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Factor taxation and Public-Input Provision under Tax Competition: A Note

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Abstract

The previous studies of tax competition and public-input provision have focused on expenditure inefficiency that occurs when mobile capital is taxed. This paper analyzes the case where immobile factors are also included in the tax base. When a uniform tax on mobile and immobile factors is imposed, the impact of tax competition on public-input provision can be explained in terms of the technical changes caused by this provision. Public inputs have the Solow-neutral or the Harrod-neutral effect on production technology, expenditure inefficiency will occur unless the elasticity of factor substitution is equal to one. On the other hand, if these inputs have the Hicks-neutral effect, tax competition does not distort the level of public-input provision.

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1. Introduction

In the tax competition literature, there are many analyses of inefficient public policies that occur when tax bases are inter-regionally mobile; see Wilson (1999), Wilson and Wildasin (2004) and Fuest et al. (2005) for surveys of the related studies. Since the seminal works by Zodrow and Mieszkowski (1986) and Wilson (1986), one of the prominent branches of the literature is the analysis of capital-tax competition. This analysis is highly relevant because state and local governments rely on source-based taxation on mobile capital (e.g., corporate income tax and business property tax). On the other hand, state and local governments also impose taxes on immobile factors, as well as mobile factors, to finance public expenditures. Business-property tax includes business land in its tax base. Taxes are imposed on labor that seems to be less mobile than business capital. In addition, it is argued that sales taxation falls to a considerable extent on businesses (the value added generated by both immobile and mobile factors), rather than on consumers.[1]

Taxing all factors including immobile ones may be particularly important when public inputs are provided, because both immobile and mobile factors are the beneficiaries of productivity-enhancing public services. Although the previous studies of tax competition and public-input provision have focused mainly on capital-tax financing, this paper assumes that mobile and immobile factors are uniformly taxed.[2] [3] Under this assumption, the impact of tax competition on public-input provision can be explained in terms of the technical changes caused by this provision. If public inputs have the Solow-neutral or the Harrod-neutral effect, the direction of expenditure inefficiency (under- or over-provision) depends on whether or not the elasticity of factor substitution exceeds one. If this elasticity is equal to one, competition for mobile capital does not distort expenditure policy. Moreover, if public inputs have the Hicks-neutral effect on production technology,[4] the level of public-input

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[1] See Bird (2006) for business taxation at state and local levels.

[2] The previous studies of capital-tax financing include Noiset (1995), Fuest (1995), Wrede (1997), Keen and Marchand (1997), Bayindir-Upmann (1998), Matsumoto (1998, 2004, 2010), Rauscher (2000), Wilson (2005), Benassy-Quere et al. (2007) and Aronsson and Wehke (2008).

[3] In this paper, we insist on uniform factor taxation because if differential taxes on mobile and immobile are available, benevolent governments will tax immobile factors only in order to avoid tax competition. This paper's focus is not on the conditions or circumstances under which competing governments rely on mobile tax bases. On the other hand, in Wilson's (2005) model of Leviathan governments and public inputs, even if differential taxes are available, mobile capital may be taxed or subsidized to mitigate political distortion. While Keen and Marchand (1997) are known as a seminal work of the expenditure composition of public goods and public inputs under capital-tax competition, their analysis also includes capital tax policy when taxes on immobile factors are in place.

[4] See Feehan (1998) for a comprehensive analysis of Hicksian public inputs.

provision is efficient in equilibrium. These results suggest that even in the case where capital-tax financing leads to under-provision, efficient provision or over-provision is possible when immobile factors are included in the tax base.

This paper is closely related to Gugl and Zodrow (2012). In their analysis, capital-tax financing of public inputs is compared with the case where all factors are taxed. They show that these financing methods may yield different welfare implications and that factor taxation may serve as an efficient benefit tax for public-input provision. However, since they focus on the log sub- and log super-modularity of production technology, their analysis is presented in a somewhat complex manner. On the other hand, our approach based on the technical-progress effect of public inputs yields a simple necessary-sufficient condition for expenditure (in)efficiency.

