Fiscal Competition for Imperfectly-Mobile Labor and Capital: A Comparative Dynamic Analysis[†]

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Abstract: Interjurisdictional *flows* of imperfectly-mobile migrants, investment, and other productive resources result in the costly dynamic adjustment of resource *stocks*. This paper investigates the comparative dynamics of adjustment to changes in local fiscal policy with two imperfectly mobile productive resources. The intertemporal adjustments for both resources depend on complentarity/substituability in production and the adjustment cost technologies for each, implying that the evaluation of the fiscal treatment of one resource must account for the simultaneous adjustment of both.

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1 Introduction

The now-large literature on fiscal competition has emphasized that subnational and national governments do not exist in isolation from the rest of the world but must compete for mobile labor and capital. In what is by now the "benchmark case" for this literature, the focus of attention is on the taxation of a single, mobile factor of production, often interpreted as "capital", by many individual governments in a system of jurisdictions. This basic modeling structure has proven remarkably fruitful as it has been varied, extended, and reinterpreted in many ways (see, e.g., Wilson (1999), Wilson and Wildasin (2004), Wildasin (2006a), for surveys and many additional references.)[1] The intellectual origins of this literature, perhaps now casionally forgotten, lie in the study of the incidence of local property taxes the US and elsewhere. In what is still called the "new view" of property tax incidence (see, e.g., Aaron (1975), Zodrow (2007)), building upon seminal work by Mieszkowski (1972), the long-run incidence of local taxes in a closed system of jurisdictions containing a fixed aggregate supply of capital is shown to fall substantially on the system-wide net return to capital. This system-wide perspective differs from an earlier tradition of analysis of the incidence of a property tax imposed by one single locality within a larger ambient economy within which the net rate of return to capital is determined. The taxation of capital by such a community, containing as it does only a "small" fraction of the system-wide stock of capital, would have only a very small impact on the economy-wide net rate of return on capital, and the "old view" of property tax incidence in this context was that the incidence of the tax would fall on local landowners, consumers, workers, or others whose welfare would be adversely affected by changes in the equilibrium prices of local non-traded goods (land rents, non-traded consumption goods including housing, or wages).[2]

[1]It goes without saying that many studies have varied the "standard model" in ways that touch upon issues discussed here. For instance, Wilson (1995) examines the problem of choosing multiple policy instruments, de Bartolome (1997) studies the implications of gradual stock adjustment in response to local taxation, and Wildasin and Wilson (1996) study fiscal competition in an overlapping generations model. Makris (200*) studies competition for mobile capital in a model with endogenous savings.

[2]As noted in an important paper by Bradford (1978), even if a small locality's tax on capital has a very small effect on the system-wide equilibrium net return to capital, this small effect is spread over the system-wide stock of capital, and its impact on the system-wide net return to capital is of the same order of magnitude – in some cases, is exactly equal to –

More recently, this modeling approach has been applied to the analysis of corporation income and other source-based taxes on capital income imposed not by small local governments but by nations within the European Union or, indeed, by all nations in a global context. It has also been applied to the analysis of decentralized taxation of labor, whether imposed by local governments, those at the state/provincial level, or, indeed, at the national level. It is directly applicable to the analysis of subsidies to labor and capital, for instance in the context of regional development policy. With modifications, it applies as well to the analysis of decentralized provision of public goods and inputs in an open economy. Still, despite – or perhaps because – of the potentially very wide applicability of the "open economy public economics" models, they do not necessarily lend themselves readily to empirical and policy applications, for at least two reasons. First, it is clearly essential to determine what factors of production are mobile, and second, to determine over what geographical scope they are mobile. When jurisdictions compete for capital investment, does this competition take place within single metropolitan areas or within states (e.g., Brueckner and Saavedra (2001), Buettner (2001), among states within the US (e.g., Chirinko and Wilson (2007, 2008)), or among countries (e.g., Sorensen (2000, 2004), (Brochner et al. (2007), Devereux and Griffith (2002), Devereux, Griffith, and Klemm (2002))? When they compete for labor, does labor mobility extend to households within a metropolitan area (e.g., Tiebout (1956) and a vast subsequent literature), among school districts (e.g., Nechyba (1999, 2000)), among households within a nation, or among households in the entire world (Wildasin (2006b, 2008)? And does competition take place for all kinds of labor and capital simultaneously, or only for some types, such as highly skilled workers (e.g., Docquier and Rapoport (2008)), welfare recipients (e.g., Peterson and Rom, Brueckner (2000, 2003)), highly liquid financial capital (e.g.,, Huizinga and Nicodeme (2004)), manufacturing investment (Chirinko and Wilson (2007, 2008)), old people (Conway and Houtenville (2001)), or any other particular categories of capital or investment?

the amount of revenue collected by the locality. Thus, the general-equilibrium effects of policies carried out even by very small localities are not negligible, a finding with far-reaching implications for many aspects of policy analysis.

There may be no definitive answers to these questions, but it seems plausible that the degree of mobility for different types of factors of production – i.e, whether or not they are mobile, and over what geographical scope – depends crucially on the time horizon of the analysis. Whereas substantial global flows of "hot money" make occur within a matter of moments, major interregional population shifts seem to occur on time scales ranging from decades to centuries. At the same time, it seems quite important to recognize that factors of production tend to co-locate, presumably at least in substantial part because of complementarities in the production process. For instance, the many buildings and machines that make up major urban agglomerations also have large numbers of people, and regions and nations that experience sustained immigration also generally experience sustained net investment. These considerations suggest that the study of fiscal competition should ultimately be grounded in an explicitly dynamic framework in which more than one factor of production is potentially mobile. Of course, such an approach raises difficult analytical challenges. The goal of the present analysis is to develop a dynamic model of a single open economy that utilizes two imperfectly mobile factors of production – say, labor and capital. The dynamics of the model hinge on the assumption that the inflow or outflow of labor and capital – i.e., migration and investment flows – entail costly adjustment, so that faster adjustment is always potentially possible, but only at greater cost.

