$0 \leq \lim_{t\to\infty} \frac{A_i}{C_i} = \lim_{t\to\infty} \frac{K_i + B_i}{C_i} = \lim_{t\to\infty} \left[(1 + b_i) \frac{K_i}{C_i} \right] < \infty,$$
$$0 \leq \lim_{t\to\infty} b_i < \infty.$$

If these are not satisfied, fiscal management is unsustainable.

Appendix B

Using the equations representing the equilibrium dynamics, we check whether the government's intertemporal budget constraint is satisfied. From (11) and (15),

$$\begin{aligned} \dot{B}_i = \beta_i Y_i &= \left[(1 - \tau_i)\alpha b_i - \lambda_i \right] \phi \sigma_i^{\alpha} K \\ &= r B_i - \lambda_i Y_i. \end{aligned} \tag{50}$$

By multiplying (50) by e^{-rt} and integrating the equation with respect to time, we obtain

$$\int_0^T \dot{B}_i(t) e^{-rt} dt = \int_0^T \left[r B_i(t) - \lambda_i Y_i(t) \right] e^{-rt} dt.$$

By applying the integral by parts to this equation, we arrive at

$$\begin{aligned} \left[B_i(t) e^{-rt} \right]_0^T + r \int_0^T B_i(t) e^{-rt} dt = r \int_0^T B_i(t) e^{-rt} dt - \lambda_i \int_0^T Y_i(t) e^{-rt} dt \\ \Leftrightarrow \left[B_i(t) e^{-rt} \right]_0^T = -\lambda_i \phi \sigma_i^{\alpha} \int_0^T K(t) e^{-rt} dt. \end{aligned} \tag{51}$$

By inserting $K(t) = K(0)e^{\gamma t}$ into (51), we have

$$\begin{aligned} \left[B_i(t) e^{-rt} \right]_0^T &= -\lambda_i \phi \sigma_i^{\alpha} \int_0^T K(0) e^{-(r-\gamma)t} dt \\ &\Leftrightarrow B_i(T) e^{-rT} - B_i(0) = -\lambda_i \phi \sigma_i^{\alpha} \int_0^T K(0) e^{-\rho t} dt. \end{aligned} \tag{52}$$

First, we consider the case where debt outstanding remains within a finite Time period. By taking the limit of (52), the present value of regional government debt is

$$\begin{aligned} \lim_{t\to\infty} B_i(t) e^{-rt} &= B_i(0) - \frac{\lambda_i \phi \sigma_i^{\alpha} K(0)}{\rho} \\ &= \left[b_i(0) - \frac{\lambda_i \phi \sigma_i^{\alpha - 1}}{\rho} \right] K_i(0). \end{aligned} \tag{53}$$

We apply a similar method to the dynamic equation $\dot{B}(t)$. By using (50), we obtain $\dot{B} = \beta_1 Y_1 + \beta_2 Y_2 = rB - \lambda_1 Y_1 - \lambda_2 Y_2$. Multiplying (50) by e^{-rt} and integrating it with respect to time,

$$\int_0^T \dot{B}(t) e^{-rt} dt = \int_0^T \left[r B(t) - \sum_{i=1}^{2} \lambda_i Y_i(t) \right] e^{-rt} dt.$$

After rearranging this equation, we arrive at

$$\begin{aligned}\lim_{t\to\infty} B(t)e^{-rt} &= B(0) - \frac{\lambda_1\phi\sigma_1^{\alpha} + \lambda_2\phi\sigma_2^{\alpha}}{\rho}K(0) \\ &= \left[b(0) - \frac{\lambda_1\phi\sigma_1^{\alpha} + \lambda_2\phi\sigma_2^{\alpha}}{\rho}\right]K(0). \end{aligned} \tag{54}$$

From (53) and (54), the initial debt outstanding must satisfy $b_i(0) = \psi_i$ if debt outstanding does not converge to zero within a finite time period. In this case, $b(0) = \Psi$ holds, where $\Psi \equiv \sum_{i=1}^{2} \lambda_i\phi\sigma_i^{\alpha}/\rho$. From (29) and (30), debt outstanding does not converge to zero in a finite Time period when $\lambda_i > 0$ and $b_i(0) > \psi_i$ (i.e., $b_i(0) > \psi_i$ holds).