2. The Model

Consider a small open region where competitive firms produce a numeraire output by using labor (*L*), capital (*K*) and a public input (*G*). While *K* is endogenous due to mobility, *L* is immobile and exogenous.[5] Production technology is given by $F(L,K,G)$. One unit of the output can be transformed into one unit of *G* or consumption good. It is assumed that marginal products are positive and diminishing ($F_{ii} < 0 < F_i$ where subscripts denote partial derivatives) and that all factors are complements in production ($F_{ij} > 0$ where $i \neq j$). In addition, we assume that *F* is CRS in private factors only: $F = F_L L + F_K K$. This means that *G* is a factor-augmenting public input.[6] This assumption means that

$$F_{LK} L + F_{KK} K = 0; \quad F_G = F_{LG} L + F_{KG} K. \tag{1}$$

Public input provision is financed by a uniform tax on capital and labor. Given public policies and factor prices, competitive firms choose the amount of factors to maximize profits. The first-order conditions for profits maximization and the public budget constraint are as follows:

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[5] We call the immobile factor "labor". Although this paper assumes that the supply of the immobile factor is exogenous, introducing endogenous supply (labor-leisure choice) does not affect our results; see Footnote 9 for further arguments.

[6] See Hillman (1978), McMillan (1979) and Feehan (1989) for classification of public inputs according to the degree of homogeneity of production functions. If the production function is constant returns to scale (CRS) in private factors only, public inputs are called "factor-augmenting". Analyzing this type is very helpful in characterizing expenditure (in)efficiency in terms of the technical-progress effect of public inputs. See Matsumoto (1998, 2000, 2004, 2010) and Wilson (2005) for capital-tax competition models with factor-augmenting public inputs. Note that Gugl and Zodrow (2012) analyze "unpaid factors" that are characterized by CRS in all factors, including public inputs, and by the same degree of rivalry as private factors. See Matsumoto and Feehan (2010) for capital-tax financing of unpaid factors.

$$F_K(L,K,G) = (1+t)r\,; \tag{2}$$

$$F_L(L,K,G) = (1+t)w\,; \tag{3}$$

$$t(wL + rK) = G\,, \tag{4}$$

where t is the tax rate, r is the net return on capital and w is the net wage rate.[7]

Residents in the region supply L and own a certain amount of capital ($\overline{K}$). The regional government sets policies so as to maximize residents' income. Note that (2) and (3) give w and K as functions of t and G ($w(t,G)$ and $K(t,G)$). Using these functions, the Lagrangean of the government's optimization is formalized as follows:

$$Max_{\ t,G}\ w(t,G)L + r\overline{K} + \lambda\{t[w(t,G)L + rK(t,G)] - G\} \tag{5}$$

where λ is Lagrange multiplier. Since the small region is a price taker in the capital market, it takes r as given.

3. The Analysis

As for (5), the first-order conditions for t and G are, respectively,

$$L\partial w/\partial t + \lambda[wL + rK + t(L\partial w/\partial t + r\partial K/\partial t)] = 0; \tag{6}$$

$$L\partial w/\partial G + \lambda[t(L\partial w/\partial G + r\partial K/\partial G) - 1] = 0\,. \tag{7}$$

Substituting (6) into (7) with respect to λ and manipulating terms yields

$$-(wL + rK)\frac{\partial w/\partial G}{\partial w/\partial t} - 1 = -rt[\partial K/\partial G - \partial K/\partial t(\frac{\partial w/\partial G}{\partial w/\partial t})]\,. \tag{8}$$

From comparative statics of (2) and (3), we have

$$\partial w/\partial t = \frac{rF_{LK} - wF_{KK}}{(1+t)F_{KK}} = -\frac{wL + rK}{(1+t)L};\quad \partial w/\partial G = \frac{F_{KK}F_{LG} - F_{KG}F_{LK}}{(1+t)F_{KK}} = \frac{F_G}{(1+t)L}, \tag{9}$$

$$\partial K/\partial t = \frac{r}{F_{KK}};\quad \partial K/\partial G = -\frac{F_{KG}}{F_{KK}}, \tag{10}$$

where the second equality of (9) is based (1).[8] Equations (8) and (9) yield the provision rule for G:

$$F_G - 1 = -rt[\partial K/\partial G + \partial K/\partial t(\frac{F_G}{wL + rK})]\,. \tag{11}$$

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[7] Note that the CRS assumption implies that in the present model, uniform factor taxation is equivalent to production taxation. Denoting the latter tax rate and revenue , respectively, by τ and τF, this equivalence implies that $\tau = t/(1+t)$.

[8] As for $\partial w/\partial G$ in (9), note that $F_{KK}F_{LG} - F_{LK}F_{KG} = F_{KK}F_{LG} + F_{KG}F_{KK}(K/L) = (F_{LG}L + F_{KG}K)(F_{KK}/L)$.

