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Corporate taxation and the efficiency gains of the 1986 Tax Reform Act*

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Summary. The 1986 Tax Reform Act (TRA) had little effect on the overall U. S. effective capital income tax rate. However, TRA significantly reduced differences in effective taxation of corporate and noncorporate capital for a number of U. S. industries. The Mutual Production Model developed in Gravelle and Kotlikoff (1989) can be used to study the efficiency gains from the reduction in corporate tax wedges within industries. Unlike the Harberger Model, the Mutual Production Model permits both corporate and noncorporate firms to produce the same goods and, therefore, to coexist within a given industry.

This paper develops an 11-industry-55-year dynamic life cycle version of the Mutual Production Model. We use this model to study the steady-state efficiency gains associated with the new law. While we do not simulate the economy's transition path, our steady-state welfare changes are those that arise from compensating transitional generations for the first-order redistribution of income associated with the Tax Reform.

We find that the 1986 Tax Reform law reduces excess burden by .85 percent of our model's economy's present value of consumption. This efficiency gain reflects the Tax Reform's reduction in corporate-noncorporate tax wedges, particularly in those industries with significant noncorporate production. Measured as a flow the 1988 estimated efficiency gain from the Tax Reform Act is $31 billion.

I. Introduction

The 1986 Tax Reform Act represented a sweeping change in tax law. While the dramatic reductions in personal tax rates have received most of the attention, the new law also greatly altered corporate tax wedges. In some industries, such as

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agriculture, the new tax law reduced by over one quarter the difference between marginal taxation of corporate and noncorporate capital income. In other industries, such as mining, the corporate tax wedge actually increased.

Conventional wisdom, that relies on various incarnations of the Harberger (1962, 1964, and 1966) Model, suggests rather small efficiency effects from these changes in corporate tax wedges. But the Harberger model appears to understate greatly the efficiency effects of changes in the corporate tax wedge for the following reason: the Harberger model does not admit production of the same good or collection of goods by both corporate and noncorporate firms. Empirical applications of the Harberger model finesse the production by both corporate and noncorporate firms of the same good by treating all firms within an industry as identical firms facing the industry-wide average rate of taxation. This procedure misses entirely differences within industries in the tax treatment of corporate and noncorporate firms.

In Gravelle and Kotlikoff (1988, 1993) we present two models in which corporate and noncorporate firms coexist within the same industry. These two 2-sector models have different structures, but their common characteristic – a very high\infinite within-industry elasticity of substitution between corporate and noncorporate output – implies an excess burden from corporate taxation that is many times larger than that predicted by the Harberger model. The new models suggest that the efficiency gains from changes in corporate tax wedges in the 1986 Tax Reform Act may be much larger than those previously estimated (see Fullerton, Henderson, and Mackie, 1987).

This paper develops an 11-sector, 55-year dynamic life cycle version of the Gravelle-Kotlikoff (1989) model and uses this model to study the efficiency effects of changes in corporate tax wedges under the new law. Our model suggests that the 1986 Tax Reform Act reduced the excess burden of the U. S. tax structure by .85 percent of the present value of consumption. On an annual basis this gain is $31 billion based on the 1988 level of U. S. consumption.

This paper's model features mutual production of the same good (collection of goods) by corporate and noncorporate firms in 8 of 11 industries. In these industries there is an upward sloping supply of noncorporate output reflecting the less than perfectly elastic supply of entrepreneurial talent available for running noncorporate enterprises. Increases in corporate tax wedges within these industries lead existing proprietors to expand their output and lead less able entrepreneurs to establish proprietorships in these industries. But noncorporate production does not drive out corporate production. While they are at a tax disadvantage, corporations are still able to compete with the less able entrepreneurs. A second feature of the model, namely the requirement that corporate firms produce above a minimum scale, ensures that corporate production cannot be repackaged into small proprietorships and thereby avoid the corporate tax. These two features notwithstanding, corporate and noncorporate firms in each of the 8 mutual production industries produce with the same constant returns to scale production function.

Gravelle and Kotlikoff (1989) present data showing that corporations coexist with noncorporate firms in every two digit industry and in all three digit industries

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for which data is available. (Noncorporate production is, however, negligible in the utilities and manufacturing industries.) Moreover, in many of these industries there has been a substantial change in the share of corporate production over time, indicating considerable scope for substitution between the two forms of production. These data suggest that corporate and noncorporate production of the same (or essentially the same) goods is a common occurrence in the economy. Further industrial disaggregation (which is not feasible given existing data) might reveal that mutual production is confined to a certain subset of commodities within three digit industries. But Gravelle and Kotlikoff (1989) point out the applicability of their model also to settings in which not all goods are produced by noncorporate firms, provided that those goods that are produced by noncorporate firms are also produced by corporations. It is hard to think of goods produced by noncorporate firms that are not also produced by corporations.

In addition to permitting mutual production of the same good by corporate and noncorporate firms, the new model has a number of advantages compared to our previous models and, in many cases, compared to the literature. First, the model merges statics with dynamics through a 55-year life cycle model of intertemporal choice. Second, it uses a fixed coefficient input-output table to take account of intermediate inputs. Third, it deals explicitly with depreciation, a factor that can alter efficiency calculations. Fourth, it takes account of personal as well as corporate marginal taxation of capital income. Fifth, it takes account of differences across industries in marginal corporate tax wedges. Sixth, it models owner-occupied housing as a separate industry whose sole input is noncorporate capital. And seventh, it takes account of the use and production of different types of capital goods.

In any intertemporal model of the kind considered here one must be concerned not to confuse intergenerational redistribution with economic efficiency. Auerbach and Kotlikoff (1987) demonstrate, that unless one properly accounts for intergenerational redistribution, steady-state utility changes may largely reflect redistribution rather than efficiency changes. In this paper we develop a variant of Auerbach's (1989) method of separating efficiency from redistribution.

Our procedure entails compensating, in a lump-sum manner, each generation (initial, transitional, and new steady-state generations) for the first-order income changes they experience as a consequence of the intergenerational incidence of policy changes. In addition, our compensation scheme has the feature that the efficiency gains from the tax reform are distributed to initial, transitional, and final steady-state generations in proportion to their initial consumption.[1] This method of

[1] Auerbach distributes efficiency gains to each initial young generation, thereby leaving the initial old generation's welfare unchanged. In contrast, we allocate the efficiency gain all generations, including the initial old generation, in proportion to their initial consumption. Clearly, the steady-state change in utility arising from a tax reform will differ as between Auerbach's method and our own. The advantage of distributing the efficiency gain in proportion to consumption is that the steady-state change in utility, measured as a fraction of the present value of steady-state consumption, will equal the steady-state value of the present value of the economy's current plus future efficiency gain divided by the present value of the economy's current plus future consumption; i.e., one can read off the aggregate economy's efficiency gain from tax reform by simply considering what happens to individual steady-state welfare. Gravelle (1989a) also discusses the issue of how to allocate efficiency gains.

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compensation has two advantages. First, it appears to mitigate differences in welfare changes between transitional and final steady-state generations, which is important given that we only simulate steady states in this paper. Second, ignoring transitional differences in welfare changes, the change in welfare of a representative individual alive in the new steady state, measured as a fraction of the present value of his lifetime consumption, equals the ratio of the present value of the economy's total (transitional plus new steady state) efficiency gain from tax reform to the present value of the economy's total (transitional plus new steady state) consumption. Thus, ignoring transitional differences, the percentage change in individual welfare also equals, and thus provides the correct measure of, the aggregate economy's efficiency gain.

In contrast to the model developed here our earlier models were limited to two sectors. There were no intermediate goods, and we used average rather than marginal corporate tax rates. The results derived from these models were compared to Harberger's (1966) and Shoven's (1976) two sector models, neither of which permit mutual production. Our earlier models produced efficiency costs of corporate taxation at least seven times as large as those of Harberger and Shoven. Some of the features in the present model are similar to those which transformed the simple two-sector Harberger model into a large-scale numerical simulation model. Shoven and Whalley (1972) and Shoven (1976) developed multi-sector versions of the Harberger model with different types of consumers. Fullerton, Shoven and Whalley (1983), Ballard, Fullerton, Shoven, and Whalley (1985), Fullerton and Henderson (1989), and Fullerton, Henderson, and Mackie (1987) introduced marginal tax rates, intermediate goods, personal taxes, saving and labor supply responses, and inter-asset distortions.[2]

Despite the many innovations in modeling the corporate tax, static welfare gains continued to be estimated by these studies at about the same magnitude. For example, Fullerton and Henderson (1989) find the total welfare gain from eliminating these distortions to be in the neighborhood of .5 percent of GNP or less-amounts quite similar to those reported by Harberger (1966). Our estimated gain, even under conservative assumptions, is four times as large. Our gains from the Tax Reform Act are also about four times the magnitude of those found by Fullerton, Henderson, and Mackie (1987), based on their estimates using the traditional view of dividends employed in this study. Since the tax rates we use are quite similar, these differences in welfare gain are due to the different modeling of the within-industry substitution between corporate and noncorporate production.

The paper proceeds in the next section II, with a description of the supply equations of the model. Section III presents the demand side of the model. Section

[2] Our model does not consider the efficiency gain from reducing the distortion of firms' choices among assets. The size of these inter-asset distortions depend on the elasticities assumed. Gravelle's (1983) estimates of the efficiency gain from eliminating the distortions between equipment and structures is about $2 billion in 1988 dollars if unitary elasticities are assumed. About 90 percent of the .2 percent efficiency gain in Fullerton, Henderson, and Mackie (1987) appears to derive from inter-asset distortions within a firm; this would amount to about $8 or $9 billion. Their larger estimates reflect, in part, the use of a net production function (which does not account for depreciation) rather than a gross production function, which makes the capital stock much more responsive to changes in relative tax rates.

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IV provides the equilibrium conditions. Section V discusses the compensation scheme and develops our efficiency gains measure. Section VI presents results, and Section VII summarizes and concludes the paper. The Appendix describes the model's calibration and its method of solution.