Next, we consider the case in which debt outstanding converges to zero within a finite time period. In this case, $\lim_{t\to\infty} B(t)e^{-rt} = 0$ holds as $\lim_{t\to\infty} B(t) = 0$. By denoting $\hat{t}_i$ as the point in time at which the debt outstanding becomes zero, using (52), we have

$$B_i(\hat{t}_i)e^{-r\hat{t}_i} = B_i(0) - \lambda_i\phi\sigma_i^{\alpha}\int_0^{\hat{t}_i} K(0)e^{-\rho t}dt = 0. \tag{55}$$

$\hat{t}_i$ is given by (55). This corresponds to the case where the public debt of the initial liability is paid out within a finite time period; from then on, the government maintains a balanced budget. In particular, from (29) and (30), when $b_i(0) < \psi_i$ and $B_i(\hat{t}_i) = 0$, the balanced budget is maintained after the repayment of the initial liability. Therefore, if the initial debt outstanding satisfies $0 \le b_i(0) \le \psi_i$ (i.e., (31)), public finance in all countries is sustainable and, therefore, the public finance of the entire economy is sustained.

To verify that these conditions are consistent with the budget equations for households, we now consider the transversality condition. Let $b(0) > \Psi$. On the left-hand side of (10), we have

$$\begin{aligned}\lim_{t\to\infty} p_i(t)A_i(t)\exp(-\rho t) &= \lim_{t\to\infty}\frac{A_i(t)}{C_i(t)}e^{-\rho t} = \lim_{t\to\infty}\frac{[1+b(t)]\,s_iK(0)}{C_i(0)}e^{-\rho t} \\ &= \frac{\left[b(0) - \frac{\lambda_1\phi\sigma_1^{\alpha}+\lambda_2\phi\sigma_2^{\alpha}}{\rho}\right]s_iK(0)}{C_i(0)} > 0.\end{aligned}$$

This inequality and (54) show that one of the budgets for households and governments will go bankrupt if $b(0) > \Psi$. When $b(0) < \Psi$, a similar method to the one mentioned above can be applied. Note that

$$b(t) = \begin{cases} \left[b(0) - \frac{\lambda_1\phi\sigma_1^{\alpha}+\lambda_2\phi\sigma_2^{\alpha}}{\rho}\right]e^{\rho t} + \frac{\lambda_1\phi\sigma_1^{\alpha}+\lambda_2\phi\sigma_2^{\alpha}}{\rho} & \text{if } t \le \hat{t} < \infty, \\ 0 & \text{if } t > \hat{t}, \end{cases} \tag{56}$$

where

$$\hat{t} \equiv \frac{\log\left[\lambda_1\phi\sigma_1^{\alpha} + \lambda_2\phi\sigma_2^{\alpha}\right] - \log\rho - \log\left[\Psi - b(0)\right]}{\rho} > 0.$$

By using (56), we arrive at

$$\lim_{t\to\infty} p_i(t)A_i(t)e^{-\rho t} = \lim_{t\to\infty}\frac{A_i(t)}{C_i(t)}e^{-\rho t} = \frac{s_iK(0)}{C_i(0)}\lim_{t\to\infty} e^{-\rho t} = 0.$$

This result shows that (10) holds if $b(0) < \Psi$. When $b_i(0) < \psi_i$ holds for $i = 1, 2$, $b(0) < \Psi$ must hold. Recall that $\lim_{t\to\infty} B_i(t)e^{-rt} = 0$ and $\lim_{t\to\infty} B(t)e^{-rt} = 0$ if $b_i(0) < \psi_i$ for $i = 1, 2$. Therefore, the upper limit of $b(0)$ must be equal to Ψ for a sustainable debt. In sum, public finance is sustainable if (31) holds.

Appendix C

(31) is rewritten as $\rho B_i(0) \leq \lambda_i \phi \sigma_i^{\alpha-1} K_i(0) = \lambda_i \phi \sigma_i^{\alpha} K(0)$. For the ratio of debt outstanding to private capital stock $b_i(\infty)$ to converge to a constant level, the growth rates of debt outstanding and private capital stock must be equal in the long run, or the former must be higher than the latter. As the growth rate of the private capital stock is identical to γ, the necessary condition for this is

$$\frac{\dot{B}_i}{B_i} \leq \frac{\dot{K}_i}{K_i} = \frac{\dot{K}}{K} = \gamma.$$

Since

$$\frac{\dot{B}_i(0)}{B_i(0)} = r - \lambda_i \frac{Y_i(0)}{B_i(0)} = r - \lambda_i \frac{\phi \sigma_i^{\alpha} K(0)}{B_i(0)}$$

holds, we have

$$\frac{\dot{B}_i(0)}{B_i(0)} - \gamma = r - \gamma - \lambda_i \frac{\phi \sigma_i^{\alpha} K(0)}{B_i(0)}.$$

By multiplying by $B_i(0)$ on both sides,

$$\begin{aligned} \dot{B}_i(0) - \gamma B_i(0) &= (r-\gamma) B_i(0) - \lambda_i \phi \sigma_i^{\alpha} K(0) \\ &= \rho B_i(0) - \lambda_i \phi \sigma_i^{\alpha} K(0) \gtreqless 0 \Leftrightarrow b_i(0) \gtreqless \lambda_i \phi \sigma_i^{\alpha-1} / \rho. \end{aligned}$$

