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We describe a model in which rental and owner housing are risky assets, tenure choice is endogenous, and each household is constrained to consume the same amount of owner housing that it has in its investment portfolio. At each iteration in the search for an equilibrium, we determine the new taxable income for each of 3,578 households (from the Survey of Consumer Finances), and we use statutory schedules to find the marginal rate and tax paid. Equilibrium net rates of return are major determinants of the amount of owner housing, but a logit model indicates that demographic factors are the main determinants of ownership rates. In our simulation, taxes on owner housing would raise welfare not only by reallocating capital but also by the government's taking part of the risk from individual properties and diversifying it away. Measures to disallow property tax or mortgage interest deductions do not help share this risk. Simulations of the 1986 tax reform indicate a small shift from rental to owner housing and welfare gains from reallocating risk.

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I. Introduction

Government has no single policy toward housing. It provides direct subsidies for low-income housing, accelerated depreciation deductions for other rental housing, and nontaxation of imputed net rental income for owner-occupied housing. It also affects the equilibrium amount of housing through the progressivity of the personal rate structure and the relative taxation of other goods and assets. For example, an important indirect benefit to housing capital is the additional corporate tax on other uses of capital. Of particular interest have been the combined effects of these tax rules on the residential capital stock and tenure choice, that is, whether to own or rent.

These multiple and indirect effects, together with the large size of the housing sector, make general equilibrium analysis important. In this paper, we introduce a new large-scale general equilibrium simulation model of household portfolio and tenure choice. In it, each household has a supply of labor that is used in production of a corporate output, a consumption choice between housing and the corporate good, and a mean-variance portfolio choice among four assets. A household may supply (1) risk-free debt that might be used by the corporate sector, by other households, or by the government; (2) risky equity that is used in the corporate sector; (3) risky rental housing used by other households; and (4) risky owner housing that can be used only by the household itself. All households have nonnegative net wealth, and all hold debt, which may be positive or negative. Each household must choose whether or not to hold positive amounts of each of the three risky assets, so we say that there are $2 \times 2 \times 2 = 8$ different "regimes." A government imposes differential taxes on these various activities and uses the revenue to pay interest, make transfers, and buy corporate output.

The current paper makes four contributions relative to existing literature.[1] First, some papers treat housing as a consumption good whose relative price is affected by tax rules (e.g., King 1980; Rosen and Rosen 1980). Other papers treat it as an investment whose relative return is affected by taxes (e.g., Summers 1981; Feldstein 1982; Poterba 1984). None of this literature considers an individual's housing as both consumption and investment.[2] In our model, both the consumption decision and the investment decision are part of utility maximization in which the owner-occupying household is constrained

[1] Excellent reviews of previous studies are available in Rosen (1985), Olsen (1987), and Smith, Rosen, and Fallis (1988).

[2] Exceptions are the theoretical model of Henderson and Ioannides (1983) and the simulation model of Hendershott and Won (in press). On a more aggregate basis, housing consumption and investment aspects are treated in Henderson (1987) and Goulder (1989).

to consume the same amount of housing that it has in its portfolio. Each household's tenure choice is based on a comparison of utility as a renter and as an owner subject to this constraint.

Second, most general equilibrium calculations aggregate households into income groups or other classifications in order to cut the cost of repeated supply and demand evaluations for successive trial price vectors (e.g., Fullerton, Shoven, and Whalley 1983). An exception is Slemrod (1985), which cuts a large sample to 500 individual households for repeated evaluations. Here, we retain all 3,578 usable observations from the 1983 Survey of Consumer Finances, weighted to represent the U.S. economy.[3] We establish behavioral parameters for each household, and we evaluate all supplies and demands at every iteration. In fact, for each household, we must evaluate utility for each of the eight different asset-holding regimes. For each trial price vector we therefore evaluate the supplies and demands of 28,624 household types.

Third, econometric models are often used to perform partial equilibrium simulations of policy changes (e.g., King 1983), whereas general equilibrium efforts borrow extraneous estimates for some parameters and then "calibrate" the model by solving algebraically for other parameters that are consistent with a benchmark equilibrium data set.[4] For our general equilibrium model, we use econometric methods to estimate important tax parameters, some consumer preference parameters, and a logit model to calculate probabilities that a household falls into each of the eight regimes. Overall consistency is still ensured by calibration for other parameters.

Fourth, our model includes more tax detail than existing models.[5] The corporate sector has asset-specific depreciation rules, nominal interest deductions, a 46 percent statutory rate in our base year (1983), and a 10 percent credit for equipment. In the household sector, regression coefficients are used with several income and demographic variables to predict each household's taxable income and allowable deductions. The household chooses whether to itemize or

[3] The 1983 survey is described in Avery and Elliehausen (1988). The 1986 survey did not become available until after we had completed most of this project. In addition, 1983 provides a better benchmark equilibrium since 1986 was a year of transition. Some provisions of the Tax Reform Act of 1986 were already in effect, and others were anticipated.

[4] For a computable general equilibrium model with estimated parameters, see Jorgenson and Yun (1990).

[5] Existing efforts may assume for each asset a single fraction of income excluded from the tax base (e.g., Galper, Lucke, and Toder 1986), a single linear income tax schedule (e.g., Hendershott and Hu 1983), or a set of linear schedules that differ among income groups (e.g., Fullerton et al. 1983).

take the standard deduction, and the statutory rate schedule is used to determine endogenously the household's marginal rate bracket and tax paid. The resulting after-tax income and net rates of return are used to evaluate consumption and asset demands.[6]

Berkovec and Fullerton (1989) employ a preliminary version of this model to simulate the effects on housing of a change in the rate of inflation. Here we concentrate on the effects of taxes. One experiment is the complete removal of all advantages for owner-occupied housing relative to rental housing. Such a policy may be quite difficult to implement since it would require tax authorities to know the rental value of owner-occupied houses, but this simulation provides the best answer to the conceptual question about the effect of tax advantages.

Our results emphasize the special features of our model. First, taxes on the return to homeownership discourage owner housing, but taxes on the variance of these returns encourage it (see Rosen, Rosen, and Holtz-Eakin 1984). In general equilibrium, when owner housing is taxed, high-bracket households want less owner housing and low-bracket groups want more. With our disaggregation of households in different situations, full taxation of owner housing would reduce its total quantity by only 3–6 percent and would actually increase the fraction of households that own. Second, welfare gains are much larger than in a standard Harberger (1966) calculation. In addition to the more efficient allocation of real resources, our model captures a more efficient allocation of risk bearing and the ability of government to share the undiversified risk of owners' individual returns. Third, we also simulate the effects of more practical reforms such as removal of deductions for property taxes or for mortgage interest paid. These partial measures do not absorb any of the variance in the return to owner housing and thus miss this major welfare benefit of taxes on owner housing. The Tax Reform Act of 1986 is found to increase total owner housing as well as the homeownership rate, so the potential welfare gains from a tax on owner housing are even greater than before.

The next section explains the household sector in some detail. The remaining sections describe the production sector, tax calculations, the government sector, equilibrium conditions, parameter selection, estimation, the data, and results.

[6] Other models may contain some, but not all, of these four important features. For example, Hendershott and Won (in press) have an endogenous tenure choice, risky owner housing, and statutory rate brackets. Our model has these features together with the econometrically estimated logit choices among regimes, explicit corporate user costs, and micro-unit disaggregation.

II. The Household Sector

We specify utility as a function of housing services, H, expected consumption, C, and the variance of income, σ^2. This variance equals $\mathbf{A}'\Sigma\mathbf{A}$, where Σ is the after-tax variance-covariance matrix of asset returns, and $\mathbf{A}$ is the vector of asset holdings. This asset vector consists of debt holdings, D, corporate equity, E, rental property, R, and owner-occupied housing, OH. We do not separately consider tax-free municipal debt. There is no saving, and wealth is fixed. Following Slemrod (1982) and Gordon and Slemrod (1983), we use a simple Cobb-Douglas combination of C and H together with a negative term for risk:

$$U(C, H, \mathbf{A}) = C^{\alpha}H^{1-\alpha} - \beta\sigma^2. \tag{1}$$

All the preference parameters and choices are household-specific, but we suppress the index for notational convenience. The share parameter, α, will be derived from each household's observed consumption, and the risk aversion parameter, β, will be derived from observed stockholdings. We assume that housing services are chosen prior to the resolution of uncertainty, so all variability of income falls on other consumption.

