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FISCAL COMPETITION IN SPACE AND TIME

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Abstract

This paper analyzes fiscal competition among numerous spatially-separated jurisdictions in an explicitly dynamic framework. The degree of factor mobility between jurisdictions is imperfect because it is costly and time-consuming to adjust factor stocks. Even if it is harmful in the long run, a jurisdiction's residents can benefit in the short run from taxing mobile factors owned by non-residents. The optimal tax on mobile factors is lower, the faster the speed with which factors adjust to fiscal policy. Anticipated taxes are less beneficial than those that can be imposed unexpectedly.

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1 Introduction

The now-large literature on fiscal competition has drawn considerable attention to the importance of factor mobility for the analysis of tax and expenditure policy. Although a wide variety of specific results can emerge under different assumptions, it is well-established that factor mobility can have major consequences for the optimal structure of local taxation and expenditures, for the efficiency and distributional impact of the fiscal policies chosen by a decentralized system of jurisdictions, for the sharing of risk through public and private institutions, and numerous other policy issues. As an example, one important general lesson that emerges from this literature is that the capacity of local governments to redistribute income is constrained by the mobility of factors of production. The exposure of local governments to external markets means that tax, transfer, and other redistributive policies involving mobile factors of production are ineffective because the net returns to these factors are determined in markets whose geographical scope extend beyond that of any single locality.[1]

Many if not all of the early contributions to this literature make specific reference to local governments in the US, units of government that are quite numerous (there are some 80,000 units of local government in the US), typically rather small in population, and almost all quite small in geographic scope, not only with reference to the entire country but in relation to the states in which they are located and even in relation to individual metropolitan areas.[2] In the context of the US and other federations, it is customarily argued that the task of redistribution – one of Musgrave's three key functions of the public sector – should rest in the hands of the national government. This argument rests precisely on the view that the redistributive capacity of subnational governments, which are presumed to be relatively open to factor mobility, is more limited than that of national governments, which are presumed to be relatively closed to factor movements.[3] And, indeed, redistribution is in fact undertaken, and on historically very large scales, by national governments in OECD countries. Public expenditures in the OECD countries of Western Europe and North America countries in no cases fall short of 35% of GDP and not infrequently exceed 50%, and these high levels of spending are mainly directed toward cash or in-kind redistributive and social-insurance policies. The redistributive policies of subnational governments are far smaller in scale, plausibly because of the "more competitive" environment within which these governments operate.

[1]This literature builds on such antecedents as Tiebout(1956), Stigler (1957), and Oates (1972), studies of property tax incidence by such authors as Mieszkowski (1972) and Bradford (1978), and subsequent development of similar models by Zodrow and Mieszkowski (1986), Wilson (1986), and many others. For surveys of much of this literature, see Wilson (1999), Oates (1999), and Wellisch (2000). See Cremer *et al.* (1996) and Wildasin (1998) for surveys that focus on redistributive policy.

[2]For example, large SMSAs typically contain one or two large municipalities and many – often well over 100 – relatively small municipalities, towns, or other units of local government.

[3]For classic statements of this view, see Stigler (1957), Musgrave (1959, 1971), and Oates (1972). This view is quite consistent, of course, with the Heckscher-Ohlin tradition in international economics, which views factors of production as completely immobile at the international level and freely mobile within countries.

Nevertheless, the lessons and analytical models developed in the literature on fiscal competition are applied with increasing frequency at the international level, in which the jurisdictional units of analysis are nations rather than local governments. In particular, there have been numerous analyses of the implications of European economic integration that draw upon formal models originally developed in the context of local public finance.[4] This may be justifiable if national factor markets are not as isolated as they once were. Certainly the volume of international capital movements and international migration have increased substantially in recent decades. To the extent that factors of production may be mobile among nations as well as among small units of local government, the lessons drawn from analyses of fiscal competition, at a fundamental level, must be similar at whatever geographical scale they are applied. However, one might be rather uneasy about drawing exact parallels between the implications of factor mobility for local governments in the US and other countries, on the one hand, and entire nations on the other. Even if fiscal competition does exist at the international level, it seems questionable whether it is "as intense" as the competition that might be found among subnational governments.

Common sense would seem to suggest that the degree of factor mobility at any given geographic scale, and thus the degree of fiscal competition at any given level of jurisdictional size, is a "matter of degree", an "empirical question" that cannot be resolved on an a priori basis. Factor mobility and the forces of fiscal competition may well be operative at all levels of government, regardless of geographical size, but "more so" at lower levels of government, i.e., for jurisdictions of smaller geographical size, than for higher levels. But what, exactly, are the proper empirical questions to ask? What parameters should be estimated? And, once they are estimated, how are they to be utilized to determine the "degree" of fiscal competition?

No doubt there are many ways that these questions might be answered. The present paper addresses them by exploring the notion that fiscal competition across *space* depends on the (actual or potential) movement of factors of production, a process that requires *time*. In any given jurisdiction, there is at any moment a stock of factors of production, some of which, like natural resources, are intrinsically immobile, but many of which, like labor and capital, are potentially mobile. These stocks produce a flow of factor services which are rewarded in local factor markets, thereby generating flows of income. Government redistributive policies intervene in this income-generation process and thus create a divergence between gross and net factor incomes. This may give rise to incentives for factors to flow in or out of a given jurisdiction and for the stock of factors thus to adjust to fiscal interventions. But this stock-adjustment process does not occur instantaneously.

Consider the adjustment of labor resources first. In some cases, labor can

[4]See, for example, Sinn (1997), Fuest and Huber (1999), Sorensen (forthcoming) and Wildasin (forthcoming). (The last of these, which contains a more extensive discussion of international factor movements and their implications in the European context, should be viewed as a companion to the present paper.) Interest in fiscal competition at the international level is not confined to academic discussions; see, e.g., OECD (1998), Dwyer (2000).

be redeployed from one place to another almost immediately, especially when physical distances are small (in the extreme case, moving workers from one task to another within a given factory or store) or when the benefits of relocation are sufficiently great to warrant high-speed (and often high-cost) transportation (e.g., using the corporate jet to assemble managers at headquarters for urgent consultations). The spatial reallocation of labor is more rapid and less costly when it does not entail changes in employment relationships. Spatial reallocation of labor of this type occurs with such frequency and rapidity that it is often not recorded statistically and certainly is not considered to be "migration" as that term is generally understood and used for statistical purposes. On the other hand, it often takes a significant amount of time for workers to change jobs, a process that may entail many forms of search, acquisition of new skills, and other costly and time-consuming activities; it may also necessitate relocation of families, changing schools, adjustment to a different social environment, or learning a new language. Perhaps the slowest adjustments are those that involve massive relocations of labor over long distances, such as the migration of labor from the Old World to the New, a process that was initiated centuries ago and that continues to the present day, though at rates that have varied over time. In between the extremes of reallocation of labor in different parts of the same business establishment and international migration over long distances lies a spectrum encompassing intermediate cases such as the reallocation of labor within a given municipality, among municipalities within a given metropolitan area, among states or provinces, or among larger regions. It is important to note that the *time* required for reallocation of labor over *space* is endogenous: such reallocations can ordinarily be accelerated, but it is costly to do so, both in pecuniary and non-pecuniary terms. Thus, the speed of adjustment in general depends on the reward to rapid adjustment in relation to its cost.

The situation with respect to capital movements is quite analogous. Some forms of capital – such as financial capital – can move extremely rapidly and at very low cost. Other forms of capital movement – for example, the buildup of an entire urban area as another urban area declines – generally proceed at a much slower pace. To some extent, the speed of adjustment depends on the durability of capital, which of course varies from one type of capital to another. It also depends on the speed with which new investment plans can be formulated and implemented, a process that in some cases is quite straightforward and immediate but that in other cases entails the harnessing of technology in novel ways and even the development entirely new industries. In general, as with labor, the speed with which capital flows from one location to another is likely to be slower, the larger the distances involved. For example, while it may be relatively easy for a retailer to open additional retail outlets within a given state or country, expansion into international markets may be considerably more involved and can ordinarily be expected to occur at a slower speed – though, as with labor, the rate of adjustment of the capital stock is endogenously determined and depends on the incentives facing capital owners.

