Global Corporate Income Tax Competition, Knowledge Spillover, and Growth

Maebayashi, Noritaka and Morimoto, Keiichi

8 April 2022

Global Corporate Income Tax Competition, Knowledge Spillover, and Growth *

Noritaka Maebayashi† Keiichi Morimoto‡

September 16, 2022

Abstract

We analyze the welfare consequences of global corporate income tax competition, using a two-country model of endogenous growth with international knowledge spillovers. Although the Nash equilibrium tax rate can be excessively high or low, according to the degree of spillover, this does not lead to significant welfare losses. The key to this outcome is that corporate income tax competition for growth maximization, which we consider hypothetically, attains the maximum growth rate, despite complex externalities and strategic interactions.

JEL classification: E62; F23; F42; H21; H54

Keywords: corporate income tax; tax competition; spillover; economic growth; welfare

*We are grateful for Kazutoshi Miyazawa's helpful comments. We also thank the participants of the 2022 Spring Meeting of the Japanese Economic Association and the seminar at Meisei University. Any remaining errors are our own.

†Faculty of Economics and Business Administration, The University of Kitakyushu, 4-2-1, Kitagata, Kokura Minami-ku, Kitakyushu, Fukuoka 802-8577, Japan. E-mail address: non818mn@kitakyu-u.ac.jp

‡Corresponding author. School of Political Science and Economics, Meiji University, 1-1, Kanda-Surugadai, Chiyoda-ku, Tokyo 101-8301, Japan. E-mail address: morimoto@meiji.ac.jp

1 Introduction

In recent years, the locations of business firms have rapidly become borderless due to globalization. Many countries consider the corporate income tax (CIT) system a key instrument for attracting global firms and enjoying economic growth. However, this leads to severe CIT competition. This study contributes to the literature by exploring the welfare consequences of global CIT competition using a two-country model of endogenous growth, focusing on firms' choices of location and knowledge spillover.

[Figure 1 is inserted here.]

The CIT competition appears to intensify continually. Figure 1 illustrates the dynamics of the regional average CIT rates globally. The monotonic decline in all regional CIT rates indicates that CIT competition is a global phenomenon. Therefore, the governments of individual countries must address this issue because the CIT rate significantly affects international investment and firms' choice of location (Djankov et al. 2010; Feld and Heckemeyer 2011; Brülhart et al. 2012). Thus, the CIT competition exhibits what is referred to as, "a race to the bottom." To address this problem, in October 2021, the G20 countries reached an international agreement that would substantially introduce a common minimal CIT rate.[1] Therefore, it is imperative to determine the welfare consequences of CIT competition.

There are several points to consider regarding modern CIT competition in the global economy. First, international knowledge spillover is important. Some empirical studies suggest that knowledge spillover due to domestic and foreign R&D capital improves total factor productivity and enhances economic growth (Coe and Helpman 1995; Coe et al. 2009; Aghion and Jaravel 2015; Schnitzer and Watzinger 2022). Second, productive public spending improves countries' conditions for tax competition by providing locating firms with environmental benefits, as Görg et al. (2009) and Hauptmeier (2012) empirically demonstrate. Third, the integration of the financial market has increased capital mobility in recent years (Hwang and Kim 2018). More importantly, the accessibility of the global financial market provides firms with more flexible choices of locations around the world. Therefore, we have incorporated these aspects into the analysis.

[1] For detail, see The Leaders of the G20 (2021).

Our model is a two-country model of endogenous growth with knowledge spillover and productive government spending; the engine of growth is expanding variety. Firms choose their locations arbitrarily, considering the growth-enhancing effect of productive government spending. Capital is freely mobile, and CIT is levied according to the residence: the set of CIT rates of the two countries is the main determinant of the firms' choice of location. Thus, each country faces a strategic situation when selecting its CIT rate. Incorporating this, each country's government sets its optimal CIT rate, that is, the growth- or welfare-maximizing CIT rate. We consider two regimes: noncooperative and cooperative. Under cooperative policy, the two governments equalize their CIT rates, choosing one that maximizes welfare globally. By contrast, under the non-cooperative policy, each government sets its own CIT rate, given that of its opponent; this is the case for CIT competition. Comparing the equilibrium CIT rates in both cases, we conduct a welfare evaluation of the CIT competition.

Our main findings are as follows: First, in the CIT competition for growth maximization, the Nash equilibrium tax rate coincides with the equilibrium tax rate under cooperative policy. In other words, CIT competition generates no losses in terms of economic growth. Intuitively, choosing the growth-maximizing tax rate in the cooperative solution maximizes firms' rate of return when entering the country. It encourages domestic spillovers by firms' location choices supported by the global financial market and compensates for the reduction in spillovers from abroad. Thus, although it is a strategic situation in the presence of international spillover, governments pursuing economic growth have no incentive to deviate from the cooperative solution, even in a non-cooperative game.

Second, in CIT competition for welfare maximization, the Nash equilibrium tax rate can be excessively high or low, depending on the degree of international knowledge spillover. Decentralized governments have an incentive to increase tax revenues and welfare by lowering tax rates to encourage entry into their countries when the degree of international knowledge spillovers is weak. Conversely, when the degree of international knowledge spillover is strong, governments choose to raise tax rates because foreign spillovers compensate for the loss of fewer firms entering the country.

Third, however, the welfare loss due to CIT competition for welfare maximization is very small in the calibrated model. We measure welfare loss by the rate of decrease in consumption due to CIT competition, compared to consumption under the cooperative policy. The size of the reduction was 0.11% in the benchmark case and 0.74% at most in a plausible parameter range. The reason for this small welfare loss due to CIT competition is not only that the dominant determinant of welfare in the long run is economic growth, but also that CIT competition does not reduce economic growth, as described above.

In summary, the main argument is that CIT competition causes little damage to global welfare in the modern environment, where firms are free to choose their location in integrated financial markets. The key to this outcome is that CIT competition does not damage economic growth, which is not evident in the presence of complex externalities. In reality, various barriers may affect this outcome, but the small welfare losses due to CIT competition should be a benchmark result.

Related Literature

This study contributes to the literature by providing a formal analysis of CIT competition, incorporating an important feature of the modern world economy: firms' borderless choice of location and knowledge spillover. In this section, we compare our study with existing studies on CIT in growing economies and on tax competition over other taxes.

CIT and growth To the best of our knowledge, few studies have examined (i) how the CIT rate affects growth and welfare and (ii) the optimal CIT rate for dynamic growth models. This is partly because the zero-profit result makes the role of the CIT in standard neoclassical growth models obsolete.[2] Recent studies have overcome this problem by using R&D-based growth models with imperfect competition. Peretto (2003) examined effective growth-enhancing tax policies, whereas Peretto (2007, 2011) focused on the welfare effects of a change in the CIT rate. Iwaisako (2016) investigated a welfare-maximizing CIT rate with patent protection policy. Aghion et al. (2016) and Hori et al. (2022) address both growth- and welfare-maximizing CIT rates by incorporating productive government spending (e.g., Barro 1990; Futagami et al. 1993). Aghion et al. (2016) focused on corruption by the government and Hori et al. (2022) considered tax evasion by firms. Suzuki (2021) investigated corporate taxation using a Schumpeterian growth model with an endogenous market structure. In contrast to our study, these studies considered closed economies and did not address CIT competition.

[2] See Barro and Sala-i-Martin (2004).

Davis and Hashimoto (2018) explored how international differences in CIT rates affect growth and welfare using an R&D-based growth model with two countries. They show that the effect of a change in the CIT rate depends on the initial level of relative CIT rates. They also find that raising the CIT rate benefits a country with a low CIT rate but may benefit or hurt a country with a high CIT rate. However, because CIT revenue is not applied to productive government spending, it remains zero in equilibrium, with no substantial CIT competition.

In this study, we successfully developed a tractable two-country R&D-based growth model with productive government spending financed by CIT revenue. This enables us to conduct a transparent analysis of the CIT competition and the consequences on welfare.

Dynamic tax competition over tax rates other than CIT Few studies have examined the theoretical link between tax competition and growth, as reported by Rauscher (2005). Most strands of this literature focus on capital tax competition. Competition over capital tax dates back to the static models by Wilson (1986) and Zodrow and Mieszkowski (1986). Wildasin (2003) and Tamai (2008) extended these models to neoclassical growth models, in which tax revenues are stock-based; that is, the capital available at home becomes the source of tax revenue. Koethenbuerger and Lockwood (2010) and Chu and Yang (2012) examine how stock-based tax competition affects growth in Romer (1986)-type AK models. The former and latter studies consider productivity shocks and imperfect capital mobility, respectively.[3] Koethenbuerger and Lockwood (2010) also extend their model to an endogenous growth model with productive government spending, assuming that local productive spending is financed by local capital tax. Extending this further, Hatfield (2015) considered both capital and labor income taxation. These show that the equilibrium tax rate under tax competition is lower than that under centralized policymaking.

Lejour and Verbon (1997) considered tax competition over capital income tax in Romer's (1986) AK model with imperfect capital mobility. Tax revenue is flow-based, and the home bias of investment due to the mobility cost of investing abroad is the source of a strategic situation. In contrast, we do not focus on imperfect capital mobility, but on international knowledge spillovers. This is because capital mobility has significantly increased in recent years (Hwang and Kim 2018). Miyazawa et al. (2019) consider tax competition when a spillover effect of capital across

[3]In addition, Becker and Rauscher (2013) consider the imperfect mobility of capital as in Chu and Yang (2012). They show that the relationship between capital mobility and capital tax rates is not monotonic and that growth and capital mobility are unambiguously positively related.

countries exists. They examined how capital income tax competition affects fiscal sustainability. Our study is similarly relevant because spillover across countries is important when considering tax competition. However, our studies differ because Miyazawa et al. (2019) neither investigated the role of productive spending nor optimal policies.

In contrast to existing models of perfectly competitive economies, the recent trend of global tax competition is attributed to firms' choice of location when pursuing higher profits (Baldwin and Krugman 2004; Borck and Pflügera 2006). Therefore, a CIT competition that levies firms' profits is realistically important.

2 A Baseline Model

Two countries, country 1 and country 2, are indexed by r or s. The population sizes of countries 1 and 2 are L_1 and L_2, respectively. These values remained constant over time.

2.1 Production of final goods

A single final good is traded freely in a perfectly competitive global market. Each country contains a continuum of identical competitive firms in the same final goods sector, with free access to production. Identical final goods are traded costlessly between the two countries (free trade without transportation costs). The production of the final good by firm j in country $r \in \{1, 2\}$ is given by

$$Y_r(j,t) = \int_0^{N_r} x_{r,r}(i_r,t)^\alpha di_r + \int_0^{N_s} x_{s,r}(i_s,t)^\alpha di_s, \qquad \alpha \in (0,1) \tag{1}$$

where $x_{r,r}(i_r, t)$ ($x_{s,r}(i_s, t)$, resp.) is the input of an intermediate good in industry i_r (i_s) produced in country r (s) and is used for the final good production in country r. N_r (N_s resp.) represents the variety of intermediate goods in country r (s). Each final good firm located in country r must incur sunk costs of $c_r(t)$ for final good production. We normalize the price of the final goods to 1.

Maximizing profit $Y_r(j,t) - \int_0^{N_r} p_{r,r}(i_r,t)x_{r,r}(i_r,t)di_r - \int_0^{N_s} p_{s,r}(i_s,t)x_{s,r}(i_s,t)di_s - c_r(t)$ yields $\alpha x_{r,k}(i_k,t)^{\alpha-1} = p_{r,k}(i_k,t)$. Using this equation and (1), the profit of firm j is reduced to $(1-\alpha)Y_r(j,t) - c_r(t)$. Because $Y_r(j,t) = Y_r(t)$ and zero profit $(1-\alpha)Y_r(j,t) - c_r(t) = 0$ hold in equilibrium, we obtain $c_r(t) = (1-\alpha)Y_r(t)$. Thus, we obtain the demand function for an intermediate good $x_{k,r}(i_k, t)$:

$$\alpha x_{k,r}(i_k, t)^{\alpha-1} = p_{k,r}(i_k, t), \quad k = r, s. \tag{2}$$

2.2 Producers of intermediate goods

2.2.1 Entry into the intermediate goods market

Each intermediate good is produced by a monopolistically competitive firm. To operate in period t, each intermediate good firm must invest η unit of the final good in period $t-1$. Intermediate goods firms finance the cost of this investment by borrowing from households in countries 1 or 2. Because of free access to the global financial market, each agent faces a common gross interest rate between periods $t-1$ and t, which is denoted by $R(t-1)$. Each intermediate goods firm operates during one period, as in Young (1998).