We now deal with three problems of implementation. The first problem is that the typical family holds only a subset of all available types of investment, even when we aggregate the data to four asset types. We assume that all households hold some positive or negative amount of debt but that each household makes a dichotomous choice about whether or not to hold a positive amount of each risky asset (no short sales). With three risky assets, there are eight asset combinations or "regimes." We introduce a set of preference parameters δ_i, estimated later, which represent transactions costs or other reasons to neglect particular assets in regime i. We then assume that decisions are made in two stages. First each household chooses the best allocation of wealth and consumption within each regime, and then it chooses the regime with the highest overall utility:

$$\max_{i=1,8}\{\max_{C_i, H_i, \mathbf{A}_i}[U(C_i, H_i, \mathbf{A}_i) + \delta_i]\} \tag{2}$$

subject to the budget constraints (the index for regimes is suppressed)

$$Y \equiv \overline{Y} + \mathbf{A}'\mathbf{r} = C + P_H H \tag{3a}$$

and

$$K = D + E + R + OH, \tag{3b}$$

where Y is income, $\overline{Y}$ is after-tax labor income and transfers, $\mathbf{r}$ is the vector of expected after-tax rates of return, P_H is the price of housing services, and K is the wealth of the household. Consumption is the numeraire, so its price is always one. Transfers are lump-sum since we do not model direct housing subsidies. The household has fixed labor, L, that earns the endogenous equilibrium wage, w. The vector $\mathbf{r}$ is (r_D, r_E, r_R, r_O), the four rates of return for debt, equity, rental property, and owner housing of that household.

A second implementation problem is that the strict portfolio model predicts a specific amount for each household's holding of rental property that may be different from the observed holding. Possible explanations are that individuals have special cost advantages, have unique information, or must invest lumpy amounts. We reconcile the model to the observed holdings by changing the perceived variance of returns. Each row and column of the variance-covariance matrix that involve rental housing are multiplied by a household-specific term γ that is derived from observed rental holdings.[7]

The third problem is that when the government taxes risky returns, it takes part of the risk as well as part of the income (Gordon 1985). Specific tax rules and government shares of risk are discussed below, but we note here that the government may or may not be able to diversify away part of this risk. To the extent that government revenues are uncertain, households must receive back some share of the risk (or else taxes would enhance welfare by making all risk disappear). In this model, we assume that the government fixes its transfer programs and expenditures on goods but pays out an additional amount to households that has zero expectation and positive variance. That is, individuals hold claims on risky government assets, in proportions given by their original income from labor and capital. The asset vector $\mathbf{A} = (D, E, R, OH)$ is effectively augmented by (E_G, R_G, O_G) to reflect the ownership of the government's risk from taxation of equity, rental housing, and owner housing. Households cannot choose the amounts of these additional three assets, but they account for all variances and covariances when they choose their own portfolio.

The model then compares one equilibrium allocation of capital to another, in the Harberger (1966) tradition, with no intertemporal framework and no capital market imperfections. One interpretation is that households can reallocate their wealth instantly and costlessly, but perhaps a better interpretation is simply that we compare long-run equilibria, after all adjustments, for a given capital stock.

[7] We also employed an alternative with a household-specific effect *added* to the variance of R, but results were substantially the same. Another alternative would alter the perceived rate of return (instead of the variance), but we thought it more natural to use a single market price. The sensitivity to our specification of γ is tested below in simulations that use econometric estimates for α, β, and γ.

Important for our purposes is that the choice of regime includes the choice of whether to owner-occupy. We return later to the choice among regimes, but first we focus on the consumption and asset allocations within each regime. Note that δ_i is irrelevant for these choices within regime i. The consumption and asset choices are similar for all regimes, but holders of the fourth asset face an additional constraint: they must hold the exact amount of the owner-housing asset needed to provide for their consumption of housing services. We therefore consider separately the four owner regimes and the four renter regimes.

A. *Renters*

The problem for renters is easier because they hold none of the fourth asset and do not face the additional constraint. Maximization of (1) subject to (3) yields the following first-order conditions:

$$\frac{\partial U}{\partial H} = 0 = (1-\alpha)\left(\frac{C}{H}\right)^{\alpha} - P_H\alpha\left(\frac{C}{H}\right)^{\alpha-1}, \quad (4a)$$

$$\frac{\partial U}{\partial E} = 0 = \alpha\left(\frac{C}{H}\right)^{\alpha-1}(r_E - r_D) - 2\beta(\Sigma_{EE}E + \Sigma_{ER}\gamma R + Z_E), \quad (4b)$$

and

$$\frac{\partial U}{\partial R} = 0 = \alpha\left(\frac{C}{H}\right)^{\alpha-1}(r_R - r_D) - 2\beta\gamma(\Sigma_{RE}E + \Sigma_{RR}\gamma R + Z_R), \quad (4c)$$

where Σ_{ij} refers to the ijth element of the variance-covariance matrix, and $Z_i = \Sigma_{iE_G}E_G + \Sigma_{iR_G}R_G + \Sigma_{iO_G}O_G$ (for $i = E, R$) refer to risk returned by the government. These equations yield analytical solutions for H, E, and R. Then consumption C is just $Y - HP_H$, and debt holdings D are $K - E - R$. For regimes in which E or R is zero, the model is the same but the appropriate first-order conditions are eliminated.

B. *Owners*

We use the normalization that one unit of housing capital produces one unit of housing services. For owners, then, $H = OH$. The first-order conditions are

$$\frac{\partial U}{\partial H} = 0 = (1-\alpha)\left(\frac{C}{H}\right)^{\alpha} - (P_H + r_D - r_O)\alpha\left(\frac{C}{H}\right)^{\alpha-1} - 2\beta(\Sigma_{OE}E + \Sigma_{OR}\gamma R + \Sigma_{OO}H + Z_O), \quad (5a)$$

$$\frac{\partial U}{\partial E} = 0 = \alpha\left(\frac{C}{H}\right)^{\alpha-1}(r_E - r_D) - 2\beta(\Sigma_{EE}E + \Sigma_{ER}\gamma R + \Sigma_{EO}H + Z_E), \tag{5b}$$

and

$$\frac{\partial U}{\partial R} = 0 = \alpha\left(\frac{C}{H}\right)^{\alpha-1}(r_R - r_D) - 2\beta\gamma(\Sigma_{RE}E + \Sigma_{RR}\gamma R + \Sigma_{RO}H + Z_R), \tag{5c}$$

where $Z_i = \Sigma_{iE_G}E_G + \Sigma_{iR_G}R_G + \Sigma_{iO_G}O_G$, for $i = E, R, O$. This set of nonlinear equations does not have a simple analytical solution, but it can be solved numerically given specific parameter values. Thus we iterate to find the utility-maximizing amount of housing for each of the four owner regimes, for each household, for each trial price vector.

III. The Production Sector

We assume perfect competition, no externalities, and constant returns to scale with zero excess profits. In the rental sector, just as for homeowners, one unit of housing services is produced from one unit of capital. In the corporate sector, output is produced according to a Cobb-Douglas production function:

$$C = \phi K_C^{\rho} L^{1-\rho} + \mu, \tag{6}$$

where ϕ is a scalar, K_C is capital used in the corporate sector, ρ is the capital share parameter, L is total household labor supply, and μ is a random element with mean zero that induces uncertainty in the return to capital. Competitive behavior then implies

$$K_C = L\left(\frac{r_C}{\rho\phi}\right)^{1/(\rho-1)} \tag{7a}$$

and

$$w = \phi(1-\rho)\left(\frac{K_C}{L}\right)^{\rho}, \tag{7b}$$

where r_C is the cost of capital to the corporate sector (discussed later) and w is the gross wage. Firms are assumed to use a fixed debt/equity ratio, b. The demand for equity is then $E_C = K_C/(1 + b)$, and the demand for corporate debt is just $D_C = K_C - E_C$. While the debt/equity ratio is fixed, the quantities of corporate debt and equity vary with the capital used in the corporate sector.

IV. Taxation

The model includes a social security tax, a personal income tax, and a corporate income tax. The first of these is the simplest, a single rate t_{ss} on the firm's use of labor. We define a unit of labor such that its net wage is one dollar in the benchmark equilibrium, so the gross wage paid by the firm is $w = 1 + t_{ss}$. Then in any tax change simulation, we calculate the gross wage or marginal product from equation (7b) and divide by $1 + t_{ss}$ to get the net wage received on each unit of labor. The revenue is just $T_{ss} = t_{ss}wL/(1 + t_{ss})$.

Next, the corporate income tax is relatively straightforward. Since provisions of this tax differ significantly among assets used by the firm, we calculate separate costs of capital for equipment, structures, land, inventories, and intangibles. Each of these assets depreciates in economic terms at an exponential rate d and is allowed depreciation deductions with a present value z. The corporation is taxed at statutory rate u and receives an investment tax credit at rate k on equipment. From Hall and Jorgenson (1967), the cost of capital or pretax rate of return is then

$$r_C = \frac{(r_C^* + d)(1 - k - uz)}{1 - u} - d, \tag{8a}$$

where

$$r_C^* = \frac{(r_E^* + \pi) + b(r_D^* + \pi)(1 - u)}{1 + b} - \pi. \tag{8b}$$

The firm's discount rate, r_C^*, depends on the real required rate of return to equity net of corporate taxes, r_E^*, the real interest rate, r_D^*, the debt/equity ratio, b, and the inflation rate, π. It is a weighted average of the cost of equity finance and the cost of debt finance, where nominal interest payments are deductible at the corporate rate u. The market rates of return r_E^* and r_D^* are used to calculate household net rates of return used in Section II above. Also, we note that the nominal after-tax interest rate $(r_D^* + \pi)(1 - u)$ is used to discount depreciation allowances in z because these allowances are fixed in nominal terms and riskless (Bulow and Summers 1984). Our single corporate firm always has sufficient tax liability to take available credits and deductions.

