Doctoral Dissertation

Study on the Optimal Matching Grant Rates in the Models of Tax Competition among Jurisdictional Governments

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Chapter 1 Introduction

1.1. Fiscal Externalities and Benefit Spillovers

This dissertation addresses the relation between the optimal matching grant rates and different kinds of externalities in the models of tax competition among jurisdictional governments.

The problem of the under-provision of local public goods in a tax competition model, in which private capital is mobile among countries, is examined by the literature on public finance. The under-provision of local public goods arises from different kinds of externalities, such as benefit spillovers and fiscal externalities.

Wilson (1986), Zodrow and Mieszkowski (1986), Bjorvatn and Schjelderup (2002) examined the under-provision of public goods in a tax competition model, in which private capital is mobile among countries. The public inputs and tax rate are both inefficiently low resulting from the fiscal externalities among jurisdictions. In these studies, in addition to the benefit spillovers of public goods, as a result of tax competition (race to the bottom), the under-provision of public goods also resulted from fiscal externalities.

In the literature, four types of externalities have been assumed: external effect of consumption, pecuniary externalities, tax externalities, and external effect of public inputs. The external effect of consumption is that local public goods that one jurisdiction provides can raise other jurisdictional inhabitants' utility. Pecuniary externalities occur when actions by jurisdictional governments affect the profit, or pecuniary gains, of a third party but not their ability to produce. Tax externalities mean that if a jurisdictional government finances its local public goods by taxing movable capital among jurisdictions, the inhabitants in other jurisdictions are also affected by the tax rate in that jurisdiction. The external effect of public inputs is that local public inputs that one jurisdiction provides can attract the movable factors of production in other jurisdictions. However, the external effect of production, which can be called the fifth type of externality, has not yet been considered. Therefore, in chapter 2 of this dissertation, the productive externalities (the productive spillover effects) that directly raise other jurisdictions' productivities are also considered, which have not been analyzed in the literature. For example, if roads, which are goods with the characteristics of both public goods and public inputs, are built in one jurisdiction, they can also work for productivity, procuring raw materials, and logistics in other jurisdictions.

In the traditional small-jurisdiction tax competition model, the after-tax return to capital is a parameter for each jurisdiction. However, there are large-jurisdiction models in the literature, including Hauer and Wooton (1999), Kanbur and Keen (1993) and many others. For example, Burbidge and Myers (1994) find that the pecuniary externality and the fiscal externality, which work in opposite directions, can be cancelled out if the capital importer subsidises capital, while the capital exporter taxes capital. Conversely, DePater and Myers (1994) confirm that the capital importer taxes capital while the capital exporter provides a subsidy on capital if a lump-sum tax is available for the jurisdictions. In addition, DePater and Myers (1994) demonstrate that the pecuniary externality among large heterogeneous jurisdictions derived from a change in the capital price, which is affected by distortionary capital taxes, should be moderately internalised by a corrective device. In chapter 4 of this dissertation, we follow DePater and Myers (1994) because the strategy of manipulating the terms of trade is incentive compatible for the jurisdictions.

1.2. The Matching Grant Program

It has been considered that the voluntary provision of public goods and the provision of local public goods with spillovers are insufficient even when using the 'Lindhal mechanism' because of the existence of free-riders and, therefore, that a matching grant from a central government to persons or to local governments for (local) public goods is required to solve the problem.

Both direct and indirect fiscal externalities can be corrected by matching revenue, matching expenditure or equalisation grants devised by the state and federal governments. Matching grants are a very particular policy device and this is relevant in the context of the vast literature. The seminal article by Boadway et al. (1989) shows the relationship between the efficient provision of public goods and an optimal matching grant rate. Roberts (1992) uses the same model and analyses issues including the efficiency of subsidies. Akai and Ihori (2002) replace individuals with local governments and examine the welfare effects of the central government's subsidies for local public goods in a Nash equilibrium model with two types of public goods, local and central. Using a model without tax competition and a model with tax competition separately, Ogawa (2006) analyzed how the optimal matching grant rate depends on the degree of benefit spillovers of public goods, the number of regions, and the private capital demand elasticity with respect to the tax rate.

In the discussion of the spillover effect of local public goods among jurisdictions, the prevailing view is that spillover will aggravate the under-provision of such goods (see e.g. Boadway and Pestieau and Wildasin 1989). However, an alternative opinion on this problem is that the spillover effect of local public goods may alleviate the under-provision of such goods in some situations. Ogawa (2006) argues that the matching grant rate may decrease with spillover effect if the elasticity of capital with respect to the capital tax rate is significant in a tax competition model. Kawachi and Ogawa (2006) find that local governments are more inclined to provide local public goods efficiently given a sufficient spillover effect in a repeated-game model with large homogeneous jurisdictions. Additionally, the role of matching grants as a commitment device has been considered in recent research (see Akai and Sato 2019). Most of the key assumptions of this dissertation correspond with the conventional wisdom presented in the studies above.

1.3. Agency Problems and Capital Tax Competition

Agency problems arise in any environment involving principal-agent relationships. Following the theory of agency, if the principal hopes to ensure that the agent will make decisions that are optimal for the principal rather than the agent themselves, the differing objectives of the pair make agency costs inevitable. This issue not only applies to firm ownership structure, but also to the political agency process. Numerous recent studies have analysed agency problems. Jensen and Meckling (1976) explain that agency costs arise in any environment without cooperation between agent and principal. Besley and Case (1995) demonstrate that the incumbent will improve his welfare by investing less effort, contradicting the objectives of voters. The marginal disutility of effort incurring agency costs can be resolved by the threats to the government's re-election (see, e.g., Seabright 1996). Dahlby (1996) has analysed agency problems for the case of fiscal externalities. Both direct and indirect fiscal externalities can be corrected by matching revenue, matching expenditure or equalisation grants devised by the state and federal governments. Within the vertical fiscal externalities framework, Dahlby and Wilson (2003) show that the jurisdictional government will underprovide or overprovide local public goods depending on the assumptions made. Furthermore, when one considers a model of fiscal federalism featuring both vertical and horizontal fiscal externalities, as Brülhart and Jametti (2019) have observed, tax competition can represent second-best efficient Leviathan taming by constraining the scope for public-sector revenue maximisation.

The literature (see, e.g., Belleflamme and Hindriks 2005; Besley and Case 1995) emphasises agency problems and confirms that agency costs can raise the marginal cost of local public goods provided in jurisdictions. Consequently, jurisdictions will experience an undersupply of local public goods if the marginal benefit of local public funds is unaffected by a given issue. However, few studies deal with agency problems in situations involving horizontal tax externalities. One example of such a study is Nishigaki and Kato (2016), who show that yardstick competition in the small jurisdictions model generates additional costs of financing public goods and increases the seriousness of the under-provision of public goods caused by tax competition. In contrast to their approach, this dissertation finds that tax competition mitigates the under-provision of local public goods if agency costs are large enough. Accordingly, the optimal matching grant rate devised by the federal government should decrease with the intensiveness of tax competition, considering the large agency costs.

In this dissertation, we introduce tax competition and benefit spillovers into the model to generalise the effect of horizontal fiscal externalities and benefit spillovers leading to under-provision of public goods on the agency cost problem.

1.4. Transaction Costs and the heterogeneity of jurisdictions

The costs of moving faced by private capital, which are also referred to as transaction costs (see, for example, Lee 1997), should not be ignored in a tax competition model. When the private capital investor has decided to locate in one jurisdiction and invest in some projects, these projects will usually last for a long period of time. Once the private capital is invested, it is usually quite difficult to abandon the projects and leave the jurisdiction because of the large moving costs. Even if the private capital can move freely among the jurisdictions in the initial stage, imperfect mobility is inevitable in the later stages. Therefore, we must consider both transaction costs and inter-temporal effects in a tax competition model. There are several relevant studies that consider such issues. For example, Lee (1997) considers the imperfect mobility of private capital arising from transaction costs in a two-period tax competition model. He shows that a jurisdictional government will over-provide local public goods in the second period because of transaction costs and that the jurisdictions may choose a lower capital tax rate than that chosen in a one-period tax competition model to increase capital stock in the first period. Furthermore, by introducing a head tax into the model, Ogawa (2000) confirms that the jurisdictional government may subsidise private capital in the first period to increase capital stock in the second period when a lump-sum tax is available to a hyperopic jurisdictional government. This result is compatible with that of the repeated game explained by Coates (1993). There are also some two-period-model constructions that are relevant to our study (for example, King, McAfee and Welling 1993). However, most of the relevant literature analysing the transaction costs and dynamic effects does not clarify the important roles played by the spillover effects of public goods and the heterogeneity of jurisdictions in a repeated-game model. Hence, the focus of this dissertation is to examine these roles.

Furthermore, Ogawa (2007) confirms that, in a tax competition model with large heterogeneous jurisdictions, the jurisdiction with less efficient production technology is likely to increase its capital tax rate to drive out private capital and obtain substantial spill-in effects from the other jurisdiction with more efficient production technology. This means that a distortional capital tax may lead to a more efficient level of local public goods funding. Thus, by introducing spillover effects into our analysis, we verify that the jurisdiction with the less efficient production technology may choose to tax private capital in the first period, assuming that a lump-sum tax is available to it, and receive substantial spillover benefits from the other jurisdiction with more efficient production technology in the second period when the jurisdiction is hyperopic and benevolent, which is quite different from Ogawa (2000). In other words, these constructions are put together to model an interesting phenomenon and not simply to arrive at predetermined results.

1.5. Overview of This Dissertation

In chapter 2, we analyze the optimal matching grant rate for local public spending that has characteristics of both public goods and public inputs. Its spillover effects to other regions are assumed to be regarding consumption and/or production. Contrary to this approach, traditional analyses of matching grants for public spending have only focused on public goods and consumptive spillover. By considering these factors, we obtain some more generalized conclusions and intriguing results; for example, even if private capital is completely immobile, the productive effect of public expenditure lowers the optimal matching grant rate when the production spillover is zero, or smaller than that of consumption, and vice versa.

In chapter 3, we examine the effect of horizontal fiscal externalities on the optimal matching grant rate in a model where agency costs are inevitable. Agency problems arise in any environment involving a principal-agent relationship. Because this chapter takes agency costs into account, the main results should differ from the standard conclusions of the tax competition literature. This chapter finds that the degree of agency costs and benefit spillovers determine the relationship between tax competition and the optimal matching grant rate. If agency costs are relatively small, and benefit spillover is zero, the optimal matching grant rate should increase with the factors of production demand elasticities with respect to the factor tax rate and vice versa. Tax competition thus may ease the inefficiency arising from agency costs only if the disutility of effort is so large that the benefits from tax competition exceed the costs when benefit spillover is zero.

In chapter 4, we introduce the spillover effect of public goods and the heterogeneity of jurisdictions to the capital tax competition literature using a two-period economy. A clear result is that the revision of a corrective device used by the central government in the first period to ensure an optimal level of a local public good is provided by a hyperopic jurisdictional government, significantly depends on the relative size of the income and spill-in effects in the second period. The relative size of the two effects, which work in opposite directions, is determined by the tastes and endowments of the jurisdictions, the form of their production functions and the degree of spillovers, among other factors.

Chapter 2 Productive Effects of Public Spending, Spillover and Optimal Matching Grant Rate[1]

2.1. Introduction

In this chapter, the optimal matching grant rate from the central government for local public spending is analyzed with the characteristics of both public goods and public inputs funded by jurisdictional governments.

A matching grant from central government to persons is a strong instrument to solve the problem of an insufficiently voluntary provision of public goods (see e.g., Boadway et al. 1989). However, that study does not assume tax competition for movable private capital; that is, the reason for the under-provision of public goods is only free-riders arising from the benefit spillovers of public goods[2].

Wilson (1986), Zodrow and Mieszkowski (1986), Bjorvatn and Schjelderup (2002) examined the under-provision of public goods in a tax competition model, in which private capital is mobile among countries. In these studies, in addition to the benefit spillovers of public goods, as a result of tax competition (race to the bottom), the under-provision of public goods also resulted from fiscal externalities.

Zodrow and Mieszkowski (1986) presented a tax competition model in which public expenditure enters a production function as a public input and increases the marginal productivity of capital. The public inputs and tax rate are both inefficiently low

[1] This chapter is based on Ohsawa and Yang (2020).

[2] Other studies that have analyzed the matching grant of the central government to the voluntary provision of public goods funded by persons or jurisdictional governments in a model without fiscal competition are Feldstein(1980), Warr(1982), Drissen(1987), Feldstein(1987), Glazer and Konrad(1996), Andreoni and Bergstrom(1996), Kirchsteinger and Puppe(1997), Roberts (1992), and Akai and Ihori (2002). For example, Feldstein (1980), Drissen (1987), and Feldstein (1987) examined whether tax subsidies are more efficient than direct expenditure on a voluntary activity favored by public policy. In addition, Warr (1982), Glazer and Konrad (1996), Andreoni and Bergstrom (1996), and Kirchsteinger and Puppe (1997) analyzed the effect of increasing a matching grant rate for an act of charity or the voluntary provision of public goods. Roberts (1992) showed the boundary of efficient subsidies. Akai and Ihori (2002) replaced individuals with local governments and examined the welfare effects of central government subsidies for local public goods in a Nash equilibrium model with two types of public goods: local and central.

resulting from the fiscal externalities among jurisdictions. However, Noiset (1995) indicated that the assumption made by Zodrow and Mieszkowski (1986) is meaningless, and the public inputs and tax may be either too high or too low. Matsumoto (1998) showed the relationship between the type of production function and the under-provision of public inputs in a tax competition model[3]. Keen and Marchand (1997) sorted local public expenditure into local public goods and local public inputs, and stated that local public inputs are over-provided relative to local public goods in local public expenditure.

Zodrow and Mieszkowski (1986) and Keen and Marchand (1997) analyzed public goods and public inputs separately as different public expenditure. However, as Keen and Marchand (1997) stated, it may be quite difficult to definitely differentiate local public goods and local public inputs from local public expenditure[4], for example, education, harbors, roads, and clean air. Specifically, roads are necessary for facilitating production (local public inputs), in addition to the enjoyment of leisure for residents in the jurisdiction and other jurisdictions (local public goods)[5].

Using a model without tax competition and a model with tax competition separately, Ogawa (2006) analyzed how the optimal matching grant rate depends on the degree of benefit spillovers of public goods, the number of regions, and the private capital demand elasticity with respect to the tax rate. However, local public inputs were not considered in the two models.

Therefore, in this chapter, we assume that jurisdictional governments provide local public expenditure with the characteristics of both public goods and public inputs; that is, local public goods for which the provision level is a variable in both the residents' utility function and the regional production function, and the spillover effects of which can influence the utility of inhabitants in other regions. First, we analyze the case in which private capital cannot move among jurisdictions. Then, we analyze the case in

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[3] Matsumoto (1998) showed that public inputs are over-provided if they are factor-augmenting public inputs, and under-provided or over-provided if they are firm-augmenting public inputs, but public inputs are under-provided if the number of firms is endogenous, even if they are firm-augmenting public inputs. Furthermore, in a tax competition model, Dhilion, Wooders, and Zissimos (2007) and Bénassy-Quéré, Gobalraja, and Trannoy (2007), and Hindriks and Myles((2013) chapter 20) analyzed the condition in which public inputs are under-provided by jurisdictional governments.

[4] Keen and Marchand (1997) stated: "In practice, of course, many items of public expenditure have both consumption and production effects, as indeed is clear from the examples just given." (p 34 note 3)

[5] Education can be seen as raising productivity, and inhabitants' utility directly and subsequently improves by receiving it. Its spillover effects of consumption and production can also be expected in other regions. Concerning environmental policies, if one region's air becomes cleaner, the air in other regions also becomes cleaner, to some degree, and inhabitants' utility and productivity improve because they become healthier.

which private capital can move freely among jurisdictions. By assuming a good with the characteristics of both public goods and public inputs, we obtain new conclusions that cannot be obtained from the above-mentioned studies in which local public goods and local public inputs were considered separately. For example, even if private capital is assumed to be immovable, the effect of raising productivity as a public input may alleviate the under-provision of public goods because of the external effect of consumption.

Moreover, in this chapter, the productive externalities (the productive spillover effects) that directly raise other jurisdictions' productivities are also considered, which have not been analyzed in the literature. For example, if roads, which are goods with the characteristics of both public goods and public inputs, are built in one jurisdiction, they can also work for productivity, procuring raw materials, and logistics in other jurisdictions. Of course, this effect may be zero in many cases[6].

