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Are Regional Asymmetries Detrimental to Tax Coordination in a Repeated Game Setting?

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Abstract

This paper reexamines the main findings of Cardarelli et al. (2002), and Contenaro and Vidal (2006), who show that regional asymmetries undermine the implicit collusion of tax coordination in a repeated game model of capital tax competition. In particular, this paper investigates how increasing regional differences in the per capita capital endowments and/or production technologies affect the willingness of each region to cooperate in achieving tax coordination. It is shown not only that there may exist cases where tax coordination is facilitated with an increase in regional asymmetries increase and the greater the degree of asymmetry in terms of the net capital exports of the regions, but also that the higher the cooperation of the regions with respect to the sustenance of tax coordination.

JEL classification: H73; H77

Keywords: Tax competition; Asymmetric regions; Cooperation; Repeated game; Tax coordination

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1 Introduction

Tax competition has been extensively investigated in a number of studies. One of the most robust findings in the tax competition literature is that fiscal competition among local governments leads to inefficiently low levels of public service in all jurisdictions. This suggests that tax harmonization can potentially remedy this inefficiency. Regions may coordinate their tax policies to avoid an underprovision of public goods. Several studies – such as Zodrow and Mieszkowski (1986), Wildasin (1989), Bucovetsky (1991), and Wilson (1991) – have examined whether or not there exist Pareto-improving harmonizing reforms of capital income taxes.

These papers provide valuable insights into tax coordination; nevertheless, their models commonly employ a one-shot, static framework, in spite of the obvious fact that interaction among local governments is not with once in the real world. More importantly, it is well recognized that repeated interactions facilitate cooperation and hence, a repeated interactions model would provide a more satisfactory explanation of how fiscal cooperation or tax coordination among local governments can be sustained. In spite of this importance, only a few works have confirmed these motivations. Coates (1993) first deals with the issue of property tax competition in a repeated game setting. He *partially* analyzes the open-loop equilibrium of a dynamic game of property tax competition, ignoring the externalities of the change in the tax rates of one local government on the tax rates of the other governments. Consequently, he focuses only on the intertemporal trade-off between the current and future consumption of private and local public goods, thereby showing that there may be incentives to subsidize capital. By extending Coates' framework to the conventional repeated game – which takes into account the strategic interactions across local governments in current and future periods – Cardarelli et al. (2002) demonstrate that tax coordination can endogenously result from repeated interactions. In addition, they demonstrate that tax coordination dose not prevail when regional asymmetries are too strong. Their study is based on the following assumptions: (1) no production activity occurs; (2) the interest rate is exogenously fixed to zero; and (3) capital mobility sunk costs are incurred when capital is invested abroad. These assumptions render their model unusual in comparison to the standard tax competition model. These

slightly peculiar features of their model do not permit a straightforward comparison of their results with those obtained from the existing literature on tax competition.

Contenaro and Vidal (2006) reexamine the same problem by employing the standard tax competition model with repeated interactions. The only exception is that the objective of the government is the procurement of revenue from capital income taxes rather than the well-being of the citizens. With the introduction of production activity Contenaro and Vidal (2006) demonstrate that tax coordination is not sustainable if the differences in size across regions are sufficiently large in a model that is based on Leviathan governments.

Within the framework of a standard tax competition model with repeated interactions and benevolent governments that maximize the well-being of their citizens, this paper further reexamines the principle findings of Cardarelli et al. (2002) and Contenaro and Vidal (2006), which confirm the existence of a negative correlation between regional asymmetries and the likelihood of cooperation in achieving tax coordination. This framework enables us to directly compare our results with those of earlier works. In this sense, our analysis complements the studies of Cardarelli et al and Contenaro and Vidal.

The most important contribution of this paper is to reveal that the negative relationship have been identified by Cardarelli et al. and Contenaro and Vidal may not prevail in an asymmetric model that is slightly more general. In the literature on tax competition, the degree of asymmetry was measured by various methods. Bucovetsky (1991) and Wilson (1991) employ asymmetry to analyze the difference in the size of the population between regions. Peralta and van Ypersele (2005) construct an enlarged asymmetrical grade by adding the differences in the per capita capital endowment. In light of these analyses, we construct a repeated game version of Peralta and van Ypersele's one-shot asymmetric tax competition model augmented by the asymmetry in production technologies across regions. Regardless of the endowment size, this extension enables the regions to be either a capital exporter or importer. Moreover, we reveal the following: the larger the difference in per capita capital endowments, the easier is the tax coordination; the larger the difference in production technologies, the more difficult is the tax coordination; and the larger the difference in the net exporting position of capital, the more likely the tax coordination across regions it is to occur.

2 The Model

The economy comprises two regions that are asymmetric with respect to their factor endowments and production technologies. For analytical convenience, we assume that both regions have equal populations and we express the per capita capital endowments for regions S (small) and L (large) as $\bar{k}_{\mathsf{S}} \equiv \overline{k} - \varepsilon$ and $\bar{k}_{\mathsf{L}} \equiv \overline{k} + \varepsilon$, respectively, where $\varepsilon \in \left(0, \bar{k}\right]$ and $\bar{k} \equiv (\bar{k}_{\mathsf{S}} + \bar{k}_{\mathsf{L}})/2$ is the *average* capital-labor ratio in the national economy. The capital is perfectly mobile across the regions, while the workers are immobile. These factors are used in the production of a homogenous consumption good. Following Bucovetsky (1991), Haufler (1997), and Peralta and Ypersele (2005), we assume that the constant-returns-to-scale production function in the capital-intensive form is as follows: $f^{\mathsf{i}}(k_{\mathsf{i}}) \equiv (A_{\mathsf{i}} - k_{\mathsf{i}})k_{\mathsf{i}}$, $i = S, L$. Here, A_{i} is the technology parameter of the region-specific production function, and $A_{\mathsf{i}} > 2k_{\mathsf{i}}$, $i = S, L$, is assumed to ensure a positive but diminishing marginal productivity of capital,[1] and k_{i} is the amount of per capita capital invested in region i. Private firms are assumed to maximize profits. Given interest rate r, source-based capital tax rates τ_{i}, and region-specific wage rate w_{i}, the profit-maximizing input choices are characterized by $r = f^{\mathsf{i}}_{\mathsf{k}}(k_{\mathsf{i}}) - \tau_{\mathsf{i}} = A_{\mathsf{i}} - 2k_{\mathsf{i}} - \tau_{\mathsf{i}}$, and $w_{\mathsf{i}} = f^{\mathsf{i}}(k_{\mathsf{i}}) - k_{\mathsf{i}} f^{\mathsf{i}}_{\mathsf{k}}(k_{\mathsf{i}}) = k_{\mathsf{i}}^2$ for $i = S, L$.[2]