II. The supply side of the model

A. Corporate production

The model has three factors of production: capital, labor, and managerial input (entrepreneurial input in the case of noncorporate firms). Each agent chooses whether to be a corporate manager, a worker, or an entrepreneur. There are 11 industries/sectors corresponding (in order 1 to 11) to rental housing, agriculture, mining, oil and gas, construction, transportation, services, trade, manufacturing, utilities, and owner-occupied housing. We discuss our modeling of owner-occupied housing, indexed as industry 11, below. The manufacturing and utility industries are totally corporate. The production functions for corporate firms in industries 1 to 10 are given in equation (1):

$$Q_{ci} = \min(1/\theta_i F_{ci}, 1/\Theta_i V_{ci}) \quad i = 1, 10 \tag{1}$$

In (1) Q_{ci} stands for corporate output in sector i. This output is determined by a production function that is fixed coefficients in a value added production function, F_{ci}, and the level of intermediate inputs indexed by V_{ci}. The terms θ_i and Θ_i are coefficients. The value added production function is given by:

$$F_{ci} = \begin{cases} f_{ci}(D_i M_{ci}, L_{ci}, K_{ci}) & M_{ci} \geq \underline{M}_{ci} \\ 0 & M_{ci} < \underline{M}_{ci} \end{cases} \quad i = 1, 10 \tag{2}$$

In (2) D_i is the managerial efficiency parameter in sector i. M_{ci} stands for corporate managers in sector i, L_{ci} stands for corporate labor in sector i, and K_{ci} stands for corporate capital in sector i. Corporate firms can only produce if they produce above a minimum scale, which we model in terms of a minimum number of managers, $\underline{M}_{ci}$. This constraint applies to each firm individually. It also applies to the industry as a whole since there is nothing to preclude a single corporate firm providing all of an industry's corporate output, provided the firm acts as a price taker.

Our purpose in adding this constraint (which, by the way, is not binding in our simulations) to the description of corporate technology is to preclude corporations from breaking up into single-manager entities which might then be indistinguishable from proprietorships to the tax authorities. Alternatively, we could simply assume that the tax authorities are able to distinguish corporate from noncorporate firms on the basis of the ability of corporate firms to expand their managerial input beyond a single manager.

The capital input, K_{ci}, represents a composite of three capital goods – structures land, equipment, and inventories – each of which is used in fixed proportions. The coefficients determining these proportions are, however, industry-specific. K_{ci} is

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defined by:

$$K_{ci} = \min(1/\psi_i S_{ci}, 1/\xi_i E_{ci}, 1/\omega_i I_{ci}) \quad i = 1, 10 \tag{3}$$

where S_{ci}, E_{ci}, I_{ci} are, respectively, structures/land, equipment, and inventories used in corporate production in sector i. The terms ψ_i, ξ_i, and ω_i are the industry-specific coefficients determining the capital composite.

The intermediate input used in the production of Q_{ci} also represents a fixed coefficients composite with industry-specific coefficients. Equation (4) defines the intermediate input:

$$V_{ci} = \min(1/v_{1i} Q^v_{1ic}, 1/v_{2i} Q^v_{2ic}, \ldots, 1/v_{10i} Q^v_{10ic}) \quad i = 1, 10 \tag{4}$$

In (4) the terms v_{ji} $(j = 1, 10)$ are input-output coefficients, and the terms Q^v_{jic} $(j = 1, 10)$ are the intermediate inputs of good j used in sector i by corporate firms.

Since the production relation (1) satisfies constant returns to scale, one can express corporate output per manager in industry i, q_{ci}, as well as intermediate input per manager, v_{ci}, in terms of corporate labor per manager, l_{ci}, and corporate capital per manager, k_{ci}, as in (5):

$$\begin{aligned} q_{ci} &= 1/\Theta_i h(D_i, l_{ci}, k_{ci}) \quad i = 1, 10 \\ v_{ci} &= \theta_i/\Theta_i h(D_i, l_{ci}, k_{ci}) \end{aligned} \tag{5}$$

B. *Noncorporate production*

Each agent in the economy can potentially become an entrepreneur in one of the 8 industries (indexed 1 to 8) that have noncorporate production; alternatively, the agent can be a manager or a worker. While all agents are equally productive as managers or workers, as entrepreneurs their productivity depends on their efficiency coefficient in the industry in which they choose to set up shop.[3] Each agent has eight efficiency coefficients – one for each industry. But if an agent chooses to be an entrepreneur, she can only operate a single firm, so she can only operate in one industry.

The $h(,,,)$ function in equation (5) also governs noncorporate output per entrepreneur, q_{ni}, and intermediate input per entrepreneur, v_{ni}, in industry i, but the coefficient D_i is replaced by A_i. Equation (5) expresses the output of an entrepreneur in industry i whose industry i efficiency coefficient is A_i.

$$q_{ni}(A_i) = 1/\theta_i v_{ni} = 1/\Theta_i h(A_i, l_{ni}, k_{ni}) \quad i = 1, 8 \tag{6}$$

The terms l_{ni} and k_{ni} stand, respectively, for the amounts of labor and capital hired by the entrepreneur. As in the case of corporate production, noncorporate capital used

[3] After developing our model we became aware of Lucas' (1978) paper that also models entrepreneurs as managers with differing abilities and demonstrates how such a model can explain secular changes in firm size. Chamley (1983) is another example of an early analysis of differing entrepreneurial abilities and the choice of occupation.

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in industry i is a composite of the three types of capital. The composition of this composite is determined by (3).

In equilibrium only those entrepreneurs of high ability will set up shop. Let $\underline{A}_i$ index the least able entrepreneurs to set up shop in industry i. Agents with a coefficient A_i that is less than $\underline{A}_i$ can earn more as a worker or manager than as an entrepreneur in industry i. Total noncorporate output in industry i, Q_{ni}, is given by:

$$Q_{ni} = \int_{\underline{A}_i}^{\bar{A}_i} \prod_{j \neq i} \int_{0}^{A_i \underline{A}_j / \underline{A}_i} q_{ni}(A_i)\, z(A_1, A_2, \ldots, A_8)\, dA_1\, dA_2 \ldots dA_8 \quad i = 1,8 \tag{7}$$

In (7) the term $\bar{A}_i$ is the maximum efficiency coefficient. As described below, entrepreneurial profits in industry i are proportional to A_i. Equation (7) adds up the output of all industry i entrepreneurs. Each of these entrepreneurs has an entrepreneurial efficiency coefficient for industry i, A_i, that satisfies two requirements. First, A_i must at least equal the minimum value $\underline{A}_i$, i.e., the agents must prefer to set up shop in industry i than become a worker and manager or at least be indifferent between these two choices. Second, the agent must prefer to be an entrepreneur in industry i than in each of the other industries $j \neq i$ ($i = 1, 8$). In (7) the 7 integrals after the product sign check that the agent can't earn more as an entrepreneur in industry $j \neq i$ than he can as an entrepreneur in industry i ($i = 1, 8$).

To understand the limits of these integrals first note that an agent with efficiency coefficient $\underline{A}_J$ in industry j is just indifferent between being an entrepreneur in industry j or a worker or a manager. Next recall that entrepreneurial profits are proportional to the entrepreneurial efficiency coefficients. Hence an agent whose industry i coefficient is A_i earns $A_i/\underline{A}_i$ times the earnings of a worker or manager. For this agent to prefer to be an entrepreneur in industry i rather than j, his industry j coefficient must be less than $(A_i/\underline{A}_i)\,\underline{A}_j$. For example, if $A_i/\underline{A}_i$ is 3 the agent could make more as an entrepreneur in industry j than as an entrepreneur in industry if his A_j exceeded 3 times $\underline{A}_j$, which is the industry j coefficient of an entrepreneur who is just indifferent between being a worker or manager.

C. *Factor prices*

To determine the pre-tax rental rate of capital in a particular industry, we need first to clarify the market price of each industry's composite capital good. Recall that the capital composites consist of structures\land, equipment, and inventories. In the model structures\land are produced by industry 5, the construction industry; hence, the price of structures\land is denoted P_5. Equipment as well as non-equipment manufactures are modeled as a single good produced by the manufacturing industry, industry 9. The price of equipment is, therefore, denoted P_9. Inventories of good i sell for price P_i. With these three prices we can express the price, P_{ki}, of a unit of capital used in industry i as:

$$P_{ki} = \psi_i P_5 + \xi_i P_9 + \omega_i P_i \quad i = 1,10 \tag{8}$$

The pre-tax rental on a unit of corporate capital used in industry i is denoted by R_{ci}. The pre-tax rental on a unit of noncorporate capital in industry i is R_{ni}. These two

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rentals are given by:

$$R_{ci} = rP_{ki}(1+\tau_{ci}) + \Delta_{ki} \quad i = 1,10 \tag{9}$$

$$R_{ni} = rP_{ki}(1+\tau_{ni}) + \Delta_{ki} \quad i = 1,10 \tag{10}$$

where r is the net rate of return, τ_{ci} is the corporate tax levied (for ease of exposition and without loss of generality) on the net return in industry i, τ_{ni} is the tax on the net return to noncorporate capital in industry i, and Δ_{ki} is the value of depreciation on a unit of capital in industry i. The tax rate τ_{ci} is a marginal effective tax rate on new investment. In the empirical implementation of the model we derive the effective tax rate from a discounted cash flow model. The discounted cash flow model accounts for the deductibility of interest, the deferral of taxes through accelerated depreciation, the taxation of capital gains on a realization rather than an accrual basis, and investment incentives including the investment tax credit. Because some of these tax features differ by industry the τ_{ci}'s and τ_{ni}'s will vary across industries.

Since inventories do not depreciate, Δ_{ki} is given by:

$$\Delta_{ki} = \delta_{i5}\psi_i P_5 + \delta_{i9}\xi_i P_9 \quad i = 1,10 \tag{11}$$

where δ_{i5} and δ_{i9} are the respective depreciation rates of structures/land and equipment in industry i.

The other two factors of production, workers and managers, have an identical factor price denoted by the wage, W.[4] This reflects our assumption that agents are equally productive either as workers or managers; since agents who don't choose to become entrepreneurs are free to choose to be either workers or managers, they must, in equilibrium, receive the same compensation.

D. Profit maximization and factor demands

In maximizing profits both corporate and noncorporate firms set the marginal revenue product of factors equal to their pre-tax rentals. The solution to these conditions permits us to write the industry i corporate demands for capital per manager, k_{ci}, and labor per manager, l_{ci}, as functions of the managerial efficiency coefficients and the wage and the pre-tax capital rental:

$$k_{ci} = D_i e_i(W/P_i, R_{ci}/P_i) \quad i = 1,10 \tag{12}$$

$$l_{ci} = D_i b_i(W/P_i, R_{ci}/P_i) \quad i = 1,10 \tag{13}$$

The corresponding demands for capital per entrepreneur and labor per entrepreneur are:

$$k_{ni} = A_i e_i(W/P_i, R_{ni}/P_i) \quad i = 1,8 \tag{14}$$

$$l_{ni} = A_i b_i(W/P_i, R_{ni}/P_i) \quad i = 1,8 \tag{15}$$

[4] Since aggregate labor supply is inelastic in this model and labor taxes are compensated back in a lump-sum to each individual, labor taxes have no effect on the equilibrium. We therefore leave them out of the model.