This is a model primarily about housing and not about corporate capital allocations, so we use fixed weights to average the costs of capital for the five assets. With the average pretax return r_C, corporate tax revenue is $T_C = r_C K_C - (r_D^* D_C + r_E^* E_C)$.

The personal income tax is more complicated. We wish to capture individual marginal rates of the actual tax law because they are major determinants of tenure choice and housing demand. The Survey of Consumer Finances has very good data on the asset holdings of each household but no information about taxable income or taxes paid. We are not able to obtain tax data directly for those households, but we are able to use information from the U.S. Treasury merge file.

The Treasury started with 195,000 tax returns for 1983, matched social security numbers for additional information, and statistically matched each household with observations in other data sets to assign nontax data such as house value, rent paid, and asset holdings. They also imputed missing data such as itemizable deductions for nonitemizers. The Treasury's Office of Tax Analysis kindly ran some regressions on their file using right-hand variables that were also available in our survey. In all, 20 variables were determined to appear in both files.[8] With their full sample, 24 separate ordinary least squares regressions were used to "predict" AGI after exemptions and to predict itemizable deductions; for single, married, and head-of-household filers; for renters and for owners; and for both the 1983 law and the fully phased-in Tax Reform Act of 1986 (at 1983 levels).

For each household in our sample, we determine marital status, homeownership, and the values of the same 20 variables. Application of the Treasury coefficients then gives us AGI minus exemptions and itemizable deductions. We compare the latter amount to the appropriate standard deduction to see if the household wishes to itemize. The resulting taxable income is then applied to the statutory schedules to determine the household's marginal tax rate and actual tax paid.

Given this marginal tax rate, τ, we can calculate the four real net rates of return for that household:

$$r_D = (r_D^* + \pi)(1 - \tau) - \pi, \tag{9a}$$

$$r_E = (r_E^* + \pi)[e(1 - g) + (1 - e)(1 - \tau)] - \pi, \tag{9b}$$

$$r_R = (r_R^* - m - t_p)\left(\frac{1 - \tau}{1 - \tau z}\right) - d, \tag{9c}$$

and

$$r_O = r_O^* - m - d - t_p(1 - I\tau). \tag{9d}$$

[8] These include wages and salaries, business income, nontaxed income, interest, dividends, capital gains, rental income, various transfers, pensions, age, sex, number of dependents, individual retirement accounts (IRAs) and Keogh accounts, mortgage and other interest paid, and rent paid or house value. The R^2's were all above .94 for predictions of adjusted gross income (AGI) and ranged between .50 and .80 for predictions of itemizable deductions.

The real net return to debt, r_D, is received after the nominal market interest rate $r_D^* + \pi$ is taxed at the household's marginal rate.

Of corporate equity, in (9b), a fraction e is financed by retained earnings. The return on these investments is received as capital gains subject to rate g, a fraction of τ that depends on the exclusion and the advantage of deferral. A fraction $1 - e$ of equity is financed by new share issues, for which the personal rate on dividends is relevant.

For rental housing, the price P_H is the rent r_R^*. Although the return is uncertain, nominal depreciation allowances are not. We therefore discount allowances at the nominal risk-free after-tax rate of return to calculate the present value z. In equilibrium, the net cost of the marginal investment must be equal to the present discounted value of the net returns:

$$1 - \tau z = \int_0^\infty (r_R^* - m - t_p)(1 - \tau)e^{-(r_R + d)t}dt. \tag{10}$$

The market rent r_R^* after maintenance at rate m and property taxes at rate t_p is subject to income tax at rate τ. This net-of-tax flow falls over time at the economic depreciation rate d and is discounted at the real net return r_R. Integration and solution for the pretax return yield an expression much like that for corporations in (8a) above. We then solve for the net return to obtain equation (9c).[9]

Finally, for owner-occupied housing, the rental return r_O^* is not taxed, and maintenance and depreciation are not deducted. Property taxes are deductible if the homeowner is an itemizer, as indicated when the dummy variable I is equal to one.[10]

Before leaving this section, we need to make two additional points. First, some of the tax parameters also apply to the variance-covariance matrix. As in (9b), each row and each column involving equity are multiplied by $e(1 - g) + (1 - e)(1 - \tau)$. Each row and each column involving rental housing are multiplied by $(1 - \tau)/(1 - \tau z)$ as in (9c). For owner housing, neither returns nor variances are

[9] Rental housing is traded and capital gains taxes are paid, but this additional tax can be more than offset by the increase of the basis for subsequent depreciation allowances. Gordon, Hines, and Summers (1987) find tax advantages to such "churning," but Gravelle (1987) shows that the net effects are small and depend on transactions costs. Rather than enter this debate, we simply assume that these effects wash or, equivalently, that one investor holds the asset for its entire life. Thus no capital gains tax appears in eq. (9c) or (10).

[10] The return to owner housing r_O and the price of owner housing P_H appear on opposite sides of the budget constraint for owners. Their definitions must be consistent but are arbitrary. Our accounting includes a fictional payment from the owner as renter to the owner as investor (where the rent is the same as for renters). Another approach might look only at cash flows (where the rent would be zero for the owner), but the results would be identical.

subject to tax. Thus O_G is zero until we simulate a tax on owner housing.

Second, we use Treasury coefficients and all initial asset holdings and returns to establish each household's initial taxable income, rate bracket, and tax paid. For a marginal change in the amount of any asset, however, the change in actual tax paid must match the difference between the market return and the household's net return. A problem would arise during simulations if we applied the Treasury coefficients to the new amounts of each type of income, because the change in the predicted amount of tax would not be the same as the additional tax implied by equations (9). For example, rental income receives one tax treatment implicit in the Treasury coefficient on rental income and a different tax treatment implicit in our formulas. Therefore, we use the Treasury coefficients only to establish benchmark levels. All changes during simulations are regulated by expressions (9).

V. The Government Sector and Equilibrium Conditions

We provide a simple treatment of government to help close the model in a way that ensures that total demands are equal to supply in the benchmark equilibrium. Government demands are then held fixed in simulations in order to isolate the effects of tax changes.

In the case of debt, for example, the total initial holdings of all households in the weighted sample are greater than the use of debt by the corporate sector. We assign the difference to a government demand for debt that is then held fixed across all simulations. The government has no demand for corporate equity. In the case of rental housing, the total initial holdings of all households in the weighted sample are less than the total initial consumption demand. Thus we assign the difference to a fixed government holding of rental housing. The government has no owner housing. These allocations characterize the benchmark equilibrium. We also assume initial rates of return for each asset.

Given initial tax rules, we can then calculate initial levels of government revenue from social security taxes, corporate taxes, personal taxes, and the market return on government holdings of rental housing. It must pay interest on its use of debt at the market rate, and it makes a fixed level of transfers to households. The remaining funds are spent on the corporate output. The initial level of government consumption is calculated as initial revenues minus transfers and interest paid, but then this level of government consumption is also held fixed in any simulation.

The next section describes the derivation of parameters such that, with *unchanged* tax rules, the simulation model finds an equilibrium price vector that exactly matches the assumed initial rates of return. Equilibrium quantities match all initial allocations, including government spending. Household wealth and preference parameters are then held fixed for counterfactual simulations with alternative tax rules.

The search for a new equilibrium proceeds with the announcement and revision of seven endogenous variables. The first three are prices: the market return to debt r_D^*, the market return to equity r_E^*, and the rental rate for housing (used for both r_R^* and r_O^*). The next three are total amounts for the government return of risks (E_G, R_G, and O_G). These act like prices in the sense that they must be known for households to set their portfolios, and yet are determined by aggregate portfolios. Finally, when tax rules change, government revenues would be affected. We wish to abstract from the effects of public deficits or spending changes, so we assume that the government scales some other tax parameter to meet all initial demand levels with a balanced budget. For results below, the seventh endogenous variable is the scalar by which the government must multiply all personal tax rates and the statutory corporate tax rate.

Given an announcement for these seven "prices," we can use equations (9) to solve for net rates of return to each household, equations (8) to obtain the cost of corporate capital, (7a) to solve for corporate capital demand, and (7b) to solve for the wage. Next we calculate asset demands and housing consumption in each of the eight regimes for each of the 3,578 households, and we predict regime probabilities using the discrete choice model. Probability-weighted demands and supplies are aggregated over sample-weighted households, and these are compared to corporate and government demands. We use the vector of excess demands in Newton's algorithm to determine a new trial price vector.[11]

Equilibrium is attained when the net supply of debt by households matches demand by corporations and the government, the supply of equity by households matches the demand by corporations, the supply of rental housing by households and the government matches the demand by households, the three types of risk received from the government match the amounts generated by taxation of household

[11] The evaluation of aggregate demands takes about an hour of CPU time on a Prime 9950. With seven prices, each Newton step requires eight function evaluations. Equilibrium can be achieved in about five iterations of the algorithm, or about 8 × 5 = 40 hours of CPU time. In the simulations with no mortgage interest deductions, the kink in the budget constraint requires multiple evaluations and can take over 100 hours.

portfolios, and government revenue matches expenditures. The calculations ensure that each household's demand equals its own supply of owner housing, and Walras's law ensures that demand equals supply for corporate output. In addition to this closed-economy model, we provide results for a stylized open-economy model described below.