Let us denote the operating profit of firm i_r in period t, located in country $r \in \{1, 2\}$ by $\pi_r(i_r, t)$. In Section 2.2.2, we discuss $\pi_r(i_r, t)$ in detail. When intermediate goods firms are located in country r, CIT is imposed on their operating profits at the rate of τ_r. Therefore, the net profit of intermediate goods firm i_r, choosing to be located in country $r \in \{1, 2\}$, is given by

$$\Pi_r(i_r, t-1) = \frac{(1-\tau_r)\pi_r(i_r, t)}{R(t-1)} - \eta.$$

Free entry into the intermediate goods market across countries implies that

$$(1-\tau_1)\pi_1(i_1, t) = (1-\tau_2)\pi_2(i_2, t) = \eta R(t-1). \tag{3}$$

2.2.2 Maximization of operating profits

Each intermediate goods firm $i_r \in N_r(t)$ located in country r produces intermediate goods for country $k\ (= r, s)$ by employing labor in country r, $l_{r,k}(i_r, t)$, using the following technology:

$$x_{r,k}(i_r, t) = Ah_r(t) l_{r,k}(i_r, t), \qquad A > 0, \quad k = r, s. \tag{4}$$

Here, $h_r(t)$ is the common labor productivity per capita for all industries i_r in country r and is given by

$$h_r(t) = \frac{G_r(t)^{\gamma}\Theta_r(N_r(t), N_s(t))^{1-\gamma}}{L_r}, \qquad r \neq s, \quad \gamma \in (0, 1). \tag{5}$$

Regarding (5), we note the following two points. First, public services in country r, $G_r(t)$, have a positive externality for producing intermediate goods in country r. Thus, it may be regarded as infrastructure used by firms located in country r (e.g., Barro 1990).

Second, the spillover function $\Theta_r(N_r(t), N_s(t))$ indicates that knowledge spillovers regarding the stock of both the home country, $N_r(t)$, and the foreign country, $N_s(t)$, enhance production.[4] We assume that $\Theta_r(N_r(t), N_s(t))$ is continuous and homogeneous of degree 1 in both arguments. Then, we can write it in the intensive form

$$N_r(t)\Theta_r\left(1, \frac{N_s(t)}{N_r(t)}\right) \equiv N_r(t)\vartheta_r(n_{rs}(t)) \quad \text{with } n_{rs} \equiv \frac{N_s(t)}{N_r(t)}, \tag{6}$$

where $\vartheta_r(n_{rs})$ satisfies $\vartheta_r(\cdot) > 0$ for $n_{rs} \geq 0$, $\lim_{n_{rs}\to+\infty} \vartheta_r(n_{rs}) = +\infty$ and $\vartheta_r'(\cdot) > 0$. We assume that the two functions $\vartheta_r(n_{rs})$ and $\vartheta_s(n_{sr})$ have the same form.

Each intermediate goods firm $i_r \in N_r(t)$ located in country r sells its products to the home country, $x_{r,r}(i_r, t)$, and exports to the foreign country, $x_{r,s}(i_r, t)$. There is a transaction cost for international trading; exporting $x_{r,s}(i_r, t)$ costs $\zeta l_{r,s}(i_r, t)$ units of labor additionally ($\zeta \geq 0$). Next, the intermediate goods firm i_r located in country r chooses $l_{r,r}(i_r, t)$ and $l_{r,s}(i_r, t)$ to maximize its profit.

$$\pi_r(i_r, t) = [p_{r,r}(i_r, t)x_{r,r}(i_r, t) - w_r(t)l_{r,r}(i_r, t)] + [p_{r,s}(i_r, t)x_{r,s}(i_r, t) - w_r(t)(1+\zeta)l_{r,s}(i_r, t)], \tag{7}$$

subject to (2) and (4) given the wage rate in country r, $w_r(t)$. The first-order condition is

$$\alpha^2 A^{\alpha} h_r(t)^{\alpha} l_{r,r}(i_r, t)^{\alpha-1} = w_r(t), \tag{8}$$

$$\alpha^2 A^{\alpha} h_r(t)^{\alpha} l_{r,s}(i_r, t)^{\alpha-1} = (1+\zeta)w_r(t), \qquad r \in \{1, 2\}. \tag{9}$$

From (8) and (9), all firms choose the same level of labor demand, $l_{r,r}(i_r, t) = l_{r,r}(t)$ and $l_{r,s}(i_r, t) = l_{r,s}(t)$. Therefore, $x_{r,k}(t)$, $p_{r,k}(t)$, and $\pi_r(t)$ are all independent of index i_r. Fur-

[4] This type of knowledge spillover is common to the literature on economic growth (e.g., Benassy 1998).

thermore, (8) and (9) lead to

$$l_{r,s}(t) = \phi l_{r,r}(t), \quad r \in \{1,2\}, \tag{10}$$

where $\phi \equiv (1/(1+\zeta))^{\frac{1}{1-\alpha}} \in (0,1]$. From (4) and (10), we obtain

$$x_{r,s}(t) = \phi x_{r,r}(t), \quad r \in \{1,2\}. \tag{11}$$

Substituting (8), (9), (10), and $1+\zeta = \phi^{\alpha-1}$ into (7) and applying (2) and (4), we obtain

$$\pi_r(t) = \alpha(1-\alpha)(1+\phi^{\alpha})A^{\alpha}\left[h_r(t)l_{r,r}(t)\right]^{\alpha}, \quad r \in \{1,2\}. \tag{12}$$

2.3 Household

The utility function of a representative household residing in country $r \in \{1,2\}$ is:

$$U_r(0) = \sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^t u(C_r(t)), \quad u(C_r(t)) = \frac{C_r(t)^{1-\sigma}}{1-\sigma}, \ \sigma > 0, \tag{13}$$

where $u(C_r(t)) = \ln C_r(t)$ when $\sigma = 1$. Here, $C_r(t)$, $\rho > 0$, and $1/\sigma$ denote consumption in period t, subjective discount rate, and intertemporal elasticity of substitution, respectively. A representative household inelastically supplies one unit of labor. The household's budget constraint is $W_r(t) = R(t-1)W_r(t-1) + w_r(t) - C_r(t)$, where $W_r(t-1)$ is the asset holding at the end of period $t-1$. Households' utility maximization yields

$$\frac{C_r(t+1)}{C_r(t)} = \left(\frac{R(t)}{1+\rho}\right)^{1/\sigma} \tag{14}$$

and the transversality condition is:

$$\lim_{t\to\infty}\frac{C_r(t)^{-\sigma}W_r(t-1)}{(1+\rho)^t} = 0. \tag{15}$$

2.4 Government

We assume that the government in country $r \in \{1, 2\}$ maintains a balanced budget for each period. The aggregate CIT revenue of the government in country r, $\tau_r \pi_r(t) N_r(t)$, is allocated to productive government spending $G_r(t)$. Thus, the government's budget constraint is given by:

$$G_r(t) = \tau_r \pi_r(t) N_r(t), \qquad r \in \{1, 2\}. \tag{16}$$

2.5 Equilibrium

The clearing condition for the labor market in country r is $L_r = \int_0^{N_r} [l_{r,r}(t) + (1+\zeta) l_{r,s}(t)] di_r$. Using (10) and $(1+\zeta) = \phi^{\alpha-1}$, we can reduce this to

$$L_r = N_r(t)(1 + \phi^{\alpha}) l_{r,r}(t). \tag{17}$$

The asset market is clear because

$$W_1(t-1)L_1 + W_2(t-1)L_2 = \eta(N_1(t) + N_2(t)). \tag{18}$$

By substituting (5), (6), (16), and (17) into (12), we obtain:

$$\pi_r(t) = (1-\alpha)\tilde{A}(\phi)\tau_r^{\frac{\beta}{1-\beta}} \vartheta_r(n_{rs}(t))^{\frac{\alpha-\beta}{1-\beta}}, \tag{19}$$

where $\beta \equiv \alpha\gamma < \alpha$ and $\tilde{A}(\phi) \equiv \left\{(1+\phi^{\alpha})^{1-\alpha} A^{\alpha} \alpha (1-\alpha)^{\beta}\right\}^{\frac{1}{1-\beta}}$. Substituting (19) with $\pi_s(t) = (1-\alpha)\tilde{A}(\phi)\tau_s^{\frac{\beta}{1-\beta}} \vartheta_s\left(n_{sr}(t)\right)^{\frac{\alpha-\beta}{1-\beta}}$ into (3) yields:

$$\left(\frac{\vartheta_r(n_{rs})}{\vartheta_s(n_{sr})}\right)^{\frac{\alpha-\beta}{1-\beta}} = \left(\frac{\vartheta_r(n_{rs})}{\vartheta_s(n_{rs}^{-1})}\right)^{\frac{\alpha-\beta}{1-\beta}} = \frac{1-\tau_s}{1-\tau_r}\left(\frac{\tau_s}{\tau_r}\right)^{\frac{\beta}{1-\beta}}. \tag{20}$$

We define $\varphi(n_{rs}) \equiv \vartheta_r(n_{rs})/\vartheta_s(n_{rs}^{-1})$. Then,

$$n_{rs}\left(\tau_r, \tau_s\right) = \varphi^{-1}\left(\left(\frac{1-\tau_s}{1-\tau_r}\right)^{\frac{1-\beta}{\alpha-\beta}} \left(\frac{\tau_s}{\tau_r}\right)^{\frac{\beta}{\alpha-\beta}}\right). \tag{21}$$

We obtain the following remark from (20), (21),

$$\varphi'(n_{rs}) = \frac{\vartheta_r'(n_{rs})}{\vartheta_s(n_{rs}^{-1})} + \frac{\vartheta_r(n_{rs})\vartheta_s'(n_{rs}^{-1})}{\vartheta_s(n_{rs}^{-1})^2 n_{rs}^2} > 0, \tag{22}$$

$\varphi(0) = \frac{\vartheta_r(0)}{\lim_{n_{sr}\to+\infty}\vartheta_s(n_{sr})} = 0$, and $\lim_{n_{rs}\to+\infty}\varphi(n_{rs}) = \frac{\lim_{n_{rs}\to+\infty}\vartheta_r(n_{rs})}{\vartheta_s(0)} = +\infty$.

Remark 1.

(i) $n_{rs}(\tau_r, \tau_s)$ is constant over time and uniquely determined for any $\tau_r \in (0,1)$ and $\tau_s \in (0,1)$.

(ii) A decrease in the CIT rate of the foreign country ($s \in \{1,2\}$) increases (decreases) the production share of the foreign country (s), if and only if $\tau_s \geq (<)\beta$ i.e.,

$$\frac{\partial n_{rs}}{\partial \tau_s} \gtreqless 0 \qquad \textit{for} \qquad \tau_s \lesseqgtr \beta.$$

Note that the number of firms globally, $N_r(t)+N_s(t)$, is a predetermined variable, while the individual values, $N_r(t)$ and $N_s(t)$, are jump variables. This is because the level of households' asset holdings at the end of the previous period determines $N_r(t)+N_s(t)$. However, the factor market balance constrains firms' locations. See the equilibrium conditions of the asset and labor markets in (18) and (17), respectively. Thus, n_{rs}, defined by $N_s(t)/N_r(t)$, jumps immediately after the policy changes in (τ_r, τ_s). In addition, this ratio remains constant over time in equilibrium.

Furthermore, the relationship between the production share of the home country, n_{rs}, and the CIT of the foreign country τ_s features the following two opposite effects: A decrease in the home country's CIT rate attracts firms because of the lowered tax burden.[5] Meanwhile, it decreases tax revenue for productive public spending and the benefit of location in the home country. See Dewit et al. (2018). The former (latter) dominates the latter (former) when CIT is higher (lower) than β. We should note such opposing effects of *tax base externalities*. These opposite *tax base externalities* affect the decision-making of the government in each country, as we shall examine in subsequent sections.

Substituting (21) into (19), we obtain:

$$\pi_r(\tau_r, \tau_s) = (1-\alpha)\tilde{A}(\phi)\tau_r^{\frac{\beta}{1-\beta}}\vartheta_r(n_{rs}(\tau_r, \tau_s))^{\frac{\alpha-\beta}{1-\beta}}. \tag{23}$$

[5] This is a standard home market effect in New Economic Geography literature, such as Baldwin et al. (2003) and Davis and Hashimoto (2018).

Equation (23) indicates that the operating profit of the intermediate goods firms is constant over time and is expressed as a function of the two countries' CIT rates, τ_r and τ_s. From (3) and (23), we obtain the following relationship for the after-tax profits of firms in the two countries:

$$(1-\tau_1)\tau_1^{\frac{\beta}{1-\beta}}\vartheta_1(n_{12}(\tau_1,\tau_2))^{\frac{\alpha-\beta}{1-\beta}} = (1-\tau_2)\tau_2^{\frac{\beta}{1-\beta}}\vartheta_2(n_{21}(\tau_2,\tau_1))^{\frac{\alpha-\beta}{1-\beta}}. \tag{24}$$

Note that (24) holds for any $\tau_1 \in (0,1)$ and $\tau_2 \in (0,1)$ because $n_{rs}(\tau_r,\tau_s)$ is determined to satisfy $(1-\tau_r)\pi_r = (1-\tau_s)\pi_s$. Therefore, Equation (24) connects the two countries through international knowledge spillover and the free entry of firms across countries.

Consider the case where $\partial n_{21}/\partial\tau_1 < 0$, that is, $\tau_1 > \beta$. A decrease in τ_1 increases the number of firms located in country 1 and their after-tax profits, $(1-\tau_1)\pi_1$, through the benefits of agglomeration. Meanwhile, a decrease in τ_1 reduces the number of firms located in country 2 but increases the firms' market power by mitigating competition. This also increases after-tax profits $(1-\tau_2)\pi_2$. Thus, a change in the CIT rate moves the after-tax profits in both countries in the same direction.