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The first-order condition for hiring managers together with equations (12) and (13) permit writing profits per corporate manager in sector i, π_{ci}, as a function of W, R_{ci}, and P_i. In equilibrium profits per corporate manager are paid out to the corporate managers as their wage; hence, we have:

$$\pi_{ci} = D_i x_i(W, R_{ci}, P_i) = W \quad i = 1, 10 \tag{16}$$

Profits of an entrepreneur in sector i with efficiency coefficient A_i, $\pi_{ni}(A_i)$, can be written using the $x_i(,,)$ function as:

$$\pi_{ni}(A_i) = A_i x_i(W, R_{ni}, P_i) \quad i = 1, 8 \tag{17}$$

E. Choice of occupation

In deciding whether to be an entrepreneur or to be a worker or manager, each agent considers the profits he would make as an entrepreneur in industry ($i = 1, 8$) as well as the wage paid to workers and managers. The marginal entrepreneur in industry i is just indifferent between being an entrepreneur and being a worker or manager. Recall that $\underline{A}_i (i = 1, 8)$ denotes the efficiency coefficient of the marginal entrepreneur in industry $i (l = 1, 8)$; hence, $\underline{A}_i (i = 1, 8)$ satisfies:

$$\pi_{ni}(\underline{A}_i) = \underline{A}_i x_i(W, R_{ni}, P_i) = W \quad i = 1, 8 \tag{18}$$

Combining (17) and (18) implies:

$$\pi_{ni}(A_i) = (A_i/\underline{A}_i) W \quad i = 1, 8 \tag{19}$$

From (19) agents who are just indifferent between being entrepreneurs in industry $j (j = 1, 8)$ and industry $k (k = 1, 8)$ satisfy:

$$\pi_{nj}(A_j) = \pi_{nk}(A_k) \quad \text{or} \quad A_j/\underline{A}_j = A_k/\underline{A}_k \quad j = 1, 8, \; k = 1, 8 \tag{20}$$

Consideration of equation (20) further clarifies the limits of integration in (7).

F. Owner-occupied housing

Owner-occupied housing, designated as industry 11, differs from the other 10 industries in that value added of housing services depends only on the amount of capital used in owner-occupied housing. As stated in equation (21), value added in the flow of owner-occupied housing services, F_{11}, is assumed to be proportional to the stock of capital used in owner-occupied housing, K_{11}, which consists of only structures/land.

$$F_{11} = H_{11} K_{11} \tag{21}$$

The pre-tax rental on housing, R_{11}, is given by:

$$R = r P_{k11} (1 + \tau_{11}) + \Delta_{11} \tag{22}$$

III. The demand side

In the actual simulation of the model we use a 55-year (age 21 through age 75), continuous-time utility function that is additively separable over time and CES over

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goods at a point in time. However, for ease of notation and exposition we present the remainder of the model using a two-period model. The two-period CES utility function is given by:

$$U_t = \frac{1}{(1-1/\eta)}[g_1 c_{1,1,t}^{1-1/\varphi} + \cdots + g_{11} c_{11,1,t}^{1-1/\varphi}]^{(1-1/\eta)/(1-1/\varphi)}$$

$$+ \frac{1}{(1-1/\eta)(1+\rho)^{1/\eta}}[g_1 c_{1,2,t+1}^{1-1/\varphi} + \cdots + g_{11} c_{11,2,t+1}^{1-1/\varphi}]^{(1-1/\eta)/(1-1/\varphi)} \quad (23)$$

In the equation $c_{k,j,t,}$ stands for consumption of good k at age j at time t, the term η is the intertemporal elasticity of substitution, the term φ is the intratemporal elasticity of substitution, and ρ is the rate of time perference. We raise the expression $(1+\rho)$ to the power $1/\eta$ because in some of our simulations, in which we consider a zero intertemporal elasticity of substitution, we still want to have a rising age-consumption profile. Blowing up the discount factor by $1/\eta$ produces that result.

Equation (24) expresses the steady-state lifetime budget constraint for a worker or manager. The budget constraint for entrepreneurs is identical except that we must substitute the entrepreneur's profit for the wage.

$$\sum_{j=1}^{2}\sum_{k=1}^{11}\frac{P_k c_{j,k}}{(1+r^g)^{j-1}} = W - m + \frac{m(1+n)}{1+r^g} \quad (24)$$

The first term on the right-hand side of (24) is first period labor earnings, W. In the second period we assume the individual is retired. (In the empirical analysis we assume 40 years of full time labor supply.) The m's reflect the compensation scheme described in the next section. The parameter n is the population plus productivity growth rate. The left hand side of (24) gives the present value of expenditure on the 11 goods. The interest factor r^g stands for a weighted average of gross of tax rates of return on the model's capital goods, where the weights are the shares of the value of each capital asset in the total value of capital assets, E. More formally:

$$r^g = \sum_{i=1}^{10} s_{ci}(R_{ci} - \Delta_i)/P_{ki} + \sum_{i=1}^{8} s_{ni}(R_{ni} - \Delta_i)/P_{ki} + s_{11}(R_{11} - \Delta_{11})/P_{k11} \quad (25)$$

where:

$$s_{ci} = \frac{P_{ki}K_{ci}}{E}, \quad s_{ni} = \frac{P_{ki}K_{ni}}{E}, \quad \text{and} \quad s_{11} = \frac{P_{k11}K_{11}}{E} \quad (26)$$

and

$$E = \sum_{i=1}^{10} P_{ki}K_{ci} + \sum_{i=1}^{8} P_{ki}K_{ni} + P_{k11}K_{11} \quad (27)$$

Equation (24) is precisely the same budget constraint that arises if future consumption and labor earnings are discounted at the net rate of return, but capital income and wage taxes are rebated in a lump-sum manner to each agent at the time the capital income taxes are paid. Hence, the budget constraint (24) incorporates the widely used assumption in studies of this kind, namely that the government returns tax payments to the consumers in a lump-sum manner.

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IV. Equilibrium

Table 1 presents the equations determining the steady-state equilibrium of the model. All quantities are measured in efficiency units, i.e., they are adjusted for population and productivity growth. Equation (28) states that the demand for labor must equal the supply of labor. In the equation $\bar{L}$ stands for the number of agents. The first term on the left of (28) gives the demand for managers and workers by corporations. The second term on the left of (28) counts the number of entrepreneurs

Table 1. The steady state model

$$\sum_{i=1}^{10} M_{ci}(1+l_{ci}) + \sum_{i=1}^{8} \int_{\underline{A}_i}^{\bar{A}_i} \prod_{j \neq i} \int_{0}^{A_i \underline{A}_j / \underline{A}_i} [1+l_{ni}(A_i)]\, z(A_1, A_2, \ldots, A_8)\, dA_1\, dA_2 \cdots dA_8 = \bar{L} \tag{28}$$

$$K_i = M_{ci} k_{ci} + \sum_{i=1}^{8} \int_{\underline{A}_i}^{\bar{A}_i} \prod_{j \neq i} \int_{0}^{A_i \underline{A}_j / \underline{A}_i} k_{ni}(A_i)\, z(A_1, A_2, \ldots, A_8)\, dA_1\, dA_2 \cdots dA_8 \quad i = 1, 10 \tag{29}$$

$$Q_i = M_{ci} q_{ni} + \sum_{i=1}^{8} \int_{\underline{A}_i}^{\bar{A}_i} \prod_{j \neq i} \int_{0}^{A_i \underline{A}_j / \underline{A}_i} q_{ni}(A_i)\, z(A_1, A_2, \ldots, A_8)\, dA_1\, dA_2 \cdots dA_8 \quad i = 1, 10 \tag{30}$$

$$C_i = \sum_{j=1}^{55} \frac{c_{j,i}}{(1+n)^{j-1}} \quad i = 1, 11 \tag{31}$$

$$Q_i = C_i + \sum_{j=1}^{11} v_{ij} Q_j + n\omega_i K_i \quad i \neq 5, 9 \tag{32}$$

$$Q_5 = C_5 + \sum_{j=1}^{11} v_{5j} Q_j + n\omega_5 K_5 + \sum_{j=1}^{11} (n + \delta_{5j}) \psi_j K_j \tag{33}$$

$$Q_9 = C_9 + \sum_{j=1}^{11} v_{9j} Q_j + n\omega_9 K_9 + \sum_{j=1}^{11} (n + \delta_{9j}) \xi_j K_j \tag{34}$$

$$P_i = \sum_{j=1}^{10} v_{ji} P_j + R_{ci} k_{ci} / q_{ci} + W(1 + l_{ci}) / q_{ci} \quad i = 1, 10 \tag{35}$$

$$A_{-i} x_i(W, R_{ni}, P_i) = W \quad i = 1, 8 \tag{36}$$

$$\frac{c_{j,k}}{c_{j,m}} = \left[\frac{P_k}{P_m}\right]^{-\varphi} \quad j = 1,2 \;\; k = 1, 10 \;\; m(\neq k) = 1, 10 \tag{37}$$

$$\frac{c_{j,k}}{c_{j,11}} = \left[\frac{P_k}{R_{11}}\right]^{-\varphi} \quad j = 1,2 \;\; k = 1, 10 \tag{38}$$

$$c_{j+1,i} = c_{j,i}(1+r)^{\eta}/(1+\rho) \quad j = 1,2 \;\; i = 1, 11 \tag{39}$$

$$\sum_{j=1}^{2} \sum_{i=1}^{11} \frac{P_i c_{j,i}}{(1+r^g)^{j-1}} = W - m + \frac{m}{(1+r^g)} \tag{40}$$

$$\sum_{i=1}^{11} P_i C_i = \bar{I} \tag{41}$$

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and employees of entrepreneurs. Equation (29) simply defines aggregate capital within industry i as K_i. In equation (29) the terms k_{ni} for $i = 9, 10$ equal zero. For $i = 11$ K_i is simply aggregate owner-occupied housing capital.

Equation (30) defines aggregate output in sector i, Q_i, as the sum of corporate and noncorporate output. For $i = 11$ Q_i is total owner-occupied housing output. Equation (31) defines the total demand for each commodity as the sum of the demands of each age group. Equation (32) states that the supply of output in sectors other than 5 and 9 must equal the sum of consumption demand, the demand for intermediate inputs, and the inventory investment demand. In the steady state inventory investment must equal n, the rate of population plus productivity growth, multiplied times the stock of inventories. Equations (33) and (34) are supply equals demand conditions for, industry 5, construction, and industry 9, manufacturing. In addition to consumption, intermediate input, and inventory demand, there is a demand for new construction to add to the stock of structures used in different industries to accommodate population and productivity growth. New construction is also used in different industries to replace structures in different industries. In the case of manufacturing there is a demand to add to the stock of equipment (produced by the manufacturing sector) at the rate of population plus productivity growth as well as a demand to replace depreciating equipment.

Equation (35) relates the price of each good to its factor input and intermediate goods prices. Note that for the price of housing services (sector 11) the wage rate does not appear since the stock of housing capital is the only input in housing services. Equation (36) is a rewrite of (18) and is used to determine minimum entrepreneurial abilities in each industry. Equations (37) and (38) are the first-order conditions for utility maximization. Equation (39) is the budget constraint for a new worker or manager; for an entrepreneur wage earnings is replaced by the entrepreneur's profits. Finally, equation (40) indicates that we have taken aggregate consumption expenditure as our numeraire.