In the light of these considerations, it appears that empirical questions concerning the degree of factor mobility facing jurisdictions of different sizes and types can fruitfully be explored by analyzing the process of dynamic adjustment of the stocks of (potentially) mobile resources. In turn, this should provide a useful basis for the assessment of the importance and impact of fiscal competition at different levels of government.

The goal of the present essay is to develop an analysis of fiscal competition in a simple but explicitly dynamic framework.[5] The analysis builds on standard models of costly dynamic adjustment that have been heavily exploited in empirical models of investment. One advantage of this approach is that the analysis thereby lends itself to empirical application; it also helps to suggest what further kinds of empirical analysis would be particularly likely to contribute to enhanced understanding of important issues of fiscal policy. Furthermore, the dynamic analysis presented here establishes a transparent linkage with – in fact is a directly generalization of – the static (or, perhaps better, atemporal) models that have been commonly employed in the literature. This helps greatly in leveraging the insights derived from previous literature to achieve economically-meaningful interpretations of results obtained in the inevitably somewhat more complex dynamic analysis.

The next section of the paper begins by recalling a now-familiar static model of fiscal competition, providing a reference point and establishing some notation useful in the dynamic analysis. The basic dynamic framework is also introduced in Section 2; it parallels the static model as far as possible in order to preserve comparability with it. Section 3 solves for the comparative-dynamic response of a small and open economy to permanent and unanticipated perturbations of fiscal policy. It then utilizes these comparative-dynamic results to determine the effects of fiscal policy on the (intertemporal) welfare of local residents and to derive a characterization of the fiscal policy that is optimal from their viewpoint. These results bear a close resemblance to those obtained in the static model, but depart from them in ways that reflect the fact that factor supplies do not adjust instantaneously, instead adjusting gradually over time. Section 4 explores what happens when local policies do not take economic agents by surprise but are, at least to some degree, anticipated by them. This analysis amounts, technically speaking, to a generalization of the case of unanticipated policy changes, and the results differ from those of the preceding case in ways that can be easily interpreted in relation to them. Section 5 offers some conclusions and discusses

[5]There have of course been previous studies that have examined various aspects of intertemporal fiscal competition. For example, Jensen and Toma (1991) develop a two-period model of tax competition in which a pair of governments use debt policy to manipulate the intertemporal structure of taxation. Dynamic models of fiscal competition with imperfectly mobile households are discussed by Hercowitz and Pines (1991) and Wildasin and Wilson (1996). Perhaps closest in spirit to the present analysis is Lee(1997), who examines a two-period model in which capital in the second period is imperfectly mobile. Lee shows that the limited mobility in the second period can lead to higher than optimal levels of taxation and spending. Like Jensen and Toma and Hercowitz and Pines, Lee's results reflect the fact that the jurisdictions being analyzed are large and thus interact strategically. It is not uncommon for game-theoretic models of strategic fiscal competition to be formulated as "stage games" with sequential decision structures e.g., Walz and Wellisch (1996), though these typically focus on the determination of a single equilibrium constellation of private and public choices rather than on the evolution of these choices over time.

directions for future research.

2 The Model

2.1 A Static Benchmark

For purposes of comparison, it is valuable to restate the "canonical" model of capital tax competition, using it to both to introduce some notation and to state results that can then be compared to those obtained in the dynamic model.

The focus of attention throughout the entire is a single small jurisdiction, inhabited by identical immobile households who can be treated as a representative agent. This agent derives utility from consumption of private and public goods. The former are treated as a single homogeneous commodity, as is valid, for example, if all private consumption goods are traded on external markets at prices that are independent of policy choices made within the jurisdiction and that can therefore be taken as exogenously fixed. This homogeneous good is taken as a numeŕaire. The representative household supplies a fixed amount of labor (and possibly other fixed, locally-owned, immobile resources that can be combined with labor into a single aggregate fixed factor). This input is used, along with capital, in a perfectly-competitive local production sector using a technology described by the production function $f(k)$ with $f'(k) > 0 > f''(k)$, where k is the amount of capital used in the local production process. The gross returns to capital and labor are given by $f'(k)$ and $w \equiv f(k) - kf'(k)$, respectively. Capital is traded on the external market where it earns a net rate of return of r, treated as exogenously fixed from the viewpoint of this single small jurisdiction.[6] It is assumed that capital is freely mobile between the jurisdiction and the external market, so that capital employed locally must earn the same net rate of return as is available elsewhere. The locality is assumed to impose a source-based tax on capital or capital income; for notational convenience, assume that the tax is levied at a rate of τ per unit of capital.[7]

The equilibrium condition that determines the level of capital in the locality

[6]By assuming a small jurisdiction, all elements of strategic fiscal competition are suppressed. Strategic issues have been widely discussed in the literature and an obviously important topic for future research is to incorporate strategic behavior in an explicitly dynamic framework like that presented below.

[7]Source-based taxes are those collected where capital is employed, as opposed to residence-based taxes, which are collected where capital owners reside. Local property taxes, corporation income taxes, and local cash or in-kind investment subsidies are examples of source-based fiscal instruments (subsidies being treated as negative taxes). The taxation of interest, dividend, and capital gains income under a personal income tax is an example of a residence-based tax. The application of a source-based instruments is contingent on the jurisdiction in which the capital is located, and hence these instruments may affect the spatial allocation of capital. The application of a residence-based fiscal instrument is contingent on the jurisdiction in which the capital owner is located, and hence these instruments may affect the spatial allocation of capital owners. Both types of fiscal instruments are important in practice. While these taxes (both source and residence-based) are often assessed on an *ad valorem* basis, the notation is slightly easier for per-unit taxes and the analysis is substantively the same.

is thus

$$f'(k) - \tau = r, \tag{1}$$

a condition that can be used to solve for k implicitly as a function of τ satisfying

$$\frac{\partial k}{\partial \tau} = \frac{1}{f''} = \frac{k}{f'}\epsilon < 0 \tag{2}$$

where $\epsilon = (d \ln f'/d \ln k)^{-1}$ is the elasticity of demand for capital in the locality.[8] Note that τ/f' is the tax rate expressed as a percentage of the before-tax rate of return on capital. Note also that τ is not restricted as to sign; in particular, τ should be interpreted as the fiscal burden on local capital, net of all subsidies and net of the monetized equivalent of in-kind benefits to capital such as local public infrastructure and other local public services that raise the local return on investment. The revenues collected from the local source-based capital tax amount to τk, and may be used either to finance local public goods or to reduce the tax burden on local residents. Letting G denote the level of expenditure on local public goods and letting T denote (net) taxes collected from local residents, the government budget constraint is

$$G = T + \tau k. \tag{3}$$

In order to focus attention on the implications of capital mobility for the local tax structure, it is assumed that the level of spending on and provision of local public goods is exogenously fixed. Furthermore, in order to suppress complications arising from the distortion of labor-leisure tradeoffs and other well-known (and thoroughly-studied) incentive effects of taxes, it is assumed that the taxes collected from (or subsidies paid to) local residents are lump-sum in nature.

It is assumed that local residents derive utility from consumption of private and local public goods. Since the latter are exogenously fixed in supply, however, the welfare of local residents varies only with the former. The private good consumption of local residents is equal to their net income from supplying labor plus the return to any capital with which they may be endowed, denoted by $\bar{k}$, i.e.,

$$Y = w - T + r\bar{k} = f(k) - kf'(k) + \tau k - G + r\bar{k} \tag{4}$$

where the second equality follows by substituting from the government budget constraint (3).

Taking into account the dependence of k on τ, one can now readily calculate that

$$\frac{dY}{d\tau} = k + (\tau - kf'')\frac{\partial k}{\partial \tau} = k\frac{\tau}{f'}\epsilon \tag{5}$$

[8] For example, if the local production technology is of the Cobb-Douglas form, $f(k) = Ak^{\alpha}$, with $0 < \alpha < 1$, then $\epsilon = 1/(\alpha - 1)$.

where the second equality follows from (2). This equation provides the key finding for the analysis of fiscal competition in the static case. Since (5) implies that τ is of the opposite sign from $dY/d\tau$, it follows that the welfare of local residents is enhanced by reducing the net fiscal burden on (or the net fiscal transfer to) capital, if it is initially non-zero, and that local welfare is maximized when local fiscal policy is structured in such a way that the net fiscal burden on local capital is equal to zero.