Next, notice that (12) with (8) yields $w_r(t)l_{r,r}(t) = \frac{\alpha}{(1-\alpha)(1+\phi^\alpha)}\pi_r(t)$. Thus, substituting (17) and (23) into the left- and right-hand sides, respectively, we obtain aggregate wage income:

$$w_r(t)L_r = \alpha\tilde{A}(\phi)\tau_r^{\frac{\beta}{1-\beta}}\vartheta_r(n_{rs}(\tau_r,\tau_s))^{\frac{\alpha-\beta}{1-\beta}}N_r(t). \tag{25}$$

Furthermore, by (23) and (3), the interest rate, $R(t)$, and the after-tax operating profit, $(1-\tau_r)\pi_r$, take a symmetric constant value:

$$R(\tau_r,\tau_s) = \frac{(1-\tau_r)\pi_r(\tau_r,\tau_s)}{\eta} = \eta^{-1}(1-\alpha)\tilde{A}(\phi)(1-\tau_r)\tau_r^{\frac{\beta}{1-\beta}}\vartheta_r(n_{rs}(\tau_r,\tau_s))^{\frac{\alpha-\beta}{1-\beta}}$$
$$\left(= \frac{(1-\tau_s)\pi_s(\tau_s,\tau_r)}{\eta} = \eta^{-1}(1-\alpha)\tilde{A}(\phi)(1-\tau_s)\tau_s^{\frac{\beta}{1-\beta}}\vartheta_s(n_{sr}(\tau_s,\tau_r))^{\frac{\alpha-\beta}{1-\beta}}\right). \tag{26}$$

Substituting (26) into (14) yields

$$\frac{C_1(t+1)}{C_1(t)} = \frac{C_2(t+1)}{C_2(t)} = \left(\frac{R(\tau_r,\tau_s)}{1+\rho}\right)^{\frac{1}{\sigma}} \equiv g_C(\tau_r,\tau_s). \tag{27}$$

CIT rates in both countries affect economic growth through the net profits of firms located in both countries. A high CIT rate decreases firms' net profits directly and has negative effects on growth

($1-\tau_r$ in (26)); meanwhile, it increases productive government spending ($\tau_r^{\frac{\beta}{1-\beta}}$ in (26)), which enhances growth. In addition to these opposite *growth externalities*, the tax base externalities affect the growth rate $(\vartheta_r(n_{rs}(\tau_r, \tau_s))^{\frac{\alpha-\beta}{1-\beta}}$ in (26)); Remark 1. In the subsequent sections, we address the interactions between growth externalities and tax base externalities as a response to tax policy changes.

Equation (23) can also be rewritten (16):

$$G_r(t) = \tau_r \pi_r(\tau_r, \tau_s) N_r(t). \tag{28}$$

Substituting (28) together with (4), (17), and (20) into (1), we obtain:

$$Y_r(t) = \frac{\tilde{A}(\phi)}{(1+\phi^\alpha)\alpha}\left[\tau_r^{\frac{\beta}{1-\beta}}\vartheta_r(n_{rs}(\tau_r,\tau_s))^{\frac{\alpha-\beta}{1-\beta}}N_r(t) + \phi^\alpha \tau_s^{\frac{\beta}{1-\beta}}\vartheta_s(n_{sr}(\tau_s,\tau_r))^{\frac{\alpha-\beta}{1-\beta}}N_s(t)\right], \tag{29}$$

for $r \in \{1, 2\}$ and $r \neq s$. See Appendix A for a detailed derivation of (29).

Finally, we consider the market-clearing condition for final goods. We can derive this by summing the households' budget constraints in the two countries: $W_1(t)L_1 + W_2(t)L_2 = R[W_1(t-1)L_1 + W_2(t-1)L_2] + w_1(t)L_1 + w_2(t)L_2 - C_1(t)L_1 - C_2(t)L_2$. Associating this with (5), (8), (17), (18), (26), (28), (29), and the total sunk costs of the final goods sector, $E_1(t) + E_2(t) = (1-\alpha)(Y_1(t) + Y_2(t))$, we obtain the market clearing condition for the final good: $\eta(N_1(t+1)+N_2(t+1)) = Y_1(t)+Y_2(t)-E_1(t)-E_2(t)-(G_1(t)+G_2(t))-C_1(t)L_1-C_2(t)L_2$. Appendix B provides more details on the derivation. In addition, as shown in Appendix B, the market-clearing condition is reduced to

$$\eta\sum_{r=1}^{2} N_r(t+1) = \sum_{r,s=1,r\neq s}^{2} \tilde{A}(\phi)[1-(1-\alpha)\tau_r]\tau_r^{\frac{\beta}{1-\beta}}\vartheta_r(n_{rs}(\tau_r,\tau_s))^{\frac{\alpha-\beta}{1-\beta}}N_r(t) - \sum_{r=1}^{2} C_r(t)L_r. \tag{30}$$

Putting $z_1(t) \equiv C_1(t)L_1/N_1(t)$ ($z_2(t) \equiv C_2(t)L_2/N_2(t)$) and using (20), (27), and (30), we obtain the following dynamic system (See Appendix C):

$$\frac{z_1(t+1)}{z_1(t)} = \frac{\eta\,[1+n_{12}(\tau_1,\tau_2)]\,g_C(\tau_1,\tau_2)}{\Phi_1(\tau_1,\tau_2) - z_1(t) - n_{12}(\tau_1,\tau_2)z_2(t)}, \tag{31}$$

$$\frac{z_2(t+1)}{z_2(t)} = \frac{\eta\left[1+n_{21}(\tau_2,\tau_1)\right]g_C(\tau_1,\tau_2)}{\Phi_2(\tau_2,\tau_1)-z_2(t)-n_{21}(\tau_2,\tau_1)z_1(t)}, \tag{32}$$

where

$$\Phi_r(\tau_r,\tau_s) \equiv \tilde{A}(\phi)\tau_r^{\frac{\beta}{1-\beta}}\vartheta_r(n_{rs}(\tau_r,\tau_s))^{\frac{\alpha-\beta}{1-\beta}}\left\{1-(1-\alpha)\tau_r+[1-(1-\alpha)\tau_s]\frac{1-\tau_r}{1-\tau_s}n_{rs}(\tau_r,\tau_s)\right\}. \tag{33}$$

From (31) and (32), we arrive at the following proposition.

Proposition 1. *A unique steady state in which $z_1(t)$ and $z_2(t)$ take the following constant values exists.*

$$z_1^* = \alpha\tilde{A}(\phi)\tau_1^{\frac{\beta}{1-\beta}}\vartheta_r(n_{12}(\tau_1,\tau_2))^{\frac{\alpha-\beta}{1-\beta}}+\left[g_C(\tau_1,\tau_2)^{\sigma}(1+\rho)-g_C(\tau_1,\tau_2)\right]\Delta\eta(1+n_{12}(\tau_1,\tau_2)), \tag{34}$$

$$z_2^* = \alpha\tilde{A}(\phi)\tau_2^{\frac{\beta}{1-\beta}}\vartheta_r(n_{21}(\tau_2,\tau_1))^{\frac{\alpha-\beta}{1-\beta}}+\left[g_C(\tau_1,\tau_2)^{\sigma}(1+\rho)-g_C(\tau_1,\tau_2)\right](1-\Delta)\eta(1+n_{21}(\tau_2,\tau_1)),$$

where $(1+\rho)g_C^{\sigma-1}>1$ holds under the transversality condition in (15), and $\Delta \equiv W_1(-1)/[W_1(-1)+W_2(-1)] \in [0,1]$ is the initial share of country 1's asset holdings. In the steady state, $C_1(t)$, $C_2(t)$, $N_1(t)$, $N_2(t)$, $Y_1(t)$, and $Y_2(t)$ grow at the same constant rate as $g_C(\tau_1,\tau_2)$. The economy initially reaches a steady state.

Proof See Appendix D.

3 Tax competition over CIT rates

Let us investigate the CIT competition between the two countries. We consider two alternative policies: growth- and welfare-maximizing.

3.1 Growth-maximizing policy

Although our primary goal is to evaluate the welfare consequences of CIT competition, it is beneficial to explore the equilibrium under a growth-maximizing policy. Under the growth-maximizing policy, each country's government chooses a CIT rate that maximizes its growth rate, given the CIT rate of the other country.

From (21), (22), (26), (27), and $\varphi(n_{rs}) \equiv \vartheta_r(n_{rs})/\vartheta_s(n_{rs}^{-1})$, we obtain:

$$\frac{\partial g_C(\tau_r, \tau_s)}{\partial \tau_r} = \left[1 - \frac{\epsilon_r(n_{rs})}{\epsilon_r(n_{rs}) + \epsilon_s(n_{rs}^{-1})}\right] \frac{g_C(\tau_r, \tau_s)(\beta - \tau_r)}{\sigma(1-\tau_r)(1-\beta)\tau_r} \gtreqless 0, \quad \text{for} \quad \tau_r \lesseqgtr \beta, \tag{35}$$

where

$$\epsilon_r(n_{rs}) \equiv \frac{\vartheta_r'(n_{rs})n_{rs}}{\vartheta_r(n_{rs})} \geq 0 \quad \text{and} \quad \epsilon_s(n_{rs}^{-1}) \equiv \frac{\vartheta_s'(n_{rs}^{-1})n_{rs}^{-1}}{\vartheta_s(n_{rs}^{-1})} \geq 0. \tag{36}$$

Appendix E provides derivations of (35) and (36). We thus obtain the following proposition:

Proposition 2. *The growth-maximizing CIT rates are* $\tau_1^{GM} = \tau_2^{GM} = \beta$*, where* τ_r^{GM} *is the growth-maximizing CIT rate for country* r*. Thus, Barro's (1990) rule holds.*

Raising the CIT rate has two opposing effects on economic growth. The first term in the bracketed part of (35) corresponds to the marginal effect of the growth externality. As in existing studies (e.g., Barro 1990), this is maximized when the CIT rate equals the output elasticity of public services, $\tau_r = \beta$. Meanwhile, the second term of the bracketed part in (35) is relevant to the knowledge spillover and corresponds to the marginal effect of the tax base externalities, which is minimized. The former always dominates the latter and the difference between them is maximized at $\tau_r = \beta$.

This result is intuitively reasonable. As mentioned in Remark 1, the production share of the home country (r), n_{sr}, is increasing in τ_r for $\tau_r \leq \beta$ because raising the CIT rate improves the firms' tradeoff between the benefits from productive public services and the CIT burden. This promotes domestic spillovers and mitigates the negative effect of the reduction in spillovers from abroad. Therefore, the marginal effect of the tax-based externalities is always smaller than that of the growth externality, and the spread is maximized at $\tau_r = \tau_s = \beta$.

The result of Proposition 2 differs from those of Koethenbuerger and Lockwood (2010) and Hatfield (2015), both of which consider capital tax competition. They showed that growth-maximizing tax rates deviate from the output elasticity of public services. The point is the difference in tax bases. The tax base is corporate income (flow-based taxation) in our model, but capital stock (stock-based taxation) in theirs. In our model, maximizing the net profits of firms located in the home country is equivalent to maximizing the share of firms; the CIT rate is set to β. In contrast, the tax base externality from the capital stock in Koethenbuerger and Lockwood (2010) and Hatfield (2015) are related to the growth externality of capitalists' assets. Thus, in their models, the tax rates are set for optimal capital accumulation (Alesina and Rodrik 1994).

3.2 Welfare-maximizing policy

First, we derive an indirect utility function for each country. Throughout this section, we consider the case when the same amount of initial assets exists between two countries: $\Delta = \frac{1}{2}$. The consumption per capita in country $r \in \{1, 2\}$ is calculated as:

$$C_r(t) = \frac{z_r^* N_r(t)}{L_r(N_r(t) + N_s(t))}(N_r(t) + N_s(t))$$
$$= \frac{z_r^*(g_C(\tau_r, \tau_s)^t N_r(0) + g_C(\tau_r, \tau_s)^t N_s(0))}{L_r(1 + n_{rs}(\tau_r, \tau_s))}, \quad \text{for} \quad r \neq s.$$

Therefore, we obtain

$$C_1(t) = \frac{z_1^* g_C(\tau_1, \tau_2)^t}{L_1(1 + n_{12}(\tau_1, \tau_2))}(N_1(0) + N_2(0)), \tag{37}$$

$$C_2(t) = \frac{z_2^* g_C(\tau_1, \tau_2)^t}{L_2(1 + n_{21}(\tau_2, \tau_1))}(N_1(0) + N_2(0)), \tag{38}$$

where we normalize $N_r(0) + N_s(0)$ to 1. Substituting (37) and (38) into (13) yields:

$$U_1(0) = \frac{(z_1^*/L_1)^{1-\sigma}\left[1/(1 + n_{12}(\tau_1, \tau_2))\right]^{1-\sigma}}{(1-\sigma)\left[1 - (1+\rho)^{-1} g_C(\tau_1, \tau_2)^{1-\sigma}\right]},$$
$$U_2(0) = \frac{(z_2^*/L_2)^{1-\sigma}\left[1/(1 + n_{21}(\tau_2, \tau_1))\right]^{1-\sigma}}{(1-\sigma)\left[1 - (1+\rho)^{-1} g_C(\tau_1, \tau_2)^{1-\sigma}\right]}, \tag{39}$$

where $1 > (1+\rho)^{-1} g_C(\tau_1, \tau_2)^{1-\sigma}$ holds by the transversality condition (15).

