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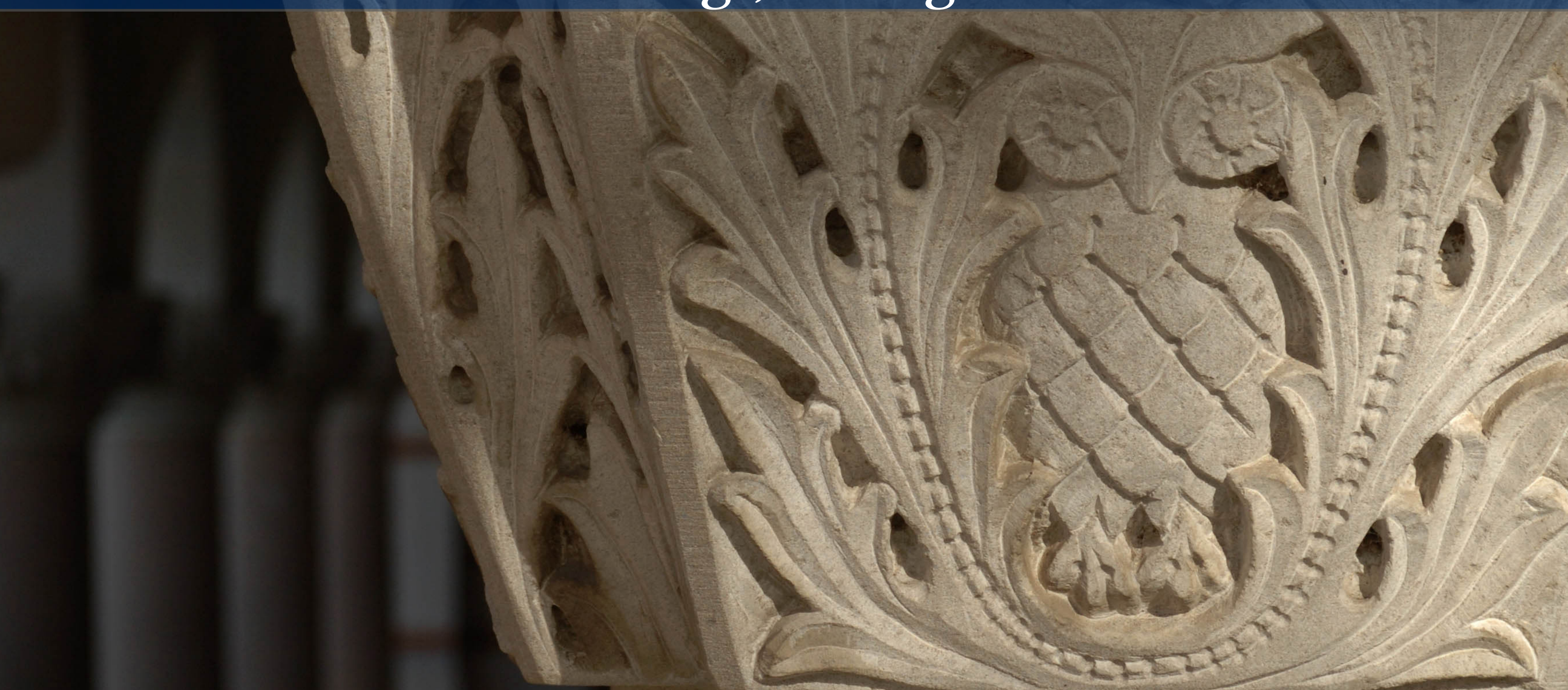

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TAX COMPETITION, LOCAL INFRASTRUCTURE, AND BUSINESS TAXATION:

A COMPARISON OF DIFFERENT TAX INSTRUMENTS

Elisabeth Gugl and George R. Zodrow

Most of the tax competition literature focuses on the provision of local public services to households. However, a number of papers, dating back to Zodrow and Mieszkowski (1986), analyze tax competition when capital taxes are used to finance local public services provided to businesses, examining the conditions under which such services are provided efficiently, under-provided, or over-provided. In addition, several prominent observers have noted that "benefit-related" business taxation is desirable on both efficiency and equity grounds and argued that such taxation should take the form of a tax based on production, such as an origin-based value-added tax. We evaluate this contention in this paper, comparing within the context of a standard model of interjurisdictional competition the relative efficiency properties of these alternative business taxes. Our simulation results suggest that under many circumstances it is more efficient to finance business public services with an origin-based production tax rather than a source-based capital tax. We also relate our results to others found in the existing literature on capital tax competition when public services are provided to businesses.

Keywords: *business public services, infrastructure, tax competition, capital taxes, production taxes, origin-based VAT*

JEL codes: *H41, H42, H21, H11*

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I. INTRODUCTION

Most of the literature on interjurisdictional tax competition focuses on the provision of local public services to households financed with taxes on mobile capital; for reviews of this voluminous literature, see Wilson (1999), Zodrow (2003), Wildasin and Wilson (2004), and Devereux and Loretz (2013). However, a number of papers, dating back to Zodrow and Mieszkowski (1986), analyze tax competition when capital taxes (or a combination of capital taxes and head taxes) are used to finance local public services provided to businesses, examining whether such services are provided efficiently, under-provided, or over-provided. In addition, several prominent experts on state and local finance have noted that "benefit-related" business taxation is desirable on both efficiency and equity grounds, and argued that such taxation is more closely approximated by a tax on production, such as an origin-based value-added tax (VAT), rather than a tax on capital or capital income. In this paper, we evaluate this contention, comparing within the context of a model of interjurisdictional tax competition the relative efficiency properties of business taxes that are assessed on production to those assessed on capital.

Three strands of the literature on state and local taxation of businesses are particularly relevant for our analysis. The first is the extension of the classic Tiebout (1956) model, under which interjurisdictional competition with perfectly mobile consumers and head tax finance results in an efficient level of local public services to households, to the efficient provision of business public services. This literature is best exemplified by the work of Oates and Schwab (1991), who construct a multi-jurisdictional tax competition model in which firms in each jurisdiction produce output using capital, labor, and a publicly provided input financed with a property tax on capital. The key assumption of the Oates-Schwab model is that the amount of the publicly provided input — which, following most of the literature, is modeled as a publicly-provided private good — is allocated to firms precisely in proportion to the stock of capital that they utilize in that jurisdiction.[1] This assumption is sufficient to make a property tax on capital equivalent to a user charge for services provided, so that local business public services are provided efficiently. A broadly similar approach is utilized by Sinn (1997), who assumes that each unit of capital must use a public service once before it can be utilized in production (e.g., capital must make a single trip on a congestible public highway before being placed in service), again implying that an appropriately set property tax on capital functions as a user charge/congestion fee for the public service and ensures efficiency in the allocation of resources to business public services.

A second strand of this literature relaxes the rather stringent assumption that the ratio of capital and public services is fixed in production, and instead assumes more generally that the production function simply includes as an input public services that are financed with property taxes (or any source-based tax on capital). For example, although Zodrow and Mieszkowski (ZM) (1986) focus on public services provided to residents, they also consider the case of publicly-provided business public services financed with property taxes and obtain two main results. First, starting from an initial equilibrium in which the efficient level of business public services is financed entirely with head taxes, they find that — as in the case of public services provided to households — the use of the property tax to finance local business public services leads to under-provision of such services, as local governments reduce reliance on the property tax to avoid driving mobile capital out of their jurisdictions. However, once property tax finance

[1] Oates and Schwab also assume that a local public good is provided to residents of the jurisdiction and financed with head taxes, following the approach utilized in the basic Tiebout model.

is introduced, the effect of a tax increase on the level of business public services is theoretically ambiguous, as it depends on how the perceived tax responsiveness of mobile capital (the capital tax "base erosion" effect), which interacts with the initial tax rate when it is positive in the initial equilibrium, varies as the tax rate increases.

