The Welfare Cost of Factor Taxation in a Perfect-Foresight Model

Kenneth L. Judd

Northwestern University

This paper examines the marginal efficiency cost of various factor taxes in a dynamic general equilibrium model. First, I derive the crucial formulas for the excess burden of anticipated and unanticipated, temporary and permanent, tax changes. Second, I derive closed-form expressions for the excess burdens when tax rates are low. Third, using a range of estimates for taste and technology parameters suggested by the empirical literature, I compute various examples and find that excess burdens are larger than indicated by previous studies that use alternative models, very sensitive to parameter estimates, and equally sensitive to anticipation effects. However, the rankings of alternative tax policies turn out to be insensitive to these estimates. Both the analytical computations and the computed examples indicate that delay increases the cost of capital income taxation but tends to reduce the efficiency cost of wage taxation. Furthermore, immediate and temporary investment tax credits are always self-financing, and an investment tax credit at a future time always dominates a capital income tax cut at that time. Generally, the timing and anticipated duration of any tax policy are as important as the technical and taste parameters in determining its efficacy.

I. Introduction

A major concern in public finance is the efficiency cost of taxation. This paper examines this issue for factor income taxation in a dynamic model of equilibrium growth, accomplishing two tasks. First, it

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analytically derives formulas for the exact marginal welfare costs of various tax policy changes, both unanticipated and partially anticipated. Second, it combines these formulas with current econometric estimates of the critical structural parameters to give examples of the magnitude of these excess burdens. The analysis indicates that the marginal cost of factor taxation may be higher than indicated by earlier analyses and that the costs of alternative tax instruments may vary substantially. It also shows that anticipation aspects of tax policies may be as important as the values of the relevant demand and supply elasticities in determining the costs of taxation.

This analysis uses the representative agent perfect-foresight model as exposited in Brook and Turnovsky (1981), differing from previous tax analyses in several important fashions. The assumption of dynamic general equilibrium with intertemporal optimizing agents distinguishes it from the static analyses of Browning (1976) and Stuart (1984), the savings rate function approach of Feldstein (1974*a*, 1974*b*) and Bernheim (1981), and the model used in Ballard, Shoven, and Whalley (1985*a*, 1985*b*), which puts savings in the utility function. These models ignore capital accumulation or treat it in an ad hoc fashion. I use the infinitely lived representative agent model instead of the life cycle model used in Summers (1981) and Auerbach and Kotlikoff (1983) for two reasons. First, this model can be thought of as including bequests, implicitly adopting Barro's (1974) treatment of bequests. Since evidence concerning bequests often indicates that they are of significant importance (see, e.g., Kotlikoff and Summers 1981), this model is an appropriate benchmark to study and compare with the overlapping generations analyses. Second, this model can be viewed as a limit of an overlapping generations model as lifetimes grow large. A representative agent model is substantially more tractable and possesses a unique equilibrium, whereas overlapping generations models often have a continuum of equilibria, making comparative dynamic exercises indeterminate.

I analytically compute the dynamic effects of marginal changes in a tax instrument. This distinguishes this analysis from the comparative steady-state analysis of Summers (1981) and the numerical approximations of nonmarginal changes by Auerbach, Kotlikoff, and Skinner (1983). In particular, I examine anticipation effects and study temporary tax changes or phased-in tax reforms. These effects do not exist in any model in which current savings are affected only by the current net rate of return, as in Feldstein (1974) and Ballard et al. (1985*a*, 1985*b*). Since anticipation effects are often used in discussions of tax policy, it is desirable to examine them instead of ruling them out a priori.

While such analytical results can sharpen our qualitative knowledge, they do not indicate the quantitative significance of various effects. Such information necessitates computations using plausible values for the underlying parameters. Using a broad range of parameterizations suggested by current U.S. tax laws and the econometric literature on aggregate consumption demand, labor supply, and factor substitutability in production, I find a number of interesting and suggestive results. First, for these parameter values, the welfare gain of an immediate and permanent cut in capital taxation is substantial, usually exceeding 25 cents per dollar of lost revenue but easily exceeding a dollar per dollar of lost tax revenue when relatively higher estimates of labor supply elasticity and intertemporal consumption substitutability are used. The cost of labor taxation in this model substantially exceeds earlier estimates, such as those of Browning (1976), because of the added dynamic elements.

Even more striking are the results for the investment tax credit, a policy parameter ignored in earlier studies. For the parameterizations, I find that the efficiency gain of a dollar in extra permanent investment tax credits is at least a dollar, generally much more. Most surprising is that an increase in the investment tax credit quite plausibly pays for itself through its impact on capital and wage income taxation and will always do so if tax rates are low or the investment tax credit is temporary.

While the level of excess burden for various taxes cannot be determined with precision because of imperfect knowledge of the important structural parameters, several qualitative conclusions are robust. In this model, when *any* proposed estimates are used for taste and technology parameters, welfare would be improved substantially at the margin by moving away from capital income taxation and toward higher labor taxation and more investment subsidies at current tax levels. This conclusion is, of course, purely an efficiency result since it ignores redistribution, as do most earlier analyses.[1]

I also find that anticipation effects are of substantial importance with these parameterizations. While unanticipated temporary taxation of capital income is effectively a lump-sum tax, the efficiency cost of an increase in capital income taxation rises rapidly as the tax increase becomes more anticipated. Somewhat less expected is the fact that the opposite is true for the investment tax credit, with anticipated tax credits being far less valuable than unanticipated credits. Also

[1] However, Judd (1981) shows that investment incentives paid for by wage taxation are very possibly Pareto-improving even in a world in which some workers initially have no assets. Hence, some of the strong bias against capital taxation remains in disaggregated versions.

interesting is the finding that the efficiency cost of labor taxation is nontrivially affected by anticipation, with anticipated future labor taxation usually being *less* distortionary than immediate labor taxation. These results are intuitively explained by the facts that future capital income taxation reduces investment immediately whereas future investment tax credit reductions and labor tax increases often encourage capital formation initially: investors use current subsidies and workers work now instead of later when taxes are greater. In general, one finds that the timing of a change in any of these tax instruments is as crucial in determining the marginal cost of tax revenue as are the underlying structural parameters and the specific tax instrument yielding the extra dollar.

Given the large differences among the values of permanent changes in the various instruments, one is struck by the apparent irrationality of the current tax structure. However, short-term changes in labor and capital taxation generate similar welfare effects given the current tax mix. Therefore, policymakers with only short-term control over tax rates perceive little gain to changes they may make. This suggests that the inability of current policymakers to determine future tax policies has a quantitatively substantial impact on the long-run structure of taxation.

Section II describes the general model and develops the necessary local properties of equilibrium. Section III derives basic results concerning the long-run response to tax changes. Section IV develops the dynamic analysis of tax changes. Section V derives exact excess burden formulas for the case of small tax rates. Section VI examines excess burdens around steady states with realistic levels of taxation. Section VII compares this study with others, and Section VIII concludes the paper.

II. The Model

I use a version of the representative agent perfect-foresight model of Brock and Turnovsky (1981) and Turnovsky (1982) and initially just review the model's basic aspects. Assume that agents value consumption paths, $c(t)$, and labor paths, $l(t)$, according to the utility function

$$U = \int_0^\infty e^{-\rho t} u(c, l) dt,$$

where u is concave in consumption and labor with $u_1 > 0 > u_2$, and ρ, the discount rate, is positive. Assume that the net production function, $F(K, l)$, is concave in capital and labor and displays constant returns to scale. Agents hold two perfectly substitutable assets: private capital stock and government bonds of negligible maturity. Taxes are assessed on investment income net of true economic depreciation at the rate of τ_K and on labor income at τ_L. An investment credit θ on gross capital investment and lump-sum transfers of Tr are made each period. The gross-of-tax returns on labor and capital are w and r, respectively. Finally, the government consumes output at the rate g, such consumption not affecting marginal rates of substitution among private goods. Any tax revenue that is not spent on government consumption is rebated at some time in a lump-sum fashion. Since lump-sum transfers are equivalent to the provision of public goods that are perfect substitutes for private consumption, we can effectively model two kinds of public goods.

In order to focus on aggregate factor supply over time and its response to taxation, this model abstracts from several related aspects of reality. Assuming a single capital stock ignores distinctions between structures and equipment. We will assume true economic depreciation, whereas the tax code's rules for depreciation discriminate among different types of capital.[2] We will generally ignore capital input distortions generated by the U.S. tax code, a central focus of Ballard et al. (1985*a*, 1985*b*). We will also ignore financial structure issues by not allowing firms any choice between debt and equity. While some extensions are possible,[3] we will ignore these issues since they are probably tied essentially to uncertainty and incomplete information. We can also abstract from adjustment costs to reduce the complexity of the exposition; this is a reasonable simplification since calculations I have made in models with adjustment costs indicate that the main points of this study would remain unaltered by their inclusion. While this model cannot address all issues in intertemporal taxation, it can address issues relating to distortions of the basic savings-consumption-leisure decisions. Furthermore, it is clear that it could be extended to higher dimensions to address problems related to multiple capital stocks and goods.

The first step in determining the equilibrium of the model is the specification of the representative agent's choices. Since bonds and capital are perfect substitutes, we can determine the intertemporal demand for consumption and leisure by examining a representative agent who holds only capital. This representative agent's problem is

[2] A more realistic description of the tax structure is possible, as Balcer and Judd (1985*a*) show in a model in which noneconomic depreciation, investment tax credits, corporate income taxation, and inflation interact in determining investment. Including these elements here, however, would unnecessarily burden the exposition and only marginally change the results.

