NBER WORKING PAPER SERIES

TAX POLICY, HOUSING PRICES, AND HOUSING INVESTMENT

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Working Paper No. 2814

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
January 1989

This paper was prepared for the NBER Conference on Residential Real Estate and Capital Formation, Newport, Rhode Island, October 7-8, 1988, and is forthcoming in Regional Science and Urban Economics. I am grateful to Don Fullerton, Patric Hendershott, Edwin Mills, Jim Poterba, and John Shoven for helpful suggestions and to Erik Beecroft and Philippe Thalmann for excellent research assistance. This research is part of NBER's research program in Taxation. Any opinions expressed are those of the author not those of the National Bureau of Economic Research.

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ABSTRACT

This paper employs a general equilibrium model to assess the effects of major components of the Tax Reform Act of 1986 on the performance of housing and other industries. The model considers both short-term and long-term effects on housing demands, house values, and investment in housing. Model results indicate that in the short run, the recent cuts in corporate tax rates, elimination of investment tax credits, and scaling back of depreciation deductions together have negative implications for investment in non-residential capital but positive effects on housing investment. This mainly reflects the fact tnat prior to the '86 tax reforms, investment tax credits and favorable depreciation rules disproportionately benefitted non-housing industries; thus their removal especially affects industries other than housing and helps "crowd in" housing investment. Over the long term, however, the tax changes imply lower investment in housing as well as in other types of capital. The reduced housing investment stems from adverse effects of the reforms on aggregate output and real income.

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Introduction

The Tax Reform Act of 1986 (TRA86) introduced the most sweeping changes in the U.S. tax code since the substantial broadening of the income tax during World War II. The new law's changes in personal and corporate income taxes, in depreciation rules and in investment credits will influence the values of existing business and residential capital and alter incentives to invest in such capital. These responses in asset prices and capital formation have important implications for individual welfare.

Predicting the overall effects of TRA86 is difficult because major components of the new tax law often seem to have opposite implications. Consider, for example, the implications of TRA86 for investment in housing. The new law's reduction in the corporate income tax rate might be regarded as hurting investment in residential capital relative to non-residential capital. Less than three percent of residential capital is owned by corporations and thus a very small proportion of residential capital income is subject to the corporate tax. Hence the corporate tax rate reduction, taken alone, would appear to offer a much larger boost to investment in non-residential capital and could potentially crowd out investment in housing. On the other hand, the elimination of the investment tax credit (ITC) tends to favor investment in housing. Since residential capital consists mainly of structures, and since the ITC applied almost entirely to equipment, it is industries other than residential housing services that benefitted most from the ITC and that lose the most from its removal. To the extent that the ITC elimination discourages investment by other industries, it would help to reduce interest rates and "crowd in" investment in housing.

This paper investigates the effects of TRA86 on housing by employing a simulation model designed to consolidate the often contradictory effects of specific components of larger policy initiatives. The model is general equilibrium in nature, addressing both cost-side and demand-side effects of policy shocks. Special attention is given to industries related to housing: namely, the residential construction industry and the "housing services industry" (which employs residential housing stocks to yield housing services enjoyed by homeowners and renters). The model considers closely the major tax instruments that affect homeownership costs and housing demands as well as those that influence costs of producing new housing.

As in many other general equilibrium models, factor prices, commodity prices, and interest rates are endogenously determined as part of the general equilibrium system. However, several features of the model distinguish it from other general equilibrium models and make it especially well suited for assessing housing issues. One critical difference is that the model incorporates adjustment dynamics and associated effects on asset prices. Most general equilibrium models assume that physical capital is perfectly mobile across industries, an assumption which is highly implausible given the different characteristics of commercial, industrial, and residential capital. Just as important, the assumption generates unrealistic policy implications. Perfect mobility implies that if taxes are raised on the capital income generated from a particular industry, capital will instantly be reallocated (flow out of the industry facing increased capital taxation) so as to restore after-tax value marginal products. This assumption leaves no room for short-run divergences in the after-tax marginal products of capital and associated differences in market prices for capital assets; it cannot be reconciled with the observation that higher taxes on the capital of a given industry often generate windfall losses to the targeted industry and, in some cases, windfall gains to the industries that were spared.

In the model used here, physical capital is industry-specific, and the level of capital in each industry is based on investment decisions of forward-looking managers (homeowners) who maximize the value of the firm (house) subject to adjustment costs. Under this specification, increases in capital taxes in a given industry particularly reduce the prospective profitability of capital in that industry and lower its market value. Such a specification is especially useful in evaluating the consequences of TRA86 for housing, since many of its capital tax changes do not apply equally to housing and other industries and thus can be expected to have different implications for house values relative to other assets like corporate equities.

This specification of adjustment dynamics follows the asset price approach originated by Summers (1981), a synthesis of the q theory of investment of Tobin (1969) and the adjustment cost investment framework of Lucas (1967) and Treadway (1968). The approach has been applied to housing issues in a partial equilibrium framework by Poterba (1984) and to other tax issues in general equilibrium by Goulder and Summers (1987). The model applied here incorporates some major extensions to the Goulder-Summers model that allow for a more satisfactory assessment of housing issues. First, it explicitly distinguishes industry uses of structures and equipment. As in Fullerton and Henderson (1986) and

Jorgenson and Yun (1986), the model recognizes the different ratios of structures to equipment across industries and allows these ratios to change in response to policy shocks.[1] Second, and in contrast with Fullerton-Henderson and Jorgenson-Yun, the model considers explicitly the different industries and technologies involved in the production of different capital goods. This enables one to consider how different industries benefit from an investment boom depending on the source of the boom. One would expect tnat a surge in demand for new housing, for example, will especially benefit the residential construction industry (which produces new residential structures) while an increase in demand for, say, agricultural products will provide greater boosts to equipment manufacturers.[2]

A third extension is a closer attention to the determinants of the costs of homeownership and the links between these costs, house prices, and housing investment. The model incorporates the important tax instruments that determine the costs of homeownership and housing investment to landlords and owner-occupants, and it accounts for the influence of these costs on rental prices and house values. Forward-looking homeowners decide on the level of investment in new housing in a manner consistent with utility maximization, taking into account the costs of homeownership and the capacity of new housing stocks to generate housing services.

These features give the model some important capabilities for exploring how tax policy initiatives affect housing costs, house prices, and housing investment. However, some limitations in the model and the scope of its useful applications should be noted. The model treats the ratio of owner-occupied to rental housing as exogenous, and thus cannot examine issues of tenure choice.[3] In addition, it does not consider land as a separate factor of production, or consider the implications of demographic change, as in some partial equilibrium models of housing.[4]

The policy changes considered in this paper are those of the new tax law. We consider both the effects of major individual components of the new law as well as the overall effects emanating from the component changes taken together. The focus is on the new law's effects on investment, output, and asset prices.

The rest of the paper is organized as follows. The next section presents the structure of the simulation model. Section II describes the model's data sources and parameterization methods. The third section analyzes the simulation results, and the final section presents conclusions.

I. MODEL STRUCTURE

A. General Features

1. Industries, Factors, and Agents. The model distinguishes six domestic industries: (1) agriculture and mining, (2) manufacturing, (3) services (other than residential housing), (4) non-residential construction, (5) residential construction, and (6) residential housing services. This breakdown of U.S. industries allows the model to track major interindustry effects and gives emphasis to housing-related industries.