In the literature, three types of externalities have been assumed: external effect of consumption, tax externality, and external effect of public inputs. The external effect of consumption is that local public goods that one jurisdiction provides can raise other jurisdictional inhabitants' utility. Tax externality means that if a jurisdictional government finances its local public goods by taxing movable capital among jurisdictions, the inhabitants in other jurisdictions are also affected by the tax rate in that jurisdiction. The external effect of public inputs is that local public inputs that one jurisdiction provides can attract the movable factors of production in other jurisdictions. However, the external effect of production, which can be called the fourth type of externality, has not yet been considered.

If we separately assume that the characteristics of public goods or public inputs and benefit spillovers are zero, this model can be regarded as that in Zodrow and Mieszkowski (1986), which introduced a matching grant from central government to jurisdictional governments for local public goods or local public inputs. For example, if jurisdictional governments provide local public expenditure without the characteristics of public goods (for example, both the effect that directly raises the jurisdictional inhabitants' utility and the external effect of consumption are zero) and the external effect of production, this model can be thought of as that in Zodrow and Mieszkowski (1986), which introduced a matching grant from central government to jurisdictional governments for local public inputs. Conversely, if jurisdictional governments provide local public expenditure without the characteristics of public inputs (i.e., both the effect that directly raises jurisdictional production and the external effect of production

[6] Even if we consider that the productive spillovers are irrelevant or we estimate them as zero, many new results can still be obtained in the chapter.

are zero) and the external effect of consumption, this model can be thought of as that in Zodrow and Mieszkowski (1986), which introduced a matching grant from central government to jurisdictional governments for local public goods.

The remainder of this chapter is organized as follows: In Section 2.2, we present the model in the absence of factor mobility, and derive the optimal matching grant rate for local public expenditure with the characteristics of both public goods and public inputs. In Section 2.3, we show the generalized and intriguing results, and discuss the intuition behind them. In Section 2.4, we introduce perfectly mobile private capital among regions, and achieve more generalized results. Finally, in section 2.5, we provide conclusions.

2.2. The Model

In our model, there are n identical jurisdictions, and in each jurisdiction i ($i = 1,2,\dots,n$), there is a single immobile resident, with preferences defined by a strictly quasi-concave utility function $\mathrm{u}(x_i, G_i)$, where x_i is the consumption of a private numeraire good and G_i is the level of a local public good that the resident consumes. The local public good consumption in jurisdiction i is defined as

$$G_i = g_i + \beta \sum_{j \neq i} g_j, \tag{2-1}$$

where g_i is the provision of the local public good by a jurisdictional government i, and $\beta\,(0 \leqq \beta \leqq 1)$ is a parameter that indicates the degree of benefit spillover from consumption.

We also assume that g_i is a public good and/or a public input (public capital), which may have the external effects of production, for example, environmental policies, or policies for the maintenance and improvement of items such as public security, education, and roads[7].

Therefore, we can see that g_i has the effect of directly increasing the utility of its jurisdiction's resident, and/or has the effect of increasing its jurisdiction's productivity. Additionally, g_i may have the effect of increasing the utilities of other jurisdictions' residents and/or have the effect of increasing other jurisdictions' productivity.

We assume that the aggregate production function in jurisdiction i is $f_i(K_i^g)$, where K_i^g is the level of the aggregate amount of local public input (private capital is assumed to be fixed in this and the next section, and therefore suppressed in these sections). We

[7] For the reason why we use the assumption about the good that local governments provide, see section 2.1 in this chapter.

also assume that $0 \leqq f_i'(K_i^g)$ and $f_i''(K_i^g) \leqq 0$ are satisfied[8].

K_i^g is defined as

$$K_i^g = g_i + \gamma \sum_{j \neq i} g_j, \tag{2-1'}$$

where $\gamma (0 \leqq \gamma \leqq 1)$ is a parameter for indicating the degree of benefit spillover from production. Jurisdictional governments impose lump-sum taxes on the resident as the source of revenue for local public good provision (in this and the next section, we assume that private capital is fixed so that we can see that tax is levied on private capital, as in Section 2.4, in which private capital is mobile), and central government imposes lump-sum taxes on the resident as the source of revenue for the matching grant. The resident's budget constraint is given by

$$x_i = f_i(K_i^g) - z_i - h, \tag{2-2}$$

where z_i is the lump-sum tax imposed by jurisdiction i and h is the tax imposed by central government, which is assumed to be identical for all jurisdictions.[9] The budget constraint of jurisdictional government i can be given by

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[8] $\frac{df_i(K_i^g)}{dK_i^g}$ denotes $f_i'(K_i^g)$.

[9] Boadway et al. (1989) and Lee (1995) showed that even if a uniform subsidy rate is assumed for all identical individuals, it may be possible for lump-sum taxes to differ.

However, in reality, at least in developed countries, it must be impossible for a government to impose different lump-sum taxes on identical individuals in a district that it governs because such a tax policy may conflict with the tax principle of "horizontal equity;" therefore, its bill will fail to pass. Regarding "horizontal equity," for example, see Rosen and Gayer (2010).

It is also impossible for a government to impose different lump-sum taxes, even on heterogeneous individuals in a district that it governs because, from the tax principle of equity, there is no reason to impose such discriminatory taxes.

In Japan, for example, there are and will be some types of lump-sum taxes. First, at present, all local governments impose lump-sum taxes on all their taxpayers (prefectures: 1,000 yen, and cities: 3,000 yen per head, in principle). Second, 35 prefectures and Yokohama city impose forest environmental taxes on all their taxpayers (300–1,200 yen per head), which have been uniform lump-sum taxes since 2017. For example, it is 500 yen per head in Hiroshima prefecture and 1,200 yen in Miyagi prefecture, for all taxpayers. In Kanagawa prefecture only, it includes a part that depends on taxpayers' income. Finally, central government will impose the forest environmental tax (1,000 yen per head) from 2024. Local and central governments can change the tax rate, but cannot impose a discriminatory tax rate. The revenue of national and local forest environmental taxes must be used for environmental policies. Therefore, these taxes and policies can be viewed as similar to the lump-sum taxes and local public goods that we analyze in this chapter.

$$z_i + s_i = g_i, \tag{2-3}$$

where s_i is the matching grant that jurisdictional government i receives from central government. Hence, matching grant s_i can be given by

$$s_i = mg_i, \tag{2-4}$$

where m is the rate of the uniform matching grant[10]. Fiscal revenue serves to finance the provision of local public goods with the characteristics of local public input. h in (2-2) should satisfy the central government's budget constraint, which is given by

$$\sum_{i=1}^{n} s_i = nh = \sum_{i=1}^{n} mg_i. \tag{2-5}$$

This model has two stages:

In stage1, central government chooses the national tax h and the matching grant rate m.

In stage 2, the jurisdictional government i chooses the local tax z_i and local public goods g_i, taking h and m as given.

Jurisdictional governments may not be necessarily efficient because they only care about their inhabitants' welfare, and are not interested in the externalities of local public goods, if m and h are not optimal.

Central government cares about all individuals in the country; however, it can neither choose private goods x_i nor g_i directly, but it wants to determine m and h, which leads to an efficient provision of local public goods by jurisdictional governments in non-cooperative equilibrium, according to the Pareto-optimal condition derived below.

Jurisdictional government i wishes to maximize the utility of its resident subject to (2-1), (2-1′), (2-2), (2-3), (2-4), taking the tax rates z_j and the provision of local public goods with the characteristics of local public capital of other jurisdictions as given. Then, the maximization problem is defined as

$$\max_{z_i, g_i} u_i = u_i(G_i, x_i),$$

[10] Boadway et al. (1989) and Ogawa (2006) assumed such local and central lump-sum taxes and the matching grant rate similar to z_i, h and m.

s.t. $G_i = g_i + \beta \sum_{j \neq i} g_j$,

$x_i = f_i(K_i^g) - z_i - h$,

$K_i^g = g_i + \gamma \sum_{j \neq i} g_j$,

$z_i + s_i = g_i$,

$s_i = m g_i$.

We use the substitution method and differentiate u_i with respect to g_i, and the first-order condition can be written as

$$\frac{\partial u_i}{\partial g_i} = \frac{\partial u_i}{\partial G_i} + \frac{\partial u_i}{\partial x_i}\left[f_i'(K_i^g) - (1-m)\right] = 0. \tag{2-6}$$

The Pareto-optimal condition, however, is derived as

$$\max_{x_i, g_i} \sum_{i=1}^{n} u_i \quad (i = 1, 2, \dots, n)$$

s.t. $\sum_{i=1}^{n} x_i + \sum_{i=1}^{n} g_i = \sum_{i=1}^{n} f_i(K_i^g)$.

Let λ denotes the Lagrange multiplier of the constraint above. Then, the Lagrange function is given by

$$L(g_i, x_i) = \sum_{i=1}^{n} u_i + \lambda\left[\sum_{i=1}^{n} x_i + \sum_{i=1}^{n} g_i - \sum_{i=1}^{n} f_i(K_i^g)\right].$$

Differentiating $L(g_i, x_i)$ with respect to g_i and x_i, we obtain

$$\frac{\partial L}{\partial g_i} = \frac{\partial u_i}{\partial G_i} + \beta \sum_{j \neq i} \frac{\partial u_j}{\partial G_j} + \lambda\left[1 - f_i'(K_i^g) - \gamma \sum_{j \neq i} f_j'(K_j^g)\right] = 0,$$

$$\frac{\partial L}{\partial x_i} = \frac{\partial u_i}{\partial x_i} + \lambda = 0,$$

which can be rewritten as

$$\frac{\frac{\partial u_i}{\partial G_i}+\beta\sum_{j\neq i}\frac{\partial u_j}{\partial G_j}}{1-f_i'(K_i^g)-\gamma\sum_{j\neq i}f_j'(K_j^g)}=\frac{\partial u_i}{\partial x_i}. \tag{2-7}$$

We have considered that all jurisdictions are identical. Therefore, (2-7) at the symmetric equilibrium can be rewritten as

$$\frac{1+\beta(n-1)}{1-[1+\gamma(n-1)]\,f'(\,K^g\,)}\frac{\partial u}{\partial G}=\frac{\partial u}{\partial x}, \tag{2-8}$$

where the jurisdiction-specific subscripts i and j are omitted.

A comparison of (2-6) and (2-8) shows that the optimal matching grant rate, which central government should choose, is given by

$$m=\frac{\beta(n-1)}{1+\beta(n-1)}+\frac{(\gamma-\beta)(n-1)}{1+\beta(n-1)}\,f'(\,K^g\,), \tag{2-9}$$

where $f'(\,K^g\,)$ is the marginal productivity of the local public good with the characteristics of local public capital. If (2-9) holds, then the budget constraint of central government $\sum_{i=1}^{n}s_i=nh=\sum_{i=1}^{n}mg_i$ is satisfied, and the goal of central government $\max_{h,m}\sum_{i=1}^{n}u_i=\sum_{i=1}^{n}u_i(G_i,x_i)$ is reached.

From (2-9), it should be noted that if $f'(K^g\,)=0$, the optimal matching grant rate m can be rewritten as $m=\frac{\beta(n-1)}{1+\beta(n-1)}$. In this case, m is the optimal matching grant rate with respect to the normal local public good Ogawa (2006) indicated. Furthermore, when $\beta=1$, m is the same as the optimal matching grant rate Boadway et al. (1989) derived.

(2-9) can be rewritten as

$$m=\frac{\beta(n-1)}{1+\beta(n-1)}[1-f'(K^g\,)]+\frac{\gamma(n-1)}{1+\beta(n-1)}f'(K^g\,). \tag{2-9'}$$

2.3. Results of Comparative Statics

The following results can be obtained in consideration of the preceding analysis.

First, differentiating (2-9), we obtain the relationships between m and β, γ and n:

$$\frac{\partial m}{\partial \beta} = \frac{(n-1)\{1-f'(K^g)[1+\gamma(n-1)]\}}{[1+\beta(n-1)]^2}, \tag{2-10}$$

$$\frac{\partial m}{\partial \gamma} = \frac{(n-1)f'(K^g)}{1+\beta(n-1)}, \tag{2-11}$$

$$\frac{\partial m}{\partial n} = \frac{\beta[1-f'(K^g)]+\gamma f'(K^g)}{[1+\beta(n-1)]^2}. \tag{2-12}$$

$\frac{\partial m}{\partial \gamma} > 0$ can be determined easily. From (2-8), if the rate of marginal substitution between G_i and x_i is positive, then $1 - f'(K^g)[1+\gamma(n-1)] > 0$. Therefore, $\frac{\partial m}{\partial \beta} > 0$ and $\frac{\partial m}{\partial n} > 0$.

Ogawa (2006) showed that $\frac{\partial m}{\partial \beta} > 0$, and $\frac{\partial m}{\partial n} > 0$ in the case where $f'(K^g) = \gamma = 0$. Therefore, we obtain the following results based on the analysis above.

Proposition 2.1 Even if a good is not only a public good but also a public input, its optimal rate of the matching grant increases with the external effect of consumption and production, and with the number of jurisdictions.

Second, (2-9) shows that if the local public good has the characteristics of local public input, then compared with the case without those characteristics, m is higher when $\gamma > \beta$, lower when $\gamma < \beta$, and the same when $\gamma = \beta$.

The results suggest the following. We assumed that the local public good has the characteristics of local public input, so it has a positive effect on regional productivity. Each jurisdictional government has been aware of this point and will spontaneously increase the provision of the local public good. For this reason, the matching grant that jurisdictional governments receive from central government should be reduced, even if we consider the entire social welfare. Furthermore, we can see from $\frac{\beta(n-1)}{1+\beta(n-1)}[1-f'(K^g)]$ in (2-9') that the effect of lowering the optimal rate of the matching grant increases with β.

However, as the characteristics of local public capital also generate the external effect of production, we can see from $\frac{\gamma(n-1)}{1+\beta(n-1)} f'(K^g)$ in (2-9′) that m increases with γ. Hence, we obtain the following result.

Proposition 2.2 Compared with the case without the characteristics of local public input, the optimal matching grant rate with respect to the local public good with the characteristics is higher when the external effect of production is larger than that of consumption, lower when that effect is smaller than that of consumption, and the same when that effect is the same as that of consumption.

(See the column "immobile private capital" in Table 2.1.)

Third, when $\gamma = 0$, we can obtain $\mathrm{m} = \frac{\beta(n-1)}{1+\beta(n-1)}\left[1 - f'(K^g)\right]$ from (2-9′). The increase of regional productivity reduces the distortion of resource allocation caused by the effect of β. Consequently, the optimal matching grant rate with respect to the local public good with the characteristics of local public input is lower than that rate regarding the normal local public good without the characteristics[11]. Furthermore, the higher the marginal productivity of this type of public good $f'(K^g)$, the lower the rate m.

Proposition 2.3 When there is no external effect of production ($\gamma = 0$), the optimal matching grant rate with respect to the local public good with the characteristics of public input is lower than that rate without the characteristics. Additionally, the higher the marginal productivity of such a public good, the lower the optimal rate with respect to the local public good with those characteristics.

If the good that is both a public good and public input raises productivity in the region ($f'(K^g) > 0$), the optimal matching grant rate m should be higher than, lower than, or equal to the rate with respect to the public good without those characteristics when $\gamma > \beta$, $\gamma < \beta$, or $\gamma = \beta$, respectively. This is because the way in which the characteristics of public input that raise productivity affect m is different through γ than through β.

The effect of raising productivity (productive effect) through γ raises m, but the effect through β lowers m. Therefore, whether the effect raises or lowers m depends on whether γ is larger than β or not, or we may say the direction of the productive effect through γ on m is the opposite of that through β.

[11] If $f'(K^g) = 0$, m is the same as Ogawa (2006) obtains.

If the productivity effect is zero ($f'(K^g)=0$), β raises m because the public good raises utilities in other regions directly through β. However, if the productive effect is positive ($f'(K^g) > 0$), then the region recognizes that the public good raises the productivity in the region, and voluntarily provides more public good. Therefore, central government does not need to correct the insufficient provision of public goods via a matching grant to some degree.