[3] See Judd (forthcoming) for an analysis in which, for tax reasons, firms use only equity and personal taxes are assessed on realized gains. Balcer and Judd (1985*b*, forthcoming) discuss the substantial complexity introduced by life cycle saving, capital gains taxation, and capital structure.

$$\max_{c,l} \int_0^\infty e^{-\rho t} u(c, l) dt,$$

$$\dot{K} = (1 - \tau_K) rK + (1 - \tau_L) wl - c + \theta(\delta K + \dot{K}) + Tr,$$

where δ is the rate of depreciation. If $\lambda(t)$ is the private marginal value of capital at t, the equations describing the agent's optimal choices are

$$\dot{\lambda} = \lambda\left[\rho - \frac{r(1 - \tau_K) + \delta\theta}{1 - \theta}\right], \tag{1a}$$

$$\dot{K} = \frac{(1 - \tau_K) rK + (1 - \tau_L) wl - c + Tr + \delta\theta K}{1 - \theta}, \tag{1b}$$

$$u_1(c, l) = \frac{\lambda}{1 - \theta}, \tag{1c}$$

and

$$-\frac{u_2(c, l)}{u_1(c, l)} = w(1 - \tau_L). \tag{1d}$$

In equilibrium, both factors must receive their marginal product:

$$r = F_K = f'(k), \tag{2a}$$

$$w = F_l = f - kf'(k), \tag{2b}$$

where $k \equiv K/l$ is the capital-labor ratio and $f(k) \equiv F(K, l)/l$ is output per unit of labor input. Equations describing the dynamic general equilibrium are derived by substituting (2) into (1), yielding

$$\dot{\lambda} = \lambda\left[\rho - \frac{f'(k)(1 - \tau_K) + \delta\theta}{1 - \theta}\right] \tag{3a}$$

and

$$\dot{K} = L(\lambda, K, \tau_L, \theta) f(k) - C(\lambda, K, \tau_L, \theta) - g, \tag{3b}$$

where $L(\lambda, K, \tau_L, \theta)$ and $C(\lambda, K, \tau_L, \theta)$ are functions giving equilibrium labor supply and consumption demand at any moment in terms of the values of K, λ, τ_L, and θ at that time and solve the agent's first-order conditions:

$$u_1(C, L) = \frac{\lambda}{1 - \theta} \tag{4a}$$

and

$$-\frac{u_2(C, L)}{u_1(C, L)} = F_l(K, L)(1 - \tau_L). \tag{4b}$$

A critical feature of the equilibrium system, (3), is its steady state. We can represent the steady-state value of a variable x by x^∞. The steady-state capital-labor ratio is given by

$$f'(k^\infty) = \frac{\rho(1-\theta) - \delta\theta}{1-\tau_K} \equiv \frac{\rho}{1-\tau_K^{\text{eff}}}, \tag{5}$$

where τ_K^{eff} is the effective capital income tax rate. We will focus on the steady states of (3) and behavior around them, assuming that equilibrium converges along a unique path to such steady states whenever taxes are forever constant. This is true if there are no taxes and also, by the structural stability of these systems, when taxes are low. In any example below we will always check that the steady state examined is saddle-point stable.

In order to analyze changes in taxes, we need to know how C and L are affected by changes in λ, K, τ_L, and θ. We need to compute only the first-order properties of C and L with respect to their arguments. Define β to be the intertemporal elasticity of consumption demand, ν the intertemporal elasticity of labor supply, and η and α the instantaneous elasticity of labor supply and consumption demand with respect to the contemporaneous wage, respectively. Let $\hat{x} \equiv dx/x$. Using these elasticities, we can express the local dependence of the instantaneous consumption demand and labor supply functions on their arguments as

$$\hat{C} = \alpha\left(\hat{w} - \frac{d\tau_L}{1-\tau_L}\right) + \beta\left(\hat{\lambda} + \frac{d\theta}{1-\theta}\right) \tag{6a}$$

and

$$\hat{L} = \eta\left(\hat{w} - \frac{d\tau_L}{1-\tau_L}\right) + \nu\left(\hat{\lambda} + \frac{d\theta}{1-\theta}\right). \tag{6b}$$

These elasticities are related to the more commonly discussed static elasticities of $u(c, l)$. If θ_l is after-tax labor income expressed as a share of consumption and I is nonlabor income, then the static uncompensated and income labor supply elasticities, e_w and e_I, respectively, for $u(c, l)$ are

$$e_w = \frac{\beta\eta - \alpha\nu + \nu\theta_l}{\beta - \nu\theta_l}, \quad e_I = \frac{\nu\theta_l}{\beta - \nu\theta_l}.$$

These are derived by combining the elasticity form of the static budget constraint, $\hat{C} = \theta_l(\hat{w} + \hat{L}) + (1-\theta_l)\hat{I}$, with (6) and solving for $e_w = \hat{L}/\hat{w}$ and $e_I = w(\partial L/\partial I) = (\hat{L}/\hat{I})(wL/I)$. The static compensated elasticity is $\bar{e}_w = e_w - e_I$. These static elasticities play important roles since e_w is the immediate and permanent labor supply response to an immediate and permanent increase in the net wage (representing, e.g., the response to a permanent change in the wage tax) and e_I is the response to a permanent income increase (such as a change in lump-sum rebates of tax revenue).

We can immediately derive some useful relationships among the static and intertemporal elasticities. First, concavity of u implies that $\beta\alpha - \eta\nu < 0$. Second, $\alpha = (\nu - \eta)\theta_l$. These two facts imply that ν must be positive if θ_l is positive. Therefore, we will always assume $\nu > 0$.

We next need to incorporate factor demand. If σ denotes the elasticity of substitution between capital and labor in net output and θ_K and θ_L denote the capital and labor shares of income, respectively, then we also know that

$$\hat{K} - \hat{L} = \sigma(\hat{w} - \hat{r}). \tag{7a}$$

Finally, the labor demand curve, $F_l(K, l) = w$, implies

$$\hat{w} = \frac{\theta_K}{\sigma}(\hat{K} - \hat{L}), \tag{7b}$$

where σ is the elasticity of substitution in the net production function.

From (6) and (7) we can solve for the instantaneous equilibrium responses of C, L, w, and r to K, λ, τ_L, and θ. Equations (6b) and (7b) imply

$$\hat{L} = \nu^e\left(\hat{\lambda} + \frac{d\theta}{1 - \theta}\right) - \eta^e\left(\frac{d\tau_L}{1 - \tau_L} - \frac{\theta_K}{\sigma}\hat{K}\right) \tag{8a}$$

and

$$\hat{w} = -\frac{\theta_K}{\sigma}\left[\nu^e\left(\hat{\lambda} + \frac{d\theta}{1 - \theta}\right) - \eta^e\frac{d\tau_L}{1 - \tau_L} - \frac{\hat{K}}{1 + (\eta\theta_K/\sigma)}\right], \tag{8b}$$

where

$$\nu^e \equiv \frac{\nu}{1 + (\eta\theta_K/\sigma)},\ \eta^e \equiv \frac{\eta}{1 + (\eta\theta_K/\sigma)}; \tag{9}$$

that is, ν^e and η^e represent the net response of labor supply to changes in the price of consumption, and capital stock and wage taxes, respectively, after one takes into account the change in the wage induced by the change in labor supply. Values of $\hat{r}$ and $\hat{C}$ are found by substituting (8) into (6a) and (7a).

III. Long-Run Effects

Having determined the equilibrium response to changes in taxes and the value and stock of capital, we will next examine the long-run effects of taxation before moving to a dynamic analysis. In order to avoid inessential complications, we will assume here that all output is consumed privately and that $\theta = 0$.

First, suppose that τ_L is increased by $d\tau_L$ with all revenue returned to the agent in a lump-sum fashion. In the long run, k will not change since the long-run cost of capital is unaffected. Therefore, the gross wage will be unchanged. Since k is unaffected, $\hat{K} = \hat{L}$ in the long run. Also, $\hat{c} = \hat{L}$ since g remains zero. These considerations imply that $\hat{L} = -\alpha(1 - \tau_L)^{-1}d\tau_L + \beta\hat{\lambda}$ and $\hat{L} = \eta(1 - \tau_L)^{-1}d\tau_L + \nu\hat{\lambda}$ in the long run. Solving for $\hat{L}$ and $\hat{\lambda}$, we find that the long-run labor response to wage taxation is

$$\hat{L}_L^\infty = -\bar{e}_w \frac{\beta - \nu\theta_l}{\beta - \nu} \frac{d\tau_L}{1 - \tau_L}.$$

Labor use falls with a rise in the wage tax since $\bar{e}_w$ is positive. However, the long-run response is less than the compensated labor elasticity since nonlabor income is also affected: an increased labor tax reduces labor supply, reducing the return to capital and, thereby, reducing investment and long-run income, which in turn increases labor supply. As ν increases, this effect increases, possibly to the point of reducing the direct effect by $1 - \theta_l$.

Second, suppose that τ_K is increased by $d\tau_K$. In this case, the long-run relation between the marginal product of capital and τ_K given in (5) implies that $\hat{k} = (-\sigma/\theta_L)d\tau_K/(1 - \tau_K)$ and $\hat{w} = (-\theta_K/\theta_L)d\tau_K/(1 - \tau_K)$. Using the identity $\hat{C} = \theta_K\hat{K} + \theta_L\hat{L}$, we find that (6)–(7) imply that the long-run labor response to capital taxation is

$$\hat{L}_K^\infty = \frac{\beta - \nu\theta_l}{\beta - \nu\theta_L}\left(\bar{e}_w\hat{w} + e_I \frac{\theta_K}{\theta_l}\hat{k}\right).$$

The long-run labor response to capital taxation is therefore ambiguous since $\bar{e}_w$ and e_I are of opposite sign. The ambiguity remains when we examine a plausible range of parameters.

If we were to focus on permanent tax changes, we would need to compute only the appropriate weighted average of the long-run and short-run effects, as in Bernheim (1981), in order to evaluate revenue and welfare effects. However, we want to examine temporary and partially anticipated changes. Therefore, we next move to a more complete examination of dynamic responses.