2.2 A Framework for Dynamic Analysis

The conventional theory of demand for factor services relates the productivity of factors to their prices. As in the preceding subsection, this approach, when applied to capital, yields a theory of the desired capital stock. Investment, however, is a flow that allows capital users to adjust this stock. Thus, a long tradition in investment analysis focuses on the *dynamic adjustment* of capital stocks. The first task in such an approach is to explain why capital stock adjustments are not instantaneous, i.e., why investment does not occur in extremely brief bursts in response to changing economic conditions. Authors such as Gould (1968) and Treadway (1969) postulate the existence of adjustment costs to explain ongoing flows of investment. Subsequent literature has drawn attention to numerous interesting issues concerning the specification of adjustment cost technologies, especially at the very disaggregated level of investment in particular capital goods for particular plants. [9] The traditional approach, however, is to suppose that the cost of altering the capital stock is an increasing and convex function of the rate of investment, a specification that gives rise to continuous flows of investment that result in gradual capital stock adjustment. This traditional approach, which is followed here, has considerable appeal when applied at the level of a jurisdiction that contains numerous firms in numerous industries.

Thus, focusing as before on a single small jurisdiction that faces an externally-given net rate of return on capital of r, let $f(k_t)$ be an increasing and concave function representing the flow of output at time t as a function of the capital stock k_t and, implicitly, labor, land, and other resources that are immobile and fixed in supply. The gross return to these fixed factors, denoted by $w_t = f(k_t) - k_t f''(k_t)$, is assumed as before to accrue to a representative local consumer. This representative consumer is immobile and, in order to obviate any issues relating to intergenerational transfers, to be infinitely-lived (or, equivalently, successive generations are linked through altruistically-motivated intergenerational transfers).

The dynamics of the model are determined largely by adjustment costs that firms must bear when they undertake local investment; in particular, these costs will preclude instantaneous adjustment of the local capital stock. Specifically, the adjustment costs incurred by local firms are given by $c(i_t)k_t$, with $c' > 0 < c''$, where i_t is the rate of gross investment within the locality at time t, i.e.,

[9]See Hamermesh and Pfann (1996) and references therein.

the amount of expenditures on capital goods expressed as a proportion of the amount of capital in the locality, k_t. This adjustment cost is assumed to take the form of lost output and is thus expressed in units of numéraire. Note that since $c(\cdot)$ is homogeneous of degree zero in the level of investment and the total stock of capital, total adjustment costs are homogeneous of degree one in these variables. Assuming that capital depreciates at a constant exponential rate of δ, the evolution of the local capital stock takes the usual form:

$$\dot{k} = (i_t - \delta)k_t. \tag{6}$$

The local government imposes a per-unit tax on capital at a rate τ which for now is assumed to be time-invariant. The cash flow of local firms at time t is thus the value of their output net of adjustment costs, less investment expenditures, less tax payments, less payments for local labor:

$$\pi_t = f(k_t) - c(i_t)k_t - \tau k_t - i_t k_t - w_t. \tag{7}$$

Assume that no agents face liquidity constraints or other capital market imperfections and that all agents plan over infinite horizons. Local residents derive utility from consumption of private and public goods, and are assumed to plan their lifetime private consumption streams subject to the constraint that the present value of lifetime consumption is equal to the present value of lifetime income net of any taxes or transfers.[10] Under these conditions, firms are naturally assumed to maximize the present value of profits net of taxes or subsidies, and thus face the problem of choosing the paths of investment i_t and capital k_t to

$$max \qquad \Pi \equiv \int_0^\infty \pi_t e^{-rt} dt \tag{P}$$

subject to (6), with an initially-given stock of capital $k_0 = K_0$.

In addition to collecting revenues from the taxation of local capital, the local government may collect revenue from or provide subsidies to local residents in a lump-sum fashion and it can spend money on the provision of public goods that benefit local residents. Let T now denote the *present value* of lump-sum taxes imposed on local residents; under the assumptions of the model, the precise time path of revenue flows from these taxes is unimportant. Assume that the level of provision of public goods is exogenously fixed and let G now denote the *present value* of public expenditures on public good provision; again, provided that

[10] The assumption that the economy of the jurisdiction is small relative to the world capital market and that there are no capital market imperfections plays a crucial role in simplifying the analysis. Much of the literature on taxation in a dynamic context assumes, by contrast, that the economy is closed or, at least, that assets on external capital markets are only imperfectly substitutable for domestic assets. In such models, policies that affect domestic rates of savings or investment influence the rate of interest and the path of intertemporal consumption. Such considerations are obviated, and the analysis is thereby very substantially simplified, under the assumptions maintained here – and, implicitly, perhaps, in the standard atemporal models of fiscal competition.

public good provision levels are fixed, it is unnecessary for analytical purposes to be explicit about their time path. Since the stock of capital in the locality can vary over time, the amount of tax revenue collected from capital taxation can also vary, with τk_t the amount of revenue collected at time t. The local government budget constraint requires that

$$G = T + \int_0^\infty \tau k_t e^{-rt} dt. \tag{3'}$$

As noted, local residents derive utility from private consumption and from local public goods, but since the latter are treated as exogenously fixed they can be ignored in the remainder of the analysis. In particular, no restrictions are placed on the role of public goods in the preference structure of households. The preferences of households over private consumption streams can also be very general; essentially all that is required is that household intertemporal utility maximization exhausts the present-value lifetime budget constraint. This basic assumption implies that the welfare of local residents is an increasing function of lifetime wealth. As already noted, households are endowed with fixed supplies of labor, earning a gross return of w_t in every period. Local residents may also be endowed with some stock of capital $\bar{k}$ which earns a flow return of $r\bar{k}$ in every period, as well as some ownership shares in local and foreign firms. Let θ represent the local ownership share in local firms, with $0 \leq \theta \leq 1$, and let $\bar{\Pi}$ represent the present value of profits derived from ownership of firms outside of the locality (that is, the product of the share of foreign firms owned by local residents and the total profits of those firms). Under these assumptions, the present value of lifetime income for local residents is given by

$$\begin{aligned} Y &= \int_0^\infty \left(f(k_t) - k_t f'(k_t)\right) e^{-rt} dt + \bar{k} + \theta\Pi + \bar{\Pi} - T \\ &= \int_0^\infty \left(f(k_t) - k_t f'(k_t)\right) e^{-rt} dt + \bar{k} + \theta\Pi + \bar{\Pi} - G + \int_0^\infty \tau k_t e^{-rt} dt, \end{aligned} \tag{4'}$$

where the second equation follows by substitution from (3′). Under the assumptions of the model, local tax policy affects the welfare of local residents only insofar as it affects Y. In particular, one can ask whether a change in the rate of capital taxation, starting from any initial level, would increase or decrease Y and thus the level of welfare of local residents. As in the static model, to answer this question one must first determine how the level of capital in the local economy depends on the local tax rate. Since the capital stock adjusts gradually over time to a change in τ, the entire dynamic path of the capital stock changes when tax policy changes, an adjustment that is considerably more complex than the static response described in (2).

3 Comparative Dynamics: Time-Invariant Local Tax Policy

The present section investigates the effects of time-invariant local policies. The first task is to understand how a once-and-for-all unanticipated and permanent change in the local tax on capital affects the evolution of the local capital stock. This will be studied under the assumption that the local economy is initially in a long-run equilibrium. It will then be possible to determine how the local tax policy affects local welfare. Issues relating to time-varying and anticipated policy changes are deferred until the next section.