We next ask whether the number of unknowns equal the number of equations in Table 1. In doing so let us ignore the purely definitional variables $K_i (i = 1, 10)$, $Q_i (i = 1, 10)$, and $C_i (i = 1, 11)$ and the equally numerous equations (29) through (31). Let us also use equations (37) and (38) to write all c_{ji}'s in terms of c_{11}. Table 1 then contains 32 variables. These variables are 10 M_{ci}s, K_{11}, 8 $\underline{A}_i$s, 10 P_is, 1 W, 1 r (recall that l_{ci}, l_{ni}, k_{ci}, and k_{ni} depend on W and r), and c_{11}. There are also 32 equations. These equations are 1 in equation (28), 11 in equations (32) through (34), 10 in equation (35), 8 in equation (36), 1 in equation (40), and 1 in equation (41).

V. Separating efficiency from redistribution

In any dynamic analysis of excess burden it is critically important to consider the welfare of generations living during the transition between steady states as well as those living in the policy-induced new steady state. Policy changes may make those living in the new steady state better off (worse off), not because such policies are more efficient, but because they make earlier generations worse off (better off). Such redistribution is simply the intergenerational expression of the incidence of the fiscal policy in question. Intergenerational incidence refers here to changes in the real tax

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burdens of different generations, where real tax burdens may differ from nominal tax burdens due to induced general-equilibrium-changes in factor and commodity prices along the economy's transition path.

In this section we (1) present an exact formula for the efficiency effects of tax reform along the economy's entire transition path, (2) show that, with our specific compensation scheme, this formula is identical to summing up the present value (discounted to the date of tax reform) change in utility (measured in dollars) of each generation divided by the present value (discounted to the date of tax reform) sum of each generation's present value of consumption, and (3) approximate this formula by using the steady-state change in utility. (Readers who wish to skip the details are invited to skip to Section VI.)

In static analyses a standard way to distinguish efficiency gains from welfare changes due to redistribution is to restore, in a lump-sum manner, the changes in real income associated with the policy's incidence. Changes in welfare remaining after this first-order restoration of real income are pure efficiency changes. Auerbach (1988) suggested this strategy for analyzing the steady-state pure efficiency gain in dynamic models. His suggestion involves compensating, in a lump-sum manner, those living in the new steady state. They are compensated not only for the differences in nominal taxes paid between the new and the previous steady state, but also for differences in factor rewards and commodity prices between the new and the initial steady state. While Auerbach focuses only on the steady state, to reach his compensated steady state one must also compensate each transitional generation for any first-order income changes it experiences due to the policy's intergenerational incidence. These generation-specific compensation payments sum to zero in present value. Given this compensation scheme, the present value sum of the dollar measure of each generation's change in utility equals the policy's total excess burden.

To see these points consider first the change in utility of the generation that is old at time t when the policy is changed by a small amount. Equation (43) expresses the change in utility for a representative member of this generation:

$$\frac{dU_{t-1}}{\lambda_{t-1}} = \sum_{i=1}^{11} P_i dc_{i2t} \tag{42}$$

In (42) the utility of the old at time t is denoted U_{t-1} since the old at time t were born at $t-1$. The term λ_{t-1} stands for the marginal utility of income of the old at time t. Again the subscript $t-1$ is used to denote the time at which the generation was born.

Equation (43) expresses the compensated budget constraint of an old individual at time s. The term $m_s (s \geq t)$ stands for the lump-sum compensation payment received by an old individual at time s. The compensation scheme is designed such that what the old generation receives in a given period equals what the young give up in that period. Since the government's net compensation payments to different generations sum to zero in each period, they clearly sum to zero in present value.

$$\sum_{i=1}^{11} P_{is} c_{i2s} = \sum_{i=1}^{11} P_{kis} k_{is} + r_s \sum_{i=1}^{11} P_{kis} [k_{cis}(1+\tau_{cis}) + k_{nis}(1+\tau_{nis})] + (1+n) m_s \tag{43}$$

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For expositional ease we ignore depreciation in equation (43) and the rest of this section. The terms P_{is}, P_{kis}, and k_{is} in equation (43) stand, respectively, for the price of output i in period s, the price of capital in industry i in period s, and total capital in industry i per old person in period s. Equation (43) states that the expenditure of the elderly at time s equals the value of their assets plus their pre-tax asset income (the second summation in the right-hand side of (43)), plus the value of the lump-sum compensation, $(1+n)m_s$.[5] The differential of the term m_s is defined in equation (44).

$$dm_s = \sum_{i-1}^{11} dP_i c_{i2} - \sum_{i=1}^{11} dP_{kis} k_{is} - d\left[r_s \sum_{i=1}^{11} P_{kis}(\tau_{cis} k_{cis} + \tau_{nis} k_{nis}) \right] - r_s \sum_{i=1}^{11} dP_{kis} k_{is}$$
$$- dr_s \sum_{i=1}^{11} P_{kis} k_{is} - \alpha \left[\sum_{i=1}^{11} P_{is} dx_{is} - r_s \sum_{i=1}^{11} P_{kis} dk_{is} \right] \tag{44}$$

where k_{is}^c and k_{is}^n stand for corporate and noncorporate capital per old person in sector i in period s, and α is the share of aggregate consumption consumed by the old. The term $\alpha = 1/[1+(1+\rho)(1+n)/(1+r_s)^n)]$. The term x_{is} stands for net output of good i at time s per old person.

Together, the differential of equation (43) and (44) imply:

$$\sum_{i=1}^{11} P_{is} dc_{i2s} = \alpha \left[\sum_{i=1}^{11} r_s P_{kis} \tau_{cis} dk_{cis} + \sum_{i=1}^{11} r_s P_{kis} \tau_{nis} dk_{nis} \right] + (1+r_s) \sum_{i=1}^{11} P_{kis} dk_{is} \tag{45}$$

The terms in brackets on the right-hand side of (45) is the period s change in excess burden arising from a small change in the tax structure. Hence, according to equations (42) and (45) and the fact that dk_{it} equals zero (since the initial stocks of capital are given), the compensation to each initial (time t) elderly individual is such that his change in utility from a small change in the tax system equals the economy's change in excess burden in the period he is old multiplied by his share of consumption. That is, the old and, as shown below, the young share each period's change in excess burden in proportion to their share of aggregate consumption.

The change in lifetime utility of a young member of generation $s (s \geq t)$ is given by:

$$\frac{dU_s}{\lambda_s} = \sum_{i=1}^{11} P_{is} dc_{ils} + \frac{1}{1+r_s} \sum_{i=1}^{11} P_{is} dc_{i2s} \tag{46}$$

To determine the value of the right-hand side of (46) we consider the division of labor income of the young at time s between their consumption and their acquisition of assets:

$$\sum_{i=1}^{11} P_{is} c_{i1s} + \sum_{i=1}^{11} P_{kis} k_{is+1} = W_s - m_s \tag{47}$$

[5] Recall that personal and corporate capital income taxes are rebated back to the owners of capital at the time the capital income is earned. In addition, we value capital at replacement cost which is equivalent to valuing capital at market value and lump-sum rebating any changes in capital value associated with tax changes, such as changes in the investment tax credit, back to the owners of capital. Also note that if each old person recieves $m_s(1+n)$ at time s, the total amount paid by each of the young at time s is m_s.

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The substitution of dm_s from (44) into the differential of (47) for $s \geqslant t$ implies, together with equation (45):

$$\sum_{i=1}^{11} P_{is} dc_{i1s} + \frac{1}{1+r_s} \sum_{i=1}^{11} P_{is} dc_{i2s} = \left[\frac{(1-\alpha)}{(1+n)} + \frac{\alpha}{1+r_s}\right]\left[\sum_{i=1}^{11} r_s P_{kis} \tau_{cis} dk_{cis} + \sum_{i=1}^{11} r_s P_{kis} \tau_{nis} dk_{nis}\right] \quad (48)$$

According to equations (47) and (48) the change in utility for the young generation born at time s is $(1-\alpha)$ times the change in excess burden at time s plus α times the present value of the change in excess burden at time $s+1$, when the young of generation s are old.

We next define the right hand side of (48), which according to (47), is the change in each member of generations' utility, as $b_s (s \geqslant t)$. Also define b_{t-1} as the right-hand side of (45). Define the present value (per initial old person) of the sum (over each generation) of these normalized (by the marginal utility of income) changes in utility as dB_t, then:

$$dB_t = \sum_{s=t}^{\infty} b_s \frac{(1+n)^{s-t}}{(1+r)^{s-t}} + b_{t-1} \quad (49)$$

To find the value of B_t^*, the excess burden from shifting from one set of absolute taxes, $r^* P_i^* \tau_{ci}^*$'s and $r^* P_i^* \tau_{ni}^*$'s, to a new set of absolute taxes, $\tilde{r} \tilde{P}_i \tilde{\tau}_{ci}$'s and $\tilde{r} \tilde{P}_i \tilde{\tau}_{ni}$'s, we define the dummy variable z which runs from 0 through 1. The variable z determines the extent to which the set of tax rates is switched from the * (initial steady state) set to the new set. For example, we express the rate of tax on corporate industry l at time t as $z\tau_{clt}^* + (l-z)\tilde{\tau}_{clt}$. The formula for B_t^* is given by integrating dB_t with respect to z over the limits $z=0$ to $z=1$. Using the definition of b_s and b_{t-1}, the formula for B_t^* is:

$$B_t^* = \sum_{s=t}^{\infty} \int_0^1 \prod_{j=t}^{s} (1+r_j)^{-1} \left[\sum_{i=1}^{11} [z(r^* P_{ki}^* \tau_{cis}^*) + (1-z)\tilde{r}\tilde{P}_{ki}\tilde{\tau}_{cis}] \frac{\delta K_{cis}}{\delta z}\right] dz + \sum_{s=t}^{\infty} \int_0^1 \prod_{j=t}^{s} (1+r_j)^{-1} \left[\sum_{i=1}^{11} [z(r^* P_{ki}^* \tau_{nis}^*) + (1-z)\tilde{r}\tilde{P}_{ki}\tilde{\tau}_{nis}] \frac{\delta K_{nis}}{\delta z}\right] dz \quad (50)$$

Formula (50) is the intertemporal analogue to Harberger's (1966) excess burden formula. Evaluating the derivatives of the capital stock in (50) at a particular value of z leads to a triangle approximation formula. If we replace $\delta K_{cis}/\delta z$, $\delta K_{nis}/\delta z$, and r_s with their new steady-state values, i.e., their values when s is very large, we arrive at the steady-state approximation for excess burden proposed by Auerbach (1988, equation 20).