IV. Dynamic Effects

We now begin our examination of dynamic effects of tax changes. Suppose that the capital stock is at the steady-state level corresponding to a set of constant government policy parameters, τ_K, τ_L, θ,

$\bar{G}$, and $\overline{Tr}$. Ideally, we would like to compute the dynamic response to any tax change. That is impossible to do in general because of the nonlinearities in the equilibrium system, (3). Instead, we will use a linearization approach to determine the impact on the economy of a policy that changes tax rates by a small amount at various times.

Suppose that the policy change announced at $t = 0$ belongs to a one-dimensional family of policy changes expressed by

$$\tau_K^*(t) = \tau_K + \epsilon h_K(t), \tag{10a}$$

$$\tau_L^*(t) = \tau_L + \epsilon h_L(t), \tag{10b}$$

$$\theta^*(t) = \theta + \epsilon z(t), \tag{10c}$$

$$G^*(t) = \bar{G} + \epsilon g(t), \tag{10d}$$

$$Tr^*(t) = \overline{Tr} + \epsilon Tr(t), \tag{10e}$$

where ϵ parameterizes the family. Function $h_K(t)$ and the other functions of time multiplied by ϵ represent the intertemporal character of the policy changes in a magnitude-free fashion since varying ϵ can be interpreted as representing the possible magnitudes of change. For example, setting $h_K(t)$ equal to unity for $T_1 < t < T_2$ and zero otherwise represents an announcement that τ_K will be increased at T_1 but will fall back to its original value at T_2. The choice of ϵ determines the magnitude of the change. Note that $\epsilon = 0$ implies that the economy remains at the initial position. Since we are interested in the marginal effects of alternative policies relative to the one that would leave the economy unchanged, ϵ is understood to be small.

If we substitute policies (10) into the equilibrium equations (3), we will have solutions for K and λ for each ϵ, denoted by $K(t, \epsilon)$ and $\lambda(t, \epsilon)$, respectively. Smooth dependence of $K(t, \epsilon)$ and $\lambda(t, \epsilon)$ on ϵ is assured by the smoothness of tastes and technology. Studying the effects of a small policy change on the economy is therefore best done by examining the impact on the paths of λ and K as we increase ϵ slightly from an initial value of zero. Define the initial impact of ϵ on λ and K as follows:

$$\lambda_\epsilon(t) = \frac{\partial}{\partial \epsilon} \lambda(t, 0), \qquad K_\epsilon(t) = \frac{\partial}{\partial \epsilon} K(t, 0),$$

$$\dot{\lambda}_\epsilon(t) = \frac{\partial}{\partial \epsilon} \frac{\partial}{\partial t} \lambda(t, 0), \qquad \dot{K}_\epsilon(t) = \frac{\partial}{\partial \epsilon} \frac{\partial}{\partial t} K(t, 0).$$

Similarly, $l_\epsilon(t)$ and $w_\epsilon(t)$ will represent labor supply and wage impacts.

To find how the paths of λ and K are affected by the announcement of a small ϵ, substitute (10) into (3), differentiate the result with respect to ϵ, and evaluate at $\epsilon = 0$. This calculation shows that λ_ϵ and K_ϵ solve the *linear* differential equations

$$\frac{\dot{\lambda}_\epsilon}{\lambda} = -\frac{1-\tau_K}{1-\theta}kf''(\hat{K} - \hat{l}) - \frac{(\rho+\delta)z(t)}{1-\theta} + \frac{f'}{1-\theta}h_K(t) \quad (11a)$$

and

$$\dot{K}_\epsilon = F(\theta_L\hat{l} + \theta_K\hat{K}) - \beta c\left[\hat{\lambda} + \frac{z(t)}{1-\theta}\right] - g(t) - \alpha c\left[\hat{w} - \frac{h_L(t)}{1-\tau_L}\right], \quad (11b)$$

where $\hat{x}$ is understood to mean $x_\epsilon(t)/x(0)$ and all terms are evaluated at the steady-state values of consumption, labor supply, and capital.

Collecting terms in (11) and using (8) and (9), we can rewrite (11) as the linear differential equation system

$$\begin{pmatrix} \dfrac{\dot{\lambda}_\epsilon}{\lambda} \\ \dfrac{\dot{K}_\epsilon}{F} \end{pmatrix} = \mathbf{J}\begin{pmatrix} \dfrac{\lambda_\epsilon}{\lambda} \\ \dfrac{K_\epsilon}{F} \end{pmatrix} + \mathbf{v}(t), \quad (12)$$

where

$$v_1(t) = f'\frac{1-\tau_K}{1-\theta}\frac{\theta_L}{\sigma}\left[\eta^e\frac{h_L(t)}{1-\tau_L} - \nu^e\frac{z(t)}{1-\theta}\right] - (\rho+\delta)\frac{z(t)}{1-\theta} + f'\frac{h_K(t)}{1-\theta},$$

$$v_2(t) = \theta_L\left[\nu^e\frac{z(t)}{1-\theta} - \eta^e\frac{h_L(t)}{1-\tau_L}\right] + \alpha\theta_c\left\{\frac{h_L(t)}{1-\tau_L} + \frac{\theta_K}{\sigma}\left[\nu^e\frac{z(t)}{1-\theta} - \eta^e\frac{h_L(t)}{1-\tau_L}\right]\right\} - \beta\theta_c\frac{z(t)}{1-\theta} - \frac{g(t)}{F},$$

and $\mathbf{J}$ is the Jacobian matrix of the system (3) evaluated at the initial steady-state values of K and λ and the initial tax rates:

$$\mathbf{J} \equiv \begin{bmatrix} -\dfrac{1-\tau_K}{1-\theta}\dfrac{\theta_L}{\sigma}\nu^e f' & \dfrac{1-\tau_K}{1-\theta}\dfrac{\theta_L}{\sigma\theta_K}\left(1 - \dfrac{\theta_K}{\sigma}\eta^e\right)f'f' \\ -\beta\theta_c + \theta_L\nu^e + \alpha\nu^e\dfrac{\theta_K}{\sigma}\theta_c & f'\left(1 + \dfrac{\theta_L}{\sigma}\eta^e - \alpha^e\dfrac{\theta_c}{\sigma}\right) \end{bmatrix}, \quad (13)$$

where θ_c is the share of net output going to private consumption in the initial steady state; J_{21} and J_{22} are the instantaneous responses of net investment to changes in the private shadow value of capital and the capital stock, respectively. Intuitively, J_{21} should be positive since a rise in the shadow price of capital should increase investment. Also, J_{22} should be positive since an increase in the capital stock increases output, which goes to investment if there is no change in the marginal utility of consumption. Both presumptions hold when $\alpha = 0$. Since λ is the private marginal value of capital in utility units, J_{11} and J_{12} represent the change in the rate of utility "capital gains" per unit of capital in response to shocks in λ; $J_{11} < 0 < J_{12}$ by the concavity of utility.

As in Judd (1982, 1985*b*), Laplace transforms will be used to analyze the marginal responses of the dynamic equilibrium changes in ϵ. Define for $s > 0$

$$\Lambda_\epsilon(s) \equiv \int_0^\infty e^{-st}\lambda_\epsilon(t)dt,\ X_\epsilon(s) \equiv \int_0^\infty e^{-st}K_\epsilon(t)dt$$

to be the Laplace transforms of λ_ϵ and K_ϵ, respectively.[4] Taking the Laplace transform of (12) and solving the resulting algebraic equation for each s yields the solution for $\Lambda_\epsilon(s)$ and $X_\epsilon(s)$:

$$\begin{pmatrix} \dfrac{\Lambda_\epsilon(s)}{\lambda} \\ \\ \dfrac{X_\epsilon(s)}{F} \end{pmatrix} = (s\mathbf{I} - \mathbf{J})^{-1}\left[V(s) + \begin{pmatrix} \dfrac{\lambda_\epsilon(0)}{\lambda} \\ \\ 0 \end{pmatrix}\right], \tag{14}$$

where $V(s)$ is the Laplace transform of $v(t)$ evaluated at s.

We will assume that $\det(\mathbf{J}) < 0$ and that $\mathbf{J}$ has two eigenvalues of opposite signs, $\zeta < 0 < \mu$. These assumptions are desired since they will imply that there is a unique local response to any tax policy change. They will hold if ν and η are small, and always if $\alpha = 0$. They also hold if J_{21} and J_{22} are positive, the intuitive cases. When necessary, we can verify these assumptions.