3.1 Fundamental Analytics

To understand the linkage between local tax policy and the local capital stock, it is necessary to analyze the behavior of firms in greater detail. Specifically, forming the current-value Hamiltonian

$$H_t \equiv \pi_t + \lambda_t(i_t - \delta)k_t,$$

the necessary conditions for a solution to the profit-maximization problem (P) are

$$\frac{\partial H}{\partial i_t} = 0 \;\leftrightarrow\; \lambda_t = 1 + c'(i_t) \tag{8}$$

$$-\dot{\lambda} + r\lambda_t = \frac{\partial H}{\partial k_t} \;\leftrightarrow\; -\dot{\lambda} = f'(k_t) - c(i_t) + (\lambda_t - 1)i_t - \tau - \lambda_t(r + \delta). \tag{9}$$

By (8), the profit-maximizing rate of investment is determined implicitly as a function $i_t = \phi(\lambda_t)$ with $\phi'(\cdot) = c''(\cdot)^{-1} > 0$. Substituting into (9) and defining $\Psi(\lambda_t) \equiv c(\phi[\lambda_t]) - c'(\phi[\lambda_t])\phi(\lambda_t)$ yields

$$-\dot{\lambda} = f'(k_t) - \Psi(\lambda_t) - \tau - \lambda_t(r + \delta). \tag{10}$$

Equations (6) and (10) define a dynamical system in the two variables k_t and λ_t. Letting λ_∞, k_∞, and i_∞ denote steady state values, (6) and (10) imply that

$$i_\infty \equiv \phi(\lambda_\infty) = \delta \tag{11}$$

$$f'(k_\infty) = \Psi(\lambda_\infty) + \tau + \lambda_\infty(r + \delta) \tag{12}$$

which uniquely determine the steady state of the system.

To see how the local capital stock depends on local taxation, first derive the variational equations

$$\frac{d\dot{k}}{d\tau} = (\phi(\lambda_t) - \delta)\,\frac{dk}{d\tau} + k_t\phi'(\lambda_t)\frac{d\lambda_t}{d\tau} \tag{13}$$

$$\frac{d\dot{\lambda}}{d\tau} = -f''(k_t)\frac{dk}{d\tau} + (r + \delta + \Psi'(\lambda_t))\,\frac{d\lambda_t}{d\tau} + 1 \tag{14}$$

from (6) and (10). These equations, together with the boundary conditions $k_0 = K_0$ and $lim_{t\to\infty}\lambda_t = \lambda_\infty = \phi^{-1}(\delta)$, provide two linear differential equations which can be solved for the functions $d\lambda_t/d\tau$ and $dk_t/d\tau$, i.e., for the comparative-dynamic response of the system to a change in the local rate of taxation on capital.[11]

In particular, assuming that the locality is initially in a steady-state equilibrium, (13) and (14) form a two-equation system with constant coefficients. To solve this system, it is convenient to reduce its dimensionality. Using (11) in (13) and noting that $\phi'(\lambda_\infty) = 1/c''(\delta)$, it follows that $d\dot{k}/d\tau = (k_\infty/c''(\delta))\, d\lambda_t/d\tau$ which can be inverted to solve for

$$\frac{d\lambda_t}{d\tau} = \frac{c''(\delta)}{k_\infty}\frac{d\dot{k}_t}{d\tau} \tag{15}$$

and hence

$$\frac{d\dot{\lambda}_t}{d\tau} = \frac{c''(\delta)}{k_\infty}\frac{d\ddot{k}_t}{d\tau}. \tag{16}$$

Noting (as is easily verified) that $\Psi'(\lambda_\infty) = -\delta$, substitution from (15) and (16) into (14) yields a second-order differential equation in $dk_t/d\tau$

$$d\frac{\ddot{k}_t}{d\tau} = r\frac{d\dot{k}_t}{d\tau} - \frac{k_\infty f''}{c''(\delta)}\frac{dk_t}{d\tau} + \frac{k_\infty}{c''(\delta)} \tag{17}$$

with the boundary conditions $k_0 = K_0$ and $lim_{t\to\infty}k_t = k_\infty$. The characteristic polynomial for this equation has two distinct real roots, denoted ρ_1 and ρ_2, where

$$\rho_1, \rho_2 = \frac{r}{2} \pm \frac{\sqrt{r^2 - 4k_\infty f''(k_\infty)/c''(\delta)}}{2}; \tag{18}$$

note that $\rho_1 > r$ and $\rho_2 < 0$, where these inequalities depend on the concavity of f and the convexity of c. Let $\epsilon_\infty \equiv f'(k_\infty)/(k_\infty f''(k_\infty))$ denote the steady-state value of the local elasticity of demand for capital. Then one can verify that the solution to the equation is

$$\frac{dk_t}{d\tau} = \frac{k_\infty}{f'(k_\infty)}\epsilon_\infty\left(1 - e^{\rho_2 t}\right). \tag{2'}$$

From (2′), it follows that

$$\frac{dk_t}{d\tau} < 0 \quad \text{for all} \quad t > 0, \tag{19}$$

that is, an increase in the local tax on capital reduces the capital stock at all subsequent times. Indeed, the reduction in the capital stock is monotonic, and

[11] See Boadway (1979) for a comparative-dynamic tax analysis, in a closed-economy context, using similar techniques. Hartman (1964, Theorem 3.1, pp. 95-96, provides the relevant results on the differentiation of the solution to a differential equation with respect to a parameter.

the magnitude of ρ_2 determines the rate at which the capital stock falls to its new, lower, steady-state value. The resemblance between (2′) and its static equivalent, (2), is remarkable; in particular, the two both depend critically on the local elasticity of demand for capital and differ by the time-dependent adjustment factor $1 - e^{\rho_2 t}$. Since this factor approaches 1 as $t \to \infty$, the long-run response of the capital stock to a tax increase is *identical* to that derived in the static model.

Note from (18) that the rate of adjustment of the capital stock depends critically on $c''(\delta)$, that is, the second derivative of the adjustment cost function. If the adjustment cost function is only mildly convex, so that c'' is close to zero, then $|\rho_2|$ is large and the adjustment to the new steady state occurs very quickly. If c'' is large, however, $|\rho_2|$ is small, and the adjustment to the steady state is slow.

The principal conclusions of this analysis can be summarized as follows:

Proposition 1: Starting from an initial steady-state equilibrium, a permanent unanticipated increase in the capital tax rate lowers the new steady-state equilibrium capital stock in proportion to the elasticity of demand for capital. The capital stock falls monotonically to its new steady-state value at a rate that depends positively on the convexity of the adjustment cost function. In particular, with linear adjustment costs, the adjustment is instantaneous.

3.2 The Welfare Analysis of Fiscal Policy with Imperfect Capital Mobility

Having characterized the comparative-dynamic effects of local capital taxes on the evolution of the capital stock, it is now possible to consider the welfare implications of capital taxation. In particular, it is of greatest interest to examine the effect of changes in τ on the welfare of local residents, as represented by their lifetime wealth Y. To facilitate the exposition, consider first the case where local firms are owned entirely by non-residents, i.e., $\theta = 0$. Differentiating (4′),

$$\begin{aligned} \frac{dY}{d\tau} &= \int_0^\infty \left(-k_\infty f''(k_\infty) \frac{dk_t}{d\tau} + \tau \frac{dk_t}{d\tau} + k_\infty \right) e^{-rt} dt \\ &= \int_0^\infty \left(k_\infty e^{\rho_2 t} + \tau \frac{dk_t}{d\tau} \right) e^{-rt} dt \\ &= \frac{k_\infty}{r - \rho_2} \left(1 - \frac{\tau}{f'} \epsilon_\infty \frac{\rho_2}{r} \right) \end{aligned} \tag{5′}$$

where the second and third equalities follow from (2′). Note that while (5′) resembles (5) in some respects, it also differs from it significantly.

To interpret (5′), consider first the case where $\tau = 0$, i.e., the locality initially raises no taxes from capital. In this case, it is clear that $dY/d\tau > 0$, that is, it is optimal for the locality to impose a positive tax on capital. This is in contrast to the analysis in the static case, culminating in (5), where, as was noted, the optimal local tax rate is zero. The gain from local capital taxation, however, depends on the value of the speed of adjustment of the capital stock; the larger the value of $|\rho_2|$, the smaller the gain from taxing capital. Indeed, in the extreme case of linear adjustment costs, adjustment is instantaneous, and the gain from local taxation of capital vanishes.