3.2.1 Welfare-maximizing condition under tax harmonization (cooperative policy)

Next, we determine the welfare-maximizing conditions under tax harmonization. Tax harmonization means that the two governments commit to choosing the same CIT rate, $\tau_1 = \tau_2 = \tau^h$. In this case, (i) $n_{12} = \varphi^{-1}(1)$ (from (21)) and (ii) $\vartheta_1(\varphi^{-1}(1)) = \vartheta_2(1/\varphi^{-1}(1))$ (from (20)) hold. Substituting (i) and (ii) into (26), (27), (33), (34), and (39), we obtain:

$$L_1 U_1^h(0) + L_2 U_2^h(0) = \frac{(z^h)^{1-\sigma}\left[1/(1 + \varphi^{-1}(1))\right]^{1-\sigma}(L_1^\sigma + L_2^\sigma)}{(1-\sigma)\left[1 - (1+\rho)^{-1}(g^h)^{1-\sigma}\right]},$$

where

$$z^h \equiv z^*\left(\tau^h, \tau^h\right) = \alpha \tilde{A}(\phi)(\tau^h)^{\frac{\beta}{1-\beta}} \vartheta_r(\varphi^{-1}(1))^{\frac{\alpha-\beta}{1-\beta}} + \eta\left[g_C(\tau^h, \tau^h)^\sigma(1+\rho) - g_C(\tau^h, \tau^h)\right],$$

$$g^h \equiv g_C\left(\tau^h, \tau^h\right) = \left[\frac{(1-\alpha)\tilde{A}(\phi)\left(1-\tau^h\right)\left(\tau^h\right)^{\frac{\beta}{1-\beta}} \vartheta_1\left(\varphi^{-1}(1)\right)^{\frac{\alpha-\beta}{1-\beta}}}{\eta(1+\rho)}\right]^{\frac{1}{\sigma}}.$$

The welfare-maximizing CIT rate under harmonization is $\tau^h = \text{argmax}\left[L_1 U_1^h(0) + L_2 U_2^h(0)\right]$. The first-order condition of this maximization problem is given by

$$\frac{\partial \ln z^h}{\partial \tau^h} + \frac{(1+\rho)^{-1}(g^h)^{1-\sigma}}{1-(1+\rho)^{-1}(g^h)^{1-\sigma}} \frac{\partial \ln g^h}{\partial \tau^h} = 0, \tag{40}$$

where

$$\frac{\partial \ln z^h}{\partial \tau^h} = \frac{\alpha \tilde{A}(\phi)\left(\tau^h\right)^{\frac{\beta}{1-\beta}} \vartheta_1\left(\varphi^{-1}(1)\right)^{\frac{\alpha-\beta}{1-\beta}} \frac{\beta}{1-\beta}\frac{1}{\tau^h} + \eta\left[\sigma(1+\rho)(g^h)^\sigma - g^h\right] \frac{\partial \ln g^h}{\partial \tau^h}}{\alpha \tilde{A}(\phi)\left(\tau^h\right)^{\frac{\beta}{1-\beta}} \vartheta_1\left(\varphi^{-1}(1)\right)^{\frac{\alpha-\beta}{1-\beta}} + \eta\left[(1+\rho)(g^h)^\sigma - g^h\right]}, \tag{41}$$

$$\frac{\partial \ln g^h}{\partial \tau^h} = \frac{\beta - \tau^h}{\sigma(1-\beta)(1-\tau^h)\tau^h}. \tag{42}$$

Equations (40), (41), and (42) lead to the following remark.

Remark 2. *A welfare-maximizing CIT under tax harmonization exists between β and 1 (i.e., $\beta < \tau^h < 1$).*

This result is worth emphasizing. Inequality $\tau^h > \tau_r^{GM}$ suggests that growth-maximizing CIT competition does not attain an optimal allocation. Although the growth- and welfare-maximizing tax rates agree in the original model of household income taxation by Barro (1990), it does not hold in our model because of CIT taxation. [6] Therefore, governments cannot pursue economic growth when designing CIT policies.

3.2.2 Welfare-maximizing policy without tax harmonization (non-cooperative policy)

We address the welfare-maximizing condition under which each country's government chooses its CIT rate in (39), taking the CIT rate of the other country as a given.

[6] The difference between τ^h and β is owing to a feature of CIT. While a marginal increase in the CIT rate at β has no first-order effect on growth rate, it expands initial consumption. This is because the increase in productive government spending raises labor income, which is exempt from taxation. For more details, see Proposition 5 and Appendix G of Hori et al. (2022).

A Nash equilibrium, denoted by $(\tau_1^{WM}, \tau_2^{WM})$, is an intersection of the best-response functions $\tau_1 = \mathcal{T}_1(\tau_2)$ and $\tau_2 = \mathcal{T}_2(\tau_1)$ defined by

$$\mathcal{T}_r(\tau_s) = \arg\max_{\tau_r} U_r(0) = \frac{(z_r^*/L_r)^{1-\sigma}\left[1/(1+n_{rs}(\tau_r,\tau_s))\right]^{1-\sigma}}{(1-\sigma)\left[1-(1+\rho)^{-1}g_C(\tau_r,\tau_s)^{1-\sigma}\right]},$$

$$\text{s.t.} \quad z_r^* = \alpha\tilde{A}(\phi)\tau_r^{\frac{\beta}{1-\beta}}\vartheta_r(n_{rs}(\tau_r,\tau_s))^{\frac{\alpha-\beta}{1-\beta}} + \left[g_C(\tau_r,\tau_s)^{\sigma}(1+\rho) - g_C(\tau_r,\tau_s)\right]\frac{\eta(1+n_{rs}(\tau_r,\tau_s))}{2}$$

and (21).

Let τ_r^{WM} be the welfare-maximizing CIT rate in Country $r \in \{1,2\}$. Then, we arrive at the following proposition:

Proposition 3. *The welfare-maximizing CIT rate is higher (lower) than the CIT rate under tax harmonization, that is,* $\tau_1^{WM} = \tau_2^{WM} > (<)\tau^h$ *if and only if*[7]

$$\left.\frac{\vartheta_r'}{\vartheta_r}\right|_{n_{rs}=1} > (<)\frac{1-\frac{\beta}{\tau^h}}{2(\alpha-\beta)}.$$

Proof: See Appendix F.

Proposition 3 suggests that the Nash equilibrium under CIT competition by decentralized governments does not attain the second-best allocation, as in the usual results in the literature: non-coordinated fiscal policies in Nash equilibria are generally inefficient.[8]

However, the underlying mechanism is distinctive for the following reasons. Intuitively, the two sources of strategic interactions have opposing welfare effects. One is the tax base effect: a decrease in the home country's CIT rate induces firms to locate in the home country (because of Remark 1 and $\tau^h > \beta$), the CIT revenue increases, and thus labor income also increases due

[7]In the case of log utility function ($\sigma = 1$), we can derive τ^h explicitly as

$$\tau^h = \frac{1-\alpha+\beta+\frac{\alpha}{\rho} - \sqrt{\left(1-\alpha+\beta+\frac{\alpha}{\rho}\right)^2 - 4\beta(1-\alpha)\left(1+\frac{\alpha}{\rho}\right)}}{2(1-\alpha)}.$$

[8]Koethenbuerger and Lockwood (2010) show that average growth rate is always higher (lower) under decentralization with deterministic (stochastic) economy. Hatfield (2015) shows that growth is higher under decentralized government.

to the increase in productive public spending. Non-cooperative governments seek to lower their own CIT rates to retain firms and secure CIT revenues.

The other source of a strategic interaction is the spillover on productivity: an increase in the number of firms in the foreign country raises the productivity of the home country. This is captured by the elasticity of the spillover effect to n_{rs},: $\frac{\vartheta'}{\vartheta}|_{n_{rs}=1}$. In contrast to harmonization, this is not perfectly internalized under CIT competition. The positive spillover effect mitigates the loss of raising the CIT rate to decentralized governments, given another country's CIT rate. Thus, strong spillovers induce governments to raise their CIT rates and tax revenues.

Since $\frac{\partial n_{rs}}{\partial \tau_r} > 0$ by $\tau^h > \beta$, the government chooses a tax rate higher (lower) than τ^h if the latter (the former) effect dominates the former (the latter). Under the reasonable range of parameter sets, $\tau^{WM} > \tau^h$ is likely to occur as we will see later, indicating that growth rate is lower under decentralization.[9]

4 Numerical Analysis

In this section, we perform standard calibrations and provide a quantitative assessment of the welfare losses due to CIT competition.

4.1 Calibration

First, we set $L_1 = L_2 = 1$ and $\zeta = 0$ because the population size and international transaction cost do not play a significant role in the analysis below. The reciprocal of the elasticity of intertemporal substitution, σ, and the subjective discount rate, ρ, are set to 1.5 and $\frac{1}{0.95} - 1$, respectively, according to the standard calibration of growth models (Jones et al., 1993). The gross markup rate of intermediate goods firms is $\frac{1}{\alpha}$. Thus, we set $\alpha = \frac{1}{1+0.2}$ and adopt 20% as the standard value of the net markup rate (Rotemberg and Woodford 1999). Following some empirical works on productive government spending, the aggregate output elasticity of public services, β, is set to 0.1. See Bom and Ligthart (2014) and Calderón et al. (2015). The curvature of the production function of intermediate goods firms γ, is determined by the relationship $\beta = \alpha\gamma$.

[9] Some previous studies on dynamic capital tax competition over the productive public goods indicate the opposite (similar) result to ours: Koethenbuerger and Lockwood (2010) show that average growth rate is always higher (lower) under decentralization with deterministic (stochastic) economy. Hatfield (2015) shows that growth is higher under decentralized government.

We specify the spillover function Θ_r by $\Theta_r(N_r, N_s) = B(N_r + \delta N_s)$, where $B > 0$ and $\delta > 0$ are constants. Note that δ measures the degree of international knowledge spillover. In this case, $\varphi^{-1}(q) = \frac{q-1+\sqrt{(q-1)^2+4\delta^2 q}}{2\delta}$ and $\epsilon_r(n_{rs}) = \frac{\delta n_{rs}}{1+\delta n_{rs}}$. Since the degree of spillover is the most important parameter, we consider various values of δ with B fixed to 1. We choose 0.2 as the reference value for δ.

Assuming the standard value of the growth rate to be 2%, we set the entry cost of intermediate goods firms, η, as follows: Since the long-run growth rate depends on the CIT rate in this model as well as η, we have to choose a standard value for the CIT rate. We choose 0.27 for the standard CIT rate because this is the average CIT rate across OECD countries from 1997 to 2021, according to *Corporate Tax Around the World* (2021), which is one of the widest databases for CIT rates. Normalizing the productivity of intermediate goods firms to 1, we control the entry cost η such that the resulting growth rate on the balanced growth path is equal to 2%.

Table 1 summarizes the baseline parameter set.

4.2 Equilibrium CIT Rates

We report the equilibrium tax rates for various values of δ, the degree of international knowledge spillover, in the calibrated model. Figure 3 shows this result. The two equilibrium welfare-maximizing CIT rates, τ^h and τ^{WM}, deviate from the growth-maximizing tax rate, τ^{GM}, by only approximately 3% at most (1% in the benchmark case) because welfare maximization is close to growth maximization in the long run. The equilibrium CIT rate increases by δ. [10] This is because spillovers amplify the growth effect of productive public spending in both the home and foreign countries.

The degree of international knowledge spillover determines whether the Nash equilibrium tax rate is high or low. The Nash equilibrium tax rate is lower than the social optimum under weak spillover, for example, $\delta < 0.05$, because the tax-base effect dominates the positive spillover effect. Conversely, when spillover effect is strong to some extent, CIT competition is apt to lead to excessive tax rates.

The difference between τ^{WM} and τ^h increases with δ. This is because the strong spillover mitigates the loss of raising CIT rates and encourages governments to increase their productive

[10] In the case of log utility function, τ^h is independent of δ: See footnote 7 associated with Proposition 3. However, this is a special case, and τ^h generally depends on δ, as Figure 3 illustrates.

public spending, as mentioned immediately after Proposition 3. However, the difference is quantitatively small: it is less than 1.5%, even in the case of strong spillover, $\delta = 0.4$. The background for this result is not only that welfare maximization is close to growth maximization, but also that the CIT competition does not damage economic growth (Proposition 2). In the next subsection, we evaluate this difference from the perspective of welfare.

4.3 Welfare loss of CIT competition

As Proposition 3 suggests, welfare-maximizing CIT competition leads to an excessively high or low equilibrium tax rate, and some welfare losses occur in the Nash equilibrium. However, the welfare loss is very small, as explained in detail below.