VI. Parameter Selection

A number of parameters must be chosen to represent the base year, 1983, as an equilibrium solution of the model. For example, households in the Survey of Consumer Finances report many different interest rates on different kinds of debt, but we need a single market interest rate for all kinds of debt in the model. Table 1 summarizes the parameter values that we have selected.

In general, the returns and variances used in the model are chosen to be consistent with historical experience and with the 1983 base year. The real return to debt and the expected inflation rate are set at 5 percent; the implied 10 percent nominal interest rate is reasonably consistent with 1983 experiences. The assumed real return to equity is 12 percent, chosen by adding a 7 percent risk premium to the riskless 5 percent debt return. This risk premium is close to the historical average when New York Stock Exchange data for 1960–80, presented in Ibbotson and Siegel (1983), are used. For rental housing, a rental rate of 11 percent minus maintenance, depreciation, and property tax yields a pretax real return of 7.2 percent. The implied 2.2 percent risk premium for rental housing is close to the risk premia for U.S. residential real estate as calculated from Ibbotson and Siegel.

The Appendix describes sources and derivations of other parameter values in table 1. We assume that the social security tax is 10 percent, the corporate tax rate is 46 percent, the ratio of debt to equity is .5, and half of corporate earnings are paid as dividends ($e = .5$). Tax provisions for 1983 include a 60 percent exclusion plus deferral of capital gains, accelerated depreciation allowances, and a 10 percent investment tax credit for equipment.

The variance-covariance matrix is derived from time-series data on stock market variations, owner-occupied housing prices, and real estate investment returns. The calculated variance for equity is 252.03, a large figure that corresponds to a standard deviation of 15.8 percent per year. The calculated variances for rental and owner housing are 66.7 and 67.1, respectively. As described in the Appendix, these derivations assume that equity investments are fully diversified but housing investments are not. An owner-occupied house is not diversified at all. This last assumption is important since it presents the govern-

TABLE 1

A. SELECTED PARAMETER VALUES

Parameter	Definition	Value
r_D^*	Real return to debt	.05
r_E^*	Real return to equity	.12
r_R^*	Real rental rate	.11
π	Inflation rate	.05
t_{ss}	Social security tax rate	.10
t_p	Property tax rate	.018
b	Debt/equity ratio	.50
d	Depreciation of housing	.01
e	Fraction of equity retained	.50
f	Fraction of capital gains taxed	.20
m	Maintenance rate	.01
u	Statutory corporate tax rate	.46
ρ	Capital share in production	.1182
ϕ	Scale parameter in production	1.1996

B. CORPORATE ASSETS

				d'	
	WEIGHT (1)	k (2)	d (3)	1983 (4)	1986 (5)
Equipment	.31	.10	.13	.340	.380
Structures	.28	.0	.03	.135	.076
Land	.17	.0	.0	.0	.0
Inventories	.14	.0	.0	.0	.0
Intangible	.11	.0	.215	∞	∞

C. VARIANCE-COVARIANCE MATRIX Σ

	Debt	Equity	Rental	Owner
Debt	0	0	0	0
Equity	0	252.03	12.48	6.06
Rental	0	12.48	66.70	26.20
Owner	0	6.06	26.20	67.10

ment with the opportunity to improve welfare by taxing owner housing and taking part of the variance. The government's diversification makes part of this risk disappear. A natural question, of course, is whether a private broker could arrange such risk sharing by homeowners. Certainly we do not observe such activity. Two possible reasons come to mind. One is that homeowners do not want such diversification. If the homeowner plans to live in the current house for a long time, then variations in its value help insure against correlated variations in the future cost of housing. Thus we may overstate the gains from the government's diversification of owner housing. A second reason is that private markets fail because of asymmetric information and adverse selection. The private arrangement may attract only the bad risks, whereas the government can coerce universal participation. Implicitly, at least, we must rely on such a market failure to explain the gains from government action.[12]

Finally, for government holdings of assets through tax receipts (E_G, R_G, and O_G), variances are calculated from the covariance matrix of the underlying investments. For equity, the risk is the same for government as for individuals. Corporate taxes can improve welfare, however, by spreading risk to other individuals who choose to hold no equity. For rental housing, much of the risk is property-specific. We assume that the government can diversify away all regional and intraregional variation, leaving only the national component. When we simulate the effects of a tax on owner housing, we again assume that subnational risk is diversified and only national-level risk is returned through O_G.

VII. Calibration and Estimation

The net rates of return for each household are used with asset holdings and other data compiled from the survey to calculate the implied values of household-specific parameters α, β, and γ. We assume that the household is optimizing at its observed quantities of C and H, asset holdings, net rates of return, and after-tax elements of Σ. For those with positive values of equity and rental property, the three first-order conditions in equations (4) or (5) can be solved for the three parameters α, β, and γ. Unique values of these parameters are consistent with each household's optimization at the observed choices. This procedure does not identify both β and γ for households that are not observed to hold both equity and rental housing. For these households β or γ was estimated using regressions on other characteristics over the households in which β and γ were identified (ignoring potential selection bias). The value of α is always obtainable from observed C and H in (4a) or (5a). Summary statistics on these household-specific parameters are presented in table 2.

Since β is derived for each household from observed holdings and the estimated variance of income, only the relative variances of the assets are important. The product $\beta\Sigma$ matters, but the scale of Σ does

[12] Even without brokers, homeowners could undo some of their property-specific risk by holding rental properties in other regions, buying an index on local foreclosures, or going short on other assets tied to the local economy. Most often, however, homeowners do not employ these techniques. Indeed, an interesting question is why homeowners often buy *more* debt from their own state or municipality.

TABLE 2

SUMMARY STATISTICS FOR HOUSEHOLD-SPECIFIC PARAMETERS

	Mean	Standard Deviation	Correlations α	β	γ
α	.771	.167	1.00		
β	.303	.567	−.15	1.00	
γ	1.533	.749	.38	−.03	1.00

not. Thus any misspecification of the level of Σ would be exactly offset in the derivation of β such that the product is unaffected. This aspect is important because, for example, it makes the assumed holding period irrelevant. This one-period model seems to imply that each house or other asset is held only 1 year before realization of the gain or loss, but longer holding periods (and thus lower variances) are irrelevant as long as they affect all assets equally.

Our method of solving for household-specific values of parameters is basically the same as using fitted values from a regression plus household-specific residuals. The advantage of this approach is that it preserves the sample diversity for simulations, but the disadvantage is that some of the observations are apt to have badly estimated parameters because of the forced exact solution of the first-order conditions. For the sensitivity analysis below, we also regress our calculated parameters on household characteristics, assign fitted values of these parameters to every household, and perform alternative simulations.

This selection of parameters completely defines the utility maximization problem conditioned on regime, but it does not define the choice among regimes. Each household also has a set of eight parameters δ_i in equation (2) that are designed to explain the observed lack of diversification for households without certain assets. They can be interpreted as a combination of taste for and fixed cost of holding certain assets.

The actual choices are observable from the data, and utility in (1) can be calculated. However, the δ_i are unobservable. To proceed, we assume that the δ_i are functions of exogenous variables X_i such as wealth, age, and household size. We say $\delta_i = X_i\Delta + \epsilon_i$ and estimate Δ as a discrete choice problem, ignoring potential endogeneity and selection bias. The ϵ_i are assumed to have extreme value errors, and Δ is then estimated using multinomial logit analysis with eight alternatives corresponding to the eight regimes.