Efficiency requires that the amount of G should be set to equate the marginal product with the marginal cost ($F_G = 1$). The RHS of (11) captures the distortion due to tax competition. If the RHS is positive (negative), tax competition leads to under-provision (over-provision) of G in the sense that $F_G > (<) 1$. The bracketed term on the RHS represents the change in K that arises when t and G are marginally increased. Thus, under-provision (over-provision) occurs if and only if the balanced-budget increase in G causes capital outflows (inflows), which is consistent with the previous studies of tax competition. Formally, differentiating $t[w(t,G)L + rK(t,G)] - G = 0$ and applying (6) and (7) to the result, we have

$$\frac{\partial w / \partial t}{\lambda} dt + \frac{\partial w / \partial G}{\lambda} dG = 0 , \tag{12}$$

showing that $-(\partial w / \partial G)/(\partial w / \partial t) = F_G /(wL + rK) = dt / dG$. Therefore, the RHS of (11) is equal to $-rt[\partial K / \partial G + (\partial K / \partial t)(dt / dG)]$. It should be also noted that (12) implies that the balanced-budget policy change does not affect the net wage rate at the neighborhood of equilibrium.[9]

Substituting (10) into (11) and recalling that $F_G = F_{LG} L + F_{KG} K$, the provision rule for G is rewritten as

$$F_G - 1 = \frac{-rtL}{F_{KK}(wL + rK)} (F_{LG} r - F_{KG} w) . \tag{13}$$

Since (2) and (3) imply that the sign of $(F_{LG} r - F_{KG} w)$ coincides with that of $\partial (F_L / F_K) / \partial G$, the following result is derived:

Proposition 1.

When immobile factors, as well as mobile ones, are included in the tax base, tax competition leads to under-provision (over-provision) of public inputs if and only if $\partial (F_L / F_K) / \partial G > (<) 0$. *On the other hand, expenditure efficiency is realized if* $\partial (F_L / F_K) / \partial G = 0$.

The impact of G on the marginal rate of technical substitution (MRTS) between private factors is

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[9] Intuitively, optimization in (5) is effectively the maximization of w. Thus, the envelope theorem implies that marginal changes in t and G that meet the budget constraint do not alter w at the neighborhood of equilibrium. One can confirm that this nature of the model also applies to the case with endogenous supply of L. Even in this case where residents' optimization yields $L = L(w)$, the provision rule for public inputs does not include any distorting term associated with policy-induced changes in the immobile tax base. While the comparative statics described in (9) and (10) become somewhat complex if L is endogenous, our main results that stated in Propositions 1 and 2 do not change at all.

crucial to the nature of equilibrium. Note, from (12), that under uniform factor taxation, the balanced-budget changes in *t* and *G* have no impact on the factor-price ratio (*r/w*) at the neighborhood of equilibrium, so that MRTS remains unchanged. Thus, as long as $\partial(F_L / F_K)/\partial G \neq 0$, *K* must change to keep MRTS unchanged. This, combined with decreasing MRTS, implies that *K* falls (rises) if $\partial(F_L / F_K)/\partial G > (<) 0$. On the other hand, *K* does not change when public-input provision is neutral to MRTS.

Proposition 1 suggests that the normative nature of expenditure policy can be explained in terms of the technical changes caused by public-input provision. To make this clear, it is helpful to consider the Hillman-McMillan definition of the production function in the presence of public inputs: $F(\alpha(G)L, \beta(G)K)$.[10] $\alpha(G)$ represents the labor-augmenting impact of *G* (the Harrod-neutral technical change) while $\beta(G)$ is the capital-augmenting impact (the Solow-neutral technical change). The Hicks-neutral technical change corresponds to the case where $\alpha(G) = \beta(G)$ for any positive *G*. Note that the sign of $\partial(F_L / F_K)/\partial G$ coincides with that of $(F_{LG}/F_L) - (F_{KG}/F_K)$. It can be shown that

$$\frac{F_{LG}}{F_L} - \frac{F_{KG}}{F_K} = (\hat{\alpha} - \hat{\beta})(1 - \frac{1}{\sigma}), \tag{14}$$

where $\hat{\alpha} \equiv \alpha'/\alpha$, $\hat{\beta} \equiv \beta'/\beta$ and σ is the elasticity of factor substitution that is defined as the percentage change in the capital-labor ratio associated with a one-percent change in MRTS.[11] Proposition 1 and (14) yield the following results:

Proposition 2.

With the Hillman-McMillan definition of production technology, tax competition leads to under-provision (over-provision) of public inputs if and only if $(\hat{\alpha} - \hat{\beta})(\sigma - 1) > (<) 0$. *Therefore,*

(a) With elastic (inelastic) substitutability (i.e., $\sigma > (<) 1$*), under-provision (over-provision) occurs if the labor-augmenting impact of public inputs is stronger than the capital-augmenting impact (*$\hat{\alpha} > \hat{\beta}$*).*

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[10] See Hillman (1978) and McMillan (1979). Using their definition of production technology, Matsumoto (2004) analyzes the provision of "factor-specific" public inputs under capital-tax competition.

