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TAXATION AND THE SIZE AND COMPOSITION OF THE CAPITAL STOCK: AN ASSET PRICE APPROACH

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ABSTRACT

This paper develops an asset price approach to the analysis of capital taxation. The costs of adjusting capital stocks cause tax changes to have important impacts on the valuation of existing capital. The recapitalizations associated with tax reforms represent an important aspect of their incidence. These effects are studied within the context of an empirically calibrated general equilibrium model. The model extends previous work by explicitly treating the process of adjustment following tax reforms, treating in detail the relationship between tax rules and interest rates and examining the differential incidence effects of corporate tax reductions and investment incentives.

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The importance of taxation in determining the size and composition of the nation's capital stock is by now widely recognized. Taxes affect both individuals' incentives to save, and the allocation of savings among alternative forms of investment. These effects have been extensively studied within the context of general equilibrium models of the type developed by Harberger (1962), and elaborated in the work of Shoven and others.[1]

These models have been used to estimate the welfare loss which arises from tax wedges which causes the pre-tax marginal product of capital in different sectors to diverge, and to analyze the long run effects of tax reforms on real wages and rates of return. However, general equilibrium models are not well suited to analyzing the short and intermediate run response of the economy to changes in tax policy. They assume that there are no costs of adjustment impeding the accumulation or reallocation of capital. As a consequence, sectoral marginal products of capital are always equated. This means that there is essentially no scope for variation in the asset price of existing capital goods. Studies of tax incidence within this framework focus on the effects of tax changes on the after tax rate of return, because the constancy of the relative price of capital goods precludes any wealth effects.

The implausibility of these assumptions may be seen by noting

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1) These studies include Shoven (1976), Fullerton, King, Shoven and Whalley (1980), and Fullerton and Gordon (1981). For a summary of the now large literature on general equilibrium modelling, modelling, see Shoven and Walley (1984).

that they imply that corporate shareowners would not gain relative to homeowners from increases in the tax burdens on residential capital and reductions in the tax burdens on corporate capital. More generally, standard general equilibrium models have the counterfactual implication that all owners of capital should have the same preferences about tax policy, since all capital will be equally affected. Capitalists would have no reason to systematically oppose taxes on their own industry. This is because the standard approach to tax incidence ignores an important aspect of the actual economy's response to such a tax change. Return to the example of a reduction in corporate taxes. In the short run, the price of existing corporate capital would rise, and of existing homes would fall, as investors reallocated their portfolios. The price changes would capitalize the expected present value of the effects of the tax reform on future returns, conferring windfall gains on the owners of corporate capital, and losses on homeowners. These price changes would act as signals to the suppliers of new capital, calling forth more plant and equipment and fewer homes, until their relative prices were again equated to their relative long run marginal costs of production.

The extreme volatility of asset prices in the American economy suggests that these "capitalization" effects are of substantial importance. The ratio of the market value of corporate capital to its replacement cost has varied by a factor of more than two over the last 15 years. The relative price of the stock of owner occupied housing has increased very substantially. Bulow and Summers (1984) point to evidence of substantial volatility in the prices of specific used capital goods. Even more extreme volatility has been observed in the relative price of non-reproducible assets such as land, gold, and Rembrandts. Such relative price changes represent important transfers of wealth, and must be considered if the incidence of tax changes is to be accurately assessed.

A second type of example suggests the importance of focusing on asset prices in examining tax incidence. Investment can be stimulated by reducing the corporate tax rate or by the use of incentives for new investment such as the investment tax credit or accelerated depreciation. In the long run, these two types may be designed to have very similar effects. But their incidence will differ dramatically. Because the former policy benefits old as well as new capital, it will confer a windfall gain on the owners of capital at the time that reform is announced. On the other hand, investment incentives may actually confer a windfall loss on the holders of existing capital. This distinction cannot be captured within the standard general equilibrium model, but requires a framework in which the distinction between new and old capital is a meaningful one.

This paper develops a general equilibrium model in which costs of adjustment are incorporated, so that it is possible to examine jointly the short run effects of tax policy on asset prices and the long run effect on patterns of capital accumulation. The model is intended to provide a realistic guide to the likely responses of the American economy to tax reforms and so it is calibrated to econometric estimates of the relevant parameters and to data from the National Income Accounts. The model is solved using the method of multiple shooting developed in Lipton, Poterba, Sachs and Summers (1982).

While the model is somewhat stylized in that it incorporates only three types of capital: corporate plant and equipment, owner-occupied housing and land, it is capable of examining the wealth effects of tax reforms on economic behavior. Consider for example, the effects of compensated reductions in the corporate tax rate. This reform is normally analyzed in terms of its effects on firms' investment incentives. But it has another potentially large effect. Such a tax reform will raise stock market values instantaneously as investors capitalize subsequent tax savings. The resulting increase in wealth will increase consumption tending to increase required rates of return on all assets.

The advantages of the asset price approach to the evaluation of tax reforms taken here are discussed in detail in Summers (1984). The only parameters in the model that are estimated statistically pertain to tastes or technology and so can be assumed to be invariant to the choice of policy rule. Thus the estimates presented here are from the Lucas critique of econometric policy evaluation exercises. Because of its forward looking character, the model developed here can easily be used to examine the effects of policy announcements and the differential impacts of temporary and permanent tax reforms.

The model developed in the paper is used to examine the effects of indexing the tax system and of various types of tax reform. The effects of inflation working through the tax system have been extensively studied. Typically, researchers have closed their models by making an arbitrary assumption about the response of interest rates to inflation. The general equilibrium character of the model developed here makes it possible to endogenously derive the response of inflation to interest rates. Changes in depreciation provisions continue to be a major issue in U.S. tax reform debates. The model presented here can be used to trace the effects of policies which benefit new but not old capital investments.

The paper is organized as follows. The next section describes a simple model illustrating the asset price approach to the analysis of investment incentives and lays out the general structure of the model used in this paper. In the second section, the corporate sector of the model is described. The markets for housing and land, along with the consumption function are discussed in the third section. The fourth section considers the long run steady state effects of changes in inflation and in tax policy. The effects of inflation and tax reforms on asset prices and on short run economic performance are taken up in the fifth section. A final section concludes the paper by discussing the implications of the analysis for current tax policy debates.

I. Asset Prices and Investment

An Illustrative Model

This section begins by presenting a very simple partial equilibrium model in which the effects of tax policy on asset prices and investment may be analyzed graphically. The model is a simplified version of the framework used in Summers' (1981) analysis of the tax returns and corporate investment, and Poterba's (1981) analysis of the effect of inflation on the price of owner occupied housing. Assume that there is one type of capital which is supplied elastically because of either internal or external adjustment costs. That is:

$$(1) \qquad \dot{K} = I(P_K) \qquad I' \geq 0, I(1) = 0$$

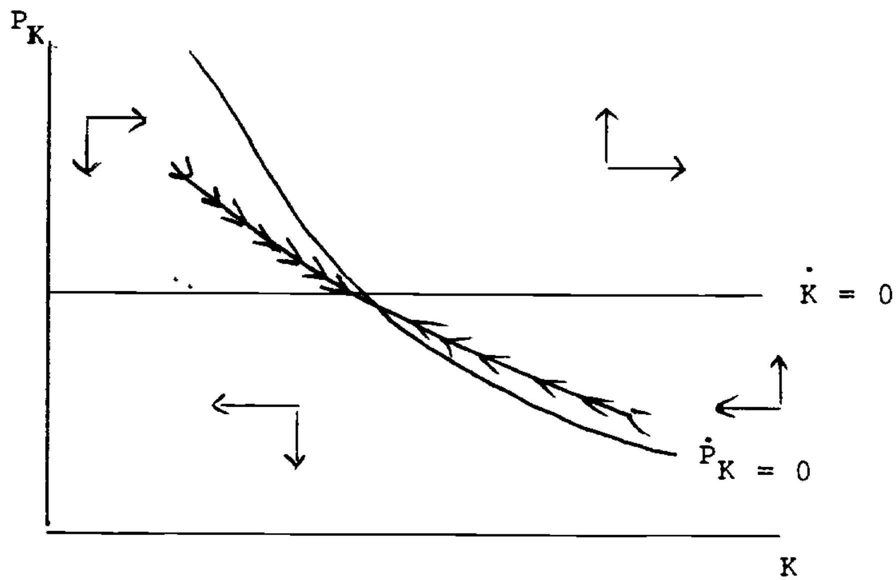
where P_K is the price of capital goods relative to consumption goods. Note that $\dot{K}$ can be negative because of depreciation. Assume further that the capital good K is used in some production process where it earns a total return $F'(K)K$ and that $F''(K)$ is negative. Finally assume that all returns are paid out and that investors require some fixed rate of return ρ, to induce them to hold the capital assets. The returns to holding a unit of capital come in the form of rents $F'(K)$ and capital gains so that

$$(2) \qquad \rho = \frac{F'(K)}{P_K} + \frac{\dot{P}_K}{P_K}$$

Equations (1) and (2) describe the dynamics of the adjustment of the quantity and price of capital. The phase diagram is depicted in Figure 1. Equilibrium occurs at the intersection of the two schedules at the point where $F'(K) = \rho$.