A model with two imperfectly mobile factors of production permits a more sophisticated approach to the study of many issues relating to fiscal competition. In such a setting, it is easy to see that fiscal policies that directly affect one mobile resource will also indirectly affect the other mobile resource. As an illustration, suppose that local taxes on capital are reduced, for instance in order to attract investment. If labor is also a mobile resource, and if it is complementary to capital, it is to be expected that reductions in capital taxation raise the demand for labor and contribute to an inflow of labor. The speed with which these factor movements take place is an important part of the allocative consequences of policy changes in such an environment. For example, the output and employment effects of tax cuts for business investment depend importantly on whether the stock of labor adjusts slowly or rapidly to policy-induced changes in the capital stock, Furthermore, the incidence of such policies, that is, the extent to which different factor owners are helped or harmed by the policies, also depend crucially on the speed of factor adjustment. If the stock of labor adjusts only slowly when business investment increases, the workers in the labor force may enjoy better employment opportunities for a long time following a cut in capital taxes, whereas any increase in their wages will quickly erode if workers from elsewhere arrive quickly to take advantage of any improvement in labor market conditions. For these reasons, the study of the simultaneous dynamic adjustment of the stocks of labor and capital in response to changes in fiscal policies that affect either workers or employers is a matter of some importance for policy evaluation as well as for the political economy of policy determination. These implications are discussed more fully in Section 4.

In order to introduce notation and to establish a benchmark for future reference, the next section of the paper presents a simple static model with two potentially mobile factors of production. Section 3 extends this model to an explicitly dynamic framework, within which the impacts of policy changes occur over time. The essential analytical tools borrow from research pioneered in Boadway (1979) in the study of tax incidence in a closed economy and utilized in Wildasin (2003) in a model with a single mobile factor of production. Using these tools, comparative dynamic analysis shows how the speed of transition in response to policy changes, from the "short" to the "long" run, is determined through dynamic optimizing behavior subject to adjustment costs. Because there are two mobile resources, and because these resources are jointly utilized in the production process, a tax or subsidy on one resource triggers simultaneous dynamic adjustment in the the amounts of both, to a degree that depends on the degree of complementarity of these factors in the production process and that depends on the cost of adjustment for both. After presenting some basic analytical results and some simple simulations, Section 4 returns to a discussion of policy and empirical implications and identifies some directions for future research.

2 Competition for Multiple Factors of Production in a Static Setting

As a reference case, and to help introduce notation, consider a small open jurisdiction in which the production process uses one or more completely immobile resources and a vector k of freely-mobile resources to produce either a homogeneous numéraire commodity or many commodities that are freely tradeable on external markets at exogenously-fixed prices. Assuming constant returns to scale with respect to *all* inputs, output, or the value of output, is a strictly concave function $f(k)$ of the variable inputs alone. Let τ be a vector of per-unit net fiscal burdens imposed on the mobile resources; for resource k_i, τ_i is the sum of all taxes imposed on each unit, net of all cash and in-kind subsidies. The mobile resources are assumed to earn exogenously-given net rates of return in the external market, denoted by the vector ρ. In equilibrium, the net return to each mobile resource located within the jurisdiction must be equal to the external net rate of return, i.e., assuming competitive factor markets,

$$f_k - \tau = \rho. \tag{1}$$

This system of equations determines the vector of equilibrium local employment of the mobile resources as an implicit function $k(\tau)$

$$\frac{\partial k_i}{\partial \tau_j} = \frac{F_{ij}}{F} \tag{2}$$

where F_{ij} is the i,j cofactor of the Hessian matrix of second-order derivatives of the production function $f(k)$ and F is its determinant. By the strict concavity of $f(k)$, $\frac{\partial k_i}{\partial \tau_i} < 0$. In the absence of further restrictions on the production technology, the cross-derivatives of k_i with respect to other fiscal variables may be of any sign.

Note for future reference that, in the special case where $f_{ij} = 0 \quad \forall i, j$, each k_i depends only on its *own* fiscal treatment τ_i and is independent of the policies applied to other factors of production. As one illustration of such a case, suppose that there are several types of freely-mobile labor that work in different traded-goods sectors of the local economy, such as chemical engineers, automotive engineers, and aerospace engineers, each of which combine with immobile, industry-specific capital to produce chemicals, cars, and airplanes. In such a setting, changes in the number of each type of engineer would not affect the productivity of other types. Differences in the fiscal treatment of one type of engineer, such as a tax break for workers in the automotive sector, would have no impact on the demand for other types of workers or on the equilibrium levels of employment or output in other sectors of the economy – that is, all cross-derivatives in (2) are zero. The analysis of fiscal policy in this case can be decomposed, sector by sector, in such a way that the local economy is simply a repeated version of an economy with a single mobile factor of production, subject to a single local fiscal instrument.

More generally, cross-effects arise when different factors of production are complements or substitutes. For instance, many macroeconomic models postulate that production is a CES (often Cobb-Douglas) function of labor and capital; in a spatial setting, such production technologies can still be assumed provided that they are extended to take account of the existence of at least one immobile factor of production such as land or natural resources.[3] Under such assumptions, mobile resources are typically complementary inputs, which implies that favorable fiscal treatment for one increases the equilibrium employment of the others.

As an extreme case, if mobile resources are used in a Leontief or fixed-proportions production technology, every component of k must vary in the same proportion. Choosing units so that input/output ratios are the same for all factors, $\frac{\partial k_i}{\partial \tau_i} \equiv \frac{\partial k_i}{\partial \tau_j} < 0 \ \forall i, j$. In this case, there is in effect just one composite variable input whose fiscal treatment is the

[3]If all factors of production are freely mobile and production takes place under constant returns to scale, the global allocation of resources is indeterminate, and, starting from an equilibrium with nonzero output in the local economy, any small change in fiscal policy could result in the complete departure of all factors of production and the complete collapse of the local economy.

composite of the net fiscal burdens imposed on each of the nominally distinct variable.

