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Interaction Model of Tax Competition**

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# Role of Spillover in the Repeated Interaction Model of Tax Competition

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## Abstract

This paper generalizes the model of Cardarelli et al. (*Journal of Public Economic Theory*, 2002, 4(1), 19-38) by adding the benefit spillover of local public goods. Traditional public finance literature suggests that a benefit spillover is 'harmful' since it causes the choices of local governments to be inefficient from the viewpoint of society as a whole. This paper, however, shows that the spillovers can act as a beneficial factor in achieving an efficient outcome.

Keywords: repeated tax competition, spillover externality

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# 1 Introduction

The literature on tax competition analyzes the inefficient local tax setting in the presence of source-based taxes on mobile capital. Most of the early studies have examined tax competition in a single-period framework and, have shown that local governments choose inefficiently low levels of public goods<sup>1</sup>.

More recent studies, notably Coates (1993) and Cardarelli, Taugourdeau and Vidal (2002; CTV hereafter), have departed from the traditional single-period framework of tax competition analysis. Coates presents a repeated game model of tax competition with perfectly mobile capital to generate a result that local governments choose negative tax rates in the equilibrium. CTV examine the conditions under which policy coordination can result from the repeated interactions among governments. They show that an efficient outcome would prevail when regional asymmetries on the income and preferences are weak.

The aim of this paper is similar to CTV's, and we follow it in agreeing that local governments are in the game of (infinitely) repeated tax competition. The features that differentiate our model from CTV's analysis is that we add the spatial externality (often called spillover) of local public goods. In the context of regional governments within a country, benefit spillover of public goods is an inevitable phenomenon since jurisdictional boundaries do not coincide with the limits to which the benefit extends. In the international context, taking the development of global environmental issues as a simple example, we find that a correlation among national governments' activities is robust, compared with the past in the world economy. Moreover, political effort to create broad economic unions is another recognition of the importance of international spillovers. Integration such as that of European Union must have promoted the diffusion of benefits originating from each

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<sup>1</sup>There is a large body of research on single-period tax competition. A partial list includes Zodrow and Mieszkowski (1986), Wilson (1986), and Wildasin (1989). See Wilson (1999), Zodrow (2003) and Wildasin and Wilson (2004) for a general review of the tax competition model.

country's public service.

One clear result in the local public finance literature is that when there is a benefit spillover (spatial externality) of local public goods, local governments underestimate the true social benefit and demand too little of the public goods. In this sense, the spatial externality of local public goods is the reason why local governments' choices about taxes tend to be socially inefficient. The classical economic solution to the spillover problem is to force local governments to consider the true social benefits. A simple way to do this is to provide a Pigovian subsidy made by a higher-level government, or to make the government's jurisdiction broad enough to include consumers who enjoy benefits [see, for example, Oates (1972), Boadway and Wildasin (1984), and Fischer (1996)].

This paper addresses the integration of repeated tax competition analysis with spillover externality to reach a somewhat surprising result: The existence of spillover externality works to make local governments choose efficient tax rates within the context of infinitely repeated tax competition. Given the presence of spillover externality with capital mobility, local governments are concerned with the spill-in effects of public goods from surrounding regions. This entails reducing the local government incentive to deviate from an efficient outcome.

This paper is organized as follows. Section 2 introduces the basic model of repeated tax competition developed by CTV. We incorporate a benefit spillover of local public goods into the model. In section 3, we turn to the analysis of one-shot game. In section 4, we derive our main result, i.e., as the degree of benefit spillover increases, local governments are likely to choose an efficient tax rate. Section 5 offers concluding remarks.

## 2 Model

This section develops a simple framework for two regions. Since the analysis is based on a model of repeated tax competition, as formalized by CTV, the

description of the model will be brief. A nation consists of two regions with an infinite time period. Regions and time periods are denoted by subscripts  $i = 1, 2$  and  $t = 0, 1, 2, \dots$ , respectively.