To complete the solution (14), we need to fix $\lambda_\epsilon(0)$, the initial jump in the private shadow value of capital. In saddle-point stable systems, this is fixed by appealing to a transversality condition, which here

[4] The Laplace transform of the function of t, $f(t)$, is a function of s, $F(s)$, defined to be the present value of $f(t)$ discounted at the rate s, as indicated in the definitions of Λ_ϵ and X_ϵ. In general, $F(s)$ is defined only for sufficiently large s; however, any positive s will be valid in this application since all functions will be bounded. The crucial property used below is that the Laplace transform of $f'(t)$ is $sF(s) - f(0)$.

implies that capital is bounded.[5] Since $\det(\mathbf{J}) < 0$ implies a saddle-point stable system, there is, for any ϵ, a unique dynamic path such that the capital stock is bounded and converges to the steady state. This implies that K_ϵ and λ_ϵ are not only continuous in ϵ by continuous dependence but also bounded. In saddle-point stable systems, it is typical that some variable jumps in order to assure boundedness. In this model, the response of the initial value of the shadow price of capital, $\lambda_\epsilon(0)/\lambda$, must be consistent with bounded K_ϵ. Therefore, $X_\epsilon(s)$ must be finite for all $s > 0$, even for $s = \mu$. However, when $s = \mu$, $s\mathbf{I} - \mathbf{J}$ is singular, resulting in a singularity in (14). Since $X_\epsilon(\mu)$ must be finite, the singularity must be removable, which is true only if

$$\begin{aligned}\frac{\lambda_\epsilon(0)}{\lambda} = \frac{J_{11} - \mu}{J_{21}} \Bigg(\theta_L\left[\nu^e \frac{Z(\mu)}{1-\theta} - \eta^e \frac{H_L(\mu)}{1-\tau_L}\right] \\ + \alpha\theta_c\left\{\left[\frac{H_L(\mu)}{1-\tau_L}\left(1 - \eta^e \frac{\theta_K}{\sigma}\right) + \nu^e \frac{\theta_K Z(\mu)}{\sigma(1-\theta)}\right]\right\} \\ - \beta\theta_c \frac{Z(\mu)}{1-\theta} - \frac{G(\mu)}{F} + \frac{K_\epsilon(0)}{F}\Bigg) \\ + (\rho + \delta)\frac{Z(\mu)}{1-\theta} - f' \frac{H_K(\mu)}{1-\theta} \\ - f' \frac{1-\tau_K}{1-\theta}\frac{\theta_L}{\sigma}\left[\eta^e \frac{H_L(\mu)}{1-\tau_L} - \nu^e \frac{Z(\mu)}{1-\theta}\right],\end{aligned} \tag{15}$$

where H_K, H_L, Z, and G are the Laplace transforms of h_K, h_L, z, and g, respectively. With (15) giving $\lambda_\epsilon(0)$, (14) expresses the complete solution for Λ_ϵ and X_ϵ. This is all the information about transition paths we need.[6]

Equation (15) gives the impact of the policy change on the private shadow value of capital. First, examination of the $H_K(\mu)$ term shows that any future increase in τ_K reduces λ at $t = 0$. From (6) and (12), this shows that consumption will drop and labor supply will rise in response, with the net effect reducing investment. Similarly, one sees that a current increase in investment tax credit will encourage investment whereas future increases may reduce investment, forcing us to examine reasonable parameter values to determine which direction is most plausible. The impact of future wage taxation is similarly ambiguous. Since these impacts are critical in determining the efficiency effects, they will be discussed in the particular cases below.

[5] See Brock and Turnovsky (1981) for a discussion of the transversality condition and stability in this model and Judd (1985*b*) for smooth dependence on ϵ.

[6] We see here that it is essential to have exactly one positive eigenvalue; otherwise $\lambda_\epsilon(0)$ would be either indeterminate or overdetermined.

We will next determine the impacts on revenue and lifetime utility. Let $\Psi_\epsilon(s)$ and $\Gamma_\epsilon(s)$ denote the sums, discounted at the rate s, of the impact of ϵ on consumption and labor supply, respectively. Brock and Turnovsky (1981) show that if the initial stock of bonds is zero, the government budget constraint is

$$0 = \int_0^\infty [g + Tr - \tau_K K F_K - \tau_L l F_l + \theta(\delta K + \dot{K})] e^{-\int_0^s \psi(\tau) d\tau} ds, \quad (16)$$

where the tax and spending rates are arbitrary functions of time and

$$\psi(\tau) = \rho - \frac{\dot{p}}{p}, \quad p = u_1(C, l), \quad (17)$$

represents the equilibrium after-tax rate of interest determined in the bond market. When we substitute the policy shocks, (10), into the budget constraint and differentiate the result with respect to ϵ, we find the condition that the budget constraint imposes on the shocks:

$$\begin{aligned} 0 = {} & Kf'(k)H_K(\rho) + l[f(k) - kf'(k)]H_L(\rho) + \tau_L[f(k) - kf'(k)]\Gamma_\epsilon(\rho) \\ & - \delta K Z(\rho) - G(\rho) + \tau_K f'(k) X_\epsilon(\rho) - \theta(\rho + \delta) X_\epsilon(\rho) \\ & + Kf''(k)(\tau_K - \tau_L)\left[\frac{X_\epsilon(\rho)}{K} - \frac{\Gamma_\epsilon(\rho)}{L}\right]k - TR(\rho), \end{aligned} \quad (18)$$

where $TR(\rho)$ and $G(\rho)$ are the present values of $Tr(t)$ and $g(t)$ discounted at ρ, respectively. The key point to note is that, when we compare the present values of revenue changes and expenditure changes, the appropriate rate of discount is ρ, the after-tax rate of return.[7] Also note that only the taxation of privately issued assets is included in (18).[8]

Since all revenues are lump-sum rebated, we will define the present value of the change in revenue from taxation of labor and privately issued assets, $dR/d\epsilon$, to be $TR(\rho)$ as determined in (18). Since we assume a bond market, the timing of the lump-sum rebates is immaterial. Therefore, $\rho dR/d\epsilon$ is the constant change in the flow of lump-sum transfers that would bring the budget back into balance after the enactment of a change in some tax parameter.

The discounted change in utility is denoted $dU/d\epsilon$. In order to be able to compare the change in welfare with the change in revenues,

[7] After writing this paper, I became aware of Chamley's (1982) attempt to generalize Judd (1981) to handle the case of elastic labor supply. However, he used f' to discount revenue streams, invalidating all his consumption equivalent excess burden calculations.

[8] If we were to include tax collections on debt paid on government debt, then the appropriate rate of discount would be the marginal product of capital. However, that procedure would be less direct since it would necessitate solving for the path of government debt issue.

we need to express the change in utility in terms of the consumption good at $t = 0$:

$$\begin{aligned}\frac{dU/d\epsilon}{u_1} &= \Psi_\epsilon(\rho) + \frac{u_2}{u_1}\Gamma_\epsilon(\rho) \\ &= (F_K - \rho)X_\epsilon(\rho) + (F_l - \overline{w})\Gamma_\epsilon(\rho) + K_\epsilon(0),\end{aligned} \tag{19}$$

where $\overline{w}$ equals the net-of-tax wage. This is the classic form for the change in utility due to a tax, where we have expressed the change in welfare in terms of the gap between supply and demand prices and the change in quantities. The impact on utility of a tax change is equivalent to the agent's consumption flow being augmented by a constant equal to $\rho dU/u_1$.

We can define the marginal deadweight loss, MDWL, to be the ratio between the change in real income due to the tax change and the constant increment in the transfer financed by the tax change, $(\rho dU/u_1)/dR$. When we discuss any of the tax parameters, MDWL is also the welfare change of using a distortionary tax instead of a constant one-dollar lump-sum tax. The term MDWL is negative if revenue and welfare move in opposite directions, the nonperverse case.

We must note that, if the extra revenue were spent on government consumption, MDWL would *not* be the loss in real income from private consumption in excess of the direct resource cost. If the extra revenue is used to increase government consumption and labor is a normal good, then the welfare loss of the direct resource cost will cause labor supply, investment, and the steady-state capital stock to increase, reducing the distortions and increasing revenues. Judd (1984), a discussion of cost-benefit analysis in this framework, found this distinction to be quite substantial.

The MDWL figure also is *not* the compensating capital stock change at $t = 0$. Straightforward calculations show that if the capital stock is shocked by $K_\epsilon(0)$ at 0, then

$$\begin{aligned}\text{MUK} \equiv \frac{\rho}{\rho - \zeta}\Bigg\{&\frac{\tau_K}{1 - \tau_K} \\ &+ \tau_L\theta_L\left[\frac{\nu^e(J_{11} - \mu)}{J_{21}\rho} + \frac{\eta^e}{\sigma(1 - \tau_K)}\right]\Bigg\} + 1\end{aligned} \tag{20}$$

is the capitalized marginal utility gain per unit of capital at $t = 0$; $\text{MUK} = 1$ if taxes were absent. Otherwise, lifetime welfare is affected as if consumption were increased by ρMUK units per period per unit increase in K at $t = 0$, with labor supply and investment held fixed. With taxes, the utility gain is the direct improvement plus the welfare impacts due to marginal factor supply changes. The net welfare impact of these changes is ambiguous, the ambiguity being reflected in the expression for MUK. The increased capital stock raises output, which when consumed yields an efficiency gain of $F_K - \rho = \rho\tau_K/(1 - \tau_K)$ per unit of extra output. It also raises wages and labor supply through the η^e term and lowers the marginal utility of consumption, reducing labor supply through ν^e. Since $\eta > 0$ and $\tau_L > 0$, the increase in wages increases labor supply and efficiency, but the fall in λ will reduce labor supply and efficiency since $\nu^e(J_{11} - \mu)/J_{21} < 0$. The net labor efficiency effect is ambiguous, with both signs realized in the parameterizations. Finally, given MDWL and MUK, the shock to capital stock at $t = 0$ that would compensate for the utility impact of a tax change is $-$MDWL/MUK per dollar of extra revenue.

This completes the formal derivation of the impact of local tax changes around a steady state of the economy. With these general formulas, we will next examine MDWL more precisely for the case of small tax rates and then for large tax rates assuming a broad range of parameter values meant to encompass empirical views of the U.S. economy.

V. Pattern of Excess Burden for Small Tax Rates

It is common in tax problems to derive explicit formulas for the excess burden of a tax when all taxes are small. For example, a well-known static result for small tax rates is that the excess burden of a tax on a good, assuming that other goods are untaxed and costs are constant, is approximately one-half the product of the compensated demand elasticity and the square of the tax rate. Such an approximation is asymptotically valid only as the tax rate decreases to zero but serves as a useful intuitive approximation.

In this section we will derive similar formulas for the dynamic model. We can similarly use equations (14)–(19) to derive explicit formulas for excess burden around a steady state with little taxation. This will allow us to examine how the structural parameters affect the excess burden of any tax assessed at any particular time when tax rates are small. While the assumption of a small tax rate is somewhat limiting here as it is whenever it is used, the analysis will provide us with a framework in which we can precisely examine conjectures and their robustness. In particular, we will focus on the effect of a delay in the imposition of a tax. To avoid inessential clutter, we will assume no government consumption. Nothing important is affected by this simplification.