The variables and estimated coefficients of the logit model are shown in table 3. The first seven parameters are regime-specific con-

TABLE 3

LOGIT MODEL VARIABLES, VALUES, AND DEFINITIONS

Variable Name	Estimated Coefficient	t-Statistic	Definition
REGIME 1 CONSTANT	−.545	−7.87	One for regime 1 (with E, R, and OH), zero otherwise
REGIME 2 CONSTANT	−.414	−7.00	One for regime 2 (with E and OH), zero otherwise
REGIME 3 CONSTANT	−1.168	−17.20	One for regime 3 (with R and OH), zero otherwise
REGIME 5 CONSTANT	−2.483	−14.16	One for regime 5 (with E and R), zero otherwise
REGIME 6 CONSTANT	−1.331	−12.98	One for regime 6 (with E only), zero otherwise
REGIME 7 CONSTANT	−2.451	−20.72	One for regime 7 (with R only), zero otherwise
OWNER-OCCUPANT	−6.645	−11.64	One for owner-occupant regimes 1–4, zero otherwise
UTILITY LEVEL	1.867	5.88	Regime utility level as in eq. (1)
UTILITY LEVEL/WEALTH	.502	10.77	Regime utility level divided by household wealth
WEALTH*OWNER	$.394 \times 10^{-3}$	1.99	Household wealth if owner regime, zero otherwise
WEALTH^2*OWNER	$-.610 \times 10^{-8}$	−1.57	Household wealth squared if owner regime, zero otherwise
HOUSEHOLD SIZE*OWNER	.734	6.39	Number of people in household if owner regime, zero otherwise
HOUSEHOLD SIZE^2*OWNER	−.069	−4.89	Number in household squared if owner regime, zero otherwise
LABOR INCOME*OWNER	.008	4.02	Household labor income if owner regime, zero otherwise
LABOR INCOME^2*OWNER	$-.533 \times 10^{-5}$	−3.87	Household labor income squared if owner regime, zero otherwise
TRANS.INC.*OWNER	−.049	−3.74	Household transfer income if owner regime, zero otherwise
TRANS.INC.^2*OWNER	$.156 \times 10^{-3}$	2.42	Household transfer income squared if owner regime, zero otherwise
AGE OF HEAD*OWNER	.145	9.05	Age of household head if owner regime, zero otherwise
AGE OF HEAD^2*OWNER	−.001	−6.30	Age of household head squared if owner regime, zero otherwise
EDUCATION*OWNER	.159	2.40	Years of education of household head if owner regime, zero otherwise
EDUCATION^2*OWNER	−.006	−1.95	Years of education of head squared if owner regime, zero otherwise
MARRIED*OWNER	.739	6.29	One if married for owner regimes, zero otherwise

NOTE.—Wealth and income terms are in units of $1,000. Regime 8 is the omitted constant. Regime 4 is the "owner-occupant" with no other assets E or R. Therefore, the first three constants represent the increment for those regimes relative to regime 4. The log likelihood is −4,461.9 in this model and −5,105.8 with constants only.

stants.[13] The next two variables show how the calculated level of utility in a given regime affects the probability of choosing that regime. Higher-utility regimes are chosen more frequently, and a given utility difference has more effect on the regime choice of a low-wealth household. The remainder of the variables are interacted with a dummy for owner occupancy in order to capture determinants of tenure choice that are not part of the utility function in equation (1). As might be expected, homeownership is positively related to being married, wealthy, older, and more educated. We could find no significant demographic effects on the probabilities of holding equity or rental housing.

The logit model then predicts regime probabilities for each household as a function of exogenous variables X and U_i calculated from equation (1). These predicted regime probabilities are then used instead of actual observed regime choices in the simulation model. We thereby capture regime shifts in response to policy changes.

VIII. Data

The data for this analysis come from the 1983 Survey of Consumer Finances. This survey contains assets holdings and other information for 4,262 households, including 438 specially selected high-income households. This full data set is used to establish our final sample of households, those with sufficient information on demographic characteristics, income sources, and various forms of wealth. In some cases we used observations with enough data to impute remaining necessary variables. The remaining 3,578 observations are then reweighted to account for deleted households and to reflect the entire U.S. population.

For each of the 3,578 households, asset holdings are aggregated into four categories: debt, including bank deposits, loans, and other interest-bearing assets and liabilities; equity, including corporate stock and the value of business holdings; rental property, including land and seasonal residences as well as other property; and owner-occupied housing.

Because of limitations of the data and the one-period framework of the model, some forms of wealth cannot be allocated to these four categories without some compromises and ad hoc adjustments. For example, trust funds were allocated between debt and equity on the basis of other holdings of the household. Also, pension wealth must

[13] The first four regimes pertain to owner occupancy: regime 1 has both equity and rental housing, regime 2 has equity but not rental housing, regime 3 has rental housing but not equity, and regime 4 has neither of these other assets. Regimes 5–8 follow the same pattern for renters.

be calculated and allocated for each household. The value of defined contribution pension plans is indicated on the survey, and this wealth is allocated equally between debt and equity.[14] A similar treatment is accorded IRA and Keogh accounts, but the more difficult defined benefit pension treatment is described in the Appendix.

Each household's pension wealth is fixed at its initial level in all simulations, but the household recognizes its pension holdings of debt and equity and is able to modify its direct holdings accordingly. Its total holding of each asset can exceed its pension holding but cannot be less than its pension holding.

To calculate each form of capital income in the base year, we use these reported and constructed asset holdings for each household together with assumed market rates of return. To calculate labor income, we take reported wages and salaries plus income from a professional practice. Transfers also are on the survey, and we aggregate over welfare programs, social security, and gifts. Each household is then run through Treasury coefficients to calculate taxable income, marginal rate, and tax paid.

The final data for our model are impossible to display fully, but they are summarized in table 4.[15] Households could be grouped by any demographic characteristic or by wealth, but we use a measure of income in order to show the effect of progressivity on tax rates and net returns. "Economic" income is defined to include labor income, transfers, and capital income before personal taxes. It includes returns to rental and owner housing after maintenance, depreciation, and property taxes.

The eight groupings are somewhat arbitrary, but the first row of the table shows that we have at least 150 households in each group. The large number of households with over $200,000 per year reflects the extra observations in the survey, but the weighted number in the second row shows the expected thinner tail of the income distribution. The third row shows that wealth also increases with income, from an average of about $3,000 per household in the lowest-income group to an average of almost $2 million in the highest-income group. On a weighted basis, the poorest 5.2 percent of households have 0.2

[14] Households would be unlikely to allocate tax-free pension wealth in the same proportions as other taxable wealth. An example of a large defined contribution pension fund is TIAA/CREF, which reports that total stocks and bond holdings are approximately equal.

[15] The use of predicted probabilities in place of actual regime choices means that aggregate amounts in the initial equilibrium do not match exactly the actual (sample-weighted) data from the survey. We use the predicted amounts as basic data, including all those displayed in table 4. This allocation represents the starting point for any simulation.

TABLE 4

AVERAGE VALUES OF KEY VARIABLES BY GROUP

	ECONOMIC INCOME GROUPS (Thousands of 1983 Dollars)								
	0–5 (1)	5–10 (2)	10–20 (3)	20–30 (4)	30–50 (5)	50–100 (6)	100–200 (7)	200+ (8)	Total (9)
Number	171	415	790	608	744	407	153	290	3,578
Weighted number	4,123	10,110	19,254	15,051	18,483	9,828	1,854	1,160	79,864
Wealth	3,055	11,744	28,914	40,714	67,586	136,471	477,105	1,835,725	86,472
Types of income:									
Labor	592	2,330	9,177	18,683	30,056	50,083	90,008	298,400	25,603
Transfers	2,281	3,039	2,453	1,697	1,387	1,399	3,280	4,376	2,047
Economic	3,724	7,452	14,914	24,547	38,337	65,717	134,949	472,953	36,322
Asset holdings:									
Debt	−1,017	374	5,205	4,246	8,238	21,993	148,939	495,578	17,321
Equity	580	1,621	2,688	3,933	5,792	13,254	76,876	716,805	16,795
Rental	329	1,258	2,535	4,261	7,317	18,964	79,446	352,307	12,581
Owner	3,163	8,492	18,487	28,274	46,239	82,258	171,844	271,036	39,775
Uses of income:									
Rent	958	1,429	1,664	1,563	1,515	1,111	951	663	1,445
Corporate goods	2,415	4,985	10,354	17,495	26,741	43,420	77,457	263,774	23,712
Standard deviation of consumption	1	2	3	4	7	13	33	143	8
Tax paid	3	105	862	2,379	4,995	12,138	37,638	178,702	6,789
Marginal tax rate	.004	.043	.134	.207	.277	.377	.468	.492	.205
Real net returns:									
Debt	.050	.046	.037	.029	.022	.012	.003	.001	.029
Equity	.120	.115	.103	.094	.085	.072	.060	.057	.094
Rental	.071	.070	.066	.063	.061	.057	.053	.052	.064
Owner	.072	.072	.072	.073	.075	.078	.080	.081	.074
Summary statistics:									
Utility	4.712	8.327	14.660	20.998	30.490	46.212	81.081	181.625	26.054
Logit surplus	1.748	2.026	2.220	2.380	2.636	3.215	3.854	5.648	2.508
Homeowner probability	.346	.404	.503	.623	.737	.848	.891	.916	.616

percent of wealth, whereas the top 1.5 percent of households have 31.0 percent of wealth.

The next three rows of table 4 show each group's average labor income, transfer income, and total economic income. The average economic income is always near the middle of the range that defines the group. Then the following four rows show the average holdings of the four assets in the model. The lowest-income group borrows, has more than its wealth in owner-occupied housing, and holds very little corporate equity or rental housing. The percentage of wealth held in owner housing falls almost monotonically to 15 percent for the highest-income group. Middle-income groups on average have more rental property than corporate equity, but the top group is reversed.

Table 4 then shows rent paid and the consumption of the corporate output, averaged over all households in each group. The standard deviation of consumption indicates the overall riskiness of the group's portfolio. The next row is the calculated tax paid, from Treasury coefficients and actual tax schedules. The marginal tax rate averages .004 for the first group, which means that most households are untaxed whereas a few have entered the first bracket with a rate of 11 percent. The marginal tax rates increase monotonically to 49.2 percent for the last group, where almost all households are in the top bracket of 50 percent.