Each industry produces a single output using inputs of labor, structures capital, equipment capital, and intermediate inputs. The outputs of the first five industries serve both as intermediate goods and as final goods. Housing services are for final use only. The final goods supplied meet demands by consumers, investors, the government, and foreigners.[5]

2. Production and Use of Structures and Equipment. In order to investigate principal interactions between housing-related and other industries, it is important to distinguish the capital used to produce housing services from the capital in other productive uses. This is the case for two reasons. First, the housing services industry is much more structures-intensive than other industries. This implies that the composition of overall investment demands in terms of demands for new structures or equipment depends on the source of the investment demands, that is, on the particular industries that are doing the investing. Second, the technology and industries employed to create housing structures differ from those involved in the production of non-residential structures (business plant, platforms, non-residential housing, etc.) These considerations imply that changes in investment levels will have very different effects on other industries depending on the sources of the changes in investment.

To capture these interactions, the model distinguishes structures and equipment and identifies explicitly the industries that manufacture residential and non-residential structures. The relationships between the different capital assets and the industries that produce them are shown in Table 1.[6]

3. Taxes. The model contains considerable detail on taxes. Industries face taxes on labor and intermediate inputs. Output taxes

Table 1

Relationships among Industries and Capital Assets

Industry	Capital Used	Industry Producing The Capital
Housing services	Residential structures	Residential construction
	Equipment	Manufacturing
All others	Nonresidential structures	Nonresidential construction
	Equipment	Manufacturing

apply to industry products and sales taxes apply to consumer goods. The model also incorporates profits taxes, depreciation deductions, investment tax credits, capital gains taxes, property taxes, and individual income taxes, as described below.

B. Production

In each industry, production follows the relationship

$$X = f[g(\bar{K},L),M] - AC \tag{1}$$

where X is gross output, $\bar{K}$ is composite capital, L is labor, M is a composite of materials (intermediate) inputs, and AC denotes total adjustment costs. The form of the value added function, g(.,.), is CES, while the function f(.,.) is Leontief. Equation (1) treats gross output as separable between inputs and total adjustment costs. The capital composite is generated by structures capital (K_s) and equipment capital (K_e) according to

$$\bar{K} = h(K_s, K_e) \tag{2}$$

where h(.,.) is a CES function.

Total adjustment costs are based on the rate of investment in each type of capital:

$$AC = \phi_s\left(\frac{I_s}{K_s}\right)I_s + \phi_e\left(\frac{I_e}{K_e}\right)I_e \qquad (3)$$

where $\phi(\cdot)$ is a convex function representing adjustment costs per unit of investment in capital of type i, and I_i is the quantity of investment in capital of type i (i = s,e). Faster rates of investment imply reductions in output as more resources are diverted from other productive purposes and used to install new capital. In the housing services industry, in particular, faster investment (purchases of new homes or expansions of existing homes) reduce the level of housing services produced from existing housing resources — labor is diverted from maintenance functions, equipment is temporarily turned off, rooms in close proximity to installation activity become temporarily uninhabitable, etc.

At each point in time, the level of each type of capital is given (determined by prior investment decisions); managers' choice variables are the input levels for labor and intermediate goods and the levels of investment in each type of capital. The fundamental behavioral assumption governing these choices is that managers aim to maximize the value of the firm. In industries 1–5, managers serve stockholders; in the housing services industries, managers are homeowners who serve themselves.

Under this specification for production, the optimal levels of materials and labor can be determined completely on the basis of current conditions and are those that minimize current labor and materials costs.[7] However, because today's investment levels affect both present and future adjustment costs (by affecting future capital stocks), the choice of investment levels is a fundamentally intertemporal problem. In order to reduce the discounted value of adjustment costs, firms approach desired long-run capital intensities gradually. The length of time necessary to attain the optimal capital intensity depends on the curvature of the adjustment cost functions.

C. Asset Values and Investment

1. House Values and Housing Services. The framework for determining house values is similar to that employed by Poterba (1984) in a partial equilibrium context. While Poterba concentrated on owner-occupied housing, we consider both owner-occupied and rental housing. House values are closely related to the net service flows that owners of housing receive at each moment in time.

The basis for determining house values is the arbitrage requirement that the (risk-adjusted) net return from owning or renting out a house be equal to the return that could be enjoyed on other assets. For owner-occupiers, the net return includes the implicit rental (value of housing services consumed) and thus accounts for the consumption benefits as well as strictly financial returns associated with homeownership. The arbitrage condition is:

$$(1 - \kappa_H)\frac{\dot{V}}{V} + (1 - \theta_H)\frac{S}{V} = (1 - \theta)i + \eta_H \qquad (4)$$

where V is the equity value of housing, S is the net service flow associated with owning (and either occupying or renting out) a house, κ is the effective concurrent tax rate on housing capital gains, θ_H is the effective tax rate on net service flows from housing, θ is the marginal tax on individual interest income, i is the nominal interest rate, and η_H is the risk premium associated with homeownership.[8] The dot over a variable denotes its rate of change with respect to time. Subject to a transversality condition requiring the net service flow to grow (in the long run) at a rate less than the after-tax risk-adjusted rate, equation (4) is solved by:

$$V_t = \int_t^\infty \left(\frac{1-\theta_H}{1-\kappa_H} \right) S_u \left(\exp \int_t^u \frac{-r_v}{1-\kappa_H} dv \right) du \tag{5}$$

where r equals $(1 - \theta)i + \eta_H$, the risk-adjusted rate of return. The value of a house is the discounted value of the net after-tax service flows that it generates.

The determination of the value for S is made complicated by the fact that the tax system treats owner-occupiers and landlords quite differently. We express S as the sum S^O and S^R, the net service flows to owner-occupants and landlords, respectively. Combining the two types of service flows is a simplification that enables one to compute a single V representing the total value of owner-occupied and rental housing employed in the production of housing services. A more elaborate model would keep the service flows separate and allow for distinct asset values, but this is beyond the scope of the present paper.[9]

S^O, the net service flow to owner-occupiers, is given by:

$$S^{O} = p_{HS}X^{O}_{HS} - p_{L}L^{O} - p_{M}M^{O} - (1 - \theta)[MI + PT^{O}] + BN^{O} - IEXP^{O} \qquad (6)$$

where p_{HS} is the (here implicit) rental price of housing services, p_L is the price of labor services, p_M is the vector of intermediate input prices, MI and PT are mortgage interest and property tax payments, BN is new debt issue, and IEXP is investment expenditure.[10] The "O" superscript refers to owner-occupied housing: thus X denotes the output of housing services from owner-occupied housing, L the labor input applied to producing (maintaining) owner-occupied housing services, etc. Equation (6) addresses the facts that homeowners cannot deduct maintenance costs but can deduct mortgage interest and property tax payments in calculating personal income taxes.

S^R, the net service flow to landlords from rental housing, is given by:

$$S^{R} = (1 - \tau^{R})(p_{HS}X^{R}_{HS} - p_{L}L^{R} - p_{M}M^{R} - iDEBT^{R} - PT^{R}) + \tau^{R}D + BN^{R} - IEXP^{R} \qquad (7)$$

The "R" superscript signifies rental housing. τ^R is the marginal tax rate on landlord's profits, a weighted average of personal and corporate tax rates, with the weights determined by the proportion of rental housing owned by corporations. DEBT is nominal debt and D is the value of currently allowable depreciation deductions. It is assumed that the services of rental and of owner-occupied housing are perfect substitutes, so that $p^{O}_{HS} = p^{R}_{HS} = p_{HS}$.[11]

Both landlords and owner-occupants are assumed to maintain debt equal to a constant fraction, b, of the value of their housing: $DEBT^i = b(P_{K_s}K_s^i + P_{K_e}K_e^i)$, $i = O,R$. Property tax payments are given by $c(P_{K_s}K_s^i + P_{K_e}K_e^i)$, $i = O,R$, where c is the property tax rate. Mortgage payments of owner-occupiers are expressed by $iDEBT^O$.