However, the effect through γ is different from that through β. If the productive effect is zero, γ does not affect welfare in other regions, and it is meaningless. Thus, the productive effect through γ raises m, provided the productive effect is not zero.

This relationship has not been recognized before now. For example, Zodrow and Mieszkowski (1986) used the Nash equilibrium model to show that a tax on movable capital results in the insufficient provision of a public good and public input. However, they analyzed them separately, that is, not simultaneously. Moreover, they neither assumed β nor γ. Keen and Marchand (1997) analyzed them simultaneously. However, they considered them as separate goods, not as a good that is both a public good and public input.

2.4. Perfectly Mobile Private Capital

Thus far, we have demonstrated the public input in the aggregate production function, but have not explicitly shown private capital. Additionally, private capital was immobile among regions, and therefore, was suppressed. However, we can see models of tax competition among the jurisdictions in many studies, such as Zodrow and Mieszkowski (1986) and Ogawa (2006 sec.3), in which private capital is perfectly mobile among regions, and jurisdictional governments can raise revenue only with a distortional capital tax in their own regions. Therefore, in the present chapter, we now rebuild the model of tax competition in which private capital is also put into production explicitly and is perfectly mobile among regions, and jurisdictional governments can raise revenue, not with a lump-sum tax but rather a distortional capital tax[12].

As before, we assume that there are n identical jurisdictions, and in each jurisdiction i ($i = 1,2,\ldots,n$), there is a single immobile resident and the resident provides labor, $l_i = 1$. The production functions in all jurisdictions are identical, and labor is not shown explicitly in those functions; that is, the production function in region i is simply given by

$$y_i = f_i(k_i^p, K_i^g), \qquad (2\text{-}13)$$

[12] As we noted, the lump-sum tax used before can be seen as a tax on immobile private capital.

where k_i^p is the private capital in region i. There is perfect private capital mobility. In equilibrium, therefore, the after-tax return to capital is equalized across jurisdictions:

$$f_{kp}\left(\mathrm{k}_i^p, K_i^g\right) - t_i = f_{kp}\left(k_j^p, K_j^g\right) - t_j = r \qquad (j \neq i) \tag{2-14}$$

for all i $(i = 1,2, \ldots, n)$, where $f_{kp}\left(k_i^p, K_i^g\right) \equiv \partial f_i\left(k_i^p, K_i^g\right) / \partial k_i^p > 0$, $f_{kpkp} < 0$, t_i is the tax rate per unit of capital in jurisdiction i and r is the after-tax return to private capital in the country.

The total supply of private capital in the country is fixed at $\bar{K}^p$ such that

$$\bar{K}^p = \textstyle\sum_{i=1}^n k_i^p. \tag{2-15}$$

The budget constraint of the resident requires

$$x_i = f_i\left(k_i^p, K_i^g\right) - f_{kp}\left(k_i^p, K_i^g\right)k_i^p + r\bar{k}_i^P - h, \tag{2-16}$$

where $\bar{k}_i^P$ is the initial endowment of private capital in jurisdiction i and h is the lump-sum tax that central government imposed. Substituting (2-14) into (2-16), (2-16) can be rewritten as

$$x_i = f_i\left(k_i^p, K_i^g\right) - t_i k_i^p + r\left(\bar{k}_i^P - k_i^p\right) - h. \tag{2-16'}$$

The jurisdictional government budget constraint is given by

$$t_i k_i^p + s_i = g_i. \tag{2-17}$$

As before, jurisdictional government i receives a matching grant from central government to provide the local public good with the characteristics of local public input. Hence, the following condition holds:

$$s_i = m g_i. \tag{2-18}$$

The lump-sum tax imposed by central government h will be chosen to satisfy that central government's following budget constraint:

$$\textstyle\sum_{i=1}^n s_i = nh = \sum_{i=1}^n m g_i \,. \tag{2-19}$$

Jurisdictional government i aims to maximize the following utility function of its resident by choosing its tax rate t_i:

$$u_i = u\left(\frac{t_i k_i^p + \beta \sum_{j \neq i} t_j k_j^p}{1-m},\ f_i\left(k_i^p,\ \ K_i^g\right) - t_i k_i^p + r(\bar{k}_i^P - k_i^p) - h\right). \tag{2-20}$$

The first-order condition yields

$$\frac{1+E(1-\beta)}{(1-m) - f_{Kg}(k_i^p, K_i^g)\ \ [1+E(1-\gamma)]} \frac{\partial u_i}{\partial G_i} = \frac{\partial u_i}{\partial x_i}{}^{13}, \tag{2-21}$$

where $f_{Kg}\left(k_i^p, K_i^g\right) \equiv \partial f_i\left(k_i^p, K_i^g\right) /\ \partial K_i^g$ and E is the private capital demand elasticity with respect to the tax rate in jurisdiction i, that is, $E \equiv \left(\frac{\mathrm{d}k_i^p}{\mathrm{d}t_i}\right)\left(\frac{t_i}{k_i^p}\right)$ $\forall i$ (see Appendix 2.1 for derivations)[14].

Because in this model, the good that jurisdictional governments provide is same as Zodrow and Mieszkowski's (1986) type of public input, if $\beta = \gamma = \frac{\partial u_i}{\partial G_i} = 0,$ the capital tax not only drives out private capital but also attracts it through the characteristics of input (tax revenue is used to produce the public good with the characteristics, which raises the marginal productivity in the jurisdiction and attracts private capital)[15]. However, as γ rises, the latter effect is weakened because the marginal productivity of other jurisdictions rises. Ultimately, if $\gamma = 1,$ the effect vanishes. Therefore, E can be positive or negative. Moreover, we assume that $\frac{\partial E}{\partial \gamma} < 0,$ and that if $\gamma = 1,$ E is a negative fixed value, whether the public good has the characteristics of public input or not[16].

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[13] Bjorvatn and Schjelderup (2002) shows showed that there is no incentive for tax competition, if $\beta = 1$, without the characteristics of input or the productive spillover. In this case, the tax competition distortion is eliminated, if $\beta = \gamma = 1$, or if $\beta = 1$ and $f_{Kg} = 0$.

[14] Note that E is not an absolute value but an ordinary value because E can be positive or negative, while commonly, elasticity is expressed by an absolute value.

[15] Zodrow and Mieszkowski (1986) excluded the possibility of the over-provision of public input, that is, the possibility that t_i will raise k_i^p, as a result of their "stable"conditions. However, Noiset (1995) indicated that the assumption made by them does not have the meaning, and the tax and the public input may be either too high or too low. Matsumoto (1998) showed the relationship between the type of production function and the under-provision. See footnote 2.

[16] We may easily understand this if E is defined as $E \equiv \varepsilon + (1-\gamma)e$ concretely, where

If private capital is fixed, we have $E = 0$ in (2-21) and it is the same as (2-6).

(2-21) can be compared with the Pareto-optimal condition (2-8), and the optimal rate of the matching grant is given by[17]

$$m = \frac{1}{1+\beta(n-1)}\left\{\beta(n-1) - E(1-\beta) + nf_{Kg}\left(\frac{n-1}{n} + E\right)(\gamma - \beta)\right\}. \tag{2-22}$$

If $f_{Kg} = 0$, (2-22) is the same as the form that Ogawa (2006) derived, where private capital is perfectly mobile among regions. Additionally, if $E = 0$, (2-22) is the same form as (2-9). Note that from (2-8), if the rate of marginal substitution between G_i and x_i is positive, then $1 - f'(K^g)[1 + \gamma(n-1)] > 0$.

Now, we can derive the following proposition from (2-22) directly.

Proposition 2.4 Whether m_f (the optimal matching grant rate with respect to the local public good with the characteristics of the local public input) is higher than m_0 (the rate in the case without the characteristics) or not is shown in Table 2.1.

For example, m_f is lower than m_0, when $E > \frac{1-n}{n}$ and $\gamma < \beta$, or when $E < \frac{1-n}{n}$ and $\gamma > \beta$, but m_f is higher than m_0, when $\gamma = 1$ and $E > \frac{1-n}{n}$, unless $\beta = 1$ (because when $\gamma = 1$, the tax effect of attracting private capital vanishes).

Proposition 2.5 Even if private capital is perfectly mobile among regions, when $E > (1-n)/n$, we still can derive Proposition 2.3. However, we cannot do so if $E \leqq (1-n)/n$.
(See the rows "$0 \leq \gamma < \beta = 1$", "$0 \leq \gamma < \beta < 1$", and "$0 = \gamma = \beta$ in Table 2.1.)

$\varepsilon(<0) \equiv \left(\frac{\partial k_i^p}{\partial t_i}\right)\left(\frac{t_i}{k_i^p}\right)_{K_i^g = const.}$ and $e(>0) \equiv \left(\frac{\partial k_i^p}{\partial g_i}\right)\left(\frac{g_i}{k_i^p}\right)\left(\frac{\partial g_i}{\partial t_i}\right) \forall i$. Therefore, ε is the private capital demand elasticity with respect to the tax rate, when public inputs are fixed, and e is the private capital demand elasticity with respect to the tax rate through the characteristics of public input, when $\gamma = 0$ $(K_i^g = g_i)$.

[17] When $\beta = \gamma = 0$, $m = -E$. Therefore, if $\frac{dK_i^P}{dt_i} < 0$, then $m > 0$. The condition $\frac{dK_i^P}{dt_i} < 0$ is the same as the "stable condition" in Zodrow and Mieszkowski (1986). They explain this as follows: "We also assume the model is stable in the sense that each jurisdiction perceives that raising taxes will drive out capital … otherwise, taxes would always be raised"(Zodrow and Mieszkowski (1986) p. 363). Noiset (1995) indicated that, under that assumption, there is an under-provision of public input. In such a case, central government will lead each jurisdiction to increase its public input, which means $m > 0$.

Moreover, using (2-22), we obtain the relationships of m with β, γ, E, and n, where we assume that if we change β and n, then E will not change with them, that is, E is constant. We have the following relationship between m and β:

$$\frac{\partial m}{\partial \beta} = \frac{n\left[\frac{n-1}{n}+E\right]}{[1+\beta(n-1)]^2}\{1 - f_{Kg}[1+\gamma(n-1)]\}. \tag{2-23}$$

From (2-8), we have $1 - f_{Kg}[1+\gamma(n-1)] > 0$. Therefore, a sufficient condition for $\frac{\partial m}{\partial \beta} > 0$ is $E > 0$,[18]. Additionally, the necessary and sufficient condition for $\frac{\partial m}{\partial \beta} > 0$ is $E > \frac{1-n}{n}$ (i.e., $-E < \frac{n-1}{n}$). This condition is the same as that in Ogawa (2006), if $E < 0$ (for example, if $e=0$ or $\gamma = 1$)[19].

Furthermore, we can derive the relationship between m and γ as follows:

$$\frac{\partial m}{\partial \gamma} = \frac{1}{1+\beta(n-1)}\left\{nf_{Kg}\left[\frac{n-1}{n} + E + (\gamma-\beta)\ \frac{\partial E}{\partial \gamma}\right] - (1-\beta)\frac{\partial E}{\partial \gamma}\right\}. \tag{2-24}$$

Therefore, if $\frac{\partial m}{\partial \beta} > 0$ and $\beta \geqq \gamma$, or $E > \frac{1-n}{n}$ and $\beta \geqq \gamma$, then $\frac{\partial m}{\partial \gamma} > 0$ because $\frac{\partial E}{\partial \gamma} < 0$.

We also have the relationship between m and n as follows:

$$\frac{\partial m}{\partial n} = \frac{\{1+E(1-\beta)\}\cdot[\beta(1-f_{Kg})+\gamma f_{Kg}]}{[1+\beta(n-1)]^2}, \tag{2-25}$$

where $1 - f_{Kg} > 0$ because $f_{Kg} < 1$ to satisfy the positive denominator on the left-hand side of (2-8). Hence, the numerator on the right-hand side of (2-25) is positive, when $E > \frac{1}{\beta-1}$ or when $\beta = 1$, unless $\beta = \gamma = 0$. For $1 > \forall\beta \geqq 0$, $\frac{1}{\beta-1} \leqq -1$. Therefore, the sufficient condition for $\frac{\partial m}{\partial n} > 0$ is $E > -1$[20]. We can derive the following proposition from the above.

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[18] In Ogawa (2006), E is necessarily negative, whereas in this model, it may be positive or negative because jurisdictional governments provide the good, which may have the characteristics of the public input.

[19] Strictly speaking, Ogawa(2006) argues that if $-E > \frac{n-1}{n}$, then m is not a monotonous function of β.

[20] This result is the same as that in Ogawa (2006), if $E < 0$ (for example, if $e = 0$ or $\gamma = 1$).

Proposition 2.6 If private capital is perfectly mobile among regions, the optimal matching grant rate m should increase with the external effect of consumption β, as long as the private capital demand elasticity with respect to the tax rate E is positive, or larger than $(1-n)/n$. However, when $E<(1-n)/n$, m should decrease with β. If $E>(1-n)/n$ and $\beta \geqq \gamma$, then m increases with the external effect of production γ. Additionally, m should increase with n when $E>1/(\beta-1)$, or when $E>-1$, unless $\beta=\gamma=0$. When $\beta=\gamma=0$, n has no effect on m.

The proposition above is shown in Tables 2.2, 2.3, and 2.4.

Next, we derive the relationship between m and E. Differentiating m with respect to E, we obtain

$$\frac{\partial m}{\partial E}=\frac{n(\gamma-\beta)f_{Kg}-(1-\beta)}{1+\beta(n-1)} \leq 0, \tag{2-26}$$

where $\frac{\partial m}{\partial E}=0$ only if $\gamma=\beta=1$; that is, the benefit spillovers on the external effect of production and consumption are perfect and equivalent (see Appendix 2.2 for derivations). This case indicates the following result: as the degree of spillovers increases, the jurisdictional government takes more of the external effect into account (see Ogawa [2006]). For $\gamma=\beta=1$, there are perfect spillovers and there is no tax competition at all (see Bjorvatn and Schjelderup [2002]). Hence, E has no effect on m.

One may think that it is not appropriate to differentiate m with respect to E because E is assumed to be an endogenous variable. However, even if we use the assumption $E \equiv \varepsilon+e(1-\gamma)$, as in note 16, and differentiate m with respect to $\varepsilon, e,$ or $(1-\gamma)e$, the results can be obtained easily and are the same as E; that is, $\frac{\partial m}{\partial \varepsilon} \leq 0$, $\frac{\partial m}{\partial e} \leq 0$, and $\frac{\partial m}{\partial e(1-\gamma)} \leq 0$.

Proposition 2.7 The optimal matching grant rate m should decrease as the private capital demand elasticity with respect to the tax rate E (or ε, e, $(1-\gamma)e$). However, E has no effect on m only if the benefit spillovers on the external effect of production and consumption are perfect and equivalent; that is, $\gamma=\beta=1$.

The above proposition is shown in Table 2.5.

2.5. Conclusions

In this chapter, we analyzed the relationship between the optimal matching grant rate m, the local public expenditure with the characteristics of public goods and public inputs, and the degree of spillovers: β and γ. In the literature, thus far, public goods or public inputs have only been analyzed separately. Thus, by considering the characteristics, β and γ, we obtained some intriguing results. For example, whether the effect of public inputs on the optimal matching rate for the expenditure is positive or negative depends on whether γ is larger than β: if $\gamma \gtreqless \beta$, then $m_f \gtreqless m_0$, where m_f is the optimal matching grant rate with respect to the public goods with the characteristics of public inputs and m_0 is the rate with respect to the public good without the characteristics. We also obtained some more generalized conclusions[21]. These are shown in Propositions 2.1–2.7 and Tables 2.1–2.5. Even if the production spillover is estimated to be zero, most of the results remain valid.

Finally, we should more specifically present the implication of policies from the above results. As the characteristics of their inputs and their productive spillover effect have not been considered until now, if we consider those, the matching grant rate for public goods, such as environmental policies, should be lower, and the rate for public goods, such as education or canals, should be higher.

[21] For example, if the public goods lack the characteristics of public inputs and the external effect of production, the results are the same as those in Ogawa (2006), irrespective of whether private capital is perfectly mobile among regions.