ZM make two assumptions in their analysis that guarantee that an increase in the property tax rate in a jurisdiction always results in capital outflow from the taxing jurisdiction. Several subsequent papers have investigated the implications of alternative assumptions, on the grounds that the business public services financed with a property tax increase might increase the productivity of capital sufficiently that capital would be attracted to the jurisdiction.[2] For example, Bayinder-Upman (1998) constructs a model in which property tax rate competition leads to under-provision (over-provision) of business public services as long as an increase in the tax rate causes capital outflows (inflows). Similarly, Dhillon, Wooders, and Zissimos (2007) construct a tax competition model in which a sufficient degree of complementarity between capital and the public good implies that a tax increase results in capital inflows and show that under-provision, over-provision, and efficient provision can result, depending on the nature of this complementarity.[3]

The third strand of the literature on state and local taxation of businesses relevant to our analysis reflects a very different approach. Rather than examining the effects of property tax finance on local public service provision, several prominent observers have argued that state and local taxation of businesses to finance the provision of business public services should be based

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[2] We discuss this literature in more detail in Section IV.

[3] See also Noiset (1995) and Matsumoto (1998), who obtains similar results in a model in which the business public service is a pure public good, and Matsumoto (2000b) who examines the implications of alternative assumptions regarding the congestibility of the business public service.

on production rather than the amount of capital utilized. This argument draws on the conventional wisdom that both efficiency and equity considerations imply that state and local governments should finance public services, including those provided to businesses, with user charges and fees that function as benefit taxes. Subnational governments, because they are effectively small open economies, should especially avoid inefficient source-based taxes on highly mobile capital that are not directly related to the benefits of business public services. However, if user charges are not available or are infeasible for technical, political, or other reasons, state and local governments must use alternative tax instruments to finance public services. In the United States, state and local taxes often take the form of property taxes, corporate income taxes, or sales taxes that are inappropriately assessed on business capital, all of which correspond roughly to the capital tax analyzed in our model and thus distort a wide variety of decisions, including those regarding capital accumulation and allocation and the level of public services provided, as stressed in the tax competition literature. For these reasons, Bird (2002, p. 225) argues that the benefit principle of taxation supports the use of a production tax — that is, to the extent that public services are provided to business, firms should be taxed to pay for the benefits they receive. More specifically, he argues that an origin-based, consumption-based VAT[4] would tax business more broadly and in a way more closely related to benefits received than would a tax on capital (such as a property tax at the municipal level or a state or provincial level corporate tax or sales tax that taxes firms' capital inputs), and would thus be more consistent with the concept of a benefit tax. In addition, McLure (2003) argues that the increasing importance of electronic commerce makes the traditional destination-based VAT

[4] Note that an income-based VAT could also be viewed as a production-related tax, as could a sales or gross receipts tax that included deductions for input costs (other than labor) and thus approximated a VAT.

difficult to enforce, and thus provides a complementary argument for the use of an origin-based VAT.

This paper extends this literature in two ways, drawing on a model constructed in Gugl and Zodrow (2014). First, we present the results of some simulation analyses that examine within the context of this model the efficiency properties of business taxes that are assessed on production levels relative to those that are assessed on capital. In particular, we show how the level of business public service provision in our model depends on the log (super/sub) modularity of the production function. Second, we provide a brief review of the literature on capital tax competition when public services are provided to businesses, attempting to reconcile various results regarding the effects of capital taxation on the extent to which business public services are under-provided, over-provided, or provided efficiently.

The paper is organized as follows. In the following section, we outline the model and our comparison of the efficiency properties of production and capital taxes. Section III provides simulation analyses of the model, focusing on the extent to which business public services are under-provided, over-provided, or provided efficiently. A brief reconciliation of these results with others that have appeared in the literature is presented in Section IV, and the final section concludes with a discussion of possible policy implications.

II. OVERVIEW OF THE MODEL AND RESULTS

A. Some Key Assumptions in the Model

The model we construct in Gugl and Zodrow (2014) is broadly similar to the model of symmetric multi-jurisdictional capital tax competition utilized by ZM. There are N identical jurisdictions, each of which faces a local labor market and national markets for capital and a single consumption good. Each jurisdiction perceives itself as a small open economy, and thus takes the rate of return r and the price of the consumption good, which is the numeraire, as given in setting its policies. Residents of a jurisdiction derive utility solely from the consumption of a private good (as only business public services are considered in the model) and labor supply L is assumed to be fixed in each jurisdiction. Each resident owns the same amount of the fixed national capital stock $\bar{K}$, so the residents of a jurisdiction earn capital income $r\bar{K} / N$, where the amount of capital employed in the jurisdiction (denoted by K) can differ from the amount of capital owned by its residents $(\bar{K} / N)$. Each jurisdiction seeks to maximize the income of its residents (and therefore total local consumption).

Given this fairly standard basic structure, a critical issue in the construction of the tax competition model is how the consumption good is produced, especially the role that business public services provided by local governments play in the production of the good, that is, the way that the public service enters as an input into the private production function. This involves two related issues: (1) whether the public service is a publicly provided private input, a congestible public input, or a pure public input, and (2) whether the production function is characterized by constant, increasing, or decreasing returns to scale in the private and public inputs.

We follow Oates and Schwab (1991) and most of the state and local public finance literature in the Tiebout (1956) tradition — as discussed, for example, by Hamilton (1983) — in assuming that the public input is a publicly provided private good (that is, it is subject to congestion to the full extent of a private good), and that the production technology exhibits constant returns to scale (CRS) in all factors, both public and private. While this characterization may not be appropriate for all types of public investments, Gramlich (1993, p. 1193) suggests that many public investment projects fall into this category. Such a technology implies that either privatization of the supply of the public input or charging the appropriate user fees would be efficient.

Firms are thus assumed to produce a single consumption good using capital *K,* business public services *B*, and fixed labor *L*, with a production function $F(K,B,L)$ that is CRS in all inputs and strictly concave in (*K*, *B*). In addition, again as in the majority of the literature, we assume complementarity between capital and the public service (but not fixed proportions), as we assume that the production function is characterized by a strictly positive cross-derivative between capital and the public service; this approach also generally follows most of the literature, including Zodrow and Mieszkowski (1986), Bayindir-Upmann (1998), Keen and Marchand (1997), and Dhillon, Wooders, and Zissimos (2007), and is one of the options considered by Feehan and Matsumoto (2000), and Matsumoto (1998, 2000a, b).

Alternative assumptions are of course possible, and various options are discussed by Feehan and Matsumoto (2000), Richter (1994), Sinn (2003), and Matsumoto (1998, 2000a). In addition, as discussed by Matsumoto (2000a), these two questions are critical to determining the optimal number of firms in a jurisdiction. For example, models such as ours that assume only one firm per jurisdiction implicitly avoid the former question, but have the flavor of a model that assumes the public service provided to businesses is either a pure public good or a pure private good. Matsumoto (2000a) notes that the optimal number of firms in a jurisdiction is one with a publicly provided congestible good if the production technology is CRS in the private inputs only. In contrast, our assumption that the production technology is CRS in all factors including the public input has the advantage that the efficient provision of the public service does not depend on the number of firms, which is indeterminate in the model.

We also must specify how the public service is produced, that is, whether the production of the public service exhibits constant, increasing, or decreasing returns to scale. We follow most of the literature in assuming constant returns to scale and thus constant marginal costs (Oates and Schwab, 1988, 1991; Sinn, 2003; Bayindir-Upmann, 1998; Keen and Marchand, 1997; Richter, 1994; Matsumoto 2000a). Two alternative approaches, which Matsomoto (2000a) points out are equivalent, are to assume either an imperfectly congestible public input and a constant marginal cost of producing that public input, or a perfectly congestible public input (i.e., our publicly provided private service) and decreasing marginal costs of producing the public service.

Given our characterization of the production function, we explore the provision of business public services under local production and capital taxes in the presence of interjurisdictional tax competition.[5] In particular, we examine the relationship between log (super/sub) modularity of the production function and the efficiency of local provision of business public services under these alternative tax structures.

Log (super/sub) modularity specifies how the marginal productivity of capital is affected by changes in the level of the public service. Specifically, if the production function is log submodular (supermodular), the marginal productivity of capital relative to output decreases (increases) as more public service is provided. This occurs if the capital elasticity of production is lower (higher) at a higher (lower) level of *B*. More formally, a production function is log modular if and only if the elasticity of the marginal productivity of the public service with respect to capital, $\zeta_{BK} = F_{BK}(K/F_B)$, is equal to the elasticity of production with respect to capital, $\varepsilon_K = F_K(K/F)$; it is log supermodular if and only if $\zeta_{BK} > \varepsilon_K$, and log submodular if and

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[5] We do not, however, consider other alternative tax instruments; for example, a tax on immobile labor would be preferable to either production or capital taxes in this model, and Bucovetsky and Wilson (1991) show that taxes on labor are generally preferred to taxes on highly mobile capital in models of tax competition even when labor is supplied elastically.

only if $\zeta_{BK} < \varepsilon_K$.