The capital market equilibrium for the national economy is achieved when the per capita capital demand in both regions is equal to the exogenously fixed capital stock per capita: $k_{\mathsf{S}}(r + \tau_{\mathsf{S}}) + k_{\mathsf{L}}(r + \tau_{\mathsf{L}}) = \bar{k}_{\mathsf{S}} + \bar{k}_{\mathsf{L}}$. At equilibrium, the interest rate and the per capita capital demanded in each region, respectively, are as follows:

$$r^* = \frac{1}{2}\left[A_{\mathsf{S}} + A_{\mathsf{L}} - (\tau_{\mathsf{S}} + \tau_{\mathsf{L}})\right] - 2\overline{k}, \tag{1}$$

$$k^*_{\mathsf{S}} = \overline{k} + \frac{1}{4}\left[(\tau_{\mathsf{L}} - \tau_{\mathsf{S}}) - (A_{\mathsf{L}} - A_{\mathsf{S}})\right], \tag{2}$$

$$k^*_{\mathsf{L}} = \overline{k} + \frac{1}{4}\left[(\tau_{\mathsf{S}} - \tau_{\mathsf{L}}) + (A_{\mathsf{L}} - A_{\mathsf{S}})\right]. \tag{3}$$

In the remainder of the paper, we assume that $A_{\mathsf{L}} - A_{\mathsf{S}} \equiv \theta \geq 0$.

The inhabitants of each region possess identical preferences and inelastically supply one

[1] In the repeated game presented in Section 3, it is straightforward to verify that the condition, $A_{\mathsf{i}} > 2k_{\mathsf{i}}$, $i = S, L$, ensures the nonnegative levels of capital associated with the Nash, deviation and cooperative phases.

[2] Derivatives are indicated by subscripts, e.g., $f^{\mathsf{i}}_{\mathsf{k}} \equiv \partial f^{\mathsf{i}}(k_{\mathsf{i}})/\partial k_{\mathsf{i}}$.

unit of labor to the regional firms. Moreover, since the individuals also invest their capital endowment in the regional firm that pays the highest after-tax return, all individuals eventually receive a common net return on their capital r^*. They use their incomes to finance the consumption of the private good c_i, and thus the budget constraint of the representative inhabitant of region i is $c_i = w_i^* + r^*\bar{k}_i$. Each government supplies a local public good g_i to its residents by levying a source-based tax on the capital, i.e., $g_i = \tau_i k_i^*$.[3] Accordingly, given other governmental policies, each government chooses τ_i to maximize the following utility function of the representative inhabitant in region i:[4]

$$u_i(c_i, g_i) \equiv c_i + g_i = f^i(k_i^*) - r^*(k_i^* - \bar{k}_i), \ i = S, L. \tag{4}$$

Note that the existence of Nash equilibrium is guaranteed because the payoff functions are concave in τ_S and τ_L. We can obtain the following unique Nash equilibrium tax rates in the one-shot tax competition game:[5]

$$\tau_S^N = \varepsilon - \frac{1}{4}\theta \ \text{ and } \ \tau_L^N = -\left(\varepsilon - \frac{1}{4}\theta\right). \tag{5}$$

Substituting (5) in (1), (2), and (3) yields the following Nash equilibrium interest rate r^N and the per capita capital demand in each region k_i^N, respectively:

$$r^N = \frac{1}{2}(A_S + A_L) - 2\bar{k}, \tag{6}$$

$$k_S^N = \bar{k}_S + \frac{1}{2}\left(\varepsilon - \frac{1}{4}\theta\right), \tag{7}$$

$$k_L^N = \bar{k}_L - \frac{1}{2}\left(\varepsilon - \frac{1}{4}\theta\right). \tag{8}$$

[3] In the subsequent analysis, it is shown that a *negative* coordinated tax rate is possible. In such a case, the objective function $u_i(c_i, g_i) \equiv c_i + g_i$ should be viewed as the *GDP* rather than the utility function since g stands for (negative) lump-sum transfers (e.g., Peralta and van Ypersele, 2005).

[4] Cardarelli et al. (2002) and Peralta and van Ypersele (2005) have also employed a linear utility function. This rather restrictive utility function is nesessary to obtain a closed-form solution for the minimum (threshold) values of the regional discount factors; these discount factors comprise several utility components associated with the different phases of the repeated game, as described in the next section.

[5] It is natural to assume that $\left|\tau_S^N\right| = \left|\varepsilon - \frac{1}{4}\theta\right| < 1$. Nevertheless, for the later analysis, we need to assume that $\left|\tau_S^D\right| < 1$ in (17), which is equivalent to assuming that $\left|\varepsilon - \frac{1}{4}\theta\right| < \frac{12}{17}$.