Chapter 3 Effect of Agency Costs on the Optimal Matching Grant Rate in a Model of Tax Competition with Benefit Spillovers[22]

3.1. Introduction

Agency problems arise in any environment involving principal-agent relationships. Following the theory of agency, if the principal hopes to ensure that the agent will make decisions that are optimal for the principal rather than the agent themselves, the differing objectives of the pair make agency costs inevitable. This issue not only applies to firm ownership structure, but also to the political agency process. Numerous recent studies have analysed agency problems. Jensen and Meckling (1976) explain that agency costs arise in any environment without cooperation between agent and principal. Besley and Case (1995) demonstrate that the incumbent will improve his welfare by investing less effort, contradicting the objectives of voters. The marginal disutility of effort incurring agency costs can be resolved by the threats to the government's re-election (see, e.g., Seabright 1996). Belleflamme and Hindriks (2005) observe that yardstick competition between jurisdictions exerts both discipline and sorting effects within the political agency framework. Voters can mitigate agency costs below the Leviathan level by adopting a successful voting strategy (as noted by Wrede 2001).

Dahlby (1996) has analysed agency problems for the case of fiscal externalities. Both direct and indirect fiscal externalities can be corrected by matching revenue, matching expenditure or equalisation grants devised by the state and federal governments. Within the vertical fiscal externalities framework, Dahlby and Wilson (2003) show that the jurisdictional government will underprovide or overprovide local public goods depending on the assumptions made. Furthermore, when one considers a model of fiscal federalism featuring both vertical and horizontal fiscal externalities, as Brülhart and Jametti (2019) have observed, tax competition can represent second-best efficient Leviathan taming by constraining the scope for public-sector revenue maximisation. Following Zodrow and Mieszkowski (1986), local public goods provided by local governments are underprovided through interregional property tax competition. Therefore, if lump-sum tax cannot be operated by the local government, the

[22] This chapter is based on Yang (2020).

under-provision of local public goods financed by the distortionary tax is inevitable in a standard model of tax competition. To solve this issue, it is often argued that an intergovernmental matching grant devised by the federal government can be introduced to ease the exorbitant marginal cost of local public funds deriving from the downward pressure on tax rates, assuming that the federal government is benevolent and omniscient (see, e.g., Dahlby 1996).

In the discussion of the spillover effect of local public goods among jurisdictions, the prevailing view is that spillover will aggravate the under-provision of such goods (see e.g. Boadway and Pestieau and Wildasin 1989). However, an alternative opinion on this problem is that the spillover effect of local public goods may alleviate the under-provision of such goods in some situations. Ogawa (2006) argues that the matching grant rate may decrease with spillover effect if the elasticity of capital with respect to the capital tax rate is significant in a tax competition model. Kawachi and Ogawa (2006) find that local governments are more inclined to provide local public goods efficiently given a sufficient spillover effect in a repeated-game model with large homogeneous jurisdictions.

The literature (see, e.g., Belleflamme and Hindriks 2005; Besley and Case 1995) emphasises agency problems and confirms that agency costs can raise the marginal cost of local public goods provided in jurisdictions. Consequently, jurisdictions will experience an undersupply of local public goods if the marginal benefit of local public funds is unaffected by a given issue. However, few studies deal with agency problems in situations involving horizontal tax externalities. One example of such a study is Nishigaki and Kato (2016), who show that yardstick competition in the small jurisdictions model generates additional costs of financing public goods and increases the seriousness of the under-provision of public goods caused by tax competition. In contrast to their approach, this chapter finds that tax competition mitigates the under-provision of local public goods if agency costs are large enough. Accordingly, the optimal matching grant rate devised by the federal government should decrease with the intensiveness of tax competition, considering the large agency costs.

In this chapter, we introduce tax competition and benefit spillovers into the model to generalise the effect of horizontal fiscal externalities and benefit spillovers leading to under-provision of public goods on the agency cost problem.

This chapter is organised as follows. The inefficiency of the agency cost problem in a closed economy with consumption spillover effect among jurisdictions is set out in section 3.2. We introduce tax competition into the model in section 3.3 to generalise the effect of horizontal fiscal externalities leading to under-provision of public goods on the agency cost problem. Finally, Section 3.4 draws conclusions.

3.2. The Model

In this section, we start with the case where private capital is not mobile. There are n identical local jurisdictions, where each jurisdiction i $(i = 1,2,\ldots,n)$ has a single immobile resident, and preferences are defined by a strictly quasi-concave utility function $\mathrm{u}(x_i, G_i)$, where x_i is the consumption of a private numeraire good and G_i is the local public good. The local public good consumption in jurisdiction i is defined by

$$G_i = g_i + \beta \sum_{j \neq i} g_j, \tag{3-1}$$

where g_i is the provision of the local public good by the jurisdictional government i, and β $(0 \leqq \beta \leqq 1)$ indicates the degree of benefit spillover. We assume that the jurisdictional governments are partly self-interested. Therefore, the welfare function of jurisdictional government i is written by $W_i = V_i[X_i(g_i)] + U_i(G_i, x_i)$, where $V_i[X_i(g_i)]$ are the agency costs, with $V_i[X_i(g_i)] > 0$, $V_i'[X_i(g_i)] < 0$, $V_i''[X_i(g_i)] < 0$. Additionally, $X_i(g_i)$ denotes the variation in effort, which reflects differences in incumbent types, with $X_i(g_i) > 0$, $X_i'(g_i) > 0$, $X_i''(g_i) > 0$[23]. Although the jurisdictional governments desire more excess rents, they must consider the utility of residents in their jurisdictions to ensure their own re-election and access to rents. However, the central government is assumed to be benevolent. For simplicity, we assume that the aggregate output is exogenous in each jurisdiction, and can be expressed by y_i. The jurisdictional governments impose lump-sum taxes on the resident to fund local public good provision, and the central government imposes lump-sum taxes on the resident to fund the matching grant. The budget constraint of the resident is given by

$$x_i = y_i - z_i - h, \tag{3-2}$$

where z_i is the lump-sum tax imposed by jurisdiction i and h is the tax imposed by central government, which is assumed to be identical for all jurisdictions. The budget constraint of the government of jurisdiction i can be given by

$$z_i + s_i = g_i, \tag{3-3}$$

where s_i is the matching grant the government of jurisdiction i receives from the central government. Hence, the matching grant s_i can be given by

$$s_i = mg_i, \tag{3-4}$$

[23] Note that agency costs decrease in $V'X'$ as $V'X' < 0$.

where m is the rate of the uniform matching grant. We assume a uniform matching grant rate because the jurisdictions are homogeneous at the symmetric equilibrium[24]. Fiscal revenue finances the provision of local public goods. In (3-2) h should satisfy the central government's budget constraint, which is given by

$$\sum_{i=1}^{n} s_i = nh = \sum_{i=1}^{n} mg_i. \tag{3-5}$$

This model involves two stages:

In stage 1, the central government chooses national tax rate h and matching grant rate m.

In stage 2, the jurisdictional government i chooses local tax rate z_i and local public good g_i, taking h and m as given.

The central government cares about all individuals in the country, and wants to set m and h so as to realise efficient provision of local public goods by jurisdictional governments in a non-cooperative equilibrium, according to the Pareto-optimal condition derived below.

The jurisdictional government i wishes to maximise the objective function W_i subject to (3-1), (3-2), (3-3), (3-4), taking the tax rates z_j and the provision of local public goods of other jurisdictions g_j as given. The maximisation problem is then defined as

$$\max_{g_i, z_i} W_i = V_i[X_i(g_i)] + U_i(G_i, x_i) \tag{3-6}$$

$$\text{s.t. } x_i = y_i - z_i - h$$

$$z_i + s_i = g_i$$

$$s_i = mg_i$$

$$G_i = g_i + \beta \sum_{j \neq i} g_j.$$

We use the substitution method and differentiate W_i with respect to g_i, and the first-order condition can be written as[25]

$$\frac{\partial W_i}{\partial g_i} = V_i' X_i' + \frac{\partial U_i}{\partial G_i} - (1-m)\frac{\partial U_i}{\partial x_i} = 0. \tag{3-7}$$

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[24] See Boadway et al (1989) and Ogawa(2006).

[25] The second-order condition is assumed to be satisfied according to the objective function.

We have considered all jurisdictions to be identical. That is, $V_i'X_i' = V_j'X_j'$, $\frac{\partial U_i}{\partial G_i} = \frac{\partial U_j}{\partial G_j}$ and $\frac{\partial U_i}{\partial x_i} = \frac{\partial U_j}{\partial x_j}$. Therefore, (3-7) at the symmetric equilibrium can be rewritten as

$$V'X' + \frac{\partial U}{\partial G} - (1-m)\frac{\partial U}{\partial x} = 0, \tag{3-8}$$

where the jurisdiction-specific subscripts i and j are omitted.

The Pareto-optimal condition, however, is derived by

$$\max_{x_i, g_i} \sum_{i=1}^{n} U_i \quad (i = 1, 2, \dots, n),$$

$$\text{s.t. } \sum_{i=1}^{n} x_i + \sum_{i=1}^{n} g_i = \sum_{i=1}^{n} y_i,$$

Let λ denotes the Lagrange multiplier of the constraint above. Then, the Lagrange function is given by

$$L(g_i, x_i) = \sum_{i=1}^{n} u_i + \lambda\left[\sum_{i=1}^{n} x_i + \sum_{i=1}^{n} g_i - \sum_{i=1}^{n} f_i(K_i^g)\right].$$

Differentiating $L(g_i, x_i)$ with respect to g_i and x_i gives us

$$\frac{\partial L}{\partial g_i} = \frac{\partial U_i}{\partial G_i} + \beta \sum_{j \neq i} \frac{\partial U_j}{\partial G_j} + \lambda = 0,$$

$$\frac{\partial L}{\partial x_i} = \frac{\partial U_i}{\partial x_i} + \lambda = 0,$$

which can be rewritten as

$$\frac{\partial U_i}{\partial G_i} + \beta \sum_{j \neq i} \frac{\partial U_j}{\partial G_j} = \frac{\partial U_i}{\partial x_i}. \tag{3-9}$$

We have considered all jurisdictions to be identical. Therefore, (3-9) at the symmetric equilibrium can be rewritten as

$$[1 + \beta(n-1)]\frac{\partial U}{\partial G} = \frac{\partial U}{\partial x}, \tag{3-10}$$

where the jurisdiction-specific subscripts i and j are omitted.

Comparison of (3-8) and (3-10) shows the optimal matching grant rate which the central government should choose is given by[26]

$$\mathrm{m} = \frac{\beta(n-1)}{1+\beta(n-1)} - \frac{V'X'}{U_x}. \tag{3-11}$$

Recalling that $V' < 0$, $X' > 0$, we know from (3-11) that the optimal matching grant rate increases with agency costs ($\partial m/\partial V'X' < 0$). Besides benefit spillovers, note that agency costs may also aggravate the under-provision of local public goods in the absence of tax competition among local jurisdictions[27]. This finding corresponds with conclusions from the literature (e.g., see Belleflamme and Hindriks 2005; Besley and Case 1995). Notably, this result is an extension of Boadway et al. (1989) and Ogawa (2006) with reference to a particular case.

3.3. The Introduction of Tax Competition

Thus far, we have shown the inefficiency of the agency cost problem in a closed economy with consumption spillover effect among jurisdictions. However, in practice, private capital is movable among jurisdictions and jurisdictional governments can raise revenue only or partly via distortional capital taxes within their own jurisdictions[28]. Therefore, in the present study, we now rebuild the model of tax competition in which private capital is put into production and is perfectly mobile

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[26] Equation (3-11) can be easily derived by substituting (3-10) into (3-8).

[27] One might argue that an incentive contract using yardstick evaluation may realise the efficient provision of local public goods in full information equilibrium. Furthermore, Nishigaki, Nishimoto and Yasugi et al. (2016) also provide a preliminary empirical test that supports these results. However, these cases are explicitly neglected in the analysis.

[28] See Zodrow and Mieszkowski (1986), Ogawa (2006), Kikuchi and Tamai (2019).

among jurisdictions, and jurisdictional governments raise revenue not with a lump-sum tax but rather a distortional capital tax[29].

As before, we assume n identical jurisdictions, where each jurisdiction i $(i = 1,2,\dots,n)$ has a single immobile resident providing the labour, $l_i = 1$. The production functions in all jurisdictions are identical, and the labor is not shown explicitly in those functions. That is, the production function in jurisdiction i is simply given by

$$y_i = f_i(k_i^p), \tag{3-12}$$

where k_i^p is the private capital in jurisdiction i. Private capital has perfect mobility. Therefore, in equilibrium the after-tax return to capital is equalised across jurisdictions

$$f_{kp}(k_i^p) - t_i = f_{kp}(k_j^p) - t_j = r \qquad (j \neq i) \tag{3-13}$$

for all i $(i = 1,2,\dots,n)$, where $f_{kp}(\mathrm{k}_i^p) \equiv \partial f_i(k_i^p)/\partial k_i^p > 0$, $f_{kpkp} < 0$, t_i is the tax rate per unit of capital in jurisdiction i and r is the after tax return to private capital in the country.

The total supply of private capital in the country is fixed at $\bar{K}^p$ such that

$$\bar{K}^p = \sum_{i=1}^{n} k_i^p. \tag{3-14}$$

The budget constraint of the resident is as follows

$$x_i = f_i(k_i^p) - f_{kp}(k_i^p)k_i^p + r\bar{k}_i^P - h, \tag{3-15}$$

where $\bar{k}_i^P$ is the initial endowment of private capital in jurisdiction i and h is the lump-sum tax imposed by the central government. Substituting (3-13) into (3-15), (3-15) can be rewritten as

$$x_i = f_i(k_i^p) - t_i k_i^p + r(\bar{k}_i^P - k_i^p) - h. \tag{3-15'}$$

The jurisdictional government budget constraint is given by

$$t_i k_i^p + s_i = g_i. \tag{3-16}$$

[29] This is similar to Ogawa (2006). However, agency costs have not been considered in a model of tax competition with benefit spillovers.

As before, the jurisdictional government i receives a matching grant from the central government to provide the local public good. Hence, the following condition holds

$$s_i = mg_i. \tag{3-17}$$

The lump-sum tax imposed by the central government h will be set to satisfy the budget constraint of the central government, as follows[30]

$$\sum_{i=1}^{n} s_i = nh = \sum_{i=1}^{n} mg_i. \tag{3-18}$$

This model involves two stages:

In stage 1, the central government chooses the national tax h and the matching grant rate m.

In stage 2, the jurisdictional government i chooses the local tax t_i and the local public good g_i, taking h and m as given.

The jurisdictional government i wishes to maximise the objective function W_i subject to (3-13), (3-14), (3-15), (3-16), and (3-17), taking the tax rates t_j and the provision of local public goods of other jurisdictions g_j as given. Then, the maximisation problem is defined as

$$\max_{g_i,t_i} W_i = V_i[X_i(g_i)] + U_i(G_i, x_i), \tag{3-19}$$

$$\text{s.t. } f_{kp}(\mathrm{k}_i^p) - t_i = f_{kp}(\mathrm{k}_j^p) - t_j = r, \qquad (j \neq i)$$

$$x_i = f_i(k_i^p) - f_{kp}(k_i^p)\mathrm{k}_i^p + r\bar{k}_i^p - h,$$

$$t_i k_i^p + s_i = g_i,$$

$$s_i = mg_i,$$

$$\bar{K}^p = \sum_{i=1}^{n} k_i^p.$$

The first-order condition gives[31]

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[30] We assume that the central government's budget constraint must satisfy the hard budget constraint. Thus, the matching grants from central government are only funded by the lump-sum tax.

[31] The second-order condition is assumed to be satisfied according to the objective function.

$$\frac{\partial W_i}{\partial t_i} = \frac{1}{1-m} V_i' X_i' \left(k_i^p + t_i \frac{\partial k_i^p}{\partial t_i} \right) + \left\{ \begin{array}{c} \frac{1}{1-m} \left(k_i^p + t_i \frac{\partial k_i^p}{\partial t_i} + \beta \sum_{i \neq j} t_j \frac{\partial k_j^p}{\partial t_i} \right) \frac{\partial U_i}{\partial G_i} + \\ \left[-k_i^p + (\bar{k}_i^P - k_i^p) \frac{\partial r}{\partial t_i} \right] \frac{\partial U_i}{\partial x_i} \end{array} \right\} = 0. \tag{3-20}$$

We have considered all jurisdictions to be identical. Therefore, (3-20) at the symmetric equilibrium can be rewritten as

$$V'X'(1-\varepsilon) + \frac{\partial W}{\partial U} \left\{ [1 - \varepsilon(1-\beta)] \frac{\partial U}{\partial G} - (1-m) \frac{\partial U}{\partial x} \right\} = 0, \tag{3-21}$$

where ε is the private capital demand elasticity with respect to the tax rate in jurisdiction i, that is, $\varepsilon \equiv -\left(\frac{dk_i^p}{dt_i} \right) \left(\frac{t_i}{k_i^p} \right) \forall i$.