Figure 1

Dynamics of Investment and Market Valuation

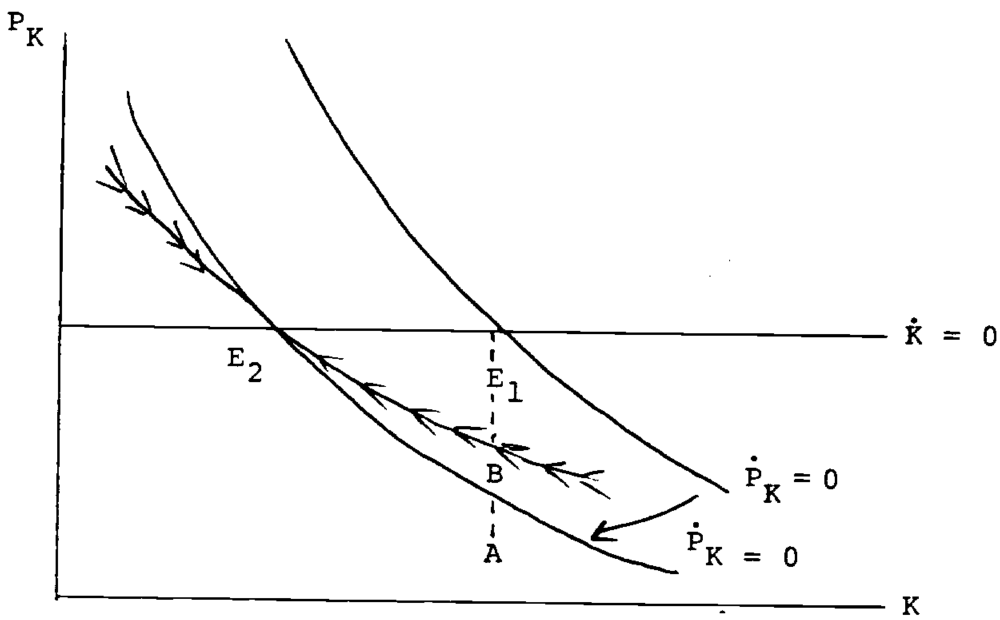


Note that the system displays saddle point stability. Except along a unique path marked by the dark arrows, the system will not converge. Only along this path does the supply of investment exactly validate the future returns capitalized into the market price of capital goods. Such saddle point stability is characteristic of asset price models. It implies that at any point in time, the stock of capital and assumption of saddle point stabiliy uniquely determine the asset price of capital.

The phase diagram in Figure 1 can be used to examine the effects of various types of tax changes. In Figure 2 the effect of a tax on the asset's marginal product is considered. Such a tax does not affect its supply curve so that the $\dot{K}=0$ locus does not shift. The reduction in after tax returns leads to a leftward shift in $\dot{P}_K = 0$ locus. Since an increase in the tax rate has no immediate effect on the capital stock the market price of capital drops from E_1 to B. As capital is decumulated, the marginal product of capital rises and the system converges from B to E_2 where P_K again equals its equlibrium value. Note that after the first instant investors always receive a fixed return ρ as reduced rents are made up for by capital gains as equilibrium is restored. The position of the adjustment path depends on the elasticity of supply of the capital good. If the elasticity is substantial, adjustment is rapid so that the tax change has little effect on the asset price of capital. If the supply of capital is relatively inelastic, there is a larger movement in the price of capital. In the limiting case, where the supply of capital is completely inelastic, the relative price of capital declines to point A along the $\dot{P}_K = 0$ locus.

Figure 2

Response to a Tax Increase



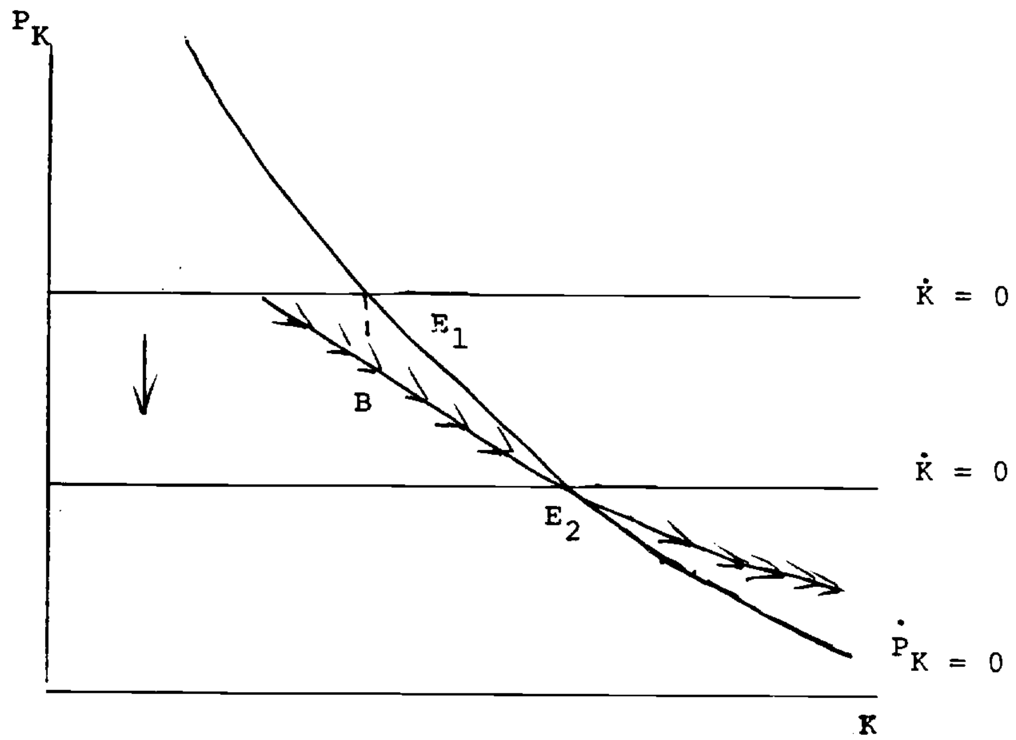
The effect of a subsidy to new capital investment which does not apply to existing capital, such as accelerated depreciation or the investment tax credit is depicted in Figure 3. This shifts the $\dot{K} = 0$ schedule but has no effect on the return from owing capital and so does not affect the $\dot{P}_K = 0$ locus. Such a subsidy leads to an increase in long run capital intensity but reduces the market value of existing capital goods. This illustrates that tax measures which encourage investment may hurt existing asset holders. The magnitude of the loss will depend upon the elasticity of the supply of capital. If it is high owners of existing capital will suffer a loss close to the subsidy rate. If not, they will continue to earn rents during the period of transition so the loss will be smaller.

This result may at first seem counter-intuitive. It occurs because the subsidy reduces the price of new capital which is a substitute for existing capital. The adverse effect of a reduction in new car prices on used car prices illustrates the effect considered here.

Note that effects of tax policy in this model depends only on the production function and the supply curve for capital goods. These parameters are technological, and so their estimation is not dependent on the assumption of a stable policy regime. This is not the case for standard approaches based on estimated investment equations. The asset-price approach can also be used to examine the effects of policy announcements, and the differential effects of permanent and temporary policies.

Figure 3

Effect of an Investment Subsidy



The General Equilibrium Model

This paper constructs a general equilibrium perfect foresight growth model in which asset market prices and investment decisions are determined in a manner parallel to that illustrated here. There are two important advantages of this approach over standard general equilibrium models which assume perfect capital mobility.

First, models which recognize that stocks of capital adjust slowly are likely to provide much more realistic estimates of the consequences of tax measures over the policy relevant horizon. A second virtue of this approach is that it provides a more satisfactory approach to the analysis of tax incidence. Without introducing adjustment costs of some type it is not possible to account for the variations in the price of existing assets relative to replacement costs, which account for most of variation in the return received by asset holders.