In view of (19), it is obvious that local welfare is maximized by choosing a positive rate of taxation τ^* on local capital such that $dY/d\tau = 0$. In fact, one can solve (implicitly) for the (locally) optimal rate of capital taxation, expressed as a proportion of the gross return on capital, as

$$\frac{\tau}{f'(k_\infty)} = \frac{r}{\epsilon \rho_2}, \tag{20}$$

an inverse-elasticity type of formula in which the rate of adjustment of the capital stock, ρ_2, again figures prominently.

These results change in a significant but straightforward fashion when local residents own some portion of the firms within the jurisdiction, *i.e.*, when $\theta > 0$. In this case, it is necessary to add the term $\theta d\Pi/d\tau$ to the expression in (5′) in order to capture the impact on local welfare from a change in the tax rate on capital. Explicit calculation of $d\Pi/d\tau$ shows that the formula for the optimal tax rate, allowing for local ownership of profit-making firms, generalizes from (20) to[12]

$$\frac{\tau}{f'(k_\infty)} = \frac{(1-\theta)r}{\epsilon \rho_2}. \tag{20′}$$

The noteworthy difference between (20) and (20′) is that local ownership of firms reduces the optimal tax rate on capital. In particular, if local firms are owned entirely by local residents, so that $\theta = 1$, the optimal tax rate on capital is zero. More generally, the higher the share of local ownership in firms, the lower the optimal tax rate. To summarize,

Proposition 2: The optimal steady-state rate of taxation of local capital is directly proportional to the share of foreign ownership of firms and inversely proportional to the elasticity of demand for capital. It is inversely proportional to the speed with which the local capital stock adjusts in response to changes in the local rate of return on capital. In particular, if adjustment is instantaneous, the optimal local tax rate is zero.

This proposition is helpful in the proper interpretation of previous results from atemporal models which abstract from the dynamics of adjustment. When adjustment costs are negligible, there are no quasi-rents to extract from the owners of local capital, and no incentive for local governments, acting in the interests of their residents, to impose fiscal burdens on this capital. However, if it is costly to adjust the local capital stock, the owners of this capital, when net fiscal burdens are imposed on them, will not find it in their interest to reduce

[12]See the Appendix for a brief presentation of this generalization as well as a sketch of some of the derivations underlying other parts of the analysis.

the capital stock immediately to a level at which it again earns a competitive net rate of return. Rather, they will allow the capital stock to fall gradually until it reaches its new steady-state value. During this transition, the net rate of return is below the level that can be obtained on external markets, and the local capital tax thus transfers quasi-rents from capital owners to local residents. Thus, a small open locality, whose policies have no perceptible effect on the net rate of return to capital on external markets, can nonetheless achieve some redistribution at the expense of the owners of *imperfectly* mobile resources even though, in the long run, the net rate of return on local capital must return to that which can be obtained on external markets. The redistributive impact of the local capital tax, however, is dependent on the amount of quasi-rents available to be captured, which depends on the costs of adjustment. Previous literature, which abstracts from adjustment costs, in effect assumes that the capital stock is able to adjust to changes in local fiscal policies without delay.

Obviously, the use of local taxes on imperfectly mobile capital to capture rents from the owners of that capital is only effective when the capital is owned by firms that in turn are owned, at least in part, by non-residents. Otherwise, the taxation of local capital only imposes a tax burden on local residents.[13]

Even if local residents enjoy the full benefits of the revenue from the capital tax, the imposition of such a tax leaves them worse off, on a net basis, because of its allocative effects: it drives capital out of the local jurisdiction over time, imposing what from the local perspective is a distortionary tax on an input that is available at a fixed price on the external market. As is well known from the theory of optimal tariffs, such a policy is not in the interest of a small open jurisdiction, in the absence of quasi-rents accruing to outsiders that can compensate, and more than compensate, for the distortionary effect of the tax.

While it is true that a locality's residents can benefit from taxing imperfectly-mobile capital when firms are owned at least in part by non-residents, the reduction in the stock of local capital reduces the productivity of local labor, and the steady-state level of wage income is reduced by the taxation of mobile capital. Taxing imperfectly-mobile capital thus involves an intertemporal tradeoff for local residents: they can enjoy the benefits of reduced taxes for local public services, but gradually their wage income erodes, ultimately by an amount greater than the tax savings that they obtain by taxing capital. The preceding analysis has shown that the taxation of local capital is in their interest *in present value terms*, when discounted at the market rate of return. However, if the effects of local policy are discounted at a lower rate, this intertemporal tradeoff becomes less favorable. Indeed, if they are not discounted at all, so that policies are judged only by their long-run effects, the local capital tax is necessarily harm-

[13]See Huizinga and Nielsen (1997) for an analysis of taxation in an open-economy setting in which, as here, the extent of foreign ownership of local firms plays a critical role in determining the optimal local tax structure. In contrast to the present analysis, Huizinga and Nielsen focus on the tradeoff between distortionary local taxes on savings or investment and distortions of costless interjurisdictional capital flows in a two-period setting. Here, by contrast, the local government has access to distortionless taxes on or transfers to local residents and, but for the imperfect mobility of capital, would never impose a capital tax.

ful to local residents, even if firms are entirely owned by outsiders, and thus should be avoided. This is another way to interpret the findings of previous analyses: by ignoring the transitional dynamics of adjustment to local policies, they have in effect focused on the long-run impacts of fiscal policy and, in doing so, have concluded that localities, acting in the interests of their residents, will not attempt to impose fiscal burdens on mobile factors of production.

4 Comparative Dynamics: Time-Varying (Anticipated) Local Tax Policy

The analysis in the preceding section has shown how the introduction of imperfect capital mobility, in the form of adjustment costs, leads to significant changes in the incentives for a locality to impose a tax on capital. The analysis of tax policy in a dynamic setting, however, naturally raises questions about how policies might vary over time, about expectations, and about time consistency. Many of these issues have been thoroughly discussed in previous literature, and do not necessarily warrant detailed analysis here. However, as has been seen noted above, the difference between the results from the static analysis in Section 2.1 and those of Proposition 2 derive from the quasi-rents accruing to non-resident owners of local capital that, in the short run, can be captured by local residents through an unanticipated permanent increase in the local tax rate. Wouldn't capital owners foresee their vulnerability and act to shield themselves from fiscal exploitation in this manner?

There are indeed several ways in which the ability of a locality to extract rents from outside owners of partially (or wholly) immobile resources may, in practice, be limited. First, if ownership of these resources is transferable, they may be sold by non-residents to residents, or never acquired by non-residents to begin with. When $\theta = 0$, as shown by (20), the optimal local tax rate is zero. This is because there are no rents to extract from outsiders, and therefore no local benefit that can offset the cost of distorting the local capital stock. Second, non-resident owners might attempt to influence the local policy-making process so as to protect their quasi-rents. In principle, they would be willing to pay up to the full amount of these rents in bribes, campaign contributions, or other rent-preserving activities. If local policymakers are perfect rent extractors, then the attempt to influence the local political process will, in effect, absorb the wealth of non-residents within the locality in much the same fashion as local taxes. On the other hand, it is conceivable that influence over the local political process can be achieved by non-resident capital owners at very low cost. In this case, the equilibrium local policy choice would involve a negligible net fiscal burden on capital. A third restraint on the use of local taxation to extract rents from non-resident capital owners is the anticipation by outside investors that their capital will be subject to taxation in the future, leading them to remove some or all of their capital from the locality before the local tax is actually imposed.

To explore this third possibility more formally, suppose, in contrast to the model of Section 2, that all agents anticipate an increase in the local tax rate at some date $t_1 \geq 0$. Specifically, the tax rate at time t is τ for $0 \leq t \leq t_1$ and $\tau + \alpha$ for $t \geq t_1$. Note that the anticipation of the change in policy at time t_1 is equivalent, technically speaking, to the unanticipated announcement, at $t = 0$, of a time-varying policy – specifically, one that maintains the initial tax rate until $t = t_1$ and then jumps to a higher level thereafter. While the discussion in the remainder of this section is limited to the case of a once-and-for-all change in policy at a specified future date t_1, it will be apparent that more complex time-varying policies, with any number of changes at any specified points of time, can be built up from combinations of this simple one-time jump. Thus the following analysis provides the foundation for essentially arbitrary perturbations of policy over time.