## 2.1 Consumer

In each region, a two period-lived immobile consumer is born every period  $t$ . The utility of a consumer born at period  $t$  in region  $i$  is defined over consumption of a private numeraire good  $c$  and a public good consumption  $G$  at time  $t + 1$ , and is simply given by

$$u_{i,t} = c_{i,t+1} + \gamma_i G_{i,t+1}, \quad (1)$$

where  $\gamma_i > 1$  and  $G_{i,t+1} \equiv g_{i,t+1} + \beta_{ji} g_{j,t+1}$ .  $g_{i,t+1}$  is the provision of public good by local government  $i$ , and  $\beta_{ji} \in (0,1)$  is the degree of benefit spillover from region  $j$  to  $i$ . When  $\beta_{ji} \rightarrow 0$ , there exists no spillover externality, and that our model reduces to that of CTV. If  $\beta_{ji}$  is positive, local public goods provided by region  $j$  yield benefits not only to the local residents of  $j$  but also those of region  $i$  as well.  $\beta_{ji} \rightarrow 1$  corresponds to complete or perfect spillovers. By allowing for interregional spillovers, our model generalizes that of CTV<sup>2</sup>.

The consumer is endowed with  $w_i$  units of the good when young, invests it either at home or abroad, and consumes the after-tax gross return from investment when he/she is old. The consumer transfers all his/her endowments to the second period of life since we assume the consumer derives utility only when he/she is old<sup>3</sup>.

When the consumer born at period  $t$  is young, he/she chooses the allocation of an initial endowment between home,  $s_{i,t}$ , and, investment abroad,  $\sigma_{i,t}$ :

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<sup>2</sup>For further analysis of spillover in the tax competition model, see Wildasin (1991), Bjorvatn and Schjelderup (2002), and Ogawa (2005).

<sup>3</sup>See also Keen and Kotsogiannis (2003) for this type of consumer behavior.

$$w_{i,t} = s_{i,t} + \sigma_{i,t}. \quad (2)$$

Following Persson and Tabellini (1992), Bacchetta and Espinosa (1993), and CTV, we assume there is a net cost from investing abroad which is represented by a strictly convex function,  $\eta(\sigma_{i,t}) = 0.5(\sigma_{i,t})^2/\mu$ , where  $\mu > 0$  is a measure of capital mobility.

The budget constraint for the consumer when he/she is old requires:

$$c_{i,t+1} = (1 - \tau_{i,t+1})s_{i,t} + (1 - \tau_{j,t+1})\sigma_{i,t} - \eta(\sigma_{i,t}), \quad (3)$$

where  $\tau_{i,t+1} \in [0, 1]$  is the tax rate levied by local government  $i$  in period  $t + 1$ . As assumed in CTV, we also assume here that the rate of interest is constant and set equal to zero<sup>4</sup>.

The consumer maximizes (1) with respect to  $s_{i,t}$  and  $\sigma_{i,t}$ , subject to (2) and (3), which yields

$$\sigma_{i,t} = \max\{0, \mu(\tau_{i,t+1} - \tau_{j,t+1})\}. \quad (4)$$

## 2.2 Governments

Local government provides local public goods that yield benefits to its own residents and generate positive spillovers across the region. Private goods can be used as an input to produce local public goods, and units can be chosen so that the public goods provision in region  $i$  at each period  $t$  can be measured in terms of units of private goods. The budget constraint on local government requires that the cost of providing local public goods must be equal to the sum of the revenue from capital tax. Thus, the budget constraint is given by

$$g_{i,t+1} = (s_{i,t} + \sigma_{j,t})\tau_{i,t+1}. \quad (5)$$

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<sup>4</sup>Assuming positive-exogenous interest rates would not modify our results.

By assuming that local governments precommit their tax policies at period  $t + 1$  to the policies announced at period  $t$ , we avoid the time consistency issues.