2. <u>House Values, Capital Prices and Housing Investment</u>. There are important and close connections between house values, the value of new residential capital (structures and equipment), and investment in (production of) new residential capital. Using (6) and (7) to substitute for S in (5) yields an expression for the value of housing in terms of housing services output, prices, taxes, and other parameters. Homeowners choose investment levels so as to maximize this value. Investment decisions are somewhat complex because homeowners need to decide on purchases of two assets — residential structures and equipment — whose contributions over time to the value of the house are interdependent. The conditions for optimal investment are derived in the appendix.

Given tastes for housing services, taxes, and the technology for producing housing service, solution of the homeowner's maximization problem gives rise to λ_s^{HS} and λ_e^{HS}, the shadow values of residential structures and equipment, respectively. These shadow values are closely related to demands for new housing capital and help determine the market prices for such capital. A shift in tastes leading to greater demands for housing services, or a change in tax policy that reduces the costs of producing housing services, will increase the shadow values of residential capital and raise housing investment demands. This will promote higher prices for such capital and induce greater production of such capital by the residential construction industry and by equipment manufacturers.

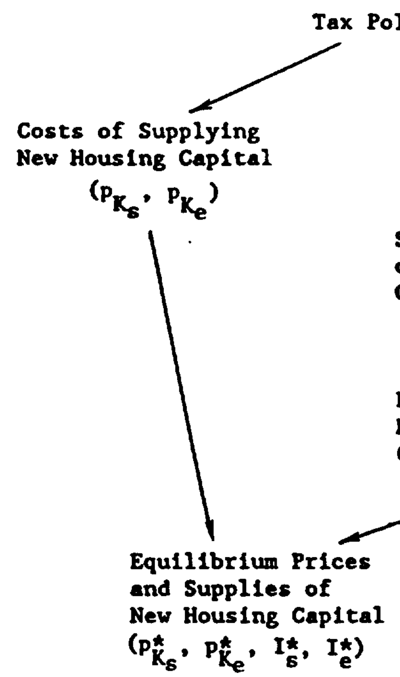
Figure 1 outlines some of the principal relationships among taxes, housing investment demands, housing capital supply costs, and market prices. Details on these relationships are provided in the appendix.

3. Other Asset Prices and Investment. The determination of asset values for the other industries is similar in fundamental respects to the calculation for the housing services industry. Again the foundation is provided by an arbitrage condition requiring the firm to offer the same risk-adjusted after-tax return to households (shareholders) as is offered elsewhere. And again the equity value of the firm is the discounted value of the stream of net returns that the firm generates. Determining the value of the firm requires one to specify firms' financing rules; these are presented in detail in Goulder and Summers (1987) and will only be briefly mentioned here. Firms finance investments with retained earnings as well as funds obtained by issuing new shares and debt. They pay out a constant fraction of after-tax profits as dividends and issue debt so as to maintain a constant ratio of debt to the value of their capital. New share issues provide the marginal source of investment funds; that is, they make up the difference between the desired expenditure on investment and the sum of retained earnings and funds from new debt issue.[12]

The appendix derives the expression that applies under these assumptions for the value of the firm in terms of the technology, prices, taxes, and parameters. Firms choose investment levels so as to maximize this value. The conditions for optimal investment are also derived in the appendix.

Figure 1

Relationships among Tax Policy Changes, House Prices and Housing Investment



D. Consumption, Government Spending, and International Transactions

Consumption and saving derive from the utility-maximizing behavior of a representative household facing an infinite time horizon and having perfect foresight. At each point in time, t, the household maximizes a utility function of the form:

$$U_t = \int_t^{\infty} e^{\rho(t-u)} \frac{\sigma-1}{\sigma} C_u^{\frac{\sigma}{\sigma-1}} du \tag{8}$$

where ρ is the rate of time preference, σ is the intertemporal elasticity of substitution in consumption, and C is an index of overall consumption. The household maximizes utility subject to the intertemporal budget constraint requiring the present value of consumption to be less than or equal to total wealth (current nonhuman wealth plus the present value of labor income and net transfers). Details are provided in Goulder and Eichengreen (1988). In each period, overall consumption is allocated across the 17 consumer goods according to fixed expenditure shares. Housing services is a consumer good identical to the output of the housing services industry. Other consumer goods are created by combining the outputs of several industries in fixed proportions.

The treatment of government behavior and of international transactions is the same as in Goulder and Eichengreen, to which the reader is referred for details. The government collects taxes, distributes transfers, and purchases goods and services, and faces an annual budget balance constraint. The levels of overall government spending (transfers plus purchases) are exogenous in every period. The model exhibits steady-state growth in the base case (or benchmark equilibrium); overall real government spending, in particular, is specified as increasing at the steady-state rate of growth. The model is calibrated so that in the base case, the government budget balances in each period. In revised case (or policy change) simulations, the levels of real overall government spending are fixed at the same levels as in the base case, and government budget balance is maintained through lump-sum adjustments to individual income taxes.

Imports and exports stem from optimizing behavior, as described in Goulder and Eichengreen. In this paper we do not consider international capital flows.

E. Equilibrium

Equilibrium must satisfy two sets of conditions. The intratemporal requirement is that, given expectations of future variables, current supplies and demands balance at each point in time. The intertemporal requirement is that of perfect foresight: expectations must conform to the values realized in later periods.

Intratemporal equilibrium requires that at each point in time: (1) the demand for labor equal its supply; (2) the demand for the output of each industry equal its supply, (3) total external borrowing by firms equal total saving by households, and (4) government revenue equal government spending. These four types of requirements yield nine equilibrium conditions for the economy (since there are six industry outputs); they determine the prices of industry outputs (including the price of housing services), the interest rate, and the scope of adjustments to personal income taxes necessary to assure government budget balance.

Perfect foresight expectations are achieved using a solution technique similar to that in Fair and Taylor (1983). Details of the solution procedure are provided in Goulder and Eichengreen.

II. DATA SOURCES AND CALIBRATION METHOD

A. Data Sources

1. Production Data. The model integrates data from several sources to form a 1983 benchmark data set. Much of the benchmark data is drawn from the general equilibrium data set assembled by Scholz (1987). This is our source for information on production function elasticities, benchmark labor intensities, intermediate good elasticities, labor input taxes, intermediate input taxes, and sales taxes.

We supplement the Scholz data with detailed information from Bureau of Economic Analysis (BEA) input-output tables for 1977 and 1982 to determine benchmark input requirements for the production of housing services. The input-output data applies to owner-occupied housing; we assume that the technology for producing rental housing services is the same.

Data on stocks of structures and equipment capital for each industry in 1983 are obtained from Bureau of Economic Analysis computer tapes. Further parameters are obtained by making use of information from Jorgenson and Sullivan (1981) on the asset composition of U.S. industries.

We combine this information with data from Auerbach (1983) on investment tax credit rates and economic depreciation rates by asset type to obtain investment tax credit rates (ITC) and depreciation rates (δ^R) by industry. Similarly, we employ the Jorgenson-Sullivan information in conjunction with data from Fullerton and Lyon (1988) on the depreciation allowances by asset type to determine industry tax depreciation rates (δ^T). For the housing services industry, δ^R and δ^T (where the latter applies only to rental housing) are calculated based on information in DeLeeuw and Ozanne (1979). Other important production-related parameters include dividend payout ratios, debt-capital ratios, and equity risk premia, as well as tax rates applying to corporate profits, capital gains, and individual capital and labor income. Sources of these parameters are described in Goulder and Eichengreen.