Note also that because it provides a basis for evaluating the windfall gains and losses from tax return, the model here can be used to address questions of horizontal equity. The importance of the announcement effects of tax policies on asset values from the perspective of equity is stressed in Feldstein (1976), who stresses the desirability of reforms which do not confer windfalls. The present model provides a basis for considering policies directed at this objective.

Taking account of adjustment costs entails other sacrifices. It is not computationally feasible to solve multi-sector models with more than a very small number of capital goods. This means that the model must be much more aggregative than many of those surveyed in Shoven and Whalley (1984). As in general equilibrium models, there is no explicit treatment of uncertainty, or effort to model the effects of taxation on corporate financial policy. Considerable attention is however devoted to modelling the effects of the non-indexation of the tax system.

The modelling of each sector is treated in subsequent sections. Here the general structure of the model is described. It is assumed that physical output is homogenous and is produced according to an aggregate production function $F(K,L) + F_T T$ where T is the economy's land endowment, and F_T are the rents generated on land. The assumption that land enters the production function in an additively separable way is maintained only for convenience and does not affect the qualitative results. Output takes two forms: the basic good X which is consumed and used as physical capital and H, housing capital which produces housing services. The composition of output depends on the relative price P_H of housing in terms of X. The production function may thus be written:

$$(3) \qquad G(X,IH) = F(K,L) + F_T T = Y$$

where IH represents the production of housing capital. Producers maximize profits by setting:

$$(4) \qquad \frac{G_{IH}}{G_X} = P_H$$

This generates an upward sloping supply schedule of housing capital.

There are three physical assets in the model: capital K, houses H, and land T. The last is inelastically supplied. The supply of the housing depends on its relative price as shown in (4). Investment in plant and equipment K is assumed to incur adjustment costs, so that it depends on Tobin's q ratio of the market value of capital to its replacement cost. This ratio is adjusted for the effects of taxes on the cost of acquiring new capital goods. This is described in more detail in the next section.

The simplest possible model of portfolio equilibrium is assumed. The three forms of physical capital are treated as perfect substitutes up to risk premiums which cause their after tax returns to differ by fixed amounts. However, the value of the rental services provided by the housing stock is assumed to be a decreasing function of the quantity of housing capital. Bonds are also treated as perfect substitutes for capital. Money does not explicitly enter the model. Implicitly, it is assumed to be demanded inelastically. Exogenous changes in the rate of inflation should be thought of as coming from movements in the rate of money growth.

II. The Corporate Sector

In the model all physical output is assumed to be produced in the corporate sector. As already noted, it is assumed that investment in the corporate sector involves internal adjustment costs. The determinants of corporate investment and the market valuation of the corporate sector are modelled using the approach developed in Summers (1981).

The model is based on q theory of investment linking the level of investment to the q ratio of the market value of the corporate capital stock to its replacement cost. The essential insight underlying Tobin's theory is that in a taxless world firms invest as long as each dollar spent purchasing capital raises the market value of the firm by more than one dollar. Tobin assumes that to a good approximation, the market value of an additional unit of capital equals the average market value of the existing capital stock--that is, average q, measured as the ratio of the market value of the capital stock to its replacement cost, is a good proxy for the value of the marginal q as an additional dollar of investment. It is natural then to assume that the rate of investment is an increasing function of q.

I draw on earlier work by others, especially Hayashi (1982) to show that under certain circumstances there is an exact correspondence between average q as measured in the conventional way, and the shadow price of capital, or "marginal q" associated with dynamic optimization of a firm's value in the presence of adjustment costs. This correspondence can be used as a basis for econometric estimation of the adjustment cost function.

I begin by examining how individuals value corporate stock and then turn to the decision problem facing a firm. Throughout it is assumed that firms neither issue new equity nor repurchase existing shares.[2] Hence share prices are proportional to the outstanding value of a firm's equity. The required return, ρ, is the sum of capital gains and dividends net of tax. It follows that

$$(3) \qquad (\rho + \pi)V_t = (1 - c)\dot{V}_t + (1 - \theta)Div_t = i(1-\theta) + \delta_K$$

where c is the capital gains tax rate on an accrual basis and θ is the personal tax rate on interest and dividend income, π is the rate of inflation and δ_K is the equity risk premium. All investors are assumed to have the same tax rates.[4]

The second equality is an arbitrage condition linking the return on stocks and bonds. Imposing a transversality condition ruling out external speculative bubbles and integrating this

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2) The formulation employed here is based on the "q<1" model of the effects of dividend taxation developed by Auerbach (1979). It is adopted for the sake of comparability with my earlier work. Poterba and Summers (1984) provide some evidence in favor of the alternative "q=1" model of the effects of dividend taxation.

3) Feldstein (1980) considers a model in which tax rates vary among shareholders.

differential equation yields an expression for V_t.

$$V_t = \int_t^{\infty} \frac{(1-\theta)}{(1-c)} Div_s \left(\exp \int_t^{s} \frac{-(\rho + \pi)}{(1-c)} du \right) ds. \tag{4}$$

Each firm is assumed to produce with constant returns to scale and to be perfectly competitive in all markets, taking as given the price of its output, the wage, and the rate of return required by investors. These competitive assumptions, together with the requirement that capital is homogeneous, are essential to the derivation of the linkage between market valuation and investment incentives that is discussed below.

The typical firm seeks to choose an investment and financial policy to maximize equation (4) subject to the constraints given by its initial capital stock, by a requirement that the sources of funds equal the uses, and the requirement that the firm maintain debt equal to a fixed fraction, b, of the capital stock.[4]

A crucial feature of the model is that there is a cost to changing the capital stock. Without this cost, the size of the firm would be indeterminate because of the constant returns to scale and the assumption of perfect competition. The cost of installing additional capital rises with the rate of capital accumulation, thereby preventing jumps in the demand for capital. The cost function is taken to be convex and linearly homogeneous in investment and capital. Under these conditions, dividends can

4) Note that if the postulated debt ratio corresponds to an optimum, the envelope theorem insures that ignoring the endogeneity of financial policy will not introduce error in estimation of the effects of small changes in tax policy.

be derived as after-tax profits minus investment expenses.[5] Thus,

$$\text{(5)} \qquad Div = [pF(K,L) - wL - pbiK](1-\tau) - (1 - ITC - b + (1-\tau)\phi)pI + \tau D + pbK(\pi - \delta^R),$$

where

K and L = factor inputs

p = overall price level

F(K,L) = production function

w = wage rate

i = the nominal interest rate

τ = corporate tax rate.

ITC = investment tax credit

ϕ = adjustment-cost function, assumed to be convex

I = investment

δ^R = rate of economic depreciation of the capital stock

D_K = value of currently allowable depreciation allowances.

5) The assumption here is that all marginal equity finance comes from retained earnings. This follows from the assumption of a constant number of shares made earlier. It accounts for some of the apparently paradoxical results described below. The last term reflects the net receipts from issuance of new debt (withdrawals) necessary to maintain the ratio of debt to capital as the capital stock depreciates and the price level rises.

The calculation of D_t assumes that the rate of depreciation used for tax purposes reflects accelerated depreciation and that tax depreciation is based on historical cost. Adjustment costs are considered expensed and ineligible for the investment tax credit. If these costs are taken to represent managerial effort, or interference with concurrent production, the assumption made here is appropriate. Treating adjustment expenses as investment under the tax law would not importantly alter the results.

Combining equations (4) and (5) and separating the terms reflecting the value of depreciation allowances on existing capital, B, and future acquisitions, Z, yields an expression for the market value of a firm's equity at time t:

$$(6) \qquad V_t = \int_t^{\infty}\Big((pF(K,L) - wL - pbKi)(1-\tau) - (1 - 1TC - Z - b + (1-\tau)\phi)pI + pbK(\pi - \delta^R)\Big)\frac{(1-\theta)}{(1-c)}\mu_s\, ds + B_t$$

All the tax parameters can be arbitrary functions of time. For the purpose of exposition the following symbols are introduced:

$$(7a) \qquad \mu_s = \exp\int - \frac{(\rho + \pi)}{(1-c)}\, du$$

$$(7b) \qquad B_t = \int_t^{\infty} \tau_s \delta^T \mu_s \frac{(1-\theta)}{(1-c)} \text{KDEP}_t [\exp(-\delta^T)(s-t)]\, ds$$

$$(7c) \qquad Z_s = \int_t^{\infty} \tau\, \delta^T \frac{\mu_u}{\mu_s} [\exp(-\delta^T)(u-s)]\, du$$

The B_t variable represents the present value of depreciation allowances on existing capital,[7] and Z_s is the present value, evaluated at time s of the depreciation allowances on a dollar of new investment.

