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TAX POLICY, ASSET PRICES, AND GROWTH: A GENERAL EQUILIBRIUM ANALYSIS

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This paper presents a multisector general equilibrium model that is capable of providing integrated assessments of the economy's short- and long-run responses to tax policy changes. The model contains an explicit treatment of firms' investment decisions according to which producers exhibit forward-looking behavior and take account of adjustment costs inherent in the installation of new capital. This permits an examination of both short-run effects of tax policy on industry profits and asset prices as well as long-term effects on capital accumulation. The model contains considerable detail on U.S. industry, corporate financial policies, and the U.S. tax system.

Simulation results reveal that the effects of tax policy differ significantly depending on whether the policy is oriented toward new or old capital. Measures like the investment tax credit stimulate investment without conferring significant windfall gains on corporate shareholders. Corporate tax rate reductions with the same revenue cost, on the other hand, yield large windfalls to shareholders while providing only a modest stimulus to investment in plant and equipment.

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The incidence and allocative effects of tax changes have long been a principal concern of both policymakers and public finance economists. Tax policies affect the industrial composition of output, the extent to which provision is made for the future through capital accumulation, and the distribution of wealth and economic well being. While economists working over the last two decades have made enormous progress in gaining an understanding of the effects of taxation, it has proved surprisingly difficult to develop realistic quantitative estimates of the effects of alternative tax policies on the level and distribution of economic welfare. In large part, this is because the models that are available either concentrate only on very long-run issues, or consider only the short-run macroeconomic impact of alternative policies. In this paper, we develop a computable general equilibrium model, based on the asset price approach to taxation developed in Summers (1981, 1985), which is capable of providing an integrated treatment of short- and long-run issues.

Beyond intellectual coherence, the development of methods for looking simultaneously at the short- and long-run effects of tax policies is important for at least two reasons. First, short-run issues are of critical importance in considering questions of tax incidence. In the standard general equilibrium model of the type pioneered by Harberger (1962) and implemented subsequently on a large scale by Shoven and Whalley (1972) and several other authors,[1] capital adjusts instantaneously to changes in tax policies so that the return to capital is equalized in all sectors. This makes it impossible to capture the capitalization effects that are central to tax incidence. Consider as an example a proposal to tax capital in a single industry. The standard model implies that after the tax is enacted, returns to capital in all sectors would be equalized immediately. This implies that the tax reform would have the same effect on investors in the taxed industry and in other industries. A moment's reflection reveals the unreality of this supposition. Owners of capital in a given industry invariably are much more concerned about capital tax increases in their industry than about capital tax increases in general. These concerns reflect the fact that capital is not perfectly mobile across sectors, so that increases in capital taxes in a given sector particularly reduce the prospective profitability of capital in that sector and lower its market value.

A second virtue of developing an integrated short- and long-run model is that it permits the analysis of a much wider range of policies than can be considered using standard models. Policy announcements, or explicitly temporary policies, cannot be analyzed using either general equilibrium models which focus only on long-run reallocations of capital, or macroeconometric models which do not incorporate forward-looking behavior. Nor do standard models provide a way of distinguishing between tax policies like changes in the corporate tax rate, which affect new and old capital alike, and changes in depreciation rules or the investment tax credit, which differentially treat new and old capital. These limitations are serious given that substantial changes in the relative tax burdens placed on old and new capital are a principal feature of the recently legislated Tax Reform Act of 1986. The model developed here, because it represents investment as being determined by forward-looking optimizing managers, is capable of addressing these issues.

The asset price approach used in the construction of our model involves a synthesis of the q theory of investment originated in Tobin (1969) and the adjustment cost investment framework developed in Lucas (1967). Following the work of Hayashi (1982), we make extensive use of the fact that the q ratio as inferred from market value data, will after several tax adjustments, be equal to the shadow price of newly installed capital. This permits us to estimate the effects of alternative policies on investment by assessing their impact on firms' market values. It also enables us to take account of the wealth effects of tax changes in evaluating alternative policies.

While some attempts have been made previously at developing models for studying the effects of tax policies in the presence of adjustment costs, these have relied on somewhat arbitary assumptions and little effort has been made to calibrate them to actual data. Fullerton (1983) analyzed the effects of imperfectly mobile capital in a model with constraints limiting the scope of capital adjustment in each industry within a given time interval. However, the (zero or infinite) costs of adjustment in the model were not linked to investment behavior, as investment was fully driven by savings. More recently, Bovenberg (1983), Summers (1985) and Wilcoxen (1986) have constructed general equilibrium models with forward-looking investment behavior and adjustment costs. Bovenberg's model distinguishes two producing sectors; Summers' model has three assets--corporate capital, land, and housing--but only one type of consumption good; Wilcoxen's model identifies five industries, but investment is only carried out by two of the industries and the model has not yet been applied to actual data. The model presented in this paper differs from these earlier models by incorporating a more disaggregate treatment of U.S. industry, by specifying in more detail the activities of the household, government, and foreign sectors, and by incorporating considerable detail on the U.S. tax system and corporate financial policies.

In this paper we employ the model to simulate the effects of several tax policy alternatives that alter the relative tax burdens between old and new capital and between corporate and noncorporate capital. We examine "surprise" policies as well as policies that are announced in advance. Our results reveal significant differences in the effects across industries as well as over time. An unannounced cut in corporate taxes, for example, benefits the corporate sectors at the expense of the (noncorporate) housing sector in the short run; in the long run, however, all industries benefit from the policy change as the tax cut raises the overall capital intensity of the economy, raises productivity and incomes, and leads to increased demand for housing services. These intersectoral and intertemporal effects are attributable in large part to capital immobilities that prevent non-corporate sectors from immediately sharing the gains associated with reduced taxation of corporate capital and that regulate the speed at which the gains increase over time.

The remainder of the paper is organized as follows. The next section presents a simple heuristic model intended to illustrate some potential dynamic effects of tax policy changes on asset prices and investment. Section II then describes the structure of the applied general equilibrium model. In Section III we describe the model's data sources and parameterization methods, and in Section IV we present the solution method. Section V reports and analyzes results from several policy simulations, and the final section provides conclusions.

I. ASSET PRICES AND INVESTMENT: AN ILLUSTRATIVE MODEL[2]

Here we present a simple partial equilibrium model in which the effects of tax policy on asset prices and investment may be analyzed graphically. This 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 effects 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[3]

$$(1) \qquad \dot{K} = I(p_K) \quad I' \geq 0$$

where p_K is the price of the capital asset relative to the numeraire good. Note that $\dot{K}$ can be negative because of depreciation. Assume further that the capital good K is used in a 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, r, 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

$$(2) \quad r = \frac{F'(K)}{p_K} + \frac{\dot{p}_K}{p_K}$$

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 $F'(\bar{K}) = r$.

Note that the system dispays 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 of capital goods. Such saddle point stability is characteristic of asset price models. It implies there is a unique path along which the capital stock and the asset price will approach (long-run) equilibrium.

The phase diagram in Figure 1 can be used to examine the effects of various types of tax changes. In Figure 2 we consider the effect of a tax on the asset's marginal product; a dividend tax or tax on profits might be interpreted as this type of tax. Such a tax does not affect the asset's supply curve; thus the $\dot{K}=0$ locus does not shift. However, the reduction in after tax returns implies a leftward shift in the $\dot{p}_K=0$ locus. In the short run, the stock of capital is fixed. However, the increase in the tax rate implies a drop in the after-tax marginal product of capital. In order to maintain the asset market equilibrium condition given by equation (2), the asset price p_K must fall. Thus point B may represent the quantity of capital and the capital asset price immediately following the policy change. Since B lies below the $\dot{K}=0$ locus, capital begins to be decumulated, causing the marginal product of capital to rise. The system converges from B to E_2 where p_K again equals its equilibrium value. Note that after the first instant investors always receive a fixed return r as reduced rents are made up for by capital gains and asset market equilibrium is restored. The position of the adjustment path depends on the elasticity of supply of the capital good, that is, the responsiveness of I to p_K in equation (1). If this elasticity is substantial, adjustment is rapid and the tax change will have 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 extreme case of costless adjustment, the equilibrium E_2 is attained instantly after the policy change and there is no change in p_K. In the other limiting case, where the supply of capital is completely inelastic, the relative price of capital declines to point A on the $\dot{p}_K=0$ locus, and p_K remains below its long-run equilibrium value.

The effect of a subsidy to new capital investment that 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 owning capital and thus 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 the fact that tax measures which encourage investment may hurt existing asset holders.[4] 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, a substitute for existing capital. The adverse effect of a reduction in new car prices on used car prices exhibits the effect considered here.

In this simple model, the supply of new capital goods is represented as a simple function of the asset price, p_K. In the simulation model which we describe below, the quantity of new capital goods supplied at any point in time will depend on both the asset price and the costs of producing new capital.

II. MODEL STRUCTURE

The model presented in this paper represents the behavior of the production, household, government, and foreign sectors. In this section we describe the modeling of each sector. In Section IV we shall explain how the model consolidates the behavior of the different sectors to obtain a general equilibrium solution for every period of time.

A. The Production Sector

1. General Features. The model distinguishes five producing industries: (1) agriculture and mining, (2) manufacturing, (3) energy, (4) services, trade, and utilities, and (5) housing services. Each industry produces a single output using inputs of labor, capital, and intermediate goods. The

optimal short-run intensities for labor and long-run intensities for both capital and labor are determined from constant elasticity of substitution (CES) value added functions. The intensities of intermediate goods are fixed.

The outputs of the five industries--producer goods--are demanded in several different ways. First, they serve as intermediate goods for each of the industries. In addition, they meet the demands for final goods by the government and the export demands of the foreign sector. Third, they combine according to fixed coefficients to produce a representative capital good; this satisfies the total demand for new capital goods given by the aggregate level of investment. Finally, they combine according to fixed coefficients to create the fifteen types of consumer goods demanded by households. The transformation of producer goods into consumer goods is necessary because the categories for outputs from production data differ from the categories for goods from consumer expenditure data.

The model contains considerable detail on taxes. Each industry faces taxes on labor and intermediate goods inputs. Output taxes apply to producer goods and sales taxes apply to consumer goods. The model also incorporates profits taxes, depreciation deductions, and investment tax credits, as described in detail below.

2. Profit Maximization and Investment: The Corporate Sector. For the first four industries, we represent firms as incorporated and as having opportunities to issue new shares. The fifth industry, housing, is largely unincorporated and requires a different treatment, as described under (3) below.

The fundamental assumption governing producer behavior is that managers of firms seek to maximize the value of the firm. The managers' choice variables at each point in time are the input levels for labor and intermediate goods and the level of investment. The levels of labor and intermediate inputs are selected to minimize costs, while the level of investment is chosen in each period so as to approach optimally the long-run (profit-maximizing) capital intensity. The length of time necessary to attain the optimal capital intensity depends critically on the adjustment costs faced by the firm.

A starting point for specifying the firm's optimizing behavior is the condition of asset market equilibrium that risk-adjusted expected returns be the same across all assets. In particular, the expected returns from holding equity must be in line with those from holding a "safe" asset such as bonds. The return from holding equity is the sum of capital gains and dividends net of tax. Thus asset market equilibrium requires that for any firm at any point in time:

$$(3)\quad (1-c)\,\frac{\dot{V} - VN}{V} + (1-\theta)\,\frac{DIV}{V} = i(1-\theta) + \eta$$

where V is the value of the firm, VN denotes new share issues, DIV is the current dividend, c is the capital gains tax rate, θ is the marginal income tax rate, i is the nominal interest rate on the safe asset, and η is the equity risk premium. The dot over a variable denotes its rate of change with respect to time. Imposing a transversality condition ruling out eternal speculative bubbles and integrating equation (3) yields the following expression for V:

$$(4)\quad V_t = \int_t^{\infty} \left[\left(\frac{1-\theta}{1-c}\right) DIV_s - VN_s \right] \left[\exp \int_t^s \frac{r_u}{1-c} du \right] ds$$

where r (= $i(1-\theta) + \eta$) is the risk-adjusted rate of return. The value of the firm is equal to the discounted value of the stream of after-tax dividends net of new share issues.[5] It should be noted that the tax parameters θ and c used in the calculation of V are not restricted to be constant over time. In addition, the risk-adjusted rate of return, r, will of course change over time with changes in the nominal interest rate.