By comparing (48) and (50) one can see that in the new steady state the ratio of B_t^* to the present value of the economy's consumption equals the ratio of the change in utility of an individual in the new steady state. The latter ratio is given by the integral over z of (46), evaluated at the right hand side of (48), divided by the present value of the individual's lifetime consumption. In the steady state the ratio of B_t^* to the present value of the economy's consumption equals the ratio of the sum of the

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integrands in (50), the annual excess burden, divided by annual consumption. But the present value of an individual's lifetime consumption in the new steady state equals the economy's annual consumption per old person divided by the first term in brackets on the right-hand side of (48). Hence, except for the fact that the transition may not be immediate, this method of compensation implies that the change in steady-state utility divided by the present value of steady-state consumption is identical to the present value of the aggregate economy's efficiency gain from tax reform divided by the present value of the aggregate economy's consumption.

The exact formula for excess burden given in equation (50) assumes that the compensation terms m_s are adjusted as one discretely alters tax rates, i.e., the value of dm_s depends on the value of z. While (44) is the correct formula for the derivative of m_s, in order to simulate the model we need a formula for the level of m_s (the integral of dm_s). While we cannot derive this formula analytically, we specify the following approximation formula for m_s:

$$m_s \cong \sum_{i=1}^{11} (\tilde{P}_i - P_i^*)\bar{c}_{i2} - \sum_{i=1}^{11} (\tilde{P}_{ki} - P_{ki}^*)\bar{k}_i - \sum_{i=1}^{11} (\tilde{r}\tilde{P}_{ki}\tilde{\tau}_{ci} - r^* P_{ki}^* \tau_{ci}^*)\bar{k}_{ci}$$
$$- \sum_{i=1}^{11} (\tilde{r}\tilde{P}_{ki}\tilde{\tau}_{ni} - r^* P_{ki}^* \tau_{ni}^*)\bar{k}_{ni} - \sum_{i=1}^{11} \overline{rP_{ki}\tau_{ci}}(\tilde{k}_{ci} - k_{ci}^*) - \sum_{i=1}^{11} \overline{rP_{ki}\tau_{ni}}(\tilde{k}_{ni} - k_{ni}^*)$$
$$- \sum_{i=1}^{11} (\tilde{r}\tilde{P}_{ki} - r_k^* P_{ki}^*)\bar{k}_i - \alpha\left[\sum_{i=1}^{11} \bar{P}_i[\tilde{x}_i - x_i^*] - \bar{r}\sum_{i=1}^{11} \bar{P}_{ki}[\tilde{k}_i - k_i^*]\right] \quad (51)$$

Since the initial value of m_s is zero, the value of m_s simply equals the change in m_s. Equation (51) is a first-order approximation (term by term) to (44), which is the formula for very small changes in m_s. In this approxmation we evaluate quantities and prices at the average of their initial and final steady-state values. In (51) the superscript $\bar{}$ denotes average value. The error introduced by using an approximation formula for m_s appears to be quite small. While the results we present below are based on (51) which evaluates quantities and prices at their average (as defined above) values, we have also tried modifications of (51) that evaluate both quantities and prices at either their initial or final steady-state values. The results are very similar. For example, in all our simulations of the 1986 Tax Reform the difference in the efficiency calculations is less than 1 percent. The difference is also less than 1 percent in all our simulations of the total removal of capital income taxes if we assume a zero intertemporal substitution elasticity. If we assume an intertemporal substitution elasticity equal to 0.25, the difference is less than 7 percent.

In combination equations (43), (47), and (51) imply:

$$\sum_{i=1}^{11} \bar{P}_i(\tilde{c}_{i1} - c_{i1}^*) + \frac{1}{1+\bar{r}}\sum_{i=1}^{11} \bar{P}_i(\tilde{c}_{i2} - c_{i2}^*) =$$
$$= \left[\frac{(1-\alpha)}{(1+n)} + \frac{\alpha}{1+\bar{r}}\right]\left[\sum_{i=1}^{11} \bar{P}_i[\tilde{x}_i - x_i^*] - \bar{r}\sum_{i=1}^{11} \bar{P}_{ki}[\tilde{k}_i - k_1^*]\right] \quad (52)$$

The left-hand side of (52) is a first-order approximation to the left-hand side of (48), while the right-hand side of (52) is a first-order approximation to the right-hand side

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of (48). Recall that the left-hand side of (48) equals the differential of lifetime utility (see (46)). Thus, our first-order approximation to m_s implies that the change in utility of each generation equals, to a first-order, the first-order approximation to the flow efficiency gain multiplied by the generation's share of consumption.

Our consumption-proportional method of generational compensation is also attractive because it appears to mitigate differences in utility changes over the transition. Indeed, in the case of only a single capital good and a zero intertemporal elasticity of substitution, one can show that, with our compensation scheme, the transition is immediate, i.e., the economy moves immediately to its new steady state. In the one-capital-good-case all generations, including initial generations, experience an identical utility change measured as a percentage of the present value of their remaining lifetime consumption. In the case of more than one capital good and a zero intertemporal elasticity of substitution, the transition may not be immediate, but it is likely to be quite quick. The reason is that our compensation scheme, when plugged into the lifetime present value budget constraint (equation 23), implies the following:

$$\sum_{i=1}^{11} \bar{P}_{ki}(\tilde{K}_i - K_i^*) = 0 \tag{53}$$

Equation (53) is akin to a fixed capital stock constraint. It says that the change in capital valued at average prices is zero. Clearly, with one capital good, this equation implies there is a fixed capital stock.

While our measure of the efficiency gain from tax reform is based on the steady-state change in utility it may overstate or, which seems quite unlikely in our simulations, understate the measure that would arise if we knew the economy's precise transition path. But, as just indicated, if we assume a zero or a small intertemporal elasticity of substitution, our compensation scheme imposes, essentially, a fixed capital stock constraint. Hence, the differences between transitional and new steady-state utility levels are likely to be quite small, at least in this case. In this regard it is worth pointing out that most of the empirical estimates of the intertemporal elasticity of substitution (e.g., Hall, 1988) indicate that this elasticity is quite small.[6]

VI. The findings

The Tax Reform Act of 1986 had a relatively small effect on the overall marginal effective tax on capital income. At the pre-Tax Reform allocations of capital the overall effective tax rate is estimated at 32 percent prior to the Tax Reform Act and 31 percent after the Tax Reform Act. There were, however, major changes in the

[6] Auerbach and Kotlikoff (1987) survey the empirical evidence on this elasticity and report most findings to be well below one. As a consequence they choose a value of 0.25 for their estimates. Hall (1988) concludes that the elasticity is unlikely to be above 0.1; he also suggests certain flaws in some of the studies which produced larger estimates. In any case, it is quite difficult to reconcile the relative stability of savings rates over time with a large intertemporal substitution elasticity.

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allocation of tax burdens across assets and sectors. The statutory corporate tax rate was reduced from 46 percent to 34 percent, and the average marginal personal tax rate on capital income fell from about 30 percent to about 23 percent due to statutory rate reductions. As the price for these rate reductions, the investment tax credit, which primarily benefited equipment and public utility structures, was repealed and depreciation was made somewhat less liberal, particularly for structures. Hence, effective marginal tax rates were increased for equipment and lowered for other assets, particularly land and inventories where there was no loss of marginal tax incentives to offset the reduced statutory rates.

Even though the investment credit and depreciation changes offset the rate reductions, leaving the overall marginal tax rate roughly the same, these changes reduced the corporate tax wedges reported in columns (3) and (6) of Table 2 in most industries. Although the investment credit repeal had the effect of increasing tax rates, other things equal, it also increased effective tax rates proportionally more in the noncorporate sector because it was provided through a credit. Thus, its effect on the corporate tax wedge (the difference between the corporate and noncorporate sector) is limited. An incentive provided in the form of a deduction would have had a more pronounced effect on the differential.

The second reason that the Tax Reform Act reduced the distortions from the corporate tax wedge is that industries with larger shares of noncorporate production typically experienced the largest reductions in the corporate tax wedge. Rental housing uses only land and structures; agriculture is also a very intensive user of land. These two industries account for 64 percent of noncorporate capital, and their tax wedges were reduced, respectively, from 0.59 to 0.42 and from 0.69 to 0.49. The Trade industry also experienced a significant reduction in its tax wedge, from 0.69 to 0.54, reflecting the importance of inventories in its capital stock. These three

Table 2. Corporate tax wedges by sector

Sector		Before Tax Reform			After Tax Reform		
#	Name	τ_{ci}	τ_{ni}	$\tau_{ci} - \tau_{ni}$	τ_{ci}	τ_{ni}	$\tau_{ci} - \tau_{ni}$
1	Rental housing	0.887	0.299	0.588	0.667	0.250	0.416
2	Agriculture	1.083	0.389	0.694	0.786	0.299	0.487
3	Oil and gas	0.515	0.124	0.392	0.493	0.149	0.343
4	Mining	0.587	0.250	0.337	0.724	0.250	0.474
5	Construction	0.613	0.099	0.514	0.786	0.299	0.487
6	Transportation	0.515	0.124	0.392	0.695	0.235	0.460
7	Trade	1.083	0.389	0.694	0.887	0.351	0.535
8	Services	0.695	0.282	0.412	0.786	0.299	0.487
9	Manufacturing	0.961			0.852		
10	Utilities	0.587			0.667		
11	Owner-occupied housing	0.042			0.042		

Tax wedges are given as a percentage of the net return. They are calculated from the effective tax rates in the Appendix table. A tax wedge τ is related to the tax rate t through the formula, $\tau = t/(1-t)$. The corporate tax wedge is the excess tax in the corporate sector compared to the noncorporate sector, or $\tau_c - \tau_n$.

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industries, rental housing, agriculture, and trade, accounted for 77 percent of noncorporate capital. Only services, which has virtually no inventories, experienced an increase in its corporate tax wedge, from 0.41 to 0.49. Of the remaining sectors the corporate tax wedge change was either quite small or increased, but there is very little noncorporate capital in these sectors.

Tabel 3 presents our efficiency gain findings. We measure the efficiency gain as the compensating variation in the initial steady state needed to obtain the final steady-state level of utility, divided by the initial steady-state present value of lifetime consumption expenditure. We report both efficiency gains from the 1986 Tax Reform Act and the efficiency gains from the complete elimination of capital income taxation. Since our main focus is on the corporate-noncorporate tax distortion, we consider values of the intertemporal substitution elasticity equal to zero as well as 0.25. Since there is no intertemporal distortion if the intertemporal elasticity is zero, the reported efficiency gain in this case will solely reflect corporate-noncorporate and interindustry tax wedges. We view the results based on the assumption of fixed entrepreneurs as the most reliable since the results based on assuming variable entrepreneurs require invoking our distribution assumptions on entrepreneurial abilities which may or may not be fully appropriate. The variable entrepreneur case also leads to much larger shifts in corporate shares of sector output than seem reasonable.