In maximizing equation (6), the firm can ignore B_t because it is independent of any current or future decisions. The constraint that capital accumulation equals net investment faced by the firm in maximizing (6) is

$$\text{(8)} \qquad \dot{K}_s = I_s - \delta^R K_s$$

This dynamic optimization problem can be solved using the Pontryagin maximum principle. A shadow price, $\lambda(t)$, is introduced for the constraint given by (8). It can be interpreted as marginal q, the change in a firm's value resulting from a unit increment to the capital stock. The first-order conditions for optimality are[8]

$$\text{(9a)} \qquad F_L = \frac{w}{p}$$

$$\text{(9b)} \qquad 1 - ITC - Z - b + \phi(1-\tau) + \frac{I}{K}\phi'(1-\tau) = \frac{\lambda(1-c)}{p(1-\theta)}$$

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7) The $KDEP_t$ refers to the depreciable capital stock at time t. It differs from K_t because of historical cost and accelerated depreciation.

8) Similar first-order conditions with different assumptions about tax effects can be found in Abel (1980) and Hayashi (1982).

(9c)
$$\dot{\lambda} = \lambda\left(\frac{(\rho+\pi)}{(1-c)} + \delta^R\right) \left((pF_K - bi)(1-\tau) - p\left(\frac{I}{K}\right)^2 (1-\tau)\phi + b(\pi - \delta^R)\right) \frac{(1-\theta)}{(1-c)}$$

The first-order condition, equation (9a), implies that labor is hired until its marginal product and wage are equal. Equation (9b) characterizes the investment function; it implictly defines a function linking investment to the real shadow price of capital, λ/p, the tax parameters, and the costs of adjustment. This equation has an intuitive explanation. The right-hand side is the shadow price of additional capital goods, which is equal to their marginal cost in after-tax corporate dollars on the left-hand side.

The third first-order condition, (9c) describes the volution of the shadow price, λ. It guarantees that the shadow price equals the present value of the future marginal produjcts of a unit of capital. In this model, capital investment is productive in terms of output and, because of the form of the adjustment-cost function, in reducing the cost of subsequent investment.

Equation (7b) is of no operational significance as a theory of investment unless an observable counterpart to the shadow price, λ/p, can be obtained. Hayashi has shown in a similar model with a less elaborate tax system how the shadow price is linked to the market valuation of existing capital.

This link can be demonstrated as follows. Note that $V_t - B_t$ given by equation (6) is homogeneous in K_t--that is, a doubling of K_t together with the optimal doubling of investment and labor in every subsequent period will double $V_t - B_t$. This is a consequence of the constant-returns-to-scale production function and the homogeneity of the adjustment-cost function. It follows directly that

$$(10) \qquad V_i^* - B_t = \gamma_t K_t$$

where V_t^* is the stock market's value at time t when the optimal path is followed. In other words, the maximized value of the firm at time t minus the value of depreciation allowances on existing capital is proportional to the value of its initial capital stock. The maximum principle implies that

$$(11) \qquad \frac{dV_t^*}{dK_1} = \lambda_t$$

This is what is meant by the assertion that λ is the shadow price of new investment, or marginal q. Combining equations (10) and (11) demonstrates that

$$(12) \qquad \lambda_t = \frac{V_\tau^* - B_t}{p_t K_t}$$

This expression provides an observable counterpart for the shadow price of new investment if it is assumed that the firm maximizes value so that $V_t = V_t^*$. It implies that the investment function can be written

$$(13) \qquad \frac{I}{K} = h\left(\frac{\frac{(V-B)(1-c)}{pK(1-\theta)} - 1 + b + ITC + Z}{1-\tau}\right) = h(Q).$$

where Q is the tax-adjusted q and $h(\cdot) = (\phi + (I/K)\phi')^{-1}$.

The various adjustments in Q for the effects of taxes may be understood quite easily. The terms $b + ITC + Z$ reflects the reduction in the effective purchase price of new capital goods caused by debt finance, the investment tax credit and the presence of depreciation allowances. Since depreciation allowances of new capital purchases are reflected in Z, it is necessary to subtract out the present value B, of remaining depreciation allowances of existing capital goods. The term $(1-c)/(1-\theta)$ results from the assumption that marginal equity investments are financed out of retentions rather than new share issues. Firms should retain earnings until the point where the marginal dollar of retentions raises market value by only $(\frac{1-\theta}{1-c})$ dollar since dividends are taxed more heavily than capital gains. Finally, the term $(1-\tau)$ in the denominator of (11) arises from the assumption that adjustment costs are expensed, so that adjustment is less expensive as the corporate tax rises. These adjustments are discussed more extensively in Summers (1981a).

It is not difficult to verify that if the adjustment cost function takes the form

$$\text{(14)} \qquad \frac{I}{K} = \frac{\frac{\beta}{2}\left(\frac{I}{K} - \gamma\right)^2}{\frac{I}{K}}$$

The relationship between investment and tax adjusted Q will take the particularly simple form

(15) $$\frac{I}{K} = h^{-1}(Q) = \alpha + \frac{1}{\beta} Q$$

The empirical estimates of Q investment equations in my earlier paper are used as a basis for estimating the parameters of the adjustment cost function. The estimated Q investment relation for the 1931-78 period using instrumental variables was:[8]

(16) $$\frac{I}{K} = \underset{(.012)}{.076} + \underset{(.013)}{.051} \cdot Q$$

This implies that the adjustment cost function is given by:

(17) $$A = 19.61\left(\frac{I}{K} - .076\right)^2 K \quad \text{for } \frac{I}{K} \geq .076$$

$$A = 0 \qquad \frac{I}{K} \geq .088$$

In all the analysis here firms will be operating in the range where adjustment costs are positive.

The remaining assumptions about the corporate sector are drawn from Summers (1981). It is assumed that production of gross output is given by a Cobb-Douglas production function. The assumption is quite common in literature on investment and is consistent with the constancy of factor shares despite the changing ratio of capital to output. The share of capital in the production function is taken to be 0.25. This is quite close to the observed value in the nonfinancial corporate sector. Effective labor supply, which is taken to be exogenously determined, is assumed to grow at 3 percent a year. Because of the focus on

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8) I use the instrumental variables estimate rather than the OLS estimate as in the simulations in my earlier paper. The equation reported here is equation 4-8 on page 92 of Summers (1981a). It implies a somewhat lower and more plausible value for adjustment costs than do the estimates in my earlier paper.

long-run issues, full employment is assumed. It is assumed that b, the fraction of new investment financed with debt, is .25. I assumed that the risk premium on equity is 8 percent. This is the difference between the after tax required return on equity and debt. It is consistent with the average real pre-tax return of 8.7 percent for stocks and 0.0 percent for treasury bills reported by Ibbotsen and Singuefield (1984).

The tax parameters are chosen to mirror closely the current U.S. tax system. The initial values are $\tau = 0.46$, $\theta = 0.35$, $c = 0.05$, ITC = 0.056 and $\delta^{\tau} = 0.17$,[10] where δ^{τ} is the rate of depreciation for tax purposes on the capital stock. One additional complication is introduced in the simulations: firms are assumed to pay corporate income taxes on FIFO inventory profits. The magnitude of this tax as a fraction of output is estimated as the product of the corporate tax rate and the ratio of the inventory valuation adjustment of the nonfinancial corporate sector to its gross output. From this procedure one can conclude that each point of inflation raises corporate taxes by 0.17 percent of output.