First, it is instructive to analyze the case where $\theta = 0$. In this case, the small region imports capital with taxation and the large region exports capital with subsidy. This result is attributed to the *pecuniary externality* or the *terms-of-trade* effect, similar to that in DePater and Myers (1994) and Peralta and van Ypersele (2005). However, it should be noted that in the Nash equilibrium, the respective regions attempt to favorably manipulate their terms of trade with respect to capital, thereby exactly cancelling out each other and leaving the interest rate r^{N} unchanged, as in (6).

Adding technological difference $\theta > 0$ may reverse the above relationship between the net exporting position of each region and its tax (or subsidy) policy.[6] In other words, the large (small) region becomes an exporter (importer) of capital if $\varepsilon - (\theta/4) > 0$. Alternatively, if the technology of the large region enables this region to be sufficiently more productive than the small region (i.e., $\varepsilon - (\theta/4) < 0$), then the former turns into an importer. This reversion stems from the fact that the greater capital demand of the large region, caused by its higher marginal product of capital, exceeds its large capital endowment. In sum, it can be expressed as follows:

Proposition 1 *The net position of capital between the two regions depends on the sign of* $\Phi \equiv \varepsilon - (\theta/4)$*; if* $\Phi > (<)\ 0$*, then the large (small) region becomes a capital exporter.*

Substituting (6), (7), and (8) in (4) yields the Nash equilibrium utility levels, i.e., $u_{\mathsf{i}}^{\mathsf{N}}$, as follows:

$$u_{\mathsf{S}}^{\mathsf{N}} = \left[\overline{k} + \frac{1}{2}\left(\varepsilon - \frac{3}{4}\theta\right)\right]\left[\overline{k} - \frac{1}{2}\left(\varepsilon + \frac{1}{4}\theta\right)\right] + r^{\mathsf{N}}\left(\overline{k} - \varepsilon\right), \tag{9}$$

$$u_{\mathsf{L}}^{\mathsf{N}} = \left[\overline{k} - \frac{1}{2}\left(\varepsilon - \frac{3}{4}\theta\right)\right]\left[\overline{k} + \frac{1}{2}\left(\varepsilon + \frac{1}{4}\theta\right)\right] + r^{\mathsf{N}}\left(\overline{k} + \varepsilon\right), \tag{10}$$

which yields the following: $u_{\mathsf{L}}^{\mathsf{N}} - u_{\mathsf{S}}^{\mathsf{N}} = \theta\overline{k} + 2\varepsilon r^{\mathsf{N}} > 0$. This implies that the more abundant the capital endowment of the large region (i.e., a larger ε) and/or the more efficient its production technology (i.e., a larger θ), the higher will be the welfare of the large region; this result holds,

[6] Alternatively, we can assume that $\theta < 0$; in other words, the technology of the small region is more productive than the large region. In this case, since $\varepsilon > 0$, $\varepsilon - (\theta/4) > 0$, the net exporting position of the two regions remains fixed such that the small region is always a capital importer.

regardless of whether the large region is an exporter or importer. In more precise terms, as ε increases, the large region exports more; hence, it receives more transfers from the small region. Conversely, as θ increases, the large region is more productive; hence, its payoff $u_{\mathsf{L}}^{\mathsf{N}}$ increases.

3 A Repeated Game

In this section, we construct a simple repeated tax game with different regional discount factors indexed by $\delta_{\mathsf{i}} \in [0, 1)$. Assume that in every period, each regional government sets its capital tax rate at a certain prescribed value, denoted by $\tau_{\mathsf{i}}^{\mathsf{C}}$, on the condition that the other government has followed it in the previous period. If a region deviates, their cooperation collapses, triggering the punishment phase that results in a Nash equilibrium, which persists forever. The conditions that are required to sustain cooperation in region $i = S,\ L$ are given by

$$\frac{1}{1-\delta_{\mathsf{i}}} u_{\mathsf{i}}^{\mathsf{C}} \geq u_{\mathsf{i}}^{\mathsf{D}} + \frac{\delta_{\mathsf{i}}}{1-\delta_{\mathsf{i}}} u_{\mathsf{i}}^{\mathsf{N}},\ i = S, L, \tag{11}$$

where $u_{\mathsf{i}}^{\mathsf{h}}$ for $h = C, D$, and N represent the utility levels associated with the cooperation, deviation, and punishment (i.e., the Nash equilibrium) phases, respectively. The left-hand side of (11) is the discounted total utility of the inhabitants of the region i, when the fiscal cooperation of both regions that imposes $\tau_{\mathsf{i}}^{\mathsf{C}}$ on capital is infinitely sustained. The right-hand side represents the sum of the current period's utility associated with the best-deviation tax rate $\tau_{\mathsf{i}}^{\mathsf{D}}$ and the total discounted utility of the inhabitants of the region i associated with the Nash equilibrium phase in all subsequent periods.

The prescribed tax rates under implicit tax coordination maximize the utilitarian social welfare function: $V \equiv u_{\mathsf{S}} + u_{\mathsf{L}} = f^{\mathsf{S}}(k_{\mathsf{S}}) + f^{\mathsf{L}}(k_{\mathsf{L}})$. The optimal choices of τ_{S} and τ_{L} yield $\tau_{\mathsf{S}} = \tau_{\mathsf{L}} \equiv \tau^{\mathsf{C}}$ [derived from the first-order condition $f_{\mathsf{k}}^{\mathsf{S}}(k_{\mathsf{S}}) = f_{\mathsf{k}}^{\mathsf{L}}(k_{\mathsf{L}})$]. Although the common tax rate τ^{C} is indeterminate, the capital demands of both regions associated with the cooperative phase are uniquely determined as $k_{\mathsf{S}}^{\mathsf{C}} = \bar{k}_{\mathsf{S}} + \Phi$ and $k_{\mathsf{L}}^{\mathsf{C}} = \bar{k}_{\mathsf{L}} - \Phi$ [obtained by substituting from $\tau_{\mathsf{S}} = \tau_{\mathsf{L}} \equiv \tau^{\mathsf{C}}$ into (2) and (3)]. These unique values in turn determine the

value of the social welfare $V \equiv f^{\mathsf{S}}(k_{\mathsf{S}}^{\mathsf{C}}) + f^{\mathsf{L}}(k_{\mathsf{L}}^{\mathsf{C}})$.[7]

