Capital Market Integration and Fiscal Sustainability

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May 15, 2019

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 against the backdrop of capital tax competition and studies whether competition for mobile capital lowers or improves 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 a marked difference exists between countries, tax competition might lower fiscal sustainability in a country with abundant capital and 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. There are also many specific examples of tax-cut competition. In particular, tax cuts became more intense with the fifth enlargement of the European Union in 2004. Twelve countries, mainly Eastern European countries, joined the EU and succeeded in attracting operations from firms in higher-tax countries. For example, France-based automaker PSA Peugeot Citroen and Germany-based engineering firm Siemens moved a part of their production to Slovakia whose tax rate was about half of Germany and France (Kennedy, 2007). These large countries threatened the low-tax countries with reduced EU subsidies if they did not stop tax dumping and explored ways to set a lower limit on corporate tax rates. However, ultimately, Germany and France were forced to lower their corporate tax rates. One of the reasons why a cooperative raise in the tax rate cannot materialize is that standards of tax base have not been unified and are different in each country. A movement toward a common tax base has just begun in terms of a proposal for a Council Directive on a Common Consolidated Corporate Tax base since 2016, but a solid framework is yet to be established, and a common tax rate is still a distant goal.

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 (MTR) 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 equilibrium.\(^2\)

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\(^1\)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. 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. 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. 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. By contrast, 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, indicating that the interdependence of fiscal policies influences fiscal sustainability.

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 reduces competition for mobile capital and, thus, lowers the growth-enhancing effect of tax competition. The static models of capital tax competition focus on strategic interactions among countries, but Köthenbürger and Lockwood (2010) and Hatfield (2015) focus on the effects of competition for mobile capital on long-run economic growth instead of setting the game theoretic interaction as a central issue. Our study is similar to theirs in that it does not emphasize aspects of strategic interdependence among countries. However, while these two preceding studies focus on the impact of tax competition on economic growth, our attention is directed toward the impact not only on fiscal sustainability.

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.

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2Specifically, 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.


4Some 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.
economic growth but also 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 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 fiscal sustainability. In short, the reasons are as follows. 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. In addition, 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, i.e., capital externality. 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.\(^5\)

Although the above results are derived in the model of symmetric countries, this paper further examines the effects of capital market integration, focusing on two countries with different conditions. The difference in condition is mainly characterized by the difference in capital stock before market integration among countries, and the analyses show that an increase in capital flows through market integration results in capital outflows from the capital-rich country, suggesting that the integration of the capital market does not necessarily have a positive effect on fiscal sustainability in countries with more capital.

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 MTR that guarantees fiscal sustainability for each country, and using MTR, we estimate the degree to which countries can lower their tax rates. Section 4 studies how the tax competition accompanied by capital market integration changes MTR and 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 (households) 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

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

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

\[
r_i = (1 - \tau_i) \frac{Y_i}{K_i} \text{ and } w_i = (1 - \alpha) \frac{Y_i}{L_i},
\]

\(^5\)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).
where $r_i$ and $w_i$ are, respectively, the after-tax interest rate and wage rate, and $\tau_i$ 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 $\nu$; 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 $\nu = 0$.

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

$$Y_i = \phi \sigma_i^\alpha K,$$

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

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

### 2.2 Capital market

Mobile capital is allocated between countries 1 and 2 to satisfy

$$\sigma_1 + \sigma_2 = 1. \quad (5)$$

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:

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

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

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

The comparative statistics yield

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

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.

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6Our 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.
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

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

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

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

where $\rho$, 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. 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

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

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

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 toward infinity.

2.4 Governments

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

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

$$T_i = \tau_i \alpha \phi \sigma^2_i K,$$

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:

$$G_i = \eta_i Y_i.$$

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

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

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

$$\beta_i = (1 - \tau_i)ab_i - \lambda_i,$$

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7 It is possible to formulate the case that government expenditure directly affects residents’ utilities by assuming $V_i = \int_0^{\infty} e^{-\rho t} [\log C_i(t) + \theta \log G_i(t)] dt$, 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.

8 The assumption that $\eta_i$ 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.
where \( b_i \equiv B_i / K_i \) and
\[
\lambda_i \equiv \alpha \tau_i - \eta_i. \tag{16}
\]
\( \lambda_i \) 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 \( \tau_i, \beta_i, \) or \( \eta_i \) needs to be determined endogenously. In the following analysis, assuming that the share of government expenditure to GDP, \( \eta_i \), 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:
\[
\frac{\dot{C}}{C} = r - \rho \quad \text{and} \quad \frac{\dot{K}}{K} = \phi \sigma_1^\alpha + \phi \sigma_2^\alpha - c - g, \tag{19}
\]
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), \( \sigma_i \) 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:
\[
\frac{\dot{b}_i}{b_i} = \frac{\beta_1 \phi \sigma_1^\alpha - \phi \sigma_1^\alpha - \phi \sigma_2^\alpha + c + g}{b_i} \quad \text{and} \quad \frac{\dot{b}}{b} = \frac{\beta_1 \phi \sigma_1^\alpha + \beta_2 \phi \sigma_2^\alpha}{b} - \phi \sigma_1^\alpha - \phi \sigma_2^\alpha + c + g. \tag{22}
\]
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.\(^9\) Formally, in our model, the long-run equilibrium is defined as follows.

**Definition 1.** The long-run equilibrium for this economy consists of equations (3)–(7), (9)–(21), and
either of the following conditions:

\[
\begin{align*}
\text{(i)} & \quad \frac{\dot{C}_i}{C_i} = \frac{\dot{K}_i}{K_i} = \frac{\dot{B}_i}{B_i} = 0, \\
\text{(ii)} & \quad \frac{\dot{C}_i}{C_i} = \frac{\dot{K}_i}{K_i} = \frac{\dot{B}_i}{B_i} \quad \text{and} \quad \frac{\dot{B}_i}{B_i} = 0 \quad \Leftrightarrow \lambda_i = 0.
\end{align*}
\]

In either case, (i) or (ii), 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:\(^{10}\)

\[
\gamma \equiv r - \rho. \tag{26}
\]

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 \(\beta_i\) 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

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

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

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

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

\[
\begin{align*}
b_i(t) &= \left[ b_i(0) - \frac{\lambda_i \phi (\sigma_i)^{\alpha-1}}{\rho} \right] e^{\rho t} + \frac{\lambda_i \phi (\sigma_i)^{\alpha-1}}{\rho}, \\
b(t) &= \left[ b(0) - \frac{\sum_{i=1}^{2} \lambda_i \phi (\sigma_i)^{\alpha}}{\rho} \right] e^{\rho t} + \frac{\sum_{i=1}^{2} \lambda_i \phi (\sigma_i)^{\alpha}}{\rho},
\end{align*}
\tag{29-30}
\]

which characterize the equilibrium dynamics of the economy.