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[10] **The basis for these estimates is discussed in Appendix B to Summers (1981a).**

III. Land, Housing and Consumption

This section describes the general equilibrium structure of the model, considering the other asset markets, and then the remaining components of aggregate demand, consumption and government spending. The benchmark steady state used in the simulations of tax return effects is then presented. The risk adjusted returns on all assets are assumed to be equal. Nominal bonds in the model are a purely inside asset. Their real after tax return is given by $i(1-\theta)-\pi$. All the risk premiums here refer to after tax spreads between the return on other assets and on nominal bonds. The tax rate on interest income is taken to be equal to the dividend tax rate of .35. This assumption is defended in Feldstein and Summers (1979) and Summers (1981a)

Land

In order that the model can have a steady state it is assumed that effective land grows at the same rate as the labor force. The asset land is assumed to represent all inelastically supplied assets such as exhaustible resources, antiques and gold as well as actual land. Land is assumed to yield per-capita rents equal to FT each year. In the benchmark steady state of the model these rents represent three percent of GNP. The risk premium on land is somewhat arbitrarily taken to equal .06. For simplicity it is assumed that the rental income and capital gains from land are untaxed. This gives rise to the portfolio equilibrium equation for land.

$$(20) \qquad \rho = \frac{FT}{P_T} + \frac{\dot{P}_T}{P_T} = i(1-\theta) - \pi + \delta_T$$

This equation characterizes the evolution of the price of land. It demonstrates that in general tax measures which affect the required after tax rate of return will affect prices of land. Note that it implies that if $\frac{di}{d\pi} = 1$ the steady state value of land prices will rise with inflation. This is the essential point of Feldstein's (1981c,d) analysis. This conclusion depends critically on the assumption made about the response of interest rates to inflation. The same tax effects which affect the pricing of land should also affect the pricing of bonds. If interest rates rise so that $\frac{di}{d\pi} = \frac{1}{1-\theta}$ there will be no effect of inflation on the price of land.

Housing

I begin by considering housing as a portfolio asset and then consider the production of housing capital. In the model all housing is owner occupied. The return in owning houses comes in the form untaxed implicit rents and capital gains. Capital gains taxes on owner occupied housing are neglected because the rollover provisions, the exemption for aged sellers, and the absence of constructive realization at death render them negligible.

The implicit rental on a unit of housing capital is assumed to be a decreasing function of the total supply of housing capital.

In particular it takes the form:

$$(21) \qquad R(H) = KH^{\frac{1}{\eta}} \cdot H_o$$

where η is the price elasticity of the demand for housing services. In order to induce investors to hold the existing stock of housing, it is necessary that the portfolio equilibrium condition:

$$(22) \qquad \frac{R(H)}{P_H} + \frac{\dot{P}_H}{P_H} = P(1-\theta) - \pi + \delta_H$$

be satisfied, where δ_H reflects depreciation, property taxes, and any risk premium associated with home ownership. This equation holds that the rental return on housing plus the real capital gain must equal the cost of housing capital. Following the microeconometric evidence of Rosen (1979), the value of η is taken to equal -1. The value of δ_H is set at .06 in the simulations reported below. Individuals' consumption of housing services is treated as P(H)H is calculating total consumption.

Note that in this model the deductibility of nominal interest payments is not the source of the tax advantage enjoyed by owner occupied housing. Individuals can borrow to finance purchases of any asset so interest deductibility does not uniquely benefit housing. Rather the source of the tax advantage to housing in this model is the fact that imputed rents escape taxation. This distinction is stressed in Summers (1981).

The supply of housing is determined by profit maximization as in Equation (4). Increases in its relative price P_H increase supply. Poterba (1984) estimates that price elasticity of the production of new owner occupied housing is 2.0. This estimate is used here as a basis for calibrating the function G in Equation (3). I assume this function takes the form.

$$(23) \qquad G(X,IH) = X + h_o IH^{h_1}$$

where both forms of output are measured per unit of labor inputs. This implies that the supply for new housing is given by:

$$(24) \qquad IH = h_1 P_H \frac{1}{(h_1 - 1)}$$

The value of h_1 is set equal to 1.5 so that the supply elasticity of housing equals 2.0. The remaining constant h_o is set so that in the benchmark steady state, housing accounts for 40 percent of the capital stock. This comports approximately with information in the Federal Reserve Board's National Balance Sheets. Finally it is assumed that housing depreciates at 4 percent a year. This estimate reflects the inclusion of maintenance costs.

Consumption

The remaining part of the model which must be described is the determination of aggregate consumption. In Summers (1981c) and (1982), I emphasize the importance of "human wealth effects".

Increases in the rate of return may tend to increase saving because they reduce the present value of future labor earnings. These effects play an important role in the consumption function postulated here. It is assumed that consumption C is proportional to full wealth, which equals the sum of the present value of future labor incomes and the market value of existing corporate capital, housing and land. That is:

$$(25) \qquad C = C_o \cdot (HW + BK + P_H H + P_T T)$$

where HW represents human wealth and all variables are expressed in per-capita terms. This expression can be derived rigorously if an infinite horizon logarithmic utility function is assumed. In general the marginal propensity to consume out of wealth will depend on the rate of return as discussed in Summers (1982) Limited sensitivity analysis suggested that allowing for these effects would not significantly alter the simulation results.

Human wealth HW represents the present value of future labor income after taxes. A 20.5 percent tax rate on labor income is assumed. The discount rate is taken to include a risk premium δ_{HW} reflecting uncertainty about future labor income. Blanchard (1984) presents an elegant derivation of a consumption function of the type used here. It follows that HW evolves according to the pseudo-arbitrage equation:
It follows that HW evolves according to the pseudo-arbitrage equation:

$$(26) \qquad \frac{YL}{HW} + \frac{HW}{HW} = i(1-\theta) - \pi + \delta_{HW}$$

Human wealth like the other assets in the model will jump in response to changes in future tax policy.

The marginal prosperity to consume C_0 is chosen so that the average propensity to save out of disposable income in the model's benchmark steady state is .05. This corresponds closely with actual economic experience.

The model is closed with an income-expenditure identity. It takes the form:

$$(27) \qquad C + IK + IH + Gov + A = F(K,L) + F_T + R(H)\,H$$

The level of government spending, Gov, is set equal to 25 percent of GNP in the benchmark steady state. The term A reflects adjustment costs.

The characteristics of the model's benchmark steady state are displayed in Table 1. The model was calibrated so that its steady state characteristics would be similar to those of the American economy, if inflation continues. An 8 percent inflation rate is assumed. The shares of consumption, investment and government spending corresond almost exactly to the average actual shares in the economy over the 1970's. In the benchmark steady state, corporate capital accounts for two-fifths of total wealth, housing comprises two-fifths, and the remaining fifth is land. In the actual economy, at the end of 1979, the replacement value of the corporate capital stock was $1,852.8 billion, owner occupied housing totaled $1,690 billion and non-corporate land was $890 billion. The last figure does not include the value of exhaustible resources, Rembrandts and other inelastically supplied assets. The major omission here is the $932.9 billion of non-corporate non-residential capital.

Table 1

Characteristics of the Benchmark Steady State

Composition of National Income	Capital Assets
$\frac{C}{Y} = .60$	$\frac{K}{Y} = .867$
$\frac{IK}{Y} = .11$	$\frac{KH}{Y} = .867$
$\frac{IH}{Y} = .04$	$\frac{T}{Y} = .434$
$\frac{GOV}{Y} = .24$	$\frac{(K + KH + T)}{Y} = 2.17$
$\frac{A}{Y} = .01$	$\frac{HW}{Y} = 12.4$

Financial Markets

$i = .100$	$\frac{DIV}{V} = .062$
$i - \pi = .02$	$\frac{V}{K} + \beta = 1.02$
$i(1-\theta) - \pi = -.015$	

Note: This model is described in the text.

In equilibrium, the model is calibrated so that the dividend price ratio is .062. This earnings-price ratio is .098 In line with recent, but not very recent, experience, the real pre-tax interest rate is two percent. Given the 35 percent tax rate on interest income discussed above, this implies a real after tax return on bonds of -1.5 percent. The equilibrium value of Tobin's q measure is 1.02. This is a coincidence reflecting the offsetting effects of tax parameters and the need for the market to be above its "no invesment equilibrium" value by enough to induce replacement investment and normal growth of the capital stock.

The parameters have been chosen so that the government's budget is balanced assuming that no debt is outstanding. The tax reforms considered below will in general cause changes in government revenue. In the simulations it is assumed that the tax rate on labor income is varied to offset these revenue effects so that the government's budget constraint is always satisfied.

The model may be solved by recognizing that it contains three-state variables, the stock of corporate capital K, of housing H, and the value of depreciation allowances on remaining capital B_t. The model has five forward-looking prices or costate variables. These are V_t, the value of the stock market; $\frac{V}{P_H}$, the housing price, P_T, the relative price of land; H_W, human wealth; and Z_t, the present value of depreciation allowances. The income-expenditure identity, Equation (26) holds as a constraint across the five-asset prices.