Substituting (1), (2), and (3) in (4) with $\tau_{\mathsf{S}} = \tau_{\mathsf{L}} \equiv \tau^{\mathsf{C}}$, the resulting utility levels of the respective regions, represented as $u_{\mathsf{i}}^{\mathsf{C}}$, are as follows:

$$u_{\mathsf{S}}^{\mathsf{C}} = \left(\overline{k} + \tau^{\mathsf{C}} - \frac{1}{4}\theta\right)\left(\overline{k} - \frac{1}{4}\theta\right) + r^{\mathsf{C}}\left(\overline{k} - \varepsilon\right), \tag{12}$$

$$u_{\mathsf{L}}^{\mathsf{C}} = \left(\overline{k} + \tau^{\mathsf{C}} + \frac{1}{4}\theta\right)\left(\overline{k} + \frac{1}{4}\theta\right) + r^{\mathsf{C}}\left(\overline{k} + \varepsilon\right), \tag{13}$$

where $r^{\mathsf{C}} = [(A_{\mathsf{S}} + A_{\mathsf{L}})/2] - \tau^{\mathsf{C}} - 2\overline{k}$ is the prevailing interest rate in the cooperative phase. Using (9), (10), (12), and (13), the so-called participation constraints for the respective regions, i.e., $u_{\mathsf{i}}^{\mathsf{C}} \geq u_{\mathsf{i}}^{\mathsf{N}}$, $i = S, L$, can be expressed as follows:

$$u_{\mathsf{S}}^{\mathsf{C}} - u_{\mathsf{S}}^{\mathsf{N}} = \tau^{\mathsf{C}}\Phi + \frac{1}{4}\Phi^2 \geq 0, \tag{14}$$

$$u_{\mathsf{L}}^{\mathsf{C}} - u_{\mathsf{L}}^{\mathsf{N}} = -\tau^{\mathsf{C}}\Phi + \frac{1}{4}\Phi^2 \geq 0. \tag{15}$$

Then, it follows from (14) and (15) that the necessary condition to sustain cooperation is:

$$\tau^{\mathsf{C}} \leq \frac{1}{4}|\Phi|. \tag{16}$$

The best-deviation tax rate $\tau_{\mathsf{i}}^{\mathsf{D}}$ maximizes the utility of region i's inhabitants, provided the rival region follows τ^{C}. These tax rates are respectively given as follows:

$$\tau_{\mathsf{S}}^{\mathsf{D}} = \frac{1}{3}\tau^{\mathsf{C}} + \frac{4}{3}\Phi \text{ and } \tau_{\mathsf{L}}^{\mathsf{D}} = \frac{1}{3}\tau^{\mathsf{C}} - \frac{4}{3}\Phi. \tag{17}$$

The associated utility levels $u_{\mathsf{i}}^{\mathsf{D}}$, $i = S, L$, are as follows (see Appendix A):

$$u_{\mathsf{S}}^{\mathsf{D}} = \left[\overline{k} - \frac{1}{2}\left(\theta - \tau^{\mathsf{C}} - 2\varepsilon\right)\right]\left[\overline{k} - \frac{1}{6}\left(\theta - \tau^{\mathsf{C}} + 2\varepsilon\right)\right] + r_{\mathsf{S}}^{\mathsf{D}}\left(\overline{k} - \varepsilon\right), \tag{18}$$

$$u_{\mathsf{L}}^{\mathsf{D}} = \left[\overline{k} + \frac{1}{2}\left(\theta + \tau^{\mathsf{C}} - 2\varepsilon\right)\right]\left[\overline{k} + \frac{1}{6}\left(\theta + \tau^{\mathsf{C}} + 2\varepsilon\right)\right] + r_{\mathsf{L}}^{\mathsf{D}}\left(\overline{k} + \varepsilon\right). \tag{19}$$

[7] This indeterminacy property has also been identified by Peralta and van Ypersele (2005) since they assumed the linear utility functions of residents. In addition, they found that the first-best capital demands of both regions coincide with each other, i.e., $f_{\mathsf{k}}^{\mathsf{S}} = f_{\mathsf{k}}^{\mathsf{L}} \Leftrightarrow k_{\mathsf{S}} = k_{\mathsf{L}}$. However, this feature no longer holds true in our model because we assumed that the two regions had different technologies.

By substituting (9), (10), (12), (13), (18), and (19) in (11) and rearranging, we can introduce the threshold (or minimum) discount factors of the respective region, $\tilde{\delta}_{\mathsf{i}}$, $i = S, L$, as follows:

$$\tilde{\delta}_{\mathsf{S}} \equiv \frac{u_{\mathsf{S}}^{\mathsf{D}} - u_{\mathsf{S}}^{\mathsf{C}}}{u_{\mathsf{S}}^{\mathsf{D}} - u_{\mathsf{S}}^{\mathsf{N}}} = \frac{\left(\tau^{\mathsf{C}} - 2\varepsilon\right)^2 - \left[2\left(\varepsilon - \frac{1}{8}\theta\right) - \tau^{\mathsf{C}}\right]\theta}{\left(\tau^{\mathsf{C}} + 7\varepsilon\right)\left(\tau^{\mathsf{C}} + \varepsilon\right) - \left[\frac{7}{2}\left(\varepsilon - \frac{1}{8}\theta\right) + 2\tau^{\mathsf{C}}\right]\theta}, \tag{20}$$

$$\tilde{\delta}_{\mathsf{L}} \equiv \frac{u_{\mathsf{L}}^{\mathsf{D}} - u_{\mathsf{L}}^{\mathsf{C}}}{u_{\mathsf{L}}^{\mathsf{D}} - u_{\mathsf{L}}^{\mathsf{N}}} = \frac{\left(\tau^{\mathsf{C}} + 2\varepsilon\right)^2 - \left[2\left(\varepsilon - \frac{1}{8}\theta\right) + \tau^{\mathsf{C}}\right]\theta}{\left(\tau^{\mathsf{C}} - 7\varepsilon\right)\left(\tau^{\mathsf{C}} - \varepsilon\right) - \left[\frac{7}{2}\left(\varepsilon - \frac{1}{8}\theta\right) - 2\tau^{\mathsf{C}}\right]\theta}. \tag{21}$$