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\(^9\)Negative growth of public debt in the long run is excluded by the assumption that the government does not lend to
residents. This is because a long-term negative growth of public debt violates the transversality condition for the household’s
optimization problem.

\(^{10}\)It is assumed that \(\phi\) is sufficiently large and \(\rho\) is sufficiently small so that a positive growth rate can be guaranteed at
any value within the range where \(\tau_i\) is less than 1.
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

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

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 2.** Fiscal management is sustainable if the ratio of debt outstanding to private capital stock \((b_i \text{ or } b)\) 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 \((b_i = \phi \sigma_1^\alpha B_i/Y_i)\). 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:

\[
0 \leq b_i(0) \leq \frac{\lambda_i \phi \sigma_1^\alpha - 1}{\rho} \equiv \psi_i.
\]

**Proof.** See Appendix B. \(\square\)

In (31), \(b_i(0)\) is the debt outstanding-capital ratio at time 0, and \(\psi_i\) is the upper bound of a sustainable debt-to-GDP ratio. (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. \(\square\)

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 \(\gamma\). 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 debt is sustainable if the tax rate satisfies the following:

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

\[\text{(32)}\]

\[11\text{See Appendix A for a derivation of these conditions.}\]
Proof. By inserting $\lambda_i = \alpha \tau_i - \eta_i$ into (31), we obtain the range of tax that ensures fiscal sustainability as

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

(33)

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

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

(34)

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

Next, we check whether (32) is binding when the government chooses its tax rate. The government in each country is assumed to maximize residents’ utilities. That is, by using (8), (9), and (26), the objective function of the government is assumed to be

$$V_i = \frac{1}{\rho} \left[ \log C_i(0) + \frac{2}{\rho} \right].$$

(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):

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

(36)

Given (36), the maximization of (35) with respect to $\tau_i$ gives the tax rates chosen by the governments. The results for symmetric countries are summarized as follows.

**Lemma 2.** Suppose that the countries are symmetric in all respects. 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.

Lemma 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. This finding indicates that, to make public finance 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 equality. The result can be summarized as follows.

**Proposition 2.** The capital tax rate chosen by the sustainable government is

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

(37)

We call the tax rate defined in (37) MTR.

With the integration of the global capital market, interregional competition for mobile capital induces governments to cut their tax rates, which leads countries toward 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

---

12 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.
fiscal sustainability constraints lowers the tax rate to a negative level, which leads to fiscal collapse.\textsuperscript{13}

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.

When (37) holds, we have the following result:

**Corollary 2.** When the government sets the minimum tax rate, given by (37), $b_i(t) = b_i(0)$ holds.

**Proof.** From (16) and (37), $\lambda_i = \rho \phi^{-1}(\sigma_i)^{1-\alpha} b_i(0)$. Substituting this equation into (29), we have

$$b_i(t) = (b_i(0) - b_i(0)) e^{\rho t} + b_i(0) = b_i(0).$$

In Definition 2, we have defined that public finance is sustainable if the ratio of debt outstanding to private capital converges to a constant level when $t \to \infty$. Under this definition, the constant level of the debt to private capital ratio may be above or below its initial level. For instance, if the government sets a tax rate above the MTR given by (37), the debt to private capital ratio will converge to zero. Corollary 2 shows that if the welfare-maximizing government chooses a tax rate that equals the MTR, the debt to private capital ratio remains at its initial level.\textsuperscript{14}

### 3.3 Room for tax reduction: Numerical calculation

Equation (37) provides useful information on how far the governments competing for mobile capital can reduce the capital tax rate. Using (37) with the values of time preference ($\rho$), capital share ($\alpha$), ratio of public expenditure to GDP ($\eta_i$), and ratio of debt outstanding to GDP ($B_i(0)/Y_i(0)$), we can obtain the minimum tax rate (MTR) for each country.

In the third to fifth columns of Table 1, the values of $\eta_i$, $B_i(0)/Y_i(0)$ and $1 - \alpha$ are shown for each country. The labor share is shown in the fifth column of Table 1, and the capital share is defined as 1 minus labor share. Using this information, we present in the sixth column the MTR that guarantees fiscal sustainability to keep the public debt to GDP ratio at the 2015 level. These lower limits of the tax rate are high because they are calculated based on the assumption that debt and capital tax alone covers expenditures. In reality, however, the government secures revenues by using not only capital tax but also other taxes. Therefore, we next derive the MTR when the government imposes a comprehensive tax.

That is, government also taxes other tax bases, i.e., labor income in our model, at a similar rate as the capital tax rate.

To derive the MTR under the comprehensive tax, suppose that the government applies the same tax rate not only to capital but also to labor income. In this case, the budget constraint of the residents in country $i$ is given as

$$\dot{A}_i = r A_i + (1 - \tau_i) w_i - C_i.$$

Since the government secures tax revenue not only from capital but also from labor income, its budget constraint becomes

$$T_i = \tau_i \alpha Y_i + \tau_i w_i L_i = \tau_i Y_i.$$

In this case, (16), representing the primary balance ratio, is rewritten as follows:

$$\lambda_i = \tau_i - \eta_i.$$  \hspace{1cm} (38)

Since (27) and (28) are unchanged, Lemma 1 still holds. Therefore, using (38), (33) is modified as follows.

$$\tau_i \geq \eta_i + \frac{\rho}{\phi} (\sigma_i)^{1-\alpha} b_i(0) = \eta_i + \frac{\rho B_i(0)}{Y_i(0)}.$$  \hspace{1cm} (39)

Equation (39) defines the MTR under comprehensive taxes, which can be obtained by substituting the values in the third and fourth columns of the table into (39). The seventh column of the table shows the estimated MTR under comprehensive taxes.

The seventh column in Table 1 highlights that Greece and Japan have the highest minimum 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 government chooses a new MTR corresponding to the shock.

\textsuperscript{13}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.

\textsuperscript{14}Although the paper omits the analysis of the transition process caused by the external shock, the steady-state debt level may be higher or lower than the initial level if it occurs. Specifically, an unexpected decrease (increase) in $\phi$ at some point raises (lowers) $b_i$ in the transition process, but $b_i$ converges to a level higher (lower) than the initial level after the government chooses a new MTR corresponding to the shock.
countries, the lower limit of the capital tax rate that ensures debt sustainability is higher than that in other countries. By contrast, countries with low government consumption and debt-to-GDP ratio tend to have relatively low MTR.