More formally, assume that we are initially at a steady state with capital tax τ_K and labor tax τ_L when we change τ_K at t by $\epsilon h_K(t)$ and τ_L at t by $\epsilon h_L(t)$ for small ϵ. (Initially we will ignore θ, setting it equal to zero.) The function $\mathrm{MDWL}(\tau_K, \tau_L, h_K, h_L)$ will denote MDWL, as defined in (19), for the patterns of tax changes represented by h_K and h_L, explicitly indicating the dependence on both the initial τ_K and τ_L and the intertemporal character of the tax changes. The identity $\mathrm{MDWL}(0, 0, \cdot, \cdot) = 0$ follows trivially from (19). Differentiating $\mathrm{MDWL}(\tau_K, \tau_L, h_K, h_L)$ with respect to τ_K and τ_L at $\tau_K = \tau_L = 0$ yields a first-order approximation to MDWL around (0, 0). More precisely, for small τ_K and τ_L,

$$\mathrm{MDWL}(\tau_K, \tau_L, h_K, h_L) \doteq \tau_K \mathrm{MDWL}_1(0, 0, h_K, h_L) + \tau_L \mathrm{MDWL}_2(0, 0, h_K, h_L).$$

This is locally valid since MDWL is obviously a C^∞ function of τ_K and τ_L.

To focus on timing, assume that h_K and h_L are of the form

$$h_T(t) = \begin{cases} 0 & t < T \\ 1 & T \leqslant t \leqslant T + i \\ 0 & t > T + i \end{cases}$$

for an infinitesimal i,[9] modeling a tax increase of arbitrarily short duration at $t = T$. Its Laplace transform is $H_T(s) = ie^{-sT}$. The term h_T allows us to compute the marginal excess burden of a momentary tax increase at $t = T$. The linear form for the impacts of tax changes on revenue and utility in (14)–(19) implies that the impact of a tax change of finite duration is a weighted sum of individual momentary changes. Therefore, we regard these momentary tax changes as the building blocks for other patterns of marginal tax changes.

In the case of a capital income tax increase at $t = T$, we find that

$$\mathrm{MDWL}(\tau_K, \tau_L, h_T, 0) \doteq \frac{\rho}{\rho - \zeta}\,\frac{\rho}{\mu - \rho}\left[\frac{e^{(\rho-\mu)T} - 1}{\theta_K}\right] \times \left[\tau_K J_{21} - \tau_L\left(\frac{\beta - \nu\theta_l}{\sigma + \eta\theta_K}\right)\theta_L \bar{e}_w\right]. \tag{21}$$

First, note that MDWL is zero if $T = 0$, reflecting the short-run fixity of capital. Second, MDWL is negative if $T > 0$ since $\bar{e}_w, J_{21} > 0$, $\beta - \nu\theta_l < 0$, and $e^{(\rho-\mu)T} < 1$. Third, MDWL becomes more negative as T increases, proving the intuitive result that foreseen increases in capital income taxation are more distortionary than less anticipated ones.

Fourth, the dependence on the structural parameters is intuitive. Consider an increase in $|\beta|$, that is, a greater intertemporal consumption elasticity. This increases the second term in brackets if $\tau_K, \tau_L > 0$.

[9] The calculations can be interpreted as the limit as i goes to zero.

Such an increase will also affect μ and ζ. However, $\mu + \zeta = J_{11} + J_{22}$ and is therefore independent of β. It is straightforward, albeit tedious, to show that, while μ and ζ both increase in magnitude as $|\beta|$ increases, the change in the brackets dominates and MDWL is aggravated by an increase in $|\beta|$. Since μ increases as $|\beta|$ increases, MDWL becomes more sensitive to T, reflecting the intuition that a large intertemporal elasticity implies a less concave utility function and a more rapidly adjusting economy, leading to greater distortions.

Fifth, the dependence on the labor parameters is displayed somewhat in (21), although the interdependency of terms in (21) makes definitive conclusions difficult. A larger $\bar{e}_w$ aggravates MDWL since a rise in τ_K reduces investment and the capital stock, reducing wages by an amount inversely proportional to σ, which reduces labor supply. If $\tau_L > 0$, then this increase in leisure represents an efficiency loss at the margin.

The case of a labor tax increase is more complex. We first compute $\text{MDWL}_1(0, 0, 0, h_T)$, implicitly examining cases in which τ_K is small but $\tau_L = 0$ initially when we shock it at $t = T$. In such cases, any distortion from a change in τ_L occurs because of movements in capital supply. We find that

$$\text{MDWL}(\tau_K, 0, 0, h_T) \doteq \tau_K \eta^e \frac{\rho}{\rho - \zeta} \frac{\rho}{\rho - \mu} \times \theta_L^{-1}\left\{[e^{(\rho-\mu)T} - 1]\theta_L\left(\frac{\beta - \nu\theta_l}{\sigma + \eta\theta_K}\right)\bar{e}_w + [\mu\rho^{-1}e^{(\rho-\mu)T} - 1](\theta_L\eta^e - \alpha^e)\right\}. \quad (22)$$

First, if $T = 0$, the tax increase reduces welfare if and only if $\theta_L\eta^e - \alpha^e > 0$. This is intuitive since a labor tax change of $d\tau_L$ causes investment to drop at $t = 0$ by $F\theta_L\eta^e d\tau_L$ through the compensated labor supply response and to rise by $\alpha^e C d\tau_L$ through the reaction of consumption to the wage. Hence, investment drops by $(\theta_L\eta^e - \alpha^e)F d\tau_L$ immediately, after which the temporary tax ends and the capital stock converges at the rate ζ back to its original value.

Second, anticipation effects arise if $T > 0$. The instantaneous effect on investment at T is the same, but its effect on MDWL is reduced for positive T. On the other hand, $\bar{e}_w$ becomes important. This anticipation term results since anticipated drops in future labor supply reduce current investment and aggravate existing capital market distortions. Some rearrangement of (22) shows that MDWL decreases algebraically as T increases if and only if $\theta_L(\beta - \nu\theta_l) + [\mu\sigma(\theta_L\eta - \alpha)/\rho] < 0$. Note that if MDWL < 0 when $T = 0$, then the second term is positive. Hence, if $|\beta|$ is small or if σ is large, then the distortion of a future labor tax is less than an unanticipated temporary increase if the latter causes a welfare loss. We will see below that MDWL falls in magnitude as T increases for most estimates of the parameters.

The term $\mathrm{MDWL}_2(0, \tau_L, 0, h_T)$ represents a labor tax change when only labor taxation is present. Since it is generally excessively complex to get a comprehensible expression, we examine the case of small η, ν, and α. In this case,

$$\mathrm{MDWL}(0, \tau_L, 0, h_T) \doteq \frac{\tau_L \eta}{\sigma} \frac{\rho}{\rho - \zeta} \frac{\rho}{\rho - \mu} \times \left\{ [e^{(\rho - \mu)T} - 1] \frac{\eta \theta_L \beta}{\sigma} + [\mu e^{(\rho - \mu)T} \rho^{-1} - 1](\eta \theta_L - \alpha) \right\} - \eta \tau_L. \quad (23)$$

First note that the $-\eta\tau_L$ term is exactly the answer in a static model. It equals MDWL if adjustment is infinitely rapid, that is, if ζ and μ are infinite. Second, the dynamic term is proportional to η^2 since a labor tax change causes an $O(\eta)$ change in labor supply, capital stock, and wages, which in turn causes an $O(\eta^2)$ change in labor supply for $t \neq T$. This dynamic term may be of either sign, aggravating or reducing the static distortion. If $T = 0$, then the only effect is proportional to $\eta\theta_L - \alpha$, the drop in investment arising from a labor tax increase. If investment does drop at the moment of the wage tax increase, then the dynamic term aggravates the static distortion. In general, the dynamic term reduces the distortion if and only if

$$\frac{\beta \eta \theta_L}{\sigma} + \frac{\mu}{\rho}(\eta \theta_L - \alpha) > 0.$$

Given the presence of μ, this condition is difficult to consider. However, if $\alpha = 0$ and η and ν are small, then computing μ shows that this holds if $\sigma > \beta/(1 - \theta_L \theta_K^{-1})$. This is very likely given current estimates.

These considerations show that anticipated labor taxation affects the economy in a way quite different from anticipated capital taxation. Whereas future capital taxation is almost certainly more distortionary than current taxation, the pattern for labor taxation is plausibly different in the presence of either capital or income taxation. This has implications for the nature of desirable tax reform. Whereas cutting current capital income taxation and financing the resulting deficit with future capital income taxation surely reduces welfare, such a strategy using labor taxation may increase welfare.

The final exercise we will conduct is an examination of the investment tax credit. Intuition tells us that raising revenue by reducing the investment tax credit is inferior to increasing the capital income tax rate since a reduction in investment credits will act directly to discourage investment whereas a capital income tax taxes the income on capital in place. We find this intuition to be strongly validated, especially in the case of temporary changes in taxes in the near future. For the sake of simplicity, we will examine only the inelastic labor supply case. Let $R_{\theta,K}$ be the marginal excess burden of raising revenue through an increase in τ_K expressed as a fraction of the marginal excess burden of raising the same revenue by reducing θ, where in both cases the tax instrument is changed for an "instant" T periods in the future. Then

$$R_{\theta,K} = 1 + \frac{\theta_K}{\theta_d} \frac{\rho - \mu}{\rho} \frac{e^{-\mu T}}{e^{-\rho T} - e^{-\mu T}}, \tag{24}$$

where θ_d is capital consumption allowances expressed as a fraction of net output. Some interesting features of $R_{\theta,K}$ are immediately apparent. First, if T is infinite, the ratio is unity. Therefore, an infinitely anticipated reduction in investment tax credit is exactly as distortionary as infinitely anticipated capital income taxation. Furthermore, since $\rho > \mu$, unity is an upper bound on $R_{\theta,K}$. Finally, note that, as T decreases to zero, $R_{\theta,K}$ becomes negative, implying that the marginal excess burden of near-term changes in θ is positive and that *increasing* the investment tax credit in the near future will *raise* revenues. In the limit the ratio becomes infinite because the marginal excess burden of capital income taxation is zero while that of the investment tax credit remains positive. Therefore, when tax rates are small, raising revenue by reducing θ at any future time is an inferior way of raising revenue compared with increasing τ_K at any, possibly other, time. This dominance is somewhat explained by future capital income tax cuts increasing investment immediately, whereas future investment tax credits may possibly decrease current investment since investors decide to wait for the subsidy.