Only when the actual discount factors of both regions are greater than any of $\tilde{\delta}_{\mathsf{i}}$, $i = S, L$, the first-best tax rate τ^{C} can be sustained as a subgame perfect Nash equilibrium of the repeated game.

We can show that $\tilde{\delta}_{\mathsf{S}}$ ($\tilde{\delta}_{\mathsf{L}}$) is a decreasing (increasing) function of τ^{C} if $\Phi > 0$ and vice versa if $\Phi < 0$, and that $\tilde{\delta}_{\mathsf{S}} = \tilde{\delta}_{\mathsf{L}} = 4/7$ at $\tau^{\mathsf{C}} = 0$ (see Appendix B). Figure 1 shows that $\delta^* = \tilde{\delta}_{\mathsf{L}}$ for $\tau^{\mathsf{C}} \in [0, (\Phi/4)]$, while $\delta^* = \tilde{\delta}_{\mathsf{S}}$ for $\tau^{\mathsf{C}} \in [-(\Phi/4), 0]$ if $\Phi > 0$, where $\delta^* \equiv \max\left[\tilde{\delta}_{\mathsf{S}}, \tilde{\delta}_{\mathsf{L}}\right]$. Figure 2 shows the case in which $\Phi < 0$. Regardless of the sign of Φ, the following two features remain valid: $\delta^* \in [4/7,\ 1]$, and the closer the absolute value of τ^{C} is to zero, the easier the cooperation it is to sustain tax coordination.

These observations lead to the following proposition:

Proposition 2 *The larger (smaller) the absolute value of the first-best capital tax, the more difficult (easier) is the tax coordination. If the large (small) region is a capital exporter (importer), then the large (small) region has a stronger incentive to deviate from the first-best tax rate when this tax rate is positive (negative), and vice versa if the large (small) region is a capital importer (exporter).*

Suppose that $\Phi > 0$, i.e., the large (small) region is a capital exporter (importer). A higher τ^{C} reduces r^{C}, which reduces the utility of the large region $u_{\mathsf{L}}^{\mathsf{C}}$, via a reduction in the capital reward. This strengthens the incentive for deviation. At the same time, the decreased r^{C} reduces $u_{\mathsf{L}}^{\mathsf{D}}$ because the price difference between r^{C} and r^{D} will be smaller, so does the utility gain (i.e., the capital reward) from lowering r^{D}, thereby deterring the deviation. Although these two effects work in opposition, on the whole, the large region's incentive to deviate is

strengthened, implying that $\tilde{\delta}_{\mathsf{L}}$ increases with τ^{C}. On the other hand, the lower r^{C} will raise the utility of the small region importing capital, $u_{\mathsf{S}}^{\mathsf{C}}$, via a rise in the capital reward, whereas it increases $u_{\mathsf{S}}^{\mathsf{D}}$. Overall, the small region's incentive to deviate is discouraged, which implies that $\tilde{\delta}_{\mathsf{S}}$ decreases with τ^{C}. These results are shown in Figure 1.

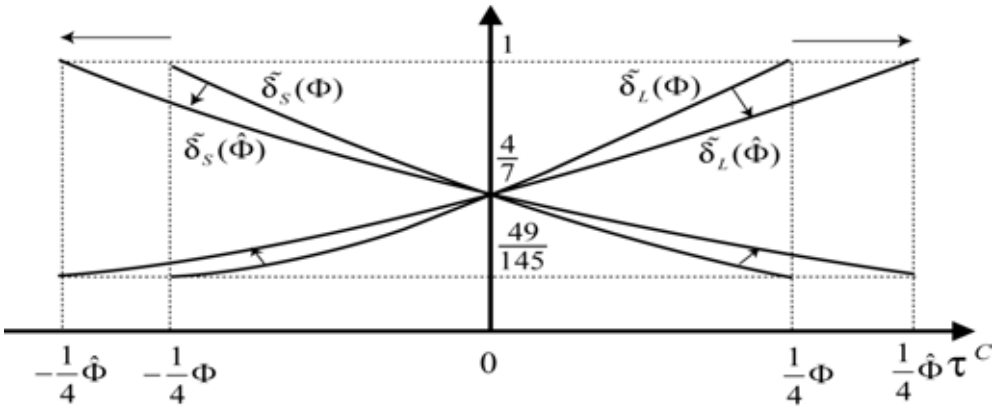

Figure 1. The effects of an increase in ε on $\tilde{\delta}_{\mathsf{i}}$, $i = S, L$, when the large (small) region is an exporter (importer); that is, $\Phi \equiv \varepsilon - (\theta/4) > 0$ and $\hat{\Phi} \equiv \hat{\varepsilon} - (\theta/4) > 0$ with $\hat{\varepsilon} > \varepsilon$

Although both the effects of the changes in τ^{C} are conflicting, the built-in transfer mechanism between the exporting and importing regions (created by the alternations in the remuneration of capital) at the cooperative phase plays a dominant role in the ultimate effect on the incentive of deviation.[8] The same transfer mechanism also operates in the case in which $\Phi < 0$; consequently, when the small (large) region becomes a capital exporter (importer), $\tilde{\delta}_{\mathsf{S}}$ increases with τ^{C} whereas $\tilde{\delta}_{\mathsf{L}}$ decreases with τ^{C}, as shown in Figure 2. In either case, the cooperative tax has no effect on the total welfare; however, its increase does raises the utility of the importing region and depresses that of the exporting region.