<table>
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<th>Gov. consumption</th>
<th>Gov. Debt</th>
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<th>Capital income tax base % estimated</th>
<th>Comprehensive tax base % estimated</th>
<th>Effective avg. tax rate % 2018</th>
<th>Combined statutory tax rate % 2018</th>
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<td>% of GDP 2015</td>
<td>% of GDP 2014</td>
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</table>

Table 1. Sustainable Tax Rates, Estimated.

Note. The time preference rate (\(\rho\)) is 0.03.

Sources. OECD Data (https://data.oecd.org/) and Penn World Table version 9.0 (http://www.rug.nl/ggdc/productivity/pwt/).
An interesting extension of the analysis would be to compare the MTR with the actual tax rate. However, in making such comparisons, the tax index used to contrast with MTR is essential because various institutions calculate the rates of tax associated with business taxes. The results of comparison vary according to the tax indices adopted. For the primary approach, Table 1 presents the combined statutory corporate tax rate (CSTR) and the effective average corporate tax rate (EATR) reported by the OECD.

The data are obtained from OECD database, *The Corporate Tax Statistics*. EATR is a synthetic tax policy indicator reflecting the average tax contribution a firm makes on an investment project earning above-zero economic profits. In the database, EATR is calculated for three different macroeconomic scenarios. In two of the three scenarios, macroeconomic variables, that is, the interest and inflation rates, are held constant at the same level across the countries. In the third scenario, country-specific macroeconomic parameters are used, which gives better indications on the tax effects on investment incentives in a specific country at a specific point in time. This paper uses the EATR based on the third scenario because we conduct a country-by-country comparison of MTRs before and after market integration.\(^\text{15}\)

There are two other representative indices of corporate tax rates. The first is that reported by the Congress of the United States (2017). This index measures the tax burden of a corporation on returns from a marginal investment. However, it only reports tax rates for G20 countries, and many EU countries that compete for capital are not included in the report. The second is the tax rate reported by the World Bank. This is a very comprehensive indicator in that it represents the business tax burden of about 190 countries. However, the scope of this index’s target firms is very narrow: it is based only on the corporate taxes that would be paid by a small and domestic manufacturing firm over the first two years of operation. Therefore, in countries that favor startup firms, the tax rate will be extremely low following the World Bank’s estimation. For example, the corporate tax rate in France was only 0.7% in 2017.\(^\text{16}\)

The pros and cons of any indicator need to be considered; hence, we use OECD data that uniformly show statutory and effective tax rates for many countries.

The eighth and ninth columns of Table 1 show the EATR and CSTR, respectively, reported by OECD. By comparing the values in the seventh and eighth columns, we can provide a little rough but useful information about the fiscal space, which shows which country has relatively little or large space for lowering the tax rate under the hypothetical situation that each country applies comprehensive tax. The comparison result reveals the followings: (i) In several Eastern European countries, there is little room for reduction in tax rates. For example, Hungary, which has the lowest effective average tax rate of 11.7%, can no longer further reduce the tax rate. Similarly, Latvia, Slovenia, Estonia, and Poland have little room for lowering their tax rates, about 10% points or less. (ii) Looking at countries other than Eastern Europe, Ireland, which is often labeled a corporate tax haven, has a low effective tax rate of 15.0% from which approximately less than 10% points space is allocated for tax rate reduction. (iii) In some countries away from Europe, the effective tax rate is relatively high, and there is plenty of space to reduce the tax rate. For example, the effective tax rate of the United States is the highest at 43.7%, and the space for reducing the tax rate remains at 31.6% points. The same is true for Chile, where there is about 35% points room for tax rate reductions. Furthermore, even in Japan, where the debt-to-GDP ratio is extremely high at 234%, there is considerable space for reducing the tax rate because the effective tax rate is still high at 37.2% and the government consumption-to-GDP ratio is relatively lower than in other countries with high debt. The above trend does not change much when comparing the MTR and CSTR shown in the eighth column.

Finally, we mention the robustness of the estimated results associated with the data of government consumption. In the OECD data, general government consumption can be broken down into two distinct groups: collective consumption and individual consumption. For collective consumption, the expenditures benefit society as a whole, whereas for individual consumption, expenditures are incurred by government on behalf of individual households. In the third column of Table 1, data on collective consumption are used because our model does not consider income transfer from the government to individuals. If the latter data are used, the share of government consumption to GDP increases in Nordic countries where social transfers in kind are large, which increases the MTR of those countries compared with the MTRs

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\(^\text{15}\)See the work of Hanappi (2018) for the details on the OECD indicators of effective average tax rate. CSTR is calculated as the combined central and sub-central (statutory) corporate income tax rate given by the central government rate (less deductions for sub-national taxes) plus the sub-central rate.

\(^\text{16}\)See World Bank Group and PwC (2017). See also PwC (2016) for similarities and differences of various indicators.
in Table 1. This means that the fiscal space of the Nordic countries is smaller than that in Table 1. However, even if we use different data representing government consumption, we can confirm that the key estimates presented in this section are still maintained: While the fiscal space of Hungary, Norway, and Latvia is not large, those in some countries that are not EU members, such as the United States, Australia, Japan, and Chile, are sufficient.

4 Market integration

Based on Proposition 2, the government sets a tax rate equal to the MTR given by (37). In this section, we study the effects of capital market integration on the MTR that ensures fiscal sustainability. If the MTR 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 MTR, 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. So, before $t = 0$, the capital accumulation in each country solely determines the amount of capital in each country. However, after $t = 0$, in addition to capital accumulation, the inter-regional capital flow is also a determinant of the amount of capital in each country.

4.1 Symmetric countries

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 all respects; that is, the capital market is closed; that is, the capital is accumulated only in its own country and capital mobility does not exist across the countries. In (41), $\eta_i$, $B_i(0)$, and $K(0)$ are the predetermined variables and the right-hand side of (41) is constant.

Next, we derive the MTR for sustainability in the integrated capital market, which was already given by (37). However, the case of the integrated 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, $\tau_i$ and $\tau_j$.