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

2. Other Data. Most of the data for the household, government, and foreign sector components of the model derive from Scholz. This includes household disposable incomes, expenditure shares, and transfers received. It also includes data on government purchases, exports, and imports. The NBER TAXSIM model was the source of data on individual income tax rates.[13]

B. Calibration

Calibrating the model involves specifying values for certain parameters based on outside estimates and deriving the remaining ones from restrictions posed by two sorts of requirements. According to the replication requirement, the model must generate a base case solution with

Table 2

Benchmark Values for Industry Tax and Behavioral Parameters

	(1) Agri-culture and Mining	(2) Manu-facturing	(3) Services	(4) Non-Resi-dential Construc-tion	(5) Residen-tial Construc-tion	(6) Housing Services
Dividend Payout Ratios (a)	.285	.274	.334	.129	.129	1.000
Debt-Capital Ratios (b)	.143	.153	.422	.080	.080	.502
Equity Risk Premia (η)	.119	.086	.093	.091	.091	.100
Rates of Economic Depreciation (δ^R)						
Structures	.041	.034	.028	.027	.027	.025
Equipment	.140	.133	.149	.170	.170	.213
Investment Tax Credits (ITC)						
Structures	.000	.000	.064	.000	.000	.000
Equipment	.085	.096	.091	.094	.097	.000
Elasticities of Substitution						
Capital-Labor	.679	.800	.800	.800	.800	.700
Struc.-Equip.	1.000	1.000	1.000	1.000	1.000	1.000

Growth Rate of Effective Labor Services (g) (steady-state real growth rate)	.03
Growth Rate of Nominal Wages (Π_0) (steady-state inflation rate)	.05
Corporate Profit Tax Rate (τ)	.46
Effective Capital Gains Tax Rate (κ)	
Housing services	.00
Other industries	.05
Rates of Tax Depreciation (δ^T)[1]	
Structures[2]	.099
Equipment	.347
Marginal Income Tax Rates	
Labor income (θ_L)	.285
Capital income (θ)	.337

[1]These rates do not apply to owner-occupied housing.

[2]The services industry includes many public utilities, and public utilities structures more favorable depreciation rules than other structures. Hence we employ a δ^T of .111 services structures, a weighted average of the rates applicable to public utility and o structures in this industry.

values matching those of the benchmark data set. According to the balanced growth requirement, the model must generate a steady-state growth path in the base case.

We first specify the exogenous growth rate of effective labor, g, the exogenous growth rate of nominal wages, π_0, and the gross of tax nominal interest rate, i. These variables take the values .03, .05, and .063 respectively. g accounts for both population growth and Harrod-neutral technical change, and determines the steady-state real growth rate of the economy.[14] π_0 determines the steady-state inflation rate.[15] We also employ a value of 0.5 for the intertemporal elasticity of substitution in consumption (σ) in standard simulations.[16]

In the steady state, the rate of gross investment, I/K, for each capital asset in each industry is given by

$$\frac{I}{K} = g + \delta^R \tag{9}$$

where industry and asset subscripts have been suppressed for convenience. Values for K, g, and δ^R are contained in the benchmark data set, allowing the initial level of investment in each industry to be derived from (11). Combining these investment levels with data on firms' incomes and with the required dividend payments implied by firms' dividend payout ratios, one can calculate the level of external borrowing by firms necessary to meet investment needs.

On the household side, one can calculate human and non-human wealth based on benchmark income flows, the benchmark interest rate, and the assumption of steady-state income growth.[17] The solution of the household utility maximization problem yields an expression for consumption in terms of total wealth, the path of interest rates, and parameters. Using the benchmark values for total wealth and the (steady-state) interest rate, along with a posited value for time preference (ρ), we calculate initial consumption; this is subtracted from initial income to obtain the initial value of household savings. The value of aggregate household savings must equal total external borrowing by firms. This requirement is applied to identify ρ. The value of ρ that satisfies this requirement is .022.

Further details on the calibration procedure are provided in Goulder and Summers. This procedure yields a fully parameterized benchmark data set. By the replication restriction, the values for flows in this data set correspond to the values generated by the model in the base case. Table 3 displays the base case values for important variables.

III. SIMULATION RESULTS

In this section we examine the effects of some of the major changes introduced under the Tax Reform Act of 1986. These include the reduction in the corporate tax rate τ from 0.46 to 0.34, the elimination of investment tax credits, and the scaling back of depreciation deductions for tax purposes. The changes in depreciation are based on information from Fullerton and Lyon (1988).

We examine the effects of these changes alone and in combination. All policy changes are treated as permanent and unanticipated.[18] In all simulations, compensating lump-sum adjustments to personal income taxes are made in each period to maintain government budget balance. Of course,

Table 3

Base Case Values for Each Industry[1]

		(1) Agri-culture and Mining	(2) Manu-facturing	(3) Services	(4) Non-Resi-dential Construc-tion	(5) Residen-tial Construc-tion	(6) Housing Services	Total
Output	(X)	405.5	2222.2	2510.4	275.6	193.5	437.7[2]	6044.9
Capital								
Structures	(K_s)	315.8	235.8	943.9	11.3	7.5	2611.6	4125.9
Equipment	(K_e)	152.8	505.3	844.6	22.3	15.0	143.8	1683.8
Labor used	(L)	50.3	437.2	974.1	76.2	35.9	8.4	1582.1
Value of firms	(V)	504.4	906.7	1560.9	51.9	34.9	2191.4	5250.2
Investment								
Structures	(I_s)	22.3	15.2	55.1	0.6	0.4	144.7	238.3
Equipment	(I_e)	25.9	82.3	151.0	4.5	3.0	34.9	301.6
Earnings	(EARN)	63.4	79.8	130.1	5.4	3.6	-	282.3
Dividends Paid	(DIV)	18.1	21.8	43.4	0.7	0.5	-	84.5
Net Service Flow	(S)	-	-	-	-	-	141.9	141.9
Corporate Taxes Paid[3]		46.3	42.9	51.4	2.7	1.8	5.0	150.1
Property Taxes Paid		8.3	6.2	24.9	0.3	0.2	69.0	108.9

[1] All values in billions of 1983 dollars.
[2] The shares for owner-occupied, noncorporate rental, and corporate rental housing are 78.1, 19.5, and 2.4 percent, respectively. The output of housing services includes imputed rents of owner-occupied dwellings.
[3] Net of investment tax credits and depreciation deductions.

TRA86 did not actually include lump-sum personal tax adjustments; rather, it contained reductions in individual marginal tax rates which helped the new law remain nearly revenue neutral. Because the simulations here do not incorporate the changes in individuals' marginal rates, as well as some other elements of TRA86, they should not be interpreted as assessing the overall effects of the new law.[19] Still, they do indicate the independent influences exerted by major business-side changes in the tax law.[20] It should be noted that policy change results are compared with a base case simulation in which the economy exhibits steady-state real growth at a rate of three percent (equal to g, the rate of effective labor force growth).