The results of this section are somewhat limited by the focus on the case of small tax rates. In any discussion of welfare costs of taxation it is desirable to have some idea of which effects are quantitatively more important. We next use our formulas for *exact* calculations of excess burdens around steady states that correspond more closely to existing tax rates.

VI. Parameterized Examples

We next examine efficiency costs for realistic values of the critical parameters. Tables 1 and 2 give examples of the magnitude of mar-

TABLE 1

MDWL OF PERMANENT CHANGES, ADDITIVELY SEPARABLE UTILITY

		$\tau_L = .3, \tau_K = .3$			$\tau_L = .4, \tau_K = .5$		
β	η	(1)	(2)	(3)	(4)	(5)	(6)
−.1	.1	−.02	−.15	−.46	−.04	−.38	−1.14
−.1	.4	−.04	−.21	−.72	−.07	−.51	−1.76
−.1	1.0	−.05	−.25	−.99	−.08	−.62	−2.47
−.5	.1	−.04	−.36	−1.87	−.07	−1.34	15.15
−.5	.4	−.12	−.42	−2.63	−.21	−1.49	9.82
−.5	1.0	−.19	−.48	−3.97	−.35	−1.68	7.30
−2.0	.1	−.05	−.69	243.86	−.09	−5.83	2.83
−2.0	.4	−.20	−.91	6.88	−.39	−22.13	2.36
−2.0	1.0	−.50	−1.31	3.53	−1.19	11.46	2.01

NOTE.—Columns 1 and 4 (2 and 5, 3 and 6) give the MDWL for permanent changes in τ_L (τ_K, θ). Also, the values $\sigma = 1$, $\theta_L = .75$, $\theta_c = .8$, and $\theta_d = .12$ are assumed.

ginal excess burdens under various assumptions concerning tax rates and their changes, labor supply, and consumption demand. In both tables capital share is set at 0.25 and capital consumption allowances are assumed to be 0.12 of net output, numbers suggested by casual examination of national income accounts. Assume that private consumption equals 0.8 of net output, a figure also suggested by the national income accounts. Except where noted, the results below are insensitive to reasonable changes in capital and depreciation share assumptions. In particular, using 0.33 for capital share and 0.9 for private consumption share would make no changes. The results are much more sensitive to alternative taste and anticipation parameters, whose values are also less precisely known. In the interest of economy, we will therefore concentrate on variations in those parameters. It is important that we examine a broad set of cases since we want to determine the implications of the model for the costs of taxation and compare them with those of other studies.

Opinions differ substantially on the effective tax rate on capital income in recent years. Feldstein, Dicks-Mireaux, and Poterba (1983) argue for rates in the United States ranging from 0.6 to 0.85 during the 1970s, whereas King and Fullerton (1984) argue for about 0.35 during the 1970s and 0.3 after the revisions of 1981 and 1982. Let τ_K vary between 0.3 and 0.5. Following Barro and Sahasakul (1983), let τ_L be 0.3 or 0.4. Set θ equal to zero always because it makes τ_K the effective capital income tax rate; this simplification is appropriate because the results depend largely on the effective rate.

First, table 1 points out some basic features when u is of the form $c^\beta + \gamma l^\eta$, where γ is chosen to assure $\theta_L = 0.75$. These are useful cases to examine since β and η can be fixed independent of tax rates and each other. Since differentiation would be an excessively tedious way to elicit the dependence of MDWL on these structural parameters, table 1 is presented as a substitute. The term η is allowed to be 0, 0.4, or 1.0, a "reasonable" range (see Killingsworth 1983). The term β is allowed to be -0.1, -0.5, or -2.0, a range suggested by the macroeconometric literature (see Weber 1970, 1975; Hall 1981; Hansen and Singleton 1983). Set $\sigma = 1.0$, assuming a Cobb-Douglas production function (see Berndt [1976] for a discussion of estimates of σ). Table 2 uses $\sigma = 0.8$ to indicate the robustness of the conclusions to alternative estimates of σ.

Table 1 examines efficiency costs for two initial levels of taxation. Columns 1, 2, and 3 give MDWL for immediate, permanent, and unanticipated increases in τ_K, τ_L, and θ, respectively, when both factors face a tax rate of 0.3. Columns 4, 5, and 6 do the same for the case $\tau_K = 0.5$ and $\tau_L = 0.4$. These choices will illustrate sensitivity to alternative estimates of the effective tax rates. The results indicate that the marginal cost of factor taxation depends on taste parameters in intuitive fashions, increasing as labor supply and consumption demand elasticities increase. The costs are also substantial and vary greatly across instruments. In table 1, the wage tax has an efficiency cost of at most 50 cents per dollar of revenue and is usually less than 15 cents in the low-tax case, whereas the capital income taxation has an efficiency cost of at least 15 cents and usually more than 40 cents. The differences are even greater in the high-tax scenario. Given that empirical analyses support many of these parameter choices, these calculations show that there is little reason to have any quantitative confidence about the true excess burden for any tax instrument. Despite the large variance in the computed excess burdens, there are important robust qualitative implications. First, for all parameters the excess burden of permanent capital taxation substantially exceeds that of permanent wage taxation. Both pale, however, when compared with the results for the investment tax credit; in fact, an increase in the investment tax credit may *increase* revenues, indicated by the positive entries for MDWL. The dominance of investment incentives to tax cuts appears to be quantitatively substantial in all realistically parameterized versions of the model.

These results should be compared with the quadratic approximation method used by Chamley (1981). The marginal efficiency costs substantially exceed those computed by Chamley. For example, in the Cobb-Douglas production and logarithmic utility case with inelastic labor supply, if $\tau_K = 0.5$ and $\tau_L = 0.3$, his method found a marginal cost of capital income taxation of about 50 cents, whereas the true cost is well over two dollars when we take into account the impact on wage taxes, and if we ignore the wage tax impact (as Chamley does), it is one dollar. Also, Chamley found (making the same assumptions about η, ν, and α) that the addition of an elastic labor supply increases the excess burden of capital taxation by a factor of between 1.0 and 1.33, whereas we find a somewhat larger range of possibilities. These differences are not surprising since we study a local approximation around a taxed equilibrium and compute the true marginal efficiency losses, whereas his globally extended approximation around the untaxed equilibrium underestimates the rate of adjustment around a taxed steady state. The importance of measuring the costs of taxation around taxed equilibria instead of untaxed was emphasized in a static context by Green and Sheshinski (1979); here we find that that lesson is equally important in dynamic contexts.

Table 1 assumes additively separable utility functions to examine the impact of critical parameters on the cost of permanent tax changes. Table 2 examines the effects of various partially anticipated and temporary tax policy changes using specifications suggested by the empirical literature and used in other intertemporal taxation analyses. One advantage of this approach is the ease with which one can determine such effects, which are of interest since tax changes are often phased in and few policy changes are permanent. In this table, T_1 is the date at which a tax parameter is increased and T_2 is the date at which it is returned to its original value. In the notation of the preceding sections, a wage tax (capital income tax, investment tax credit) increase is represented by setting $h_L(t)$ ($h_K(t)$, $z(t)$) equal to one for $t \in [T_1, T_2]$ and zero otherwise. Define one period as that amount of time, $t_{.01}$, such that $e^{-\rho t}.01 = 0.99$; hence, utility is discounted by 1 percent during one period. This normalization affects no substantive result but gives the reader a way to relate beliefs about discounting to the model. For example, if one believes that individuals discount utility at 4 percent per year, then the unit of time is a quarter.

The first panel of table 2 assumes the utility function used in Auerbach et al. (1983), based on Ghez and Becker (1975),[10] allowing comparisons with the results of their overlapping generations model. The explicitly dynamic work of MaCurdy (1981, 1983) is also used. The second panel uses a utility function estimated in MaCurdy (1983),[11] whereas the third panel uses estimates from MaCurdy (1981). These

[10] That is, we take the utility function they use and assume no growth in labor quality over time. Our uncompensated elasticity differs from what they called an uncompensated elasticity since, in interpreting Ghez and Becker, they assumed that wage changes were temporary. We use their utility function instead of interpreting Ghez and Becker differently since this gives agents in the two models the same tastes.

[11] I evaluate his estimated utility function at the means of the wage, income, and various demographic factors.