These elasticities are not related in any particular way to the elasticity of substitution between labor and capital (σ_{LK}) for standard production functions. For example, consider the following production function with parameters $\alpha < 0$ or $0 < \alpha < 1$ and $\beta > 0$

$$
\begin{aligned}
&F(L,K,B) = \left(\beta L^{\alpha/2} K^{\alpha/2} + B^{\alpha}\right)^{1/\alpha} \\
&\zeta_{KB} = \frac{1-\alpha}{2}\left(\beta L^{\alpha/2} K^{\alpha/2} + B^{\alpha}\right)^{-1} \beta L^{\alpha/2} K^{\alpha/2} \\
&\varepsilon_K = \frac{1}{2}\left(\beta L^{\alpha/2} K^{\alpha/2} + B^{\alpha}\right)^{-1} \beta L^{\alpha/2} K^{\alpha/2} \\
&\sigma_{LK} = 1
\end{aligned}
$$

This production function is log supermodular for $\alpha < 0$ and log submodular for $0 < \alpha < 1$, while the substitution elasticity between labor and capital is kept constant at $\sigma_{LK} = 1$ in all cases.

Log (super/sub) modularity plays an important role in the matching literature when there are search frictions, as positive (negative) assortative matching requires that all matching sets be convex, which is determined by the log modularity properties of the production function (Peters and Siow, 2002; Smith, 2006). However, to the best of our knowledge, the implications of the log modularity properties of the production function have not been examined in models of interjurisdictional tax competition. We show in the following section that log (super/sub) modularity of the production function determines whether jurisdictions anticipate that an increase in business public services financed with a production tax will increase or decrease the demand for capital within the taxing jurisdiction and thus lead to efficient provision, overprovision, or underprovision of business public services. In addition, we show underprovision of business public services is guaranteed in a capital tax equilibrium if the production function is log modular or log submodular, while efficient provision, overprovision, or underprovision of business services can result under capital tax finance of business public services when the production function is log supermodular; this analysis includes an examination of the implications of the log modularity properties of the commonly used Cobb-Douglas and CES production functions.

B. Modeling a Production Tax

Consider first the production tax equilibrium in our model of interjurisdictional competition. As noted above, Bird (2002) argues that production taxes are more consistent with benefit taxation than capital taxes. In particular, since output is a function of all inputs including the public service, a tax on output can be viewed as a uniform tax on all inputs including the publicly provided service. By comparison, unless capital and the public service are inextricably linked as in the Tiebout-related business public service models described previously, a capital tax imposes tax on a single input and violates the production efficiency theorem of Diamond and Mirrlees (1971). In addition, a production tax has a broader tax base and imposes a relatively low tax rate on a relatively less mobile input, labor. Both of these factors make it more likely that the production tax will be more efficient than a capital tax.

The model and results of Gugl and Zodrow (2014), who analyze the efficiency properties of a production tax when public inputs are provided to firms and local jurisdictions compete for mobile capital, can be summarized as follows.[6] In the case of a tax on production, the local jurisdiction chooses its production tax rate *t* to maximize total resident income

$$I = (1-t)F(K,B,L) - rK + r\overline{K} / N$$

subject to its budget constraint

[6] There is a large literature on the performance on origin-based versus destination-based VATs, and the Diamond-Mirrlees result assumes the existence of an efficient set of destination-based commodity taxes. However, in all of these models, tax revenues are used to provide public services to residents or to finance an exogenous level of government expenditures rather than providing business public services; see Gugl and Zodrow (2014) for further discussion.

$$B = t\,F(K,B,L).$$

Firms choose capital to maximize profits or

$$\max_K \left(1-t\right)F(K,B,L) - rK - wL,$$

which yields the first order condition

$$r = (1-t)F_K(K,B,L).$$

Local jurisdictions realize that by increasing their production tax unilaterally, the amount of capital employed in the jurisdiction may change. Substituting from above, the perceived change in the jurisdiction's capital in response to an increase in the production tax is obtained from

$$\frac{\partial B}{\partial t} = \frac{F}{1-tF_B},$$

$$\frac{\partial B}{\partial K} = \frac{tF_K}{\left(1-F_B t\right)}$$

$$\frac{dK}{dt} = \frac{\dfrac{F_K}{\left(1-t\right)} - F_{KB}\dfrac{\partial B}{\partial t}}{\left(F_{KK} + F_{KB}\dfrac{\partial B}{\partial K}\right)} = \frac{F_K\left(1-F_B t\right) - F_{KB}F\left(1-t\right)}{\left(1-t\right)\left(F_{KK}\left(1-F_B t\right) + F_{KB}F_K t\right)}$$

Gugl and Zodrow (2014) show that the denominator of this expression is negative. The sign of the numerator of dK/dt varies depending which of two opposing effects outweighs the other. The first term in dK/dt expresses the marginal increase in the cost of capital to firms due to an increase in *t.* An increase in the production tax at the current level of the capital in the jurisdiction lowers the value of the marginal productivity of capital all else equal. As firms are paid less for their product, this means they would lower the amount of capital to maximize profits. However, as shown in the second term, an increase in the production tax at current levels of capital also increases the public service and with it the marginal productivity of capital. Which effect dominates determines whether the local government anticipates an outflow or inflow of capital as it raises its production tax.

Rearranging the terms in the numerator of *dK*/*dt* the sign of the numerator is determined by

$$-F_K + F_{KB}F + t(F_K F_B - F_{KB}F).$$

Recall that the production function is log modular if the elasticity of the marginal productivity of the public service with respect to capital is equal to the capital elasticity, or if

$$\zeta_{BK} = F_{KB}\frac{K}{F_B} = F_K\frac{K}{F} = \varepsilon_K .$$

Hence if the production function is log modular, $F_K F_B - F_{KB}F = 0$. In evaluating which production tax to set, suppose the government chooses one where $F_B = 1$ given the current level of capital. Then the first term can be rewritten as $-F_K + F_{KB}F = -F_K F_B + F_{KB}F$. Since the production function is log modular this term necessarily is zero. Hence the government would anticipate no change in the amount of capital employed in its jurisdiction if it set a production tax such that the public service is provided in the efficient amount. From this discussion one can also see, that in the case of log super or submodularity of the production function, the local government would anticipate a change in the amount of capital employed if it set its production tax so that $F_B = 1$ at the current level of capital. So perceiving a change in the amount of capital and setting a production tax that leads to $F_B = 1$ at current levels of capital is inconsistent. This consideration is the source of inefficiency in providing a public service financed by a production tax when the production function is not log modular.[7]

[7] We thank Timothy Goodspeed whose comments facilitated this interpretation of the results under the production tax.

Note that since all jurisdictions are identical, they will all follow the same tax policy, which implies that capital does not change in any jurisdiction in the symmetric equilibrium; however, each jurisdiction fails to realize this and perceives that a tax increase will cause the capital response shown above.

Gugl and Zodrow derive the following optimality condition for the production tax

$$F_K t\left(F_{KB}F - F_B F_K\right) - F_{KK}F\left(F_B - 1\right) = 0.$$

In the log modular case, $F_B = 1$ and $F_K F_B = F_K = F_{KB}F$, which implies that business public services are provided efficiently, and $dK / dt = 0$, that is, in this efficient equilibrium each jurisdiction perceives that the capital stock in their jurisdiction will remain unchanged in response to an increase in the production tax and in equilibrium.

By comparison, if the production function is log submodular or log supermodular, $\zeta_{BK} \neq \varepsilon_K$, the level of public services is inefficient, and the production tax rate is

$$t = \frac{K\left(-F_{KK}\right)\left(1 - F_B\right)}{F_B F_K\left(F_{BK}K / F_B - F_K K / F\right)}.$$

This implies overprovision $(F_B < 1)$ if and only if the production function is log supermodular and $\zeta_{BK} > \varepsilon_K$, and underprovision $(F_B > 1)$ if the production function is log submodular and $\zeta_{BK} < \varepsilon_K$.