Here, based on Lucas's (1987) idea, we measure the welfare loss by the decrease in consumption due to CIT competition in the case of symmetric countries. Given a constant ψ, let $\hat{C}_r(t) = (1-\psi)C_r^h(t)$, where $C_r^h(t)$ is the per capita consumption of country r at time t under tax harmonization. Letting $\hat{U}_r(0) = \sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^t \frac{\hat{C}_r(t)^{1-\sigma}}{1-\sigma}$, we obtain $\hat{U}_r(0) = (1-\psi)^{1-\sigma}U_r^h(0)$, where $U_r^h(0) = \sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^t \frac{(C_r^h(t))^{1-\sigma}}{1-\sigma}$. By solving this with respect to ψ, we obtain $\psi = 1-\left(\frac{\hat{U}_r(0)}{U_r^h(0)}\right)^{\frac{1}{1-\sigma}}$. If we replace $\hat{U}_r(0)$ with the discounted sum of the household's utility in the Nash equilibrium of the welfare-maximizing CIT competition, denoted by $U_r^{WM}(0)$, we can measure the welfare loss of the CIT competition by

$$\psi = 1 - \left(\frac{U_r^{WM}(0)}{U_r^h(0)}\right)^{\frac{1}{1-\sigma}}. \tag{43}$$

That is, we measure welfare loss by calculating what percentage of consumption would be lost relative to the case of the cooperative solution when the CIT competition takes place.

Under the benchmark parameter value, we calculate the welfare loss ψ as a percentage for various values of the degree of international knowledge spillover δ. Table 2 summarizes the results. As can be seen at first glance, the welfare loss ψ increases in δ. This is because the source of strategic interaction is international knowledge spillovers.

However, the welfare loss is quite small for any value of δ, because the unit of analysis is a percentage. For the reference value $\delta = 0.2$, the welfare loss is $\psi = 0.114\%$. It is only up to 0.740% even in the case of $\delta = 1$, where the spillover effect from abroad is as strong as that from home.

The reason for such tiny welfare losses is that growth-maximizing CIT competition, which is hypothetically explored in Section 3.1, leads to the same allocation as that of growth-maximizing policy under tax harmonization; Proposition 2. In other words, the CIT competition is not detrimental to economic growth. Because the growth rate is the dominant factor in economic welfare in the long run, the welfare-maximizing policy is similar to the growth-maximizing policy. Thus, in welfare-maximizing CIT competition, the loss of growth rate is small, and so is welfare loss.

5 Concluding Remarks

Using a two-country model of endogenous growth with international knowledge spillover and an integrated financial market, we show that the Nash equilibrium under CIT competition generates few welfare losses. Of course, this model contains some simplifications for the tractability of analyses, but also captures the characteristics of the modern international economy. Our results direct some questions at the seemingly dominant view that global CIT competition leads to excessively low CIT rates and causes significant damage to global welfare. Accordingly, cooperative policies, such as the historic agreement by the leaders of the G20 (2021) on international corporate taxation that effectively imposes a 15% minimum tax rate, may not have a significant impact on economic welfare. In fact, the recent decline in CIT rates has begun to show signs of convergence above the minimum rate even before this agreement was reached: See Figure 1.

Despite its contributions, we believe that his study has certain limitations, which research in the future should seek to address. Since we employ a model without a transition process, the weight of the long-run growth rate in welfare is large. As a result, it is possible that the welfare losses due to CIT competition are somewhat underestimated. However, even if we consider a model with a transition process by introducing public capital as a stock variable (Futagami et al. 1993) instead of public services as a flow variable, there is no difference in that CIT competition does not damage the long-run growth rate. Moreover, even in a model with a transition process, the long-run growth rate accounts for a large share of welfare. Thus, it is unlikely that the results will change significantly. However, a quantitative examination of cases in which a transition process is considered should be conducted in the future.

The study also does not consider factors that would cause the optimal CIT rate to deviate significantly from Barro's (1990) rule, such as fraud by public officials in Aghion et al. (2016)

and firms' tax evasion in Hori et al. (2022). Such factors are specific but quantitatively important, as the data suggest, and it would be worthwhile to analyze how they affect the consequences of CIT competition.

Appendix

A Derivation of (29)

By substituting (5), (17), (20), (28) (with $\beta \equiv \alpha\gamma$ and $\tilde{A}(\phi) \equiv \left\{(1+\phi^\alpha)^{1-\alpha} A^\alpha \alpha (1-\alpha)^\beta\right\}^{\frac{1}{1-\beta}}$) in (4) yields

$$\begin{aligned} x_{r,r}(t)^\alpha &= A^\alpha \left[\frac{G_r(t)^\gamma N_r(t)^{1-\gamma} \vartheta_r(n_{rs}(\tau_r,\tau_s))^{1-\gamma}}{(1+\phi^\alpha)N_r(t)}\right]^\alpha \\ &= (1+\phi^\alpha)^{-\alpha} A^\alpha \left(G_r(t)/N_r(t)\right)^\beta \vartheta\left(n_{rs}(\tau_r,\tau_s)\right)^{\alpha-\beta} \\ &= (1+\phi^\alpha)^{-\alpha} A^\alpha \left(\tau_r \pi_r(\tau_r,\tau_s)\right)^\beta \vartheta\left(n_{rs}(\tau_r,\tau_s)\right)^{\alpha-\beta} \\ &= (1-\alpha)^\beta (1+\phi^\alpha)^{-\alpha} A^\alpha \tilde{A}(\phi)^\beta \tau_r^{\frac{\beta}{1-\beta}} \vartheta_r(n_{rs}(\tau_r,\tau_s))^{\frac{\alpha-\beta}{1-\beta}} \\ &= \frac{\tilde{A}(\phi)}{(1+\phi^\alpha)\alpha} \tau_r^{\frac{\beta}{1-\beta}} \vartheta_r(n_{rs}(\tau_r,\tau_s))^{\frac{\alpha-\beta}{1-\beta}}. \end{aligned} \tag{A.1}$$

This, combined with (11), yields

$$x_{r,s}(t)^\alpha = \frac{\phi^\alpha \tilde{A}(\phi)}{(1+\phi^\alpha)\alpha} \tau_r^{\frac{\beta}{1-\beta}} \vartheta_r(n_{rs}(\tau_r,\tau_s))^{\frac{\alpha-\beta}{1-\beta}}, \quad r \neq s. \tag{A.2}$$

By inserting (A.1) and (A.2) into (1), we have

$$\begin{aligned} Y_1(t) &= N_1(t)x_{1,1}(t)^\alpha + N_2 x_{2,1}(t)^\alpha \\ &= \frac{\tilde{A}(\phi)}{(1+\phi^\alpha)\alpha}\left[\tau_1^{\frac{\beta}{1-\beta}} \vartheta_1(n_{12}(\tau_1,\tau_2))^{\frac{\alpha-\beta}{1-\beta}} N_1(t) + \phi^\alpha \tau_2^{\frac{\beta}{1-\beta}} \vartheta_2(n_{21}(\tau_2,\tau_1))^{\frac{\alpha-\beta}{1-\beta}} N_2(t)\right], \quad \text{(A.3)} \\ Y_2(t) &= \frac{\tilde{A}(\phi)}{(1+\phi^\alpha)\alpha}\left[\tau_2^{\frac{\beta}{1-\beta}} \vartheta_2(n_{21}(\tau_2,\tau_1))^{\frac{\alpha-\beta}{1-\beta}} N_2(t) + \phi^\alpha \tau_1^{\frac{\beta}{1-\beta}} \vartheta_1(n_{12}(\tau_1,\tau_2))^{\frac{\alpha-\beta}{1-\beta}} N_1(t)\right]. \quad \text{(A.4)} \end{aligned}$$

From (A.3) and (A.4), we obtain (29).

B Derivation of the final good market clearing condition and (30)

From (29), the aggregate final goods production in the two countries is given by

$$Y_1(t) + Y_2(t) = \frac{\tilde{A}(\phi)}{\alpha}\left[\tau_1^{\frac{\beta}{1-\beta}} \vartheta_1(n_{12}(\tau_1,\tau_2))^{\frac{\alpha-\beta}{1-\beta}} N_1(t) + \tau_2^{\frac{\beta}{1-\beta}} \vartheta_2(n_{21}(\tau_2,\tau_1))^{\frac{\alpha-\beta}{1-\beta}} N_2(t)\right]. \tag{B.1}$$

From (25) and (B.1), we have

$$w_1(t)L_1 + w_2(t)L_2 = \alpha\tilde{A}(\phi)\left[\tau_1^{\frac{\beta}{1-\beta}}\vartheta_1(n_{12}(\tau_1,\tau_2))^{\frac{\alpha-\beta}{1-\beta}}N_1(t) + \tau_2^{\frac{\beta}{1-\beta}}\vartheta_2(n_{21}(\tau_2,\tau_1))^{\frac{\alpha-\beta}{1-\beta}}N_2(t)\right]$$
$$= \alpha^2(Y_1(t) + Y_2(t)). \tag{B.2}$$

Equations (18) and (26) lead to

$$R(W_1(t-1)L_1+W_2(t-1)L_2) = R\eta(N_1(t)+N_2(t)) = (1-\tau_1)\pi_1 N_1(t)+(1-\tau_2)\pi_2 N_2(t). \tag{B.3}$$

Equation (B.3) together with (16), (23), and (B.1) yield

$$R(W_1(t-1)L_1 + W_2(t-1)L_2)$$
$$= (1-\alpha)\tilde{A}(\phi)\left[\tau_1^{\frac{\beta}{1-\beta}}\vartheta_1(n_{12}(\tau_1,\tau_2))^{\frac{\alpha-\beta}{1-\beta}}N_1(t) + \tau_2^{\frac{\beta}{1-\beta}}\vartheta_2(n_{21}(\tau_2,\tau_1))^{\frac{\alpha-\beta}{1-\beta}}N_2(t)\right] - G_1(t) - G_2(t)$$
$$= (1-\alpha)\alpha(Y_1(t) + Y_2(t)) - (G_1(t) + G_2(t)). \tag{B.4}$$

Substituting (B.2), (B.4), and (18) into the sum of the total household budget constraints in the two countries, $W_1(t)L_1 + W_2(t)L_2 = R[W_1(t-1)L_1 + W_2(t-1)L_2] + w_1(t)L_1 + w_2(t)L_2 - C_1(t)L_1 - C_2(t)L_2$, we obtain:

$$\eta(N_1(t+1) + N_2(t+1)) = \alpha(Y_1(t) + Y_2(t)) - (G_1(t) + G_2(t)) - C_1(t)L_1 - C_2(t)L_2$$
$$= Y_1(t) + Y_2(t) - E_1(t) - E_2(t) - (G_1(t) + G_2(t)) - C_1(t)L_1 - C_2(t)L_2,$$

where the total sunk cost of the final goods sector is $E_1(t) + E_2(t) = (1-\alpha)(Y_1(t) + Y_2(t))$. Thus, we obtain the final good market-clearing condition:

$$\eta(N_1(t+1) + N_2(t+1)) = \alpha(Y_1(t) + Y_2(t)) - (G_1(t) + G_2(t)) - C_1(t)L_1 - C_2(t)L_2. \tag{B.5}$$

Using (28) and (29), (B.5) can be rewritten as:

$$\eta(N_1(t+1)+N_2(t+1))$$
$$= \tilde{A}(\phi)\left[[1-(1-\alpha)\tau_1]\tau_1^{\frac{\beta}{1-\beta}}\vartheta_1(n_{12}(\tau_1,\tau_2))^{\frac{\alpha-\beta}{1-\beta}}N_1(t)+[1-(1-\alpha)\tau_2]\tau_2^{\frac{\beta}{1-\beta}}\vartheta_2(n_{21}(\tau_2,\tau_1))^{\frac{\alpha-\beta}{1-\beta}}N_2(t)\right]$$
$$- C_1(t)L_1 - C_2(t)L_2.$$

Thus, we obtain (30).

C Derivation of the dynamic system (31) and (32)

By dividing (30) by $N_1(t)$ and using $z_1(t) \equiv \frac{C_1(t)L_1}{N_1(t)}$ and $\frac{C_2(t)L_2}{N_1(t)} = \frac{C_2(t)L_2}{N_2(t)} \cdot \frac{N_2(t)}{N_1(t)} = \frac{N_2(t)}{N_1(t)} z_2(t)$, we obtain:

$$\eta\left[1+n_{12}(\tau_1,\tau_2)\right]\frac{N_1(t+1)}{N_1(t)}$$
$$= \tilde{A}(\phi)\left[[1-(1-\alpha)\tau_1]\tau_1^{\frac{\beta}{1-\beta}}\vartheta_1(n_{12}(\tau_1,\tau_2))^{\frac{\alpha-\beta}{1-\beta}}+[1-(1-\alpha)\tau_2]\tau_2^{\frac{\beta}{1-\beta}}\vartheta_2(n_{21}(\tau_2,\tau_1))^{\frac{\alpha-\beta}{1-\beta}}n_{12}(\tau_1,\tau_2)\right]$$
$$- z_1(t) - n_{12}(\tau_1,\tau_2)z_2(t). \tag{C.1}$$

Applying (20) to (C.1), we obtain

$$\frac{N_1(t+1)}{N_1(t)} = \frac{\Phi_1(\tau_1,\tau_2) - z_1(t) - n_{12}(\tau_1,\tau_2)z_2(t)}{\eta\left[1+n_{12}(\tau_1,\tau_2)\right]}. \tag{C.2}$$

Next, by dividing (30) by $N_2(t)$ and conducting the same calculation as that for Country 2, we obtain

$$\frac{N_2(t+1)}{N_2(t)} = \frac{\Phi_2(\tau_2,\tau_1) - z_2(t) - n_{21}(\tau_2,\tau_1)z_1(t)}{\eta\left[1+n_{21}(\tau_2,\tau_1)\right]}. \tag{C.3}$$

By using (C.2) and (C.3) together with (27), we obtain (31) and (32).