The firm's dividends and new share issues in each period are related through the cash flow identity that equates sources and uses of funds:

$$(5)\quad EARN + BN + VN = DIV + IEXP$$

In the above expression, EARN represents earnings after taxes and interest payments, BN is the value of new debt issue, and IEXP is the value of investment expenditure. The firm's earnings are given by:

$$(6)\quad EARN = [pF(K,L,M) - wL - p_M M - iDEBT]\,(1 - \tau) + \tau D$$

where

K and L = inputs of capital and labor

M = vector of inputs of intermediate goods

p = output price (net of output taxes)

F = quantity of output by the firm (gross of adjustment costs)

w = wage rate (gross of indirect tax on labor)

p_M = vector of intermediate input prices (gross of intermediate input taxes facing the industry)

DEBT = nominal debt

τ = corporate tax rate

and

D = value of currently allowable depreciation allowances

To determine the value of the firm, it is necessary to specify the firm's behavior regarding borrowing and the payment of dividends. Although there is considerable debate on these issues, we adopt a specification in which firms maintain a constant debt-capital ratio through time and pay dividends equal to a constant fraction, a, of after-tax profits net of economic depreciation. This specification conforms to the "traditional" view of dividend behavior. Some empirical support for this view is presented in Poterba and Summers (1985). Further evidence comes from the large volume of share repurchases in recent years documented by Shoven (1986). Our specification implies that, at the margin, increased investment is financed through new share issues (VN) and the new debt issue (BN) necessary to maintain a constant ratio of debt to capital. Thus, for the first four industries, we have:

$$(7)\quad DIV = a(EARN - \delta^R p_K K)$$

$$(8)\quad DEBT = bp_K K$$

$$(9)\quad BN = \frac{d}{dt}(bp_K K) = b(p_K \dot{K} + \dot{p}_K K)$$

In the above equation, p_K refers to the replacement price of capital goods.

Finally, investment expenditure is the sum of the "direct" costs of the new capital (net of the investment tax credit) and the adjustment costs associated with its installation:

$$(10) \quad IEXP = (1 - ITC)p_K I + (1 - \tau)p\phi I$$

where ITC represents the investment tax credit rate, I is the quantity of investment, and $\phi(I/K)$ represents adjustment costs per unit of investment. Here we model adjustment costs as internal to the firm, that is, as involving a loss in output.[6] The notion is that in order to install new capital, currently available resources (labor, existing capital, and intermediate goods) must be devoted to the installation of new equipment and thus are diverted from producing the firm's output. Our treatment of adjustment costs assumes that output, X, is separable between inputs and adjustment costs:

$$(11) \quad X = F(K,L,M) - \phi I$$

Using the condition

$$(12) \quad \dot{K} = I - \delta^R K$$

and substituting equations (7) - (10) and (12) into equation (5), we obtain the following expression for new share issues:

$$(13) \quad VN = (a - 1)EARN - a\delta^R p_K K + (1 - ITC - b)p_K I - b\dot{p}_K K + (1 - \tau) p\phi I$$

Substituting (6) and (13) into (4) gives an expression for the value of the firm in terms of I, L, M, prices, and the technology. Firms maximize this value subject to the capital accumulation condition (12). A detailed discussion of the solution to this sort of problem is provided in Summers (1981). If the production technology exhibits constant returns to scale and the adjustment cost function ϕ is homogenous of degree zero in I/K, then optimal investment is a function of Q, or tax-adjusted q. Specifically, optimal investment is given by

$$(14) \quad \frac{I}{K} = h(Q) = h\left[\left[\frac{V-B}{p_K K} - 1 + ITC + b + \omega Z\right] \left[\frac{p_K}{(1-\tau)p}\right] \right]$$

where $h(\cdot) = [\phi + (I/K)\phi']^{-1}$, B is the present value of depreciation allowances on existing capital, Z is the present value of depreciation allowances on a dollar of new investment, and $\omega = a(1-\theta)/(1-c) - a + 1$. It can be shown that if the adjustment cost function takes the form

$$(15) \quad \phi(I/K) = \frac{\beta/2 \ (I/K-\gamma)^2}{I/K}$$

then the relationship between the rate of investment and Q is simply:

$$(16) \quad \frac{I}{K} = \gamma + \frac{1}{\beta}Q$$

In the model employed for this study, we adopt the adjustment cost function presented in (15). The rate of investment therefore increases with Q, and higher adjustment costs (lower γ, higher β) imply slower rate of investment for any given Q.

Under this specification of firm behavior, given the "gross" production function, F, and any set of prices and taxes, it is relatively straightforward to calculate optimal demands for labor and intermediate goods.[7] The optimal level of investment, however, depends on Q, which in turn depends on the variables V, B, and Z, as indicated by equation (14). These variables incorporate expectations about the future, as they are defined in terms of discounted streams of dividends or depreciation allowances. Clearly it is not possible to evaluate the current Q on the basis of current magnitudes alone. In Section IV we shall describe how the model calculates the correct value for Q in each period.

3. Housing Sector Behavior. In many ways, the treatment of firm behavior in the housing industry parallels that of the other industries. As in the other industries, owners of capital in the housing services industry pursue forward-looking strategies intended to maximize the asset value of their capital. The main differences in the treatment of housing stem from the fact that the housing industry is largely unincorporated, with less than 2.5 percent of housing capital employed by corporations. This means that for most of the housing services industry, it is not possible to finance new investment through share issues. Thus, for this industry, new share issues (VN) do not enter into the arbitrage condition (3) and the equity value of the firm (see equation (4)) is simply the discounted value of after-tax dividends. For this industry, we treat firms as financing additional investment by reducing dividends and issuing new debt sufficient to maintain a constant debt-capital

ratio.[8]

The calculation of after-tax earnings, EARN, is also slightly different from the approach given for the other industries in equation (6) above. Gross earnings include the return from rental housing and the implicit returns from owner-occupied housing. Since nearly all housing is non-corporate, the corporate tax rate only applies to a small fraction of these returns. In addition, most interest payments in this industry can be expressed at the personal, rather than corporate, tax rate.[9]

B. The Household Sector

1. Aggregate Consumption and Saving. Households, like producers, exhibit forward-looking behavior and are regarded as having perfect foresight. Aggregate consumption and saving derive from the utility maximizing behavior of a representative household with an infinite time horizon. It will be convenient to express the household maximization problem in discrete time. In each period t, the household maximizes a utility function of the form

$$(17)\quad U = \sum_{s=t}^{\infty} \frac{1}{(1+\rho)^{s-t}} \ln C_s$$

where ρ is the rate of time preference and C is an index of overall consumption. Households maximize utility subject to the wealth constraint

$$(18)\quad \sum_{s=1}^{\infty} \bar{p}_s C_s d_s = W_t + YK_t + \sum_{s=1}^{\infty} (\hat{w}_s L_s + TR_s)\hat{d}_s$$

where $\bar{p}_s$ is the price index for consumption, W is nonhuman wealth, YK is current capital income (dividends and bond interest income) net of all taxes, $\hat{w}$ is the wage rate net of all taxes, L is the labor supply, and TR is net exogenous transfers. The variable d_s is the discounting operator for period s, defined according to

$$(20)\quad d_s = \begin{cases} \prod_{u=1}^{s-1} (1+r_u)^{-1} & , s>1 \\ 1 & , s=1 \end{cases}$$

where r_u is the rate of discount applied by the household between periods u and u+1. We assume that households consider the future streams of labor and transfer income to involve some risk and therefore include a risk premium in discounting these returns. Thus, while the consumer discounts future consumption at the rate $r = (1-\theta)i$, future labor and transfer earnings are discounted at the rate $\hat{r} = r + \mu$, where μ is the consumer's risk premium. Thus $\hat{d}_s \neq d_s$. As indicated by Blanchard (1985), the use of a risk premium in discounting future labor earnings provides a way of approximating, within an infinite-horizon model, the aggregate behavior of life-cycle individuals with finite lifetimes.

The utility function specified in (17) has the property that the optimal value of consumption is homogeneous of degree one in total wealth. The logarithmic utility function implies that the fraction of total wealth represented by current consumption is independent of the expected rate of return. Expected total wealth is the right-hand side of equation (18): we can express expected total wealth in period t (TW_t) by

(20) $TW_t = W_t + YK_t + HW_t$

where $HW_t = \sum_{s=1}^{t} (\hat{w}_s L_s + TR_s)\hat{d}_s$ and refers to expected human and transfer wealth. Since HW_t depends on future labor and transfer streams, it cannot be evaluated simply from the current period prices. In Section IV we describe how the model calculates the values for HW in every period.

2. Consumption of Specific Commodities. The variable C_t above refers to overall consumption in period t. This is a composite of the consumption of fifteen specific consumer goods. The composition of C_t in terms of specific goods is according to fixed expenditure shares. The price of overall consumption, $\bar{p}_t$, is determined from the individual consumer good prices, according to

$$(21) \quad \bar{p} = \prod_{i=1}^{15} \left[\frac{p_i}{\alpha_i}\right]^{\alpha_i}$$

where p_i is the price of consumer good i and α_i is the expenditure share of consumer good i in overall consumption.

C. The Government Sector

The government has three functions in the model: collecting taxes, distributing transfers, and purchasing goods and services (producer goods).

1. Taxes. The model incorporates each of the major taxes in the United States. Table 1 shows how these are modeled.

The model incorporates features of the U.S. tax code which introduce different effective tax rates on new and old capital. The explicit treatment of profit taxes, investment tax credits, and capital gains taxes allows us to capture the effects of tax policy on investment and dividend payment decisions. The model also distinguishes economic from tax depreciation. In each industry j, real depreciation proceeds at an exogenously specified rate, δ_j^R. A different parameter, δ_j^T, describes the rate at which capital may be depreciated for tax purposes. Depreciation allowances (D) in a given period are given by

$$(22) \quad D_t = \delta^T KDEP_t$$

where KDEP is the capital stock basis for tax purposes. KDEP is calculated on an historical (rather than real) cost basis. Thus, the model incorporates an important non-neutrality of the tax code with respect to the rate of inflation: the real value of KDEP erodes more quickly the greater is the inflation rate. The inflation rate itself is exogenous in the model.

2. Transfers and Purchases. The level of overall government spending (transfers plus purchases) is exogenous in every period. The model exhibits steady-state growth in the base (or status quo) case, and thus overall real government spending is specified to increase at the steady-state rate of growth, g. The model is calibrated so that in the base case, the government budget balances in each period. In revised case (policy change) simulations,

the levels of real overall government spending are fixed at the same levels as in the base case. This facilitates welfare evaluations, since the household utility functions do not account for welfare from the consumption of government-provided goods and services. In revised case simulations, the model scales personal tax rates so as to maintain budget balance.

Transfers and purchases each represent a fixed share of overall spending. Purchases divide into purchases of specific producer goods according to fixed expenditure shares.

D. The Foreign Sector

The treatment of foreign trade is the same as the "constant elasticity offer curve" formulation described in Goulder, Shoven, and Whalley (1983). Constant elasticity import supply and export demand functions generate current account flows. An exchange rate variable adjusts to bring about current account balance in every period.

III. DATA SOURCES AND PARAMETERIZATION METHODS

A. Data Sources

1. Production Data. The model integrates data from several different sources to form a 1973 benchmark data set. Much of the information used in the production side of the model derives from the data set developed by Fullerton, Shoven, and Whalley and documented in Ballard *et al*. (1985). This

is our source for information on production function elasticities, benchmark labor intensities, intermediate good intensities, labor input taxes, intermediate good taxes, output taxes, and sales taxes.