As for comparison of (3-8) and (3-10), comparison of (3-21) and (3-10) shows the optimal matching grant rate that the central government should choose is given by

$$\mathrm{m} = \frac{\beta(n-1) + \varepsilon(1-\beta)}{1+\beta(n-1)} - \frac{V'X'(1-\varepsilon)}{U_x}. \tag{3-22}$$

We assume that we are on the left side of the Laffer curve, that is, $1-\varepsilon > 0$. Recalling once again that $V' < 0$, $X' > 0$, we know from (3-22) that the optimal matching grant rate increases with agency costs even given horizontal fiscal externalities among jurisdictions ($\partial m / \partial V'X' < 0$). Notably, this result is an extension of Ogawa (2006) with reference to a particular case.

Next, we derive the relationship between m and ε. Differentiating m with respect to ε, we obtain

$$\frac{\partial m}{\partial \varepsilon} = \frac{1-\beta}{1+\beta(n-1)} + \frac{V'X'}{U_x}. \tag{3-23}$$

To study the effects of tax competition and benefit spillovers on the optimal matching grant rate, we present the following basic rationale: Generally, the larger the factors of production demand elasticities with respect to the factor tax rates are, the more intense tax competition becomes. The marginal cost of public funds is widely considered to be larger for local jurisdictions facing a situation of tax competition and benefit spillovers. Therefore, jurisdictional governments are inclined to provide fewer local public goods under such a situation. Consequently, agency costs will decrease because $V_i'[X_i(g_i)] < 0$ and $X_i'(g_i) > 0$. However, the welfare of residents will be decreased owing to less provision of local public goods. This means that the utilitarian form of welfare considering agency costs in each jurisdiction significantly depends on the two effects working in the opposite direction[32]. For example, if agency costs and benefit spillovers are small[33], the decrease of agency costs is smaller than the decrease of the welfare of residents. The net effect is that the utilitarian form of welfare considering agency costs in each jurisdiction is decreased. Restated, the inefficiency of each jurisdiction is increased. For that reason, the matching grant rate from the central government should be increased to eliminate the inefficiency resulting from tax competition and benefit spillovers. Conversely, if agency costs are large enough, the decrease of those agency costs exceeds the decrease in the welfare of residents. The net effect is an increase in the utilitarian form of welfare considering agency costs in each jurisdiction. The inefficiency of each jurisdiction thus is mitigated. Accordingly, the matching grant rate from the central government should be decreased.

Assuming agency costs are inevitable[34], we obtain the following proposition:

Proposition 3.1: We assume that $1 - \varepsilon > 0$. The following results can be obtained.

(1) If agency costs are relatively small, that is, $1 + \frac{V'X'}{U_x} > 0$, and $\beta = 0$, the optimal matching grant rate should increase with the private capital demand elasticities with respect to the capital tax.

(2) If agency costs are relatively small, that is, $1 + \frac{V'X'}{U_x} > 0$, and $\beta = 1$, the optimal matching grant rate should decrease with the private capital demand elasticities with respect to the capital tax.

(3) If agency costs are relatively small, that is, $1 + \frac{V'X'}{U_x} > 0$, and $0 < \beta < 1$, the relationship between the optimal matching grant rate and the private capital demand elasticities with respect to the capital tax is ambiguous.

(4) If $\frac{V'X'}{U_x} = -1$ and $\beta = 0$, no relation exists between the optimal matching grant rate and the private capital demand elasticities with respect to the capital tax.

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[32] Under information asymmetry, economic competition among jurisdictional governments also has both positive and negative effects on the underinvestment in jurisdictional infrastructure within a complex decentralized system (see Gorbachuk, Dunaievskyi and Suleimanov 2019).

[33] Bjorvatn and Schjelderup (2002) shows that there is no incentive for tax competition, if $\beta = 1$. In this case, the tax competition distortion is eliminated.

[34] Where no agency costs exist in the jurisdictions, the results will be in accordance with the existing literature.

(5) If $\frac{V'X'}{U_x} = -1$ and $\beta > 0$, the optimal matching grant rate should decrease with the private capital demand elasticities with respect to the capital tax. This is especially so if $\frac{V'X'}{U_x} = -1$ and $\beta = 1$, $\frac{\partial m}{\partial \varepsilon} = -1$.

(6) If agency costs are sufficiently large, that is, $1 + \frac{V'X'}{U_x} < 0$, the optimal matching grant rate should decrease with the private capital demand elasticities with respect to the capital tax, independent of benefit spillovers.

The above proposition is shown in TABLE 3.1.

Note that horizontal fiscal externalities originating from tax competition and benefit spillovers result in under-provision of local public goods (inefficiency). However, these externalities also can ease the under-provision of local public goods resulting from agency costs (inefficiency correction). These two effects simultaneously work in opposite directions. If agency costs are small and benefit spillover is zero, the former effect exceeds the latter one, meaning horizontal fiscal externalities aggravate the under-provision of local public goods. Conversely, when agency costs are small and benefit spillovers are perfect, or when agency costs are large enough, the latter effect exceeds the former one, which means horizontal fiscal externalities may ease the under-provision of local public goods. In particular, when agency costs are small and benefit spillovers are imperfect, the magnitude of the two effects will be ambiguous. Additionally, when $\frac{V'X'}{U_x} = -1$ and benefit spillover is zero, the two effects cancel each other out, which means horizontal fiscal externalities cannot affect the provision of local public goods.

3.4. Conclusions

This chapter has focused on the effect of horizontal fiscal externalities on the optimal matching grant rate in a model where agency costs are inevitable. When benefit spillover is zero, the relationship between the optimal matching grant rate and private capital demand elasticities with respect to capital tax depends on agency costs. This means that the inefficiency arising from agency costs may be eased by tax competition only if the disutility of effort is so large that the benefits resulting from tax competition exceed its costs when benefit spillover is zero. However, if benefit spillovers occur among jurisdictions, the results will be ambiguous.

Note that the analysis abstracts from dynamic aspects. The ratchet effect is frequently introduced in a two-period setting where timing and commitment of policies (including capital taxes imposed by sub-central governments and matching grants from central government) matter and should also be addressed in future research.

Evidently agency costs (the disutility of effort) in providing local public goods should be set to equal the marginal increase in the probability of re-election multiplied by the value of being re-elected[35]. By ignoring the problems associated with re-election, we obtain some succinct results in our paper. Therefore, the robustness of the results should be further tested by introducing incumbent politicians into the model. In particular, we choose a simple form of social welfare function to formulate the maximisation problem. Therefore, employing a more general form of objective function and considering re-election may provide intriguing insights, an avenue that is left to future research. In addition, our model also needs the verification of empirical analysis in the future research.

Finally, we should more concretely present the policy implications of the above results. Agency costs may aggravate the under-provision of local public goods when no tax competition exists among local jurisdictions. Therefore, the matching grant rate from central government to local governments with relatively large agency costs should be relatively high. Although the matching grant rate increases with agency costs even given horizontal fiscal externalities and benefit spillovers among jurisdictions, the horizontal fiscal externalities among jurisdictions decrease the seriousness of the under-provision of public goods caused by agency costs if agency costs in the political agency process are sufficiently large. Accordingly, the matching grant rate from central government to local governments with relatively large agency costs, *ceteris paribus*, should be appropriately reduced.

[35] See Seabright (1996).

Chapter 4 A Corrective Device for Large Heterogeneous Jurisdictions in a Two-Period Economy with Spillover Effects[36]

4.1. Introduction

This chapter reconsiders the provision of a local public good by a jurisdictional government in a two-period economy with spillover effects when the jurisdictional government is assumed to be hyperopic or farsighted. The corrective device used by the central government to ensure the optimal level of the local public good is provided by the jurisdictional government should be adjusted accordingly.

The literature analysing capital tax competition is relevant to this study (see, for example, Zodrow and Mieszkowski 1986; DePater and Myers 1994). The basic idea of Zodrow and Mieszkowski (1986) is that perfect mobility of private capital among small homogeneous jurisdictions results in under-provision of a local public good, which is financed by a distortionary property tax because a lump-sum tax is unavailable. However, DePater and Myers (1994) demonstrate that the pecuniary externality among large heterogeneous jurisdictions derived from a change in the capital price, which is affected by distortionary capital taxes, should be moderately internalised by a corrective device. In the traditional small-jurisdiction tax competition model, the after-tax return to capital is a parameter for each jurisdiction. In this chapter, there are only two jurisdictions, so the after-tax return to capital is endogenous, which, unsurprisingly, leads to tax exporting. There are large-jurisdiction models in the literature, including Hauer and Wooton (1999), Kanbur and Keen (1993) and many others. This chapter is based on a large-jurisdiction model that is similar to those in the literature above.

The costs of moving faced by private capital, which are also referred to as transaction costs (see, for example, Lee 1997), should not be ignored in a tax competition model. When the private capital investor has decided to locate in one jurisdiction and invest in some projects, these projects will usually last for a long period of time. Once the private capital is invested, it is usually quite difficult to

[36] This chapter is based on Yang (2021).

abandon the projects and leave the jurisdiction because of the large moving costs. Even if the private capital can move freely among the jurisdictions in the initial stage, imperfect mobility is inevitable in the later stages. Therefore, we must consider both transaction costs and inter-temporal effects in a tax competition model. There are several relevant studies that consider such issues. For example, Lee (1997) considers the imperfect mobility of private capital arising from transaction costs in a two-period tax competition model. He shows that a jurisdictional government will over-provide local public goods in the second period because of transaction costs and that the jurisdictions may choose a lower capital tax rate than that chosen in a one-period tax competition model to increase capital stock in the first period. Furthermore, by introducing a head tax into the model, Ogawa (2000) confirms that the jurisdictional government may subsidise private capital in the first period to increase capital stock in the second period when a lump-sum tax is available to a hyperopic jurisdictional government. This result is compatible with that of the repeated game explained by Coates (1993). There are also some two-period-model constructions that are relevant to our study (for example, King, McAfee and Welling 1993). However, most of the relevant literature analysing the transaction costs and dynamic effects does not clarify the important roles played by the spillover effects of public goods and the heterogeneity of jurisdictions in a repeated-game model. Hence, the focus of this study is to examine these roles.

The problem of capital tax competition may be solved by making a transfer from one jurisdiction to another jurisdiction when a lump-sum tax is not available in a capital tax competition model with imperfect population mobility among large heterogeneous jurisdictions (see Burbidge and Myers 1994). Burbidge and Myers (1994) find that the pecuniary externality and the fiscal externality, which work in opposite directions, can be cancelled out if the capital importer subsidises capital, while the capital exporter taxes capital. Conversely, DePater and Myers (1994) confirm that the capital importer taxes capital while the capital exporter provides a subsidy on capital if a lump-sum tax is available for the jurisdictions. In this chapter, we follow DePater and Myers (1994) because the strategy of manipulating the terms of trade is incentive compatible for the jurisdictions.

In the discussion on the spillover effects of local public goods among different jurisdictions, the prevailing view is that such spillover effects will aggravate the under-provision of local public goods (see, for example, Boadway, Pestieau and Wildasin 1989). However, another quite different view is that the spillover effects of local public goods may alleviate the under-provision of local public goods in some situations. In a repeated-game model with large homogeneous jurisdictions, Kawachi and Ogawa (2006) find that the jurisdictional governments are more inclined to provide an efficient level of local public goods when the degree of the spillover effects is sufficient. Furthermore, Ogawa (2007) confirms that, in a tax competition model with large heterogeneous jurisdictions, the jurisdiction with less efficient production technology is likely to increase its capital tax rate to drive out private capital and obtain substantial spill-in effects from the other jurisdiction with more efficient production technology. This means that a distortional capital tax may lead to a more efficient level of local public goods funding. This finding is a key motivation and implication for the chapter.

This chapter is closely related to the literature on fiscal federalism. It has been considered that the voluntary provision of public goods and the provision of local public goods with spillovers are insufficient even when using the 'Lindhal mechanism' because of the existence of free-riders and, therefore, that a matching grant from a central government to persons or to local governments for (local) public goods is required to solve the problem. Matching grants are a very particular policy device and this is relevant in the context of the vast literature. The seminal article by Boadway et al. (1989) shows the relationship between the efficient provision of public goods and an optimal matching grant rate. Roberts (1992) uses the same model and analyses issues including the efficiency of subsidies. Akai and Ihori (2002) replace individuals with local governments and examine the welfare effects of the central government's subsidies for local public goods in a Nash equilibrium model with two types of public goods, local and central. Furthermore, Ogawa (2006) argues that the matching grant rate may decrease with spillover effects if the elasticity of capital with respect to the capital tax rate is significant in a tax competition model. Additionally, the role of matching grants as a commitment device has been considered in recent research (see Akai and Sato 2019). Most of the key assumptions of this chapter correspond with the conventional wisdom presented in the studies above. Finally, we note that matching grants are especially empirically relevant for China and Japan.

By introducing spillover effects into our analysis, we verify that the jurisdiction with the less efficient production technology may choose to tax private capital in the first period, assuming that a lump-sum tax is available to it, and receive substantial spillover benefits from the other jurisdiction with more efficient production technology in the second period when the jurisdiction is hyperopic and benevolent, which is quite different from Ogawa (2000). In other words, these constructions are put together to model an interesting phenomenon and not simply to arrive at predetermined results.

The remainder of the chapter is organised as follows. The basic model is set out in section 4.2, in which we introduce the spillover effects of public goods and the heterogeneity of jurisdictions into a two-period economy. In section 4.3, we show the Stackelberg equilibria by employing backward induction to obtain the optimal corrective device to be employed by the central government in the two periods. In section 4.4, we discuss our findings based on the derived optimal corrective device. Section 4.5 draws conclusions.

4.2. The Model

The model that we use is similar to that used in Ogawa (2000). There are two heterogeneous jurisdictions in a two-period game[37] and, in each jurisdiction i $(i = 1,2)$[38], the immobile resident is normalised to unity, with preferences defined by a strictly quasi-concave utility function[39] $U_p^i(x_p^i, G_p^i)$, where x_p^i is the consumption of a private numeraire good in period p $(p = 1,2)$ and G_p^i is the consumption of a local public good in period p. The local public good G_p^i is defined by:

$$G_p^i = g_p^i + \beta_{ji} g_p^j, \tag{4-1}$$

where g_p^i is the provision of the local public good by jurisdictional government i and β_{ji} $(0 \leqq \beta_{ji} \leqq 1)$ is a parameter indicating the degree of spillover benefits from jurisdiction j to jurisdiction i.

We assume that the well-behaved aggregate production function in jurisdiction i is $f_i(k_p^i)$, and that $\frac{df_i(k_p^i)}{dk_p^i}$ and $\frac{d^2 f_i(k_p^i)}{d(k_p^i)^2}$ can be rewritten as $f_{kp}^i(k_p^i)$ and $f_{kkp}^i(k_p^i)$, respectively, where k_p^i is the private capital employed by jurisdiction i in period p. The production function can be assumed to take the quadratic form, for example, $f^i(\mathrm{k}_p^i) = a_i k_i - 0.5 b_i k_i^2$, which is also used by Wildasin (1991) and Ogawa (2007) in their numerical analyses, because the marginal productivity of private capital can take a linear and concise form, that is, $f_{kp}^i(k_p^i) = a_i - b_i k_i$. The production technology in the jurisdiction depends on the parameters a_i and b_i. The private capital is perfectly mobile in the first period and perfectly immobile in the second period. We assume that the private capital is myopic, following Ogawa (2000). The reason behind this is that the jurisdictional governments cannot commit to second-period taxes given the immobility of private capital in the second period. Even if the private tax rate was 100% in the second period, the private capital could not move to another jurisdiction. Thus, the private capital providers consider the tax rate only in the first period when making the location decision because they do not believe in the jurisdictional government's commitment to the tax rate in the second period. In other words, the capital owners do not take into account second-period taxation in their location decision.