In all of these cases, fiscal burdens imposed on mobile factors of production have zero (or very small) effects on their net returns, which are determined in external markets. From a political economy viewpoint, this means that the owners of mobile resources have no incentive to influence the local political process, whereas the owners of immobile resources do have such incentives. A standard result is that the optimal policy, from the viewpoint of immobile factor owners, is to set the net fiscal burden on mobile resources equal to zero if the set of fiscal instruments is sufficiently rich.[4]

3 Competition for Mobile Resources with Costly Dynamic Adjustment

3.1 A Dynamic Model

Following the outline of the static model spelled out above, suppose now that there are adjustment costs associated with changes in the stocks of variable inputs, and that these stocks change gradually over time in response to economic incentives. More precisely, suppose that the value of output within a small open jurisdiction at time t depends on the time-invariant stock of immobile resources and on the stocks of *two* mobile factors of production, k_{1t} and k_{2t}, as given by the strictly concave function $f(k_t)$, where $kt = (k_{1t}, k_{2t})$ is the vector of mobile input stocks. Let $f_i(k_t) > 0$ denote the value of the marginal product of variable factor i and let $f_{ij}(k_t)$ denote the cross-partial derivatives of $f(k_t)$. The matrix $[f_{ij}]$ is negative definite, i.e., $f_{ii} < 0 < F \equiv |[f_{ij}]|$. Assuming that production takes place under conditions of constant returns to scale with respect to *all* inputs, the marginal product of the immobile resource(s) is $f(k_t) - f_k(k_t)k_t$, where $f_k(k_t)$ is the vector of marginal products for the variable inputs.

[4] School districts in the US historically depended very heavily on the local property tax as a source of finance, captured in theoretical models such as Zodrow and Mieszkowski (1986) in the assumption that local taxes on capital are the sole source of local government revenue. Under this assumption, immobile residents do not drive the tax rate on freely-mobile capital to zero, since that would imply zero provision of local public goods.

In the present section, the two mobile factors of production called "capital" (of types 1 and 2, respectively) as a matter of terminological convenience. Their stocks evolve over time according to

$$\dot{k}_{it} = (g_{it} - \delta_i)k_{it}, i = 1, 2 \tag{3}$$

where g_{it} is the rate of "gross investment" and δ_i is a constant exponential rate of "depreciation." However, it should be borne in mind that k_{it} could represent a particular type of labor, in which case g_{it} would be more correctly called "net migration rate" and δ_{it} would be a constant exponential rate of "natural decrease."

Producers in the local economy are perfectly competitive firms that maximize the present value of profits, discounted at the externally-given net rate of return on capital r. At each point in time, they choose the level of employment of immobile resources and the rates of investment for each type of capital. It is costly to adjust the stocks of capital, with $c_i(g_{it})$ denoting the cost of adjustment of capital of type i per unit of capital; the adjustment cost functions are assumed to be nonnegative, strictly increasing, and strictly convex in the rate of investment: $c_i'(g_{it} > 0 < c_i''(g_{it}$ with $c_i(0) = 0$.[5]

The cash flow of a representative firm at time t is the value of its output, less its expenditures on investment, less adjustment costs, less any net time invariant fiscal burdens imposed on these stocks $\tau \equiv (\tau_1, \tau_2)$, less payments to the owners of immobile factors w_t. Fiscal policies are assumed to be *time-invariant*, which greatly simplifies the analysis but of course limits its scope as well.[6]

$$\pi_t = f(k) - \sum_i (g_{it} + c_i(g_{it}))\, k_{it} - \tau k_t - w_t \tag{4}$$

and hence the present value of profits is given by

$$\Pi = \int_0^\infty \pi_t e^{-rt} dt. \tag{5}$$

[5]This is a standard specification; see, e.g., Hayashi (1982).

[6]The analysis of the time-invariant case is a useful precursor to more general cases, some of which are discussed in Wildasin (2003).

Necessary conditions for the maximization of Π subject to (3) can be expressed in terms of the current value Hamiltonian

$$H_t \equiv \pi_t + \sum_i \lambda_{it}(g_{it} - \delta it)k_{it} \tag{6}$$

as

$$\frac{\partial H_t}{\partial g_{it}} = 0 \;\leftrightarrow\; \lambda_{it} = 1 + c_i'(g_{it}) \tag{7}$$

$$-\dot{\lambda}_{it} + r\lambda_{it} = \frac{\partial H_t}{\partial k_{it}} \;\leftrightarrow\; -\dot{\lambda}_{it} = f_i(k_t) - c_i(g_{it}) + (\lambda_{it} - 1)g_{it} - \tau_i - \lambda_{it}(r + \delta_i) \tag{8}$$

for $i = 1, 2$.

Equation (7) determines g_{it} implicitly as a function of λ_{it}, $\phi_i(\lambda_{it})$, satisfying $\phi_i'(\lambda_{it}) = 1/c_i'' > 0$. Substituting into (8) and defining $\Psi_i(\lambda it) \equiv c_i(\phi_i[\lambda_{it}]) - c_i'(\phi_i[\lambda_{it}])\phi_{it}(\lambda_{it})$ yields

$$-\dot{\lambda}_{it} = f_i(k_t) - \Psi_i(\lambda_{it}) - \tau_i - \lambda_{it}(r + \delta_i) \tag{9}$$

for $i = 1, 2$. Note that $\Psi_i' = -\phi_i c_i'' \phi_i' = -\phi_i$. Equations (3) and (9) form a 4-equation dynamical system in the variables k_t, λ_t with boundary conditions

$$k_{i0} = K_{i0}$$

$$lim_{t\to\infty}\lambda_{it} \equiv \lambda_{i\infty} = \phi_i^{-1}(\delta_i) \tag{10}$$

for $i = 1, 2$ and with a unique steady state satisfying

$$g_{i\infty} \equiv \phi_i(\lambda_{i\infty}) = \delta_i \tag{11}$$

$$f_i(k_\infty) = \Psi_i(\lambda_{i\infty}) + \tau_i + \lambda_{i\infty}(r + \delta_i) \tag{12}$$

where K_{i0} denotes a fixed initial stock of k_i and where subscript ∞ denotes a steady-state value.

3.2 Policy Impacts on Mobile Resources: Short Run, Long Run, and Transitional

In order to see how changes in fiscal policy affect the equilibrium capital stocks, differentiate equations (3) and (9) with respect to one of the policy instruments, τ_j, to obtain the "variational equations" (see Boadway (1979) and the appendix for additional discussion)

$$\frac{d\dot{k}_{it}}{d\tau_j} = (\phi_i(\lambda_{it}) - \delta_i)\frac{dk_{it}}{d\tau_j} + k_{it}\phi_i'(\lambda_{it})\frac{d\lambda_{it}}{d\tau_j} \tag{13}$$

$$\frac{d\dot{\lambda}_{it}}{d\tau_j} = -f_{ik}(k_t)\frac{dk_t}{d\tau_j} + (r + \delta_i + \Psi_i'(\lambda_{it}))\frac{d\lambda_{it}}{d\tau_j} + \Delta_{ij} \tag{14}$$

where Δ_{ij} is the Kronecker delta and where $f_{ik} = (f_{i1}, f_{i2})$.