A. Individual Policy Changes

1. The Corporate Tax Cut. Table 4 displays simulation results, offering a comparison of short-run (first-year) and long-run (steady-state) effects. The table reveals striking differences between effects on the housing services industry and effects on other industries. Consider first the effects of the corporate tax cut. For industries other than housing, this policy change raises the after-tax marginal product of capital, allowing for higher earnings and dividends in every period. Equity values rise, reflecting the increases in the stream of earnings (or, more specifically, in the discounted stream of after-tax dividends less share issues). In the initial period, V increases by 16.1 percent over the base case in industries 1-5. These increases in V imply a significant increase in household wealth, leading to increases in consumption and a reduction in the savings-income ratio at any given

Table 4

Effects of 1986 Tax Reforms

	Reduction in Corporate Tax Rate				Elimination of ITC				Scaling Back of Depreciation Allowances				All Changes in Combination			
	Housing Services Industry		Other Industries		Housing Services Industry		Other Industries		Housing Services Industry		Other Industries		Housing Services Industry		Other Industries	
	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR
Net Service Flow or Earnings	-0.2	1.2	11.2	10.3	5.0	-2.1	-0.3	-3.1	4.2	-1.7	-1.7	-5.6	6.5	-1.6	9.7	4.8
Equity Value	-1.4	-0.5	16.1	15.5	5.6	-2.2	-0.1	-4.4	1.4	-1.7	-1.6	-2.6	3.9	-3.1	15.0	10.0
Asset Price	-0.9	0.6	14.5	12.7	3.5	-0.5	0.0	3.8	0.9	0.8	-1.7	4.5	2.3	1.1	13.2	19.9
Invest-ment	-1.1	-1.6	0.1	-0.5	2.8	-1.7	-4.5	-10.3	1.1	-3.5	-4.1	-8.8	2.2	-5.6	-5.6	-13.7
Output	0.2	-1.6	0.1	0.0	-0.4	-1.7	0.4	-3.6	-0.4	-3.4	0.3	-3.2	-0.4	-5.4	0.6	-4.8

Note: All figures express percentage changes from the base case. "SR" refers to effect in first period; "LR" refers to effects in the new steady state. All figures are based on changes in real variables; a producer price index was employed to convert from nominal to real magnitudes. "Equity value" is identical to V in the text. "Asset Price" is defined as $(V + DEBT)/\bar{K}$.

interest rate. The shift in the savings schedule contributes to a rise in the interest rate; in the first period, it rises to 6.6 percent, as compared with 6.3 percent in the base case. The tax cut has relatively little effect on investment by industries 1-5: it tends to stimulate investment by reducing taxes on earnings, but it discourages investment by reducing the present value of depreciation deductions.

The effects on the housing services industry are quite different. Since only about 2.4 percent of housing capital is owned by corporations, the corporate tax cut implies a much smaller reduction in the overall rate of capital taxation in housing than in other industries. Hence the policy change has little direct effect on housing net service flows or on house values, the present value of these flows. House values decline by 1.4 percent initially and by 0.5 percent in the long run. The decline is primarily attributable to the rise in interest rates. Housing services output changes very little in the short run, as the policy change has little to do with short-run housing services demand or supply. Over the longer term, output falls significantly, a consequence of the reduced investment in housing capital and the lowered production potential of the industry.

2. Eliminating Investment Tax Credits. We next consider the effects of eliminating all investment tax credits. Results for this experiment also appear in Table 4. Again, effects differ considerably between the housing services industry and other industries. In the first period, eliminating the ITC yields a reduction in investment of 4.5 percent in industries other than housing services. In contrast, investment in housing rises by 2.8 percent. Prior to the new tax law, investment

credits applied almost exclusively to equipment. Since the housing services industry is highly structures-intensive, repealing the ITC especially hurts industries other than housing. The increase in housing investment reflects the increased relative attractiveness of investment in housing and the decline in interest rates associated with the reduction in aggregate investment demand. Lower interest rates also help promote the 5.6 percent increase in the value of existing homes in the short run.

Over the longer term, repealing the ITC lowers investment by the housing industry as well as by other industries. This stems from the fact that the policy change lowers the overall capital intensity of the economy, implying lower overall output, reduced real incomes, and a diminished demand for housing services as well as other goods and services. In the long run, housing services demand falls by 1.7 percent.

Thus, while the corporate tax cut generally produces similar short- and long-run impacts, the ITC elimination has different effects over time. The ITC elimination has a more pronounced effect on investment, and long-run effects become significantly different from short-run effects as the differences in investment cumulate into significant differences in capital stocks. The results in Table 4 underscore the importance of using a dynamic analysis to assess the effects of the ITC elimination on housing investment. They show that while this policy change makes housing investment more attractive relative to other investment, it yields higher investment in housing only in the short run.

3. Decelerating Tax Depreciation. The third policy that we consider is the scaling back of tax depreciation allowances. These changes are represented in the model as reductions in the rates of tax depreciation

(δ^T) applying to structures and equipment in different industries. TRA86 instituted the changes in depreciation deductions prospectively: firms are permitted to continue to apply pre-tax-reform depreciation rules to capital assets purchased prior to 1987. The model takes account of this provision, distinguishing capital assets purchased prior to and after the policy change.

The pattern of effects under this policy change is quite similar to that under the ITC elimination. In the short run, investment and asset values fall in industries other than housing as a result of less liberal depreciation provisions. In contrast, housing investment rises. The cutback in depreciation rules applies to only a small fraction of homeowners; owner-occupiers were not able to deduct depreciation prior to or after TRA86. Consequently, the changes in depreciation rules have a greater impact on other industries. Reduced investment by other industries helps reduce interest rates and prompts increases in investment in housing.

Over the longer term, investment and asset values fall in housing as well as other industries. As in the ITC elimination policy, the cutback in overall investment leads to lowered output and incomes and thus to lower demands for housing services.

B. Policy Changes in Combination

The last set of columns in Table 4 displays the results from simulating the three policy changes in combination. These results suggest some interaction among the component policies in that the percentage changes from combined policies are generally less than the sum of the percentage changes of individual policies.[21]

When the policies are combined, the dominant investment effects are those generated by the ITC elimination and scaling back of depreciation deductions. Thus, in the short run, investment falls by 5.6 percent in industries 1-5 and rises by 2.2 percent in housing services. In the long run, investment falls (relative to the base case) in all industries. The differences between effects on housing investment and other investment parallel some results obtained by Hendershott (1988) in a comparative statics analysis.[22] The policy combination implies higher asset values for all industries in the short run. However, housing asset values rise by considerably less than the capital assets of other industries. This reflects the significant differences in the effects of the corporate tax cut on housing values as compared with other asset values.[23]

In the long run, the effects on housing investment and on the total value of housing assets become negative. This is in keeping with the negative long-run effects on investment and asset values of each of the component policy changes. The policy combination ultimately leads to a lower overall capital stock (relative to the base case), which implies lower output and incomes and reduced demands for housing services. This in turn implies lowered housing investment and a reduced total value of housing assets. These results reveal the dependence of the housing sector on overall economic performance and signal the usefulness of a general equilibrium framework for investigating the effects of tax policy on the housing sector. It may be noted that although total asset values for housing fall in the long run, values per unit of housing capital (house prices) rise. Thus, the long-run decline in the total value of housing reflects a decline in housing quantities, not prices.

Table 5 shows how the effects of the policy combination change over time in all six industries. In the short term, the largest relative changes in output are experienced by the non-residential construction industry, in keeping with the cutback in aggregate investment demands. The residential construction industry enjoys the largest percentage increase in output in the short run, in keeping with the increase in housing investment. As the percentage changes in housing investment switch from positive to negative values over time, the percentage changes for residential construction output change sign accordingly. In general, about half of the output adjustment to the new steady state (measured as percentage changes from the base case output path) occurs within 20 years of the policy shock.

C. Sensitivity Analysis

Table 6 presents results from simulations of the combined policy changes under alternative values for important parameters. Results are quite robust: in all simulations, the basic pattern of effects across industries and across time is the same as in the central case. With lower adjustment costs, short-run investment effects become more pronounced, although long-run effects do not change much. Doubling or halving industry elasticities of substitution between structures and equipment makes very little difference to the results. The final simulation presented in the table incorporates "representative" TRA86 reductions in individual marginal tax rates in addition to the three other types of changes already considered.[24] The negative investment impact of the TRA86 changes (on non-housing industries) is somewhat smaller once the individual tax cuts are taken into account. The cuts in individuals' marginal rates imply higher after-tax rates of return (inducing more investment) and higher after-tax earnings (implying higher asset values).