Now we consider the efficient behavior of local government. Local governments control capital tax rate. CTV assumes each local government maximizes the discounted utility of the residents in the model without spillover externality:

$$V_i = \prod_{t=0}^{\infty} \delta_i^t (c_{i,t+1} + \gamma_i g_{i,t+1}). \quad (6)$$

Then they derive the autarkic social optimum tax rate as  $\tau_{i,t+1} = 1 \forall i$ . We can easily show that the introduction of spillover externality strengthens their result, and that the optimal tax rates still equal 1<sup>5</sup>.

### 3 One-shot game

A one-shot game is formalized as follows. Local governments at period  $t$  are assumed to be myopic in the sense that they only consider the welfare of consumers in their own region born at period  $t$ ,  $u_{i,t} = c_{i,t+1} + \gamma_i (g_{i,t+1} + \beta_{ji,t+1} g_{j,t+1})$ . Then the maximization problem for local government  $i$  in the one-shot game is formulated as

$$\begin{aligned} \max \quad & u_{i,t} = c_{i,t+1} + \gamma_i (g_{i,t+1} + \beta_{ji,t+1} g_{j,t+1}) \\ \text{s.t.} \quad & (2), (3), (4), (5). \end{aligned}$$

After some straightforward manipulations, the reaction function is given by

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<sup>5</sup>To clarify the distinct result, in this paper, we have used a linear utility function. The readers may feel that the optimal tax rate and the degree of spillover are independent of each other. In our model, if we allow non-linear preferences and assume CES type of utility function, we can easily derive the optimal tax rate that is affected by the degree of spillover. Assuming that the social welfare function is given by  $\prod_{i=1}^n \prod_{t=0}^{\infty} \delta_i^t c_{i,t+1} + \gamma_i (g_{i,t+1} + \beta_{ji,t+1} g_{j,t+1})^{\frac{1}{\alpha}}$ , where  $\gamma_i > 1$ ,  $\alpha < 1$ ,  $i \neq j$ , we have the optimal tax rate as  $\tau = [1 + \gamma^{\frac{1}{\alpha-1}} (1 + \beta)^{\frac{\alpha}{\alpha-1}}]^{-1} < 1$ . CTV provides a numerical exercise that shows CES utility function would be chosen without affecting the nature of the main results.

$$\tau_{i,t+1} = \begin{cases} \frac{(\gamma_i-1)w_i + \gamma_i\mu\tau_j(1+\beta_{ji})}{2\mu\gamma_i} & \text{if } \tau_{i,t+1} < \tau_{j,t+1} \\ \frac{(\gamma_i-1)w_i + \mu\tau_j[\gamma_i(1+\beta_{ji})-1]}{\mu(2\gamma_i-1)} & \text{if } \tau_{i,t+1} > \tau_{j,t+1}. \end{cases} \quad (7)$$

The following two assumptions are made in the following analysis:

$$\begin{aligned} \text{A1.} \quad & \frac{w_i(\gamma_i-1)}{\gamma_i(1-\beta_{ji})} \leq \frac{w_j(\gamma_j-1)}{\gamma_j(1-\beta_{ij})} \\ \text{A2.} \quad & w_i < \frac{\gamma_i\mu(1-\beta_{ji})}{\gamma_i-1}, w_j < \frac{\gamma_j\mu(1-\beta_{ij})}{\gamma_j-1}. \end{aligned}$$

A1 is made no loss of any generality, and A2 ensures an interior solution.