Households have individual net rates of return that depend on taxation. As summarized in table 4, the lowest-income group faces almost no taxes and averages a net real return to debt equal to the full 5 percent market rate. They also receive the full 12 percent on equity and 11 percent on housing, but we subtract maintenance, depreciation, and property taxes to get the net return of 7.1 percent. With taxes the net returns are given by equations (9), so the top income group gets only 5.2 percent on rental housing but 8.1 percent on owner housing. Because the 10 percent nominal interest rate is taxed by almost half, before 5 percent inflation is subtracted, the net return to debt is near zero.

At the bottom of table 4, "utility" refers to the calculated utility from equation (1), weighted by the probability of falling into each of the eight regimes. "Logit surplus" refers to the calculated expected maximum utility from equation (2), where expectations are taken over the unobserved ϵ_i error terms. "Homeowner probability" refers to the sum of the four owner regimes' calculated probabilities from the logit model. This value increases from 35 percent to 92 percent across the income groups, averaging 62 percent overall. These calculated percentages closely reflect actual homeownership characteristics.

IX. Simulation Results

We consider four tax changes in this model, represented by the columns of table 5. Each is discussed below. Panel A of table 5 shows summary results for the standard case of a closed economy. With no international capital flows, the equilibrium interest rate depends on changes in both demand for and supply of debt. In panel B of table 5, we perform alternative calculations that hold the real interest rate constant. The interpretation is that a foreign sector has perfectly elastic demand for U.S. debt, and any excess of domestic supply over demand flows overseas and earns the 5 percent real rate. The foreign sector pays interest in terms of output or uses any interest receipts to purchase U.S. output. Thus payments always balance. This "open-economy" model is stylized since debt is perfectly mobile but equity and housing must still be owned domestically. In panel C of table 5, we return to the closed economy but respecify the benchmark equilibrium gross return to housing from 11 percent to 14 percent. The net return is thereby changed from 7.2 percent to 11.2 percent, so the implied risk premium changes from 2.2 to 6.2 percent. In panel D of table 5, we investigate the impact of our procedure for calibrating α, β, and γ. This alternative model replaces these household-specific parameters with fitted values from a regression of our calculated parameters on household characteristics. This regression procedure should lead to fewer extreme values for these parameters.

A. *Level Housing*

For our first experiment, we investigate the effect of the current advantages to owner-occupied housing. These advantages can be seen clearly by comparing equations (9c) and (9d): the landlord is taxed on rental income but the owner is not. We treat interest payments as deductible in any case, but owners who itemize get an extra deduction for property taxes. For the simulation, we simply treat all housing like rental housing in equation (9c). In this case there is no tax benefit to owner-occupying, but the estimated δ_i imply that some households have a preference for owning their own home.

Table 5 shows that this "level" treatment of housing raises much extra tax revenue and allows all statutory rates to be scaled down by 10 percent. For the standard case, in panel A, the real interest rate falls from 5 to 4.3 percent. The return to equity rises slightly and the return to rental housing falls slightly. Other panels of table 5 indicate that this general pattern is repeated in all sensitivity cases.

To explain these results in general equilibrium, we note first that a potential owner faces two effects that work in opposite directions. The "rate of return effect" is that the new tax reduces the return on this investment and thereby makes owning less attractive. The "variance effect" is that the tax also allows the government to pool some of the risk and thereby make owning more attractive (Rosen et al. 1984). The combined effect depends on the individual's risk aversion and tax rate, as seen in the detailed results of table 6. Using the average of households in each group, this table shows the ratios of key variables in the simulation to their values in the benchmark.

To see the effects of the marginal tax rate on the interest rate, start with the net rates of return in the highest-income group. The real net return to debt was only .001 for this group, calculated as the nominal interest rate (.05 + .05) times (1 − .492) minus inflation of 5 percent. When these households' marginal tax rate falls to .442, their real net interest rate doubles to .002, calculated as (.043 + .05) × (1 − .442) − .05. Their net return to owner housing falls to 64 percent of its former value. This group is induced to increase its supply of debt 30 percent, as shown at the top of that column. It is its overall wealth that leads to the increase in the aggregate supply of debt that drives down the market interest rate.

Table 6 also shows that this bracket holds 24 percent less owner housing (even though these households are constrained to purchase 24 percent less housing services for consumption). This reduction would be even greater if the "variance effect" did not offset part of the "return effect." The logit model indicates that the change in utility as an owner (relative to utility as a renter) reduces their probability of owning by only 0.3 percent. This result highlights the importance of separating tenure choice from the amount of owner-occupied housing. The logit model implies that tenure is determined primarily by demographic factors that are unaffected by this tax change, such as age, wealth, and family size. Changes in the relative rates of return (and variance) affect the relative utility of owning, which has only a small effect on tenure. But once a household decides to own, in this mean-variance portfolio model, relative rates of return have a much larger effect on the amount of owner housing. This distinction is missed in previous housing studies that concentrate only on the effects of taxes on tenure choice.

Because the lowest-income households are untaxed, their real net interest rate falls from 5 to 4.3 percent. Their ratio of new debt holdings to old debt holdings is 1.395, which indicates that they increase their negative position (from −$1,017 to −$1,419 per household). They buy more equity and rental housing, and since they are unaffected by the taxation of owner housing, they also buy 6 percent

TABLE 5

SUMMARY SIMULATION RESULTS

	Base Values	Level Housing	Disallow Property Tax Deduction	Disallow Mortgage Interest Deduction	1986 Law
	A. Standard Case: Closed Economy, $r_R^* = .11$, Household-Specific Parameters				
r_D^*	.0500	.0430	.0450	.0457	.0370
r_E^*	.1200	.1238	.1214	.1203	.1165
r_R^*	.1100	.1060	.1077	.1080	.1053
r_C	.1059	.1040	.1042	.1039	.1074
Tax scalar	1.0000	.8991	.9570	.9725	1.1470
Wage rate	1.0000	1.0024	1.0022	1.0026	.9982
Equivalent variation per household ($)		382	90	30	339
Percentage with gains (%)		72	68	56	61
	B. Open Economy				
r_D^*	.0500	.0500	.0500	.0500	.0500
r_E^*	.1200	.1252	.1222	.1210	.1195
r_R^*	.1100	.1099	.1106	.1091	.1139
r_C	.1059	.1080	.1069	.1062	.1156
Tax scalar	1.0000	.9099	.9669	.9792	1.1817
Wage rate	1.0000	.9974	.9987	.9996	.9883
Equivalent variation per household ($)		503	169	42	544
Percentage with gains (%)		81	66	59	37

			C. Start with $r_R^* = .14$		
r_D^*	.0500	.0396	.0447	.0453	.0366
r_E^*	.1200	.1244	.1213	.1207	.1163
r_R^*	.1400	.1351	.1380	.1381	.1362
r_C	.1059	.1028	.1041	.1039	.1072
Tax scalar	1.0000	.8745	.9570	.9681	1.1529
Wage rate	1.0000	1.0041	1.0024	1.0026	.9984
Equivalent variation per household ($)		382	76	6	307
Percentage with gains (%)		70	67	54	58
			D. With Fitted Parameters		
r_D^*	.0500	.0393	.0433	.0466	.0354
r_E^*	.1200	.1251	.1219	.1210	.1169
r_R^*	.1100	.1052	.1075	.1075	.1040
r_C	.1059	.1036	.1037	.1033	.1071
Tax scalar	1.0000	.8884	.9438	.9559	1.1469
Wage rate	1.0000	1.0024	1.0025	1.0028	.9987
Equivalent variation per household ($)		344	91	13	245
Percentage with gains (%)		67	67	60	57

TABLE 6

TAX OWNER AS RENTAL (Level Housing), STANDARD CASE: SIMULATED/BASE RATIOS FOR KEY VARIABLES

	Economic Income Groups (Thousands of 1983 Dollars)								
	0–5 (1)	5–10 (2)	10–20 (3)	20–30 (4)	30–50 (5)	50–100 (6)	100–200 (7)	200+ (8)	Total (9)
Economic income	.992	.991	.995	.998	.996	.993	.983	.980	.991
Asset holdings:									
Debt	1.395	−2.663	.492	.245	.573	.940	1.137	1.304	1.014
Equity	1.196	1.219	1.258	1.244	1.264	1.199	1.026	.940	1.030
Rental	1.340	1.383	1.365	1.262	1.190	1.109	.966	.877	1.030
Owner	1.056	1.063	1.055	1.040	1.013	.959	.885	.764	.972
Uses of income:									
Rent	.989	.985	.982	.984	.997	1.016	1.066	1.104	.992
Corporate goods	.989	.987	.995	1.001	.999	.999	1.003	1.034	1.005
Standard deviation of consumption	1.066	1.061	1.030	1.002	.979	.955	.938	.967	.976
Tax paid	.924	.970	.975	.979	1.001	1.021	1.004	.940	.980
Marginal tax rate	1.031	1.056	.974	.940	.950	.940	.919	.899	.949
Real net returns:									
Debt	.859	.848	.843	.850	.830	.816	.931	2.290	.844
Equity	1.031	1.029	1.037	1.051	1.056	1.079	1.122	1.154	1.049
Rental	.944	.944	.948	.955	.958	.966	.980	.989	.954
Owner	.942	.921	.873	.830	.772	.700	.650	.641	.819
Fraction of group:									
Win	.721	.646	.713	.822	.778	.598	.590	.810	.725
Lose	.268	.348	.284	.175	.219	.400	.410	.190	.271
Draw	.011	.006	.003	.004	.003	.002	.000	.000	.003
Summary statistics:									
Homeowner probability	1.012	1.009	1.014	1.013	1.006	1.001	.998	.997	1.008
Equivalent variation*	−34	−78	61	223	281	222	855	15,469	382

*The average gain per household in 1983 dollars.

more owner housing. Their probability of owning increases by only 1.2 percent.