Table 3. Efficiency gains from the 1986 Tax Reform Act and the complete elimination of capital income taxation

σ_1	σ_2	φ	η	F/V	T/N	Efficiency gain[1]
1	1	1	0	F	T	0.85
1	1	1	0.25	F	T	0.84
1	1	0.5	0	F	T	0.82
0.75	1.25	1	0	F	T	0.85
1.25	0.75	1	0	F	T	0.81
1	1	1	0	V	T	1.99
1	1	1	0	F	N	1.96
1	1	1	0.25	F	N	2.87
1	1	0.5	0	F	N	1.77
0.75	1.25	1	0	F	N	2.07
1.25	0.75	1	0	F	N	1.81
1	1	1	0	V	N	2.97

[1] Efficiency gain is the steady-state compensating variation in utility divided by the initial steady-state present value of lifetime consumption.

σ_1 = factor substitution elasticity in rental housing and agriculture.

σ_2 = factor substitution elasticity in all other sectors.

φ = intratemporal demand elasticity.

η = intertemporal demand elasticity.

F = fixed entrepreneurs.

V = variable entrepreneurs.

T = Tax Reform Act.

N = no tax.

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The first five rows of Table 3 consider the efficiency gain from tax reform in the case of fixed entrepreneurs, but under alternative parameter assumptions. In each case the efficiency gain is about four fifths of one percent of the present value of consumption. This is a reasonably large figure when compared with the efficiency gains from alternative tax reforms discussed in the public finance literature. Given the 1988 value of aggregate U. S. consumption, this efficiency gain corresponds to roughly $31 billion per year, a quite significant amount. As one would expect, the assumption of variable entrepreneurs raises the estimated efficiency gain considerably; indeed, it more than doubles it.

Since the 1986 Tax Reform Act did not greatly alter the overall effective marginal tax on capital income, it is not surprising that the efficiency gains from the reform are very similar in the cases of zero and 0.25 intertemporal elasticities of substitution. There is a larger difference, however, if capital income taxes are completely removed. Rows 7 and 8 indicate that the efficiency gain from eliminating all capital income taxes is 1.96 percent of consumption in the case of a zero intertemporal elasticity and 2.87 in the case of a 0.25 intertemporal elasticity. These figures suggest that most of the excess burden from capital income taxes in the U. S. is due not to the intertemporal distortion, but rather to the distortion in the allocation of the use of capital at a point in time. This finding, while based on a quite different model than Chamley's (1981), accords with Chamley's assessment of the relative size of intertemporal and static distortions associated with capital income taxation.

The large efficiency gains in our model from eliminating the corporate tax wedge reflect significant increases in the corporate share of sector output in those sectors that originally are significantly noncorporate. In particular, our simulations predict that the rental housing industry becomes substantially more corporate. While the predicted increase in corporate capital in all the other sectors seems reasonable by historic standards, the shift predicted for rental housing is quite large. Gravelle (1989) modifies the model to disaggregate rental housing into a multi-family rental housing sector with corporate as well as noncorporate production and a single family rental housing sector which is solely noncorporate. This modification limits the reallocation of rental housing toward corporate housing and reduces the estimated efficiency gain from the 1986 Tax Reform by about one half, to $15 billion dollars per year. This efficiency gain, amounting to 0.43 percent of 1988 U. S. consumption is, nonetheless, quite substantial. It is over five times the corresponding efficiency gain predicted by the Harberger model.

VII. Conclusion

This paper has shown that how one models the corporate-noncorporate tax distortion is crucial for assessing the efficiency effects of the 1986 Tax Reform Act and other tax reforms. It also presents a method of using steady-state information to assess an economy's efficiency changes along its transition path. While our finding of a $31 billion annual efficiency gain from the 1986 Tax Reform Act may be viewed as somewhat high, given its dependence on a significant reincorporation of the rental housing industry, even the $15 billion figure that results from a more conservative treatment of rental housing is substantial.

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In addition to demonstrating that the corporate-noncorporate distortion in the U. S. may be much more serious than previously believed, this paper suggests that the intratemporal distortion in the allocation of capital may be more serious than the intertemporal distortion. Moreover, certain behavioral responses not incorporated in this model, such as firm-substitution among different assets, substitution between intermediate and other inputs, and the labor-leisure choice, would probably increase the efficiency gains (particularly the intratemporal gains) from the Tax Reform Act and policies such as corporate tax integration.

The findings have important implications for the design of tax structures. For example, if the major source of capital income tax distortion involves the corporate-noncorporate tax wedge, integration of the corporate and individual income taxes is a policy option deserving of much more attention. In comparison with policies that reduce the corporate tax wedge, policies, such as changes in the investment tax credit, which primarily affect the intertemporal distortion, may be less effective in reducing the excess burden from capital income taxation.

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Appendix

Calibrating and solving the model

To solve the model we need to specify functional forms for production, utility, and the distribution of entrepreneurial efficiency coefficients. We assume a CES production function, hence corporate output per-manager in sector $i (l = 1, 10)$ is given by:

$$q_{ci} = (H_i/\mu_i)[(1 - a_i - b_i)_{D_i}^{(1-1/\sigma_i)} + a_i l_{ci}^{(1-1/\sigma_i)} + b_i k_{ci}^{(1-1/\sigma_i)}]^{\sigma_i/(\sigma_i-1)} \qquad \text{(A1)}$$

In (A1) σ_i is the factor substitution elasticity, and H_i, a_i, and b_i are coefficients. The term μ_i is a coefficient relating the F_{ci} (value added) function to the Q_{ci} function in equation (1), that is $F_{ci} = \mu Q_{ci}$. The production function for the noncorporate sector is identical except that D_i is replaced by A_i, which varies for different entrepreneurs. In the case of owner-occupied housing, b_{11} equals 1 and a_{11} equals zero.

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The joint density function, $z(A_1, A_2, \ldots, A_8)$, is written as the product of eight independent exponential functions $\Gamma_i \exp(-\Gamma_i A_i)$ times $\bar{L}$, the labor force, with $\bar{A}_i$ set to infinity. The values of the Γ_i's are determined in the calibration of the model. We also consider the case where the supply of entrepreneurs to each sector is fixed at their initial levels. In this case, the increase in noncorporate production arising from an increase in the corporate tax wedge is due solely to the expansion of output by existing noncorporate firms. In the fixed entrepreneur case since the percentage changes in capital and labor used by entrepreneurs in sector i are identical for all entrepreneurs in sector i and depend solely on changes in output and factor prices, there is no need to calculate the values of Γ_i or A_i.

A. Calibration of the model

In the initial observed equilibrium all inputs are measured in units such that all eleven prices, W, r, and all Di's equal unity. The rental rates as expressed in equations (9), (10), and (22) are larger than unity owing to depreciation and taxes; these rental rates in the initial equilibrium are denoted R_{ci}^* and R_{ni}^* to distinguish them from the new equilibrium values. With the exception of the input-output coefficients all data used to calibrate the model are contained in Table A1. These

Table A1. Data used to calibrate the model

	Q_{ci}/Q_i	β	s	α	t_c^*	t_n^*	δ
Rental Housing	0.097	0.770	0.05	0.135	0.47	0.23	0.14
Agriculture	0.293	0.580	0.03	0.100	0.52	0.28	0.32
Oil and Gas	0.848	0.776	0.03	0.185	0.34	0.11	1.17
Mining	0.844	0.435	0.01	0.425	0.37	0.20	1.54
Construction	0.731	0.321	0.05	0.410	0.38	0.09	2.31
Transportation	0.923	0.351	0.04	.467	0.34	0.11	1.64
Trade	0.829	0.421	0.20	0.386	0.52	0.28	0.73
Services	0.666	0.296	0.22	0.315	0.41	0.22	1.54
Manufacturing	1.000	0.301	0.24	0.369	0.49		1.00
Utilities	1.000	0.621	0.06	0.220	0.37		0.94
Owner-Occupied Housing	0.000	1.000	0.07	0.000		0.04	0.14

	ω	ξ	ψ	δ_9	t_c	t_n
Rental Housing	0.00	0.00	1.00		0.40	0.20
Agriculture	0.10	0.11	0.79	2.39	0.44	0.23
Oil and Gas	0.05	0.09	0.86	2.87	0.33	0.13
Mining	0.03	0.37	0.60	2.93	0.42	0.20
Construction	0.05	0.68	0.27	3.30	0.44	0.23
Transportation	0.02	0.43	0.53	2.41	0.41	0.19
Trade	0.36	0.14	0.45	3.87	0.47	0.26
Services	0.03	0.42	0.55	3.17	0.44	0.23
Manufacturing	0.30	0.31	0.39	2.64	0.46	
Utilities	0.04	0.24	0.72	2.28	0.40	
Owner-Occupied Housing	0.00	0.00	1.00			0.04

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data include, for each industry, the share of output which is corporate (Q_{ci}/Q_i), the distribution of value added across industries, s_i, the aggregate shares of capital income by industry, β_i, the share of labor income by industry α_i, corporate and noncorporate effective marginal tax rates by industry, τ_{ci} and τ_{ni}, average and asset-specific depreciation rates by industry, and the composition of capital by industry. Given the values of depreciation rates, tax rates, and the normalized unitary values of r and all output prices, we use equations (9), (10), and (22) to calculate the observed rental rates, R_{ci}^* and R_{ni}^*.

Because of tax differentials capital's share of income by industry will (except in the Cobb-Douglas case) differ between the corporate and noncorporate sectors. The labor share of income is the same. These shares are related to the underlying coefficients in the production functions by:

$$\alpha_i = a_i^{\sigma_1} H_i^{\sigma_1 - 1} \tag{A2}$$

$$\beta_{ci} = R_{ci}^{*1-\sigma_1} b_i^{\sigma_1} H_i^{\sigma_1 - 1} \tag{A3}$$

$$\beta_{ni} = (R_{ci}^*/R_{ni}^*)^{\sigma_1 - 1} \beta_{ci} \tag{A4}$$

where β_{ci} refers to the corporate share of capital income, and β_{ni} refers to the noncorporate share of capital income. It is not necessary in calibrating or solving the model to calculate the values of a_i, b_i, or H_i, since all equilibrium equations can be written in terms of initial income shares.

To proceed further with the calibration of the model requires the functional forms of the relationships between inputs and outputs. The corporate production functions and the three first-order conditions result in four equations for each sector. Similarly, the noncorporate production function and its two first-order conditions result in three additional equations. The requirement that profits of the marginal entrepreneur equal the wage rate produces another equation. These eight equations are the first eight equations in Table A2 (equations (A5)–(A12)), listing functional relationships and providing the specific forms of these variables for use in the equations of Table 1. These forms can apply to both calibration and solution of the model as W, R_{ci}, and R_{ni} refer to the new equilibrium. For purposes of calibrating the model these values are set to 1, R_{ci}^* and R_{ni}^* respectively. Owner-occupied housing is treated in the same fashion as corporate production, but only has one first-order condition, so that only equation (A5) and equation (A9) appear for owner occupied housing.