C. Modeling a Capital Tax

Consider next the case in which local jurisdictions tax capital in order to finance the public service to firms. Each jurisdiction chooses its capital tax rate τ to maximize the aggregate income of its residents $I = F(K,B,L) - (r+\tau)K + r\overline{K}$ subject to a budget constraint of $B = \tau K$. In addition, firms choose their capital stock to maximize firm profits $F(K,B,L) - (r+\tau)K - wL$

which implies $F_K(K, B, L) = (r + \tau)$. Local jurisdictions again perceive increasing their capital tax unilaterally may change the amount of capital employed in the jurisdiction, although in the symmetric equilibrium with all jurisdictions acting identically this in fact will not occur. Substituting from above, the perceived change in the jurisdiction's capital in response to an increase in the capital tax is

$$\frac{dK}{d\tau} = \frac{1 - F_{KB}K}{F_{KK} + F_{KB}\tau}.$$

The denominator of $dK/d\tau$ is unambiguously negative. The numerator reflects the difference between the cost of a marginal increase in the tax on capital, given by 1, and the benefit of the associated marginal increase in B on the marginal productivity of capital, given by $F_{KB}K$. If the marginal cost and marginal benefit of another unit of capital from the firm's perspective are not equal, firms will lower their demand for capital if $F_{KB} < 1$ and increase it if $F_{KB} > 1$.

The first order condition for the optimal capital tax is

$$K\left(F_B - 1\right) + F_B \tau \frac{dK}{d\tau} = 0.$$

Consistent with Bayinder-Upmann (1998), Gugl and Zodrow show that the capital tax equilibrium can be characterized in one of the three ways:

(1) The perceived change in the capital stock $dK/d\tau = 0$ and the public service is provided efficiently, i.e., $F_B = 1$.

(2) There is a perceived outflow of capital, $dK/d\tau < 0$, and the public service is underprovided, i.e., $F_B > 1$.

(3) There is a perceived inflow of capital, $dK/d\tau > 0$, and the public service is overprovided, i.e. $F_B < 1$.

These outcomes depend on the log (sub/super) modularity properties of the production function. There is neither perceived inflow nor outflow of capital if

$$1 - F_{KB}K = 0$$
$$\zeta_{KB} = F_{BK}\frac{K}{F_B}$$
$$\zeta_{KB} = \frac{1}{F_B}.$$

The numerator of $dK/d\tau$ is zero if and only if the elasticity of the marginal productivity of the public service with respect to capital is equal to the inverse of the marginal productivity of the public service. It is thus impossible to have efficient provision in the case of a production function that is log (sub)modular and strictly concave in (*K, B*). To see this, note that if the production function is log submodular, $\zeta_{KB} \leq \frac{F_K K}{F}$. Efficiency requires $F_B = 1$ and thus $\zeta_{KB} = 1$. But given that $F_K K / F < 1$ by our assumption of strict concavity in of *F* in *K*, the numerator of $dK/d\tau$ can never equal zero. Thus production functions that are log submodular in (*K*, *B*) cannot result in an equilibrium with efficient provision of the business public service. Indeed, the case of a production function that is log submodular always results in underprovision. To see this, note that since overprovision would result only if $F_B < 1$, which occurs only if the numerator of $dK/d\tau$ is negative; this in turn requires $\zeta_{KB} > 1$, which is impossible since $F_K K / F < 1$ by our assumption of strict concavity in of *F* in *K*.[8] On the other hand, if the production functions is log supermodular, it is possible that $F_B = 1$ and $\zeta_{KB} = 1$ hold simultaneously, and efficient provision, underprovision, and overprovision are all possible.

To conclude this section, we note that Gugl and Zodrow (2014) obtain the following three results for the cases of production tax finance and capital tax finance of business public

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[8] See Gugl and Zodrow (2014) for an alternative proof of this result.

services

(1) If the production function is log modular, then the production tax is efficient and the capital tax leads to underprovision of the public service to firms.

(2) If the production function is log submodular, then the production tax and the capital tax lead to underprovision of the public service to firms.

(3) If the production function is log supermodular, then the production tax leads to overprovision and the capital tax may lead to overprovision, underprovision, or efficient provision of the public service to firms.

In addition, we also prove that in the cases of production functions that are log modular and log submodular in (K, B), the production tax is unambiguously more efficient than the capital tax, while the relative efficiency properties of the two taxes are theoretically ambiguous if the production function is log supermodular.

III. Simulation Results

In this section, we provide some simulation results that illustrate the results outlined above and provide an indication of the relative magnitudes of the various effects analyzed, including the extent of underprovision or overprovision of business public services and the associated efficiency costs, under various scenarios for both production tax and capital tax finance of business public services. Consider first the Cobb-Douglas production function, the most common log modular production function.[9] We keep $L = 1$ fixed for all of the numerical examples provided in Table 1. The first column reports the amount of capital and thus the capital-labor ratio in equilibrium in a representative jurisdiction. In the second and third columns we consider various combinations of the capital share parameter β and the public services share

[9] Recall that log modularity requires $\zeta_{KB} = \varepsilon_K$; for the Cobb-Douglas production function $\zeta_{KB} = \varepsilon_K = \beta$.

parameter γ.[10] Recall that a production tax is efficient in the Cobb-Douglas case, so we report only the efficient production tax rate (t) for each set of parameter values. In fact, the efficient production tax is equal to the output elasticity of the public service (as well as ζ_{KB}), which equals the public services share parameter, i.e. $t = \gamma$ (columns 3–4). We report the optimal capital tax rate (τ) in the fifth column, the percentage reduction in business public services under the capital tax in column (6), and the percentage loss in residents' income if the efficient production tax is replaced with an inefficient capital tax, which results in under-provision of business public services, in the final column. These results indicate that use of the capital tax results in significant underprovision of public services (by 22–65 percent), coupled with smaller reductions in the income of local residents (between 0.3–11.6 percent). As would be expected, the magnitude of the inefficiency under the capital tax regime increases with increases in the values of the public services share parameter and the capital share parameter.

[Table 1 goes about here]

The Cobb-Douglas production function, which has an elasticity of substitution between each pair of inputs of one, is often used in the literature. However, the assumption of a unitary elasticity of substitution between labor and capital is controversial; for example, Chirinko (2002) argues that most empirical studies find an elasticity of substitution in production between labor and capital between 0.2 and 0.6, and Chirinko, Fazzari, and Meyer (2004) obtain an estimate of 0.4.

On the other hand, empirical evidence on the elasticity of substitution between capital

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[10] We include some relatively large values of the public service share parameter to examine their implications for the simulations; note also that the shares under the capital tax, which are more comparable to the observed shares, are roughly 20–65 percent smaller than those under the efficient production tax.

and public services is limited. In a recent survey of the effects of public investment on private capital, Pereira and Andraz (2013) note that most studies simply assume a Cobb-Douglas production function, implying a unitary elasticity of substitution. However, although they do not directly measure the elasticity of substitution between capital and public services, Munnell (1990) and Eisner (1991) provide evidence which suggests that public and private capital are highly substitutable. Moreover, a moderately high elasticity of substitution seems plausible for most business public services provided by state and local governments. For example, private capital could relatively easily substitute for water supply infrastructure, public transportation, police protection (surveillance systems and more secure structures), and fire protection (sprinkler and monitoring systems, more fire retardant construction).

Accordingly, we consider next the case of a constant elasticity of substitution (CES) production function that allows for substitution elasticities other than one. The function is given by

$$F(K,B,L) = \left(\beta K^{\alpha} + \gamma B^{\alpha} + L^{\alpha}\right)^{\frac{1}{\alpha}}$$
$$\zeta_{KB} = \beta(1-\alpha)\left(\frac{K}{F}\right)^{\alpha}$$
$$\varepsilon_K = \beta\left(\frac{K}{F}\right)^{\alpha}$$
$$\sigma_{LK} = \sigma_{KB} = \frac{1}{1-\alpha} = \sigma$$

As noted above, the CES function is log supermodular with $\zeta_{BK} > \varepsilon_K$ if and only if $\sigma_{KB} < 1$, and it is log submodular with $\zeta_{BK} < \varepsilon_K$ if and only if $\sigma_{KB} > 1$.