Appendix D

At $t = 0$, (7) reduces to

$$\begin{aligned} \dot{A}_i(0) &= r A_i(0) + w_i(0) - C_i(0) \\ &= [1 + b(0)]\, r s_i K(0) + (1-\alpha) \phi \sigma_i^{\alpha} K(0) - C_i(0). \end{aligned} \tag{57}$$

By using the condition that the initial asset endowment of each country is $A_i(0) = s_i[K(0) + B(0)]$, (18), and (22), we have

$$\dot{A}_i(0) = s_i \left[\dot{K}(0) + \dot{B}(0) \right] = \left[\gamma + \beta_1 \phi \sigma_1^{\alpha} + \beta_2 \phi \sigma_2^{\alpha} \right] s_i K(0). \tag{58}$$

By integrating (57) and (58), the initial consumption level is given by

$$\begin{aligned} C_i(0) &= \left\{ [1 + b(0)]\, r s_i + (1-\alpha) \phi \sigma_i^{\alpha} - \gamma s_i - s_i \sum_{j=1}^{2} \beta_j(0) \phi \sigma_j^{\alpha} \right\} K(0) \\ &= \left\{ \left[\rho + \sum_{j=1}^{2} \lambda_j \phi \sigma_j^{\alpha} \right] s_i + (1-\alpha) \phi \sigma_i^{\alpha} \right\} K(0). \end{aligned}$$

Appendix E

The maximization of (35) with respect to τ_i gives

$$\frac{\partial V_i}{\partial \tau_i} = \frac{1}{\rho^2} \left\{ \frac{1}{C_i(0)} \frac{\partial C_i(0)}{\partial \tau_i} \rho + \frac{\partial \gamma}{\partial \tau_i} \right\} = 0. \tag{59}$$

Using (36), we obtain

$$\frac{1}{C_i(0)} \frac{\partial C_i(0)}{\partial \tau_i} = \frac{\sum_{j=1}^{2} \alpha \lambda_j \phi \sigma_j^{\alpha-1} \frac{\partial \sigma j}{\partial \tau_i} s_i + \phi \sigma_i^{\alpha} s_i \frac{\partial \lambda_i}{\partial \tau_i} + (1-\alpha) \alpha \phi \sigma_i^{\alpha-1} \frac{\partial \sigma_i}{\partial \tau_i}}{\left[\rho + \sum_{j=1}^{2} \lambda_j \phi \sigma_j^{\alpha} \right] s_i + (1-\alpha) \phi \sigma_i^{\alpha}}. \tag{60}$$

The second term between the square brackets in (59) shows the effects of a change in the capital tax rate on the growth rate, which is obtained by $\partial\gamma/\partial\tau_i = \partial r/\partial\tau_i = -\alpha\phi\sigma_i^{\alpha} < 0$, and shows the positive aspect of tax competition in a dynamic setting, as suggested by Hatfield and Kosec (2013) and Hatfield (2015). Although tax competition for mobile capital tends to decrease the tax rate in each country, it leads to a higher interest rate. It thus results in an increase in savings and, thereby, economic growth through capital accumulation.

At the symmetric equilibrium, $\sigma_1 = \sigma_2 = s_1 = s_2 = 1/2 = \sigma$ holds. Then, (60) can be rewritten as

$$\frac{1}{C_i(0)}\frac{\partial C_i(0)}{\partial \tau_i} = -\frac{\tau\alpha\phi\sigma^{\alpha}}{\{\rho + [1-\eta-(1-\tau)\alpha)]\,\phi\sigma^{\alpha-1}\}\,(1-\tau)}. \tag{61}$$

The substitution of (61) and $\partial\gamma/\partial\tau_i = -\alpha\phi\sigma_i^{\alpha} < 0$ into (59) gives

$$\frac{\partial V_i}{\partial \tau} = -\left(\frac{\alpha\phi\sigma^{\alpha}}{\rho^2}\right)\frac{\rho + [1-\eta-(1-\tau)\alpha)]\,(1-\tau)\,\phi\sigma^{\alpha-1}}{\{\rho + [1-\eta-(1-\tau)\alpha)]\,\phi\sigma^{\alpha-1}\}\,(1-\tau)}.$$

Since the lower bound of τ is given at a level that satisfies $C_i(0) = 0$, the following condition holds:

$$\sup(1-\tau) = \frac{\rho + (1-\eta)\phi s^{\alpha-1}}{\alpha\phi s^{\alpha-1}} > 1.$$