The solution of these equations is greatly facilitated by assuming that the system is initially in a steady-state equilibrium. The steady-state assumption means this system of four first-order linear differential equations in $d\lambda_t/d\tau_j$ and $dk_t/d\tau_j$ has constant coefficients. In a steady state, $\Psi_i' = -\delta_i = -\phi_i$ and (13) can be written as

$$\frac{d\lambda_{it}}{d\tau_j} = \frac{c_i''(\delta_i)}{k_{i\infty}}\frac{d\dot{k}_{it}}{d\tau_j} \tag{15}$$

from which it follows that

$$\frac{d\dot{\lambda}_{it}}{d\tau_j} = \frac{c_i''(\delta_i)}{k_{i\infty}}\frac{d\ddot{k}_{it}}{d\tau_j}. \tag{16}$$

Using (15) and (16), terms in (14) involving λ_{it} can be eliminated to produce a system of two second-order differential equations in the variables $dk_{it}/d\tau_j$.

This system must satisfy the boundary conditions

$$\begin{aligned} &\frac{\partial k_{i0}}{\partial \tau_j} = 0 \quad i,j = 1,2, \\ &\frac{\partial k_{i\infty}}{\partial \tau_j} = \Delta_{ij}\left(\frac{-f_{jj}}{F}\right) + (1-\Delta_{ij})\left(\frac{f_{ji}}{F}\right), i,j = 1,2, i \neq j, \end{aligned} \tag{17}$$

where $\partial k_{i\infty}/\partial \tau_j \equiv lim_{t\to\infty}\partial k_{it}/\partial \tau_j$.

These conditions describe the short- and long-run effects of changes in fiscal policy on the amounts of mobile factors of production employed in the local economy:

Proposition 1: (a) An increase in the net tax burden on any mobile resource decreases its long-run equilibrium level, i.e., $\partial k_{i\infty}/\partial \tau_i < 0$;

(b) an increase in the net tax burden on a mobile resource reduces the long-run equilibrium level of the other mobile factor if the two inputs are complements in the production process, but increases the equilibrium level of they are substitutes, i.e., $\text{sgn}(\partial k_{i\infty}/\partial \tau_j) = \text{sgn}(f_{ji})$;

(c) the long-run comparative-dynamic response of mobile resources to changes in fiscal policies depend only on the properties of the production technology and are not (directly) affected by adjustment costs.

The results in (17) are identical in form to those obtained in the static model of Section 2, as shown in (2). In particular, the properties of the adjustment cost technology do not affect the comparative steady-state effects of fiscal policy.[7] The dynamic model thus encompasses, at its extremes, a "short-run" in which no resources are mobile and a "long-run" in which equilibrium stocks of mobile resources adjust exactly as predicted in the static model.

While it is important to understand the short and long run effects of policy changes, much of the important impact of policy – in fact, the entire impact, other than the most transitory effects and the effects that are only realized asymptotically – occurs during the transition from the short to the long run.

This transition, in particular the equilibrium speed of adjustment, depends on the adjustment cost technology, as can be seen from the four characteristic roots of the system derived from (13)–(16)

$$\frac{r}{2} \pm \frac{\sqrt{b_1 \pm 2\sqrt{b_2}}}{2} \tag{18}$$

[7] This is only true of the *form* of the results that appear in (2) and (17).

where

$$b_1 \equiv r^2 - 2\left(\tfrac{k_1 f_{11}}{c_1''} + \tfrac{k_2 f_{22}}{c_2''}\right) \tag{19}$$

$$b_2 \equiv \left(\tfrac{k_1 f_{11}}{c_1''} - \tfrac{k_2 f_{22}}{c_2''}\right)^2 + 4\tfrac{k_1 f_{12}}{c_2''}\tfrac{k_2 f_{21}}{c_1''}. \tag{20}$$

Concavity of the production function and convexity of the adjustment cost functions imply that (i) $b_1 > r^2$ and $b_2 > 0$, so that $b_1 + 2\sqrt{b_2} > r^2$, and (ii) $b_1 - 2\sqrt{b_2} > 0$. Hence, all roots are real, with two positive and two negative roots.

The boundary conditions imply that only terms involving the negative roots appear in the solutions to these equations. Specifically, defining $\gamma_1 \equiv r - \sqrt{b_1 + 2\sqrt{b_2}}$ and $\gamma_2 \equiv r - \sqrt{b_1 - 2\sqrt{b_2}}$, these solutions are

$$\frac{\partial k_i}{\partial \tau_i} = \frac{\partial k_{i\infty}}{\partial \tau_i}\left(1 - \frac{e^{\gamma_1 t} + e^{\gamma_2 t}}{2}\right) - \left(\frac{f_{22} k_2}{|F| c_2''} - \frac{k_1}{c_1''}\right)\frac{e^{\gamma_1 t} - e^{\gamma_2 t}}{2\sqrt{b_2}} \tag{21}$$

$$\frac{\partial k_i}{\partial \tau_j} = \frac{\partial k_{i\infty}}{\partial \tau_j}\left(\left[1 - \frac{e^{\gamma_1 t} + e^{\gamma_2 t}}{2}\right] - \left[f_{11}\frac{k_1}{c_1''} + f_{22}\frac{k_2}{c_2''}\right]\frac{e^{\gamma_1 t} - e^{\gamma_2 t}}{2\sqrt{b_2}}\right), \quad i \neq j. \tag{22}$$

To interpret these results, note first that the expression $1 - (e^{\gamma_1 t} + e^{\gamma_2 t})/2$ appear in the leading terms in each equation. At $t = 0$, this expression is equal to 0, and it approaches 1 as $t \to \infty$. The leading terms thus start at 0, the immediate or short-run effects of a policy change, and converge monotonically to the long-run effects shown in (17).