Under A1 and A2, we find the following Nash equilibrium tax rates:

$$\tau_i^N = \frac{(2\gamma_j-1)(\gamma_i-1)w_i + \gamma_i(\gamma_j-1)(1+\beta_{ji})w_j}{\gamma_i\mu\{(\gamma_j-1)(1-\beta_{ji}) + \gamma_j[2-\beta_{ij}(1+\beta_{ji})]\}}, \quad (8)$$

$$\tau_j^N = \frac{(\gamma_j-1)[2\gamma_iw_j + (\gamma_i-1)w_i] + (\gamma_i-1)\gamma_jw_i\beta_{ij}}{\gamma_i\mu\{(\gamma_j-1)(1-\beta_{ji}) + \gamma_j[2-\beta_{ij}(1+\beta_{ji})]\}} \geq \tau_i^N. \quad (9)$$

Since it is our intention to analyze the effects of benefit spillovers on the equilibrium, we simply assume that regions are symmetric, except for the degree of spillovers ( $\gamma_i = \gamma_j = \gamma, w_i = w_j = w, \beta_{ji} \neq \beta_{ij}$ ). This implies that A1 and A2 reduce to

$$\begin{aligned} \text{A1'.} \quad & \beta_{ji} \leq \beta_{ij} \\ \text{A2'.} \quad & w < \frac{\gamma\mu(1-\beta_{ji})}{\gamma-1}, w < \frac{\gamma\mu(1-\beta_{ij})}{\gamma-1}. \end{aligned}$$

In this case, the equilibrium tax rates are given by

$$\begin{aligned} \tau_i^N &= \frac{(\gamma-1)(3\gamma-1 + \gamma\beta_{ji})w}{\gamma\mu\{(\gamma-1)(1-\beta_{ji}) + \gamma[2-\beta_{ij}(1+\beta_{ji})]\}} \\ &\leq \tau_j^N = \frac{(\gamma-1)(3\gamma-1 + \gamma\beta_{ij})w}{\gamma\mu\{(\gamma-1)(1-\beta_{ji}) + \gamma[2-\beta_{ij}(1+\beta_{ji})]\}}, \end{aligned} \quad (10)$$

so that capital is driven out from region  $j$  to  $i$  if  $\beta_{ji} < \beta_{ij}$ :



$$\sigma_i = 0, \quad (11)$$

$$\sigma_j = \frac{(\gamma - 1)(\beta_{ij} - \beta_{ji})w}{(\gamma - 1)(1 - \beta_{ji}) + \gamma[2 - \beta_{ij}(1 + \beta_{ji})]}. \quad (12)$$

This result shows that region  $j$ , which receives a relatively high level of benefit spillover from region  $i$  has an incentive to choose a relatively high tax rate,  $\tau_i < \tau_j$ , when  $\beta_{ji} < \beta_{ij}$ . The intuition underlying this result is understood when we consider the behavior of local government  $j$ , which considers that if it drives out capital by choosing a high tax rate, capital escaping from region  $j$  contributes to an increase in the level of local public goods in region  $i$ , so that region  $j$  receives an abundance of beneficial spill-in effects. This implies that the marginal cost of increasing taxes in region  $j$  is less than that in region  $i$ .

Next, the welfare comparison gives us the following result.

**Proposition 1.** Assume symmetric regions, except for the degree of spillovers ( $\gamma_i = \gamma_j = \gamma, w_i = w_j = w, \beta_{ji} < \beta_{ij}$ ). The residents of region  $j$  can be shown to be better off than those of region  $i$ ,  $u_i < u_j$ , in the one-shot equilibrium.

**proof.** The equilibrium values allow us to calculate

$$\begin{aligned} u_j^N - u_i^N &= (\tau_j^N - \tau_i^N)(\gamma - 1)w + \frac{1}{2}\mu(\tau_j^N - \tau_i^N)^2 + \gamma(\beta_{ij}\tau_i^N - \beta_{ji}\tau_j^N)w \\ &\quad + \gamma\mu(\tau_j^N - \tau_i^N)(\beta_{ij}\tau_i^N + \beta_{ji}\tau_j^N) - \gamma\mu(\tau_j^N - \tau_i^N)(\tau_j^N + \tau_i^N) \\ &= \frac{(\gamma - 1)(\beta_{ij} - \beta_{ji})w^2 J}{2\mu H^2}, \end{aligned}$$