In formal terms, systems of this type are two-point boundary value problems. In order to solve them uniquely, it is necessary to specify initial conditions for the state variable and terminal conditions for the asset price variables. The latter simply involve specifying transversality conditions ensuring the model's convergence. Solution of models of this type which need to integrate both forwards and backwards is numerically difficult. It can be accomplished using the method of Multiple Shooting as described in Lipton, Poterba, Sachs and Summers (1982). The program described there is used in the calculations reported in in this paper.

IV. Steady State Effects of Tax Reforms

This section uses the model described in the preceding sections to examine the long run steady state effects of various tax reforms. A discussion of transition paths and the effects of tax reforms on asset prices is provided in the next section.

Table 2 considers the long run effects of changes in the rate of inflation. The results show clearly that inflation has a large negative effect on corporate capital accumulation. An increase in the rate of inflation from 8 to 12 percent would, for example, reduce the steady state capital stock by 9.2 percent. The level of the stock market in the long run steady state is about 9 percent lower than in the presence of 8 percent inflation. The results of the calculation of the effects of zero percent inflation and four percent inflation suggest comparable effects of inflation on corporate capital accumulation. Since the model is structured so that inflation is neutral apart from tax effects, the zero inflation steady state also indicates the effect of indexing the tax system.

A striking feature of the results is the insensitivity of the required rate of return on bonds, $i(i-\theta)-\pi$ with respect to the rate of inflation. This implies that to a very good approximation $\frac{di}{d\pi} \cong 1.5$. The demand for output in this model is very elastic with respect to the real interst rate so that shocks to the inflation rate are accommodated with only negligible variations in real interest rates. This finding suggests that contrary to the implications of the discussion of Feldstein and Summers (1978), the key determinant of the sensitivity of

Table 2

Steady State Tax Effects of Inflation

	π = 0	π = .04	π = .12
$i(1-\theta) - \pi$	-.015	-.015	-.015
% ΔK	25.0	11.3	-9.2
% ΔK	27.6	11.6	-9.0
% ΔKH	-2.2	-.8	.6
% ΔP_H	-1.0	-.4	.3
% ΔP_T	-2.0	.1	.6
% ΔY	5.6	2.6	-2.2
% ΔC	3.9	1.9	-2.0

Note: Calculations are described in the text.

of interest rates to inflation is the marginal tax rate on individual interest income, rather than the marginal tax rate on corporations. In terms of the analysis presented there, the long run supply of funds to the corporate sector appears to be very elastic relative to the MPIR schedule so that its movement with inflation determines the equilibrium relation between interest rates and inflation.

An important implication of this analysis is that analyses of the effects of inflation and taxes which assume $\frac{di}{d\pi} = 1$ are likely to be misleading. The standard argument that corporations benefit from the deductibility of nominal rather than real interest payments depends on the ad-hoc assumption that nominal interest rates only adjust to inflation to a limited extent. The conclusion here should not be surprising. The gain corporations realize from the deductibility of nominal interest payments is largely offset by the loss their debtholders incur. Inflation subsidizes corporate investment only to the extent that $\tau > \theta$.

Increases in inflation reduce slightly the equilibrium real after tax interest rate because of the reduced demand for investment. This raises the equilibrium price of land and housing, and raises by a small amount the steady state level of housing consumption. In the model, these effects are very small. Indexation of the tax system reduces land prices by only about 2.0 percent. The absence of a strong positive relation between inflation and the prices of land and housing is a consequence of the fact that $\frac{di}{d\pi} > 1$ which in turn results from the high elasticity of savings.

with respect to the real rate of return in the model. This high elasticity causes the ratio of wealth-to-labor income to decline with increases in the rate of inflation, if real after tax interest rates decline at all. If a savings function were postulated that did not have this property, it would be necessary for the change in the market value of stocks of housing and land to equal the change in the stock market. In this greater changes in the rate of return on housing and land prices would be observed. A savings function with a lower interest elasticity could be introduced into the model by assuming that some consumers were liquidity constrained, or by assuming a lower elasticity of substitution between present and future consumption.

The steady state effects of various statutory tax reforms are considered in Table 3. The first column considers an acceleration of tax depreciation roughly comparable to the American ACRS program as enacted in 1981. The rate of tax depreciation is assumed to rise from 17 percent a year to 33 percent a year. This probably understates the actual acceleration of depreciation because most investment may be treated as equipment for tax purposes, and because double declining balance depreciation is permitted.

Table 3

Long Run Effects of Alternative Tax Reforms

	Benchmark	Accel. Deprec.*	Elim. Corp. Income Tax	Elim. Cap. Gains Tax	Elim. Divid. Tax	Elim. Int. Inc. Tax
i	.100	.101	.105	.100	.102	.065
$i - \pi$	.02	.021	.025	.02	.02	-.015
$i(1-\theta) - \pi$	-.015	-.014	-.012	-.015	-.013	-.015
% ΔK	--	12.4	16.8	10.7	-1.5	4.5
% ΔV	--	5.5	86.5	3.2	51.7	4.6
% ΔKH	--	-.9	-4.7	-.5	-1.6	-.4
% ΔP_H	--	-.4	-.24	-.3	.8	-.2
% ΔP_T	--	4.	-7.4	-.7	-2.2	-.5
% ΔY	--	3.1	3.2	2.0	-.3	1.1
% ΔC	--	2.2	2.2	1.6	0	.8

*The assumed acceleration of depreciation is a doubling of effective tax lives by raising the exponential rate of tax depreciation from .17 to .33.

**Results refer to an increase of one percentage point in the tax rate expressed as a fraction of the market value of homes.

As one would expect the results suggest that accelerating depreciation allowances would significantly increase long run capital intensity. The predicted increase of 12.4 percent is sufficient to raise steady state GNP by 3.1 percent and real wages by 2.5 percent. The fact that the real after tax rate of return rises by only 10 basis points in equilibrium means that a substantial fraction of the long run benefit from accelerated depreciation falls on workers rather than the owners of capital. Because the increased demand for business investment bids up interest rates, there is again some crowding out of housing investment and land. This effect is small. The total reduction in the value of land and the housing stocks is only about one-eighth of the increase in the capital stock.

The second column considers the effects of eliminating the corporate income tax. This is predicted to have only a slightly greater impact on long run capital intensity than the acceleration of depreciation. However its other effects are quite different. Where accelerating depreciation reduces the effective purchase price of new capital goods, elimination of corporate income taxes raises the effective purchase price because of the expensing of adjustment costs and the presence of accelerated depreciation. For this reason, the ratio of the value of the stock market to the stock or corporate capital rises a great deal when the corporate income tax is removed. This increase also reflects the fact that the elimination of the corporate tax applies to the return on old as well as new capital.

The substantial increase in wealth caused by the change in the value of the market relative to the corporate capital stock raises consumption, thus bidding up interest rates. While elimination of the corporate income tax spurs only slightly more corporate investment than acceleration of depreciation, it crowds out almost six times as much housing investment. It also reduces land prices by 7.4 percent. The effects on market value shown here reveal that the long run incidence of eliminating the corporate income tax is very different than that of accelerating depreciation allowances.

The third column of the table examines the effects of eliminating capital gains taxation. Recall that in the model only corporate capital is subject to capital gains taxation. This reform has a significant effect on capital formation despite its relatively small impact on the stock market. The reason for this involves the assumption that all equity investment is financed from retentions rather than new equity issues. Reductions in the capital gains tax raise the effective price of new capital goods, because they increase the tax penalty to paying dividends. Because this type of return has only small wealth effects, it has only a negligible impact on the prices of housing and land.

The dividend tax reduction considered in the fourth section has what may seem to be a paradoxical effect. It actually reduces the long run capital stock by about 1.5 percent. This result arises because of the assumption that equity investment is financed out of retained earnings. Reductions in dividend taxes raise the cost of capital by an amount just sufficient to offset the increased return to shareholders. Thus they are neutral with respect to new investment. The reduction in dividend taxes does however have a wealth effect, as it raises the equilibrium value of stock market. This increases consumption raising demand and the interst rate, in turn reducing capital intensity. The increased interest rate slightly reduces the price of land and houses.