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[37] The model can be written in a simpler way using only one period (see, for example, Ogawa 2007). However, as this chapter focuses on how the degree of governmental hyperopia and asymmetry in capital ownership affect the optimal redistribution mechanism, the dynamic effects must be considered.

[38] For simplicity, we assume that there are only two jurisdictions in the model. It can be confirmed that most of the results in this paper will not change qualitatively even if there are more than two jurisdictions.

[39] The properties of the utility functions are similar to those in the extant literature (for example, Ogawa 2000).

The total supply of private capital in the country is fixed at $\bar{k}$ such that:

$$\bar{k} = k_p^i + k_p^j. \tag{4-2}$$

In equilibrium, therefore, the after-tax return to capital in the first period is equalised across jurisdictions as follows:

$$f_{k1}^i(k_1^i) - t_1^i = f_{k1}^j(k_1^j) - t_1^j = r_1, \qquad (\ j \neq i\ ) \tag{4-3}$$

where t_1^i is the tax rate per unit of capital employed by jurisdiction i and r is the after-tax return to private capital in the country in the first period. Based on the established conventions, for example, see Bucovetsky (1991) and Ogawa (2007), we obtain the effect of changes in the first-period tax rate on the after-tax return to private capital and the location of private capital by taking total derivatives of (4-2) and (4-3), as follows:

$$\frac{\partial k_1^i}{\partial t_1^i} = \frac{1}{f_{kk1}^i + f_{kk1}^j} < 0 \tag{4-4}$$

$$\frac{\partial k_1^j}{\partial t_1^i} = -\frac{1}{f_{kk1}^i + f_{kk1}^j} > 0 \tag{4-5}$$

$$\frac{\partial r_1}{\partial t_1^i} = -\frac{f_{kk1}^j}{f_{kk1}^i + f_{kk1}^j} < 0 \tag{4-6}$$

The budget constraint of the resident in the first period requires that:

$$x_1^i = f_i(k_1^i) - f_{k1}^i(k_1^i)k_1^i + r_1\overline{k_1^i} - h_1^i, \tag{4-7}$$

where $\overline{k_1^i}$ is the initial endowment of private capital in jurisdiction i with $\overline{k_1^i} = \alpha^i\bar{k}$ and h_1^i is the uniform lump-sum tax that the central government has imposed. Following Ogawa (2000), we postulate that α^i is a fraction of the capital stock owned by the resident in jurisdiction i and that it does not change with time, where $\alpha^i + \alpha^j = 1$. Local and central governments can change the tax rate, but cannot impose a discriminatory tax rate. Moreover, it is required that the revenue from the national and local forest environmental taxes must be used for environmental policies. Therefore, these taxes and policies can be viewed as similar to the lump-sum taxes and the local public goods that we analyse in this article.

Substituting (4-3) into (4-7), (4-7) can be rewritten as:

$$x_1^i = f_i(k_1^i) - t_1^i k_1^i + r_1(\overline{k_1^i} - k_1^i) - h_1^i. \tag{4-7'}$$

During the second period, the after-tax return to capital may differ between the two jurisdictions because of the immobility of private capital. Therefore, the budget constraint of the resident in the second period requires that:

$$x_2^i = f_i(k_2^i) - f_{k2}^i(k_2^i)k_2^i + \alpha^i\{[f_{k2}^i(k_2^i) - t_2^i]k_2^i + [f_{k2}^j(k_2^j) - t_2^j]k_2^j\} - h_2^i. \tag{4-8}$$

The jurisdictional government budget constraint is given by:

$$g_p^i = t_p^i k_p^i + s_p^i. \tag{4-9}$$

The central government establishes a corrective device to encourage the jurisdictional government i to provide the local public good. Hence, the following condition holds:

$$s_p^i = m_p^i g_p^i, \tag{4-10}$$

where s_p^i is the matching grant received by the jurisdictional government i from the central government in period p and m_p^i is the rate of the matching grant received by the jurisdictional government i from the central government in period p.

The lump-sum tax (subsidy) imposed (offered) by the central government h_p^i will be chosen to satisfy the following budget constraint of that central government:

$$s_p^i + s_p^j = h_p^i + h_p^j = m_p^i g_p^i + m_p^j g_p^j. \tag{4-11}$$

Modelling intergovernmental transfer/taxes in such a way is well-established in the literature (see, for example, Ogawa 2006 and Boadway et al. 1989).

4.3. The Stackelberg Equilibria

We assume that the central government and the jurisdictional governments play a Stackelberg game with centralised leadership and that there is a unique Stackelberg equilibrium in each period. As this two-period game is a subgame perfect equilibrium, we employ backward induction to solve the problem for each jurisdictional government.

4.3.1. The Second Period

In the second period, there are two stages:

In stage 1, the central government chooses the national lump-sum tax (subsidy)

h_2^i and the matching grant rate (the Pigovian tax rate) m_2^i as a Stackelberg leader.

In stage 2, the jurisdictional government i chooses the capital tax rate t_2^i, and the local public good g_2^i as a Stackelberg follower, taking h_2^i and m_2^i as given.

In the second period, the jurisdictional government i maximises the utility of the residents by choosing t_2^i and g_2^i, given t_2^j and g_2^j. Although the jurisdictional governments cannot commit to second-period taxes, some facts (for example, the laws and policies in the jurisdictions) stop the capital-importing country from taxing away all capital and redistributing it to its citizens. Therefore, the capital owners would foresee this in their location decision. Following Ogawa (2000), the optimisation problem for jurisdictional government i can be written as:

$$\max_{t_2^i, g_2^i} \; U_i(x_2^i, G_2^i),$$

$$\begin{aligned} \text{s.t.} \quad & x_2^i = f_i(k_2^i) - f_{k2}^i(k_2^i)k_2^i + \alpha^i\{[f_{k2}^i(k_2^i) - t_2^i]k_2^i + [f_{k2}^j(k_2^j) - t_2^j]k_2^j\} - h_2^i, \\ & G_2^i = g_2^i + \beta_{ji}g_2^j, \\ & g_2^i = t_2^i k_2^i + s_2^i, \\ & s_2^i = m_2^i g_2^i. \end{aligned}$$

The first-order condition for jurisdictional government i is given by:

$$\frac{\partial u_2^i}{\partial t_2^i} = U_{G2}^i\left[\frac{k_2^i}{1-m_2^i}\right] + U_{x2}^i(-\alpha^i k_2^i) = 0, \qquad (4\text{-}12)$$

where the jurisdictional government i takes k_2^i as k_1^i in the first period. It can be derived that the second-order condition is satisfied under some realistic functional assumptions and the properties of the equilibria are fully determined (see Ogawa 2007). Rearranging (4-12), we have:

$$\frac{U_{G2}^i}{U_{x2}^i} = \alpha^i(1 - m_2^i). \qquad (4\text{-}13)$$

The optimal corrective device that the central government should choose is given by:

$$m_2^i = 1 - \frac{1}{\alpha^i}\frac{U_{G2}^i}{U_{x2}^i}. \qquad (4\text{-}14)$$

The Pareto-optimal condition is derived by:

$$\max_{x_2^i, g_2^i} \quad U_2^i(x_2^i, G_2^i) + U_2^j(x_2^j, G_2^j),$$

$$\text{s.t.} \quad x_2^i + x_2^j + g_2^i + g_2^j = f_i(k_2^i) + f_j(k_2^j).$$

Let λ denotes the Lagrange multiplier of the constraint above. Then, the Lagrange function is given by:

$$L(x_2^i, g_2^i) = U_2^i + U_2^j + \lambda[x_2^i + x_2^j + g_2^i + g_2^j - f_i(k_2^i) - f_j(k_2^j)].$$

Differentiating $L(x_2^i, g_2^i)$ with respect to x_2^i, g_2^i and λ, yields:

$$\frac{\partial L}{\partial g_2^i} = U_{G2}^i + \beta_{ij} U_{G2}^j + \lambda = 0,$$

$$\frac{\partial L}{\partial x_2^i} = U_{x2}^i + \lambda = 0,$$

$$\frac{\partial L}{\partial \lambda} = x_2^i + x_2^j + g_2^i + g_2^j - f_i(k_2^i) - f_j(k_2^j) = 0,$$

which can be rewritten as:

$$U_{G2}^i + \beta_{ij} U_{G2}^j = U_{x2}^i. \tag{4-15}$$

A comparison of (4-13) and (4-15) shows that the optimal matching grant rate (the Pigovian tax rate) that the central government should choose is given by:

$$m_2^i = 1 - \frac{1}{\alpha^i}(1 - \beta_{ij} \frac{U_{G2}^j}{U_{x2}^i}). \tag{4-16}$$

This finding corresponds with the conclusions from the existing literature (for example, see Bjorvatn and Schjelderup 2002). Notably, this result is an extension of Ogawa (2000) with reference to a particular case.

The inefficiency here arises first from the under-provision of local public goods resulting from the spillover effects. This is determined by the degree of spillovers. The larger are the degree of spillovers, the larger is the positive externality. In addition, inefficiency arises from the over-provision of local public goods resulting from tax exporting[40]. This effect is determined by the proportion of the capital stock owned by the jurisdiction's residents. The larger this proportion is, the larger is the negative fiscal externality ignored by the jurisdictional government. If the former positive externality is larger than the latter negative fiscal externality, the net effect is that local public goods are under-provided by the jurisdictional government in the second period, which means that the optimal corrective device provided by the central government is a matching grant. Conversely, if the former positive externality is smaller than the latter negative fiscal externality, the net effect is that local public goods are over-provided by the jurisdictional government in the second period, which means that the optimal corrective device that the central government should provide is a Pigovian tax. This finding may be summarised in the following proposition.

Proposition 4.1: If the spillover effect is larger than the tax-exporting effect in the second period, the central government should choose the matching grant as a corrective device. In this sense, the local public good is under-provided. On the contrary, if the spillover effect is smaller than the tax-exporting effect in the second period, the central government should choose the Pigovian tax as a corrective device. In this case, the local public good is over-provided.

This proposition mainly restates what the prior literature has found in similar contexts (see, for example, Bjorvatn and Schjelderup 2002).

4.3.2. The First Period

In the first period, there are two stages:

In stage 1, the central government chooses the national lump-sum tax (subsidy) h_1^i and the matching grant rate (the Pigovian tax rate) m_1^i as a Stackelberg leader.

In stage 2, the jurisdictional government i chooses the capital tax rate t_1^i and the local public good g_1^i as a Stackelberg follower, taking h_1^i, h_2^i, m_1^i and m_2^i as given.

[40] See Noiset (2003).

The capital tax rate in the second period depends on the amount of private capital located in jurisdiction i in the second period. Owing to the immobility of private capital in the second period, the amount of private capital located in jurisdiction i in the second period is equal to the amount in the first period, that is, $k_1^i = k_2^i$. At the same time, the amount of private capital located in jurisdiction i in the first period depends on the capital tax rate, which is chosen by the jurisdictional government in the first period. Therefore, following Ogawa (2000), we assume that $t_2^i = q(t_1^i)$, where t_2^i is expressed as a function of t_1^i. This means that how the jurisdictional government i chooses the optimal capital tax rate in the second period is significantly determined by the capital tax rate that it chose in the first period. Note that this does not mean that t_2^i is predetermined. The jurisdictional government chooses t_1^i to maximise the discounted sum of the utilities in the two periods, given the variables for jurisdictional government j. If the jurisdictional government is hyperopic, the maximisation problem for jurisdictional government i in the first period can be written as:

$$\max_{t_1^i, g_1^i} u_1^i = U_i(x_1^i, G_1^i) + \delta^i U_i(x_2^i, G_2^i),$$

$$\begin{aligned}
\text{s.t.}\quad & x_1^i = f_i(k_1^i) - f_{k1}^i(k_1^i)k_1^i + r_1\overline{k_1^i} - h_1^i,\\
& x_2^i = f_i(k_2^i) - f_{k2}^i(k_2^i)k_2^i + \alpha^i\{[f_{k2}^i(k_2^i) - t_2^i]k_2^i + [f_{k2}^j(k_2^j) - t_2^j]k_2^j\} - h_2^i,\\
& G_1^i = g_1^i + \beta_{ji}g_1^j,\\
& G_2^i = g_2^i + \beta_{ji}g_2^j,\\
& g_1^i = t_1^i k_1^i + s_1^i,\\
& g_2^i = t_2^i k_2^i + s_2^i,\\
& s_1^i = m_1^i g_1^i,\\
& s_2^i = m_2^i g_2^i,\\
& k_1^i = k_2^i,\\
& t_2^i = q(t_1^i),
\end{aligned}$$

by assuming that the discount factor for the jurisdictional government is $\delta^i \geq 0$. To derive the first-order condition, we use the substitution method and differentiate u_1^i with respect to t_1^i. Substituting (4-1), (4-3), (4-7), (4-8), (4-9) and (4-10) into the objective function, we obtain:

$$\frac{\partial u_1^i}{\partial t_1^i} = U_{G1}^i\left[\frac{1}{1-m_1^i}\left(k_1^i + t_1^i\frac{\partial k_1^i}{\partial t_1^i}\right) + \frac{1}{1-m_1^j}\beta_{ji}t_1^j\frac{\partial k_1^j}{\partial t_1^i}\right] + U_{x1}^i\left[\left(\overline{k_1^i} - k_1^i\right)\frac{\partial r_1}{\partial t_1^i} - k_1^i\right]$$

$$+\delta^i U_{x2}^i\left\{\left[\alpha^i(f_{k2}^i - t_2^i) - (1-\alpha^i)k_2^i f_{kk2}^i\right]\frac{\partial k_2^i}{\partial t_1^i} - \alpha^i k_2^i\frac{\partial t_2^i}{\partial t_1^i}\right\}$$

$$+\delta^i U_{G2}^i \left[\frac{1}{1-m_2^i}\left(t_1^i \frac{\partial k_2^i}{\partial t_1^i} + k_2^i \frac{\partial t_2^i}{\partial t_1^i}\right) + \frac{1}{1-m_2^j} \beta_{ji} t_2^j \frac{\partial k_2^j}{\partial t_1^i}\right]. \quad (4\text{-}17)$$

Substituting (4-13) into (4-17), (4-17) can be rewritten as:

$$\frac{\partial u_1^i}{\partial t_1^i} = U_{G1}^i \left[\frac{1}{1-m_1^i}\left(k_1^i + t_1^i \frac{\partial k_1^i}{\partial t_1^i}\right) + \frac{1}{1-m_1^j}\left(\beta_{ji} t_1^j \frac{\partial k_1^j}{\partial t_1^i}\right)\right] + U_{x1}^i \left[\left(\overline{k_1^i} - k_1^i\right)\frac{\partial r_1}{\partial t_1^i} - k_1^i\right]$$

$$+\delta^i U_{G2}^i \left\{\frac{1}{1-m_2^i}\left[\left(f_{k2}^i - t_2^i\right) - \frac{1-\alpha^i}{\alpha^i} k_2^i f_{kk2}^i\right]\frac{\partial k_2^i}{\partial t_1^i} - \frac{1}{1-m_2^i} k_2^i \frac{\partial t_2^i}{\partial t_1^i}\right\}$$

$$+\delta^i U_{G2}^i \left[\frac{1}{1-m_2^i}\left(t_1^i \frac{\partial k_2^i}{\partial t_1^i} + k_2^i \frac{\partial t_2^i}{\partial t_1^i}\right) + \frac{1}{1-m_2^j} \beta_{ji} t_2^j \frac{\partial k_2^j}{\partial t_1^i}\right]. \quad (4\text{-}18)$$

Rearranging (4-18) with cancellation, we have:

$$\frac{\partial u_1^i}{\partial t_1^i} = U_{G1}^i \left[\frac{1}{1-m_1^i}\left(k_1^i + t_1^i \frac{\partial k_1^i}{\partial t_1^i}\right) + \frac{1}{1-m_1^j}\left(\beta_{ji} t_1^j \frac{\partial k_1^j}{\partial t_1^i}\right)\right] + U_{x1}^i \left[\left(\overline{k_1^i} - k_1^i\right)\frac{\partial r_1}{\partial t_1^i} - k_1^i\right]$$

$$+\delta^i U_{G2}^i \left[\frac{1}{1-m_2^i}\left(f_{k2}^i - \frac{1-\alpha^i}{\alpha^i} k_2^i f_{kk2}^i\right)\frac{\partial k_2^i}{\partial t_1^i} + \frac{1}{1-m_2^j} \beta_{ji} t_2^j \frac{\partial k_2^j}{\partial t_1^i}\right]. \quad (4\text{-}19)$$

Using (4-2) and the assumption that $k_1^i = k_2^i$, the first-order condition can be written as:

.

$$\frac{\partial u_1^i}{\partial t_1^i} = U_{G1}^i \left[\frac{1}{1-m_1^i}\left(k_1^i + t_1^i \frac{\partial k_1^i}{\partial t_1^i}\right) - \frac{1}{1-m_1^j}\left(\beta_{ji} t_1^j \frac{\partial k_1^i}{\partial t_1^i}\right)\right] + U_{x1}^i \left[\left(\overline{k_1^i} - k_1^i\right)\frac{\partial r_1}{\partial t_1^i} - k_1^i\right]$$

$$+\delta^i U_{G2}^i \left\{\frac{1}{1-m_2^i}\left[f_{k2}^i - \frac{1-\alpha^i}{\alpha^i} k_2^i f_{kk2}^i\right] - \frac{1}{1-m_2^j} \beta_{ji} t_2^j\right\}\frac{\partial k_1^i}{\partial t_1^i} = 0. \quad (4\text{-}20)$$

It can be derived that the second-order condition is satisfied under some realistic functional assumptions and the properties of the equilibria are fully determined (see Ogawa 2007).