The first step in calibrating the model is to use the observed distribution of aggregate value added, along with the relationships in (A3) through (A7) to obtain the implied distribution of the aggregate capital stock and the values of the corporate and noncorporate capital income shares. Note that the ratio of k_{ci} to q_{ci} is equal to the ratio of aggregate K_{ci} to Q_{ci} and the ratio of $k_{ni}(A)$ to $q_{ni}(A)$ is equal to the ratio of aggregate K_{ni} to Q_{ni}. Dividing (A9) by (A10), and rearranging, produces an expression for the share of corporate capital in each industry as a function of output shares.

$$K_{ci}/K_i = \frac{(Q_{ci}/Q_i)}{(1 - Q_{ci})^* (R_{ci}^*/R_{ni}^*)^{\sigma_1} + (Q_{ci}/Q_i)} \tag{A14}$$

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Table A2. Equations used to calibrate the model

$$(k_{ci}/q_{ci}) = (\mu_i \beta_{ci}/R_{ci})\,[(1-\beta_{ci})(WR^*_{ci}/R_{ci})^{(1-\sigma_i)} + \beta_{ci}]^{\sigma_i/(1-\sigma_i)} \tag{A5}$$

$$k_{ni}(A_i)/q_{ni}(A_i) = (k_{ci}/q_{ci})(R_{ci}/R_{ni})^{\sigma_i} \tag{A6}$$

$$k_{ci} = (\beta_{ci}/(1-\alpha_i-\beta_{ci})^{\sigma_i}(W/R_{ci})^{\sigma_i} R^{*(\sigma_i-1)}_{ci} \tag{A7}$$

$$l_{ci} = \alpha_{ci}/[1-\alpha_i-\beta_{ci}] \tag{A8}$$

$$R_{ci}k_{ci}/q_{ci} + W(1+l_{ci})/q_{ci} = \mu_i\,[(1-\beta_{ci})\,W^{(1-\sigma_i)} + \beta_{ci}(R_{ci}/R^*_{ci})^{(1-\sigma_i)}]^{(1/(1-\sigma_i))} \tag{A9}$$

$$\underline{A}_i = [1-(\beta_{ci}/(1-\alpha_i-\beta_{ci}))((R_{ci}/R^*_{ci}W)^{(1-\sigma_i)} - (R_{ni}/R^*_{ci}W)^{(1-\sigma_i)})]^{-1/(1-\sigma_i)} \tag{A10}$$

$$k_{ni}(A_i) = A_i[(\beta_{ci}/(R^*_{ci}(1-\alpha_i-\beta_{ci}))) \times ((R^*_{ci}W/R_{ci})^{(1-\sigma_i)} + (\beta_{ci}/(1-\alpha_i-\beta_{ci}))(R_{ci}/R_{ni})^{(1-\sigma_i)})]^{\sigma_i/(1-\sigma_i)} \tag{A11}$$

$$l_{ni}(A_i) = k_{ni}(A_i)(\alpha_i/\beta_{ci})\,R^{*(1-\sigma_i)}_{ci}(R_{ni}/W)^{\sigma_i} \tag{A12}$$

$$c_i = g_i^{\phi} P_i^{\phi} \Big/ \left(\sum_{i=1}^{11} g_i^{\phi} P_i^{(1-\phi)}\right) \tag{A13}$$

Since the sum of total capital income, $\beta_i Q_i$, equals the sum of capital income in both sectors, we can also use (A8) to obtain the value of β_{ci}.

$$\beta_{ci} = \beta_i \frac{1}{(Q_{ci}/Q_i) + (R^*_{ci}/R_{ni})^{(\sigma_i-1)}(1-Q_{ci}/Q_i)} \tag{A15}$$

We can similarly use these relationships to obtain the shares of total capital in the eleven industries by using the distribution of value added (value added is $\mu_i Q_i$):

$$K_i/\bar{K} = \frac{s_i\beta_i/(K_{ci}R^*_{ci}/K_i + K_{ni}R^*_{ni}/K_i)}{\sum_{i=1}^{11} s_i\beta_i/(K_{ci}R^*_{ci}/K_i + K_{ni}R^*_{ni}/K_i)} \tag{A16}$$

This process results in all 19 allocations of capital (10 Kci's, 8 Kni's and K11) as a share of an as yet unknown total capital stock plus all of the values of the initial capital income shares.

Equations (A5) and (A6), which relate value added to capital, can be used to calibrate the initial total level of the capital stock, given that the sum of value added is equal to GNP. Thus, the sums of value added are rewritten as the sums of aggregate capital stocks multiplied by functional relationships. Dividing by total capital, $\bar{K}$, results in an equation for the total capital stock as a function of prices, capital shares, and GNP. Once total capital is measured, the total levels of the 19

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capital stocks can be determined. Next we can measure M_{ci} (equal to K_{ci}/k_{ci}), L_{ci} (equal to $M_{ci}l_{ci}$), and L_{ni} (since L_{ni}/K_{ni} equals $l_{ni}(A)/k_{ni}(A)$, via equations (A7), (A8) and (A12).

The next step in calibrating the model is to determine the total labor force $\bar{L}$ and the eight values of Γ_i. Total $\bar{L}$ is the sum of the already measured values of M_{ci}, L_{ci} and L_{ni} and the entrepreneurs. The integral in equation (28) contains two parts, the first measuring the entrepreneurs and the second noncorporate labor. Consider the first part, and substitute the exponential density function described above in the integral measuring entrepreneurs for sector 1. The solution to this integral produces a series of 128 terms all of the form e^{-x}/x. The first positive term in the series is $x = \Gamma_1 A_1$, the the next seven terms are all of the form $x = \Gamma_1 A_1 + \Gamma_2 A_2$, $\Gamma_1 A_1 + \Gamma_3 A_3, \ldots$ and enter with a negative sign. The next 21 terms, which enter with a positive sign are the sum of $\Gamma_1 A_1$ and all unique combinations of two of the remaining coefficients, i.e., $\Gamma_1 A_1 + \Gamma_2 A_2 + \Gamma_3 A_3$, $\Gamma_1 A_1 + \Gamma_2 A_2 + \Gamma_4 A_4, \ldots$. There are then 35 terms (with negative sign) which include unique combinations of three of the remaining sectors, 35 terms with positive sign which include unique combinations of 4, 21 terms with negative sign which include unique combinations of 5, 7 with positive signs which include unique combinations of 6, and the final term with a negative sign which is the sum of all terms, i.e., $\Gamma_1 A_1 + \Gamma_2 A_2 + \Gamma_3 A_3 + \Gamma_4 A_4 + \Gamma_5 A_5 + \Gamma_6 A_6 + \Gamma_7 A_7 + \Gamma_8 A_8$. These 128 terms are added, and the total is, in turn, multiplied by LA_i. A similar form occurs for the other seven sectors. Since all of these are multiplied by $\bar{L}$ and since total $\bar{L}$ is the sum of these entrepreneurs and other labor, we can obtain a solution for $\bar{L}$ of the form:

$$\bar{L} = \left[\sum_{i=1}^{11} L_{ci} + \sum_{i=1}^{11} M_{ci} + \sum_{i=1}^{11} L_{ni} \right] \Big/ \prod_{i=1}^{8} (1 - e^{-\Gamma_i A_i}) \tag{A17}$$

When summing, for each sector, capital in the noncorporate sector there is an A_i term multiplying the density function. (The remaining terms for $k_{ni}(A_i)$ relating to factor shares and prices can be taken outside the integrals as constants.) The solution to this integral also involves a series of 128 terms except that the functional form is now $e^{-x}(1/x + 1/x^2)$. The sum of this series of terms is all multiplied for each sector by $LA_i\Gamma_i$, but $\bar{L}$ can now be written using equation (A17). Since total K_{ni} (which is known) is equal to the integral of $k_{ni}(A_i)$ we now have eight equations in the eight unknown values of Γ_i, which can be solved simultaneously. Once these values are known we can calculate the value of $\bar{L}$ from (A17) and the number of entrepreneurs in each sector.

Another version of the model is calibrated under the assumption that entrepreneurs in each sector are in fixed supply. In this case the sum of M_{ci}, L_{ci}, and L_{ni} is held constant (since that will lead to a fixed labor supply with fixed entrepreneurs) and there are no distributional parameters in the model. Rather, the value of each integral for capital is measured as a fixed quantity (only the functional terms containing prices which can be brought outside the integral vary).

At this point all the levels of labor, capital and output are determined, and we can use equations (32) through (34) to determine the amounts of consumption for each of the eleven commodities. The eleven first-order conditions from the utility function

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can be used to form the ten ratios of consumption which along with holding of the sum of consumption expenditure constant lead to the functional forms of the ratios of consumption of each good to total consumption in equation (A13). These eleven equations can be used to solve for the eleven g's.

The final parameter value needed is the rate of time preference. By combining the relationships between observed patterns of consumption with the growth rate and interest rate, we have, in our 55-year continuous-time model, the steady-state equation:

$$\frac{\sum_{i=1}^{11} P_i C_i}{\sum_{i=1}^{11} \mu_i P_i Q_i - R_{ci} K_{ci} - R_{ni} K_{ni}} = \frac{(1 - e^{-(n+\rho-r\eta)^{55}})(1 - e^{-r^{g40}})(\rho + r^g - r\eta)n}{(1 - e^{-(\rho+r^g-r\eta)^{55}})(1 - e^{-n^{40}})(n + \rho - r\eta)r^g} \quad \text{(A18)}$$

In a model without rents, the denominator on the left-hand side of the equation would simply be WL; since there are rents in this model, we must calculate labor income as a residual of GNP minus capital income. This equation is used to calibrate the time preference factor ρ. Note that while we are free to set r to any value (including unity) by defining capital in units larger than a dollar, (and must also conform measures of depreciation flows and net investment flows accordingly) in the present value formulation r and n must represent pure rates. This is a simple procedure. If r measured as a rate is 0.05 and our units of capital are measured as twenty dollar units, the pre-tax, net of depreciation, rental must be divided by twenty to produce r as a rate per dollar.

B. Solving the model

To solve the model, when a new set of tax rates is introduced we guess values of r and W. Using the eleven forms of equation (35) as modified by equation (A9), we then solve for the eleven prices which are consistent with these values. Because the model includes capital asset prices, these equations are non-linear and must be solved numerically. The new set of prices along with the new tax rates are used to calculate the values of *Rci* and *Rni*, and, with R_{ci} amd R_{ni}, the values of A_i. Next we solve for the amounts of noncorporate capital, the levels of noncorporate output, and the number of noncorporate workers and entrepreneurs, all of which depend solely on the calibrated parameters and the levels of r, W, prices, and tax rates. Given the prices and the numeraire convention that fixes total expenditures on consumption, we can also determine the consumption of each good.