We simulate the model for various parameter values. To obtain an interior solution for *B* while still allowing for the possibility of an efficient solution $(F_B = 1)$, we consider only 0 < γ < 1. In all simulations we keep the capital-labor ratio equal to 0.25. We also choose parameter values such that the optimal capital tax rates fall into a plausible range; note, however, that many parameter combinations would result in unreasonably high capital tax rates in the model.

Consider first the case of a log submodular CES production function with an elasticity of substitution between capital and business public services greater than one $\sigma_{KB} = \sigma > 1$. The results shown in Table 2 confirm that both the production and capital tax scenarios lead to underprovision of the business public service. We also show the degree of underprovision of the business public service and the resulting reductions in residents' income when a capital or production tax is used, relative to a lump sum or head tax efficient equilibrium. The first four rows of Table 2 show how the optimal tax rates change as the elasticity of substitution in production increases. Higher substitutability implies less public services and therefore lower tax rates, and the degree of underprovision declines as the substitution elasticity increases. Although the capital tax is more inefficient than the production tax, the efficiency losses are quite small for both taxes. Increases in the coefficients for both capital and public services increase the differential between the optimal capital tax rate and the optimal production tax rate, as illustrated in the last four rows of Table 2, which shows that this differential can be quite large. In addition, these results confirm that the production tax is always less inefficient than the capital tax with a CES production function with an elasticity of substitution greater than one. Moreover, the underprovision of public services associated with the production tax is minimal. By comparison, with the capital tax the degree of underprovision can be as high as 32.3 percent, although this still results in an efficiency loss of only 0.14 percent.

[Table 2 goes about here]

Consider next the case of a log supermodular CES production function with an elasticity of substitution between capital and public services less than one $\sigma_{KB} = \sigma < 1$. In this case, the production tax leads to overprovision of business public services, while the capital tax can result in underprovision, efficient provision, or overprovision. In Table 3, we begin with an example that results in the efficient provision of business public services in the capital tax equilibrium. This is the case when the parameters satisfy

$$\gamma = \left(\frac{-\alpha\beta K^{\alpha} - L^{\alpha}}{(1-\alpha)\beta K^{\alpha}} \right)^{1-\alpha}.$$

We calculate the degree of overprovision of business public services and the percentage decrease in residents' income when a production tax is used. We then consider several inefficient equilibria under the capital tax by altering the elasticity of substitution in production while holding all the other parameters constant. An increase in the substitution elasticity results in underprovision in case of a capital tax, while a decrease in the substitution elasticity results in overprovision. Note that as we move further away from the efficient parameter constellation by decreasing the substitution elasticity, the production tax becomes more efficient than the capital tax. These results suggest that a production tax leads to a relatively small loss in residents' income as compared to lump-sum taxes. As noted, a capital tax can result in an efficient equilibrium, but for most parameter values, it results in rather high capital tax rates and a larger loss in residents' income than under the production tax.[11]

[Table 3 goes about here]

In Table 4, we compare the sensitivity of the optimal capital tax rate to a change in the coefficient on capital relative to the change in the optimal production tax (see also Table 2). In

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[11] As we move further away from the efficient equilibrium, we found many cases in which there was no interior solution to the capital tax equilibrium but the production tax still had an interior solution.

Table 4 the capital tax is more efficient than the production tax but the welfare loss with a production tax is still low. We can also see once again that overprovision as well as underprovision can be the result in a capital tax equilibrium.

[Table 4 goes about here]

Table 5 considers some additional cases that reflect equilibria that are inefficient under the capital tax. In this table we choose the same parameter changes for the coefficients on capital and on the public service as in Table 2.

[Table 5 goes about here]

In summary, these results suggest that a production tax tends to produce small welfare losses more consistently than a capital tax. Tables 3–5 also reveal an important issue raised by the production tax, relative to the capital tax: the optimal production tax results in relatively high tax rates that may be politically infeasible.

An alternative simulation approach is to show the government's first order conditions graphically under the various tax regimes as a function of the level of business public services *B*. The first order conditions for the capital tax and the production tax,

$$\tau\left(F_{KB}B - F_B\tau\right) - F_{KK}B\left(F_B - 1\right) = 0$$
$$F_K t\left(F_{KB}B - F_B F_K t\right) - F_{KK}B\left(F_B - 1\right) = 0,$$

can be rewritten as functions of the level of business public services. The first equation for the capital tax becomes

$$B\left(F_{KB}K - F_B\right) - F_{KK}K^2\left(F_B - 1\right) = 0,$$

and the second equation for the production tax is

$$F_K B\left(F_{KB}F - F_B F_K\right) - F_{KK}F^2\left(F_B - 1\right) = 0.$$

For the CES functional forms, these equations become, in the case of the production tax,

$$-\alpha\beta\gamma\frac{B^{\alpha}}{(L^{\alpha}+\beta K^{\alpha}+\gamma B^{\alpha})}K^{\alpha}+(1-\alpha)(L^{\alpha}+\gamma B^{\alpha})\left[\gamma\left(\frac{(L^{\alpha}+\beta K^{\alpha}+\gamma B^{\alpha})^{1/\alpha}}{B}\right)^{1-\alpha}-1\right],$$

and in case of the capital tax,

$$-\gamma B^{\alpha}(L^{\alpha}+\alpha\beta K^{\alpha}+\gamma B^{\alpha})+\beta(1-\alpha)K^{\alpha}(L^{\alpha}+\gamma B^{\alpha})\left[\gamma\left(\frac{(L^{\alpha}+\beta K^{\alpha}+\gamma B^{\alpha})^{1/\alpha}}{B}\right)^{1-\alpha}-1\right],$$

with *B* as the dependent variable. [12]

We plot these two equations for specific parameter values in Figure 1. In generating this graph, we take advantage of the fact that in equilibrium each jurisdiction has the same capital stock as it would if user fees could be charged. Hence the graph plot the left hand side of these equations as functions of *B*, holding capital fixed. These simulations can be run for a wide range of parameter constellations and thus can be used to assess whether there is a strong case to be made in favor of capital taxes if the production function is log supermodular. This, however, appears not to be the case. Although the capital tax can be efficient (as shown in Table 3 above) and the production tax always leads to inefficient overprovision, as we change one of the parameters holding the others constant, the production tax outperforms the capital tax. The results shown are typical of those obtained in a wide range of simulations of the model, which are available online as described below. Moreover, in cases where the capital tax is more efficient than the production tax, the differences in efficiency gains are relatively small.

Figure 1 provides an example of these graphical analyses for a log supermodular CES production function; it matches the second row of Table 5 ($\sigma = 0.6, \beta = 0.5, \gamma = 0.1$)

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[12] Note that in our model focusing on provision levels of the public service rather than the tax rate, does not change the nature of the equilibria; Sinn (1997) makes the same point. However, there are other models (e.g., Wildasin, 1988 and Wilson, 2005) in which the equilibria change depending on whether jurisdictions compete in expenditure or in tax rates.

[Figure 1 goes about here]

In Figure 1, the point at which the red "capital tax" line crosses the horizontal axis indicates the amount of business public services provided in the capital tax equilibrium. The intersection of the blue "production tax" line with the horizontal axis marks the level of public services provided in the production tax equilibrium, and the intersection between the black "efficient *B*" line and the horizontal axis marks the efficient amount of *B*. In this CES case with log supermodularity, the capital tax is inefficiently low and the public service is overprovided in the production tax equilibrium.[13]

In Table 4 we saw that the capital tax can lead to over-, under- and efficient provision in the log supermodular case. In Figure 2 we plot the public service level under each tax regime and the efficient service level as a function of the public service share coefficient γ, for a fixed substitution elasticity $\sigma = 0.5$ and a fixed capital share parameter of $\beta = 0.5$. The figure thus provides examples of comparative static results for variations in γ, holding all other parameter values constant.[14]

[Figure 2 goes about here]

Figure 2 includes the efficient provision under the capital tax that is also reported in Tables 3 and 4. This is where the black line (always efficient provision) and the red line (provision under the capital tax) cross. One can verify that this happens at a value of the coefficient on public service

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13 The reader can examine a wide variety of additional cases by downloading the file "FOCs.01.cdf" from http://web.uvic.ca/~egugl.