The optimal corrective device that the central government should choose is given by:

$$m_1^i = 1 - \frac{U_{G1}^i\left(k_1^i + t_1^i \frac{\partial k_1^i}{\partial t_1^i}\right)}{U_{x1}^i\left[k_1^i - \left(\overline{k_1^i} - k_1^i\right)\frac{\partial r_1}{\partial t_1^i}\right] + U_{G1}^i\left(\frac{1}{1-m_1^j}\beta_{ji} t_1^j \frac{\partial k_1^i}{\partial t_1^i}\right) - \delta^i U_{G2}^i\left[\frac{1}{1-m_2^i}\left(f_{k2}^i - \frac{1-\alpha^i}{\alpha^i} k_2^i f_{kk2}^i\right) - \frac{1}{1-m_2^j}\beta_{ji} t_2^j\right]\frac{\partial k_1^i}{\partial t_1^i}}. \quad (4\text{-}21)$$

The Pareto-optimal condition is derived by:

$$\max_{x_1^i, g_1^i} \quad U_1^i(x_1^i, G_1^i) + U_1^j(x_1^j, G_1^j) + \varphi[U_2^i(x_2^i, G_2^i) + U_2^j(x_2^j, G_2^j)],$$

$$\text{s.t.} \;\; x_1^i + x_1^j + g_1^i + g_1^j = f_i(k_1^i) + f_j(k_1^j),$$

$$x_2^i + x_2^j + g_2^i + g_2^j = f_i(k_2^i) + f_j(k_2^j),$$

where we assume that the discount factor for the central government is $\varphi \geq 0$. Let π and ω denote the Lagrange multipliers of the constraints above, respectively. Then, the Lagrange function is given by:

$$L(x_1^i, g_1^i, x_2^j, g_2^j) = U_1^i + U_1^j + \varphi(U_2^i + U_2^j) + \pi[x_1^i + x_1^j + g_1^i + g_1^j - f_i(k_1^i) - f_j(k_1^j)] +$$
$$\omega\varphi[x_2^i + x_2^j + g_2^i + g_2^j - f_i(k_2^i) - f_j(k_2^j)].$$

Differentiating $L(x_1^i, g_1^i, x_2^j, G_2^j)$ with respect to x_1^i, g_1^i, x_2^j, g_2^j, π and ω gives us:

$$\frac{\partial L}{\partial g_1^i} = U_{G1}^i + \beta_{ij} U_{G1}^j + \pi = 0,$$

$$\frac{\partial L}{\partial x_1^i} = U_{x1}^i + \pi = 0,$$

$$\frac{\partial L}{\partial g_2^i} = \varphi(U_{G2}^i + \beta_{ij} U_{G2}^j + \omega) = 0,$$

$$\frac{\partial L}{\partial x_2^i} = \varphi(U_{x2}^i + \omega) = 0,$$

$$\frac{\partial L}{\partial \pi} = x_1^i + x_1^j + g_1^i + g_1^j - f_i(k_1^i) - f_j(k_1^j) = 0,$$

$$\frac{\partial L}{\partial \omega} = \varphi[x_2^i + x_2^j + g_2^i + g_2^j - f_i(k_2^i) - f_j(k_2^j)] = 0,$$

which can be rewritten as:

$$U_{G1}^i + \beta_{ij} U_{G1}^j = U_{x1}^i, \tag{4-22-1}$$

$$U_{G2}^{i} + \beta_{ij} U_{G2}^{j} = U_{x2}^{i}. \tag{4-22-2}$$

A comparison of (4-20), (4-22-1) and (4-22-2) shows that the optimal matching grant rate (the Pigovian tax rate) that the central government should choose is given by:

$$m_1^i = 1 - \frac{U_{G1}^i\left(k_1^i + t_1^i \frac{\partial k_1^i}{\partial t_1^i}\right)}{\left(U_{G1}^i + \beta_{ij} U_{G1}^j\right)\left[k_1^i - (\overline{k_1^i} - k_1^i)\frac{\partial r_1}{\partial t_1^i}\right] + U_{G1}^i\left(\frac{1}{1-m_1^j}\beta_{ji} t_1^j \frac{\partial k_1^i}{\partial t_1^i}\right) - \delta^i U_{G2}^i\left[\frac{1}{1-m_2^i}\left(f_{k2}^i - \frac{1-\alpha^i}{\alpha^i} k_2^i f_{kk2}^i\right) - \frac{1}{1-m_2^j}\beta_{ji} t_2^j\right]\frac{\partial k_1^i}{\partial t_1^i}}. \tag{4-23}$$

Notably, this result is an extension of Ogawa (2000) with reference to a particular case. It may appear that it is a kind of extensive form game in which the central government does not have to commit in the second period to the matching grant that it chose in the first period. However, the matching grant can be used as a commitment device in some situations (see, for example, Akai and Sato 2019). Therefore, to simplify the analysis in the model, we assume that the central government can commit in the second period to the matching grant that it chose in the first period.

4.4. Discussion

To sign $\frac{\partial m_1^i}{\partial \delta^i}$, we differentiate the optimal corrective device with δ^i, yielding:

$$\frac{\partial m_1^i}{\partial \delta^i} = -\frac{U_{G1}^i U_{G2}^i\left(k_1^i + t_1^i \frac{\partial k_1^i}{\partial t_1^i}\right)\left[\frac{1}{1-m_2^i}\left(f_{k2}^i - \frac{1-\alpha^i}{\alpha^i} k_2^i f_{kk2}^i\right) - \frac{1}{1-m_2^j}\beta_{ji} t_2^j\right]\frac{\partial k_1^i}{\partial t_1^i}}{\left\{\left(U_{G1}^i + \beta_{ij} U_{G1}^j\right)\left[k_1^i - (\overline{k_1^i} - k_1^i)\frac{\partial r_1}{\partial t_1^i}\right] + U_{G1}^i\left(\frac{1}{1-m_1^j}\beta_{ji} t_1^j \frac{\partial k_1^i}{\partial t_1^i}\right) - \delta^i U_{G2}^i\left[\frac{1}{1-m_2^i}\left(f_{k2}^i - \frac{1-\alpha^i}{\alpha^i} k_2^i f_{kk2}^i\right) - \frac{1}{1-m_2^j}\beta_{ji} t_2^j\right]\frac{\partial k_1^i}{\partial t_1^i}\right\}^2}. \tag{4-24}$$

We assume that we are on the left-hand side of a Laffer curve, $k_1^i + t_1^i \frac{\partial k_1^i}{\partial t_1^i} > 0$. As $\frac{\partial k_1^i}{\partial t_1^i} < 0$, the sign of $\frac{\partial m_1^i}{\partial \delta^i}$ depends only on the bracketed term in the numerator. On the one hand, the hyperopic jurisdictional government has an incentive to decrease the tax rate in the first period to attract the private capital because the jurisdictional government considers the income in the second period (the income effect). The first term in the bracketed term of the numerator is positive. However, if the spillover effect in the second period is taken into account by the hyperopic jurisdictional government, the jurisdictional government has an incentive to increase the tax rate in the first period to drive out the private capital and obtain the spillover benefits from the other jurisdiction (the spill-in effect). The second term in the bracketed term of the numerator is negative. The relationship between the corrective device in the first period and the degree of hyperopia of the jurisdictional government significantly depends on the relative size of the two effects that are working in the opposite direction in the second period, as stated succinctly in the following proposition.

Proposition 4.2: When the income effect is larger than the spill-in effect in the second period, the optimal matching grant rate (the Pigovian tax rate) in the first period from the central government to a more hyperopic jurisdictional government should be increased (decreased). Conversely, when the spill-in effect is larger than the income effect in the second period, the optimal matching grant rate (the Pigovian tax rate) in the first period from the central government to a more hyperopic jurisdictional government should be decreased (increased).

Notice that the external validity of this proposition depends on a political strategy of the politicians. The benefits that the politicians can obtain in one jurisdiction (the re-election rent) equals the marginal increase in the probability of re-election multiplied by the value of being re-elected. Of course, these factors are seen as the exogenous variables in this model. If the politicians would like to stand for election for the next term, the conclusion would be valid and could also be a benchmark for some extensions in the future. However, if the politicians would like to stand down, they would be myopic and their discount factor might be zero in the first period. The result would collapse into the finding in Ogawa (2007).

To see the properties of the capital allocation among the two jurisdictions in such an equilibrium, differentiation of the optimal corrective device with respect to $\overline{k_1^i} - k_1^i$ shows that:

$$\frac{\partial m_1^i}{\partial(\overline{k_1^i}-k_1^i)} =$$

$$-\frac{U_{G1}^i\left(U_{G1}^i+\beta_{ij}U_{G1}^j\right)\left(k_1^i+t_1^i\frac{\partial k_1^i}{\partial t_1^i}\right)\frac{\partial r_1}{\partial t_1^i}}{\left\{\left(U_{G1}^i+\beta_{ij}U_{G1}^j\right)\left[k_1^i-(\overline{k_1^i}-k_1^i)\frac{\partial r_1}{\partial t_1^i}\right]+U_{G1}^i\left(\frac{1}{1-m_1^j}\beta_{ji}t_1^j\frac{\partial k_1^i}{\partial t_1^i}\right)-\delta^i U_{G2}^i\left[\frac{1}{1-m_2^i}\left(f_{k2}^i-\frac{1-\alpha^i}{\alpha^i}k_2^i f_{kk2}^i\right)-\frac{1}{1-m_2^j}\beta_{ji}t_2^j\right]\frac{\partial k_1^i}{\partial t_1^i}\right\}^2} > 0. \tag{4-25}$$

This equation corresponds with that of Bucovetsky (1991) and Lee (1997). It is obvious that the equilibrium is a symmetric equilibrium when $\overline{k_1^i} - k_1^i = 0$, which means the capital does not move at all. The jurisdiction is a capital exporter if $\overline{k_1^i} - k_1^i > 0$, and it is a capital importer if $\overline{k_1^i} - k_1^i < 0$. As $\frac{\partial m_1^i}{\partial(\overline{k_1^i}-k_1^i)} > 0$, we have the following relationships for jurisdiction i:

$$\text{if } \overline{k_1^i} - k_1^i > 0 \text{ then } m_1^i > m_1^{i*},$$
$$\text{if } \overline{k_1^i} - k_1^i = 0 \text{ then } m_1^i = m_1^{i*},$$
$$\text{if } \overline{k_1^i} - k_1^i < 0 \text{ then } m_1^i < m_1^{i*},$$

where m_1^{i*} is the optimal matching grant rate from the central government in a symmetric equilibrium. This conclusion is a generalisation of that derived by Ogawa (2000) in a strategic tax competition model. We obtain the third result as follows.

Proposition 4.3: In the first period, the optimal matching grant rate (the Pigovian tax rate) from the central government to a capital-exporting jurisdictional government is larger (smaller) than that in the symmetric equilibrium. However, the optimal matching grant rate (the Pigovian tax rate) from the central government to a capital-importing jurisdictional government is smaller (larger) than that in the symmetric equilibrium.

The intuition behind this result is interpreted as follows. The capital exporter desires a high after-tax return to private capital to increase the capital income arising from exporting capital. Thus, in the first period, the capital exporter would choose a lower tax rate and a lower level of local public goods than in the symmetric equilibrium to manipulate the terms of trade[41]. For that reason, in the first period, the optimal matching grant rate (the Pigovian tax rate) from the central government to a capital-exporting jurisdictional government is larger (smaller) than that in the symmetric equilibrium. Conversely, the capital importer desires a low after-tax return to private capital to reduce the capital costs arising from importing capital. Thus, in the first period, it would choose a higher tax rate and a higher level of local public goods than in the symmetric equilibrium to manipulate the terms of trade. Accordingly, in the first period, the optimal matching grant rate (the Pigovian tax rate) from the central government to a capital-importing jurisdictional government is smaller (larger) than that in the symmetric equilibrium.

Now, we state the boundaries of the research and applications of the model. In some suburban areas, for example, less populated areas surrounding a metropolitan area but of lower socioeconomic status, beneficial spillovers of local public goods from the urban core are necessary and essential for the suburban residents. If the politicians in these kinds of jurisdictions place a significant weight on the distant future, the under-provision of local public goods might be eased to some extent. Accordingly, the

[41] See Ogawa (2007) and Burbidge and Myers (1994).

central government should decrease the current period's optimal matching grant rate to some extent. However, in some urban areas, for example, a densely populated urban core in a metropolitan area with high socioeconomic status, benefit spillovers of local public goods from the surrounding territories are unnecessary and negligible for these urban residents. If the politicians in these kinds of jurisdictions place a significant weight on the distant future, the under-provision of local public goods might be aggravated to some extent. Accordingly, the central government should increase the current period's optimal matching grant rate to some extent.

This result is quite different from Ogawa (2000). One jurisdictional government might tax private capital in the first period to receive more benefit spillovers from other jurisdictions in the second period even if a lump-sum tax is available for the benevolent and hyperopic jurisdictional government. Of course, the robustness and external validity of this research requires further analysis and the incorporation of other key assumptions such as, for example, political re-election motivations.

4.5. Conclusions

This chapter has focused on the effect that the degree of hyperopia of jurisdictional government has on the optimal corrective device in a two-period model in which spillover effects are considered. We have obtained the following results.

(1) If the spillover effect is larger than the tax-exporting effect in the second period, the central government should choose a matching grant as a corrective device. Conversely, if the spillover effect is smaller than the tax-exporting effect in the second period, the central government should choose a Pigovian tax as a corrective device.

(2) When the income effect is larger than the spill-in effect in the second period, for example, if the production technology in the jurisdiction is significantly higher than in other jurisdictions and the spillover benefits received by the jurisdiction are not very large, the optimal matching grant rate (the Pigovian tax rate) in the first period, which is set by the central government and directed to the more hyperopic jurisdictional government, should be increased (decreased). Conversely, when the spill-in effect is larger than the income effect in the second period, for example, the production technology in the jurisdiction is significantly lower than in other jurisdictions and the spillover benefits received by the jurisdiction are relatively large, the corresponding optimal matching grant rate (the Pigovian tax rate) in the first period should be decreased (increased).

(3) In the first period, the optimal matching grant rate (the Pigovian tax rate) from the central government to a capital-exporting jurisdictional government is larger (smaller) than that in the symmetric equilibrium. However, the optimal matching

grant rate (the Pigovian tax rate) set by the central government in relation to a capital-importing jurisdictional government is smaller (larger) than that in the symmetric equilibrium.

For simplicity, it has been assumed that capital is perfectly immobile in the second period. If we introduce transactions costs into the model in the second period, our results may be adjusted quantitatively. However, our findings about the provision of local public goods will not be changed even if capital is imperfectly mobile in the second period.

There is no inter-temporal redistribution via public debt or public investment as would usually be relevant when determining public finances across time (for example, Barro 1979; Jensen and Toma 1991). In a dynamic model, the timing of and commitment to policies (for example, see Wildasin 2003) matter. However, for simplicity's sake, these issues are not addressed in the present research. In addition, alternative ways of redistributing resources between jurisdictions (for example, sharing the tax revenue, as in Hindriks et al. 2008) may lead to more efficient outcomes. This topic is left for future research.