where  $H \equiv (\gamma - 1)(1 - \beta_{ji}) + \gamma[2 - \beta_{ij}(1 + \beta_{ji})] > 0$  and  $J \equiv 4(3 - \beta_{ji} - \beta_{ji}\beta_{ij} - \beta_{ij})\gamma^2 - (4 - 5\beta_{ji} + \beta_{ij})\gamma + (\beta_{ij} - \beta_{ji})$ . Since  $\gamma > 1$  and  $0 < \beta_{ji}, \beta_{ij} < 1$ , it is shown that  $J > 0$ , so that  $u_j^N > u_i^N$  as  $\beta_{ij} > \beta_{ji}$ .

## 4 Repeated Tax Competition

In this section, we discuss the traditional infinitely repeated game setting. We now consider the possibility of local governments choosing efficient tax rates,  $\tau_i = 1$ . Assume now that regions are perfectly symmetric ( $\gamma_i = \gamma_j = \gamma$ ,  $w_i = w_j = w$ ,  $\beta_{ji} = \beta_{ij} = \beta$ ), so that A1' and A2' reduce to

$$A3. \quad w < \frac{\gamma\mu(1-\beta)}{\gamma-1}.$$

An efficient outcome is supported through the use of a trigger strategy represented by

$$\begin{aligned} \tau_{i,t+1} &= 1 && \text{if } \tau_{j,t} = 1 \\ &= \tau_i^N && \text{otherwise.} \end{aligned}$$

In the trigger strategy of an infinitely repeated game, each local government chooses a tax rate equal to one in the current period if another local government choose an efficient tax rate in the previous period. If any local government defected in the previous period, then other governments would revert to the single-shot Nash equilibrium forever.

We follow the usual assumption in the infinitely repeated game literature that the game continues for infinite periods,  $t = 0, 1, 2, \dots, \infty$ , and that each local government discounts its future residents' welfare by the discount factor  $0 < \delta_i \leq 1$ . In period  $t$ , each government  $i$  decides to choose either cooperation or defection. As usual,  $\hat{\delta}$  exists as the critical value of  $\delta$  for local governments so that those local governments choose efficient tax rates; for all  $\delta \geq \hat{\delta}$ , local governments choose the efficient tax rate, while for  $\delta < \hat{\delta}$ , an efficient outcome can not be supported.

Since computing the full solution is laborious, we relegate the details to the appendix and summarize the main result as follows.

**Proposition 2.** Under A3,  $\hat{\delta}$  is a monotonous decreasing function of  $\beta$ . That is, as the degree of spillover increases local governments are likely to choose efficient tax rates.

The intuition behind this result is explained as follows. Region  $i$  has an incentive to not provide cooperation since it can promote capital inflow by reducing its tax rate. Region  $i$  recognizes that when it reduces its tax rate, capital flows in, so that reducing tax rates raises revenue for the public good provision in region  $i$ . However, it also accounts for the fact that it can benefit less from the public goods provision in region  $j$  when region  $i$  siphons off region  $j$ 's capital. For region  $i$ , the gain from the defection from cooperation is small when  $\beta_{ji}$  is large. Since the single-period incentive to defect declines as the degree of benefit spillover increases, the critical value of the discount parameter,  $\hat{\delta}_i$ , diminishes as  $\beta_{ji}$  increases.

## 5 Concluding Remarks

The conventional wisdom is that the presence of spillover externality is 'harmful' in the sense that it induces local governments to choose inefficient levels of capital tax. However, we have identified another role of spillover that works in the opposite direction. In this paper, we argue that the increase in spillover actually reduces local government's incentives to not participate in the cooperative outcome, so that local governments are more likely to choose efficient tax rates when the degree of benefit spillovers increases.