With this anticipated jump in the tax rate at a future date, firms must plan their investments both before and after t_1 in a profit-maximizing fashion. This does not drastically change the conditions characterizing the solution to the profit-maximization problem (P); in particular, the form of the current-value Hamiltonian is unaffected and the optimal choice of the control variable i_t must still satisfy (8). A condition like (9) also continues to hold, but its form reflects the change in the tax rate at t_1:

$$-\dot{\lambda} + r\lambda_t = \frac{\partial H}{\partial k_t} \leftrightarrow$$
$$- \dot{\lambda} = (f'(k_t) - c(i_t) + (\lambda_t - 1)i_t - \tau - \Delta_t\alpha) - \lambda_t(r + \delta). \tag{9'}$$

where $\Delta_t \equiv 0$ for $0 \leq t < t_1$ and $\Delta_t \equiv \alpha$ for $t > t_1$.

As before, (8) and (9′) combine to yield

$$-\dot{\lambda} = f'(k_t) - \Psi(\lambda_t) - \tau - \Delta_t\alpha - \lambda_t(r + \delta). \tag{10'}$$

Conditions (6) and (10′) define a dynamical system in k_t and λ_t which depends on the parameter α. The unique steady state of this dynamical system is defined by (11) and by

$$f'(k_\infty) = \Psi(\lambda_\infty) + \tau + \alpha + \lambda_\infty(r + \delta). \tag{12'}$$

To see how the local capital stock depends on local taxation, first derive the variational equations

$$\frac{d\dot{k}}{d\alpha} = (\phi(\lambda_t) - \delta)\frac{dk}{d\alpha} + k_t\phi'(\lambda_t)\frac{d\lambda_t}{d\alpha} \tag{13'}$$
$$\frac{d\dot{\lambda}}{d\alpha} = -f''(k_t)\frac{dk}{d\alpha} + (r + \delta + \Psi'(\lambda_t))\frac{d\lambda_t}{d\alpha} + \Delta_t. \tag{14'}$$

This pair of linear differential equations can be solved for the functions $d\lambda_t/d\alpha$ and $dk_t/d\alpha$.

To do so, it is convenient to convert these first-order linear differential equations in two variables into a single second-order linear equation in $dk_t/d\alpha$ alone. As before, it is assumed that the system is initially in a steady-state equilibrium, and that the policy perturbation is small, which amount to evaluating derivatives at $\alpha = 0$. The relevant second-order equation is

$$d\frac{\ddot{k}_t}{d\alpha} = r\frac{d\dot{k}_t}{d\alpha} - \frac{k_\infty f''}{c''(\delta)}\frac{dk_t}{d\alpha} + \Delta_t\frac{k_\infty}{c''(\delta)}. \tag{17$'$}$$

However, in contrast to the analysis of time-invariant tax policy presented in the previous section, the right-hand-side of (17′) is now piecewise continuous and must be solved separately for the intervals $0 \leq t \leq t_1$ and for $t \geq t_1$, resulting in two equations with four constants of integration. The solutions to these equations must must satisfy the boundary conditions $k_0 = K_0$ and $lim_{t\to\infty}\lambda_t = \lambda_\infty = \phi^{-1}(\delta)$, as before, and, in addition, both the state and the costate variables that solve the profit-maximization problem, k_t and λ_t, must be continuous functions of time, providing four conditions to determine the constants of integration.

As can be verified, the solution to (17′) is

$$\frac{dk_t}{d\alpha} = \frac{k_\infty}{f'(k_\infty)}\epsilon_\infty\frac{-\rho_2}{(\rho_1-\rho_2)e^{\rho_1 t_1}}\left(e^{\rho_1 t} - e^{\rho_2 t}\right) \text{ for } 0 \leq t \leq t_1 \tag{2a$''$}$$

$$= \frac{k_\infty}{f'(k_\infty)}\epsilon_\infty\left(1 - \left[\frac{\rho_1 e^{\rho_1 t_1} - \rho_2 e^{\rho_2 t_1}}{e^{\rho_1 t_1}e^{\rho_2 t_1}(\rho_1-\rho_2)}\right]e^{\rho_2 t}\right) \text{ for } t > t_1 \tag{2b$''$}$$

where ρ_1 and ρ_2, respectively the positive and negative roots of the characteristic polynomial associated with (17′), are given in (18). Note that this solution satisfies

$$\frac{dk_t}{d\tau} < 0 \quad \text{for all} \quad t > 0, \tag{19$'$}$$

and, in particular,

$$\frac{dk_{t_1}}{d\alpha} = \frac{k_\infty}{f'(k_\infty)}\epsilon_\infty\frac{-\rho_2}{(\rho_1-\rho_2)e^{\rho_1 t_1}}\left(e^{\rho_1 t_1} - e^{\rho_2 t_1}\right) < 0. \tag{21}$$

Comparing (19) with (19′), it is clear that the qualitative impact of an increase in the local tax rate is the same, whether the tax increase is unanticipated or anticipated: in both instances, higher taxes cause the capital stock to be lower at every point in time. This means, of course, that the mere anticipation of a tax increase is sufficient to cause the capital stock to start shrinking right away, even though the actual policy change may lie far in the future. However, and as would be expected intuitively, the pre-implementation impact of an anticipated policy change is more limited, the more distant in time the policy change is.[14] Differentiating (21) with respect to t_1, one can see that more of the long-run

[14] From (2a″), a higher value of t_1 implies a smaller change in k_t for any given $t < t_1$.

adjustment will have been completed by the time that the higher tax rate takes effect, the longer the time between the announcement of the policy change and its implementation (i.e., the larger the value of t_1). The long-run effects of the tax increase are exactly the same regardless of whether or not the tax increase is anticipated.[15]

Although the qualitative effects of anticipated policy changes are identical to those of unanticipated ones, the two differ in degree. In particular, the rate of decline of the capital stock in the pre-implementation stage of adjustment – i.e., in the period $0 \leq t \leq t_1$ – is slower than would be true if the policy were implemented immediately. Thereafter, the process of adjustment continues, eventually resulting in the same reduction in the steady-state level of capital as would be true for the unanticipated policy change. To summarize,

Proposition 3: (a) Starting from an initial steady-state equilibrium, a permanent anticipated increase in the capital tax rate lowers the new steady-state equilibrium capital stock in proportion to the elasticity of demand for capital. The capital stock falls monotonically to its new steady-state value at a rate that depends positively on the convexity of the adjustment cost function. In particular, with linear adjustment costs, the adjustment is instantaneous.

(b) The anticipation of a tax increase causes the capital stock to begin falling immediately. The more in advance the tax change is anticipated (or announced), the more the capital stock will have adjusted by the time the tax increase takes place.

Part (a) of Proposition 3 merely recapitulates the results stated in Proposition 1, thus emphasizing the qualitative similarity of the two cases. The second part, which is unique to the analysis of anticipated changes, is very intuitive. Convex adjustment costs imply that the capital stock adjusts gradually over time. It makes sense, then, that the *anticipation* of a tax increase causes adjustment to begin right away, allowing a longer period of time for adjustment to take place. The anticipation of a policy change, does not, however, affect the desired long-run adjustment. Hence, the main effect of anticipation of a policy change is to lengthen and slow down the adjustment process.