It is worth noting that the degree of hyperopia of jurisdictional government is determined by the probability of re-election and the rent from being re-elected for the politicians. If the politicians in the jurisdiction can obtain high rent from being re-elected or if the probability that the politicians will be re-elected in the next term is very high, the jurisdictional government may be possess greater foresight in this term, and vice versa. Although these factors are seen as the exogenous variables in this study, the finding could provide a benchmark for some extensions in the future. Therefore, in future work, it would be interesting to take into account these issues concerning the incumbents and the anti-incumbency factors.

Chapter 5 Conclusions

This dissertation analyzed the relationship between the optimal matching grant rates and different kinds of externalities, such as benefit spillovers and fiscal externalities, in the models of tax competition among jurisdictional governments.

This dissertation first surveyed the existing literature on some different kinds of externalities in the standard models of capital tax competition. The problem of the under-provision of local public goods in a tax competition model, in which private capital is mobile among countries, is examined by the literature on public finance. It is considered that the matching grant program from a central government to the jurisdictional governments is a strong instrument to solve the problem of an insufficiently provision of local public goods.

Second, this dissertation analyzed the optimal matching grant rate for local public spending that has characteristics of both public goods and public inputs. Its spillover effects to other regions are assumed to be regarding consumption and/or production. Contrary to this approach, traditional analyses of matching grants for public spending have only focused on public goods and consumptive spillover. By considering these factors, we obtain some more generalized conclusions and intriguing results; for example, even if private capital is completely immobile, the productive effect of public expenditure lowers the optimal matching grant rate when the production spillover is zero, or smaller than that of consumption, and vice versa.

Third, this dissertation examined the effect of horizontal fiscal externalities on the optimal matching grant rate in a model where agency costs are inevitable. Agency problems arise in any environment involving a principal-agent relationship. Because this chapter takes agency costs into account, the main results should differ from the standard conclusions of the tax competition literature. This chapter finds that the degree of agency costs and benefit spillovers determine the relationship between tax competition and the optimal matching grant rate. If agency costs are relatively small, and benefit spillover is zero, the optimal matching grant rate should increase with the factors of production demand elasticities with respect to the factor tax rate and vice versa. Tax competition thus may ease the inefficiency arising from agency costs only if the disutility of effort is so large that the benefits from tax competition exceed the costs when benefit spillover is zero.

Finally, this dissertation introduced the spillover effect of public goods and the heterogeneity of jurisdictions to the capital tax competition literature using a two-period economy. A clear result is that the revision of a corrective device used by the central government in the first period to ensure an optimal level of a local public good is provided by a hyperopic jurisdictional government, significantly depends on the relative size of the income and spill-in effects in the second period. The relative size of the two effects, which work in opposite directions, is determined by the tastes and endowments of the jurisdictions, the form of their production functions and the degree of spillovers, among other factors.

Note that the robustness of the above-mentioned results should be further tested by introducing incumbent politicians into the model. In particular, we choose a simple form of social welfare function to formulate the maximisation problem. Therefore, employing a more general form of objective function and considering re-election may provide intriguing insights, an avenue that is left to future research. In addition, our model also needs the verification of empirical analysis in the future research.

Appendix 2.1

Differentiating (2-20), we obtain

$$\frac{\partial u_i}{\partial t_i}=\frac{\partial u_i}{\partial G_i}\left(\frac{1}{1-m}\right)\left\{k_i^p+t_i\frac{\mathrm{d}k_i^p}{\mathrm{d}t_i}+\beta\sum_{j\neq i}t_j\frac{dk_j^p}{dt_i}\right\}$$

$$+\frac{\partial u_i}{\partial x_i}\left\{\left[f_{kp}\left(k_i^p,K_i^g\right)-t_i-r\right]\frac{dk_i^p}{dt_i}-k_i^p+\left(\bar{k}_i^p-k_i^p\right)\frac{\partial r}{\partial t_i}+f_{Kg}(k_i^p,K_i^g)\frac{\partial K_i^g}{\partial t_i}\right\}=0.$$

(A2.1-1)

From (2-14), $f_{kp}\left(k_i^p,K_i^g\right)-t_i-r=0$, and because of the assumption that all jurisdictions are identical, that is, $\bar{k}_i^p-k_i^p=0$, we therefore obtain

$$\left(\frac{1}{1-m}\right)\left\{k_i^p+t_i\frac{\mathrm{d}k_i^p}{\mathrm{d}t_i}+\beta\sum_{j\neq i}t_j\frac{dk_j^p}{dt_i}\right\}\frac{\partial u_i}{\partial G_i}=\left\{k_i^p-f_{Kg}\left(k_i^p,K_i^g\right)\frac{dK_i^g}{dt_i}\right\}\frac{\partial u_i}{\partial x_i}. \quad \text{(A2.1- 2)}$$

From (2-1'), (2-17), and (2-18) we obtain

$$K_i^g=g_i+\gamma\sum_{j\neq i}g_j=\frac{t_ik_i^p}{1-m}+\gamma\sum_{j\neq i}\frac{t_jk_j^p}{1-m}. \quad \text{(A2.1-3)}$$

Differentiating (A2.1-3) we obtain

$$\frac{dK_i^g}{dt_i}=\left(\frac{1}{1-m}\right)\left(k_i^p+t_i\frac{\mathrm{d}k_i^p}{\mathrm{d}t_i}\right)+\left(\frac{1}{1-m}\right)\left(\gamma\sum_{j\neq i}t_j\frac{dk_j^p}{dt_i}\right). \quad \text{(A2.1-4)}$$

Substituting (A2.1-4) into (A2.1-2), we obtain

$$\left(\frac{1}{1-m}\right)\left\{k_i^p+t_i\frac{\mathrm{d}k_i^p}{\mathrm{d}t_i}+\beta\sum_{j\neq i}t_j\frac{dk_j^p}{dt_i}\right\}\frac{\partial u_i}{\partial G_i}$$

$$=\left\{k_i^p-f_{Kg}\left(k_i^p,K_i^g\right)\left[\left(\frac{1}{1-m}\right)\left(k_i^p+t_i\frac{\mathrm{d}k_i^p}{\mathrm{d}t_i}\right)+\left(\frac{1}{1-m}\right)\left(\gamma\sum_{j\neq i}t_j\frac{dk_j^p}{dt_i}\right)\right]\right\}\frac{\partial u_i}{\partial x_i}.$$

(A2.1- 5)

Differentiating (2-15), we obtain

$$\sum_{j\neq i}t_j\frac{dk_j^p}{dt_i}=-\frac{\mathrm{d}k_i^p}{\mathrm{d}t_i}. \quad \text{(A2.1-6)}$$

Using (A2.1-6) and $t_i = t_j$, we obtain

$$\left(\frac{1}{1-m}\right)\left\{k_i^p + t_i \frac{\mathrm{d}k_i^p}{\mathrm{d}t_i}(1-\beta)\right\}\frac{\partial u_i}{\partial G_i}$$

$$= \left\{k_i^p - f_{Kg}\left(k_i^p, K_i^g\right)\left(\frac{1}{1-m}\right)\left[k_i^p + t_i \frac{\mathrm{d}k_i^p}{\mathrm{d}t_i}(1-\gamma)\right]\right\}\frac{\partial u_i}{\partial x_i}. \qquad \text{(A2.1- 7)}$$

Multiplying (A2.1- 7) by $\frac{1-m}{k_i^p}$, we obtain (2-21).

Appendix 2.2

It is clearly shown from (2-26) that if $\gamma = \beta = 1$, $\frac{\partial m}{\partial E} = 0$ is derived, and if $\gamma < \beta$, $\frac{\partial m}{\partial E}$ <0 is derived. Furthermore, if $\gamma = \beta < 1$, $\frac{\partial m}{\partial E} < 0$ is also derived. We now consider the case where $\gamma > \beta$. Substituting f_{Kg} with $\frac{1}{1+\gamma(n-1)}$ into (2-26) using $f_{Kg} < \frac{1}{1+\gamma(n-1)}$, which we derived because of the positive denominator on the left-hand side of (2-8), we obtain

$$\frac{\partial m}{\partial \varepsilon} = \frac{nf_{Kg}(\gamma-\beta)-(1-\beta)}{1+\beta(n-1)} < \frac{\frac{n}{1+\gamma(n-1)}(\gamma-\beta)-(1-\beta)}{1+\beta(n-1)} = \frac{\gamma-1}{1+\gamma(n-1)} \leqq 0, \tag{A2.2-1}$$

where, if $f_{Kg} < \frac{1}{1+\gamma(n-1)}$, the numerator in (A2.2-1) is larger than it is when $f_{Kg} = \frac{1}{1+\gamma(n-1)}$ as $\gamma > \beta$. Therefore, we argue that $\frac{\partial m}{\partial E} < 0$ if $\gamma > \beta$.

Regarding $\frac{\partial m}{\partial \varepsilon} \leqq 0$, $\frac{\partial m}{\partial e} \leqq 0$, and $\frac{\partial m}{\partial e(1-\gamma)} \leqq 0$, the logic is the same as that for $\frac{\partial m}{\partial E} \leqq 0$.

TABLE 2.1

	immobile private capital	mobile private capital		
	$E = 0$	$E > \frac{1-n}{n}$	$E = \frac{1-n}{n}$	$E < \frac{1-n}{n}$
$1 = \gamma > \beta$	$m_f > m_0$	$m_f > m_0$	$m_f = m_0$	$m_f < m_0$
$1 > \gamma > \beta$	$m_f > m_0$		$m_f < m_0$	$m_f < m_0$
$1 > \gamma = \beta$	$m_f = m_0$	$m_f < m_0$	$m_f < m_0$	$m_f < m_0$
$1 = \gamma = \beta$	$m_f = m_0 = (n-1)/n$			
$0 \leq \gamma < \beta = 1$	$m_f < m_0$	$m_f < m_0$	$m_f = m_0$	$m_f > m_0$
$0 \leq \gamma < \beta < 1$	$m_f < m_0$	$m_f < m_0$	$m_f < m_0$	
$0 < \gamma = \beta < 1$	$m_f = m_0$	$m_f < m_0$	$m_f < m_0$	$m_f < m_0$
$0 = \gamma = \beta$	$m_f = m_0 = 0$	$m_f < m_0$	$m_f < m_0$	$m_f < m_0$

m_f is the optimal matching grant rate with respect to the public good with the characteristics of the public input and m_0 is the rate with respect to the public good without the characteristics.

E is the private capital demand elasticity with respect to the tax rate in the jurisdiction.

Note that we assumed above that if $\gamma = 1$, E is a negative fixed value, whether the public goods have the characteristics of the public input or not.

TABLE 2.2

	$E > \frac{1-n}{n}$	$E < \frac{1-n}{n}$	$E = \frac{1-n}{n}$
the private capital is not mobile among regions	$\frac{\partial m}{\partial \beta} > 0$ $(E = 0)$		
the private capital is mobile perfectly	$\frac{\partial m}{\partial \beta} > 0$	$\frac{\partial m}{\partial \beta} < 0$	$\frac{\partial m}{\partial \beta} = 0$

TABLE 2.3

	$E = 0$	$E > \frac{1-n}{n}$ and $\beta \geqq \gamma$
the private capital is not mobile among regions	$\frac{\partial m}{\partial \gamma} > 0$	
the private capital is mobile perfectly		$\frac{\partial m}{\partial \gamma} > 0$

TABLE 2.4

	besides $\beta = \gamma = 0$	$E > \dfrac{1}{\beta - 1}$ besides $\beta = \gamma = 0$	$\beta = \gamma = 0$
the private capital is not mobile among regions	$\dfrac{\partial m}{\partial n} > 0$	$\dfrac{\partial m}{\partial n} > 0$ $(E = 0)$	$\dfrac{\partial m}{\partial n} = 0$
the private capital is mobile perfectly among regions		$\dfrac{\partial m}{\partial n} > 0$	$\dfrac{\partial m}{\partial n} = 0$

TABLE 2.5

	besides $\beta = \gamma = 1$	$\beta = \gamma = 1$
the private capital is not mobile among regions		
the private capital is mobile perfectly	$\frac{\partial m}{\partial E} < 0, \frac{\partial m}{\partial \varepsilon} < 0,$ $\frac{\partial m}{\partial e(1-\gamma)} < 0, \frac{\partial m}{\partial e} \leqq 0$	$\frac{\partial m}{\partial E} = \frac{\partial m}{\partial \varepsilon}$ $= \frac{\partial m}{\partial e(1-\gamma)} = \frac{\partial m}{\partial e} = 0$

Mathematical Note: Derivation of (2-22)

From (2-8), (2-21), and $f'(K^g) = f_{kg}\left(k_i^p, K_i^g\right)$, we obtain

$$\frac{1+\beta(n-1)}{1-[1+\gamma(n-1)]f_{Kg}} = \frac{1+E(1-\beta)}{(1-m) - f_{Kg}[1+E(1-\gamma)]}, \tag{M2-1}$$

where the jurisdiction-specific subscript i is omitted. From (M2-1) we can reach the solution for m.

TABLE 3.1. The Relationship between m and ε

	$\frac{V'X'}{U_x} < -1$	$\frac{V'X'}{U_x} = -1$	$0 > \frac{V'X'}{U_x} > -1$	$\frac{V'X'}{U_x} = 0$
$\beta = 0$	$\frac{\partial m}{\partial \varepsilon} < 0$	$\frac{\partial m}{\partial \varepsilon} = 0$	$\frac{\partial m}{\partial \varepsilon} > 0$	$\frac{\partial m}{\partial \varepsilon} = 1$
$0 < \beta < 1$	$\frac{\partial m}{\partial \varepsilon} < 0$	$\frac{\partial m}{\partial \varepsilon} < 0$	$\frac{\partial m}{\partial \varepsilon} \substack{= \\ < \\ >} 0$	$\frac{\partial m}{\partial \varepsilon} > 0$
$\beta = 1$	$\frac{\partial m}{\partial \varepsilon} < 0$	$\frac{\partial m}{\partial \varepsilon} = -1$	$\frac{\partial m}{\partial \varepsilon} < 0$	$\frac{\partial m}{\partial \varepsilon} = 0$

For instance, some simulated values for the parameters above can be considered as TABLE 3.2 below.

TABLE 3.2. Some Simulated Values for $\boldsymbol{\beta}$, $\boldsymbol{n}$ and $\boldsymbol{\frac{V'X'}{U_x}}$

	$\frac{V'X'}{U_x} = -2$	$\frac{V'X'}{U_x} = -1$	$\frac{V'X'}{U_x} = -0.4$	$\frac{V'X'}{U_x} = 0$
$\beta = 0$ $n = 21$	$\frac{\partial m}{\partial \varepsilon} = -1$	$\frac{\partial m}{\partial \varepsilon} = 0$	$\frac{\partial m}{\partial \varepsilon} = 0.6$	$\frac{\partial m}{\partial \varepsilon} = 1$
$\beta = 0.05$ $n = 21$	$\frac{\partial m}{\partial \varepsilon} = -1.525$	$\frac{\partial m}{\partial \varepsilon} = -0.525$	$\frac{\partial m}{\partial \varepsilon} = 0.075$	$\frac{\partial m}{\partial \varepsilon} = 0.475$
$\beta = \frac{1}{15}(0.067)$ $n = 21$	$\frac{\partial m}{\partial \varepsilon} = -1.6$	$\frac{\partial m}{\partial \varepsilon} = -0.6$	$\frac{\partial m}{\partial \varepsilon} = 0$	$\frac{\partial m}{\partial \varepsilon} = 0.4$
$\beta = 0.25$ $n = 21$	$\frac{\partial m}{\partial \varepsilon} = -1.875$	$\frac{\partial m}{\partial \varepsilon} = -0.875$	$\frac{\partial m}{\partial \varepsilon} = -0.275$	$\frac{\partial m}{\partial \varepsilon} = 0.125$
$\beta = 1$ $n = 21$	$\frac{\partial m}{\partial \varepsilon} = -2$	$\frac{\partial m}{\partial \varepsilon} = -1$	$\frac{\partial m}{\partial \varepsilon} = -0.4$	$\frac{\partial m}{\partial \varepsilon} = 0$

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