D Proof of Proposition 1

First, we derive the steady-state values of z_1^* and z_2^*. From $W_r(t) = R(\tau_r,\tau_s)W_r(t-1)+w_r(t)-C_r(t)$, we obtain $\frac{W_r(t)}{R(\tau_r,\tau_s)^{t+1}} = W_r(-1) + \sum_{v=0}^{t}\frac{w_r(v)-C_r(v)}{R(\tau_r,\tau_s)^{v+1}}$. In addition to the transversality condition $\lim_{t\to\infty}\frac{W_r(t)}{R(\tau_r,\tau_s)^{t+1}}=0$, we obtain

$$W_r(-1)+\sum_{v=0}^{\infty}\frac{w_r(v)-C_r(v)}{R(\tau_r,\tau_s)^{v+1}}=0. \tag{D.1}$$

In the steady state, $w_r(v)=w_r(0)g_C(\tau_r,\tau_s)^v$ and $C_r(v)=C_r(0)g_C(\tau_r,\tau_s)^v$ hold from (25), (27), and $N_r(t+1)/N_r(t)=g_C(\tau_r,\tau_s)$. Then, (D.1) can be rewritten as

$$\begin{aligned}&W_r(-1)+\sum_{v=0}^{\infty}\frac{w_r(0)-C_r(0)}{R(\tau_r,\tau_s)^{v+1}}g_C(\tau_r,\tau_s)^v\\ \iff\quad &[R(\tau_r,\tau_s)-g_C(\tau_r,\tau_s)]W_r(-1)+w_r(0)=C_r(0).\end{aligned} \tag{D.2}$$

Substituting (25) and (27) into (D.2), we obtain:

$$[g_C(\tau_r,\tau_s)^{\sigma}(1+\rho)-g_C(\tau_r,\tau_s)]\,W_r(-1)+\alpha\tilde{A}(\phi)\tau_r^{\frac{\beta}{1-\beta}}\vartheta_r(n_{rs}(\tau_r,\tau_s))^{\frac{\alpha-\beta}{1-\beta}}N_r(0)=C_r(0). \tag{D.3}$$

By dividing (D.3) by $N_r(0)$ and using $z_r^*=C_r(0)/N_r(0)$, we obtain:

$$z_r^*=\alpha\tilde{A}(\phi)\tau_r^{\frac{\beta}{1-\beta}}\vartheta_r(n_{rs}(\tau_r,\tau_s))^{\frac{\alpha-\beta}{1-\beta}}+[g_C(\tau_r,\tau_s)^{\sigma}(1+\rho)-g_C(\tau_r,\tau_s)]\,\frac{W_r(-1)}{N_r(0)}. \tag{D.4}$$

Because the international asset market is clear, as (18), we have $W_1(-1)+W_2(-1)=\eta(N_1(0)+N_2(0))$. Here, we define the initial share of country 1's asset holdings as $\Delta\equiv W_1(-1)/[W_1(-1)+W_2(-1)]\in[0,1]$. This, together with $W_1(-1)+W_2(-1)=\eta(N_1(0)+N_2(0))$, yields

$$\begin{aligned}\frac{1}{\eta(1+n_{12}(\tau_1,\tau_2))}\frac{W_1(-1)}{N_1(0)}&=\Delta,\\ \frac{1}{\eta(1+n_{21}(\tau_2,\tau_1))}\frac{W_2(-1)}{N_2(0)}&=1-\Delta.\end{aligned} \tag{D.5}$$

Substituting (D.5) into (D.4), we obtain

$$z_1^*=\alpha\tilde{A}(\phi)\tau_1^{\frac{\beta}{1-\beta}}\vartheta_r(n_{12}(\tau_1,\tau_2))^{\frac{\alpha-\beta}{1-\beta}}+[g_C(\tau_1,\tau_2)^{\sigma}(1+\rho)-g_C(\tau_1,\tau_2)]\,\Delta\eta(1+n_{12}(\tau_1,\tau_2)), \tag{D.6}$$

$$z_2^*=\alpha\tilde{A}(\phi)\tau_2^{\frac{\beta}{1-\beta}}\vartheta_r(n_{21}(\tau_2,\tau_1))^{\frac{\alpha-\beta}{1-\beta}}+[g_C(\tau_1,\tau_2)^{\sigma}(1+\rho)-g_C(\tau_1,\tau_2)]\,(1-\Delta)\eta(1+n_{21}(\tau_2,\tau_1)). \tag{D.7}$$

Equation (D.6) (resp. (D.7)) satisfies (31) (resp. (32)) in the steady state: $z_1(t+1) = z_1(t) = z_1^*$ and $z_2(t+1) = z_2(t) = z_2^*$. To demonstrate this, we set $z_1(t+1) = z_1(t) = z_1^*$ in (31).

$$\Phi_1(\tau_1, \tau_2) - z_1^* - n_{12}(\tau_1, \tau_2) z_2^* = \eta[1 + n_{12}(\tau_1, \tau_2)] g_C(\tau_1, \tau_2). \tag{D.8}$$

Substituting (D.4) into the LHS of (D.8) and using (24), (26), (27), and (33), we obtain:

$$\begin{aligned}
\text{The LHS of (D.8)} =& \Phi_1(\tau_1, \tau_2) - \alpha \tilde{A}(\phi) \tau_1^{\frac{\beta}{1-\beta}} \vartheta_r(n_{12}(\tau_1, \tau_2))^{\frac{\alpha-\beta}{1-\beta}} \\
& - \left[g_C(\tau_1, \tau_2)^\sigma (1+\rho) - g_C(\tau_1, \tau_2)\right] \eta (1 + n_{12}(\tau_1, \tau_2)) \\
& - n_{12}(\tau_1, \tau_2) \alpha \tilde{A}(\phi) \tau_2^{\frac{\beta}{1-\beta}} \vartheta_r(n_{21}(\tau_2, \tau_1))^{\frac{\alpha-\beta}{1-\beta}} \\
=& \Phi_1(\tau_1, \tau_2) - \alpha \tilde{A}(\phi) \tau_1^{\frac{\beta}{1-\beta}} \vartheta_r(n_{12}(\tau_1, \tau_2))^{\frac{\alpha-\beta}{1-\beta}} \\
& - (1-\alpha)(1-\tau_1) \tilde{A}(\phi) \tau_1^{\frac{\beta}{1-\beta}} \vartheta_r(n_{12}(\tau_1, \tau_2))^{\frac{\alpha-\beta}{1-\beta}} \\
& + \eta[1 + n_{12}(\tau_1, \tau_2)] g_C(\tau_1, \tau_2) \\
& - n_{12}(\tau_1, \tau_2) \frac{1-\tau_1}{1-\tau_2} \alpha \tilde{A}(\phi) \tau_1^{\frac{\beta}{1-\beta}} \vartheta_r(n_{12}(\tau_1, \tau_2))^{\frac{\alpha-\beta}{1-\beta}} \\
=& \eta[1 + n_{12}(\tau_1, \tau_2)] g_C(\tau_1, \tau_2) = \text{The RHS of (D.8)}.
\end{aligned}$$

Thus, (D.6) satisfies (31) in steady state. Similarly, we can demonstrate that (D.7) satisfies (32) in the steady state.

Next, we examined the properties of $z_1(t+1) = z_1(t)$ and $z_2(t+1) = z_2(t)$ loci. From (31), the $z_1(t+1) = z_1(t)$ locus is given by:

$$z_1(t) = \Phi_1(\tau_1, \tau_2) - \eta \left[1 + n_{12}(\tau_1, \tau_2)\right] g_C(\tau_1, \tau_2) - n_{12}(\tau_1, \tau_2) z_2(t).$$

From (32), $z_2(t+1) = z_2(t)$ locus is given by:

$$z_2(t) = \Phi_2(\tau_2, \tau_1) - \eta \left[1 + n_{21}(\tau_2, \tau_1)\right] g_C(\tau_1, \tau_2) - n_{21}(\tau_2, \tau_1) z_1(t).$$

Here, we demonstrate the following relationship.

$$\Phi_1(\tau_1, \tau_2) n_{21}(\tau_2, \tau_1) = \Phi_2(\tau_2, \tau_1) \quad (\Leftrightarrow \Phi_2(\tau_2, \tau_1) n_{12}(\tau_1, \tau_2) = \Phi_1(\tau_1, \tau_2)). \tag{D.9}$$

The proof is as follows:

By using (33) and (20): $\left[\frac{\vartheta_1(n_{12})}{\vartheta_2(n_{21})}\right]^{\frac{\alpha-\beta}{1-\beta}} = \frac{1-\tau_2}{1-\tau_1}\left(\frac{\tau_2}{\tau_1}\right)^{\frac{\beta}{1-\beta}}$ with $n_{12}(\tau_1,\tau_2)^{-1} = n_{21}(\tau_2,\tau_1)$ (or $n_{21}(\tau_2,\tau_1)^{-1} = n_{12}(\tau_1,\tau_2)$), we can transform the LHS of (D.9) into

$$
\begin{aligned}
&\Phi_1(\tau_1,\tau_2)n_{21}(\tau_2,\tau_1)\\
&= \tilde{A}(\phi)\tau_1^{\frac{\beta}{1-\beta}}\vartheta_1(n_{12}(\tau_1,\tau_2))^{\frac{\alpha-\beta}{1-\beta}}\left\{1-(1-\alpha)\tau_1+[1-(1-\alpha)\tau_2]\frac{1-\tau_1}{1-\tau_2}n_{12}(\tau_1,\tau_2)\right\}n_{21}(\tau_2,\tau_1)\\
&= \tilde{A}(\phi)\tau_1^{\frac{\beta}{1-\beta}}\vartheta_1(n_{12}(\tau_1,\tau_2))^{\frac{\alpha-\beta}{1-\beta}}\left\{[1-(1-\alpha)\tau_1]n_{21}(\tau_2,\tau_1)+[1-(1-\alpha)\tau_2]\frac{1-\tau_1}{1-\tau_2}\right\}\\
&= \tilde{A}(\phi)\tau_1^{\frac{\beta}{1-\beta}}\frac{1-\tau_2}{1-\tau_1}\left(\frac{\tau_2}{\tau_1}\right)^{\frac{\beta}{1-\beta}}\vartheta_2(n_{21}(\tau_2,\tau_1))^{\frac{\alpha-\beta}{1-\beta}}\left\{[1-(1-\alpha)\tau_1]n_{21}(\tau_2,\tau_1)+[1-(1-\alpha)\tau_2]\frac{1-\tau_1}{1-\tau_2}\right\}\\
&= \tilde{A}(\phi)\tau_2^{\frac{\beta}{1-\beta}}\vartheta_2(n_{21}(\tau_2,\tau_1))^{\frac{\alpha-\beta}{1-\beta}}\left\{[1-(1-\alpha)\tau_1]\frac{1-\tau_2}{1-\tau_1}n_{21}(\tau_2,\tau_1)+1-(1-\alpha)\tau_2\right\}\\
&= \Phi_2(\tau_2,\tau_1) = \text{the RHS of (D.9)}.
\end{aligned}
$$

Thus, $z_1(t+1) = z_1(t)$ and $z_2(t+1) = z_2(t)$ loci are lines with negative slopes that take the following common values:

$$
\begin{aligned}
z_1(t) &= \Phi_1(\tau_1,\tau_2) - \eta[1+n_{12}(\tau_1,\tau_2)]g_C(\tau_1,\tau_2) \ \text{ when } \ z_2(t)=0,\\
z_2(t) &= \Phi_2(\tau_2,\tau_1) - \eta[1+n_{21}(\tau_2,\tau_1)]g_C(\tau_1,\tau_2) \ \text{ when } \ z_1(t)=0.
\end{aligned}
$$

Thus, $z_1(t+1) = z_1(t)$ and $z_2(t+1) = z_2(t)$ loci overlap in the z_2-z_1 plane, as depicted in Figure 2.

[Figure 2 is inserted here.]

The remainder of this appendix proves that the steady state (z_1^*, z_2^*) is unstable, and the economy must be in the steady state (z_1^*, z_2^*) initially.