We also employ data from Hulten and Wykoff (1981) on capital stocks in each industry by asset type. We aggregate across assets to obtain total capital stocks for the industries other than housing. Capital stock data for the housing industry for 1973 derive from the February 1981 Survey of Current Business (SCB).

A simulation model by Auerbach and Hines (1986) contains much detail on specific provisions of the U.S. tax code. This model converts detailed tax provisions into overall economic depreciation rates, investment tax credit rates, and the present value of depreciation deductions by asset type. We apply these economic depreciation and investment tax credit rates to the Hulten-Wykoff asset-industry data to obtain the corresponding rates (δ^R and ITC) for the first four industries. In addition, we combine the depreciation deductions from the Auerbach-Hines model with the Hulten-Wykoff data to obtain tax depreciation rates by industry (δ^T). For the housing sector, the values for δ^R and δ^T were calculated based on information in DeLeeuw and Ozanne (1979). The ITC is zero in this sector.

Debt-capital ratios (b) by industry derive from Fullerton and Gordon (1983) and Standard and Poor's Basic Statistics (1978); these are aggregated to the five-sector level using capital stocks as weights. Dividend payout ratios (a) by industry are calculated from dividends and profits as reported in the July 1976 and July 1978 SCB. The adjustment cost parameters (γ and β) are taken from the estimates in Summers (1985). These are the only available econometric estimates for adjustment cost formulations comparable to the specification employed in the model.

We calculate the equity risk premium (η) for each sector using information from Fullerton and Gordon. Here we invoke the capital asset pricing model to infer equity risk premia by industry from equity betas and the expected average return on the market portfolio.[10]

Finally, we impose a value of 0.46 in the base case for the corporate profit tax rate and a value of 0.05 for the tax rate on capital gains.

Table 2 presents the base case values for industry tax and behavioral parameters employed in the model.

2. Other Data. The data for the household, government, and foreign sector components of the model derive from Fullerton, Shoven, and Whalley. This includes household disposable incomes, expenditure shares, marginal tax rates, transfers, and income taxes paid; government purchases of producer goods and capital endowments; and levels of imports and exports of each type of good.

B. Parameterization

The parameterization procedure must satisfy two sorts of requirements.

Replication Requirement. In the base case, the model must generate an equilibrium solution with values matching those of the benchmark data set. In particular, the levels of inputs in each sector, the levels of factor incomes, and the magnitudes of various tax payments must be identical to those of the benchmark data set.

Balanced Growth Requirement. In the base case, the model must generate a steady-state growth path.

The parameterization procedure involves selecting certain parameters from outside sources and identifying remaining parameters or economic flows from restrictions implied by the two requirements above. In this subsection we briefly describe some main aspects of the parameterization procedure. For convenience, we supress subscripts referring to a given sector.

First, we specify exogenously the rate of inflation, π, the steady-state growth rate, g, and the rate of time preference, ρ. In our standard simulations, these take the values .062, .03, and .01, respectively. In the steady state, the rate of gross investment, I/K, in each sector must satisfy

$$(23) \quad I/K = g + \delta^R$$

Values for K, g, and δ^R are contained in the benchmark data set. We use the above equation to obtain the initial level of investment in each industry. Given the parameters of the adjustment cost function, we apply (23) and invert equation (16) to solve for the steady-state value of Q. The definition of KDEP and the requirement of balanced growth imply that in the initial data set,

$$(24) \quad \frac{K}{KDEP} = \frac{(1+\pi)(1+g) - (1-\delta^T)}{g+\delta^R}$$

We employ (24) to solve for KDEP in each sector. Then, using the values for K, KDEP, θ, τ, δ^T, and a guess for the nominal interest rate, i, we calculate initial steady-state values for Z, B, and V. From the capital stocks, nominal interest rate, and debt-capital ratios, we calculate bond interest payments and new bond issues. Applying the arbitrage condition (3), the cash-flow identity (5), and the steady-state condition that $\frac{\dot{V}}{V} = (1+g)(1+\pi) - 1$, we then obtain the initial new share issues and dividend payments in each sector.

On the household side, we determine total nonhuman wealth (W) by adding up debt and equity ownership across sectors. From initial labor income and transfers, the household discount rate $\hat{r}$, and the steady state growth rate, we also calculate the present value of labor and transfer earnings (HW). The solution of the household utility maximization problem requires that

$$(25) \quad \bar{p}C = \frac{\rho}{1+\rho} TW$$

where TW = W + HW. In the benchmark, units are defined so that all goods prices are unity; thus equation (25) yields initial consumption. Consumption is subtracted from initial income to obtain the initial value of household savings.

The value of household savings must equal total borrowing requirements of firms. If the assumed interest rate does not bring these into balance, we update the guess and repeat the calibration procedure until equality is achieved.

Tables 3 and 4 present the base case (calibrated) values for important variables used in the model.

IV. SOLVING THE MODEL

The solution of the model satisfies two sorts of equilibrium conditions. "Within period" equilibrium conditions require that, in any period, given any set of expectations for future variables, current supplies and demands are in balance. Intertemporal equilibrium conditions require that expectations conform to the values eventually realized in later periods.

At any given point in time, t, expectations about the future are embedded within the current period values of the variables V_t, Q_t, Z_t, B_t, and HW_t. By inverting equation (14), it is possible to express V_t in terms of Q_t, B_t, Z_t, and prices and parameters from period t. In addition, B_t can be written in terms of Z_t and current values. For the corporate sectors, for example, the expression for B_t is:

$$(26) \quad B_t = (1 - \delta^T) \text{ KDEP } a\left(\frac{1-\theta}{1-c}\right) \left[Z_t \frac{\tau}{1-\delta^T}\right]$$

Thus, expectations held in period t about the future are fully summarized by the values for Q, Z, and HW in period t. The time paths of each of these variables have certain characteristics that can be exploited: as shown in the appendix, it is possible to derive explicit relationships (in discrete time) of the form:

$$(27) \quad Q_t = Q_t(A_{1t}, V^*_{t+1})$$

$$(28) \quad Z_t = Z_t(A_{2t}, Z^*_{t+1})$$

$$(29) \quad HW_t = HW_t(A_{3t}, HW^*_{t+1})$$

where the variables A_{1t}, A_{2t}, and A_{3t} refer to magnitudes (prices and quantities) observed in period t, and V^*_{t+1}, Z^*_{t+1}, and HW^*_{t+1} refer to the values, expected in period t, for the variables V, Z, and HW in the next period. We shall refer to V^*_{t+1}, Z^*_{t+1}, and HW^*_{t+1} as lead values.

Solution of the model proceeds on two levels. First, we make guesses of the lead variables V^*_{t+1}, Z^*_{t+1}, and HW^*_{t+1} for $t = 2,3, \ldots, T+1$, where T is the last period simulated. Conditional on these guesses, we calculate a general equilibrium solution for every period; this is the within-period equilibrium problem. On the next level, we solve for the correct values for the lead variables; this is the intertemporal equilibrium problem. In the following two subsections, we outline the solution method for each type of equilibrium problem.

A. Within-Period Equilibrium

Figure 4 suggests the method for calculating each within-period solution. The demand for labor in each sector depends on the current capital stock, current prices and taxes, and the production technology. Given the interest rate, current prices and taxes, and the lead values for V and Z, we calculate current values for Q and Z in each sector (as detailed in the appendix). From the current Q we then derive investment, adjustment costs, and borrowing for each sector. Once adjustment costs are known, we can calculate each sector's output supply from the desired input level and the current capital stock.

Given the lead value for HW, current prices, and the interest rate, we calculate the current value for expected human and transfer wealth, HW. From Q, Z, and current magnitudes we calculate the values of firms and nonhuman wealth, W. Current prices and the variables HW and W allow the calculation of total wealth, consumption, and saving.

Import supplies and the demands for domestic goods by the government and foreign sectors can be calculated from current prices and tax rates.

The demands for final goods by households, the government, foreigners, and firms (investment) are combined to determine total final demands for each produced good. This total implies a demand for gross output, given the production technology.

Within-period equilibrium requires that the overall demand for labor equal its (exogenous) supply, that output demand equal output supply for each sector, that firms' demands for funds (total borrowing exclusive of retained earnings) equal total household saving, and that government expenditures equal government revenues. To obtain these equilities, we employ the Powell (extension of Newton) algorithm which tries alternative values for the price of labor, the five output prices, the interest rate, and the scalar for adjusting marginal income tax rates. Thus in any period, the Powell algorithm tries eight "prices" and evaluates eight excess demands.

Once the within-period equilibrium is obtained for the first period, we augment the capital stocks based on the levels of net investment and perform the same equilibrium calculations for the next period. In this manner we solve for every period in the simulation interval.

B. Intertemporal Equilibrium

Perfect foresight requires that the values of the lead variables HW^*, V^*, and Z^* conform to realized values. To achieve this conformity, we implement an algorithm which is similar in many respects to that of Fair and Taylor (1983). Our algorithm operates as follows. First, we calculate the new steady-state values for HW, V, and Z which ultimately prevail after a policy change. In the base case, the steady-state values for these variables emerge from the calibration procedure; in revised case simulations, a more complex simulation procedure is required.[11] We then assign the steady state values to the terminal values for the lead variables, that is,

(30) $HW^*_{T+1} = HW_{ss}$

(31) $V^*_{T+1} = V_{ss}$

(32) $Z^*_{T+1} = Z_{ss}$

where T is the last simulation period, and the subscript ss denotes the value for a variable in the new steady state. Next, we assign an initial path for the lead variables. For the lead variable, HW^*, for example, the path is represented by HW_2^*, HW_3^*, ..., HW_{T+1}^*.

We then solve the model for each within-period equilibrium given the initial paths of lead variables. The within-period equilibrium solution provides a path of derived values: HW_1, HW_2, ..., HW_T; V_1, V_2, ..., V_T; and Z_1, Z_2, ..., Z_T. At this point we compare the lead variables with contemporaneous derived values; if the lead and derived values are not sufficiently close to one another,[12] we update the paths of guesses in a Gauss-Seidel fashion. For example, we adjust the HW^* path according to

$$(34)\quad HW_t^{*(k+1)} = \lambda HW_t^{(k)} + (1-\lambda)HW_t^{*(k)}, \qquad t=2,T$$

where k represents the iteration number and λ is a parameter between 0 and 1. This procedure generally brings lead and realized values within .1 percent of one another within fifty iterations.[13]

The equilibrium paths for HW, V, and Z have the appropriate slope across any two consecutive periods, since agents have perfect foresight and impose the appropriate relationship across periods in determining a current value on the basis of the corresponding lead variable. Each equilibrium path also has the appropriate level, as determined by the terminal values for each variable.

V. SIMULATION RESULTS

The "base case" sequence of equilibria is the standard against which the effects of policy changes are measured. As mentioned above, the economy exhibits steady-state growth in the base case at an annual rate of three percent. We generally perform simulations over an interval of 75 years, with the equilibria spaced one year apart. Thus T=75. In most simulations, the economy approaches quite closely the new steady state well before the 75th year, and we find that using larger values for T does not significantly affect the simulation results.

In all simulations, the path of real government spending is kept the same as in the base case. Government budget balance is maintained in each period by lump-sum increases or reductions in personal income taxes.

A. A Corporate Tax Cut

1. Unanticipated Policy Change. The first experiment evaluates the effects of a reduction in the corporate income tax rate from 0.46 to 0.34 in all industries. The reduction is assumed to be unanticipated and to take effect in the first period. Figure 5a displays the effects of the policy change in a "typical" sector, manufacturing. The figure compares the time paths of investment, the capital stock, and the asset value of firms in the policy change and base cases. The cut in the corporate tax raises the after-tax marginal product of capital, allowing higher earnings and dividends in every period. The stock or asset value for the industry, V, rises immediately to reflect the increases in the stream of earnings, or more specifically, in the discounted stream of after-tax dividends less share issues. In the initial period, V increases by 18.5 percent over the base case. The increase in V is sustained over time, and in the new steady state the asset value exceeds the base case steady-state value by 21.5 percent.