IV. CONCLUSIONS

This paper has explored the effects of recent tax reforms using a model that differs in several respects from traditional general equilbrium models. Simulation results indicate that the differences are important for understanding the implications of TRA86 for housing prices and housing investment.

An important feature of the model is its attention to characteristics that distinguish the housing sector from other producing sectors of the economy. These differences — in tax treatment, in the types of capital used, and in the industries producing the capital used — help explain how recent tax reforms affect housing and other industries. While the major TRA86 initiatives tend to discourage most nonresidential investment, they promote increased investment in housing in the short term. And while these reforms tend to promote fairly large increases in the asset values of non-residential capital, they yield only minor increases in house values. These results are attributable to differences in the degree to which housing and other capital is owned by corporations and differences in the structures-equipment intensity of housing and other industries.

A second key feature of the model is its ability to consider adjustment dynamics and related differences between short- and long-run

Table 6

Sensitivity Analysis

Simulation:	Investment: Housing Services Industry SR	Investment: Housing Services Industry LR	Investment: Other Industries SR	Investment: Other Industries LR	Equity Value: Housing Services Industry SR	Equity Value: Housing Services Industry LR	Equity Value: Other Industries SR	Equity Value: Other Industries LR
(1) Central Case	2.2	-5.6	-5.6	-13.7	3.9	-3.1	15.0	10.0
(2) Low Adjustment Costs —all sectors	4.8	-5.2	-6.4	-14.4	3.7	-2.8	15.3	10.2
(3) High Adjustment Costs —all sectors	1.7	-5.8	-5.1	-13.3	3.6	-3.3	15.1	10.1
(4) Low Adjustment Costs —housing sector only	3.9	-5.5	-5.7	-13.9	3.5	-3.1	14.7	9.8
(5) High Adjustment Costs —housing sector only	1.2	-6.0	-5.3	-13.1	3.6	-3.2	15.4	10.6
(6) Low Structures-Equipment Substitution	2.2	-5.7	-5.5	-13.6	3.8	-3.2	15.0	10.1
(7) High Structures-Equipment Substitution	2.2	-5.6	-5.6	-13.8	3.8	-3.1	14.9	10.0
(8) TRA86 Personal Tax Rate Reductions Included	0.0	-6.1	-4.1	-10.7	1.4	-1.4	17.0	13.6

Note: The high and low adjustment cost simulations involve changes in the parameter β of the adjustment cost function $\phi(I/K) = [(\beta/2)(I/K - \xi)^2](I/K)^{-1}$ with compensating changes in ξ that leave the value of ϕ unchanged at the benchmark value for I/K. Central case values for β and ξ are 19.607 and 0.076. Simulations (2) and (4) incorporate 50% reductions in β; simulations (3) and (5) incorporate 50% increases in β. Simulations (6) and (7) halve and double the central case structures-equipment elasticity of substitution. Simulation (8) includes personal tax rate reductions in addition to the other combined policy changes. θ_L is reduced from .28 to .230, and θ is reduced from .337 to .229.

effects. For the housing sector, changes over time are dramatic. While TRA86 has a positive influence (relative to a no-policy-change scenario) on housing investment and house values in the short run, it has the opposite impact in the long term. The negative long-term consequences for housing stem from adverse long-term effects of TRA86 on aggregate output and income. These overall effects imply reduced demands for housing services and ultimately lead to reductions in housing investment and the value of housing assets. These results indicate not only the significance of distinguishing short- and long-term effects, but also the importance of attending to interactions between the housing sector and other sectors of the economy in analyzing tax reforms.

The model allows for several natural extensions. One would be the incorporation of tenure choice. Although this is not likely to alter the main results obtained here, it would permit an assessment of how tax reforms might differently affect owner-occupants and landlords. Another useful extension would be the introduction of government borrowing in the model. This would allow for more realistic investigations of policies that are not revenue-neutral.

FOOTNOTES

1. The Fullerton-Henderson model contains a great deal of detail regarding asset demands: 34 categories of assets are distinguished in demand. There is much less detail regarding asset supply. All assets are produced from a single production technology, and perfect mobility applies across asset types so that excess supplies of one type of asset in one industry can be used to reduce excess demands for another type of asset in another industry. The Jorgenson-Yun model's distinction of capital assets by durability (short-lived vs. long-lived) roughly corresponds to the distinction between structures and equipment. As in Fullerton-Henderson, the production technology is the same for all assets and perfect mobility is assumed.

2. Hamilton and Whalley (1985) separate the industries that produce housing capital from those that produce other capital. In contrast with the present model, their model does not distinguish structures and equipment in each industry: there is one type of capital good in each industry (either housing capital or other capital). Nor does their model consider forward-looking behavior or adjustment dynamics.

3. See, for example, Rosen and Rosen (1980), Haurin, Hendershott, and Ling (1987), and Henderson and Ionnides (1983) for analyses of tenure choice issues.

4. Demographic determinants of housing choices are examined in Haurin, Hendershott, and Ling (1987), Hendershott (1987), and Mankiw and Weil (this volume).

5. Consumers' final demands for industry outputs stem from their demands for the 17 consumer goods distinguished by the model. The translation from consumer goods demands to demands for industry outputs is made by way of a fixed coefficient matrix A, where each element a_{ij} indicates the quantity of industry good i required per unit of consumer good j.

6. It would be relatively straightforward to distinguish the industries that produce residential equipment from those that make non-residential equipment, but the differences between these assets and industries did not seem great enough to warrant the additional detail.

7. Since adjustment costs are separable from labor and materials in the production function, current input levels of labor and materials have no effect on future costs, and determining optimal labor and materials inputs is fundamentally a static problem.

8. A very small fraction of net service flow income is taxed. However, θ_H is nonzero to account for taxes paid by individuals on dividends received from corporations providing housing services.

9. The calculation of the value of housing assets follows equation (5); combining the service flows S^O and S^R in calculating V for housing yields no aggregation errors provided that the effective tax rates θ and κ_H are evaluated correctly. In evaluating these tax rates, we assume that owner-occupied and rental housing maintain fixed shares of the total value of housing services produced at any point in time. Of course, tax policy may alter these shares. Our simplifying assumption is likely to bias downward the total net service flows generated by housing capital, since the model does not allow owners to reduce tax burdens by shifting into the form of housing that receives the smaller tax increase after a policy change. In future work we hope to examine closely how tax policy might differently affect owner-occupied and rental housing, and for that investigation a separate consideration of the asset values of each type of housing would be especially useful.

10. The appearance of debt issue in the definition of S^O may seem counterintuitive. It helps to imagine the implicit rental to be a cash flow, so that additional borrowing enables owners to retain more cash (pay themselves a higher "dividend") after meeting maintenance and other expenses. The additional borrowing entails costs — higher interest payments — that appear in subsequent periods and, other things equal, reduce future "dividends."

The inclusion of investment expenditure (IEXP) in the definition of net service flows is necessary for deriving housing investment from optimizing behavior. Households trade off the costs of investment in terms of reduced current net service flows against the benefits in terms of the higher future housing services output and service flows generated by a higher capital stock. Poterba (1984) excluded investment expenditure from the net service flow calculation, and specified an ad hoc relationship between house values and investment.

11. This assumption would be relaxed in a model where rental and owner-occupied housing had different characteristics, as in models of tenure choice.

12. This specification conforms to the "traditional" view of dividend behavior. See Poterba and Summers (1985) for a discussion of alternative views and for a presentation of some empirical findings in support of the traditional view.

13. We are grateful to Andrew Mitrusi for generating this information from TAXSIM data.

14. The model is indifferent as to the relative contributions of population growth and Harrod-neutral technical change to the overall growth of effective labor.