TABLE 2

MDWL of Partially Anticipated, Temporary Changes

T_1	T_2	$\tau_L = .3, \tau_K = .3$ (1)	(2)	(3)	$\tau_L = .3, \tau_K = .5$ (4)	(5)	(6)
		$\sigma = .8, \beta = -.25, e_w = -.13, e_I = -.85, \zeta/\rho = -.024, \mu/\rho = .035$					
0	1	−.57	−.01	2.30	−.93	−.02	2.91
8	9	−.50	−.10	2.88	−.72	−.28	3.63
16	17	−.44	−.20	3.95	−.58	−.55	4.99
32	33	−.37	−.37	19.70	−.42	−1.04	26.07
160	161	−.25	−.90	−1.02	−.26	−2.08	−2.14
0	16	−.51	−.09	2.79	−.74	−.25	3.50
0	80	−.38	−.33	9.97	−.47	−.86	9.91
0	20,000	−.32	−.53	−5.70	−.37	−1.28	−17.86
		$\sigma = .8, \beta = -1.37, e_w = .7, e_I = -.77, \zeta/\rho = -2.6, \mu/\rho = 5.1$					
4	5	−6.42	−.13	1.40	15.12	−.37	1.70
12	13	−2.70	−.38	1.58	−5.77	−1.24	1.94
32	33	−1.15	−1.02	2.69	−1.27	−4.88	3.50
160	161	−.61	−2.20	−2.26	−.70	−15.16	−15.25
0	16	−4.31	−.22	1.45	−98.20	−.62	1.77
0	80	−1.41	−.81	2.13	−2.01	−2.82	2.47
0	160	−1.10	−1.08	2.89	−1.46	−4.06	3.03
0	20,000	−.98	−1.24	3.78	−1.26	−4.91	3.52
		$\sigma = .8, \beta = -1.2, e_w = .08, e_I = -.061, \zeta/\rho = -1.7, \mu/\rho = 3.2$					
0	1	−.11	−.01	2.97	−.16	−.02	3.00
4	5	−.10	−.05	3.40	−.15	−.14	3.27
10	11	−.10	−.11	4.37	−.13	−.33	3.82
32	33	−.08	−.32	−34.75	−.10	−1.05	10.99
160	161	−.06	−.82	−.97	−.06	−2.68	−2.86
0	16	−.10	−.08	3.82	−.14	−.23	3.52
0	32	−.10	−.15	5.34	−.13	−.44	4.23
0	20,000	−.07	−.47	−3.73	−.09	−1.44	−135.17

Note.—Columns 1 and 4 (2 and 5, 3 and 6) give the MDWL for a change in τ_L (τ_K, θ) announced at $t = 0$ to begin at $t = T_1$ and end at $t = T_2$. Also, values of $\sigma = 1$, $\theta_L = .75$, $\theta_c = .8$, and $\theta_d = .12$ are assumed.

three studies were chosen since they represent alternative approaches to estimation of dynamic labor supply. They are based on a variety of data sources (the Panel Study of Income Dynamics, Seattle-Denver Income Maintenance Experiment, and census data), and they fairly represent the broad range of empirical estimates on consumption demand and labor supply for our purposes.[12] It is important that we examine a broad collection of taste parameters instead of choosing a single set since the results are quite varied in magnitude, implying low confidence in the magnitudes of the efficiency costs of various tax policies. However, we do find robust results concerning the ranking of various policies. Above each panel of table 2 are listed the important parameters, β, e_w, and e_l, and the eigenvalues, ζ and μ, that apply for that panel.

In table 2, $\tau_L = 0.3$ and $\sigma = 0.8$ are assumed. Marginal deadweight loss numbers are presented in six columns, the first three assuming $\tau_K = 0.3$ and the second three assuming $\tau_K = 0.5$. Each set of three columns yields MDWL for a marginal change in τ_L, τ_K, and θ, respectively. Each row corresponds to a choice of T_1 and T_2, indicating the timing of the policy announced at $t = 0$.

Several interesting features are robust across the parameterizations. First, announcements that τ_K will be increased during $[T_1, T_1 + 1]$ are examined. The efficiency cost rises substantially as T_1 increases. In fact, after 200 periods (not displayed), such a tax increase often has a perverse impact on revenue. This is expected since capital is fixed in the short run. Second, we find that the cost of labor taxation has a nontrivial dynamic component, but in the opposite direction, since future labor tax increases generally have lower efficiency costs than immediate increases. In these cases, capital accumulation and labor supply are initially stimulated by an announced future wage tax increase, yielding an immediate improvement in efficiency that partially counters the increased distortion in the labor market at the time the tax is actually imposed. There are a couple of unreported cases in which these anticipation effects were different. If one takes Hausman's (1981) estimate for static labor supply and combines it with $\beta = -0.6$ or takes Abbott and Ashenfelter's (1976, 1979) estimates combined with $\beta = -0.3$, anticipated labor taxation increases current investment and has a lower efficiency cost than current labor taxation.

[12] The working paper version of this paper also considered estimates from Abbott and Ashenfelter (1976, 1979) and Hausman (1981), finding few differences except where noted below. In terms of the magnitude of MDWL, the three examples considered in the text represent the high, medium, and low ranges of values that arise when existing empirical estimates of the crucial parameters are used. Other estimates, such as Lucas and Rapping (1969) and others noted in Killingsworth (1983), yield no substantially different results.

However, nontrivially different values of β reverse these results or make the utility function convex. Therefore, these counterexamples, occurring only when parameter estimates from different studies are combined, appear contrived and do not strongly counter the argument that empirical estimation of dynamic labor supply and consumption demand indicates that the cost of labor taxation falls with anticipation.

Third, the impacts of pulses of θ are even more dramatic. In all our examples, future investment tax credits reduce current investment. On the other hand, immediate temporary increases in θ often improve efficiency so much that both utility and revenues rise. This self-financing possibility was also found in the overlapping generations simulation analysis of Auerbach and Kotlikoff (1983). However, they conjectured that it was due to intergenerational differences in marginal propensities to consume. This analysis shows that the self-financing possibility is robust to these model specifications, not due to intergenerational differences. As the investment tax credit is pushed into the future, the revenue impacts usually cease to be perverse. Furthermore, the excess burden of raising revenues by decreasing future investment tax credits drops with anticipation, but always substantially exceeding that of an increase in labor or capital income taxation. Note that, for very distant changes, investment tax credits and capital income tax changes have nearly identical efficiency costs, nearly repeating the result found above for the case of small initial tax rates.

When $T_1 = 0$, an announcement is made that a policy instrument is increased immediately, but for only T_2 periods, after which the instrument is assumed to return to its original value. Table 2 displays the efficiency costs of such a change for various values of T_2. This perturbation helps us understand the incentives in tax policy formation. Optimal taxation policy is "dynamically inconsistent" (see Kydland and Prescott 1977) in this model because of the presence of the capital stock. In the short run, the capital stock is fixed and capital taxation has a low efficiency cost, whereas future capital taxation is more distortionary since people will decumulate in response to it. Hence, an optimal program will likely call for a greater reliance on capital taxation in the short run than in the long run.[13] However, when the economy gets near the "long run," policymakers will want to go back on the earlier "promise" of low capital taxation and again impose high taxation of capital in the short run. In an environment in which

[13] See Judd (1985*a*) for a proof that in the long run there should be no net capital income taxation in this model even if capital markets are not perfect, long-run capital supply has a finite elasticity, and the government has a redistributive motive.

policymakers have influence only over current and short-run policies, the policymaker at $t = 0$ can effect a change in policy only for t between 0 and some time T_2 when his control ends, even though he may care about the long-run impact on welfare. Hence, he will examine only the consequences of what he can do, that is, a T_2-period immediate change in policy. When T_2 is not large, capital taxation has a lower efficiency cost than labor taxation of the same duration, but as T_2 increases, capital taxation generally becomes inferior at the margin. Note, however, that only capital income tax cuts of substantial duration dominate. In this model, the efficiency cost difference between capital and labor income taxation is small from the point of view of any one policymaker with control over only 16–32 periods of the immediate future. If the trade-off were zero, then we would be at a Phelps-Pollak (1968) equilibrium, one of the proposed solutions to the dynamic consistency problem. These various tax preference combinations would constitute Phelps-Pollak equilibria in the model for duration of control between 20 and 80 periods. Also, there is much less incentive to any actual policymaker to deviate from current levels of capital and labor taxation than indicated by table 1, which implicitly takes the perspective of a policymaker with control over the entire future. While a more complete game-theoretic analysis would be desirable, these calculations indicate that dynamic inconsistency plays a quantitatively significant role in pushing tax structures away from an "optimal" one.[14]

In comparing the first three columns in each panel with the second three columns, we find that the higher capital tax rate associated with the latter columns leads to a greater efficiency cost for all tax instruments. This is expected for the investment tax credit and capital income tax since they are directly associated with the capital stock. However, the nontrivial impact of τ_K on the welfare cost of labor taxation is due to the cross-effect of labor supply on investment. Since labor supply falls as labor is taxed more, the return to capital falls and investment is reduced. In a capital market distorted by a positive τ_K, this reduction in capital stock will reduce the economy's efficiency, and increasingly so as τ_K is greater.

The last row in each panel of table 2 represents a (practically) permanent change in a tax instrument. Note that the patterns of table

[14] Chamley (1982) attempts to argue that a dynamically consistent equilibrium would tax capital much less than labor. However, he assumes that a policymaker can determine taxes for the infinite future but must assess the same tax now as at any time in the future. The true problem instead is that policymakers can vary the tax rates over their period of influence but cannot determine future taxation. From the results above, we see that Chamley's analysis was severely biased against capital taxation because of the infinite horizon of influence by the policymaker.

1 continue to hold here. Finally, note that for no parameterization considered above would an equal, immediate, and permanent decrease in both capital and labor tax rates increase revenues. However, such a perverse movement of revenue is more likely in this model than indicated in the analysis of Fullerton (1982). He argues that even if income tax rates were around 0.8, further tax increases would increase revenue. In this intertemporal optimizing framework, tax rate increases at that level of taxation reduce revenues unless intertemporal substitution in consumption is very low.

VII. Comparisons with Alternative Studies

We next turn to a comparison of our results with those of other models and methodologies. While this model is simple, it is an alternative to the relatively simple static and ad hoc models used earlier in discussions of the costs of factor taxation and provides a test of the importance of alternative hypotheses concerning rationality and aggregation.