The trailing terms in (21) and (22) each contain the expression $e^{\gamma_1 t} - e^{\gamma_2 t}$. Because both roots are negative, this expression is equal to 0 at $t0$ and it also approaches zero as $t \to \infty$, verifying that the solutions in (21) and (22) satisfy the boundary conditions (17). Since $\gamma_1 < \gamma_2$, intermediate values of t, $e^{\gamma_1 t} - e^{\gamma_2 t} < 0$ for all $t > 0$.

The magnitude of this expression depends on the magnitude of $\gamma_1 - \gamma_2 = \sqrt{b_1 - 2\sqrt{b_2}} - \sqrt{b_1 + 2\sqrt{b_2}}$ and hence on the magnitude of b_2. Although b_2 contains many terms, the special "symmetric" case where the two mobile factors enter the production and adjustment cost technology symmetrically and where they receive identical fiscal treatment provides a useful benchmark. In this case, the squared term in (20) vanishes, leaving only a non-negative term involving the cross-partial derivatives of the production function f. From this, it is clear that $\gamma_1 = \gamma_2$ when the mobile factors are neither substitutes nor complements. In this special case, the "own" comparative dynamic adjustment of the mobile factor whose fiscal treatment is being analyzed simply involves monotonic convergence toward the long-run effect given in (17), while, from (22)there is no cross effect on the other factor, whether initially, in the long run, or during the transition.

More generally, note that the bracketed expressions in the trailing terms of both (21) and (22) are negative. In (21), this means that the sign of the entire impact is negative for all $t > 0$. In (22), the cross-effect is theoretically ambiguous in any case depending on whether the two mobile resources are substitutes or complements.

Finally, it should be noted that the speed of adjustment of the mobile factors is determined by the size of the roots γ_i, which depend on the convexity of the adjustment cost functions. If the c_i'' terms are small, the roots are large in absolute value, which means that the speed of adjustment of the system is rapid. The intuition is straightforward: if high rates of adjustment are not much more costly (at the margin) than low rates, there is little incentive to defer adjustment to policy changes. If (marginal) adjustment costs rise steeply as the rate of adjustment increases, however, there is a significant cost savings to be realized by slowing the adjustment process, even though this defers the adjustment to new conditions. Note in addition that the speed of adjustment of each variable input depends not only on its own adjustment cost technology, but on the adjustment costs for the *other* input. To illustrate this last remark, suppose that the production technology is Cobb-Douglas, with equal factor shares for both variable inputs. In this case, the speed of adjustment of *both* k_i's is increasing in *each* of the c_i'''s, that is, the flatter the marginal cost of adjusting *either* input, the faster the equilibrium adjustment for *both*. This finding is depicted in Figures 1 and 2.

To summarize, the preceding analysis has shown how local fiscal policy, applied to one of two mobile factors of production, affects the dynamic equilibrium allocation of both factors of production. The system adjusts gradually to a long-run equilibrium, with effects on equilibrium allocations that depend on the local production technology, including complementarity or substitutability of the mobile factors. The speed with which this adjustment occurs, for each of the two factors of production, depends on the costs of adjustment for both.

Since gross factor prices are determined by factor supplies, the impacts of fiscal policy on the returns to local mobile and immobile factors are readily determined from the preceding analysis. For example, an increase in the fiscal burden on a mobile factor, of production, say as the result of a tax increase, has no immediate impact on factor allocations and thus no immediate impact on the gross return to any factor of production. The net return to the more heavily taxed factor thus falls by the amount of the increase in tax, while net returns to other factors are unaffected. In the long run, the gross return to the more heavily taxed factor rises sufficiently to restore the net return to its externally-given value. The impacts of the higher tax on gross and net returns to the other mobile resource and to the immobile factor(s) depend upon complement/substitute relationships in production. If the process of adjustment to higher taxes is slow, the net return to the more heavily-taxed factor can be substantially depressed for a long period of time. If instead this process is fast, the net return quickly approaches the externally-determined level. There may then be equally rapid impacts on the amount of the other mobile resource and on the gross and net returns to it and to the immobile factor.

3.3 Optimal Fiscal Policy in a Dynamic Setting

The "dynamic fiscal incidence" effects just discussed can form the basis for an analysis policy choice within the locality. Following a standard approach in the literature on fiscal competition, assume that all local residents are identical, so that there is no basis for political conflict and no need to investigate how the political process reconciles conflicting interests. Although this "representative agent" sweeps aside many interesting issues, it reveals most transparently how the incentives to choose policies are affected by factor mobility. In the present context, the issue of greatest interest is to see how the dynamics of adjustment of mobile factors to changes in local policy affect the evaluation of policy from the view point of local residents.

To tackle this question, it is important to recognize that adjustment costs give rise to quasi-rents to the variable inputs that accrue as profits to local firms. Because local policies affect these profits, the impacts of policies on local residents depend on the ownership of profits. Many different cases are worthy of investigation, but let us focus here on the simple special case where firms are owned by non-residents.

Assume that local taxes are used to finance an exogenously-given stream of government expenditures on public goods and that, in addition to taxing mobile factors of production, the local government may also impose taxes on immobile factor owners. Because the immobile resources are inelastically supplied, this tax is lump-sum in nature. Assuming that the local government – indeed, all agents – face perfect capital markets, the local government's intertemporal budget constraint requires that

$$\int_0^\infty \left(\sum_{i=1}^{2} \tau_i k_{it} \right) e^{-rt} dt + T = G \tag{23}$$

where T denotes the present value of any lump-sum taxes paid by local residents and G denotes the present value of the exogenously-fixed stream of local public expenditures (net of any congestion costs associated with variable inputs).