Equipped with these results, it is now possible to consider the welfare implications of local tax policy when policy changes are anticipated. Intuitively, one would expect that the gains from taxation, identified in Section 2, are diminished. To check this, it is necessary to calculate the effect of an anticipated change in the local tax rate on the net income of local residents. The method of analysis is the same as for the case of unanticipated policy changes. Detailed

[15] Note from (2b$''$) that only the last term in brackets depends on time, and that it approaches zero as time increases, thus insuring that the long-run behavior of the system is identical both to the case of anticipated policy changes as discussed in Section 2.2 and to the result for the static model shown in (2).

calculations[16] show that

$$\frac{dY}{d\alpha} = \frac{k_\infty}{r-\rho_2}\left([1-\theta] - \frac{\tau}{f'}\epsilon_\infty\left[\frac{\rho_2}{r}e^{-rt_1} + e^{-\rho_1 t_1} - e^{-rt_1}\right]\right). \tag{5''}$$

This expression is a generalization of (5′), reducing to it when $\theta = 0$ and $t_1 = 0$ – i.e., in the case corresponding to (5′) where the profits of firms accrue to non-residents and where the change in tax policy is unanticipated. More generally, it is clear from (5″) that the potential gains from an increase in the local tax rate are reduced, to the extent that local firms are owned by local residents, as one might expect. Furthermore, since the terms on the right-hand-side of (5″) depend negatively on t_1, it is clear that the anticipation of a tax increase reduces whatever positive impact such a policy might have on local residents. Indeed, setting the derivative in (5″) equal to zero and solving for the optimal tax rate, one obtains

$$\frac{\tau}{f'(k_\infty)} = \frac{(1-\theta)}{\epsilon}\frac{r}{\rho_2 - \rho_1\left[e^{(\rho_1 - r)t_1} - 1\right]}. \tag{20''}$$

This expression generalizes (20′), reducing to it when $t_1 = 0$, i.e., in the case, corresponding to (20′), where changes in local tax policy are unanticipated. This expression shows that it is indeed optimal for local residents to impose a tax on local capital, even when this policy is anticipated, and even when a portion of the profits of local firms accrue to residents. However, (20″) shows that the higher the value of t_1, the lower the optimal local tax rate. In fact, as $t_1 \to \infty$, the optimal local tax rate approaches zero.

These findings can be summarized as

Proposition 4: (a) The optimal steady-state rate of taxation of local capital is directly proportional to the share of foreign ownership of firms and inversely proportional to the elasticity of demand for capital. It is lower, the greater the speed with which the local capital stock adjusts in response to changes in the local rate of return on capital. In particular, if adjustment is instantaneous, the optimal local tax rate is zero.

(b) To the extent that an increase in the local tax rate is anticipated, the optimal local tax rate is reduced; the more in advance the tax change is anticipated (or announced), the lower is the optimal local tax rate.

The first part of this proposition is almost identical to Proposition 2. The second part is quite intuitive in light of the findings presented in Proposition 3: since the anticipation of a tax increase causes an outflow of capital to begin even before the higher tax takes effect, and since this outflow reduces the benefits to local residents from higher taxes, it makes sense that the optimal tax rate is lower when the owners of local capital are not taken completely by surprise by changes in local tax policy.

[16]These calculations are outlined in an Appendix.

The formula for the optimal tax rate in (20″) lends itself to empirical estimation, and it is of interest to present some illustrative calculations based on it. Suppose, for example, that the local production technology is Cobb-Douglas and that the share parameter for capital is .25; this implies an elasticity of demand for local capital $\epsilon = -1.33$. Assume a real interest rate of $r = .05$. The parameters ρ_1 and ρ_2 reflect the adjustment-cost technology and would presumably vary, depending on the specific jurisdiction and on the type of capital being analyzed. It is beyond the scope of the present analysis to estimate these parameters. However, note from (2′) and (2b″) that ρ_2 is the proportionate rate of decline of the local capital stock subsequent to the implementation (whether anticipated or unanticipated) of a higher local tax. This means that the half-life of the post-implementation adjustment process is $T = \ln(.5)/\rho_2$. Since $\rho_1 = r - \rho_2$, it is a simple matter to determine the values of ρ_1 and ρ_2 that correspond to different assumptions about the post-implementation speed of capital stock adjustment.

Table 1 presents calculations showing the optimal local tax rate for different assumed values of critical parameters of the model. Each panel is based on a different assumption about the degree to which any change in local tax policy is anticipated, ranging from the assumption that any change in policy is a total surprise (Case A) to the assumption that policy changes are foreseen 50 years in advance (Case D). Different columns of each panel reflect different assumptions about the adjustment cost technology, as reflected in the half-life of the adjustment process, ranging from very rapid adjustment (a half-life of only 6 months) to quite slow adjustment (a half-life of 20 years). Finally, different rows in each panel correspond to different assumptions about the share of the profits of local firms accruing to local residents.

Qualitatively, the results follow the expected patterns. For example, it is not in the interest of local residents to impose any tax at all on local capital if this capital is employed in firms that entirely locally-owned; in this case, there are no rents to capture from non-residents and the capital tax merely harms local residents by distorting the level of local investment. The more rapid the response of the capital stock to changes in the local net return to capital, the lower the optimal tax rate. With extremely rapid adjustment, the optimal local tax rate is effectively nil, but if capital can only be adjusted slowly, and if significant amounts of capital are owned by non-residents, then substantially higher rates of taxation may be called for. At least this is the case if the local tax can be imposed without warning, as shown in the top panel. However, if firms foresee the threat of local taxes well in advance, the optimal policy is to impose only minimal burdens on local capital, even if it can adjust only slowly to local policy changes.

Although the calculations in Table 1 are only illustrative, one can readily see how the theoretical analysis culminating in (20″) lends itself to empirical application. Estimates of critical parameters characterizing production technologies (ϵ), cross-ownership of factors of production (θ), and speeds of adjustment (ρ_1, ρ_2) are in some cases relatively readily available for different countries or other geographic units. Speeds of adjustment for spatial reallocations of capital (or other factors of production, like labor) have not been the focus of much of nearly as much empirical analysis, but, in principle at least, these can also be determined empirically. For example, Decressin and Fatas (1995) have explicitly estimated the migration response to local labor demand shocks in regions of comparable size (roughly corresponding to US states) in the US and in the EU, and have found that the speed of response in Europe is approximately half that for the US.[17] It is easy to see, from (20′′) or from Table 1, exactly what implications these findings have for the determination of optimal local fiscal policy. More estimates of this nature for regions or jurisdictions of different size within countries and at the international level, for labor (of different types) and for capital (of different types), could be used, for example, to test whether greater factor mobility does indeed constrain governments in using fiscal policy to impose net burdens or offer net subsidies. Of course, it is necessary simultaneously to assess the degree of cross-ownership of factors of production, a non-trivial task. As noted at the beginning of this section, the desire of governments to capture quasi-rents from non-resident owners of imperfectly mobile resources may discourage cross-ownership of such resources. It is often noted (e.g., Baxter and Jermann (1997))that international cross-ownership of capital is insufficient to achieve full diversification of risks on financial assets. An intriguing question is whether political-economy considerations (essentially, risk of expropriation through fiscal or other policies) plays a role in explaining this fact.[18] One might anticipate that low degrees of factor mobility (the ρ_i's) would be associated empirically with a high degree of local ownership (θ). These issues warrant further theoretical and empirical investigation.

5 Conclusion

The preceding sections have presented an explicitly dynamic analysis of fiscal competition built on a standard model of costly adjustment of the stock of a factor of production. This analysis has shown how an endogenously-determined level of factor mobility affects the response to changes in fiscal policy and how this in turn alters the desirability of alternative policies. The results do not represent a complete break with those obtained in static or atemporal analyses; on the contrary, the results from the dynamic analysis emerge as direct generalizations of those derived within standard static models. Broadly speaking, the analysis indicates that governments may have incentives to impose net fiscal burdens on imperfectly-mobile factors of production, even though this is harmful in the long run, because there are short-run rents that can be captured from the non-resident owners of these factors. On balance, the short-run gains can offset the long-run losses, at least for modest rates of net taxation. However,

[17]For an interesting recent analysis of labor migration between the US and Mexico, see Robertson (2000), who finds that labor flows occur more rapidly between parts of Mexico that border the US than is true for more interior locations of Mexico.

[18]See Wildasin and Wilson (1998) for a formal model that addresses the implications of local rent-capture for risk pooling and welfare, as well as for references to related literature.

the ability of a government to capture these rents depends in part on being able to "surprise" non-resident owners of the imperfectly mobile resources, and the magnitude of the rents themselves depend on the costliness of factor mobility.

How quickly capital or labor can flow from one real-world jurisdiction to another is an empirical question. It is commonly argued, and it is no doubt broadly true, that there are more impediments to international factor flows than to flows within countries. Such impediments presumably reduce the volume of factor flows observed in practice, and give rise to differentials in rates of return gross of the costs of factor relocation. They probably also tend to reduce the speed of equilibrating factor market adjustments, although it must be noted that this is not necessarily the case.[19] The analysis developed above invites empirical application and indicates exactly what sorts of empirical analysis are likely to shed the greatest light on policy-relevant issues.