In this case, we obtain the following conditions:

$$\frac{\partial V_i}{\partial \tau}|_{\tau=1} = -\infty$$

and

$$\begin{aligned}\left.\frac{\partial V_i}{\partial \tau}\right|_{\tau=\inf\tau} &= -\left(\frac{\alpha\phi s^{\alpha}}{\rho^2}\right)\frac{\rho + \left[1-\eta-\frac{\rho+(1-\eta)\phi s^{\alpha-1}}{\alpha\phi s^{\alpha-1}}\alpha\right]\frac{\rho+(1-\eta)\phi s^{\alpha-1}}{\alpha\phi s^{\alpha-1}}\phi\sigma^{\alpha-1}}{\{\rho + [1-\eta-(1-\inf\tau)\alpha)]\,\phi\sigma^{\alpha-1}\}\,(1-\tau)} \\ &= \left(\frac{\alpha\phi s^{\alpha}}{\rho^2}\right)\frac{\frac{\rho^2}{\alpha\phi s^{\alpha-1}} + \frac{(1-\eta-\alpha)\rho}{\alpha}}{\{\rho + [1-\eta-(1-\inf\tau)\alpha)]\,\phi\sigma^{\alpha-1}\}\,(1-\tau)} = +\infty.\end{aligned}$$

Hence, there exists τ so that $\partial V_i/\partial\tau = 0$, which is solved for τ as

$$(1-\tau^*) = \frac{(1-\eta)\phi\sigma^{\alpha-1} + \sqrt{[(1-\eta)\phi\sigma^{\alpha-1}]^2 + 4\rho\alpha\phi\sigma^{\alpha-1}}}{2\alpha\phi\sigma^{\alpha-1}} > 1 \Rightarrow \tau^* < 0.$$

In this case, the ratio of the primary balance to GDP is obtained as follows:

$$\lambda^* = \alpha\tau^* - \eta = \alpha - \frac{(1-\eta)\phi\sigma^{\alpha-1} + \sqrt{[(1-\eta)\phi\sigma^{\alpha-1}]^2 + 4\rho\alpha\phi\sigma^{\alpha-1}}}{2\phi\sigma^{\alpha-1}} - \eta.$$

Since $\tau^* < 0$, we find from (16) that $\lambda^* < 0$ holds.

Appendix F

When the capital market is not integrated, the output of country i is $Y_i^c = \phi K_i^c$. The sustainable tax rate for country i in the case of A closed capital market is

$$\tau_i^c = \frac{1}{\alpha}\left[\eta_i + \rho\frac{B_i(0)}{\phi K_i^c}\right]. \tag{62}$$

Since the right-hand side is constant, τ_i^c is constant. Substituting (62) into (43), for $i = 1$, we obtain

$$\tau_1^o = \frac{1}{\alpha}\left[\eta_1 + (\alpha\tau_1^c - \eta_1)\frac{\sigma_1^{-\alpha}}{1+m})\right],$$

which can be rewritten as

$$\frac{\tau_1^o - \frac{\eta_1}{\alpha}}{\tau_1^c - \frac{\eta_1}{\alpha}} = \frac{\sigma_1^{-\alpha}}{1+m}. \tag{63}$$

Since $B_1(0) > 0$, τ_1^o and τ_1^c are greater than η_1/α . Then, from (63),

$$\tau_1^o < \tau_1^c \leftrightarrow \frac{\sigma_1^{-\alpha}}{1+m} < 1. \tag{64}$$

Now, country 1's share in the integrated capital market is obtained as

$$\sigma_1 = \frac{(1-\tau_1^o)^{\frac{1}{1-\alpha}}}{(1-\tau_1^o)^{\frac{1}{1-\alpha}} + (1-\tau_2^o)^{\frac{1}{1-\alpha}}}.$$

Taking the inverse of this equation, we obtain

$$\sigma_1^{-1} = 1 + \left(\frac{1-\tau_2^o}{1-\tau_1^o}\right)^{\frac{1}{1-\alpha}}.$$

Using this, (64) is rewritten as

$$\begin{aligned}
\tau_1^o < \tau_1^c \quad &\leftrightarrow \quad \sigma_1^{-\alpha} < 1+m \\
&\leftrightarrow \quad 1 + \left(\frac{1-\tau_2^o}{1-\tau_1^o}\right)^{\frac{1}{1-\alpha}} < (1+m)^{\frac{1}{\alpha}} \\
&\leftrightarrow \quad \frac{1-\tau_2^o}{1-\tau_1^o} < \left[(1+m)^{\frac{1}{\alpha}} - 1\right]^{1-\alpha}.
\end{aligned}$$

Thus, we obtain (45). Similarly, for $i = 2$, we first obtain

$$\tau_2^o < \tau_2^c \leftrightarrow \frac{m\sigma_2^{-\alpha}}{1+m} < 1. \tag{65}$$

Using this, we obtain (46).

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