Assume finally that local residents are infinitely lived and that they optimize their intertemporal streams of private consumption subject to their intertemporal budget constraints. The welfare of the representative local household thus depends monotonically on the present value of lifetime net income, denoted by Y. Assuming that local residents own the immobile resource,

$$Y \equiv \int_0^\infty \left(f(k_t) - \sum_{i=1}^{2} k_{it} f_i(k_t) \right) e^{-rt} dt - T. \tag{24}$$

Substituting into (24), and noting from the analysis in Section 3.2 that the stocks of each mobile resource adjust dynamically to a change in fiscal policy, one can compute the effect of a change in either fiscal variable on local welfare:

$$\frac{dY}{d\tau_s} = k_s + \int_0^\infty \left(-\sum_j \left[\sum_{i=1}^{2} k_{it} f_{ij}(k_t) + \tau_j \right] \frac{\partial k_j}{\partial \tau_s} \right) e^{-rt} dt \tag{25}$$

where $s = 1$ or 2. This expression can in principle be used to evaluate any change in fiscal policy. In particular, the policy vector policy (τ_1^*, τ_2^*) that maximizes local welfare satisfies

$$\frac{dY}{d\tau_s} = 0, s = 1, 2. \tag{26}$$

The optimal values of (τ_1, τ_2) in this model depend on the properties both of the production and adjustment cost functions, and in complex ways. In the special case where the adjustment costs are identical and the variable inputs enter the production function symmetrically, the optimal policy reflects the symmetry of the technologies and $\tau_1 = \tau_2$. In this special case, it can be verified that

$$\frac{dY}{d\tau_i}|_{\tau=0} > 0, \quad i = 1, 2 \tag{27}$$

that is, it is optimal to impose *positive* fiscal burdens on variable inputs. By continuity, optimal policy is characterized by positive fiscal burdens on both mobile factors in models that are not far from the symmetric case.

The fact that it is optimal to impose net fiscal burdens on mobile resources highlights a basic difference between a dynamic model with imperfect factor mobility and the usual static models with freely-mobile resources, in which the optimal policy is to impose zero net burdens on these resources. In the dynamic framework presented above, mobile resources earn the externally-given net rate of return in the long run, and thus cannot bear any net burden from local fiscal policy in the long run, just as in standard static models. Furthermore, the long-run effect of taxes on mobile resources is to reduce the net returns to immobile resources, harming local residents. Nevertheless, because the adjustment of mobile resources is a costly and time-consuming process, local residents can benefit initially, and for some period of time, by imposing net burdens on mobile resource owners. The crucial issue facing local residents in setting fiscal policy is the trade-off between short-run gains and long-run losses. With a positive discount rate, it is always optimal, in present-value terms, to impose a positive burden on mobile resource owners. As discussed further in a similar model with only one variable input (Wildasin [2003]), the optimal net burden to impose on mobile factor owners in a dynamic model is likely to be smaller, the faster the equilibrium speed of adjustment, i.e., the greater is the degree of factor mobility.

As a partial illustration of the importance of adjustment costs for policy evaluation, suppose that the production function is Cobb-Douglas. Figure 3 illustrates the value of the derivative in (27) for *one* policy instrument, as a function of the adjustment cost parameters for *both* of the adjustment cost parameters. The marginal welfare gain from raising τ_1, say, is greater when c_1'' is larger, that is, as it becomes more costly to adjust the stock of k_1 quickly. The marginal welfare gain from raising τ_1 is also greater when c_2'' is larger, that is, as it becomes more costly to make rapid changes in the stock of the other mobile resource, k_2. This illustration highlights the fact that the optimal fiscal policies for each of several imperfectly mobile resources must be determined jointly.

A complete analysis of optimal fiscal policy and its determinants go beyond the scope of the present paper. With two factors, there are many alternative specifications for production and adjustment technologies, and few general results about optimal policy can be derived in such a setting. The results presented above, aside from illustrative special cases, have not relied upon particular specifications for production functions and adjustment costs, and they are thus quite general. It is, however, possible to develop the analysis further by introducing specific functional forms and by calibrating the model to fit empirical cases of interest. Simulation methods can then be used to examine quantitatively the impacts of policy changes and to estimate values for optimal fiscal policies.

4 Empirical and Policy Implications

The preceding analysis has examined a somewhat abstract dynamic model of the impacts of fiscal policy in an open economy with two imperfectly mobile factors of production. To conclude, it is useful to highlight some of the potential policy and empirical applications of this modeling approach.

First, explicit analysis of dynamic adjustment of variable inputs highlights the importance of the equilibrium *speed of adjustment* of factors of production in response to changes in fiscal policy and other incentives. Some empirical studies have shed light on the magnitudes of these adjustment speeds. For example, Decressin and Fatas (1995) conclude that spatial adjustment of workers in response to regional demand shocks occurs about twice as quickly in the US as among EU regions of comparable size. Huizinga and Nicodème (2004) find that financial balances move rapidly across international boundaries, with essentially complete adjustment occurring within less than one year. The theoretical analysis above links such observed speeds of adjustment (capital flows, migration) to underlying model parameters and shows how these parameters determine the allocative, distributional, and welfare impacts of fiscal policies in a dynamic setting.

Other things the same, the analysis of fiscal competition in such a setting suggests that there is a relatively high payoff to the residents of a jurisdiction from imposing net fiscal burdens on resources that respond relatively slowly to changes in incentives, while highly-mobile resources are less attractive targets for such impositions. Subnational governments typically impose only very small taxes on highly liquid financial asset holdings (e.g., bank account balances), while relying more heavily on taxes on real property, earnings, consumption, and other somewhat less mobile resources and activities for their revenues. In the absence of effective capital controls, the ability of national governments to impose heavy burdens on the owners of liquid financial assets, including through the manipulation of monetary policy to achieve high inflation, also appears to be very limited.

Simultaneous flows of labor and capital have accompanied the development of important economic regions over different time scales. Authors such as Hatton and Williamson (1994) have documented the long-term flows of labor and capital from the Old World to the New World and their important effects on output, factor prices, and the distribution of income in both regions during the nineteenth century. The twentieth century in the US has witnessed South/North (early-mid century), East/West (century-long), Rust Belt/Sun Belt (latter decades), and rural/urban (century-long) flows of labor and capital among major regions. The growth and decline of particular agglomerations, such as New York, Detroit, or St. Louis, are records of simultaneous flows of both labor and capital. These dynamic adjustment processes are ongoing and reflect underlying complementarities in production and the resulting partial synchronization of migration and investment flows. Exactly how the costs of labor and capital stock adjustment interact to produce observed flows has not so far been investigated empirically, but this simultaneous adjustment process, stemming ultimately from production complementarities, must also give rise to "policy complementataies" in which, for example, the provision of local educational services and local tax policies affect the attractiveness of a region for workers *and* for complementary investments in nonhuman capital, and the tax treatment of local business and the provision of public infrastructure affect the profitability of business investment *and* the employment conditions for local workers.