The higher asset values imply larger values for Q and stimulate investment, which in the first period rises by 4.9 percent over the level of the base case. Sustained higher rates of investment lead to steady increases in the capital stock; by the fifth period, the capital stock exceeds the base case level for the same period by 2.1 percent, and in the new steady state, the capital stock is above the base case value by 9.1 percent. Although the rate of investment (I/K) eventually returns to its value prior to the policy change, the level of investment remains above the base case level, in keeping with the higher capital stock.

The pattern of results is similar for the other industries except for housing, as indicated by Table 5. The table shows the effects of the policy change on investment, after-tax earnings, and stock values in each industry for periods 1 and 5 and the new steady state. In sectors 1-4, the cut in the corporate tax rate immediately stimulates investment demands and eventually leads to a higher capital intensity in the steady state. The steady-state percentage increases in investment in Table 5 are also the percentage increases in the capital stock, since the investment-capital ratio returns to the benchmark value in the new steady state. The increased investment in these sectors contributes to a 4.1 percent increase in the aggregate private capital stock in the new steady state. The corporate tax cut has an immediate and sustained effect on asset values, yielding increases in industries 1-4 of from 15 to 21 percent over the base case levels in the initial and later periods.

The situation differs for the housing sector. Since only a small fraction (approximately 2.4 percent) of housing capital is employed by corporations, the corporate tax cut implies a much smaller reduction in the overall rate of capital taxation in the housing sector than in other sectors. While asset values rise in the other sectors, the reduced relative attractiveness of housing capital causes asset values to decline initially by 1.3 percent in the housing sector. The lower stock values discourage investment, which initially declines by 1.2 percent relative to the base case. Although the housing sector suffers in the short run, over the longer term the sector experiences increases in asset values and in the capital stock relative to the base case. This seems to reflect the fact that the higher overall capital intensity of the economy improves productiveness, raises incomes, and ultimately calls for increases in the production of housing services. Although the housing sector's share of output falls, in the long run the corporate tax cut has a positive effect on the absolute level of output from the sector.

The different effects across sectors are attributable in large part to the existence of capital immobilities that prevent the non-corporate (especially housing) sectors from immediately sharing the gains associated with reduced taxation of corporate capital.

2. Announcement Effects. We also consider the implications of the same corporate tax cut when the policy change is announced three full years prior to its implementation (the tax reduction takes effect in year 4). Results for sector 2 appear in Figure 5b. The cut in corporate taxes will reduce Z, the present value of depreciation allowances on a dollar of investment, once the policy change takes effect. This induces firms to invest at a more rapid rate prior to the policy change than after, and accelerates the movement in the

capital stock toward its new steady-state intensity. The value of firm equity rises immediately following the policy announcement, but by less than in the case where the tax cut is immediately enacted.

The steady-state consequences of this pre-announced policy change are the same as those in the unnanounced case previously considered: in the long run, the capital intensity of each sector changes (increases) by that amount necessary to bring the after-tax marginal product of capital into its appropriate relationship with the cost of new capital.

These simulations indicate that the announcement of a prospective cut in corporate taxes hastens the gains to be achieved in terms of capital formation, productivity, and real incomes. Thus, for this policy change, the prior announcement of the policy seems preferable to maintaining uncertainty as to whether the policy will be implemented.

B. Eliminating the Investment Tax Credit

1. Unanticipated Policy Change. We next consider the effects of eliminating the investment tax credit in each industry. The effects for the manufacturing sector are presented in Figure 6a. These effects are fairly typical of the effects occurring in sectors other than housing. Lowering the ITC lowers Q directly and causes an immediate reduction in the rate of investment. In the short run, the level of investment falls by approximately seven percent. Over time, the capital stock declines relative to the base case, as does the productiveness of capital. Thus, over the longer term, earnings and the asset value of firms fall. In the long run, the rate of

investment (I/K) returns to the steady-state value, but both the capital stock and the level of investment are lower than in the base case by about 12 percent.

Table 5 reveals the effects of this policy change across the five industries. Repealing the ITC especially discourages investment in the agriculture, manufacturing, and services sectors, where the initial ITC value was relatively high (see Table 2). In the energy and housing sectors, the initial ITC values were low (zero for housing), and thus repealing the ITC has a smaller impact. In fact, investment in housing actually increases somewhat (relative to the base case) in the short term after the ITC is eliminated. This reflects the increased relative attractiveness of investment in housing and the decline in interest rates associated with the reduction in aggregate investment demand. In the first year, nominal interest rates fall to a value of 7.0 percent, as compared with 7.3 percent in the base case. The short-term effects on asset values are similar to the effects on investment and reflect the changes in the relative attractiveness of investment in the different industries. While eliminating the ITC lowers firm values for the agriculture, manufacturing, and services sectors, the policy change yields slight increases in asset values for the energy and housing sectors.

In the long run, repealing the ITC lowers investment and stock prices in all industries. Even the energy and housing sectors experience reductions in asset values in the new steady state; this seems to reflect the fact that the overall capital intensity of the economy is lower, implying lower capital productiveness, lower real incomes, and a diminished demand for the output from these industries.

2. Announcement Effects. In addition we consider the ITC elimination when the policy change is announced three years before it is put into effect. The results for the manufacturing sector appear in Figure 6b. The policy announcement lowers the overall attractiveness of investment and leads to a downward shift in the investment profile. However, the reduction in investment is slight in the years prior to implementation of the new policy, as firms continue to take advantage of the original investment credits right up to the time of the change. The steady-state effects of this policy change are the same as in the pre-announced policy case previously described: lowered investment leads to a reduced productiveness of capital, lower earnings and dividends, and a decline in the equity value of firms.

Results for each industry appear in Table 5.

C. Combined ITC Elimination and Corporate Tax Reduction

Two key features of the Tax Reform Act of 1986 are the elimination of the ITC and reductions in corporate income taxes. Here we consider the effects of a combined policy of this type, the elimination of the investment tax credit accompanied by a reduction of the corporate tax rate to 0.35. In the model, this combined policy is "revenue neutral" over the first five periods.[14] However, it is revenue losing after this time as a result of behavioral adjustments to the new tax regime, and thus offsetting lump-sum increases in personal taxes are required to ensure government budget balance in later periods.

The previous discussion indicates that eliminating the ITC and cutting the corporate tax have opposite effects on Q and investment. Our simulation results indicate that the effect of the ITC elimination predominates when the two changes are combined. Figure 7 and Table 5 reveal that the combined policy discourages investment in the short run, despite the favorable influence of a lower corporate tax. Aggregate private investment falls by 2.2 percent in the first period. In the long run, the combined policy reduces the aggregate capital stock by 3.5 percent. Even though the ITC elimination and corporate tax cut have revenue effects that essentially cancel each other out, the ITC elimination has a greater effect on investment since it is targeted specifically to new capital, rather than all capital. These results suggest that policies (like the new tax law) involving the elimination of the ITC may be very costly in terms of capital formation, even if accompanied by reductions in the corporate tax.

As indicated in Table 5, this policy combination generates windfalls to capital owners (higher asset values) in both the short and long run. What makes these results particularly onerous is that the windfall to capital owners is not accompanied by any increase in capital accumulation.

These results suggest that the opposite type of combined policy -- a doubling of the ITC combined with a revenue preserving increase in the corporate tax -- would be preferable in terms of capital formation, leading to higher investment and a higher long-run capital stock. Simulating this "opposite" policy indicates that this is indeed the case: aggregate private investment rises by 3.2 percent in the first period and the aggregate capital stock is 6.9 percent higher in the long run. Of course, there are important issues of dynamic consistency associated with this combined policy and with the policy reduction combination previously discussed. The potential gains will depend significantly on whether the policy in question is believed to be permanent and whether it is anticipated.[15]

D. An Increase in Gasoline Taxes

In this experiment, we double the tax rate on gasoline. In the model, gasoline is one of the 15 consumer goods produced by combining the five industry or producer goods. Gasoline, in particular, is produced in the model using the producer goods from the energy and services sectors and no producer goods from other sectors.

Figure 8a displays the effects of the gasoline tax increase on the output price, investment, the capital stock, and the stock price in the energy sector. The output price is net of the gasoline tax (and other retail taxes). In the short run, energy producers bear the burden of the tax as demands fall and the net of tax price declines. The lower prices imply lower earnings and dividends, and the value of equity in the energy sector falls by about eight percent. The lower asset values make investment less attractive, and thus the energy sector invests more slowly and the capital stock declines relative to the base case. The slower growth (relative to the base case) of the energy sector effectively reduces supply and causes prices to return toward original levels. In the long run, the supply cutback transfers the burden of the gasoline tax from energy producers to energy consumers.

Figure 8b illustrates the fact that the gasoline tax has different incidence effects across sectors. The gas tax (if perceived to be permanent) causes investors to reallocate their portfolios, giving rise to windfall losses to owners of energy capital and windfall gains to owners of other capital. The values of non-energy stocks rise by between 0.2 to 1.4 percent in the short run. Over the longer term, the changes in the sectoral allocation of capital bring about changes in output prices and cause asset values to move back somewhat toward their base case levels. These different effects across sectors underscore the importance of incorporating adjustment costs and forward-looking behavior in general equilibrium models evaluating tax incidence.

It may seem contradictory that the variable V is permanently lowered in the energy sector, despite the fact that in the long run, energy prices (net of gasoline taxes) return to the original level. However, it should be noted that V represents the total asset value of energy capital; since the quantity of capital falls relative to the base case, the total value also falls.

E. Sensitivity Analysis

Our final simulations explore the sensitivity of the model's results to the adjustment cost parameters and to the tax replacement scheme. To consider the implications of different adjustment cost assumptions, we alter the slope of the adjustment cost function, $\phi(I/K)$. In a low adjustment cost scenario, we reduce both γ and β in a way that reduces by fifty percent the first derivative of the ϕ function while leaving the value of the function unchanged at the base case I-K ratio. Similarly, in a high adjustment cost scenario, we raise γ and β so as to double the slope of the ϕ function while leaving its value unchanged in the base case. In Figure 9 we present results from simulations of an unannounced elimination of the investment tax credit under the low and high adjustment cost assumptions. The solid line indicates the results under the central case adjustment cost secenario already considered.

The most important difference introduced by changing the adjustment cost paramenters is the length of the transition to the new steady state. Under low adjustment costs, the capital-output ratio moves halfway to its new steady-state value within eight years; under higher adjustment costs, this takes approximately 17 years.

The long-term incidence effects of this policy change are quite similar across adjustment cost specifications. However, as Figure 9 illustrates, the short-term effects can be quite different depending on the magnitude of adjustment costs. The elimination of the ITC produces two opposing effects on the equity value of the firm. On the one hand, the policy change makes existing capital attractive relative to new capital and thereby has a positive influence on the value of the firm in the short term. On the other hand, until the desired new capital intensity is attained, there will be inframarginal losses associated with existing capital, and this tends to reduce V. This latter effect gains importance to the extent that adjustment costs are high and the long-run capital intensity is realized slowly. Thus, in the case of low adjustment costs, V rises in the short run, while in the intermediate and high adjustment cost cases, it falls. These results indicate that more precise estimates as to the extent of adjustment costs across industries would be of considerable value for tax incidence analysis.

VI. CONCLUSIONS AND DIRECTIONS FOR FURTHER RESEARCH

The simulation experiments presented above illustrate the importance of incorporating forward-looking investment behavior and accounting for short-run immobilities in general equilibrium policy evaluation models. The incidence patterns revealed by these simulations are consistent with economic theory and yet would not have emerged from models with perfectly mobile capital or static expectations. The results also highlight the significance of distinguishing taxes on new capital from those on existing capital.

One important result emerging from our simulations is that a combined policy involving the elimination of the investment tax credit and the reduction of corporate taxes generates windfalls to capital owners yet produces no favorable effect on capital accumulation. This result may be promoted by the recently enacted tax reform package, which also combines these (and other) tax changes.