Thus high-income households shift out of owner housing, and their overall wealth ensures that total owner housing for the economy falls by 3 percent. In the open-economy model, total owner housing falls by 6 percent. At the same time, low-bracket households shift into owner housing, and their greater number ensures that the overall percentage of owners rises (by 1 percent). This result highlights the importance of using micro-unit data in the general equilibrium model. Even though the tax change discourages owner housing, we get an increase in the aggregate number of owners. This possibility is missed in previous housing studies that use more aggregate groups or a "marginal investor."

The bottom row of table 6 shows the average equivalent variation in each group. Because the utility function has no analytical solution for demands, we cannot solve for indirect utility or the expenditure function. Instead, after all the new equilibrium prices, quantities, and utility levels are available, we solve numerically for the equivalent variation. For each household, an initial guess is added to old income at old prices, and it is modified upward or downward until that household attains the new utility level.[16] Table 6 shows that this tax change hurts the poor and helps the rich. A major reason for this regressive outcome is that the extra revenue is used to scale down marginal tax rates in a multiplicative fashion. When all rates are multiplied by .8991 (from table 5), the top-bracket rate changes from .492 to .442 and the bottom-bracket rate of zero is unaffected.

The bottom-right entry indicates, however, that the average household in the economy would gain by $382 per year. This "efficiency gain" is 1.05 percent of the average household's economic income ($36,322 in table 4). In the open-economy case, the figure is $503 per household or 1.4 percent of income. These gains arise from three sources. First, a misallocation of capital is removed by leveling the playing field between untaxed owner housing and highly taxed business assets (Harberger 1966). Second, a misallocation of risk is reduced since the row for the standard deviation of consumption shows that the tax on owner housing shifts risk from high to low brackets (Slemrod 1982). Third, efficiency gains here arise from the ability of the government to pool the risk of owners who are unable to diver-

[16] The reported equivalent variations are based on the logit formula, in which each household has expected utility over its choice among the eight regimes. An alternative calculation is based on a probability-weighted average of the utilities in the eight regimes, in which each household really represents many households in the U.S. economy that actually enter all eight regimes in proportions given by the probabilities. The alternative equivalent variations are always very close to the reported ones.

sify. This result highlights the importance of treating housing as a risky asset.

To determine the size of this new effect in our model, we simulated the same tax on the return to owner housing in a case in which all the risk is returned to the private sector. With just the first two sources of efficiency gain, the average equivalent variation is \$190. This figure represents 0.5 percent of income, a result very much in line with other standard Harberger calculations. Thus the additional ability of government to diversify away some of the risk of homeownership, in this model, *doubles* the size of the efficiency gain from taxing owner housing.

Other results in table 6 are worth mentioning. Even though all marginal tax rates are scaled down by 10 percent, the change in definition of taxable income puts some households into higher rate brackets. Thus most groups do not experience a 10 percent drop in the average of their marginal tax rates. Also, the amount of tax paid reflects the relative importance of owner-occupied housing in portfolios, particularly for the sixth and seventh groups with income between \$50,000 and \$200,000 per year. Detailed results for the open economy and for the other sensitivity cases indicate a similar pattern.

Finally in table 6, we show effects on "horizontal equity" within each group, that is, the fraction of households with an equivalent variation that is more than \$1.00 (win), less than −\$1.00 (lose), or in between (draw). Although the lowest two income groups have negative average equivalent variations, over 70 percent of these households still gain. And although the highest-income group has a huge positive average gain, 19 percent of those households still lose. These results highlight the importance of maintaining sample diversity.

B. *Disallow Property Tax Deduction*

The level treatment of owner and rental housing answers the conceptual question about current advantages to owners, but the taxation of imputed net rents may not be a practical policy option. We consider next a more realistic alternative in which the federal government just disallows deductions for state and local property taxes paid by owners. Table 5 indicates that this change would affect prices in the same direction, and by almost as much, as the full taxation of owner housing. The interest rate falls from .050 to .045 (instead of .043). The extra revenue would allow tax rates to be scaled down by 5 percent, half as much as before. Again the sensitivity calculations provide similar results. But the average equivalent variation is only \$90, much smaller than the \$382 for the full taxation of owner housing. The reason is that this tax change does not apply to any risk in the return to owner housing and thus does not allow government to help owners diversify. The $90 is only the standard Harberger efficiency gain from increasing the tax on an untaxed asset.

Table 7 shows more detailed results in which again high-bracket households shift out of housing and into holding debt. They gain an average of $5,485, primarily via tax rate reduction. The lowest-income bracket again experiences a lower cost of borrowing and increases its negative position in debt. This group does not benefit from rate reduction and has a negative average equivalent variation. In this simulation, however, the sixth and seventh income groups also experience losses because of the importance of owner housing in their portfolios. The percentages of winners and losers reflect the relative numbers of owner-occupants in each group.

C. *Disallow Mortgage Interest Deduction*

Another possible reform that might be thought to affect the relative advantages to owner-occupants would be for the government to disallow mortgage interest deductions. In our model, however, debt is homogeneous. Households can hold positive or negative positions in debt regardless of whether they own a house. To model this policy option, we therefore limit deductibility for any household's negative position in debt to the amount of wealth in taxable assets. In other words, households can deduct interest paid on loans used to finance equity or rental housing, but not on additional loans that might be used to finance owned homes (or consumer spending). Implicitly, households are assumed to rearrange their affairs in order to draw down any taxable debt holdings before borrowing at a nondeductible interest rate.

Table 5 indicates that this reform would have very little impact. It reduces the real interest rate only from .05 to .0457, and it raises only enough revenue to scale down marginal tax rates by 2.7 percent. The average equivalent variation is only $30 per household. As in the previous simulation, this reform also does not apply to the variance in a way that would allow government to help owners diversify. Effects are even smaller, however, which indicates that few households would actually be subject to the constraint. In particular, households in high-income groups mostly have enough positive debt holdings to finance their homes. At the other end of the income spectrum, low-income households are often untaxed and are therefore unaffected by the disallowance of this deduction. Even families that face the constraint can use their own debt holdings first, at a cost given by the after-tax interest rate, before borrowing at the market interest rate.

TABLE 7

ELIMINATE PROPERTY TAX DEDUCTION, STANDARD CASE: SIMULATED/BASE RATIOS FOR KEY VARIABLES

	Economic Income Groups (Thousands of 1983 Dollars)								
	0–5 (1)	5–10 (2)	10–20 (3)	20–30 (4)	30–50 (5)	50–100 (6)	100–200 (7)	200+ (8)	Total (9)
Economic income	.994	.992	.995	.998	.997	.994	.989	.990	.994
Asset holdings:									
Debt	1.289	−.967	.766	.630	.848	1.052	1.082	1.109	1.013
Equity	1.123	1.112	1.122	1.119	1.126	1.089	1.022	.991	1.027
Rental	1.300	1.228	1.161	1.118	1.074	1.034	.976	.955	1.013
Owner	1.039	1.031	1.026	1.021	1.000	.964	.930	.882	.979
Uses of income:									
Rent	.989	.989	.988	.987	.992	1.004	1.042	1.053	.992
Corporate goods	.992	.991	.998	1.003	1.003	1.002	1.003	1.016	1.004
Standard deviation of consumption	1.041	1.038	1.026	1.020	1.010	.997	.989	1.000	1.006
Tax paid	.937	.944	.957	.965	.982	1.001	.997	.973	.983
Marginal tax rate	.990	.955	.958	.961	.969	.969	.966	.957	.965
Real net returns:									
Debt	.900	.900	.897	.892	.876	.837	.647	.354	.889
Equity	1.012	1.014	1.019	1.023	1.026	1.034	1.049	1.062	1.022
Rental	.968	.970	.973	.976	.978	.982	.987	.992	.975
Owner	.968	.968	.962	.949	.921	.886	.866	.860	.937
Fraction of group:									
Win	.708	.615	.684	.812	.715	.484	.403	.655	.676
Lose	.280	.374	.307	.186	.276	.511	.594	.345	.317
Draw	.012	.011	.009	.002	.009	.004	.003	.000	.007
Summary statistics:									
Homeowner probability	1.011	1.007	1.009	1.008	1.004	1.001	.999	.998	1.006
Equivalent variation*	−22	−58	2	84	69	−87	−133	5,485	90

*The average gain per household in 1983 dollars.