From (31) and (32), $z_1(t+1)/z_1(t) \gtrless 1$ if and only if

$$z_1(t) \gtrless \Phi(\tau_1,\tau_2) - \eta\left[1+n_{12}(\tau_1,\tau_2)\right]g_C(\tau_1,\tau_2) - n_{12}(\tau_1,\tau_2)z_2(t),$$

and $z_2(t+1)/z_2(t) \gtrless 1$ if and only if

$$z_2(t) \gtrless \Phi(\tau_2,\tau_1) - \eta\left[1+n_{21}(\tau_2,\tau_1)\right]g_C(\tau_1,\tau_2) - n_{21}(\tau_2,\tau_1)z_1(t).$$

If $(z_1(t), z_2(t))$ is above the $z_1(t+1) = z_1(t)$ locus ($z_2(t+1) = z_2(t)$ locus), both $z_1(t)$ and $z_2(t)$ explode, and both $N_1(t)$ and $N_2(t)$ eventually equal zero from (C.2) and (C.3). When $N_1(t) = N_2(t) = 0$, both $Y_1(t) = Y_2(t) = 0$ and $C_1(t) = C_2(t) = 0$ violate the first-order conditions of the representative household.

In contrast, if $(z_1(t), z_2(t))$ is below the $z_1(t+1) = z_1(t)$ locus ($z_2(t+1) = z_2(t)$ locus), both $z_1(t)$ and $z_2(t)$ eventually equal zero. From $C_1(t) = z_1(t)N_1(t)/L_1$ and $C_2(t) = z_2(t)N_2(t)/L_2 = z_2(t)n_{12}(\tau_1, \tau_2)N_1(t)/L_2$, $z_1(t) = z_2(t) = 0$ leads to $C_1(t) = C_2(t) = 0$, violating the first-order conditions of the representative household.

Thus, $z_1(t)$ and $z_2(t)$ jump to steady-state values (z_1^*, z_2^*) on the $z_1(t+1) = z_1(t)$ locus ($z_2(t+1) = z_2(t)$ locus) initially.

E Derivation of (35)

From (26) and (27), we have that

$$\frac{\partial g_C(\tau_r, \tau_s)}{\partial \tau_r} = \frac{g_C(\tau_r, \tau_s)}{\sigma(1-\beta)} \left[\frac{\beta - \tau_r}{(1-\tau_r)\tau_r} + (\alpha - \beta) \frac{\vartheta'(n_{rs})}{\vartheta(n_{rs})} \frac{\partial n_{rs}}{\partial \tau_r} \right]. \tag{E.1}$$

From (21), the derivative of n_{rs} with respect to τ_r is:

$$\frac{\partial n_{rs}}{\partial \tau_r} = \frac{\varphi(n_{rs})}{\varphi'(n_{rs})} \frac{\tau_r - \beta}{(\alpha - \beta)\tau_r(1-\tau_r)}. \tag{E.2}$$

Substituting (E.2) into (E.1), we obtain:

$$\frac{\partial g_C(\tau_r, \tau_s)}{\partial \tau_r} = \frac{g_C(\tau_r, \tau_s)}{\sigma(1-\beta)} \left[1 - \frac{\varphi(n_{rs})\vartheta'(n_{rs})}{\varphi'(n_{rs})\vartheta(n_{rs})} \right] \frac{\beta - \tau_r}{(1-\tau_r)\tau_r}. \tag{E.3}$$

From (22) and $\varphi(n_{rs}) \equiv \vartheta_r(n_{rs})/\vartheta_s(n_{rs}^{-1})$, we obtain:

$$\frac{\varphi(n_{rs})\vartheta'(n_{rs})}{\varphi'(n_{rs})\vartheta(n_{rs})} = \frac{\epsilon_r(n_{rs})}{\epsilon_r(n_{rs}) + \epsilon_s(n_{rs}^{-1})}. \tag{E.4}$$

From (E.3) and (E.4), we obtain (35).

F Proof of Proposition 3

By $\frac{\partial U_r(0)}{\partial \tau_r} = U_r(0)\frac{\partial \ln U_r(0)}{\partial \tau_r}$, we have

$$\frac{\partial U_r(0)}{\partial \tau_r} = \frac{(z_r^*/L_r)^{1-\sigma}\left[1/(1+n_{rs}(\tau_r,\tau_s))\right]^{1-\sigma}}{1-(1+\rho)^{-1}g_C(\tau_r,\tau_s)^{1-\sigma}} \times \left[\frac{\partial \ln z_r^*}{\partial \tau_r} - \frac{n_{rs}(\tau_r,\tau_s)}{1+n_{rs}(\tau_r,\tau_s)}\frac{\partial \ln n_{rs}}{\partial \tau_r} + \frac{(1+\rho)^{-1}g_C(\tau_r,\tau_s)^{1-\sigma}}{1-(1+\rho)^{-1}g_C(\tau_r,\tau_s)^{1-\sigma}}\frac{\partial \ln g_C}{\partial \tau_r}\right].$$

Because $1-(1+\rho)^{-1}g_C(\tau_r,\tau_s)^{1-\sigma} > 0$, we obtain:

$$\text{sign}\frac{\partial U_r(0)}{\partial \tau_r} = \text{sign}\left[\frac{\partial \ln z_r^*}{\partial \tau_r} - \frac{n_{rs}(\tau_r,\tau_s)}{1+n_{rs}(\tau_r,\tau_s)}\frac{\partial \ln n_{rs}}{\partial \tau_r} + \frac{(1+\rho)^{-1}g_C(\tau_r,\tau_s)^{1-\sigma}}{1-(1+\rho)^{-1}g_C(\tau_r,\tau_s)^{1-\sigma}}\frac{\partial \ln g_C}{\partial \tau_r}\right]. \tag{F.1}$$

Here, from (34) and $\Delta = \frac{1}{2}$,

$$\frac{\partial \ln z_r^*}{\partial \tau_r} = \frac{\alpha\tilde{A}(\phi)\tau_r^{\frac{\beta}{1-\beta}}\vartheta_r(n_{rs})^{\frac{\alpha-\beta}{1-\beta}}\left[\frac{\beta}{(1-\beta)\tau_r} + \frac{\alpha-\beta}{1-\beta}\frac{\vartheta_r'(n_{rs})}{\vartheta_r(n_{rs})}\frac{\partial n_{rs}}{\partial \tau_r}\right]}{\alpha\tilde{A}(\phi)\tau_r^{\frac{\beta}{1-\beta}}\vartheta_r(n_{rs})^{\frac{\alpha-\beta}{1-\beta}} + \left[g_C^\sigma(1+\rho)-g_C\right]\frac{\eta(1+n_{rs})}{2}} + \frac{\frac{\eta(1+n_{rs})}{2}\left[\sigma g_C^\sigma(1+\rho)-g_C\right]\frac{\partial \ln g_C}{\partial \tau_r} + \frac{\eta}{2}\left[g_C^\sigma(1+\rho)-g_C\right]\frac{\partial n_{rs}}{\partial \tau_r}}{\alpha\tilde{A}(\phi)\tau_r^{\frac{\beta}{1-\beta}}\vartheta_r(n_{rs})^{\frac{\alpha-\beta}{1-\beta}} + \left[g_C^\sigma(1+\rho)-g_C\right]\frac{\eta(1+n_{rs})}{2}}. \tag{F.2}$$

From (E.2), the term $\frac{\alpha-\beta}{1-\beta}\frac{\vartheta_r'(n_{rs})}{\vartheta_r(n_{rs})}\frac{\partial n_{rs}}{\partial \tau_r}$ in (F.2) is reduced to $\frac{\varphi(n_{rs})\vartheta'(n_{rs})}{\varphi'(n_{rs})\vartheta(n_{rs})}\frac{\tau_r-\beta}{(1-\tau_r)\tau_r(1-\beta)}$: From (E.4), this term can be rewritten as $\frac{\epsilon_r(n_{rs})}{\epsilon_r(n_{rs})+\epsilon_s(n_{rs}^{-1})}\frac{\tau_r-\beta}{(1-\tau_r)\tau_r(1-\beta)} = \frac{1}{2}\frac{\tau_r-\beta}{(1-\tau_r)\tau_r(1-\beta)}$ because $\epsilon_r(n_{rs}) = \epsilon_s(n_{rs}^{-1})$. Substituting this into (F.2) and evaluating (F.2) in the symmetric Nash equilibrium (i.e., $(\tau_1,\tau_2) = (\tau^*,\tau^*)$ and $n_{12} = n_{21} = 1$) yields

$$\frac{\partial \ln z_r^*}{\partial \tau_r}|_{\tau_r=\tau^*} = \frac{\alpha\tilde{A}(\phi)(\tau^*)^{\frac{\beta}{1-\beta}}\vartheta_r(1)^{\frac{\alpha-\beta}{1-\beta}}\left[\frac{\beta}{(1-\beta)\tau^*} + \frac{\alpha-\beta}{1-\beta}\frac{\vartheta_r'(1)}{\vartheta_r(1)}\frac{\partial n_{rs}}{\partial \tau_r}|_{\tau_r=\tau^*}\right]}{\alpha\tilde{A}(\phi)(\tau^*)^{\frac{\beta}{1-\beta}}\vartheta_r(1)^{\frac{\alpha-\beta}{1-\beta}} + \eta\left[g_C(\tau^*,\tau^*)^\sigma(1+\rho)-g_C(\tau^*,\tau^*)\right]} + \frac{\eta\left[\sigma g_C(\tau^*,\tau^*)^\sigma(1+\rho)-g_C(\tau^*,\tau^*)\right]\frac{\beta-\tau^*}{2\sigma(1-\beta)(1-\tau^*)\tau^*}}{\alpha\tilde{A}(\phi)(\tau^*)^{\frac{\beta}{1-\beta}}\vartheta_r(1)^{\frac{\alpha-\beta}{1-\beta}} + \eta\left[g_C(\tau^*,\tau^*)^\sigma(1+\rho)-g_C(\tau^*,\tau^*)\right]} + \frac{\left[g_C(\tau^*,\tau^*)^\sigma(1+\rho)-g_C(\tau^*,\tau^*)\right]\frac{\partial n_{rs}}{\partial \tau_r}|_{\tau_r=\tau^*}}{\alpha\tilde{A}(\phi)(\tau^*)^{\frac{\beta}{1-\beta}}\vartheta_r(1)^{\frac{\alpha-\beta}{1-\beta}} + \eta\left[g_C(\tau^*,\tau^*)^\sigma(1+\rho)-g_C(\tau^*,\tau^*)\right]}, \tag{F.3}$$

where we have used

$$\frac{\partial \ln g_C}{\partial \tau_r}|_{\tau_r=\tau^*} = \frac{\beta-\tau^*}{2\sigma(1-\beta)(1-\tau^*)\tau^*}. \tag{F.4}$$

When $\Theta_r(N_r(t), N_s(t))$ takes the same form between the two countries, the FOC of policy harmonization (40) (including (41) and (42)) is written as

$$\frac{\tilde{A}(\phi)\left(\tau^h\right)^{\frac{\beta}{1-\beta}}\vartheta_1(1)^{\frac{\alpha-\beta}{1-\beta}}\frac{\beta}{1-\beta}\frac{1}{\tau^h}+\eta\left[\sigma(1+\rho)(g^h)^\sigma-g^h\right]\cdot\frac{\beta-\tau^h}{\sigma(1-\beta)(1-\tau^h)\tau^h}}{\alpha\tilde{A}(\phi)\left(\tau^h\right)^{\frac{\beta}{1-\beta}}\vartheta_1(1)^{\frac{\alpha-\beta}{1-\beta}}+\eta\left[(1+\rho)(g^h)^\sigma-g^h\right]}$$
$$+\frac{(1+\rho)^{-1}(g^h)^{1-\sigma}}{1-(1+\rho)^{-1}(g^h)^{1-\sigma}}\cdot\frac{\beta-\tau^h}{\sigma(1-\beta)\left(1-\tau^h\right)\tau^h}=0. \tag{F.5}$$

Evaluating (F.1), (F.3), and (F.4) at $\tau_r=\tau^*=\tau^h$, and using (F.5), we obtain

$$\begin{aligned}&\text{sign}\frac{\partial U_r(0)}{\partial \tau_r}|_{\tau_r=\tau^*=\tau^h}\\&=\text{sign}\left[\frac{1}{1-\tau^h}-\frac{\partial n_{rs}}{\partial \tau_r}|_{\tau_r=\tau^*=\tau^h}\right].\end{aligned} \tag{F.6}$$

Substituting (E.2) and (E.4) into (F.6), we obtain

$$\frac{\partial U_r(0)}{\partial \tau_r}|_{\tau_r=\tau^*=\tau^h}\gtrless 0\Leftrightarrow\frac{\vartheta_r'(1)}{\vartheta_r(1)}\gtrless\frac{1-\frac{\beta}{\tau^h}}{2(\alpha-\beta)}.$$

Finally, we derive τ^h explicitly when $\sigma=1$. By applying $\sigma=1$ into (40), (41), and (42) and substituting (41) and (42) into (40), we can rewrite (40) as

$$(1-\alpha)\left(\tau^h\right)^2-\left(1-\alpha+\beta+\frac{\alpha}{\rho}\right)\tau^h+\beta\left(1+\frac{\alpha}{\rho}\right)=0. \tag{F.7}$$

Solving (F.7) yields the expression for τ^h in the case of the logarithmic utility function.