The benefit spillover of public goods is an inevitable phenomenon in the context both of regional governments within a country and of national governments within the world economy. Our finding is significant from a policy aspect since it tells us that we need not have an extensive subsidy program implemented by a supra-regional government when we encounter an increase in the benefit spillover of public policies.

Finally, it should be noted that some of our assumptions could be re-

laxed without changing the main result of this paper. Specifically, although our assumption of a linear utility function allows us to derive clear-cut results, some relaxation of this assumption would only change the results in a quantitative sense.

## Appendix

The critical value of  $\delta$  would be obtained by

$$\hat{\delta} = \frac{u_i^D - u_i^C}{u_i^D - u_i^N},$$

where

$$\begin{aligned} u_i^D(\tau_i^D, 1) &= (1 - \tau^D)w + \gamma[(\tau^D + \beta)w + \mu(1 - \tau^D)(\tau^D - \beta)], \\ u_i^N(\tau_i^N, \tau_j^N) &= w[1 - \tau^N + \gamma\tau^N(1 + \beta)], \\ u_i^C(1, 1) &= \gamma w(1 + \beta), \\ \tau_i^D &= \frac{(\gamma - 1)w + \gamma\mu(1 + \beta)}{2\gamma\mu}, \\ \tau^N &= \frac{(\gamma - 1)w}{\gamma\mu(1 - \beta)}. \end{aligned}$$

Solving  $\hat{\delta}$  explicitly, we have

$$\hat{\delta} = \frac{(1 - \beta)[\gamma\mu(1 - \beta) - w(\gamma - 1)]}{(1 - \beta)[\gamma\mu(1 - \beta) - w(\gamma - 1)] + 4w(\gamma - 1 + \gamma\beta)}.$$

Under A3, a straightforward numerical check shows that  $\hat{\delta}$  is a monotonous decreasing function of the degree of benefit spillovers,  $\beta$ ;

$$\frac{\partial \hat{\delta}}{\partial \beta} = -\frac{4w\{[\gamma\mu(1 - \beta) - w(\gamma - 1)](2\gamma - 1) + \gamma\mu(1 - \beta)(\gamma - 1 + \gamma\beta)\}}{\{(1 - \beta)[\gamma\mu(1 - \beta) - w(\gamma - 1)] + 4w(\gamma - 1 + \gamma\beta)\}^2} < 0.$$

Furthermore, we prove here that  $\hat{\delta}$  is in  $[0,1]$ . Denote the resident's utility level in region  $i$  when it deviates (D) and cooperate (C) as  $v_i^D$  and  $v_i^C$ , respectively

$$\begin{aligned}
v_i^D &= u_i^D(\tau_i^D, 1) + \frac{\delta}{1-\delta}u_i^N, \\
v_i^C &= \frac{1}{1-\delta}u_i^C.
\end{aligned}$$

Now we define  $\psi(\delta) \equiv (1-\delta)(v_i^C - v_i^D)$ . Then if we have  $\hat{\delta} \in [0, 1]$  which yields  $\psi(\delta) > 0 \forall \delta \in (\hat{\delta}, 1)$ , regions keep cooperating. We can easily prove that  $\exists \hat{\delta} \in [0, 1]$ , since the following relationship holds:

$$\begin{aligned}
\psi'(\delta) &= u_i^D - u_i^N \\
&= \frac{1 - \tau_i^N}{4} \left[ 2w(\gamma - 1)(1 + \beta) + 4w\gamma\beta + \gamma\mu(1 - \beta)^2(\tau_i^N + 1) \right] > 0, \\
\psi(0) &= u_i^C - u_i^D = -\frac{[\gamma\mu(1 - \beta) - (\gamma - 1)w]^2}{4\gamma\mu} < 0, \\
\psi(1) &= u_i^C - u_i^N = w(1 - \tau_i^N)[(\gamma - 1) + \gamma\beta] > 0.
\end{aligned}$$

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