14 The reader can examine a wide variety of additional cases by downloading the file "EquilibriumProvision.02.cdf" from http://web.uvic.ca/~egugl.

$\gamma = 0.0625$. We let the coefficient vary from 0 to 0.2

Finally, Figure 3 examines the percentage deviations of the equilibrium provision of business public services under capital and production taxes relative to the efficient level of provision for various values of the coefficient capital on capital β. We fix the coefficient on public service at at $\gamma = 0.0625$ and the substitution elasticity at $\sigma = 0.5$. The case includes the efficient capital tax at $\beta = 0.5$. We let the coefficient vary from 0 to 2.

[Figure 3 goes about here]

It should be noted that while the capital tax leads to efficiency under one particular parameter constellation, the production tax more consistently results in relatively small deviations from the efficient level of provision of public services. This pattern appeared in a wide range of parameter constellations using our graphical simulations program.[15]

To summarize, this section illustrates the theoretical results presented in Section II using numerical examples. Since the performance of production taxes and capital taxes can not be ranked in the case of log supermodular production functions, we look at a wide range of parameter constellations. We find that while the difference between a more efficient capital tax and the less efficient production tax tends to be small (Figure 3) in cases where the production tax is more efficient than the capital tax, the increase in inefficiency due to the capital tax can be quite large (Figure 2).

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[15] The reader can examine a wide variety of additional cases by downloading the file "EquilibriumDeviation.01.cdf" from http://web.uvic.ca/~egugl.

IV. RELATIONSHIP OF CAPITAL TAX RESULTS TO THE EARLIER LITERATURE

In this section, we briefly relate the results presented above to some others that have appeared in the literature. As noted in the introduction, ZM obtain two main results in their analysis of the effects of capital taxation on the provision of business public services. First, starting from an initial equilibrium in which the efficient level of business public services is financed solely with head taxes, they find that — as in the case of public services provided to households — the use of the property tax to finance local business public services leads to underprovision of such services, as local governments reduce reliance on the property tax to avoid driving mobile capital out of their jurisdictions. Second, once property tax finance of business public services is introduced (through an exogenous reduction in the permitted level of head taxes from the efficient level), the effect of a property tax increase on the level of business public services is theoretically ambiguous; specifically, it depends on how the perceived responsiveness of mobile capital (the capital tax "base erosion" effect), which interacts with the initial tax rate when it is positive in the initial equilibrium, varies as the tax rate increases. For example, if the base erosion effect increases or declines only modestly as the tax rate increases, the standard result of under-provision of local public services in the presence of interjurisdictional tax competition is obtained. However, if the base erosion effect declines sufficiently — in part because additional business public services make the jurisdiction more attractive to capital — then concern about tax-induced capital out-migration is more than offset by the fact that the tax-financed increase in public services makes the firm's capital and labor inputs more productive. In this case, the net result is over-provision of business public services.

ZM, however, made two assumptions to ensure that the base erosion effect never became negative, that is, that an increase in the tax rate on capital in a jurisdiction always led to an outflow of capital. First, ZM (equation 17) made a stability assumption that, as Dhillon et al. (2007, p. 407) describe, “rules out a destabilizing ‘virtuous circle’ in which more capital facilitates more public good provision which enhances productivity to the extent that the demand for capital increases, and so on.” We follow Dhillon et al. and ZM in adopting this stability assumption; indeed Dhillon et al. show that this assumption is essential for the existence of a capital tax equilibrium. Moreover, assuming only two inputs, mobile capital and the public input, they show that the stability condition is violated for the Cobb-Douglas production function with CRS and more generally for CES production functions. By comparison, we show that this stability condition is satisfied by our three-factor production function, as long as it is strictly concave in both capital and the public service.

Adoption of this stability assumption, however, does not guarantee that a capital tax rate increase leads to capital outflow from the jurisdiction. To ensure this condition, ZM (p. 363, equation 16) also assume that “...the marginal cost of diverting a unit of output to public services for firms (which is equal to unity) is greater than the associated increase in output due to the increased marginal productivity of capital.” The two assumptions together guarantee that the local government anticipates an outflow of capital if it unilaterally increases the tax rate on capital. Noiset 1995, Sinn 1997, Matsumoto 1998, and Dhillon et al. 2007 all question this latter assumption, and instead do not rule out the case in which the capital tax results in more public services which raise the productivity of capital sufficiently to make jurisdictions believe that by raising taxes they can attract more capital. For example, Dhillon et al. replace ZM’s condition with a weaker condition and show that a capital tax equilibrium exists and that it may involve underprovision, efficient provision or overprovision of public services. Complementing their analysis, Gugl and Zodrow (2014) focus on the global properties of production functions. In particular, we show that the assumptions of (1) strict concavity of the production function in capital and public services, and (2) strict concavity in the marginal product of capital (public service) in public service (capital) are sufficient to establish that underprovision of public services financed by capital taxes must occur at an interior solution, and that production functions that are log modular or log submodular in capital and the public service satisfy the latter assumption. If the production function is log supermodular, however, the second assumption is not satisfied, and all three cases — over, efficient, and underprovision — are possible.

Dhillon et al. (2007) also show that the Cobb-Douglas production function with decreasing returns to scale (DRS) always results in underprovision of public services in a capital tax equilibrium. This result is consistent with our analysis, as the Cobb-Douglas technology with DRS is an example of a log modular technology. Our analysis is also complementary to Dhillon et al. in that we show that the introduction of a fixed factor in our model implies that the assumption of constant returns to scale in production is consistent with the existence of a capital tax equilibrium.

Taking a different approach, Matsumoto (1998) treats business public services as a pure public input in a model that assumes constant returns to scale in all inputs and a fixed number of firms. He also finds that the effect of capital taxes on the supply of capital to the taxing jurisdiction is theoretically ambiguous. Matsumoto assumes an initial capital tax equilibrium, and thus does not focus on the stability condition mentioned above and existence of the equilibrium. He finds that whether there is under-provision, efficient, or over-provision of business public services in a capital tax equilibrium depends on the sign of the difference between the marginal productivity of the public service and the increased marginal productivity of capital due to the increased business public services financed with an increase in the capital tax. Our analysis extends these results by showing that the assumption that the production function is log modular or log submodular in capital and public service is sufficient to rule out efficient or overprovision of public services in his analysis.

We close this section by describing two recent contributions to the literature.[16] [17] Carbonnier (2013) models business public services under the assumption that the production function is Cobb-Douglas and CRS in all inputs and, consistent with our analysis, finds underprovision of the public service. He then discusses whether decentralization of infrastructure decisions is more efficient than a centralized approach, given the inefficiency associated with subnational interjurisdictional tax competition. He also examines the implications of administrative costs and the possibility that subnational governments have more information than national governments regarding which infrastructure projects should be completed.

Matsumoto and Sugahara (2014) consider several forms of taxation and focus on production functions of the form $F[\alpha(B)K, \beta(B)L]$ where the technology is CRS in private factors only and hence $F = F_L L + F_K K$. They find that if the substitution elasticity between labor and capital is one, a uniform tax on labor and capital is efficient. A uniform tax on labor and capital is also efficient when the public service enters the production function in Hicks neutral form. Our results are different — the substitution elasticity between capital and labor does not

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[16] Another, less directly relevant recent contribution is by Pauser (2013), who incorporates an imperfect labor market in a ZM-type model of tax competition. He assumes that unemployment exists because labor is paid more than its marginal product, and shows that overprovision of business public services can arise under these circumstances.