[11] Denote αL and βK by *l* and *k*, respectively. The CRS assumption means that $F = F_l l + F_k k$ ($F_L = \alpha F_l$; $F_K = \beta F_k$) and that $F_{il} l + F_{ik} k = 0$ ($i = l$ or k). σ is equal to $F_l F_k /(F_{lk} F)$. It can be confirmed that

$$F_{LG} = \alpha' F_l + \alpha(F_{ll}\alpha' L + F_{lk}\beta' K) = \alpha' F_l + F_{lk} K(\alpha\beta' - \beta\alpha');$$
$$F_{KG} = \beta' F_k + \beta(F_{lk}\alpha' L + F_{kk}\beta' K) = \beta' F_k - F_{lk} L(\alpha\beta' - \beta\alpha').$$

Using these equations yields (14).

Conversely, if the capital-augmenting impact is relatively strong, elastic (inelastic) substitutability implies over-provision (under-provision).

(b) Expenditure efficiency is realized if public inputs have the Hicks-neutral effect on production technology or if the elasticity of factor substitution is equal to one.

Generally speaking, the labor-augmenting and capital-augmenting impacts of *G*, respectively, raise the effective supply of *L* and *K*, changing each factor's marginal productivity. The resulting change in MRTS depends on the magnitude of factor substitutability. As for Part (b), uniform factor taxation serves as an efficient benefit tax for public-input provision with the Hicks-neutral effect. Without this neutrality, the uniform tax does not meet the benefit-tax principle.[12] On the other hand, when $\sigma = 1$, efficiency is realized regardless of the relative magnitude of $\hat{\alpha}$ and $\hat{\beta}$.[13] The relative magnitude of the productivity impacts of *G* is relevant to the direction of expenditure inefficiency when $\sigma \neq 1$.

Finally, a brief comparison with the case of capital-tax financing might be in order. In the present model, if only mobile capital were taxed, the provision rule for *G* would be as follows:

$$F_G - 1 = \frac{-rtL}{F_{KK}K} F_{LG}, \tag{15}$$

where the RHS is based on the linear homogeneity of *F* ($F_G - F_{KG}K = F_{LG}L$). This rule shows that the condition for under-provision is that public inputs and immobile factors are complements in production ($F_{LG} > 0$), which is consistent with Matsumoto's (1998, 2010) arguments on capita-tax financing of factor-augmenting public inputs.[14] Compared (13) with (15), a bias toward over-

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[12] Feehan and Matsumoto (2000) show that in general, the benefit-tax system for factor-augmenting public inputs must take the form of differential factor taxes.

[13] This case may be easily understood by referring to the case of Cobb-Douglas production functions ($L^a K^b G^c$) where σ =1 and the Hicks-neutrality holds. Interestingly, with Cobb-Douglas specification, Gugl and Zodrow (2012) also show that the provision of unpaid factors is efficient under production taxation. In their model, production taxation leads to expenditure efficiency when production technology is log modular in mobile factors and public inputs. The Cobb-Douglas function satisfies this efficiency condition.

[14] While the assumption that public inputs and private factors are complements ($F_{LG} > 0$ and $F_{KG} > 0$) seems to be reasonable under the aggregation of production in the present model, the Hillman-McMillan production function implies from equations in Footnote 11 that

$$\sigma > \theta_K (1 - \frac{\hat{\beta}}{\hat{\alpha}}) \Leftrightarrow F_{LG} > 0; \quad \sigma > \theta_L (1 - \frac{\hat{\alpha}}{\hat{\beta}}) \Leftrightarrow F_{KG} > 0,$$

where θ_L and θ_K are, respectively, the factor income share of *L* and *K* ($\alpha F_l / F$ and $\beta F_k / F$). From these conditions, $F_{LG} > 0$ and $F_{KG} > 0$ will be held unless elasticity of factor substitution is very low.

provision, which is captured by $-F_{KG}$, appears as a distorting impact of public-input provision in the present model. As a result, even if capital-tax financing leads to under-provision, over-provision or efficient provision is theoretically possible when immobile factors are also included in the tax base.

4. Conclusion

This paper has considered the normative nature of public-input provision in the case where mobile and immobile factors are uniformly taxed. Adding immobile factors to the tax base will significantly alter the impact of tax competition on the provision of productivity-enhancing public services. Interestingly, our analysis shows that expenditure (in)efficiency can be described in terms of the technical-progress effect of public inputs. This result provides a helpful, simple benchmark formula for the future analyses of tax competition and public-input provision.

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