That is, in the integrated market, we have

$$Y_i(0) = 2^{(\alpha - 1)\nu} \xi \sigma_i^o K(0),$$

where $\sigma_i = \sigma_i(\tau_1, \tau_2)$.\(^\text{18}\) The substitution of (42) into (37) yields the MTR in the integrated market:

$$\tau_i^c = \frac{1}{\alpha} \left[ \eta_i + 2^{1 - (1 - \alpha)(1 - \nu)} B_i(0) \right].$$

Substituting $X = K/n^\nu$ into (1), $Y_i = \xi \eta_i^{\nu - 1} \nu K_i^\nu K_i^{1 - \alpha} L_i^{1 - \alpha}$. Since $L_i = 1$, $K_i = K$, and $n = 1$ hold in the case of a closed capital market, $Y_i(0)$ can be obtained as $Y_i(0) = \xi K_i(0)$. Under the symmetric equilibrium, we have $K_i(0) = K(0)/2$, which is used to obtain (40).

Substituting $X = K/n^\nu$ into (1), $Y_i = \xi \eta_i^{\nu - 1} \nu K_i^\nu K_i^{1 - \alpha} L_i^{1 - \alpha}$. Since $L_i = 1$, $\sigma_i = K_i/K$, and $n = 2$ hold in the case of the integrated capital market, $Y_i(0)$ can be obtained as (42)
Proposition 3. Suppose countries are symmetric in all respects; \( K_1(0) = K_2(0) = 0.5K(0) \), \( B_1(0) = B_2(0) \), and \( \eta_1 = \eta_2 = \eta \). Then, capital market integration increases fiscal sustainability.

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

\[
\tau^o_i = \frac{1}{\alpha} \left[ \eta + 2^{1-(1-\alpha)(1-v)} \rho \frac{B_i(0)}{\xi K(0)} \right] \leq \frac{1}{\alpha} \left[ \eta + 2\rho \frac{B_i(0)}{\xi K(0)} \right] = \tau^c_i. \tag{44}
\]

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 capital 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.

Figure 1 illustrates the essence of Proposition 3. If the government decides the tax rate without paying attention to the fiscal sustainability, it selects \( \tau^*_i \). This is a situation in which the government gives subsidies to capital and manages its finance, relying only 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 \( \tau^c_i \) 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 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 \( \tau^c_i \) to \( \tau^o_i \). This means that tax competition accompanied by capital market integration expands the range of taxes the government can choose and therefore increases fiscal sustainability.

To clarify the difference in the MTRs before and after market integration, \( \tau^c_i \) and \( \tau^o_i \), it is helpful to consider an example in which they can be explicitly compared.

Example 1 (Symmetric countries). Taking French data in Table 1 as an example, we derive the MTRs before and after the market integration. From (40) and (41), the MTR of country \( i \) in the closed market is given by

\[
\tau^c_i = \frac{1}{\alpha} \left[ \eta + \rho \frac{B_i(0)}{Y_i(0)} \right]. \tag{45}
\]

Suppose \( \rho = 0.03 \) and \( \nu = 0 \). Table 1 shows that the following are applicable in the case of France (\( i = f \)): \( \alpha_f = 0.37 \), \( \eta_f = 0.083 \), and \( B_f(0)/Y_f(0) = 1.20 \). Substituting these into (45), we have

\[\text{Note. } \tau^c_i \text{ and } \tau^o_i \text{ denote the minimum tax rates (MTRs) before and after the capital market integration. } \tau^*_i \text{ is the tax rate when the government is not subjected to the MTR.} \]

\[\text{Figure 1: Tax ranking} \]

\[\text{Graph showing the tax ranking with } \tau^c_i, \tau^o_i, \text{ and } \tau^*_i. \]

\[19\text{It is straightforward that } \tau^c_i = \tau^o_i \text{ if no interregional knowledge spillover exists, } \nu = 1.\]
\( \tau^c_1 = 0.321 \). Now, suppose that France has integrated its capital market with its neighbor, assuming that the neighboring country is the same in all respects with France. Then, from (43), the MTR of France after the market integration is given as \( \tau^c_1 = 0.287 \). This indicates that the MTR has dropped by 3.4% points, which means that the market integration increases the fiscal sustainability in France.

### 4.2 Asymmetric countries

In Section 4.1, we showed that capital market integration enhances fiscal sustainability if countries are symmetric in all respects. Then, we discuss the extent to which the results change if we allow asymmetries between two countries. Asymmetry can be modeled by three variables: \( \eta_i \), \( B_i(0) \), and \( K_i(0) \). Without any loss of generality, we define \( m \) to satisfy

\[
K_2(0) = mK_1(0),
\]

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

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

\[
\tau_1^0 = \frac{1}{\alpha} \left[ \eta_1 + \rho_B \frac{B_1(0)}{\phi K_1(0)} \frac{1}{\sigma^1 \alpha} \right] \quad \text{and} \quad \tau_2^0 = \frac{1}{\alpha} \left[ \eta_2 + \rho_B \frac{B_2(0)}{\phi K_2(0)} \frac{1}{m \sigma^2 \alpha} \right],
\]

where

\[
\sigma_1 = \frac{(1 - \tau_1^0)^{\frac{1}{1 - \alpha}}}{(1 - \tau_1^0)^{\frac{1}{1 + \alpha}} + (1 - \tau_2^0)^{\frac{1}{1 - \alpha}}} \quad \text{and} \quad \sigma_2 = \frac{(1 - \tau_2^0)^{\frac{1}{1 - \alpha}}}{(1 - \tau_1^0)^{\frac{1}{1 + \alpha}} + (1 - \tau_2^0)^{\frac{1}{1 - \alpha}}}.
\]

Four variables, \( \tau_1^0 \), \( \tau_2^0 \), \( \sigma_1^0 \), and \( \sigma_2^0 \), are determined by the four equations in (47) and (48), but unfortunately, we cannot obtain an explicit solution of them. However, the change in the MTR associated with market integration can be clarified by comparing \( \tau_1^c \) and \( \tau_2^c \) as follows. Let us look at country 1. The MTR in the closed market is given by (37); hence, we insert it into (47) and delete \( B_1(0) \) to obtain

\[
\tau_1^0 = \frac{1}{\alpha} \left[ \eta_1 + \left( \alpha \sigma_1^c - \eta_1 \right) \frac{1}{\sigma^1 \alpha} \right],
\]

which can be rewritten as

\[
\frac{\tau_1^0 - \eta_1}{\tau_1^c - \eta_1} = \frac{\sigma^{-\alpha}_1}{1 + m}.
\]

Since \( B_1(0) > 0 \), \( \tau_1^c \) and \( \tau_1^c \) are greater than \( \eta_1/\alpha \). Then, from (49), the capital market integration enhances fiscal sustainability if

\[
\tau_1^0 < \tau_1^c \Leftrightarrow \frac{\sigma^{-\alpha}_1}{1 + m} < 1.
\]

Now, country 1’s share in the integrated capital market, \( \sigma_1 \), is obtained as (48). Taking the inverse of (48), we obtain

\[
\sigma_1^{-1} = 1 + \left( \frac{1 - \sigma_2}{1 - \sigma_1} \right)^{\frac{1}{\alpha}}.
\]
Figure 2: \( m = 1 \ (K_1(0) = K_2(0)) \)

Note. \( \eta = \eta_i \) 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.