Finally, we consider the effects of increasing the degree of asymmetry on each region's incentive of cooperation in terms of either ε or θ. When $\Phi > 0$, the locus of $\tilde{\delta}_{\mathsf{L}}$ ($\tilde{\delta}_{\mathsf{S}}$) turns clockwise (counterclockwise) around the intersection point $(0, 4/7)$ as ε becomes larger (see Appendix C). Figure 1 shows that the locus of δ^* shifts downward with ε over the range of τ^{C}, except in the case where $\tau^{\mathsf{C}} = 0$. Hence, a larger ε tends to widen the feasible range

[8] We are heavily indebted to one of the anonymous referees of this journal for providing this intuition.

of τ^{C}, indicated by (16), thus facilitating tax coordination. When $\Phi < 0$, the loci of $\tilde{\delta}_{\mathsf{S}}$ and $\tilde{\delta}_{\mathsf{L}}$ rotate around the point $(0, 4/7)$ with ε in opposite directions, such that the range of τ^{C} given by (16) is reduced, as illustrated in Figure 2. This, in turn, makes the realization of tax coordination more difficult.

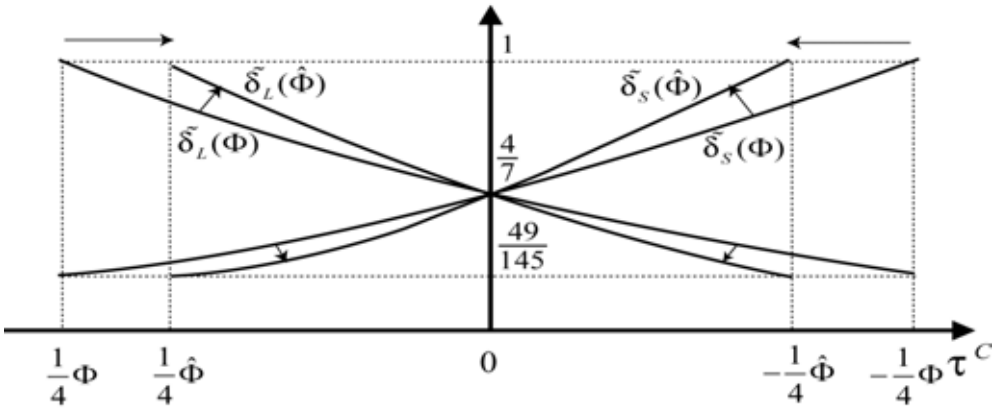

Figure 2. The effects of an increase in ε on $\tilde{\delta}_{\mathsf{i}}$, $i = S, L$, when the small (large) region is an exporter (importer); that is, $\Phi \equiv \varepsilon - (\theta/4) < 0$ and $\hat{\Phi} \equiv \hat{\varepsilon} - (\theta/4) < 0$ with $\hat{\varepsilon} > \varepsilon$

On the other hand, given a certain value of ε, increasing θ tends to narrow the range of τ^{C}, indicated by (16); this is because higher values of θ result in a clockwise (counterclockwise) turn of the locus of $\tilde{\delta}_{\mathsf{S}}$ ($\tilde{\delta}_{\mathsf{L}}$) around the intersection point $(0, 4/7)$. This implies that a larger θ hampers cooperation.[9] Our main results are summarized as follows:

Proposition 3 *If $\Phi > (<)\ 0$ and $\tau^{\mathsf{C}} \neq 0$, increasing ε facilitates (hampers) tax coordination, while increasing θ hampers (facilitates) tax coordination. When $\tau^{\mathsf{C}} = 0$, the willingness to sustaining tax coordination is unaffected by changes in either ε or θ.*

Corollary 1 *The larger the difference in the net position between the capitals in the two regions, the more cooperative are the regions in implementing tax coordination.*

[9] In addition, note also that since the parameters ε and θ affect the key term $\varepsilon - (\theta/4)$ in opposite directions, they work in a precise and parallel manner although the effect of a change in θ is the opposite of that in ε.

Cardarelli et al. (2002) claim that the small region always has a stronger incentive to deviate; this is consistent with the results of Bucovetsky (1991) and Wilson (1991), who show that the small region has stronger incentives to lower tax rates in a static tax competition model. In the model of Cardarelli et al., the coordinated tax rate is set at 100% and the small region importing capital can potentially receive more capital rewards by attracting a larger tax base from the large region than the large region can receive. Therefore, the small region always has a stronger incentive to undercut capital taxes. In our model, due to the abovementioned transfer mechanism, the exporting region does not benefit at the cooperative phase if the tax rate is positive; however, the importing region does not benefit at the cooperative phase if the tax rate is negative. Since our model assumes that the small region can be either a capital exporter or importer, the small region may or may not be the first deviator.