We also observe significant differences across sectors in the effects of various tax policy changes. For example, reducing the corporate income tax stimulates investment and raises firm values for most sectors, but has adverse consequences for the housing sector, particularly in the short run. These different effects are largely attributable to the existence of costs of adjustment which prevent the benefits of reduced corporate taxes from being immediately shared with the (largely unincorporated) housing sector. The model indicates that reducing the corporate tax from 46 to 34 percent would lower the stock value of housing capital by approximately 1.3 percent in the short run.

The current model allows for several natural extensions. First, it would be useful to disaggregate the capital goods producing industry and allow for different types of capital goods. Distinguishing structures from equipment would be particularly worthwhile, allowing for analysis of the effects of tax policy on the asset composition, as well as the industry composition, of investment.

Incorporating liquidity constraints in the treatment of household behavior also seems a worthwhile enterprise. Because these constraints are absent in the current model, it may overstate the importance of wealth effects on consumption and understate the potential effects of policy changes on interest rates.

Finally, expanding the treatment of the foreign sector might yield significant rewards. The current model treats somewhat primitively the interactions between domestic tax policy and the behavior of the foreign sector. In the model, the effects of domestic tax initiatives on interest rates occur mainly through the interactions of domestic saving and investment. Recent experience demonstrates that changes in the supply of funds from foreigners significantly influence U.S. interest rates. Thus one profitable investment in model development might be to expand the current model to capture the principal determinants of current and capital account flows.

FOOTNOTES

1. Shoven and Whalley (1984) provide an excellent survey of computable general equilibrium models applied to tax incidence and other issues.

2. Much of this section is taken from Summers (1985).

3. Under external adjustment costs, the costs of adjustment are borne through payments to an agent (for example, an enterprise providing installation services) external to the firm. Under internal adjustment costs, the costs of adjustment take the form of reduced productiveness of the firm's own factors of production. For a discussion of the different economic implications of the two types of adjustment costs, see Mussa (1978).

4. Notice that the 1981 TEFRA tax legislation had as centerpiece a program of accelerated depreciation which reduced the acquisition cost of purchasing new capital goods. The analysis here implies that it should have had an ambiguous effect on the stock market.

5. This expression for V is derived in Poterba and Summers (1985).

6. An alternative is to incorporate external adjustment costs, as described in footnote 2.

7. The quantity of labor demanded should yield a value marginal product equal to the wage. This quantity of labor, combined with the current stock of capital, implies a particular level of value added. The ratio of value added to intermediate inputs is constant given the fixed coefficient nature of the technology, and thus the optimal intermediate input levels can be derived from K and L.

8. Thus, in the housing industry, we adopt an alternative approach to the

marginal source of finance. Dividends are determined according to:

$$DIV = EARN + BN - IEXP$$

9. For the housing sector, we define

$$\tau_{h1} = s_1\tau$$

$$\tau_{h2} = s_1\tau + (1-s_1)\tau$$

as the effective tax rates for profits and interest payments, respectively, in that sector. Here s_1 is the share of housing services value added produced by corporations. We then express after-tax earnings in this sector as

$$EARN = [pF(K,L,M) - wL - P_M M](1-\tau_{h1}) - iDEBT(1-\tau_{h2}) + \tau_{h1}D$$

The adjusted rate τ_{h1} accounts for the fact that the implicit rentals from owner-occupied homes and the rentals from non-corporate tenant-occupied housing escape taxation at the industry level. This rate also is appropriate for determining depreciation deductions ($\tau_{h1}D$) in this sector. The rate τ_{h2} acknowledges the fact that interest payments made by non-corporate housing can be expensed at the personal income tax rate. The resulting expression for Q for this sector is also slightly different from that of equation (13). Solving the optimization problem yields

$$Q = [(\frac{1-c}{1-\tau_{h3}})(\frac{V-B}{p_K K}) - 1 + b + ITC + Z]\frac{p_K}{(1-\tau_{h1})p}$$

where τ_{h3} is the effective tax at the individual level on returns from the housing sector.

10. The capital asset pricing model asserts that the risk premium for a given industry is the product of the industry beta and the excess return on the average market portfolio. From Fullerton and Gordon we derive the equity betas and the average excess return.

11. The simulation procedure involves the solution of the general equilibrium model under steady-state constraints. In the constrained system we iterate over capital stocks as well as prices to obtain a general equilibrium in which the derived industry Q's are equal to the steady-state values.

12. We generally require the corresponding lead and derived values to differ by no more than .1 percent.

13. Another algorithm for solving this type of intertemporal problem is the multiple shooting algorithm presented in Lipton et al (1982). However, the multiple shooting algorithm is significantly more difficult to implement than the Fair-Taylor-type algorithm that we have employed. In addition, with the large dimensionality of the intertemporal problem that we face, multiple shooting is likely to be more costly in terms of computation time.

14. The combined policy is revenue-gaining in the first period and revenue-losing in periods 2-5. Over the first five periods the present value of the lump-sum adjustments necessary to maintain benchmark tax revenues is approximately zero.

15. For example, the combined policy of doubling the ITC and raising corporate taxes has some unfavorable consequences in the short run if it is anticipated. When we simulate this policy change as anticipated three years prior to its implementation, aggregate investment drops by approximately 1.5 percent (relative to the base case) in each of the three periods immediately preceding implementation. Once the policy takes place, investment rises relative to the base case.

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Appendix: Deriving Q, Z, and HW from Lead Values

Z

The variable Z_t represents the present value of depreciation allowances, evaluated at time t, per dollar of new investment. In discrete time we may write Z_t as

$$\text{(A-1)} \quad Z_t = \delta^T \sum_{s=t}^{\infty} \frac{(1-\delta^T)^{s-t} \tau_{s+1}}{\prod_{u=1}^{s} (1+r_u)}$$

where δ^T is the depreciation rate for tax purposes and r_t is the rate of return over the interval from period t to period t+1. Evaluating Z over two successive time periods yields the relationship:

$$\text{(A-2)} \quad Z_t = \frac{1-\delta^T}{1+r_t} Z_{t+1} + \frac{\delta^T \tau_{t+1}}{1+r_t}$$

This relationship is employed to determine the current period Z on the basis of a guessed value for the next period.

Q

The determination of Q_t requires more steps. First, an initial guess I^*

is made of current investment. Using this guess it is possible to derive the nominal depreciable capital stock, KDEP, for the next period, based on the relationship

$$(A-3) \quad KDEP_{t+1} = (1-\delta^T)KDEP_t + p_{K_t} I^*_t$$

The values of B and Z for a given period are related according to

$$(A-4) \quad B_t = (1 - \delta^T)KDEP\ \omega[Z_t + \delta^T \frac{\tau_t}{1 - \delta^T}]$$

Using (A-3) and (A-4) it is possible to determine B_{t+1} on the basis of I^*_{t+1} and Z^*_{t+1}. The guess of investment allows us to calculate dividends and new share issues in the current period based on current prices and taxes. The arbitrage condition expressed by equation (3) implies a relationship for the values of V across successive periods:

$$(A-5) \quad V_t = \frac{(1-c)(V_{t+1}-VN_t) + (1-\theta)DIV_t}{1 - c + r_t}$$

Using the lead value V^*_{t+1}, and the relationship in (A-5), we calculate the current value for V. Then, using he derived values for V_t, B_t, and Z_t, we calculate the current value of Q using (13). This value of Q implies a certain level of investment. If this value does not match the initial guess of investment which helped to generate it, the initial guess is updated and the entire sequence of derivations is performed again. This procedure is repeated until the initial investment guess matches the derived investment level.

HW

Evaluating HW over two successive periods yields

$$(A\text{-}6) \quad HW_t = \hat{w}_t L_t + TR_t + \frac{HW_{t+1}}{1 + \hat{r}_t}$$

Thus, HW_t can be calculated based on a lead variable for HW_{t+1} and variables observed in period t.