Using this equation, we can finally rewrite (50) as

\[
\tau_o^1 < \tau_o^c \leftrightarrow \sigma_1^{-\alpha} < 1 + m \\
\leftrightarrow 1 + \left( \frac{1 - \tau_o^2}{1 - \tau_o^1} \right)^{\frac{1}{1-\alpha}} < (1 + m)^{\frac{1}{\alpha}} \\
\leftrightarrow \frac{1 - \tau_o^2}{1 - \tau_o^1} < \left[ (1 + m)^{\frac{1}{\alpha}} - 1 \right]^{1-\alpha} \\
\leftrightarrow \tau_o^1 < 1 - \frac{1 - \tau_o^2}{\left[ (1 + m)^{\frac{1}{\alpha}} - 1 \right]^{1-\alpha}}. \tag{51}
\]

In a similar manner, we can derive the following condition for country 2:

\[
\tau_o^2 < \tau_o^c \leftrightarrow \tau_o^2 < 1 - \frac{1 - \tau_o^1}{\left[ (1 + m)^{\frac{1}{\alpha}} - 1 \right]^{1-\alpha}}. \tag{52}
\]

From (51) and (52), the following proposition is derived.

**Proposition 4.** Suppose that two countries are asymmetric before market opening. Market integration increases fiscal sustainability in two asymmetric countries if (51) and (52) hold simultaneously. Otherwise, market integration lowers fiscal sustainability in either country.

Figure 2 illustrates (51) and (52) with the equality, in which the two lines pass through (1,1). In Figure 2, \( K_1(0) = K_2(0) \), that is, \( m = 1 \) is assumed.\(^{20}\) The valid area in Figure 2 is restricted by \( \tau_o^i > \eta_i / \alpha \) since \( B_i(0) > 0 \) (see (41)).

The combination of (\( \tau_o^1, \tau_o^2 \)) that satisfies (51) and (52) is indicated by \( C \). In area \( A \) of Figure 2, market integration decreases the MTR 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.

\(^{20}\)Even if \( m = 1 \), \( \tau_o^1 \) and \( \tau_o^2 \) are not necessarily equal because \( \eta_i \) and \( B_i(0) \) could be different between two countries. If countries are symmetric in all respects, \( \tau_o^1 = \tau_o^2 \) holds, then the equilibrium is located on the 45 degree line in Figure 2. In this case, the analysis goes back to the case of symmetric countries in the previous section, and therefore, Proposition 3 is restored.
To understand the intuition of this classification, let us look at point $\iota$ included in area $B$ in Figure 2, where the MTR of country 1 is higher than that of country 2, $\tau_1^o > \tau_2^o$. Behind point $\iota$, a difference exists in the debt outstanding between the two countries. As can be seen from (47), when the debt outstanding before market integration is higher in country 1 than in country 2, country 1 has less space for lowering the tax rate after the market integration because the burden of debt repayment is heavier in country 1. Therefore, the MTR of country 1 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 $K_1(0) = K_2(0)$. 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 at point $\iota$, 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, which works to lower fiscal sustainability.

In sum, at point $\iota$, 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 $\iota$, 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.

The point $\omega$ can be interpreted similarly. Behind point $\omega$, there is the assumption that the debt outstanding of country 2 is slightly larger than that of country 1. Debt repayment is relatively heavy in country 2; hence, it has less space to reduce the tax rate, resulting in a little higher MTR. This leads capital flow from country 2 to country 1 after the market integration. In this case, country 1 receives the two benefits of capital externality and capital inflow, and thus, the fiscal sustainability in country 1 is increased by market integration. By contrast, the market integration has both a negative and positive impact on country 2. On the one hand, it produces positive capital externality to country 2. On the other hand, it causes capital outflow from country 2. At point $\omega$, since the tax gap between the two countries is not very large, capital externality outperforms capital outflow, causing country 2 to increase its fiscal sustainability.

Using the data in Table 1, we provide the following example to illustrate what happens at point $\omega$ in Figure 2.

**Example 2** ($K_1(0) = K_2(0)$ and $B_1(0)/Y_1(0) < B_2(0)/Y_2(0)$). We use the data from Slovakia and France in Table 1 as we mentioned the tax competition between the two countries in Section 1. Suppose that they hold the same amount of capital and labor, but their debt-to-GDP ratios are different at time 0. Let Slovakia and France be country 1 and country 2, respectively, and assume $\rho = 0.03$ and $\nu = 0$. The MTR of Slovakia in the closed market is $\tau_1^o = 0.233$, and that of France is $\tau_2^o = 0.321$. Now, suppose that the capital market is integrated between Slovakia and France. The numerical solution gives the MTR in the integrated economy as $\tau_1^o = 0.220$ and $\tau_2^o = 0.287$. The comparison of $\tau_1^o$ and $\tau_2^o$ reveals that after the market integration, there is room for lowering the tax rate by 1.3% points in Slovakia and 3.4% points in France. Thus, market integration can enhance fiscal sustainability in both countries, which corresponds to point $\omega$ in Figure 2.

In this example, the capital share of Slovakia is given by $\sigma_1 = 0.51$, implying that market integration leads to a capital outflow from France to Slovakia. For France, capital outflows have a negative impact on fiscal sustainability, but at the same time, market integration benefits France because it generates positive capital externality. As the latter outweighs the former in this example, the market integration has enabled not only Slovakia but also France to increase fiscal sustainability.

Next, we study the case of $m > 1$, in which country 2 has more capital than country 1 before market integration, $K_2(0) > K_1(0)$. Let us look at point $\iota$ in Figure 3, where $K_1(0) < K_2(0)$ and $B_1(0)/Y_1(0) > B_2(0)/Y_2(0)$ before market integration. The point where (51) and (52) intersect the horizontal axis moves to the right as $m$ increases (Figure 3). At point $\iota$, country 1’s MTR is higher, $\tau_1^o > \tau_2^o$, because its outstanding debt is relatively large. In this case, after the capital market integration, the capital moves from country 1 to country 2, which lowers the fiscal sustainability of country 1. However, country 1 that has less capital can receive greater capital externality through market integration. Countries with lesser capital benefit more from the market integration because they can access other major countries’ knowledge and information. At point $\iota$, the effect of receiving capital externality outweighs the negative
Note 1. $\eta = \eta_1$ 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.