15. Many computable general equilibrium models are homogeneous of degree zero in all prices, so that the price level has no significance. In this model, the price level (and thus the rate of inflation) is important in that the basis for an asset's depreciation deductions is the asset's original (nominal) cost. Hence higher inflation rates have real effects in that they lower the real value of depreciation deductions.

16. Econometric estimates of σ vary considerably. We consider a range of values spanning most of the low estimates from time-series analyses and higher ones from cross-sectional studies. See Hall (1985) for a general discussion and recent estimates.

17. Human wealth is the present value of the infinite stream of after-tax earnings and transfers; non-human wealth is the present value of the stream of dividends net of share issues.

18. Effects of anticipated corporate tax cuts and investment tax credit eliminations are examined in Goulder and Summers (1987).

19. Other changes not considered here include removal of capital gains exclusions and changes in accounting rules and passive loss provisions.

20. No policy change is entirely independent of other offsetting changes. Given the level of government spending, a change in a particular tax will have revenue effects that must either be offset by other tax changes or by changes in government borrowing. In this model, only the former alternative applies, as the government is constrained to run a balanced budget. Making up the needed revenue through lump-sum taxes seems to provide the clearest picture of the effects of the various policy changes, since these taxes do not change relative prices and introduce further distortions into the economy.

21. There is an intuitive basis to these interactions. Depreciation deductions are based on the product of the corporate tax rate and the rate of tax depreciation. The percentage reduction in the product is smaller than the sum of the percentage reduction of each rate, and thus the effect (expressed in percentage changes) of combining both tax cuts is likely to be less than the sum of the effects of each tax cut taken individually.

22. Hendershott's model does not incorporate time, and thus does not address the adjustment and asset valuation issues examined in this paper. The model adopts a cost-of-capital approach to determine the implications of TRA86 on required rates of return for investment. Results indicate that the new law will raise required rates for investment in most corporate assets and lower required returns for investment in residential structures.

23. Because the combined policy changes reduce overall investment demands, they induce a drop in interest rates. This is partly responsible for the short-term increase in housing asset values and investment. The significance of interest rate effects for evaluating the impacts of TRA86 has been emphasized by Hendershott, Follain, and Ling (1987).

24. The model employs one marginal rate for individual labor income, and one for individual capital income. These are weighted averages of the marginal rates across income classes, where the weights are the labor and capital incomes of the different income groups. In Simulation (8) of Table 6, the reductions in individuals' marginal rates largely bring about a revenue-neutrality which in other simulations is accomplished solely by lump-sum reductions in individual taxes. Thus the essential difference between Simulation (8) and the central case simulation is the difference between reductions in individual marginal rates and lump-sum reductions in individual tax obligations.

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APPENDIX

1. House Values, Capital Prices and Housing Investment

Define α_1, α_2, and α_3 as the shares of housing services produced in owner-occupied, landlord-owned and corporation-owned dwellings, respectively. Net income of each group of housing services provider is:

$$\text{(A1)} \qquad S^O = (p_{HS}X_{HS}^O - p_L L^O - p_M M^O) - (1-\theta)(ib+c)p_K K^O + BN^O - IEXP^O.$$

$$\text{(A2)} \qquad S^R = (1-\tau^R)(p_{HS}X_{HS}^R - p_L L^R - p_M M^R) - (1-\tau^R)(ib+c)p_K K^R$$

$$+ \tau^R D^R + BN^R - IEXP^R.$$

where

$$\text{(A3)} \qquad \tau^R = \frac{\alpha_2}{\alpha_2 + \alpha_3} + \frac{\alpha_3}{\alpha_2 + \alpha_3}\,\tau$$

τ^R is the marginal tax rate on landlord profits, θ is the marginal tax rate on individual interest income, and τ is the marginal corporate income tax rate. These expressions make use of the assumptions that housing services are produced with constant returns to scale, that services of rental and owner-occupied housing are perfect substitutes, and that both landlords and owner-occupants maintain debt equal to the same constant fraction of the value of their stock of capital. Adding up the service flows S^O and S^R, the total net flow of housing services is

$$\text{(A4)} \qquad S = (1-\tau_2)(p_{HS}X_{HS} - p_L L - p_M M) - (1-\tau_3)(ib+c)p_K K + \tau_2 D$$

$$+ BN - IEXP$$

where

$$\text{(A5)} \qquad \tau_2 = \alpha_2\theta + \alpha_3\tau$$

$$\text{(A6)} \qquad \tau_3 = (\alpha_1 + \alpha_2)\theta + \alpha_3\tau$$

τ_2 is the marginal tax paid by landlords on total net revenue, and τ_3 is the total marginal tax on net revenue.

New debt issue is given by

$$\text{(A7)} \qquad BN = \frac{d}{dt} \sum_{i=s,e} b p_K^i K^i = \sum_{i=s,e} b(p_K^i \dot{K}^i + \dot{p}_K^i K^i)$$

$$= \sum_{i=s,e} b(p_K^i I^i - p_K^i \delta^{Ri} K^i + p_K^i K^i)$$

where δ^R is the rate of economic depreciation. Investment expenditure is given by

(A8) $$IEXP = \sum_{i=s,e} [(1-ITC^i)p_K^i I^i + (1-\tau_2)p^i \phi^i I^i]$$

where $\phi^i(I^i/K^i)$ is the adjustment cost function, which depends on the investment rate. Arbitrage between assets requires

(A9) $$(1-\theta)i + \eta_H = (1-\kappa_H)\frac{\dot{V}}{V} + (1-\tau_1)\frac{S}{V}$$

where

(A10) $$\tau_1 = \alpha_3\theta$$

the marginal tax paid by shareholders of incorporated landlords. Define the required rate of return

(A11) $$r_H = (1-\theta)i + \eta_H$$

Integrate (A9) to get

(A12) $$V = \int_t^{\infty} \frac{1-\tau_1}{1-\kappa_H} S_u \mu_u du$$

Substitute S from (A4), (A7) and (A8) to get

$$\text{(A13)} \qquad V_t = \int_t^\infty \frac{1-\tau_1}{1-\kappa_H} \Big\{ (1-\tau_2)(p_{HS_u} X_{HS_u} - p_{L_u} L_u - p_{M_u} M_u)$$

$$+ \tau^2 D_u - \sum_{i=s,e} \Big[(b\delta^{Ri} + (1-\tau_3)(i_u b + c)) p^i_{K_u} K^i_u - b\dot{p}^i_{K_u} K^i_u$$

$$- (bp^i_{K_u} - (1-ITC^i) p^i_{K_u} - (1-\tau_2) p_u \phi^i) I^i_u \Big] \Big\} \mu_u du$$

with

$$\text{(A14)} \qquad \mu_u = \exp \int_t^u \frac{-r_{Hv}}{1-\kappa_H} dv$$

Define

$$\text{(A15)} \qquad \int_t^\infty \frac{1-\tau_1}{1-\kappa_H} \tau_2 D_u \mu_u du = \int_t^\infty \frac{1-\tau_1}{1-\kappa_H} Z^s_u p^s_{K_u} I^s_u \mu_u du + B^s_t$$

$$+ \int_t^\infty \frac{1-\tau_1}{1-\kappa_H} Z^e_u p^e_{K_u} I^e_u \mu_u du + B^e_t$$

where Z_u is depreciation allowances on a dollar of new capital and B_t is total depreciation allowances on existing capital. Define also