Figure 1

Dynamics of Investment and Market Valuation

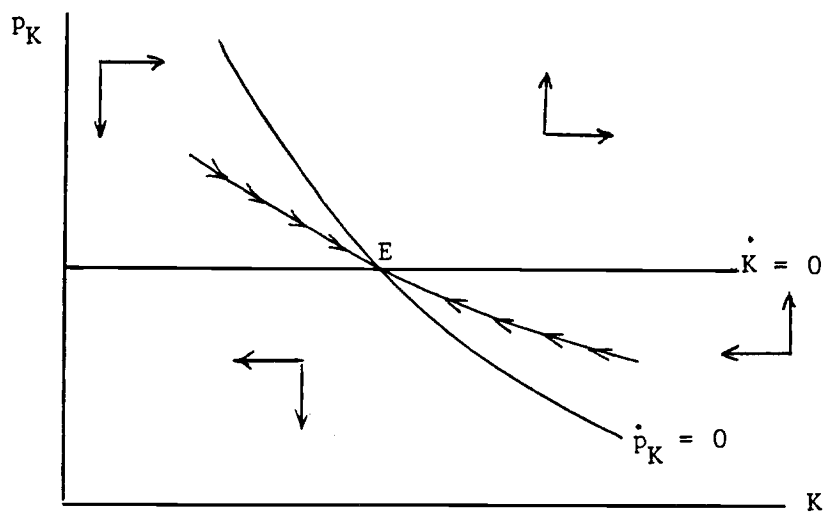


Figure 2

Response to a Capital Tax Increase

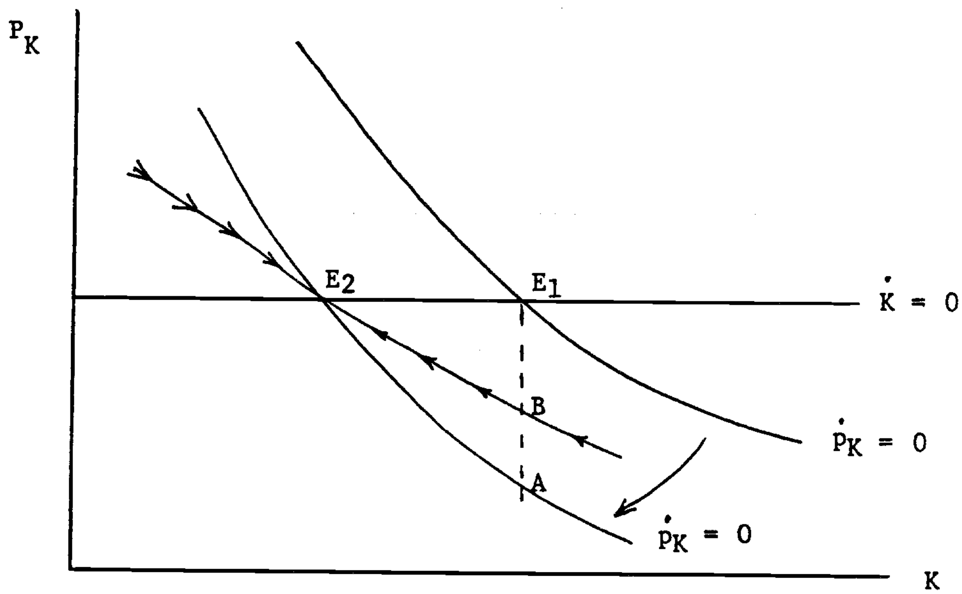


Figure 3

Response to an Investment Subsidy

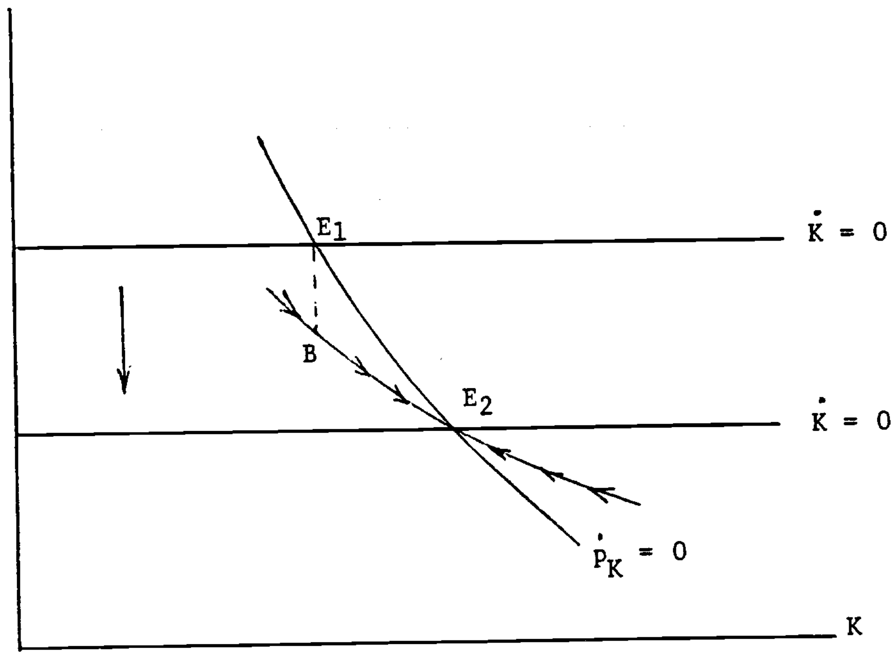


Table 1

Model Treatment of Taxes

Tax	Treatment in Model
1. Corporate income tax	Ad valorem tax on profits by industry; bond interest payments are expensed
2. Property tax and corporate franchise taxes	Ad valorem tax on capital stocks by industry
3. Investment tax credits	Ad valorem subsidy to investment by industry
4. Depreciation deductions	Tax credit based on the value of depreciable capital stock, tax depreciation rate, and corporate income tax rate
5. Contributions to Social Security, Unemployment Insurance, and Workmen's Compensation	Ad valorem tax on the use of labor services by industry
6. Motor vehicles tax	Ad valorem tax on the use of motor vehicles by industry
7. Excise taxes, other indirect business taxes, and nontax payments to government	Ad valorem taxes on output of producer goods
8. Retail sales taxes	Ad valorem tax on purchases of consumer goods
9. Personal income taxes (including state and local)	Linear function of labor and capital income (net of capital gains taxes)
10. Social Security benefits, unemployment compensation, and other transfers	Lump-sum income transfer constituting a fixed share of overall government spending

Table 2

Benchmark Values for Industry Tax and Behavioral Parameters

Parameter	(1) Agri-culture and Mining	(2) Manufac-turing	(3) Energy	(4) Services, Trade and Utilities	(5) Housing Services
rate of economic depreciation (δ^R)	.010	.089	.052	.067	.014
rate of tax depreciation (δ^T)	.179	.119	.100	.103	.070
equity risk premium (η)	.118	.062	.074	.083	.100
effective investment tax credit rate (ITC)	.072	.073	.033	.071	.0
debt-capital ratio (b)	.143	.153	.145	.422	.502

scalars:

corporate tax rate (τ)	0.46
capital gains tax rate (c)	0.05
marginal income tax rate (θ)	0.254
steady-state growth rate (g)	0.03
inflation rate (π)	0.062
nominal interest rate (i)	0.073
adjustment cost parameters	
γ	0.076
β	19.6

Table 3[1]

Base Case Values for Each Industry

	(1) Agriculture and Mining	(2) Manufac-turing	(3) Energy	(4) Services, Trade and Utilities	(5) Housing Services	Total
X	396.8	2,810.3	164.3	2,582.9	375.4	6,329.7
K	288.3	820.7	425.8	2,504.8	3,275.6	7,315.2
L	63.2	777.3	18.8	1,072.3	6.4	1,938.0
Adjustment Costs	8.2	15.1	1.1	10.6	2.5	37.4
KDEP	137.1	461.0	179.0	1,232.9	881.0	2,891.0
V	350.0	926.1	367.0	1,535.1	2,158.6	5,336.8
Z	0.348	0.310	0.292	0.295	0.006	
B	41.4	126.3	45.3	308.8	5.6	527.4
Q	1.057	0.851	0.320	0.407	0.173	
"Tobin's Q"[2]	1.137	1.281	1.007	1.035	1.161	
I	37.5	98.0	34.7	242.3	144.1	556.6
Bond Interest Paid	2.8	8.4	4.1	70.6	109.0	195.8
EARN	72.8	120.2	47.9	225.1	151.3	617.3
DIV	38.6	38.2	23.0	58.7	149.7	287.5
DIV/V	0.110	0.041	0.063	0.038	0.069	0.054
Retained Earnings	31.6	76.9	25.5	166.6	3.0	303.6
Borrowing	3.2	13.9	8.1	19.4	141.1	185.7
Corporate Taxes Paid[3]	32.6	44.4	25.0	66.8	0.7	169.5

1. To facilitate comparisons with recent historical values, we have scaled up the 1973 benchmark values to 1985 levels by multiplying the original 1973 values by the ratio of 1985 to 1973 nominal GNP. All values in the table are expressed in billions of 1985 dollars. Benchmark prices are equal to unity; thus the figures given for quantity variables X, K, L, and I can be interpreted either as values or as quantities.

2. Defined as $V/(P_K K) + b$; base case p_K is equal to 1.

3. Net of depreciation deductions and the investment tax credit.

Table 4

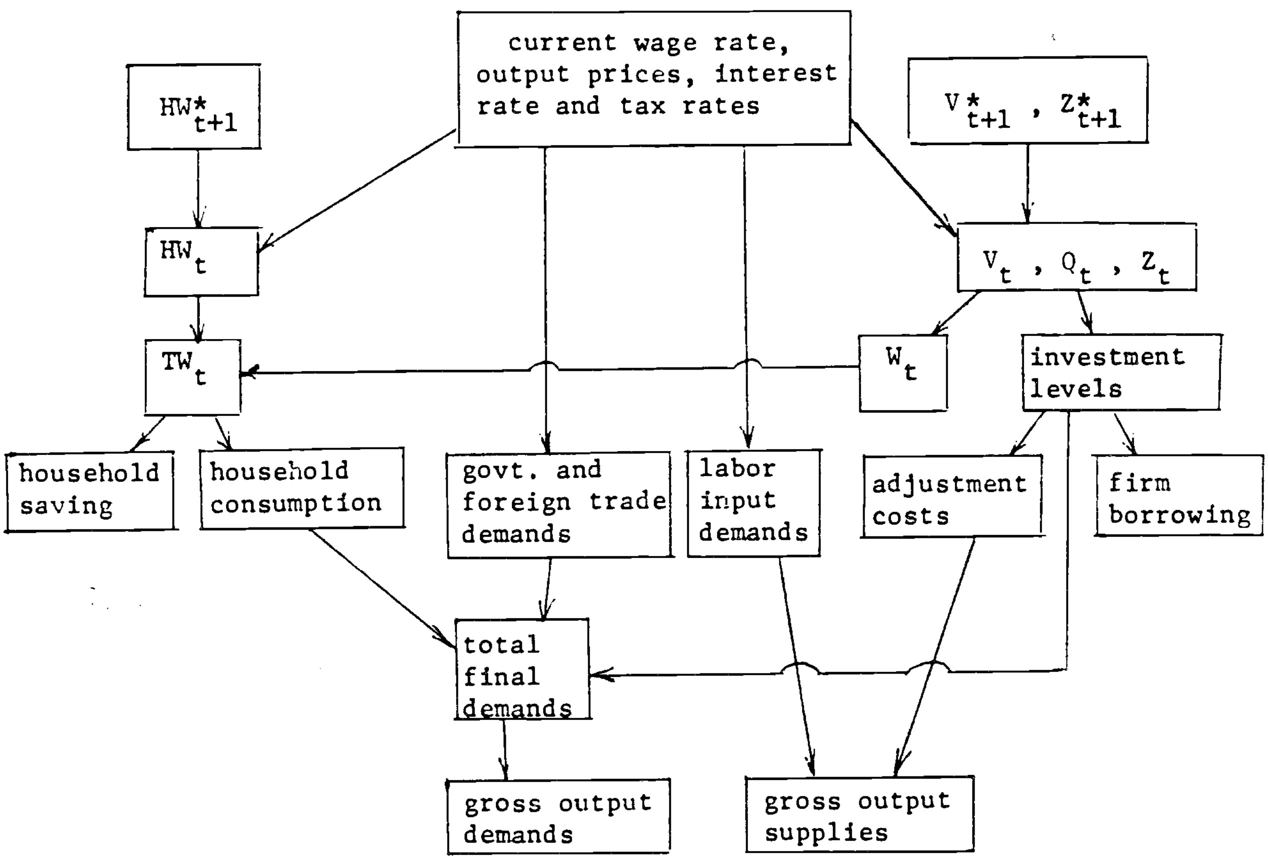
Base Case Wealth, Income, Saving, and Consumption[1]

Total Private Wealth (TW)	260,075
Non-human Wealth (W + YK)[2]	9,178
Human and Transfer Wealth (HW)	250,898
Household Income[3]	
Labor Income	2,344
Capital Income[4]	526
Taxes Paid	366
Transfers Received	320
Total Private Saving	552
Industry Retained Earnings	304
Household Saving	248
Household Consumption	2,575

1. All values have been scaled to 1985 levels (see Note 1 from Table 3) and are expressed in billions of 1985 dollars.
2. Includes value of privately owned capital employed by government.
3. Income figures are gross of personal income taxes.
4. Includes implicit rentals from owner-occupied housing.

Figure 4

Outline of Within-Period Solution Structure



Within-Period Equilibrium Conditions

aggregate labor demand = aggregate labor supply
gross output demand = gross output supply (for each sector)
firm borrowing = household saving
government spending = government revenue

Intertemporal Equilibrium Conditions

$HW_t^* = HW_t \quad , \quad t = 2,3,\ldots,T$

$V_t^* = V_t \quad , \quad t = 2,3,\ldots,T$

$Z_t^* = Z_t \quad , \quad t = 2,3,\ldots,T$

$HW_{T+1}^* = HW_{ss}$

$V_{T+1}^* = V_{ss}$

$Z_{T+1}^* = Z_{ss}$

Table 5

Results from Alternative Tax Policy Experiments[1]

	Corporate Tax Cut						ITC Elimination						Combined Corp. Tax Reduction and ITC Elimination			Doubling of Gasoline Tax		
	Suprise			Announced			Suprise			Announced								
Period	1	5	SS	1	5	SS	1	5	SS	1	5	SS	1	5	SS	1	5	SS
Investment																		
sector 1	4.06	4.97	7.63	7.76	5.58	7.63	-5.84	-6.72	-9.99	-1.49	-6.26	-9.99	-1.26	-1.46	-2.72	0.21	0.21	0.13
2	4.91	5.97	9.15	9.26	6.61	9.15	-6.90	-8.02	-12.13	-1.95	-7.37	-12.13	-1.46	-1.71	-3.24	0.31	0.31	0.21
3	5.96	6.41	7.77	7.10	6.74	7.77	-3.00	-3.74	-6.28	-0.67	-3.29	-6.28	2.86	2.51	0.99	-7.25	-6.80	-6.02
4	1.72	2.44	5.68	4.34	2.98	5.68	-7.78	-9.25	-15.17	-1.61	-8.51	-15.17	-5.10	-5.79	-8.64	0.20	0.17	-0.01
5	-1.19	-0.59	0.90	-2.13	-0.19	0.90	1.87	1.28	-1.42	0.27	1.62	-1.42	0.61	0.64	-0.29	0.77	0.73	0.56
Earnings After Tax																		
sector 1	16.35	16.02	15.46	2.52	15.70	15.46	-1.93	-2.09	-2.79	-0.51	-2.02	-2.79	12.81	12.66	11.53	0.21	0.21	0.14
2	12.82	13.18	14.08	0.98	13.32	14.08	-0.95	-1.89	-4.93	-0.26	-1.41	-4.93	10.74	10.45	8.65	0.38	0.36	0.18
3	14.91	13.73	10.50	0.60	14.00	10.50	0.39	-0.57	-2.57	0.08	-0.06	-2.57	13.93	12.05	7.57	-10.62	-9.72	-5.84
4	8.76	10.10	12.15	-1.01	10.54	12.15	0.90	-0.54	-3.66	0.14	0.17	-3.66	9.02	9.19	8.86	0.45	0.34	-0.05
5	-4.53	-1.66	1.39	-6.08	-0.58	1.39	6.14	3.73	-2.21	1.21	5.19	-2.21	1.38	1.88	-0.64	2.12	1.80	0.58
Asset Value of Firms																		
sector 1	19.71	19.85	20.40	12.15	19.82	20.40	-1.45	-1.86	-3.60	-1.81	-1.65	-3.60	16.24	16.09	14.80	0.23	0.22	0.13
2	18.49	19.28	21.47	13.06	19.66	21.47	-1.76	-2.88	-6.81	-2.24	-2.23	-6.81	14.77	14.48	12.62	0.37	0.35	0.20
3	16.22	15.85	14.91	11.05	16.07	14.91	0.33	-0.39	-2.51	-0.69	0.06	-2.51	14.99	14.04	11.26	-8.28	-7.83	-6.00
4	16.55	17.38	19.23	11.82	17.81	19.23	-1.87	-3.04	-5.41	-2.69	-2.54	-5.41	12.89	12.73	12.61	0.35	0.25	-0.01
5	-1.33	-0.55	1.05	-2.65	-0.02	1.05	2.56	1.59	-1.77	0.38	2.16	-1.77	1.07	0.97	-0.48	1.24	1.09	0.56

[1] All figures are percentage changes from the base case.