Note 2. $(M_1, M_2) = \left(1 - \left[\frac{(1 + m)^{1/\alpha} - 1}{1 - \left[\frac{(1 + m)^{1/\alpha} - 1}{1 - \alpha}\right]}\right], 1 - \left[\frac{(1 + m)^{1/\alpha} - 1}{1 - \alpha}\right]^{\alpha - 1}\right)$. Effect of capital outflow, so unlike the case of point $\iota$ in Figure 2, market integration enhances the fiscal sustainability of country 1. By contrast, market integration always increases the fiscal sustainability of country 2 at point $\iota$ because it produces two positive effects: capital externalities and capital inflow both from country 1.

A similar explanation can be applied to interpret the situation of point $\omega$ in Figure 3. At point $\omega$, it is assumed that $B_2(0)/Y_2(0) > B_1(0)/Y_1(0)$, which means that the MTR in country 2 is higher than in country 1. This causes capital flows from country 2 to country 1. Country 1 with a small capital endowment benefits greatly from capital externalities through market integration. At the same time, capital flows into country 1, so the market integration necessarily increases its fiscal sustainability. By contrast, in country 2 with more capital, market integration reduces fiscal sustainability. On the one hand, the merit of capital externality that country 2 can receive through integration is small because the capital of the neighboring country is small. On the other hand, capital flows out because of market integration. As the latter effect exceeds the former, the fiscal sustainability of country 1 is reduced.

The following example helps to see point $\omega$ in Figure 3.

**Example 3 ($K_1(0) < K_2(0)$ and $B_1(0)/Y_1(0) < B_2(0)/Y_2(0)$).** We use the data from Greece and Slovakia in Table 1 to see the effects of market integration on fiscal sustainability when $m > 1$. According to the Penn World Table, the capital stock in Greece is 3.8 times larger than in Slovakia. Moreover, the labor force in Greece is 1.8 times that of Slovakia; hence, the capital per worker is 2.11 times larger. Let Slovakia be country 1 and Greece be country 2. So, we set $m = 2.11$. Assume also $\rho = 0.03$ and $\nu = 0$. Using the data in Table 1 for two countries, we get the MTRs in the open market as $\tau_1^o = 0.210$ and $\tau_2^o = 0.335$. In the case of closed market, the MTRs of Greece and Slovakia were given by $\tau_2^c = 0.325$ and $\tau_1^c = 0.233$, respectively. The result suggests that the MTR in Greece has increased because of market integration, implying that the market integration with Slovakia lowers fiscal sustainability in Greece.

In this example, we calculate the capital share and obtain $\sigma_1 = 0.606$, which indicates that 60.6% of the capital that the two countries try to attract flows into Slovakia. This is a large value than expected. For example, suppose that the capital stock per labor in Slovakia before the market integration is 1000, $K_1(0) = 1000$. In this case, the capital stock of Greece before the market integration is given by $K_2(0) = 2110$ since $K_2(0) = mK_1(0)$, where $m = 2.11$. Therefore, the total capital stock in the two
countries is 3110. In this case, \( \sigma_1 = 0.606 \) indicates that the capital in Slovakia increases from 1000 to 1885 (= 3110 \times 0.606) because of market integration, which helps to increase the fiscal sustainability in Slovakia. By contrast, although Greece receives some degree of capital externality by market integration, large amount of capital outflows from Greece. In fact, the amount of capital drops by more than 42% from 2110 to 1225, which significantly lowers GDP and undermine fiscal sustainability in Greece.

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, and is correct in one aspect. In fact, however, 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, and what we emphasized is that countries receive greater positive externalities from an integrated market. Specifically, they can increase their productivities by receiving Romer-type knowledge spillovers in an integrated capital market. This increases the production in each country and allows the repayment of debt easier. 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 countries are symmetric in all respects. Our theoretical hypothesis thus shows that, while countries are forced to reduce their capital tax rates when capital market is integrated and thus rely on bond-financing management, fiscal sustainability is somewhat maintained in relatively similar countries.

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 relatively 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.

Our results are derived within the context of a model that is general in some respects, but they obviously depend on other, less general assumptions. Specifically, to enable analysis focusing on capital flows in the dynamic framework, our analysis abstracts several elements, particularly the following two important factors.

First, to obtain analytical solutions, we have assumed that the production function is homogeneous in all countries. This assumption might be somewhat restrictive but could be supported when we suppose that competition among countries in similar development stages or technology catch-up through spillover of information occurs in a relatively short period of time. However, if our focus is on the tax competition between countries at different development stages, it would be plausible to assume some heterogeneity in technology. To give some insights on how the heterogeneity in production technology affects our key result, that is, Proposition 1, we suppose that the marginal productivity of capital investment varies among the countries, given that the capital input is constant. The implications of such differences will be as follows. Suppose a particular country has a higher marginal productivity of investment than other countries. Even if the government of this country raises the tax rate to some extent, the outflow of capital is small because technology advantage attracts investment. Hence, even facing competition over capital, this country will not lower the capital tax compared with other countries. This brings about an improvement in the primary balance, \( \lambda_i \), which contributes to raising the fiscal sustainability. This result indicates that the country with higher output elasticity of capital or TFP has a relatively wider range of tax rate that guarantees fiscal sustainability than other countries.

Second, in our model, we assumed that residents do not migrate across the countries. This assumption
is plausible as a primary approach because labor migration across countries is still relatively low. For example, according to the United Nations Population Division (2018), the proportion of international migrants relative to the world population remained relatively stable at around 3% over the last 25 years. However, there are factors such as reductions in migration costs, that promote labor migration in the future. What will be the possible consequences of allowing labor migration? To anticipate this, suppose the situation that people can choose the country of their residence, and the government taxes such mobile population. As in the baseline model, if government expenditure financed by taxation does not affect the residents’ utility, raising direct taxes involves outflow of population. The mechanism of labor outflow is equivalent to capital outflow caused by capital taxation, and in that sense, labor migration has the effect of lowering the tax rate imposed on the residents. Beyond this, labor migration can be a new factor that further reduces or ease the decline in capital tax rates. On the one hand, the decline in capital tax increases the growth rate through the rise in interest rate and capital accumulation, which induce labor inflow, and thus labor supply increases. This increases the marginal productivity of capital, resulting in capital inflows. Moreover, these incentivize governments to further reduce the capital tax rate. On the other hand, if government expenditure financed by taxation benefits residents’ utility, the opposite of the above may happen. Declining capital tax rates cut the public expenditures that directly lower residents’ utility. This induces residents to move to other countries. In this case, migration will be a break to lower the capital tax rate. In any case, it will be certain that the consequences of allowing labor migration depend on the extent to which public expenditure affects the utility of residents.