Furthermore, Cardarelli et al. (2002) and Contenaro and Vidal (2006) argue that if the difference in endowments or productivities is sufficiently large, then tax coordination may not be sustainable. Their conclusions appear to contradict those obtained in this study.[10] The reason for this discrepancy can be explained as follows: In the model of Cardarelli et al., the utility gain of the small region from deviation increases with ε because the small region can capture a larger tax base from the large region. Hence, the small region importing capital plays a critical role in sustaining tax coordination. In contrast, in our model, an exporter (importer) of capital will be the first deviator when the tax rate is positive (negative) due to the built-in transfer mechanism. Increasing the difference in endowments further augments the amount of capital exported by the large region. When the coordinated tax rate τ^{C} is positive, the capital remuneration accrued to the large region increases with ε (i.e., the amount of transfers to the exporter decreases); this discourages the large region's incentive to deviate.[11]

In contrast, if the small region is a capital exporter, a higher ε reduces the amount of

[10] This is because Contenaro and Vidal (2006) show that tax coordination is sustained only when the Nash equilibrium tax rate is smaller than the coordinated tax rate. As a result, tax coordination is not sustained if the difference in the regional scale of production between regions is sufficiently large; this is because increasing the difference in the parameters that reflect the scale of production expands the Nash tax rate differential between regions, i.e., the large- (small-) scale region is willing to charge a higher (lower) Nash tax rate.

[11] Since the changes in the parameter ε (or θ) simultaneously affect $u_{\mathsf{i}}^{\mathsf{D}}$ and $u_{\mathsf{i}}^{\mathsf{N}}$ as well as $u_{\mathsf{i}}^{\mathsf{C}}$, $i = S, L$, detailed computation is needed to precisely quantify these effects and thus on $\tilde{\delta}_{\mathsf{i}}$, $i = S, L$. This analysis was conducted in the discussion paper's version of Itaya et al. (2006), which confirms that the transfer effects working at the cooperative phase have a dominant effect on the incentive of deviation.

capital exported by the small region, thus leading to a reduction in the remuneration of capital accrued to the small region (i.e., the amount of transfers to the importer decreases). This negative transfer effect in turn enhances the incentive for the small region to deviate when τ^{C} is positive as illustrated in Figure 2. In sum, as a result of increased trade, the closer the connection between the regions the more likely is the sustenance of tax coordination.

Appendix A

By choosing $\tau_{\mathsf{S}}^{\mathsf{D}}$, when region S deviates from τ^{C} and region L follows τ^{C}, we obtain the following: $r_{\mathsf{S}}^{\mathsf{D}} = (A_{\mathsf{S}} + 2A_{\mathsf{L}})/3 - 2\overline{k} - 2\left(\tau^{\mathsf{C}} + \varepsilon\right)/3$ and $k_{\mathsf{S}}^{\mathsf{D}} = \overline{k} - \left(\theta - \tau^{\mathsf{C}} + 2\varepsilon\right)/6$. These are obtained by substituting $\tau_{\mathsf{S}}^{\mathsf{D}}$ in (17) and τ^{C} in τ_{S} and τ_{L} in (1) and (2). Associated utility level (18) is obtained by substituting $r_{\mathsf{S}}^{\mathsf{D}}$ and $k_{\mathsf{S}}^{\mathsf{D}}$ into (4). Analogously, by choosing $\tau_{\mathsf{L}}^{\mathsf{D}}$, when region L deviates from τ^{C} and region S follows τ^{C}, we obtain the following: $r_{\mathsf{L}}^{\mathsf{D}} = (2A_{\mathsf{S}} + A_{\mathsf{L}})/3 - 2\overline{k} - 2\left(\tau^{\mathsf{C}} - \varepsilon\right)/3$ and $k_{\mathsf{L}}^{\mathsf{D}} = \overline{k} + \left(\theta + \tau^{\mathsf{C}} + 2\varepsilon\right)/6$. Further, substituting $r_{\mathsf{L}}^{\mathsf{D}}$ and $k_{\mathsf{L}}^{\mathsf{D}}$ in (4) yields (19).

Appendix B

To draw the graphs, we express $\tilde{\delta}_{\mathsf{i}}$ as a function of τ^{C}, i.e., $\tilde{\delta}_{\mathsf{i}}(\tau^{\mathsf{C}})$, $i = S, L$. We substitute the upper- and lower-bound values of τ^{C}, given by (16), into (20) and (21) to yield $\tilde{\delta}_{\mathsf{S}}(-\Phi/4) = \tilde{\delta}_{\mathsf{L}}(\Phi/4) = 1$ and $\tilde{\delta}_{\mathsf{L}}(-\Phi/4) = \tilde{\delta}_{\mathsf{S}}(\Phi/4) = 49/145$. In addition, $\tilde{\delta}_{\mathsf{S}}(0) = \tilde{\delta}_{\mathsf{L}}(0) = 4/7$. Differentiating (20) and (21) with respect to τ^{C} yields the following:

$$\frac{\partial\tilde{\delta}_{\mathsf{S}}}{\partial\tau^{\mathsf{C}}} = \frac{6}{\Gamma_{\mathsf{S}}^2}\Phi(\tau^{\mathsf{C}} - 2\Phi)\left(2\tau^{\mathsf{C}} + 5\Phi\right), \tag{B1}$$

$$\frac{\partial\tilde{\delta}_{\mathsf{L}}}{\partial\tau^{\mathsf{C}}} = \frac{6}{\Gamma_{\mathsf{L}}^2}\Phi\left(\tau^{\mathsf{C}} + 2\Phi\right)\left(5\Phi - 2\tau^{\mathsf{C}}\right), \tag{B2}$$

where $\Gamma_{\mathsf{S}} \equiv \left(\tau^{\mathsf{C}} + 7\varepsilon\right)\left(\tau^{\mathsf{C}} + \varepsilon\right) - \left[7\left(\varepsilon - (\theta/8)\right)/2 + 2\tau^{\mathsf{C}}\right]\theta$ and $\Gamma_{\mathsf{L}} \equiv \left(\tau^{\mathsf{C}} - 7\varepsilon\right)\left(\tau^{\mathsf{C}} - \varepsilon\right) - \left[7\left(\varepsilon - (\theta/8)\right)/2 - 2\tau^{\mathsf{C}}\right]\theta$. First, consider the case where $\Phi > 0$. Recalling $\tau^{\mathsf{C}} \leq |\Phi|/4$, the sign of $\partial\tilde{\delta}_{\mathsf{S}}/\partial\tau^{\mathsf{C}}$ in (B1) turns out to be negative. This stems from the fact that the second