(A16) $$A_u = (1-\tau_2)(p_{HS_u}X_{HS_u} - p_{L_u}L_u - p_{M_u}M_u)$$

Then

(A17) $$V_t = \int_t^{\infty} \frac{1-\tau_1}{1-\kappa_H} \left\{ A_s - \sum_{i=s,e} \left[(b\delta^{Ri} + (1-\tau^3)(i_u b+c)) p_K^i K_u^i \right.\right.$$

$$\left.\left. - b\dot{p}^i_{K_u} K_u^i + (1-ITC^i - b - Z_u^i)p^i_{K_u})p_u^i \phi_2^i I_2^i \mu_u du \right]\right\} u$$

$$+ B_t^s + B_t^e$$

Optimization by the representative homeowner corresponds to the maximization of V_t under the capital adjustment constraints $\dot{K}_u^i = I_u^i - \delta^{Ri}K_u^i$. The Hamiltonian is:

(A18) $$H_u = \frac{1-\tau_1}{1-\kappa_H} \left\{ A_u - \sum_{i=s,e} \left[(b\delta^{Ri} + (1-\tau_3)(i_u b+c)) p^i_{K_u} K_u^i \right.\right.$$

$$\left.\left. - b\dot{p}^i_{K_u} K_u^i + (1-ITC^i - b - Z_u^i)p^i_{K_u} I_u^i + (1-\tau_2)p_2\phi^i I_u^i \right]\right\} \mu_u du$$

$$+ \lambda_u^s \mu_u (I_u^s - \delta^{Rs}K_u^s) + \lambda_u^e \mu_u (I_u^e - \delta^{Re}K_u^e)$$

The first-order conditions yield

$$\text{(A19)}\qquad \frac{1-\tau_1}{1-\kappa_H}\left[\left(1-ITC^i-b-Z_u^i\right)p_{K_u}^i + (1-\tau_2)p_u\left(\phi^i + \phi^{i'}\cdot\frac{I_u^i}{K_u^i}\right)\right] = \lambda_u^i$$

$$\text{(A20)}\qquad \frac{1-\tau_1}{1-\kappa_H}\left\{\frac{\partial A_u}{\partial K_u^i} - \left[b\delta^{Ri} + (1-\tau_3)(i_u b+c)\right]p_{K_u}^i + b\dot{p}_{K_u}^i + (1-\tau_2)p_u\phi^{i'}\right.$$

$$\left.\cdot\left(\frac{I_u^i}{K_u^i}\right)^2\right\} = -\dot{\lambda}_u^i + \left(\frac{r_{Hu}}{1-\kappa_H} + \delta^{Ri}\right)\lambda_u^i \qquad i=s,e$$

Multiplying both sides of (A19) by $-I_u^i$, multiplying both sides of (A20) by K_u^i, and adding the four resulting equations together yield:

$$\text{(A21)}\qquad \frac{1-\tau_1}{1-\kappa_H}\left\{\frac{\partial A_u}{\partial K_u^s}K_u^s + \frac{\partial A_u}{\partial K_u^e}K_u^e - \sum_{i=s,e}\left[(b\delta^{Ri} + (1-\tau_3)(i_u b+c))p_{K_u}^i K_u^i\right.\right.$$

$$\left.\left. - b\dot{p}_{K_u}^i K_u^i + (1-ITC^i - b - Z_u^i)p_{K_u}^i I_u^i + (1-\tau_2)p_u\phi^i I_u^i\right]\right\}$$

$$= \sum_{i=s,e}\left[-\dot{\lambda}_u^i K_u^i + \left(\frac{r_{Hu}}{1-\kappa_H} + \delta^{Ri}\right)\lambda_u^i K_u^i - \lambda_u^i I_u^i\right]$$

Since the production technology and the capital composition function both have constant returns to scale, the first two terms add up to A_u. Use the capital adjustment constraints for the right-hand side of (A21), multiply both sides by the integrating factor μ_u and integrate from t to infinity to get the following expression for the equity value of the housing stock.

(A22) $$V_t - B_t^s - B_t^e - \lambda_t^s K_t^s + \lambda_t^e K_t^e$$

2. Other Asset Prices and Investment

Sectors other than housing services issue new shares VN. The arbitrage equation corresponding to (A10) is

(A23) $$(1-\theta)i + \eta - (1-\kappa)\,\frac{\dot{V}-VN}{V} + (1-\theta)\,\frac{DIV}{V}$$

Integrating (A23) subject to a transversality condition of finite final value of the firm gives

(A24) $$V_t - \int_t^{\infty} \left[\left(\frac{1-\theta}{1-\kappa}\right) DIV_u - VN_u\right]\mu_u du$$

with

(A25) $$\mu_u - \exp\int_t^{u} \frac{-r_v}{1-\kappa}\, dv$$

Profits after taxes and interest payments and including depreciation deductions are

$$(A26) \qquad \Pi_1 = A - (1-\tau)i \sum_{i=s,e} bp_K^i K^i + \tau D$$

where A is defined as in (A16). The cash-flow identity is

$$(A27) \qquad \Pi_1 + BN + VN = DIV + IEXP$$

Let dividends be a constant fraction a of net profits:

$$(A28) \qquad DIV = a(\Pi_1 - p_K^s \delta^{Rs} K^s - p_K^e \delta^{Re} K^e)$$

New debt issue and net investment expenditure are the same as in (A8) and (A9). Substitute those expressions together with (A26)-(A28) in (A24) to get

$$(A29) \qquad V_t = \int_t^\infty \Big\{ \gamma A_u + \gamma\tau D_u + \sum_{i=s,e} \Big[-\gamma(1-\tau)i_u b p_{K_u}^i K_u^i$$

$$+ (1-\gamma-b)p_{K_u}^i \delta^{Ri} K_u^i + b\dot{p}_{K_u}^i K_u^i - (1-ITC^i-b)p_{K_u}^i I_u^i$$

$$- (1-\tau)p_u \phi^i I_u^i \Big] \Big\} \mu_u du$$

where

$$\text{(A30)} \qquad \gamma = 1 - (1 - \frac{1-\theta}{1-\tau})a$$

As in (A15), split depreciation deductions into those that apply to existing and to new capital. This yields:

$$\text{(A31)} \qquad V_t = \int_t^{\infty} \Big\{\gamma A_u + \sum_{i=s,e} \Big[-\gamma(1-\tau)i_u b p^i_{K_u} K^i_u + (1-\gamma-b)p^i_{K_u} \delta^{Ri} K^i_u$$

$$+ b\dot{p}^i_{K_u} K^i_u - (1-ITC^i - b - \gamma Z^i_u)p^i_{K_u} I^i_u$$

$$- (1-\tau)p_u \phi^i I^i_u\Big]\Big\}\mu_u du + B^s_t + B^e_t$$

Optimization by the representative firm corresponds to the maximization of V_t under the capital adjustment constraints. The first-order conditions are very similar to those of the homeowner:

$$\text{(A32)} \qquad (1-ITC^i-b-\gamma Z^i_u)p^i_{K_u} + (1-\tau)p_u\left(\phi^i + \phi^{i'} \cdot \frac{I^i_u}{K^i_u}\right) = \lambda^i_u$$

(A33)
$$\gamma \frac{\partial A_u}{\partial K_u^i} - \gamma(1-\tau)i_u b p_{K_u}^i + (1-\gamma-b)p_{K_u}^i \delta^{Ri} + b\dot{p}_{K_u}$$

$$+ (1-\tau)p_u \phi^{i\prime}\left(\frac{I_u^i}{K_u^i}\right)^2 = -\dot{\lambda}_u^i + \left(\frac{r_u}{1-\kappa} + \delta^{Ri}\right)\lambda_u^i \qquad i=s,e$$

The same transformations of equations (A32) and (A33) that lead from (A19)-(A20) to (A22) yield an equivalent expression for the equity value of firms in non-housing sectors:

(A34)
$$V_t - B_t^s - B_t^e = \lambda_t^s K_t^s + \lambda_t^e K^e \; .$$