As a possible recent example, the rapid growth of the Irish economy has been accompanied by large inflows of both investment and migrants, including return migration of Irish expatriates. The impact of the inflow of skilled workers is estimated by Barrett et al. (2002)) to have played a very important role in limiting wage growth for these workers, in permitting more rapid economic growth, and in raising the demand for unskilled workers, estimated to be complementary to skilled workers in the production process. No doubt many policy issues have been involved in this process, but major changes in business tax policy reportedly stimulated business investment in Ireland, contributing, it would appear, to the labor market impacts described by Barrett et al.[8]

The preceding analysis has largely abstracted from issues of political economy. However, analysis of the dynamics of imperfect factor mobility can yield significant insight into the potential payoffs to different agents from voting or otherwise attempting to influence local policymaking (e.g., through lobbying or campaign contributions). As noted in Section 3.3, the owners of immobile resources in a jurisdiction have incentives to manipulate fiscal policies so as to capture rents that would otherwise accrue to the owners of local quasi-fixed factors. The owners of these quasi-fixed factors likewise have an incentive to try to limit the amount of redistribution that occurs at their expense. For nonresident owners of highly mobile resources, such as highly liquid financial assets, the threat of "exit" is very credible (Hirschman, 1970), and this threat may adequately constrain the ability of residents to extract rents from them. By the same token, these agents would have little incentive to exercise "voice" in the political process. Such considerations may help to explain why young people and renters generally have lower voter participation rates in local elections than older people and homeowners, an empirical regularity that suggests that relatively less-mobile people may exert greater direct influence on the local policy process than those who are more footloose (Wildasin (2006a). More generally, how factor mobility interacts with the political process to produce observed policies and the accompanying dynamic responses of employment, investment, and growth warrants

[8] It should be noted, however, that the complementarity or substitutability of skilled and unskilled workers is a topic of ongoing research and, it seems, little consensus. See Borjas et al. (2008) and references therein. Presumably, this question turns in part on the dynamics of substitution in production and thus cannot be completely answered other than within the context of some time horizon.

additional investigation. It is clear that issues of time consistency and the evolution of policies over time will be important elements in such investigation (Kehoe (1989)).

Appendix: The Method of Variational Equations

This appendix provides a concise informal discussion of variational equations. It draws upon Hartman (1964, Theorem 3.1, pp. 95-96. See also Boadway (1979).

Suppose that the evolution of a vector $x(t)$ is described by the system

$$\dot{x} = f(x(t), \theta) \tag{A.1}$$

where θ is a parameter of the system. A solution to this system is a vector $\xi(t, \theta)$, depending on time t and on the parameter θ. For present purposes, existence and local uniqueness of a solution is assumed.

The problem of interest is to understand the dependence of the solution $\xi(t, \theta)$ on the parameter θ. A first-order approximate of the rate of change of the solution with respect to the parameter is given by the partial derivative $\partial\xi(t, \theta)/\partial\theta$ which, in general, is time-varying. Since $\xi(t, \theta)$ satisfies (A.1) for all values of θ,

$$\dot{\xi}(t, \theta) \equiv f(\xi(t, \theta), \theta). \tag{A.2}$$

Differentiating with respect to θ,

$$\frac{\partial\dot{\xi}(t, \theta)}{\partial\theta} = f_x(\xi(t, \theta), \theta)\frac{\partial\xi(t, \theta)}{\partial\theta} + f_\theta(\xi(t, \theta)) \tag{A.3}$$

where f_x and f_θ denote partial derivatives of f with respect to x and θ, resp.

Assuming that the system (A.1) is initially in equilibrium, i.e., $\dot{x}(t) = 0$ and $x(t) = x^*$, (A.3) can be written as system of linear differential equations with constant coefficients,

$$\dot{y} = f_x(x^*, \theta)y + f_\theta(x^*, \theta) \tag{A.4}$$

where, for notational convenience, $y(t, \theta)$ denotes $\partial\xi(t, \theta)/\partial\theta$. Such systems can be solved explicitly for $y(t)$, the time-varying rate of change of the solution of the system (A.1) with respect to the parameter θ.

In the analysis of Section 3, the state of the system depends on the capital stock $k(t)$ and on the shadow value of capital. Differentiation of equations (3) and (9) produce a system of two first-order differential equations (13) and (14) differential equations in k_t and λ_t which, with some manipulation and standard relabeling, can be equivalently expressed as a system of two second-order differential equations in k_t alone, as described in the text.

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FIGURE 1:

Own-Effect of Fiscal Burden on Resource Stock

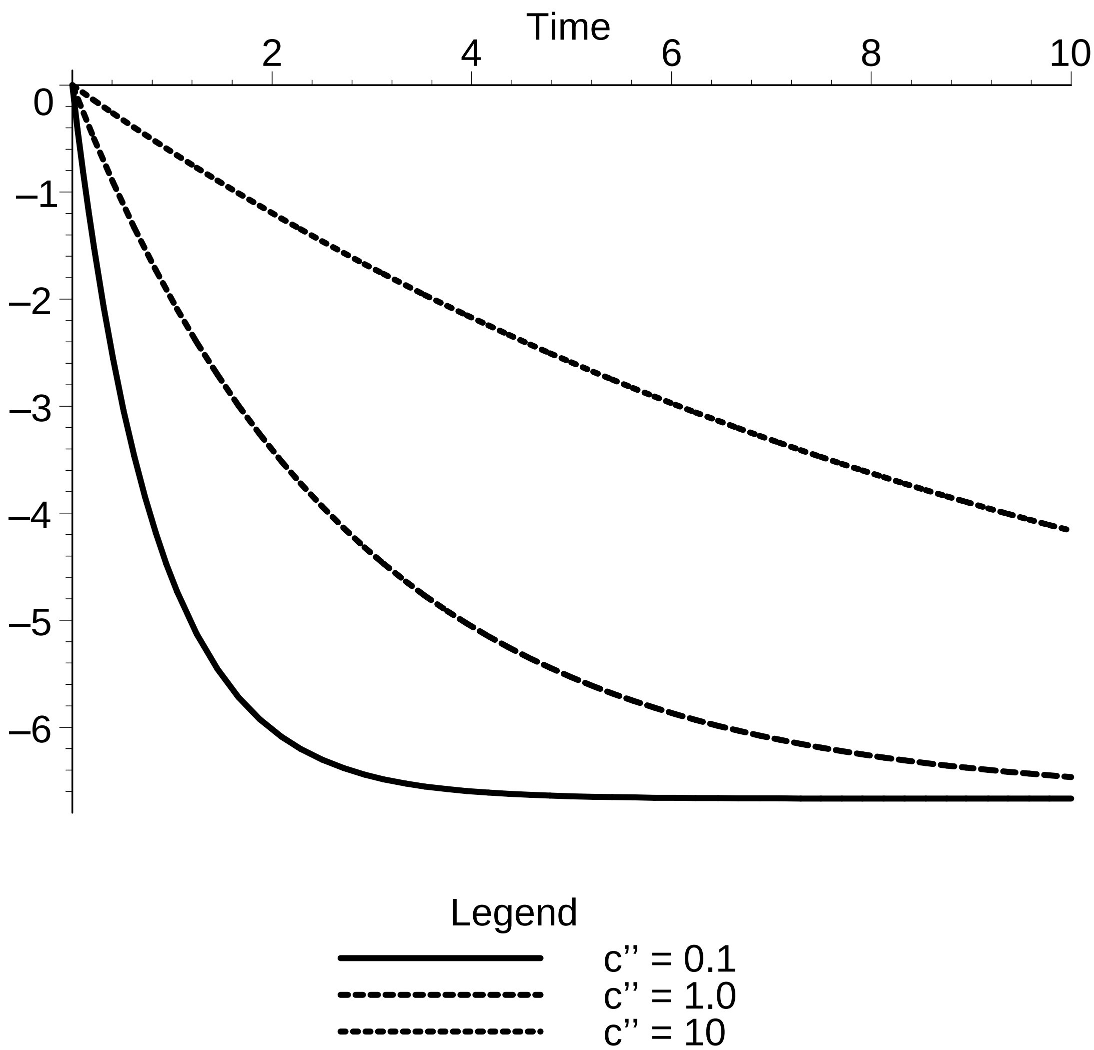

FIGURE 2:

Cross-Effect of Fiscal Burden on Resource Stock

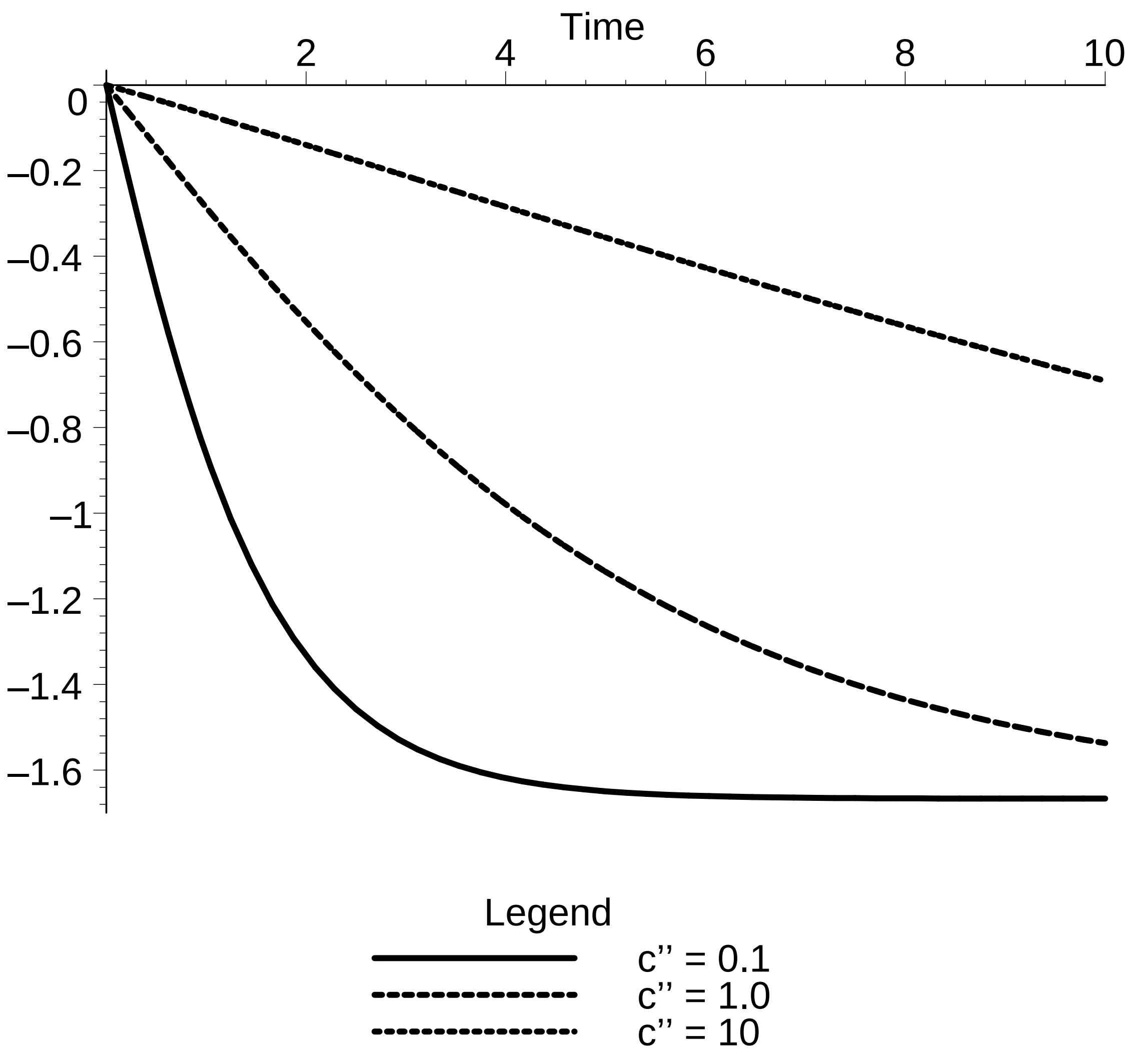

FIGURE 3:

Impact on Welfare of Small Fiscal Burden on Input 1,

Symmetric Adjustment Costs