[17] Another strand of this literature considers the effects of tax competition in models that include both public provision of business inputs and "Leviathan" local governments that are assumed to benefit directly from the size of the budgets they control; for example, see Edwards and Keen (1996) and Wilson (2005). In such models, tax competition is more likely to be efficiency enhancing, as it limits the extent to which the budget-maximizing tendencies of local governments result in over-expansion of the public sector.

play a role in the determination of over-, efficient, or under-provision — because we assume that the production function is CRS in all inputs for the reasons of consistency mentioned above, because we do not restrict our analysis to production functions of the form $F[\alpha(B)K,\beta(B)L]$,[18] and because we focus on a tax on output. Thus the tax base includes the contribution of the public service to production. Note that the following production function is not of the form analyzed by Matsumoto and Sugahara:

Consider a nested production function, $F(L,Q(K,B))$ with both $Q(K,B)$ and $F(L,Q(K,B))$ CRS. The production function is log supermodular if and only if $\zeta_{BK} > \varepsilon_K$,

$$
\begin{aligned}
&F_K = F_Q Q_K, F_B = F_Q Q_B \\
&F_{KB} = F_{QQ} Q_K Q_B + F_Q Q_{KB} \\
&\zeta_{BK} = \left(\frac{F_{QQ} Q_K}{F_Q} + \frac{Q_{KB}}{Q_B} \right) K \\
&\varepsilon_K = \frac{F_Q Q_K}{F} K
\end{aligned}
$$

that is if and only if

$$
\begin{aligned}
&\frac{F_{QQ} Q_K}{F_Q} + \frac{Q_{KB}}{Q_B} > \frac{F_Q Q_K}{F} \\
&-\frac{F_{QQ}}{F_Q} + \frac{F_Q}{F} < \frac{Q_{KB}}{Q_B Q_K}
\end{aligned}
$$

This means that how $Q(K,B)$ enters the production function is crucial in determining whether the production function is log supermodular. Note that the Cobb-Douglas production function emerges as a special case. In this case both sides of the inequality above are equal to 1. In case of a Cobb-Douglas production function nested in a CES production function, such that

[18] Of the production functions considered in our simulations, only the Cobb-Douglas production function is of the form $F\left(\alpha\left(B\right)K,\alpha\left(B\right)L\right)$.

$F(L,Q) = \left(\beta L^{\alpha} + (1-\beta)Q^{\alpha}\right)^{1/\alpha}$ and with parameters $\alpha < 0$ or $0 < \alpha < 1$ and $0 < \beta < 1$, log supermodularity would require

$$\frac{(1-\alpha)\beta L^{\alpha} + (1-\beta)Q^{\alpha}}{\left(\beta L^{\alpha} + (1-\beta)Q^{\alpha}\right)Q} < 1$$

With $0 < \alpha < 1$ and evaluated at $Q(K,B) > 1$, this inequality is not satisfied. In fact it goes the other way and hence we have log submodularity. We no longer have this strong relationship between the substitution elasticity of capital and labor and the log super/sub modularity properties.

V. CONCLUSION

The results of the simulations of our admittedly highly stylized model of interjurisdictional tax competition suggest that under many (although certainly not all) circumstances it is more efficient to finance business public services with an origin-based production tax rather than a source-based capital tax. We close with some speculative comments on the relevance of these results for subnational tax policy.

In the United States, the only tax approximating an origin-based VAT was the Single Business Tax (SBT), which was a significant source of revenue for the state of Michigan until it was phased out, ending in 2007. Although Hines (2002) argues that the SBT was an attractive tax alternative for the state, he notes that problems in dealing with multi-state firms and especially strong opposition to significant taxation of firms with no profits — even though entirely consistent with the principles of benefit taxation — ultimately doomed the tax. (Of course, property taxation of businesses also suffers from the latter problem.) More generally, the use of production-based business taxes at the state and local level in the United States is generally declining. Indeed, many states that use a formula-apportioned state corporate income tax have moved away from taxing the production-based components of the tax by switching to formulas that put a relatively small or zero weight on the productive factors used by businesses within the taxing jurisdiction (payroll and property); they instead have attached larger (sometimes unitary) weights on a destination-based measure of gross sales. These reductions in production-based business taxes may reflect the effects of interjurisdictional tax competition — perhaps coupled with a realization that business taxes were significantly higher than the value of public services received by business (Testa and Mattoon, 2006), often because property taxes on businesses are assessed at rates similar to those applied to residential property.[19] Under these circumstances, the imposition of an additional production-based tax would be inconsistent with the "benefit-related" taxation of business envisioned by Bird (2000).

On the other hand, taxation of businesses — even in excess of benefits received — may be politically popular. For example, recent experience in Canada suggests that the replacement of provincial retail sales taxes (RSTs) which tax business purchases to a significant extent with a pure consumption tax linked to the national Goods and Services Tax (GST) — known as Harmonized Sales Tax (HST) — faces fierce political opposition.[20] For example, FightHST, a political organization whose goal was to repeal the HST in British Columbia, stated in a voters guide to a mail-in referendum that, "Exempting business from sales taxes means government is taking all of its sales tax revenues from consumers inside our economy and then transferring $1.9 billion of it back to corporations, some of which are headquartered in Europe, Asia or the U.S."

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[19] Note, however, that property taxation of businesses can be viewed as analogous to benefit taxation to the extent that zoning or negotiation between local governments and businesses ensures that property taxes paid equal the sum of benefits received and the costs of externalities imposed by local businesses (Oates, Fischel, and Youngman, 2013). The extent to which this occurs in practice is unclear. Even in this case, however, the imposition of an additional production-based tax would result in business taxes paid that would exceed benefits received.

[20] Both retail sales taxes and value-added taxes in principle tax consumption goods while exempting purchases of business inputs. However, in practice, exemption of business purchases is much more easily achieved under the value-added tax than under the typical retail sales tax (see, for example, Gillis, Mieszkowski, and Zodrow (1996)).

(Elections Canada, 2011, p.5).

In order to appease voters before the referendum, the provincial government announced modifications to the HST that included a rate reduction from 12% to 10% by 2014, an increase of the corporate income tax rate from 10% to 12% in 2012, and the postponement of a planned small business tax reduction that had been scheduled for April 2012 (CBC News, 2011). These actions can be interpreted as an attempt to convince voters that business in British Columbia is paying “its fair share.” Nevertheless, despite these efforts, in August 2011 a majority of the voters who cast their mail-in ballot voted to repeal the HST, and the government of British Columbia is now looking for other ways to restructure its tax system to meet the challenge of increasing health and education expenditures. As harmonization with the federal GST is no longer an option, a provincial origin-based VAT might be considered as a replacement for the RST. It would, after all, deal with some of the criticism levied against the HST by taxing local production rather than local consumption, and in addition might be more efficient than the provincial retail sales tax it would replace.

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Table 1

Simulations with Cobb-Douglas Production Function

(Underprovision with Capital Tax, Efficient Provision with Production Tax)

(1) Capital-Labor Ratio K	(2) Capital Share Parameter β	(3) Public Services Share Parameter γ	(4) Production Tax Rate t (%)	(5) Capital Tax Rate τ (%)	(6) Reduction in Public Service (%) due to Underprovision with Capital Tax	(7) Loss in Income (%) due to Underprovision with Capital Tax
1.00	0.33	0.33	33	6.8	64.5	11.6
0.75	0.25	0.25	25	7.6	60.3	7.4
0.50	0.25	0.25	25	9.9	60.3	7.4
0.25	0.25	0.25	25	15.7	60.3	7.4
0.25	0.25	0.15	15	16.4	42.5	1.9
0.25	0.25	0.10	10	14.5	31.2	0.6
0.25	0.40	0.10	10	13.1	22.0	0.3

Table 2

CES Simulations with Elasticity of Substitution in Production $\sigma_{KB} = \sigma > 1$

Parameters			Capital Tax			Production Tax		
(1) Elasticity of Substi-tution in Production $\sigma > 1$	(2) Coefficient on Capital β	(3) Coefficient on Public Services γ	(4) Capital Tax Rate τ (%)	(5) Decrease in Public Services (%)	(6) Decrease in Residents' Income (%)	(7) Product-ion tax rate t (%)	(8) Decrease in Public Services (%)	(9) Decrease in Residents' Income (%)
1.35	0.5	0.05	21.0	12.0	0.01	1.75	0.29	0.00
1.40	0.5	0.05	15.5	11.5	0.01	1.50	0.28	0.00
1.45	0.5	0.05	12.0	11.0	0.01	1.30	0.27	0.00
1.50	0.5	0.05	9.5	10.4	0.01	1.12	0.26	0.00
1.50	0.5	0.10	23.8	25.0	0.08	3.14	0.73	0.00
1.50	0.3	0.10	15.8	32.3	0.14	3.15	0.45	0.00
1.50	0.3	0.05	6.7	14.4	0.01	1.12	0.16	0.00

Table 3

Efficient Capital Tax Equilibrium and Small Deviations Due to Changes in the Substitution Elasticity