bracket of the product $\left(\tau^{\mathsf{C}} - 2\Phi\right)\left(2\tau^{\mathsf{C}} + 5\Phi\right)$ is positive, while the first one is $\tau^{\mathsf{C}} - 2\Phi < \tau^{\mathsf{C}} - (\Phi/4) \leq 0$. Similarly, it follows that in (B2), $\partial\tilde{\delta}_{\mathsf{L}}/\partial\tau^{\mathsf{C}}$ is positive because the first bracket of the product $\left(\tau^{\mathsf{C}} + 2\Phi\right)\left(5\Phi - 2\tau^{\mathsf{C}}\right)$ is positive, while the second one is $5\Phi - 2\tau^{\mathsf{C}} = 2\left[(5\Phi/2) - \tau^{\mathsf{C}}\right] > 2\left[(\Phi/4) - \tau^{\mathsf{C}}\right] \geq 0$.

Analogously, we can prove that when $\Phi < 0$, $\partial\tilde{\delta}_{\mathsf{S}}/\partial\tau^{\mathsf{C}} > 0$ and $\partial\tilde{\delta}_{\mathsf{L}}/\partial\tau^{\mathsf{C}} < 0$ over the range given in (16).

Appendix C

We differentiate respectively the threshold values of the regional discount factors given by (20) and (21) with respect to ε and θ respectively yield:

$$\begin{aligned}
\frac{\partial\tilde{\delta}_{\mathsf{S}}}{\partial\varepsilon} &= \frac{6\tau^{\mathsf{C}}}{\Gamma_{\mathsf{S}}^2}\left(\tau^{\mathsf{C}} + 2\Phi\right)\left(5\Phi - 2\tau^{\mathsf{C}}\right) \text{ and } \frac{\partial\tilde{\delta}_{\mathsf{S}}}{\partial\theta} = \frac{3\tau^{\mathsf{C}}}{2\Gamma_{\mathsf{S}}^2}\left(\tau^{\mathsf{C}} - 2\Phi\right)\left(2\tau^{\mathsf{C}} + 5\Phi\right), \\
\frac{\partial\tilde{\delta}_{\mathsf{L}}}{\partial\varepsilon} &= \frac{6\tau^{\mathsf{C}}}{\Gamma_{\mathsf{L}}^2}\left(\tau^{\mathsf{C}} + 2\Phi\right)\left(2\tau^{\mathsf{C}} - 5\Phi\right) \text{ and } \frac{\partial\tilde{\delta}_{\mathsf{L}}}{\partial\theta} = \frac{3\tau^{\mathsf{C}}}{2\Gamma_{\mathsf{L}}^2}\left(\tau^{\mathsf{C}} + 2\Phi\right)\left(5\Phi - 2\tau^{\mathsf{C}}\right).
\end{aligned}$$

Noting that $\Phi \gtrless 0$, these expressions imply the following:

$$\frac{\partial\tilde{\delta}_{\mathsf{S}}}{\partial\varepsilon} \gtreqless 0, \quad \frac{\partial\tilde{\delta}_{\mathsf{L}}}{\partial\varepsilon} \lesseqgtr 0, \quad \frac{\partial\tilde{\delta}_{\mathsf{S}}}{\partial\theta} \lesseqgtr 0, \quad \frac{\partial\tilde{\delta}_{\mathsf{L}}}{\partial\theta} \gtreqless 0 \text{ if } \tau^{\mathsf{C}} \in \left[0, \frac{1}{4}\Phi\right], \tag{C1}$$

$$\frac{\partial\tilde{\delta}_{\mathsf{S}}}{\partial\varepsilon} \leqslant 0, \quad \frac{\partial\tilde{\delta}_{\mathsf{L}}}{\partial\varepsilon} \geqslant 0, \quad \frac{\partial\tilde{\delta}_{\mathsf{S}}}{\partial\theta} \geqslant 0, \quad \frac{\partial\tilde{\delta}_{\mathsf{L}}}{\partial\theta} \leqslant 0 \text{ if } \tau^{\mathsf{C}} \in \left[-\frac{1}{4}\Phi, 0\right). \tag{C2}$$

References

Bucovetsky, S. (1991) Asymmetric tax competition, *Journal of Urban Economics* **30**, 167-181.

Cardarelli, R., E. Taugourdeau, and J-P. Vidal (2002) A repeated interactions model of tax competition, *Journal of Public Economic Theory* **4**, 19 - 38.

Coates, D. (1993) Property tax competition in a repeated game, *Regional Science and Urban Economics* **23**, 111-119.

Contenaro, M., and J-P. Vidal (2006) Implicit tax co-ordination under repeated policy interactions, *Recherches Economiques de Louvain* 72, 1-17.

DePater, J., and G.M. Myers (1994) Strategic capital tax competition: a pecuniary externality and a corrective device, *Journal of Urban Economics* 36, 66-78.

Haufler, A. (1997) Factor taxation, income distribution, and capital market integration, *Scandinavian Journal of Economics* 99, 425-446.

Itaya, J., Okamura, M., and C. Yamaguchi (2006) Asymmetric Tax Competition in a Repeated Game Setting, *Discussion Paper* 135*, Hokkaido University.*

Peralta, S., and T. van Ypersele (2005) Factor endowments and welfare levels in an asymmetric tax competition game, *Journal of Urban Economics* 57, 258-274.

Wildasin, D. E. (1989) Interjurisdictional capital mobility: Fiscal externality and a corrective subsidy, *Journal of Urban Economics* 25, 193-212.

Wilson, J. D. (1991) Tax competition with interregional differences in factor endowments, *Regional Science and Urban Economics* 21, 423-451.

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.