Since corporate capital, K_{ci}, can be written in terms of corporate output Q_{ci}, via equation (A5), the eleven supply and demand equations in (32)–(34) can be used to solve for the eleven values of Q_{ci} (treating owner-occupied housing in the same manner as corporate output), and in turn for the values of K_{ci}, M_{ci}, and L_{ci}. All of the allocations of capital, labor and output have now been made. If we have guessed the equilibrium values for r and W, the resulting allocations will satisfy the labor constraint in (28) and the budget constraint that arises after substituting in the

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compensation scheme. This constraint is:

$$\frac{(n+\rho-\tilde{r}\eta)(1-e^{(\rho+\bar{r}-\tilde{r}\eta)55}}{(1-e^{-(n+\rho-\tilde{r}\eta)55})(\rho+\bar{r}-\tilde{r}\eta)}\Sigma\bar{P}_i\tilde{C}_i=$$

$$\frac{(n+\rho-r^*\eta)(1-e^{-(\rho+\bar{r}-r^*\eta)55})}{(1-e^{-(n+\rho-r^*\eta)55})(\rho+\bar{r}-r^*\eta)}[\Sigma\bar{P}_i\tilde{C}_i+(n-\bar{r})\Sigma\bar{P}_{ki}(\tilde{K}_i-K_i^*)] \quad \text{(A19)}$$

C. Data sources

The model is calibrated using data on corporate shares of productions, industry shares of total value added, aggregate shares of income accruing to capital income and to workers, depreciation rates, and the composition of the capital stock in each industry, as well as estimated initial tax rates. Initial prices, wage rates, and net returns to capital are set to 1. Table A1 lists the data used to calibrate the model with the exception of the input-output coefficients. Data sources differ slightly with respect to their dates, although all come from the early 1980's. This reflects differences in data availability. Shares of corporate output are taken from Gravelle and Kotlikoff (1989). Shares of value added and capital income shares were obtained from the National Income and Product Accounts for 1982. Capital income shares are the sum of depreciation, profits, interest, and property taxes divided by value added. Rosenberg's (1969) data were used to allocate property taxes and proprietorship income to capital and labor. We use the most recent input-output data. These are the 1981 input-output accounts reported in *The survey of current business*, January 1987. Labor income shares are estimated from data on payments to labor from sole proprietorship tax returns for 1980, the last year in which such data were reported for agriculture.

The derivation of marginal tax rates requires a detailed description. In earlier studies, such as Shoven (1976), the level of tax burden was typically judged by current (the cash flow of) taxes divided by some measure of current income. These average tax rates did not properly account for the advantage of the timing of tax write-offs, such as depreciation allowances, and they failed to distinguish taxation of the existing stock of capital from taxation of new investment. As is well known, average tax rates based on the cash flow of taxes have no necessary relationship to marginal effective tax rates on new investment and it is the latter that governs the efficiency effects of tax policies.

Our marginal effective tax rates are based on a discounted cash flow formula which compares the internal rate of return with and without taxes. This measure accounts for all of the timing effects associated with certain tax preferences, including accelerated depreciation and deferral of taxes on capital gains until realization. Most current studies, such as Fullerton, Henderson, and Mackie (1987) and Gravelle (1982) employ such marginal tax rates.

In the case of a depreciating asset, the relationship between the pre-tax return and the after-tax return in the corporate sector is determined by the rental price formula of Hall and Jorgenson (1967):

$$r_p=((r_f+\delta)(1-t_f\,\mathrm{PVD}(1-mk)-k))/(1-t_f)-\delta \quad \text{(A20)}$$

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where r_p is the pre-tax real return, r_f is the after-tax discount rate of the firm, δ is the economic depreciation rate, t_f is the statutory tax rate of the firm (equal to the corporate tax rate for corporate production and equal to the individual tax rate for noncorporate production), PVD is the present value of depreciation deductions for tax purposes, k is the investment tax credit rate, and m is the fraction of k that reduces the basis for depreciation purposes. Note that t refers to the tax on gross income as more commonly used; it is related to τ by $t = \tau/(1+\tau)$. The value of depreciation is discounted at the nominal discount rate, $r_f + \pi$, where π is the rate of inflation. This formula applies to investments in equipment and structures which are subject to depreciation.

In the case of an appreciating asset, assuming that returns are not indexed:

$$e^{(r_f+\pi)T} = e^{(r_p+\pi)T}(1-t_f) + t_f \tag{A21}$$

where T is the holding period. This type of calculation applies to inventories at the level of the firm, when FIFO (first-in, first-out) accounting is used. When LIFO (last-in, first-out) accounting is used, π is set to zero in equation (A21). This formula simply expresses the mathematical relationship between pre-tax and after-tax returns when income is taxed on a realization basis. This approach treats inventories as goods under construction whose accrued value is not taxed until the product is sold. This deferral aspect is relatively unimportant in the case of inventories where holding periods are very short. The same type of formula is used, however, in the calculation of effective capital gains tax rates on corporate equity where deferral of tax is important.

Discount rates will differ between the corporate and noncorporate sector. For the noncorporate firm, the discount rate is the overall net after-tax return, r. In the case of the corporate sector, however, there is another layer of tax imposed, so that r_f for the corporate firm is different from r. Corporations are allowed to deduct interest at their higher statutory tax rate, including the inflation premium and this interest is subject to individual tax at the personal level. In addition, the equity return to capital is subject to tax as dividends and capital gains. The discount rate of the corporation is equal to a weighted average of debt and equity:

$$r_f = f(i(1-t_f) - \pi) + (1-f)E \tag{A22}$$

where f is the fraction financed by debt, i is the nominal interest rate, τ_f is the corporate statutory rate, and E is the return required by stockholders prior to personal level taxes. The discount rate of the noncorporate firm is:

$$r = f(i(1-t_f) - \pi + (1-f)E(1-v) \tag{A23}$$

where τ_f in this formula is the individual tax rate and v is the effective tax rate on corporate equity at the personal level. This formula simply says that the overall net after-tax return is a weighted average of the after-tax return to debt and the after-tax return to equity, assuming individuals must earn the same return on their equity investments in the noncorporate sector as in the corporate sector. The value of v is determined by the formula:

$$E(1-v) = s_d E(1-t_f) + (\ln(e^{(E(1-s_d)+\pi)T}(1-t_g) + t_g)/T - \pi) \tag{A24}$$

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where s_d is the share of the real return paid out as dividends, τ_f in this equation is the individual statutory tax rate, T is the capital gains holding period, and τ_g is the capital gains tax rate. The first part of this equation is the after-tax return on dividends; the second part is the after-tax return on capital gains, derived from a formula of the same functional form as (A21).

The tax rate on owner occupied housing is calculated by determining a cost of capital which is:

$$r_p = f(i(1-nt_f)-\pi)+(1-f)E(1-v)-n\tau_g \tag{A25}$$

where n is the fraction of interest and property taxes deducted by homeowners and g is property taxes as a percent of asset value. The effective tax rate is increased because of the inability to deduct interest payments in full and lowered by the ability to deduct property taxes in part. Effective tax rates levied on pre-tax income, t's, are measured as $(r_p - r)/r_p$; the tax wedge, τ, which is measured as a tax on after-tax income, is $(r_p - r)/r$.

The depreciation rates for equipment and structures are taken from Hulten and Wykoff (1981). Rates for rental housing and owner occupied housing are set at one percent. The inflation rate is set at .0456, the nominal interest rate is set at .0804, and the real return to corporate equities before personal tax is set at .0883. These values are those used by Hendershott and Hu (1981). The holding period for inventories is set at four months, based on the ratio of inventories to sales, and half of inventories are assumed to be covered by FIFO. The holding period for capital gains, following Bailey (1969), is set at 40 years. Data on the average holding period of corporate stock indicate a holding period of 7 years. A substantial fraction of gains, however, are held until death (most estimates suggest about three quarters) and assignment of a long holding period accounts for the failure to tax gains passed on at death. Based on data from tax returns, about half of property taxes and interest on owner-occupied housing are deducted; property taxes are estimated to be 1.4 percent of asset value. Following Fullerton, Gillette, and Mackie (1987), the share deducted falls to 40 percent after the Tax Reform Act.

There are a number of unsettled issues in the economics literature, especially as to how corporations choose debt/equity ratios and dividend pay-out ratios. The conventions adopted in this study use an averaging approach; alternative conventions could alter tax rates. The value of f is set at one third (see Fullerton and Henderson, 1987). Based on historical averages, two thirds of the real return on corporate equities is paid out as dividends. When aggregating capital to construct tax rates, capital stock shares are weighted by pre-tax returns. The capital stock shares reported in Table A1 are based on cumulating historical investment over time and applying depreciation weights to obtain capital stocks for 28 different business assets. These assets are allocated to industry using the capital flows tables. For further detail on the construction of assets as well as the measurement of tax lives and investments credits see Gravelle (1982, 1983). The stock of land and allocations of land among industries are taken from Eisner (1980). Allocations of inventories are taken from the *Internal revenue service statistics of income, corporate tax returns, 1984.*

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The corporate tax rate is 46 percent under prior law and 34 percent under the new tax law. The average marginal tax rates under prior and new law vary by type of income sources. In this analysis, a composite tax rate is used and is set at 30 percent under prior law and 23 percent under the new tax law, based on data from the Office of Tax Analysis, U. S. Treasury. Effective tax rates prior to the 1986 Tax Reform law are denoted by an asterisk.

The assumptions given above result in an after-tax real rate of return of .0488. The growth rate is chosen to ensure that investment demand fully accounts for the output of the construction industry; that rate is .014. The tax rates reported here do not account for some of the specialized provisions of the Tax Reform Act, which are quite difficult to model. Although these provisions accounted for a considerable amount of revenue loss, rough calculations suggest that they were relatively unimportant in marginal tax rate calculations. Fullerton, Henderson, and Mackie (1987) reach similar conclusions. Many provisions produce revenue, particularly in the short run, but are important in their effects on new investment because most of the revenue arises from existing capital. The only provision of any importance in marginal tax rate calculations is the inventory capitalization rule. Incorporating that rule would slightly reduce the efficiency gains reported in this study. On the other hand, this study uses a relatively conservative assumption of the share of inventories under FIFO (first in, first out) accounting, which appears to roughly compensate for this omission. Gravelle (1988) finds that the minimum tax, while producing revenues in the short run, has little effect on the marginal tax rate. In a study of rental housing, Gravelle (1987) finds that the passive loss restriction is relatively unimportant for new investment due to restrictions on depreciation and lower inflation rates; most revenue gain is probably associated with existing tax shelters.

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