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, except for labor income tax in Section 3.2. 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 other tax instruments. 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

\[
\lim_{t \to \infty} p_t A_t e^{-\rho t} = \lim_{t \to \infty} A_t e^{-\rho t} = 0, \quad (53)
\]

\[
\lim_{t \to \infty} B_t e^{-rt} = 0. \quad (54)
\]

Specifically, (54) can be rewritten, by using \( K(t) = K(0)e^{\gamma t} \), as follows:

\[
\lim_{t \to \infty} B_t e^{-rt} = \lim_{t \to \infty} B_t \frac{K_t}{K_i} Ke^{-rt} = \lim_{t \to \infty} b_t \sigma e^{-\rho t} = 0. \quad (55)
\]
From (59) and (60), the initial debt outstanding must satisfy
\[ 0 \leq \lim_{t \to \infty} \frac{A_t}{C_i} = \lim_{t \to \infty} \frac{K_i + B_i}{C_i} = \lim_{t \to \infty} \left[ (1 + b_i) \frac{K_i}{C_i} \right] < \infty \text{ and } 0 \leq \lim_{t \to \infty} b_i < \infty. \]

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),
\[ \dot{B}_i = \beta_i Y_i = [(1 - \tau_i) \alpha b_i - \lambda_i] \phi \sigma_i K_i \\
= r B_i - \lambda_i Y_i. \tag{56} \]

By multiplying (56) by \( e^{-rt} \) and integrating the equation with respect to time, we obtain
\[ \int_0^T \dot{B}_i(t)e^{-rt}dt = \int_0^T [rB_i(t) - \lambda_i Y_i(t)] e^{-rt}dt. \]

By applying the integral by parts to this equation, we arrive at
\[ [B_i(t)e^{-rt}]^T_0 + r \int_0^T B_i(t)e^{-rt}dt = r \int_0^T B_i(t)e^{-rt}dt - \lambda_i \int_0^T Y_i(t)e^{-rt}dt \\
\Rightarrow [B_i(t)e^{-rt}]^T_0 = -\lambda_i \phi \sigma_i \int_0^T K(t)e^{-rt}dt. \tag{57} \]

By inserting \( K(t) = K(0)e^{\gamma t} \) into (57), we have
\[ [B_i(t)e^{-rt}]^T_0 = -\lambda_i \phi \sigma_i \int_0^T K(0)e^{-(\gamma - r)t}dt \\
\Rightarrow B_i(T)e^{-rT} - B_i(0) = -\lambda_i \phi \sigma_i \int_0^T K(0)e^{-\rho t}dt. \tag{58} \]

First, we consider the case where debt outstanding remains within a finite-time. By taking the limit of (58), the present value of regional government debt is
\[ \lim_{t \to \infty} B_i(t)e^{-rt} = B_i(0) - \frac{\lambda_i \phi \sigma_i \gamma K(0)}{\rho} \\
= \left[ b_i(0) - \frac{\lambda_i \phi \sigma_i \gamma - 1}{\rho} \right] K_i(0). \tag{59} \]

We apply a similar method to the dynamic equation \( \dot{B}(t) \). By using (56), we obtain \( \dot{B} = \beta_1 Y_1 + \beta_2 Y_2 = rB - \lambda_1 Y_1 - \lambda_2 Y_2 \). Multiplying (56) by \( e^{-rt} \) and integrating it with respect to time,
\[ \int_0^T \dot{B}(t)e^{-rt}dt = \int_0^T \left[ rB(t) - \sum_{i=1}^{2} \lambda_i Y_i(t) \right] e^{-rt}dt. \]

After rearranging this equation, we arrive at
\[ \lim_{t \to \infty} B(t)e^{-rt} = B(0) - \frac{\lambda_1 \phi \sigma_1 + \lambda_2 \phi \sigma_2}{{\rho}} K(0) \\
= \left[ b(0) - \frac{\lambda_1 \phi \sigma_1 + \lambda_2 \phi \sigma_2}{{\rho}} \right] K(0). \tag{60} \]

From (59) and (60), the initial debt outstanding must satisfy \( b_i(0) = \psi_i \) if debt outstanding does not converge to zero within a finite-time. In this case, \( b(0) = \Psi \) holds, where \( \Psi \equiv \sum_{i=1}^2 \frac{\lambda_i \phi \sigma_i}{\rho} \). From (29)
) and (30), debt outstanding does not converge to zero in a finite-time 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, \( \lim_{t \to \infty} B(t)e^{-\gamma t} = 0 \) 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 (58), we have

\[
B_i(\hat{t}_i)e^{-\gamma \hat{t}_i} = B_i(0) - \lambda_i \phi \sigma^p \int_0^{\hat{t}_i} K(0)e^{-\rho t} dt = 0. 
\]

(61)

\( \hat{t}_i \) is given by (61). 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 \( 0 \leq b_i(0) \leq \psi_i \) (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

\[
\lim_{t \to \infty} p_i(t)A_i(t) \exp(-\rho t) = \lim_{t \to \infty} \frac{A_i(t)}{C_i(t)} e^{-\rho t} = \lim_{t \to \infty} \frac{[1 + b(t)] s_i K(0)}{C_i(t)} e^{-\rho t} 
\]

\[
= \left[ b(0) - \frac{\lambda_1 \phi \sigma^p + \lambda_2 \phi \sigma^p}{\rho} \right] \frac{s_i K(0)}{C_i(t)} > 0.
\]

This inequality and (60) 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

\[
b(t) = \begin{cases} 
\left[ b(0) - \frac{\lambda_1 \phi \sigma^p + \lambda_2 \phi \sigma^p}{\rho} \right] e^{\rho t} + \frac{\lambda_1 \phi \sigma^p + \lambda_2 \phi \sigma^p}{\rho} & \text{if } t \leq \hat{t}_i < \infty, \\
0 & \text{if } t > \hat{t}_i,
\end{cases}
\]

where

\[
\hat{t}_i \equiv \log \left[ \frac{b(0) - \frac{\lambda_1 \phi \sigma^p + \lambda_2 \phi \sigma^p}{\rho}}{\rho} - \log \rho - \log \left( \Psi - b(0) \right) \right] > 0.
\]

By using (62), we arrive at

\[
\lim_{t \to \infty} p_i(t)A_i(t)e^{-\rho t} = \lim_{t \to \infty} \frac{A_i(t)}{C_i(t)} e^{-\rho t} = \frac{s_i K(0)}{C_i(t)} \lim_{t \to \infty} e^{-\rho t} = 0.
\]

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 \( \lim_{t \to \infty} B_i(t)e^{-\gamma t} = 0 \) and \( \lim_{t \to \infty} B(t)e^{-\gamma t} = 0 \) if \( b_i(0) < \psi_i \) for \( i = 1, 2 \). Therefore, the upper limit of \( b(0) \) must be equal to \( \Psi \) for a sustainable debt. In sum, public finance is sustainable if (31) holds.