The theoretical analysis presented here is nonetheless quite simplified in a number of respects, and a number of important extensions remain to be undertaken. The analysis here has focused on the case of a jurisdiction that is sufficiently small that its policies do not affect equilibrium factor prices in external markets. As in the theory of the firm in a perfectly competitive industry, this obviates the need to be concerned with strategic interactions among governments. If, however, two or more jurisdictions are sufficiently large relative to external factor markets that their policies have non-negligible impacts on factor prices, the choice of fiscal policy by one will affect the optimal choices of others, and conversely. The analysis of strategic fiscal interactions in a dynamic setting such as that presented above may offer useful new insights.

In focusing on optimal policy for a single jurisdiction, the analysis has not explicitly addressed the welfare properties of fiscal competition among a *system* of jurisdictions. It is apparent, however, that imperfect mobility of factors gives rise to incentives for small governments to impose distortionary fiscal policies. In a world where all jurisdictions are perfectly symmetric, the fact that each imposes an identical net burden on a mobile resource causes no spatial factor misallocations. However, in the more general and realistic case where jurisdictions have differeing production or adjustment-cost technologies or differ in the degree of local ownership of mobile resources, they will optimally impose unequal fiscal policies on imperfectly-mobile factors, resulting, in the equilibrium of the entire system, in an inefficient spatial allocation of resources. (This is in contrast to the results obtained in the standard atemporal models with free factor mobility, where, in equilibrium, no small jurisdiction would impose a non-zero fiscal burden on mobile factors which are thus, in equilibrium, allocated efficiently over space.) An obvious topic for further investigation is whether and how local policies can be constrained or coordinated (e.g., through restrictions imposed by higher-level governments or through intergovernmental agreements) so as to limit or eliminate these inefficiencies.

[19]In the formal analysis above, the speed of adjustment is dictated not by the "level" of adjustment costs but by the "convexity" of the adjustment cost function – i.e., its second derivative. Knowing that adjustment costs are high is not equivalent to knowing that adjustment takes place slowly.

From the viewpoint of empirical applicability, one of the more serious limitations of the above analysis is the fact that it is restricted to the case of a single imperfectly-mobile factor of production. In many contexts, it is of considerable interest to analyze the simultaneous dynamic adjustment of two or more factors of production, such as labor and capital, different types of labor (e.g., skilled and unskilled), or different types of capital (e.g., long-lived structures as compared with short-lived equipment or inventories). The foregoing analysis can be generalized almost immediately to the case where different industries within a jurisdiction use different mobile factors of production in combination with different immobile factors, and where the different mobile factors can be subjected to different fiscal treatment. In this case, each immobile factor can be analyzed independently along the lines developed above. Such an analysis would show, for example, that it is optimal to impose smaller fiscal burdens on those factors of production for which the speed of adjustment or the degree of local ownership is particularly high. While this case is perhaps not entirely without interest, it is much more natural in many instances to view different imperfectly-mobile factors of production as complementary inputs in the local production process and, at least in some instances, as likely to be subject to uniform fiscal treatment. An explicit analysis of the joint stock-adjustment problem with complementary inputs would shed light on the optimal structure of fiscal treatment for different factors of production, an issue of considerable empirical and policy relevance.

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APPENDIX

This appendix spells out some additional details behind the results in the text.

It is a straightforward matter to verify that equations (2a′′) and (2b′′) solve (17′), which implies, as a special case, that (2′) solves (17). Propositions 1 and 3 follow easily once these solutions are obtained.

To calculate the effect of a change in α on local welfare, as measured by Y, begin by noting that

$$\begin{aligned}\frac{d\Pi}{d\alpha} &= \int_0^\infty \frac{d\pi_t}{d\alpha} e^{-rt} dt \\ &= \int_0^\infty \left\{ (f' - [c+i]) \frac{dk_t}{d\alpha} - k_\infty (1 + c'(\delta)) \frac{di_t}{d\alpha} \right\} e^{-rt} dt \\ &\quad - \int_0^\infty \left\{ \tau \frac{dk_t}{d\alpha} + k_\infty \Delta_t - \frac{dw_t}{d\alpha} \right\} e^{-rt} dt \end{aligned} \tag{22}$$

Substituting from (8) and (9′),

$$\begin{aligned}&\int_0^\infty \left\{ (f' - [c+i]) \frac{dk_t}{d\alpha} - k_\infty \frac{di_t}{d\alpha} \right\} e^{-rt} dt = \\ &\qquad \lambda \int_0^\infty \left\{ r \frac{dk_t}{d\alpha} - k_\infty \frac{di_t}{d\alpha} \right\} e^{-rt} dt + \int_0^\infty \tau \frac{dk_t}{d\alpha} \qquad e^{-rt} dt \\ &\qquad\qquad = \int_0^\infty \tau \frac{dk_t}{d\alpha} e^{-rt} dt \end{aligned} \tag{23}$$

where the second equality is obtained by noting first that $k_\infty di_t/d\alpha = d\dot{k}_t/d\alpha$ in a steady state and then by integrating by parts.

Differentiation of (4′) (see (5′) for comparison), using (22) and (23),

$$\frac{dY}{d\alpha} = (1-\theta) \int_0^\infty \left\{ \tau \frac{dk_t}{d\alpha} - k_\infty f''(k_\infty) \frac{dk_t}{d\alpha} \right\} e^{-rt} dt + \theta \int_0^\infty \tau \frac{dk_t}{d\alpha} e^{-rt} dt \tag{24}$$

It is easy to see from this expression why the term $(1-\theta)$ appears in (20′) and (20′′) and not in (20).

The remaining rather tedious task is to substitute for $dk_t/d\alpha$ from (2a′′) and (2b′′) and to perform the relevant integrations in order to solve explicitly. The details are omitted, but the interested reader will wish to note from (18) that $\rho_1 - r = -\rho_2$, which facilitates some cancellations and simplification.

Table 1. Optimal Local Tax Rate (in percent)

Case A: Unanticipated Policy Change						
Local Ownership	**Half-life of Adjustment Process (in Years)**					
Share	0,5	1	2	5	10	20
0,00	2,7	5,4	10,8	27,1	54,2	100,0
0,25	2,0	4,1	8,1	20,3	40,7	81,4
0,50	1,4	2,7	5,4	13,6	27,1	54,2
0,75	0,7	1,4	2,7	6,8	13,6	27,1
1,00	0,0	0,0	0,0	0,0	0,0	0,0

Case B: Tax Increase Anticipated by 1 Year						
Local Ownership	**Half-life of Adjustment Process (in Years)**					
Share	0,5	1	2	5	10	20
0,00	0,7	2,6	7,4	22,6	48,3	99,9
0,25	0,5	2,0	5,5	16,9	36,2	74,9
0,50	0,3	1,3	3,7	11,3	24,1	49,9
0,75	0,2	0,7	1,8	5,6	12,1	25,0
1,00	0,0	0,0	0,0	0,0	0,0	0,0

Case C: Tax Increase Anticipated by 5 Years						
Local Ownership	**Half-life of Adjustment Process (in Years)**					
Share	0,5	1	2	5	10	20
0,00	0,0	0,2	1,7	11,5	31,7	74,2
0,25	0,0	0,1	1,3	8,6	23,7	55,6
0,50	0,0	0,1	0,9	5,7	15,8	37,1
0,75	0,0	0,0	0,4	2,9	7,9	18,5
1,00	0,0	0,0	0,0	0,0	0,0	0,0

Case D: Tax Increase Anticipated by 50 Years						
Local Ownership	**Half-life of Adjustment Process (in Years)**					
Share	0,5	1	2	5	10	20
0,00	0,0	0,0	0,0	0,0	1,0	8,8
0,25	0,0	0,0	0,0	0,0	0,7	6,6
0,50	0,0	0,0	0,0	0,0	0,5	4,4
0,75	0,0	0,0	0,0	0,0	0,2	2,2
1,00	0,0	0,0	0,0	0,0	0,0	0,0