Parameters			Capital Tax			Production Tax		
(1) Elasticity of Substitution $\sigma < 1$	(2) Coefficient on Capital β	(3) Coefficient on Public Services γ	(4) Capital Tax Rate τ (%)	(5) Change in Public Services (%)	(6) Decrease in Residents' Income (%)	(7) Production Tax Rate t (%)	(8) Change in Public Services (%)	(9) Decrease in Residents' Income (%)
0.5	0.5	0.0625	25	Efficient	Efficient	27	9	0.19
0.6	0.5	0.0625	15	–8	0.12	20	5	0.04
0.3	0.5	0.0625	59	34	6.67	50	26	4.21
0.2	0.5	0.0625	83	51	29.52	67	32	12.6

Table 4

Efficient Capital Tax Equilibrium and Small Deviations Due to Changes in the Coefficient on Capital

Parameters			Capital Tax			Production Tax		
(1) Elasticity of Substitution $\sigma < 1$	(2) Coefficient on Capital β	(3) Coefficient on Public Services γ	(4) Capital Ta: Rate τ (%)	(5) Change in Public Services (%)	(6) Decrease in Residents' Income (%)	(7) Production Tax Rate *t* (%)	(8) Change in Public Services (%)	(9) Decrease in residents' income (%)
0.5	0.5	0.0625	25	Efficient	Efficient	27	9	0.19
0.5	0.4	0.0625	28	–2.77	0.02	26	8	0.14
0.5	0.6	0.0625	23	2.18	0.01	27	10	0.21

Table 5

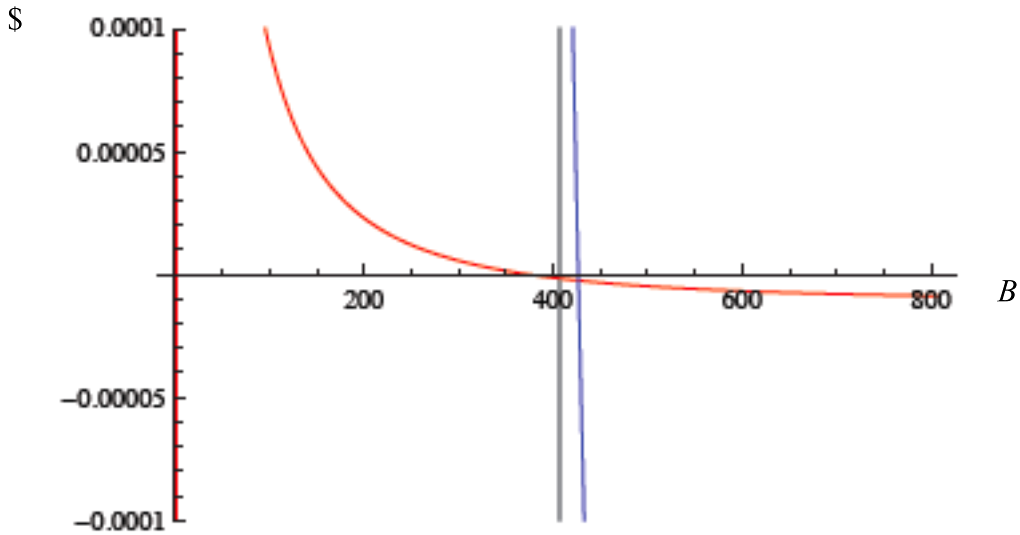
Efficient Capital Tax Equilibrium and Small Deviations,

Holding the Elasticity of Substitution in Production Constant $\sigma_{KB} = 0.6$

Parameters			Capital Tax			Production Tax		
(1) Elasticity of Substitution $\sigma < 1$	(2) Coefficient on Capital β	(3) Coefficient on Public Services γ	(4) Capital Tax Rate τ (%)	(5) Change in Public Services (%)	(6) Decrease in Residents' Income (%)	(7) Production Tax Rate *t* (%)	(8) Change in Public Services (%)	(9) Decrease in Residents' Income (%)
0.6	0.5	0.005	14	-6.38	0.06	17	4	0.02
0.6	0.5	0.1	16	-14.85	0.51	26	6	0.07
0.6	0.3	0.1	21	-23.93	1.44	26	4	0.03
0.6	0.3	0.05	19	-11.93	0.22	17	3	0.01

Figure 1

Equilibrium Provision of Public Services, $\sigma = \sigma_{KB} < 1$



Capital Tax	————————
Production Tax	————————
Efficient B	————————

Figure 2

Public Service Level as a Function of the Coefficient on Public Services as γ Varies
$(\sigma = 0.5,\ \beta = 0.5)$

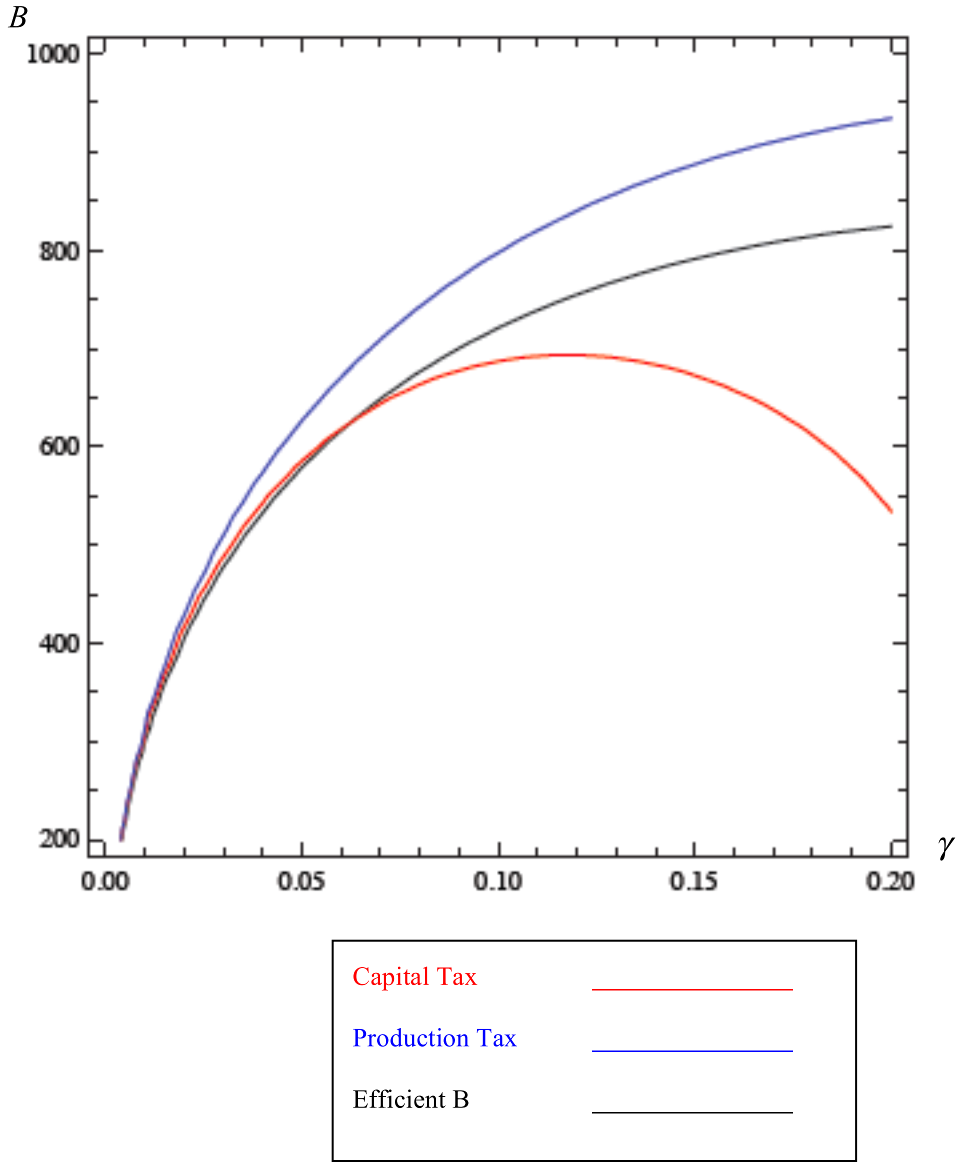


Figure 3

Percentage Deviations from Optimal Public Service Level as β Varies
$(\sigma = 0.5, \gamma = 0.0625)$