References

[1] Aghion, P., U. Akcigit., J. Cagé, and W. R. Kerr (2016), Taxation, corruption, and growth. *European Economic Review* 86, 24–51.

[2] Aghion, P., and X. Jaravel (2015), Knowledge spillovers, innovation, and growth. *Economic Journal* 125, 533–573.

[3] Alesina, A. and D. Rodrik (1994), Distributive politics and economic growth. *Quarterly Journal of Economics* 109, 465–490.

[4] Baldwin, R., Forslid, R., Martin, P., Ottaviano, G., and F. Robert-Nicoud (2003), *Economic Geography and Public Policy*. Princeton, NJ: Princeton University Press.

[5] Baldwin, R.E. and P. Krugman (2004), Agglomeration,integration and tax harmonisation. *European Economic Review* 48, 1–23.

[6] Barro, R. J. (1990), Government spending in a simple model of endogenous growth. *Journal of Political Economy* 98, 103–125.

[7] Barro, R. J. and X. Sala-i-Martin (2004), *Economic Growth*, 2nd edition. Cambridge, MA: MIT Press.

[8] Becker, D. and M. Rauscher (2013), Fiscal competition and growth when capital is imperfectly mobile. *Scandinavian Journal of Economics* 115, 211–233.

[9] Benassy, J. P. (1998), Is there always too little research in endogenous growth with expanding product variety? *European Economic Review* 42, 61–69.

[10] Bom, P.R.D., and J.E. Ligthart (2014), What have we learned from three decades of research on the productivity of public capital? *Journal of Economic Surveys* 28, 889–916.

[11] Borck, R., and M. Pflüger (2006), Agglomeration and tax competition. *European Economic Review* 50, 647–668.

[12] Brülhart, M., Jametti, M. and K. Schmidheiny (2012), Do agglomeration economies reduce the sensitivity of firm Location to tax differentials? *Economic Journal* 122, 1069–1093.

[13] Calderón, C., Moral-Benito, E., and L. Servén (2015), Is infrastructure capital productive? A dynamic heterogeneous approach. *Journal of Applied Econometrics* 30, 177–198.

[14] Campbell, J. and G. Mankiw (1989), Consumption, income, and interest rates: Reinterpreting the time series evidence. *NBER Macroeconomics Annual* 4, 185–216.

[15] Chu, A.C. and C.C. Yang (2012), Fiscal centralization versus decentralization: growth and welfare effects of spillovers, leviathan taxation, and capital mobility. *Journal of Urban Economics* 71, 177–188.

[16] Coe, D.T. and E. Helpman (1995), International R&D spillovers. *European Economic Review* 39, 859–887.

[17] Coe, D.T., Helpman, E. and A.W. Hoffmaister (2009), International R&D spillovers and institutions. *European Economic Review* 53, 723–741.

[18] Davis, C. and K. Hashimoto (2018), Corporate tax policy and industry location with fully endogenous productivity growth. *Economic Inquiry* 56, 1135–1148.

[19] Djankov, S., Ganser, T., McLiesh, C., Ramalho, R., and A. Shleifer (2010), The effect of corporate taxes on investment and entrepreneurship. *American Economic Journal: Macroeconomics* 2, 31–64.

[20] Dewit, G., Hynes, K., and D. Leahy (2018), Corporate tax games with cross-border externalities from public infrastructure. *Economic Inquiry* 56, 1047–1063.

[21] Feld, L., and J. Heckemeyer (2011), FDI and Taxation: A Meta- Study. *Journal of Economic Surveys* 25, 233–271.

[22] Futagami, K., Y. Morita, and A. Shibata (1993), Dynamic analysis of an endogenous growth model with public capital. *Scandinavian Journal of Economics* 95, 607–625.

[23] Galí, J., López-Salido, J.D., and J. Vallés (2004), Rule-of-thumb consumers and the design of interest rate rules. *Journal of Money, Credit and Banking* 36, 739–763.

[24] Görg, H., Molana, H., and C. Montagna (2009), "Foreign Direct Investment, Tax Competition and Social Expenditure. *International Review of Economics and Finance* 18, 31–37.

[25] Hatfield, J.W. (2015), Federalism, taxation, and economic growth. *Journal of Urban Economics* 87, 114–125.

[26] Hauptmeier, S., Mittermaier, F., and J. Rincke (2012), Fiscal Competition over Taxes and Public Inputs. *Regional Science and Urban Economics* 42, 407–419.

[27] Hori, T., Maebayashi, N., and K. Morimoto (2022), Tax evasion and optimal corporate income tax rates in a growing economy. *Macroeconomic Dynamics*, published online. https://doi.org/10.1017/S1365100521000638

[28] Hwang, S.H. and Y.J. Kim (2018), Capital mobility in OECD countries: A multi-level factor approach to saving-investment correlations. *Economic Modelling* 69, 150–159.

[29] Iwaisako, T. (2016), Effects of Patent Protection on Optimal Corporate Income and Consumption Taxes in an R&D-Based Growth Model. *Southern Economic Journal* 83, 590–608.

[30] Jones, L.E., Manuelli, R. and P. Rossi (1993), Optimal taxation in models of endogenous growth. *Journal of Political Economy* 98, 1008–1038.

[31] Koethenbuerger, M. and B. Lockwood (2010), Does tax competition really promote growth? *Journal of Economic Dynamics and Control* 34, 191–206.

[32] Lejour, A.M. and H.A. Verbon (1997), Tax competition and redistribution in a two-country endogenous-growth model. *International Tax and Public Finance* 4, 485–497.

[33] Lucas Jr., R.E. (1987), *Models of business cycles (Yrjo Jahnsson Lectures)*. Blackwell Publishers.

[34] Mankiw, G. (2000), The savers-spenders theory of fiscal policy. *American Economic Review* 90, 120–125.

[35] Miyazawa, K., Ogawa, H. and T. Tamai (2019), Capital market integration and fiscal sustainability. *European Economic Review* 120, 103305.

[36] Peretto, P. F. (2003), Fiscal policy and long-run growth in R&D-based models with endogenous market structure. *Journal of Economic Growth* 8, 325–347.

[37] Peretto, P. F. (2007), Corporate taxes, growth and welfare in a Schumpeterian economy. *Journal of Economic Theory* 137, 353–382.

[38] Peretto, P. F. (2011), The growth and welfare effects of deficit-financed dividend tax cuts. *Journal of Money, Credit and Banking* 43, 835–869.

[39] Rauscher, M. (2005), Economic growth and tax-competing leviathans. *International Tax and Public Finance* 12, 457–474.

[40] Romer, P. (1986), Increasing returns and long-run growth. *Journal of Political Economy* 94, 1002–1037.

[41] Rotemberg, J. and M. Woodford (1999), Oligopolistic Pricing and the Effects of Aggregate Demand. *Journal of Political Economy* 100, 1153–1207.

[42] Schnitzer, M. and M. Watzinger (2022), Measuring the Spillovers of Venture Capital. *Review of Economics and Statistics* 104, 276–292.

[43] Suzuki, K. (2021), Corporate tax cuts in a Schumpeterian growth model with an endogenous market structure. *Journal of Public Economic Theory*, published online. https://doi.org/10.1111/jpet.12545

[44] Tamai, T. (2008), A note on dynamic analysis of fiscal competition. *Urban Studies* 45, 651–657.

[45] Tax Foundation (2021), Corporate tax rates around the world 2021. https://taxfoundation.org/publications/corporate-tax-rates-around-the-world/

[46] The Leaders of the G20 (2021), G20 Rome Leaders' Declaration. https://www.consilium.europa.eu/media/52730/g20-leaders-declaration-final.pdf

[47] Wildasin, D.E. (2003), Fiscal competition in space and time. *Journal of Public Economics* 87, 2571–2588.

[48] Wilson, J.D. (1986), A theory of interregional tax competition. *Journal of Urban Economics* 19, 296–315.

[49] Young, A. (1998), Growth without scale effects. *Journal of Political Economy* 106, 41–63.

[50] Zodrow, G.R. and P. Mieszkowski (1986), Pigou, Tiebout, property taxation, and the underprovision of local public goods. *Journal of Urban Economics* 19, 356–370.

Table 1: Baseline Parameter Value

	benchmark	source
α	0.833	markup rate $= 0.2$ (Rotemberg and Woodford 1999)
γ	0.120	$\partial \ln Y / \partial \ln G = 0.1$
τ	0.270	average CIT rate of OECD countries
σ	1.50	Jones et al. (1993)
ρ	0.020	Jones et al. (1993)
ζ	0	The quantitative results are independent of ζ.
L	1	normalization ($L_1 = L_2 = L$)
A	1	normalization
δ	0.2	reference value as a free parameter
η	0.086	growth rate $= 0.02$

Table 2: Degree of spillover (δ) and welfare loss (ψ) of the CIT competition in (43)

δ	0.1	0.2	0.4	0.6	0.8	1.0
ψ	0.026%	0.114%	0.284%	0.443%	0.595%	0.740%

Figure 1: Regional average CIT rate in the world (Source: Corporate tax rates around the world 2021, Tax Foundation)

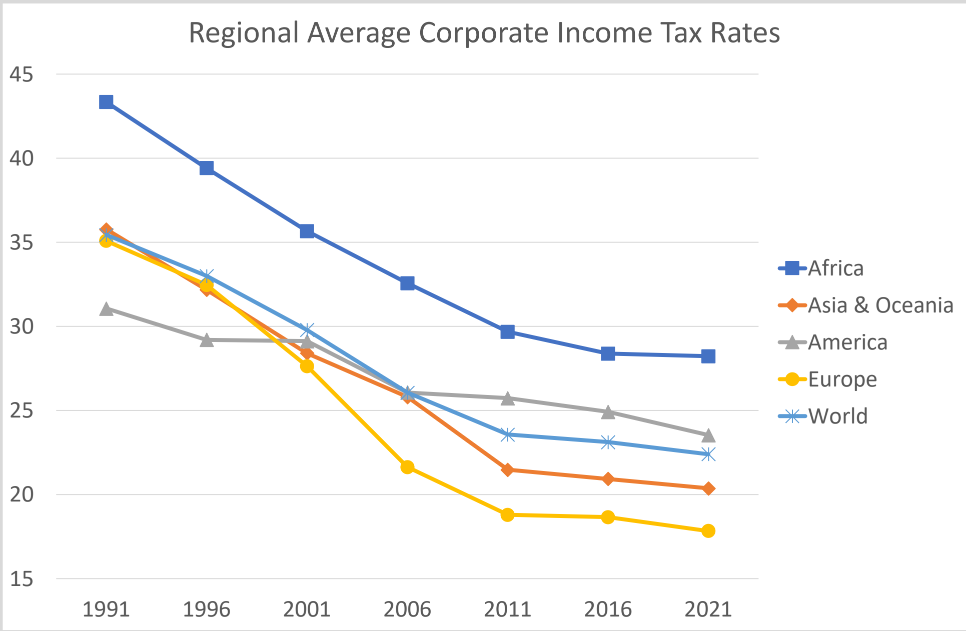

Figure 2: Phase diagram of $(z_1(t), z_2(t))$

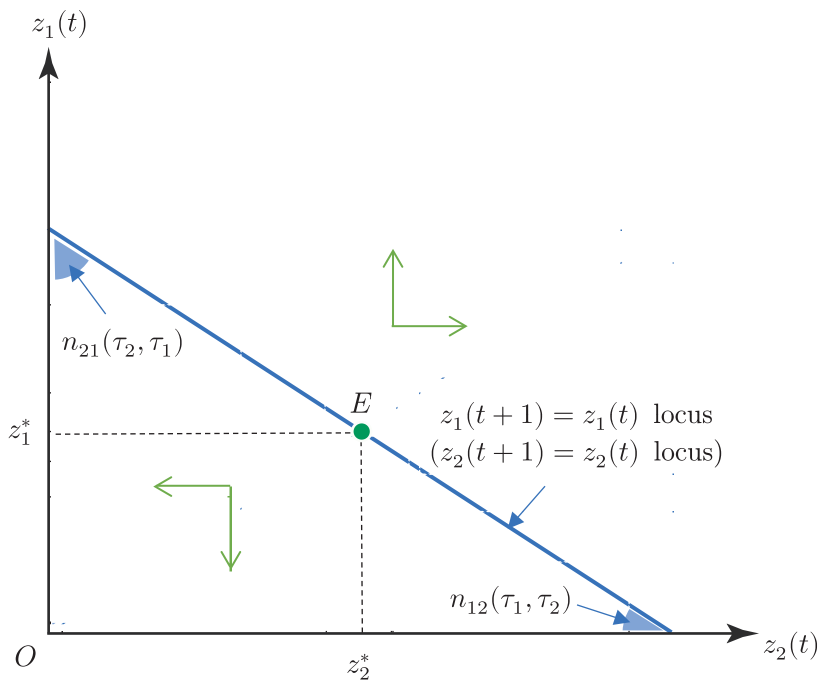

Figure 3: Degree of spillover (δ) and equilibrium CIT rates