Figure 5a

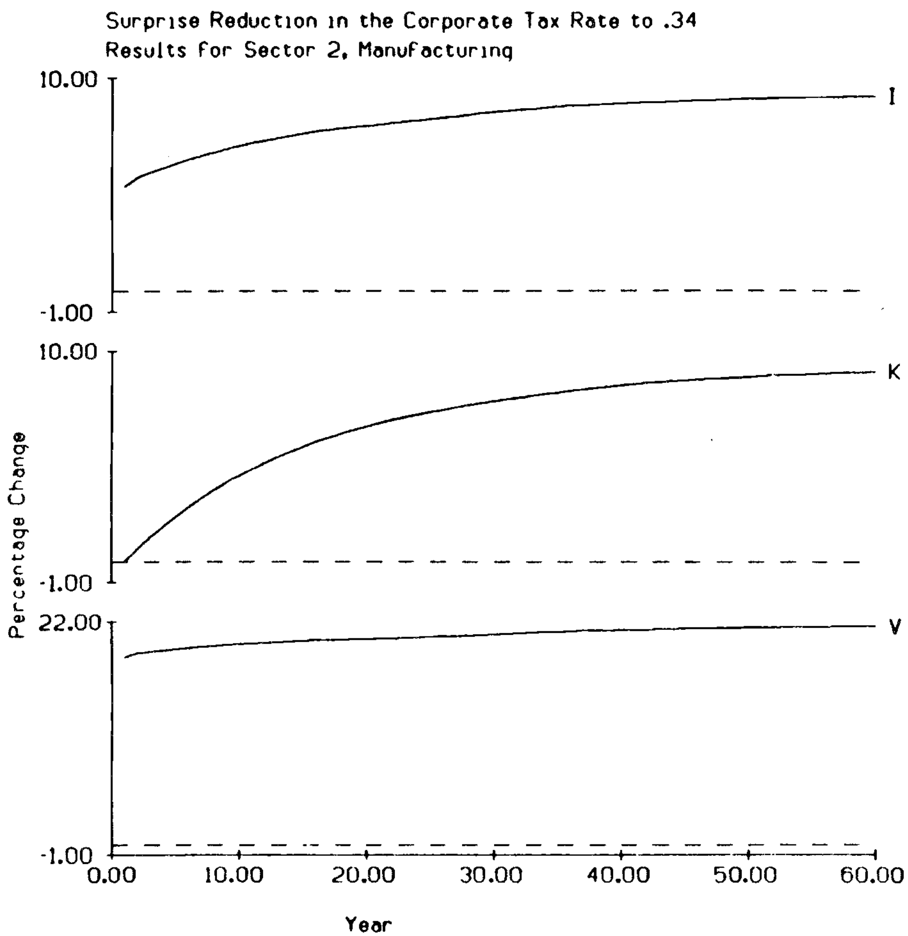


Figure 5b

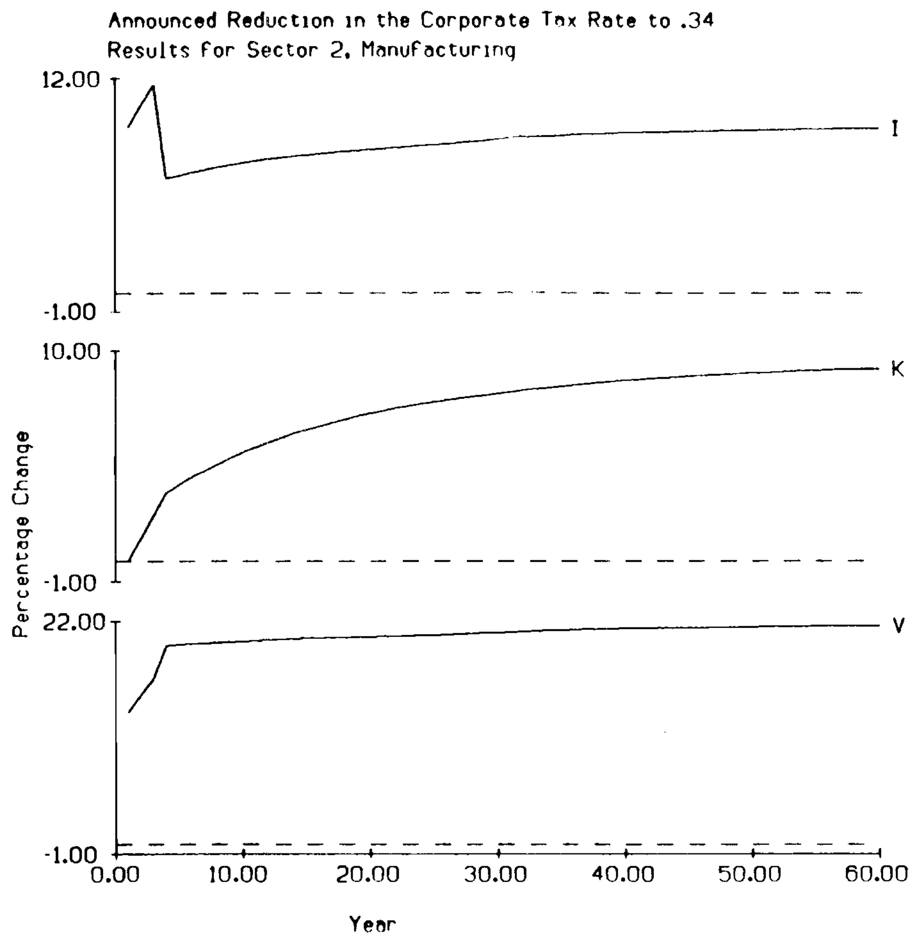


Figure 6a

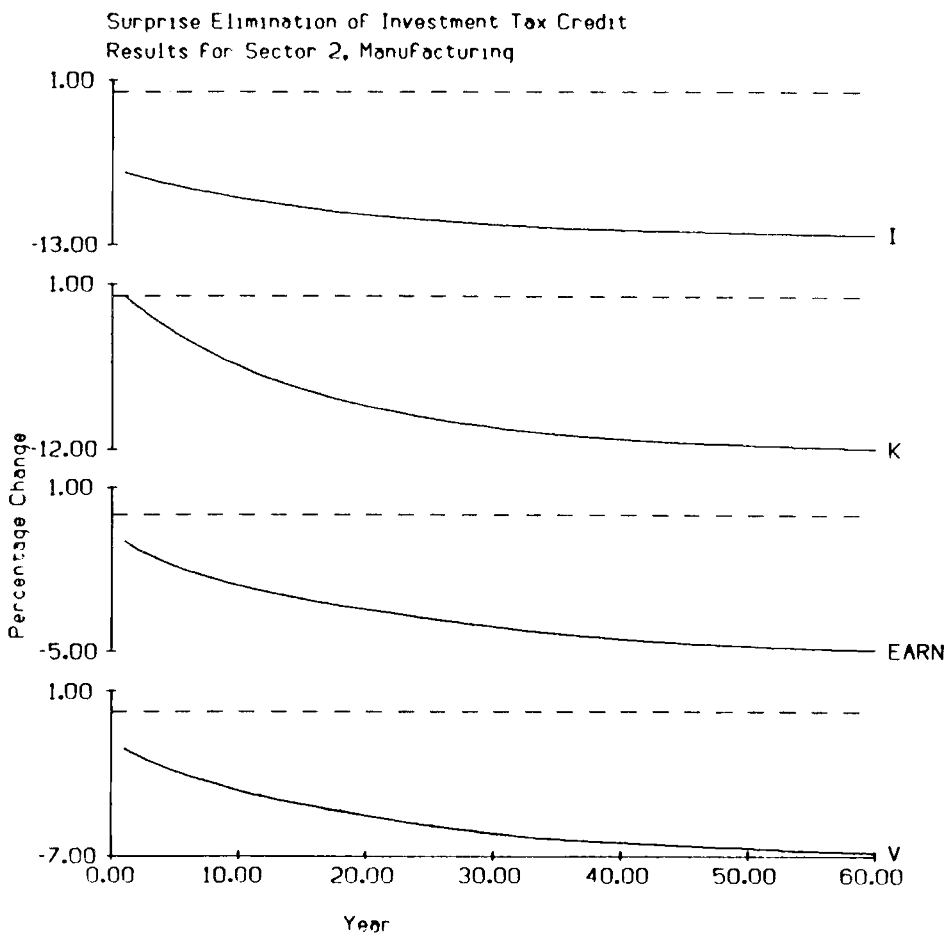


Figure 6b

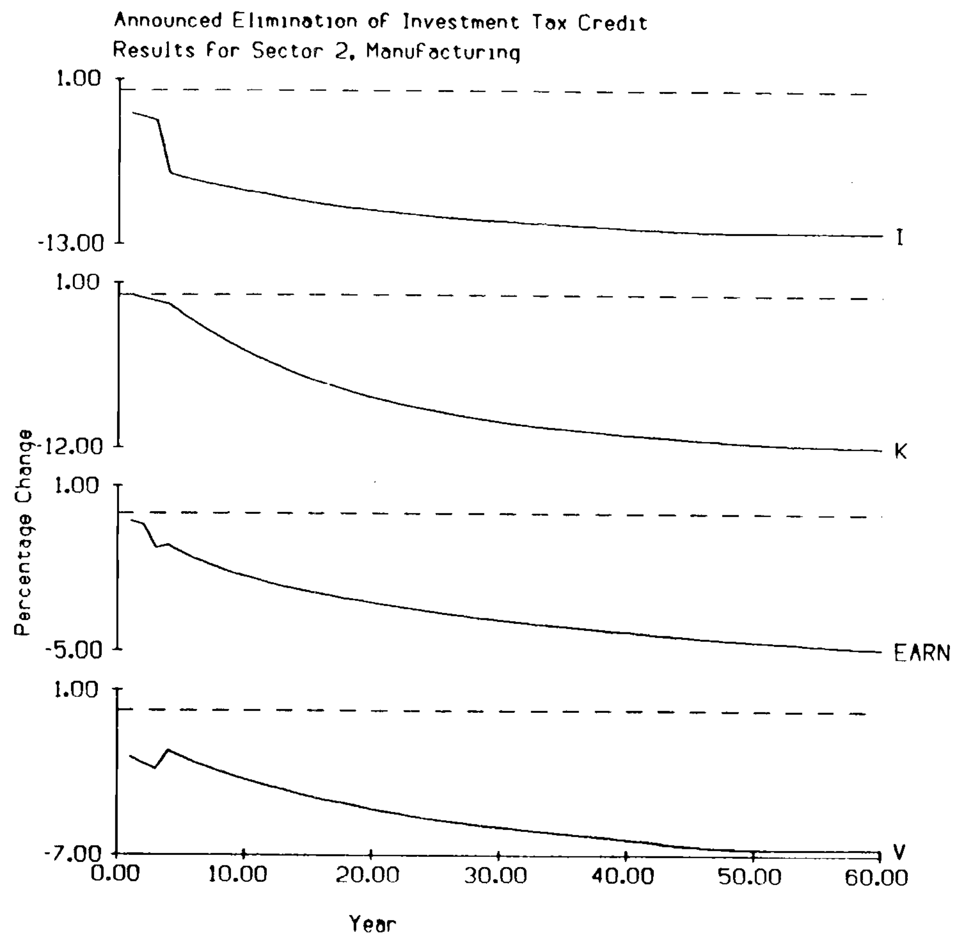


Figure 7

Surprise Reduction in the Corporate Tax Rate and Elimination of ITC
Results for Sector 2, Manufacturing