There is obviously an important moral for policy here. Insofar as marginal investment is financed out of retentions, reductions in tax rates on high bracket individuals are likely to confer windfalls without spurring significant amounts of new investment. This conclusion is supported by the simulation in the fifth column of the effects of eliminating the interest income tax. This encourages corporate investments slightly and discourages investment in housing and land. The result occurs because corporations deduct interest payments at the 46 percent rate while households deduct them at a lesser rate. If interest rates adjusted to the change in θ by only enough to keep the real after tax individual return on bonds constant, corporations would gain because of their reduced borrowing costs, and no one else would lose--so the income expenditure identity would not be satisfied. Hence the real return rises slightly but not enough to offset all the stimulus to corporate investment.

Steady state calculations of the type reported here are only approximate guides in analyzing tax policy. The next section considers the transition path of the economy following several alternative tax reforms. Particular attention is devoted to the windfall effects arising from asset revaluations following tax changes.

V. The Transition Path Following Tax Reforms

In Table 4, the transition path of the economy following full indexation of tax system is considered. The windfall effect conferred on existing shareholders from idexation is about 10 percent. Capital losses of about 5 percent would be suffered by the owners of land and capital. A notable feature of the results is the large capital gain which long term bondowners would realize. While no long term bonds are explicitly included in the model, a yield can be calculated by applying a term structure relation to the sequence of short term interest rates. The yield on a 20 year bond would fall by about 3.5 points if the tax system were indexed, implying a capital gain of over 30 percent. Of course a similar loss is realized by the bond issuer.

These windfall gains and losses occur because the adjustment path of the economy following this type of tax change is quite slow. The impact effect of indexing the tax system is estimated to be an 11.1 percent increase in the rate of investment in plant and equipment an an 8.34 percent decline in the rate of housing investment. Only half of the adjustment in the corporate capital stock is completed within 2 years. The adjustment in the housing stock is somewhat more rapid.

An interesting feature of the results is the behavior of interest rates. Following the indexation of the tax system, the real after tax short term interest rate rises. This occurs because the demand for goods and services arise immediately as consumers and investors take account of reductions in future tax

Table 4

Effects of Full Indexation of the Tax System

Year	%ΔV	%ΔP_H	%ΔP_T	%ΔK	%IK	%ΔKH	%ΔIH	Δi
1	10.3	-4.85	-5.53	0	11.1	0	-8.34	-3.4
2	12.1	-4.53	-5.12	1.56	12.0	-.334	-8.34	-3.4
3	13.8	-4.21	-4.89	2.89	12.8	-.667	-8.34	-3.5
4	15.3	-3.90	-4.67	7.22	13.7	-1.00	-8.34	-3.5
5	16.5	-3.79	-4.45	5.56	14.5	-1.34	-8.34	-3.6
10	20.7	-2.63	-3.56	10.9	17.9	-2.23	-5.56	-3.7
15	23.1	-1.90	-2.89	14.9	19.7	-2.67	-2.78	-3.8
20	24.2	-1.48	-2.45	17.9	21.4	-2.78	-2.78	-3.9
50	27.6	-.95	-2.00	25.6	25.6	-2.28	-2.78	-4.1

Note: All items except Δi refer to percentage changes from the benchmark steady state described in Table 1. Due to round-off errors the calculations are not precise.

liabilities. In the short run, output is fixed and so real interest rates are bid up. In the longer run, capital is accumulated and the rate of interest declines until the real after tax rate of return returns to its original level. This path of interest rates implies that there is significant short run crowding out following indexation, but much less in the long run.

In Tables 5 and 6, the incidence of eliminating the comparable tax system and using accelerated depreciation are examined. Both have quite similar long run effects on capital intensity in the corporate sector. However, their incidence effects are very different. The elimination of the corporate income tax causes corporate shareholders to receive a windfall excess return of 76.2 percent when the tax reform is announced. Significant capital losses are suffered by the owners of houses and land. On the other hand, the windfall from accelerating depreciation is a less than 1 percent increase in the value of the stock market and much smaller reductions in the value of housing and land.

The differences point up the importance of taking an asset price approach to the analysis of tax incidence. Traditional approaches would convert an acceleration of depreciation allowances into a reduction in the effective tax rate, and then focus on differences in the steady state rate of return to capital. They would reveal only very small differences between the effects of the two types of tax reform considered here, and

Table 5

Effects of Elimination of the Corporate Income Tax

Year	%ΔV	%ΔP_H	%ΔP_T	%ΔK	%ΔIK	%ΔKH	%ΔIH	% INT
1	76.2	-7.0	-8.67	0	7.69	0	-13.9	1.10
2	76.8	-6.65	-8.23	1.00	7.69	-.556	-13.9	1.10
3	77.4	-6.02	-8.00	1.89	8.55	-.100	-11.2	1.10
4	77.9	-5.59	-7.78	2.78	9.40	-1.45	-11.2	1.00
5	78.5	-5.56	-7.56	3.56	9.40	-1.89	-11.2	1.00
10	80.7	-4.44	-6.89	7.00	11.1	-3.34	-8.34	.090
15	82.4	-3.59	-6.45	9.56	12.8	-4.12	-8.34	.080
20	83.5	-3.27	-6.23	11.4	13.7	-4.56	-5.56	.070
50	86.1	-2.43	-6.00	16.1	16.2	-4.78	-5.56	.050

Note: All items except Δi refer to percentage changes from the benchmark steady state described in Table 1. Due to round-off errors the calculations are not precise.

Table 6

Effects of Acceleration of Depreciation Allowances

Year	%ΔV	%ΔP_H	%ΔP_T	%ΔK	%ΔIK	%ΔKH	%ΔIH	Δi
1	.716	-2.42	-2.00	0	5.98	0	-5.56	+.5
2	1.15	-2.21	-1.56	.778	5.98	-.223	-5.56	+.4
3	1.43	-2.11	-1.56	1.55	6.84	-.334	-2.78	+.4
4	1.72	-1.90	-1.33	2.27	6.84	-.556	-2.78	+.4
5	2.01	-1.80	-1.33	2.78	7.69	-.667	-2.78	+.4
10	3.15	-1.16	-.667	5.44	8.55	-1.00	-2.78	+.3
15	3.87	-.843	-.445	7.44	9.40	-1.22	-2.78	+.7
20	4.44	-.632	-.223	9.00	11.1	-1.22	0	+.7
50	5.56	-.316	-.445	12.44	12.8	-.889	0	+.1

Note: All items except Δi refer to percentage changes from the benchmark steady state described in Table 1. Due to round-off errors the calculations are not precise.

miss entirely the windfall effect of reducing the corporate income tax. The source of the difference between the two policies is their differential effect on the value of used capital as explained in the preceding section. Note that the analysis here suggests that there is nothing paradoxical about the failure of the stock market to respond strongly to the recently enacted tax package. It may also help to explain the tendency for business to support statutory rate reduction as a preferred form of tax relief.

These results show that corporate tax changes have important effects on interest rates. The pattern of response is similar in both simulations. Following expansionary policy, the interest rate rises and then returns toward its equilibrium level as capital is accumulated. In the case of corporate tax elimination, the effect is very substantial as long turn bond holders would suffer losses of over 10 percent.

The implications of the results for tax incidence are very different in the long and short run. The short run incidence is reflected in the windfall gains and losses discussed in the preceding section. The long run effect of tax reforms appears to be primarily on the real wage.

A surprising feature of all the simulations is the relative unimportance of induced changes in land and housing prices, arising from inflation or changes in tax policy. The cause is the insensitivity of interest rate to tax changes. This in turn is a consequence of the form of the consumption function which makes savings highly interest elastic. If savings were more inelastic, taxes would have a greater impact on interest rates and larger spillover effects on other asset prices. Another way of generating larger effects on other asset prices would be to postulate lower risk premiums. This would cause changes in interest to have larger effects on asset prices. Absent data on the "dividend yield" of houses and land, it is difficult to see how to check the validity of the assumptions made here.

VI. Conclusions

The simulations of the model may shed some light on recent economic experience. The model predicts the observed negative relationship between changes in stock market values and the rate of inflation, as well as the positive relationship between inflation and housing and land prices. These predictions based on tax effects, first made in the late 1970's, have stood up very well during the disinflation of early 1980's. Real stock prices have risen dramatically whereas real housing prices have actually declined. The composition of capital investment between residential and non-residential investment has also fluctuated as predicted by the model presented here.