**Appendix C**

(31) is rewritten as \( \rho B_i(0) \leq \lambda_i \phi \sigma^p K_i(0) = \lambda_i \phi \sigma^p K(0) \). 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 \( \gamma \), 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

\[
\frac{\dot{B}_i(0)}{B_i(0)} = r - \lambda_i Y_i(0) B_i(0) = r - \lambda_i \phi \sigma^p K(0) B_i(0)
\]

holds, we have

\[
\frac{\dot{B}_i(0)}{B_i(0)} - \gamma = r - \gamma - \lambda_i \phi \sigma^p K(0).
\]

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By multiplying by $B_i(0)$ on both sides,
\[
\dot{B}_i(0) - \gamma B_i(0) = (r - \gamma)B_i(0) - \lambda_i \phi \sigma_i^a K(0) \\
= \rho B_i(0) - \lambda_i \phi \sigma_i^a K(0) \geq 0 \iff b_i(0) \geq \lambda_i \phi \sigma_i^a - 1 / \rho.
\]

**Appendix D**

At $t = 0$, (7) reduces to
\[
\dot{A}_i(0) = rA_i(0) + w_i(0) - C_i(0) \\
= [1 + b(0)] r s_i K(0) + (1 - \alpha) \phi \sigma_i^a K(0) - C_i(0).
\]

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
\[
\dot{A}_i(0) = s_i \left[ K(0) + B(0) \right] = [\gamma + \beta_1 \phi \sigma_i^a + \beta_2 \phi \sigma_j^a] s_i K(0).
\]

By integrating (63) and (64), the initial consumption level is given by
\[
C_i(0) = \left\{ [1 + b(0)] r s_i + (1 - \alpha) \phi \sigma_i^a - \gamma s_i - s_i \sum_{j=1}^{2} \beta_j(0) \phi \sigma_j^a \right\} K(0) \\
= \left\{ \rho + \sum_{j=1}^{2} \lambda_j \phi \sigma_j^a \right\} s_i + (1 - \alpha) \phi \sigma_i^a \right\} K(0).
\]

**Appendix E**

The maximization of (35) with respect to $\tau_i$ gives
\[
\frac{\partial V_i}{\partial \tau_i} = \frac{1}{\rho^2} \left\{ \frac{1}{C_i(0)} \frac{\partial C_i(0)}{\partial \tau_i} \rho + \frac{\partial V_i}{\partial \tau_i} \right\} = 0.
\]

Using (36), we obtain
\[
\frac{1}{C_i(0)} \frac{\partial C_i(0)}{\partial \tau_i} = \frac{\sum_{j=1}^{2} \alpha \lambda_j \phi \sigma_j^a \omega_j \phi \sigma_j^a s_i + \frac{\phi \sigma_i^a}{\phi \sigma_i^a} \omega_i \phi \sigma_i^a s_i}{\left[ \rho + \sum_{j=1}^{2} \lambda_j \phi \sigma_j^a \right] s_i + (1 - \alpha) \phi \sigma_i^a}.
\]

The second term between the square brackets in (65) shows the effects of a change in the capital tax rate on the growth rate, which is obtained by $\partial \gamma / \partial \tau_i = \partial \gamma / \partial \tau_i = -\alpha \phi \sigma_i^a < 0$, 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, (66) can be rewritten as
\[
\frac{1}{C_i(0)} \frac{\partial C_i(0)}{\partial \tau_i} = \frac{\tau \alpha \phi \sigma_i^a}{\left\{ \rho + [1 - \eta - (1 - \tau) \alpha] \phi \sigma_i^{a - 1} \right\} (1 - \tau}).
\]

The substitution of (67) and $\partial \gamma / \partial \tau_i = -\alpha \phi \sigma_i^a < 0$ into (65) gives
\[
\frac{\partial V_i}{\partial \tau} = -\left( \frac{\alpha \phi \sigma_i^a}{\rho^2} \right) \frac{\rho + [1 - \eta - (1 - \tau) \alpha] \phi \sigma_i^{a - 1} \left\{ \rho + [1 - \eta - (1 - \tau) \alpha] \phi \sigma_i^{a - 1} \right\} (1 - \tau)}{(1 - \tau) \phi \sigma_i^{a - 1} (1 - \tau)}.
\]

Since the lower bound of $\tau$ is given at a level that satisfies $C_i(0) = 0$, the following condition holds:
\[
\sup(1 - \tau) = \frac{\rho + (1 - \eta) \phi \sigma_i^{a - 1}}{\alpha \phi \sigma_i^{a - 1}} > 1.
\]
In this case, we obtain the following conditions:
\[
\frac{\partial V_i}{\partial \tau} \bigg|_{\tau=1} = -\infty
\]
and
\[
\frac{\partial V_i}{\partial \tau} \bigg|_{\tau=\inf \tau} = - \frac{\alpha \phi^\sigma}{\rho^2} \left\{ \rho + \frac{1-\eta - \alpha^2 (1-\eta)(\phi^{\sigma-1})}{\phi^{\sigma-1}} \right\} \left( 1 - \tau^* \right) = +\infty.
\]

Hence, there exists \( \tau \) so that \( \partial V_i / \partial \tau = 0 \), which is solved for \( \tau \) as
\[
(1 - \tau^*) = \frac{(1 - \eta)\phi^{\sigma-1} + \sqrt{[(1 - \eta)\phi^{\sigma-1}]^2 + 4\rho\phi^{\sigma-1}}}{2\phi^{\sigma-1}} > 1 \Rightarrow \tau^* < 0.
\]

In this case, the ratio of the primary balance to GDP is obtained as follows:
\[
\lambda^* = \alpha\tau^* - \eta = \frac{(1 - \eta)\phi^{\sigma-1} + \sqrt{[(1 - \eta)\phi^{\sigma-1}]^2 + 4\rho\phi^{\sigma-1}}}{2\phi^{\sigma-1}} - \eta.
\]

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

References


Domar, E. D. (1944), The “burden of the debt” and the national income, American Economic Review 34, 798-827.