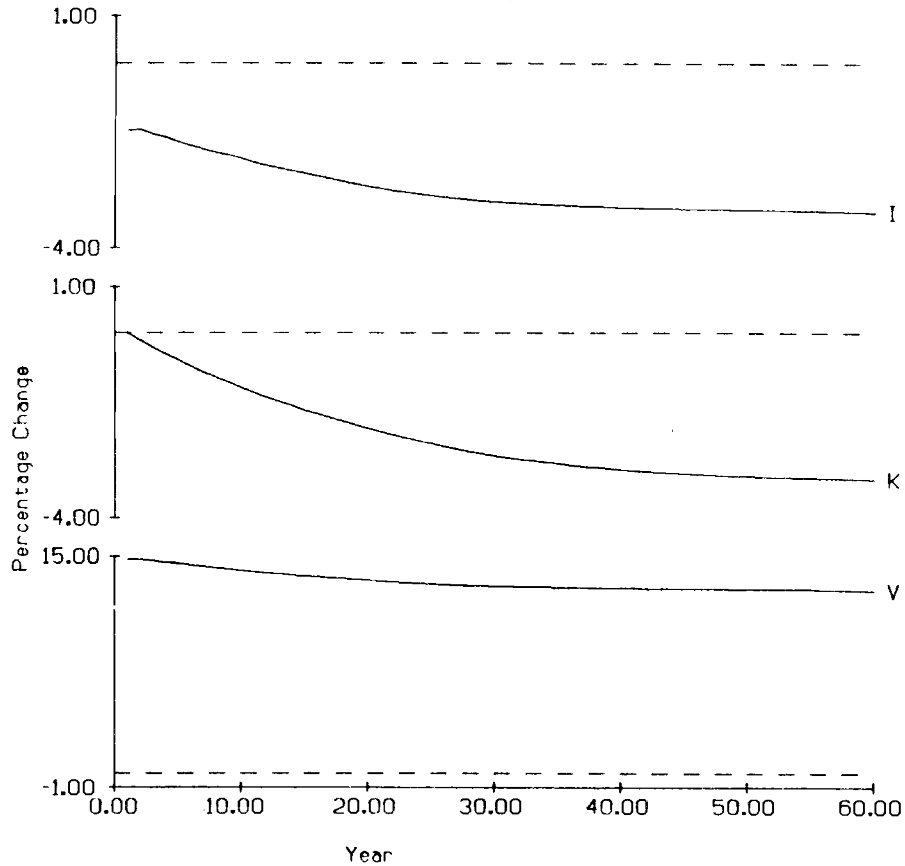


Figure 8a

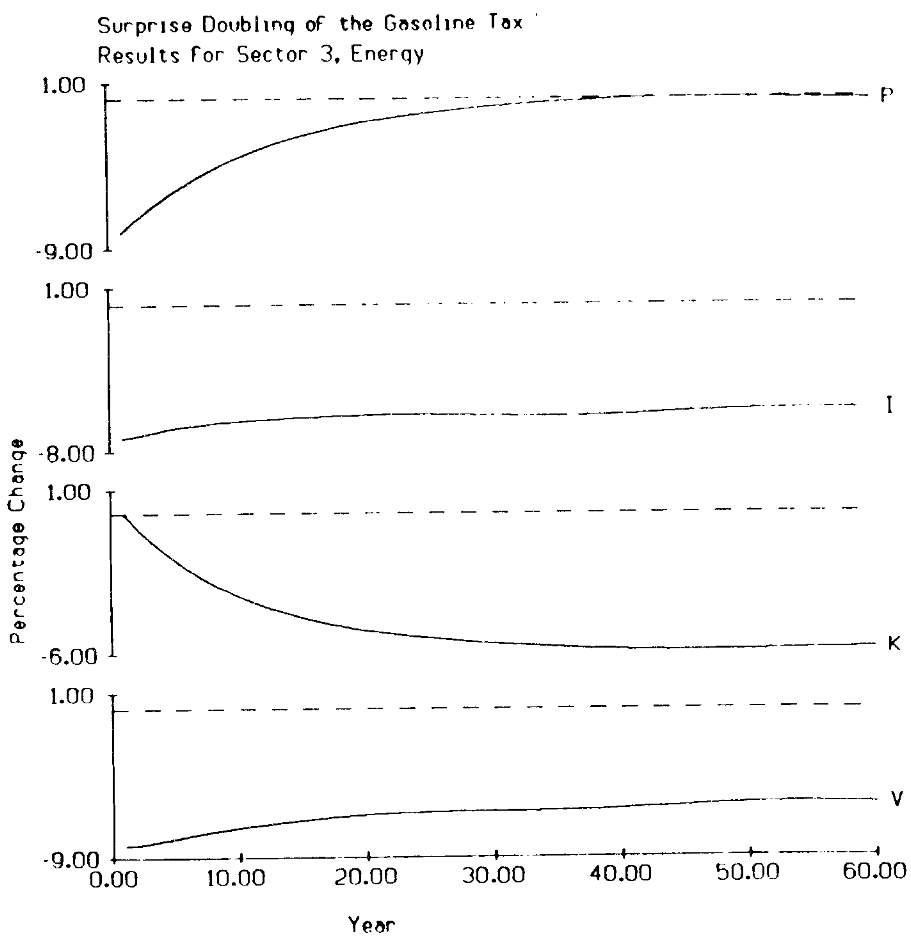


Figure 8b

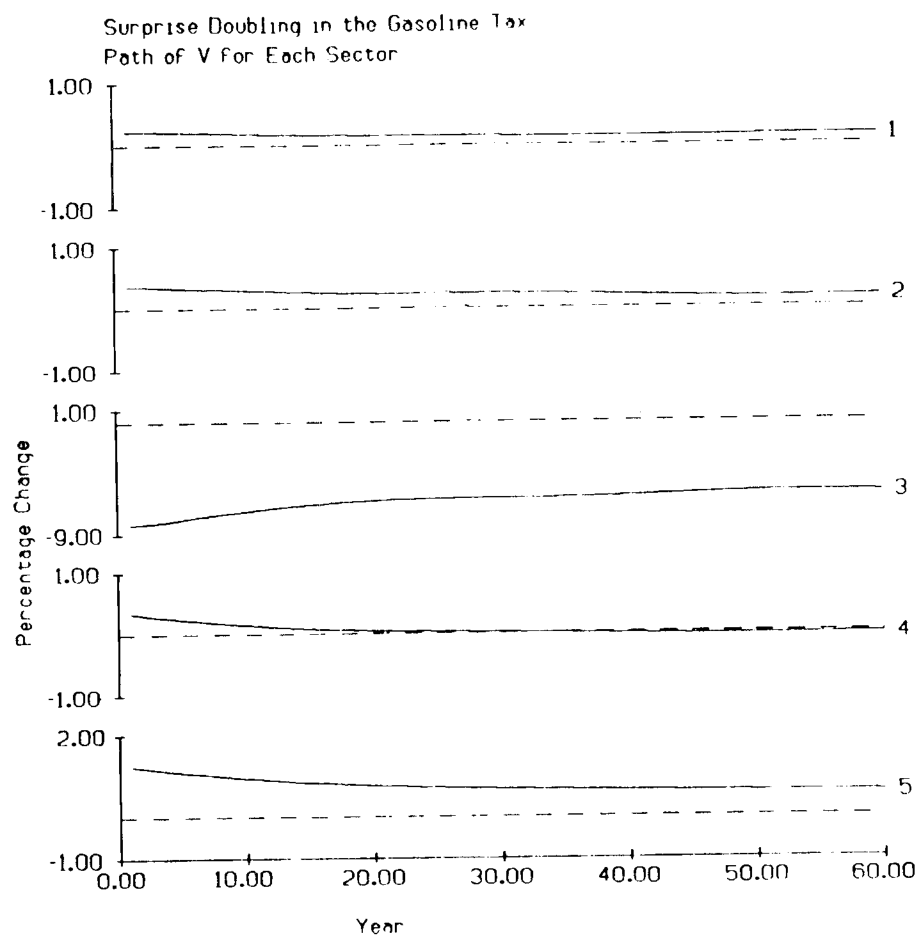
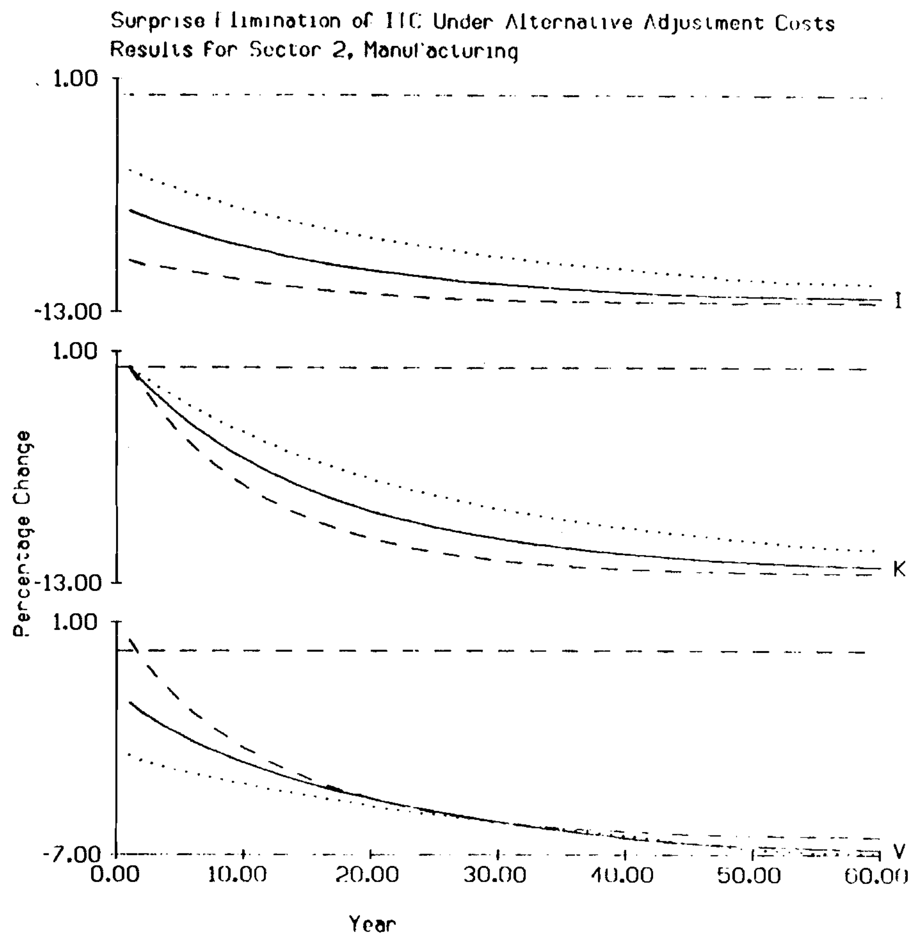


Figure 9



Surprise Elimination of ITC Under Alternative Adjustment Costs
Results for Sector 2, Manufacturing
1.00
-13.00
I
1.00
-13.00
K
1.00
-7.00
V
Percentage Change
0.00
10.00
20.00
30.00
40.00
50.00
60.00
Year