In no sense can this model be interpreted as a descriptive theory of stock market prices, other asset prices or investment. It is clear that forces other than changes in the tax law account for most of the variations in these variables. Tax factors may help to explain their movements, but they are only a small part of the story. In analogy to a regression equation, their coefficients are large and significant but the R^2 is very low. The model does reveal one very striking anomaly--the behavior of interest rates in the face of rising inflation. The model yields the conclusion that inflation should raise interest rates by far more than point for point. The calculations indicate that each extra percentage point of inflation should raise nominal interest rates by close to 150 basis points. This is a prediction about the effects of long run changes in the underlying inflation rate, caused by changes in the rate of money growth, not high frequency movements in inflation. In Summers (1983), I show that this prediction is not borne out.

This anomaly raises important doubts about analysis of the effects of inflation and its interactions with the tax system. In what sense can this model be interpreted as demonstrating that the interaction of inflation and taxes partially explains the downturn in the stock market and the level of investment during the 1970's. The negative relationship between inflation and these variables in the model is predicated on an assumed increase in interest rates. If behavior more like the actual reality is inserted into the model, and interest rates are assumed to rise point for point with inflation, the implication would be an increase in the stock market and investment. This is the essential point of the analyses of Gordon (1980) and Hendershott (1980).

There is clearly more than one way to look at the question. I believe that a general equilibrium model of the type used here is the "right" way to examine inflation-taxation interactions. It provides a way of examining the "pure" effects of changes in the rate of inflation unaccompanied by other real shocks. The failure of interest rates to rise more fully with inflation presumably reflects either some form of inflation illusion or a historical correlation between rates of inflation and real shocks. In neither case would it be appropriate to ignore the forces affecting interest rates in considering the behavior of asset prices or investment. The usual procedure of estimating or postulating an inflation-interest rate relationship and then using it as a basis for analyzing tax effects involves an odd hybrid of theory and evidence. If the goal is to examine tax effects only, a general equilibrium model of the type used here is appropriate. If the objective is describing the actual behavior of the economy, it is necessary to model the full effects of whatever accounts for the absence of a stronger relationship between inflation and nominal interest rates.

The results here have implications for the analysis of statutory tax reform. Perhaps most importantly, they illustrate the importance of recognizing adjustment costs. The half-life of the adjustment of the capital stock following shocks is over a decade in the simulations reported here. Because of these substantial lags in the adjustment of the capital stock, tax reforms have important wealth effects. They confer large windfalls on the owners of different types of capital assets. For example, the simulations suggest that eliminating the corporate income tax would confer a windfall excess return of over 70 percent on the owners of corporate stock. Measures which benefit only new capital such as the investment tax credit are likely to involve much smaller windfalls.

The finding that adjustment costs are large enough to lead to such sluggish behavior of investment may at first seem very surprising. Without such sluggishness, it is impossible to explain the observed volatility in asset prices. Regardless of the sources of the extremely volatile valuation of existing capital, there would only be small effects on stock market prices as long as new capital was very elasticially supplied. The puzzle of market volatility that has followed in the wake of Shiller (1981) has an extra piece--explaining why q is not maintained at a more constant level by the elastici supply of new capital goods. An important priority for future research must be determining the nature of the adjustment costs which lead to the sluggish response of investment to tax changes.

A second major conclusion which comes from the analysis is the sensitivity of the supply of funds to the corporate sector to the rate of return. Because of the high elasticity of overall savings with respect to the rate of return, and the reallocation of investors' portfolios, changes in business taxation have only very small effects on interest rates. Eliminating the corporate income tax for example, which would raise the after tax marginal product of corporate capital by about 5 percent in the short run, is estimated to increase interest rates by 1.1 points in the short run and only .5 points in the long run. This finding is consistent with the empirical evidence in Feldstein and Summers (1978) suggesting that changes in tax policy have only very small effects on long term bond rates. It implies that analyses of the effects of business tax incentives can to a first approximation omit the crowding out effect of rising interest rates.

The model in this paper should be regarded as a preliminary empirical application of an asset price approach to investment. The model presented here can and will be refined much further along a variety of dimensions. These include increasing the number of sectors so that the capital assets in the model exhaust those in the economy. In addition more exact calibration of the model to National Income Accounts data will be attempted. Perhaps more important, it is necessary to explore the effects of alternative consumption functions. The introduction of liquidity constraints which would sharply reduce the importance of "human wealth" effects might well increase the sensitivity of interest rates to changes in tax policy.

At somewhat greater remove models of this type could be used to examine the welfare consequences of alternative tax policies. If we were able to assume that all assets were perfect substitutes, and had the same required rate of return, it would not be difficult to use an intertemporal utility function to compute the effects of tax reform on lifetime utility, and then to compute compensating or equivalent variations. The difficulty comes when risk is introduced. Welfare analysis becomes impossible when ad-hoc line risk premiums enter the model. A more adequate treatment of uncertainty does not appear to be feasible at this point. Additional valuable extensions might include a more satisfactory treatment of corporate financial policy, and recognition of heterogeneity among consumers.

It would clearly also be possible to use the model developed in this paper to examine the effects of changes in the level of government spending, or the introduction of public debt. The effects of anticipated changes in monetary policy might also be considered.

The analysis here does demonstrate the importance of incorporating adjustment costs and the resulting variations in asset prices into models of the effects of taxation. It also suggests that in the presence of a tax system anything like that of the United States, inflation is likely to be far from neutral.

References

Blanchard, O.J., "Debt, Deficits and Finite Horizons," Journal of Political Economy, February 1985.

Federal Reserve System, Board of Governors, Flow of Funds Section, Division of Research and Statistics, "Balance Sheets for the U.S. Economy," unpublished data mimeo, June 1980.

Feldstein, M., "Inflation and the Stock Market," American Economic Review, 1980.

_______, "Inflation, Tax Rules and the Stock Market," Journal of Monetary Economics, July, 1980.

_______, "Inflation, Tax Rules and the Prices of Land," Journal of Public Economics, 1980.

Fullerton, D., and R. Gordon, "A Re-examination of Tax Distortions in General Equilibrium Models."

Fullerton, D., and R. Gordon, "A Re-examination of Tax Distortions in General Equilibrium Models," in Behavioral Simulation Methods in Tax Analysis (ed. M. Feldstein).

Fullerton, D., and A.T. King, J. Shoven and J. Whaley, "Static and Dynamic Resource Allocation Effects of Corporate and Personal Tax Integration in the U.S.: A General Equilibrium Approach," American Economic Review, September 1981.

Gordon, R., "Inflation, Taxation and Corporate Behavior," Quarterly Journal of Economics, 1982.

Hayashi, F., "Tobin's Marginal q and Average q: A Neoclassical Interpretation," Econometrica, 1982.

Hendershott, P.H., "The Decline in Aggregate Share Values: Inflation and Taxation of the Returns from Equities and Owner-Occupied Housing," American Economic Review, 1981.

Ibbotson, R.G. and R.A. Sinquefield, "Stocks, Bonds, Bills, and Inflation: Year-by-Year Historical Returns (1926-1974)," Journal of Business, vol. 49 (January 1976), pp. 11-47.

Lipton, D., et al., "Multiple Shooting in Rational Expectations Models," Econometrica, 1982.

Lucas, R.E., Jr., "Econometric Policy Evaluation: A Critique," in THE PHILLIPS CURVE AND LABOR MARKETS, Carnegie-Rochester Conference Series on Public Policy, vol. 1 (Amsterdam: North Holland, 1976), pp. 19-46.

Poterba, J., "Inflation, Income Taxes and Owner-Occupied Housing," Quarterly Journal of Economics, 1984.

Shiller, R.J., "Do Stock Prices Move Too Much to be Justified by Subsequent Changes in Dividends?" American Economic Review 71(3), June, pp. 421-436.

Shoven, J.B., and J. Whalley, "Applied General-Equilibrium Models of Taxation and International Trade," Journal of Economic Literature, September 1984.

Shoven, J.B., "The Incidence and Efficiency Effects of Taxes on Income from Capital," Journal of Political Economy, December 1976, pp. 1261-83.

Summers, L.H., "Inflation, the Stock Market and Owner-Occupied Housing," American Economic Review, vol. 71 (May 1981), pp. 429-34.

_______, "Taxation and Capital Accumulation in a Life Cycle Growth Model," American Economic Review, September 1981.

_______, " Taxation and Corporate Investment: A Q Theory Approach," Brookings Papers on Economic Activity, 1981:1, pp. 67-127.

_______, "Taxation, the Rate of Return and Private Savings," NBER Working Paper 996, 1982.

_______, "The Non-Adjustment of Nominal Interest Rates: A Study of the Fisher Effect," in PRICES AND QUANTITIES (ed., James Tobin), Brookings, 1983.

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