Comparisons with Browning (1976) allow us to determine the potential importance of dynamic considerations for the cost of labor taxation. He computed the excess burden to be $\bar{e}_w \tau_L$, which is much less than the MDWL values for permanent changes in table 2.[15] This is due to the presence of capital income taxation since labor taxation reduces the return to capital, causing the undersupply of capital to be aggravated. Not only is a dynamic model necessary to compare the relative costs of labor and capital income taxation, but it is necessary even if we want to estimate the cost of labor taxation alone since the two factor markets interact substantially.

The only other dynamic perfect-foresight approach is the simulation of an overlapping generations model by Auerbach et al. (1983). Even though they did not compute excess burdens, we can make some comparisons. They generally found smaller efficiency costs of taxation, presumably because of their assumed absence of bequest motives. Since they assumed that an individual equates two utils at death with one util at birth, adding a bequest motive would substan-

[15] The static analysis of Stuart (1984) reports substantially larger numbers than Browning (1976). However, that is due to substantive differences between models and excess burden concepts. First, when Stuart altered the tax rate, he assumed that the marginal rate rises by much more than the average rate, implicitly raising the lump-sum rebate implicit in nonproportional linear tax schedules as he raised the marginal rate. I prefer to examine a proportional tax and regard the rebate as a transfer that does not rise as the marginal rate rises in these exercises. The differences are not important but must be kept in mind when comparing studies. Second, Stuart assumed an untaxed, "underground" sector to the economy. Otherwise, his study is essentially the same as Browning's for excess burden questions.

tially increase current responsiveness to future prices and raise the efficiency costs of future taxation. Their analysis of wage taxation is not as favorable as this one since they found that a switch to wage taxation from a proportional income tax would necessarily hurt some generation. This result is at least partially due to their limited use of age-specific adjustments in any tax reform. They did find that switching to a consumption tax would be preferable to wage taxation, a result similar to the finding that investment incentives financed by wage taxation if necessary (a combination similar to consumption taxation) would enhance efficiency. Therefore, the two models reach similar qualitative conclusions concerning the desirability of investment incentives relative to other policy innovations.[16]

Feldstein (1978) examined a two-period model of the life cycle and appears to have found smaller costs of capital taxation.[17] This is expected since a two-period model of life implicitly assumes that the agent can choose only two consumption rates: one for early life and one for late life. The multiperiod approach here avoids that aggregation and the downward bias it brings.

Another alternative dynamic approach to excess burden calculations is exemplified by Ballard et al. (1985*b*).[18] They estimate the average excess burden of capital taxation to be about 15–36 cents per dollar of revenue. However, they show that much of that cost is due to heterogeneous tax treatment of different types of capital, a consideration ignored here. Therefore, the dynamic portion of the cost of capital income taxation in their model is substantially less than that found here.

[16] There are also some important technical differences between the two approaches. In this analytic approach, problems of existence and local uniqueness of equilibrium would become immediately apparent by **J** having eigenvalues of the same sign. Since this never arose in the cases examined, we have examined only economies with locally unique dynamics around their steady state. This analysis follows the general approach outlined in Kehoe and Levine (1985). On the other hand, overlapping generations models have potentially severe problems with local uniqueness. Kehoe and Levine (1985) show that overlapping generations models may have a continuum of equilibria locally, whereas equilibria in representative agent economies are generally locally unique. These economies do not have to be perverse in order to display indeterminacy, as Kehoe (1985) shows in an example. The possibility of indeterminacy increases as the agents live more periods, as seen in Kehoe and Levine (1985). Since comparative dynamic exercises around indeterminate equilibria are also indeterminate, overlapping generations analyses are not completely reliable unless one has settled the determinacy issues. Auerbach et al. (1983) do not examine them.

[17] It is difficult to make tight comparisons since it is difficult to relate empirical estimates of structural parameters based on quarterly or annual observations to such two-period models.

[18] The marginal excess burdens computed in Ballard et al. are not comparable to the ones computed here since they examined the marginal cost of taxation when marginal revenue went to finance the provision of public goods that do not affect private demand.

The reason for the small dynamic cost in Ballard et al. is probably found in their formulation of savings behavior. The major parameter in their model is the elasticity of savings. While there is no analogous parameter in the perfect-foresight model, an econometrician proceeding as in Boskin (1978) or Howrey and Hymans (1980) could still estimate one. In this model, regressing the log of gross savings against the log of the net-of-tax rate of return as the economy approached its steady state would yield an "elasticity of savings," ϵ_s, that would equal

$$\epsilon_s = \frac{(\zeta + \delta)\sigma\delta^{-1}}{\eta^e\theta_K\sigma^{-1} + \nu^e\theta_L(J_{11} - \mu)J_{21}^{-1} - \theta_L}.$$

Further computations show that ϵ_s is extremely sensitive to δ and ζ but bears no significant relation with excess burdens. In fact, with δ = 0.12, the savings elasticities in table 2 range from 0.3 to 3, whereas if δ = 0.25 of net output, *all* the parameterizations would display negative ϵ_s. However, *no* excess burden number in table 2 for labor or capital taxation would be affected by more than 5 percent.[19] In contrast, efficiency costs of taxation are substantially affected by the savings elasticity in Ballard et al. Therefore, if one were truly in a world described by the dynamic optimization model, estimating ϵ_s and using it in a savings rate model would not give a reliable approximation and would miss the nonnegligible anticipation effects of future taxation found above. However, none of this would appear to affect their estimate of the cost of nonuniform treatment of heterogeneous capital. Hence, an analysis combining both nonuniform capital taxation and dynamically optimizing investors would presumably find costs of capital taxation substantially exceeding the costs found here or in Ballard et al.

These comparisons indicate that various approaches to excess burden analysis differ substantially when it comes to determining the magnitude of the costs of factor taxation. The key element of this analysis is the representative agent formulation of aggregate decision making. However, the qualitative similarities found between this analysis and Auerbach et al., another perfect-foresight analysis, indicate that some of these results are robust to specifications of bequests. Furthermore, the ranking of permanent changes in capital and wage taxation is similar to that found in Ballard et al. Since these three dynamic models represent extreme combinations of assumptions concerning bequest motives and foresight, they jointly form a framework in which one can assess the importance of these elements in determining the efficiency cost of taxation. Since both the extent of bequest

[19] Of course, the excess burden for the investment tax credit would be substantially affected because of the much greater level of replacement investment.

motives and the rationality of agents are empirical questions, a choice among these alternative approaches ultimately rests on empirical analysis.

VIII. Caveats and Conclusions

In this paper we determined the short-run impacts and the marginal efficiency cost of factor taxation of intertemporally complex tax changes around the steady state of a simple perfect-foresight model. First, it was shown that such an exercise is tractable. The method used here is extendable to cases of multiple types of capital, human capital accumulation, and nonadditive preferences. Second, while one cannot pick any one number for an estimate of excess burden, qualitatively robust implications were found. We found that, when standard reference values for parameters of tastes and technology are taken, the resulting estimates for excess burdens are large, with substantial differences across various instruments. This analysis strongly indicates that the desired directions of permanent tax reform from the point of view of aggregate efficiency are increases in the investment tax credit and labor taxation, a result robust across a broad range of estimates for the crucial parameters. Third, the excess burdens turn out to be very sensitive to the *timing* of the tax. In fact, knowing the timing of a policy is as important as knowing tastes and technology since the cost of capital taxation rises rapidly with anticipation whereas that of labor taxation usually falls. Also, since labor taxation dominates capital taxation only in the long run, policymakers with a moderate horizon of control are likely to always choose substantial capital income taxation despite its substantially higher long-run costs. Finally, we found that the excess burdens computed in this model tend to run greater than alternative approaches that ignore anticipation effects or do not take a multiperiod approach to an individual agent's economic life.

There are several aspects of reality ignored by this analysis. First, we ignored adjustment costs, which have played an important role in investment theory. In the case of convex adjustment costs with inelastic labor supply, other computations I have made show that the range of excess burdens is not affected by adjustment cost parameters as suggested by the empirical literature. However, it is not clear that the convex specification is the best. Rothschild (1971) has argued for concave costs of adjustment, whereas Kydland and Prescott (1982) studied a time-to-build specification. These, particularly the latter, only delay the beginning of adjustment, not slow the ultimate rate. Hence, it is not clear that adjustment costs would substantially alter the conclusions concerning any but the most short-run policies.

We have also abstracted from much of the complexity of the tax system by ignoring heterogeneous treatment of alternative financing structures and capital inputs. In the case of capital gains taxation, this aggregation is most questionable, as shown in Balcer and Judd (1985*a*) and Judd (forthcoming). One suspects, however, that these simplifications do not bias the results against capital taxation since a more realistic model would give agents more ways to avoid paying taxes, leading to more elastic revenue responses without affecting marginal distortions.

Uncertainty is another important aspect missing in this analysis. However, it is not clear what bias results from that omission. Bulow and Summers (1984) argued that riskiness substantially increased the efficiency cost of capital taxation; however, Gordon and Wilson (1986) have shown that their formula was wrong, omitting elements that reduce the bias they asserted. In fact, in earlier work, Hamilton (1981) generalized the isoelastic utility function analysis of Levhari and Sheshinski (1972) to include white noise in returns and showed that the cost of capital taxation is *unchanged* by such uncertainty if all investments are taxed at the same rate. Therefore, any biases of the deterministic approach relative to a more realistic model with uncertainty must arise from decreasing returns in capital intensity and third-order properties of utility functions.

Given all these aspects of reality ignored in this model, I cannot claim that these results are directly applicable to the U.S. economy. The primary objective was to analyze efficiency costs of factor taxation in a commonly used model of dynamic general equilibrium and to examine the impact of various technical and taste parameters. The result is an analytically tractable benchmark analysis, implicitly emphasizing individual rationality and bequest motives, which can be compared with the implications of alternative views of intertemporal economic behavior.

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