This ordering rule mitigates the impact of the reform, and perhaps it overstates to some degree the actual response of households. It is a rational response, however, and it is quite similar to the observed large shift into home equity loans after the 1986 Tax Reform Act removed the deductibility of consumer interest (Skinner and Feenberg 1990).

Table 8 has more detailed results for this simulation. The fifth row shows that no income group changes its holdings of owner housing in either direction by more than a few percentage points. The first six income groups lose, on average, and only the top two groups gain.

A major conclusion is that the success of a reform designed to address the relative taxation of owner and rental housing depends greatly on whether it allows the government to help owners diversify. With halfway measures related to property taxes or mortgage interest deductions, the amount of tax is not tied to variations in the return to the asset. Risk sharing can be accomplished only through a tax on imputed net rents or through a capital gains tax with full loss offset on the price of the owner-occupied house.

D. *The Tax Reform Act of 1986*

This paper provides a full description of our housing model and a discussion of potential housing tax reforms. This is not the place to enter a lengthy description of the complicated 1986 Tax Reform Act, especially since that reform does not particularly address the relative taxation of rental and owner housing. However, a brief discussion of the 1986 act will help put the housing simulations in perspective.

On the corporate side, we change the statutory rate from .46 to .34, eliminate the investment tax credit, and change depreciation allowances as shown in table 1 using procedures from Fullerton and Lyon (1988). On the personal side, the 1986 act eliminated the second-earner deduction, income averaging, the capital gains exclusion, state sales tax deductions, some IRAs, and other special credits and deductions. The personal exemption was increased to $2,000, the rates and brackets were overhauled, and provisions were added for the taxation of passive losses. The Treasury models all such changes carefully, and we are able to take advantage of their efforts by using regression coefficients to predict each household's new AGI after exemptions and itemizable deductions.

As before, we apply the new coefficients once, at the beginning, to the household's observed amount of each type of income and other characteristics. Marginal changes are then governed by equations (9).

TABLE 8

ELIMINATE MORTGAGE INTEREST DEDUCTION, STANDARD CASE: SIMULATED/BASE RATIOS FOR KEY VARIABLES

	Economic Income Groups (Thousands of 1983 Dollars)								
	0–5 (1)	5–10 (2)	10–20 (3)	20–30 (4)	30–50 (5)	50–100 (6)	100–200 (7)	200+ (8)	Total (9)
Economic income	.994	.993	.995	.997	.996	.995	.992	.994	.995
Asset holdings:									
Debt	1.254	−.530	.888	.940	1.081	1.086	1.020	1.010	1.015
Equity	1.111	1.092	1.094	1.100	1.096	1.084	1.023	1.006	1.031
Rental	1.261	1.197	1.152	1.129	1.083	1.033	.986	.969	1.021
Owner	1.034	1.021	.997	.976	.960	.956	.979	1.008	.974
Uses of income:									
Rent	.991	.992	.997	1.003	1.006	1.017	1.027	1.033	1.002
Corporate goods	.992	.991	.996	1.001	1.003	1.005	1.006	1.012	1.004
Standard deviation of consumption	1.033	1.029	1.011	1.000	.991	.991	.998	1.010	1.001
Tax paid	1.033	1.013	1.014	1.017	1.014	.998	.976	.967	.988
Marginal tax rate	.954	.858	.744	.662	.651	.724	.846	.904	.709
Real net returns:									
Debt	.915	.924	.989	1.112	1.276	1.595	2.447	3.939	1.079
Equity	1.002	1.007	1.035	1.075	1.112	1.144	1.123	1.090	1.064
Rental	.973	.982	1.022	1.078	1.127	1.146	1.097	1.051	1.063
Owner	.972	.973	.973	.973	.974	.973	.973	.972	.973
Fraction of group:									
Win	.708	.574	.539	.558	.514	.550	.650	.805	.558
Lose	.280	.400	.442	.426	.477	.445	.350	.192	.428
Draw	.012	.026	.019	.015	.009	.005	.000	.004	.014
Summary statistics:									
Homeowner probability	1.008	1.003	.997	.996	.998	.998	1.000	.998	.998
Equivalent variation*	−18	−54	−45	−32	−65	−40	293	4,646	30

*The average gain per household in 1983 dollars.

We also capture the phantom 33 percent rate bracket and the extent to which it depends on the number of exemptions.[17]

Table 5 indicates that the real interest rate falls from 5 to 3.7 percent, and the rates of return to equity and rental housing fall slightly. Corporate taxes increase, despite the lower statutory rate, primarily because of the repeal of the investment tax credit. The cost of capital increases only slightly because the lower equilibrium cost of funds offsets the higher taxes. The tax scalar indicates that all statutory rates must be scaled up by 14.7 percent in order to cover fixed government expenditures (despite the lower cost of government debt). That is, the 15 percent rate becomes about 17 percent, and the 28 percent rate becomes 32 percent. Still, however, table 9 shows that all groups' marginal tax rates are lower than they were before. The top group's marginal rate is 65 percent of its former value.

Whether the economy is open or closed in this model, results are similar in that untaxed households increase negative holdings of debt, whereas top-bracket taxpayers shift into holding debt (because rate reduction increases their net return from .001 to .009). The top-bracket group holds less rental housing by 34 percent, in a way similar to predictions of rental project models that use someone with a high tax rate as the "marginal investor." Other groups increase rental holdings, however, so the total falls by only 3 percent. Rents either rise slightly (open economy) or fall slightly (closed economy), but the equilibrium increase in the cost of rental housing is nowhere near the 12–30 percent predicted by partial equilibrium rental project models.[18]

In our model, the Tax Reform Act increases the number of homeowners at all income levels and by 2.2 percent overall. It increases owner housing by 2.4 percent. The substantial rate reduction increases utility most in the highest-income bracket and overall by an average of $339 per household. This efficiency gain results primarily from a reallocation of portfolios and risk bearing since it does not include changes in labor/leisure choices, compliance, or firms' asset

[17] Changes to income still can push any household into a different bracket; the new marginal tax rate is used in eqq. (9) to calculate new net rates of return. Also, we ensure that itemizable deductions include property taxes that correspond to the chosen value of an owner-occupied home. The choice of whether to itemize is endogenously determined at each set of trial price and asset vectors by comparing itemizable deductions to the appropriate standard deduction.

[18] See Burman, Neubig, and Wilson (1987). The conventional wisdom is that the 1986 act devastates rental housing via passive loss rules, longer depreciation lives, higher capital gains rates, and especially rate reduction, which raises the opportunity cost of funds for the high-bracket marginal investor. Here, however, that opportunity cost is affected by the large fall in the equilibrium interest rate, and there exist low-bracket investors for whom rental housing is relatively more attractive rather than less.

TABLE 9

TAX REFORM ACT OF 1986, STANDARD CASE: SIMULATED/BASE RATIOS FOR KEY VARIABLES

	ECONOMIC INCOME GROUPS (Thousands of 1983 Dollars)								
	0–5 (1)	5–10 (2)	10–20 (3)	20–30 (4)	30–50 (5)	50–100 (6)	100–200 (7)	200+ (8)	Total (9)
Economic income	.981	.977	.985	.992	.989	.982	.962	.938	.975
Asset holdings:									
Debt	1.857	−5.122	.202	−.349	.197	.698	1:130	1.574	.989
Equity	1.295	1.301	1.348	1.382	1.398	1.258	.985	.820	.978
Rental	1.950	1.837	1.667	1.472	1.271	1.095	.839	.664	.968
Owner	1.123	1.088	1.083	1.078	1.050	1.017	.968	.864	1.024
Uses of income:									
Rent	.961	.963	.940	.929	.908	.881	.915	1.082	.928
Corporate goods	.975	.972	.986	.993	.991	.987	.987	1.039	.997
Standard deviation of consumption	1.086	1.076	1.054	1.041	1.020	1.001	.963	.913	.989
Tax paid	.610	.827	.939	.970	.985	.979	.927	.806	.905
Marginal tax rate	.797	.901	.954	.937	.905	.858	.781	.653	.893
Real net returns:									
Debt	.740	.736	.707	.687	.681	.719	1.620	11.187	.714
Equity	.972	.975	.977	.986	1.006	1.058	1.175	1.334	.998
Rental	.935	.932	.919	.912	.911	.916	.943	.998	.920
Owner	.935	.935	.930	.922	.908	.903	.916	.903	.920
Fraction of group:									
Win	.710	.603	.653	.676	.606	.427	.565	.745	.615
Lose	.285	.394	.344	.315	.386	.571	.435	.255	.380
Draw	.005	.002	.003	.009	.008	.002	.000	.000	.005
Summary statistics:									
Homeowner probability	1.048	1.028	1.031	1.026	1.018	1.011	1.005	1.002	1.022
Equivalent variation*	−49	−125	−55	30	−120	−454	309	30,392	339

*The average gain per household in 1983 dollars.

choices. This tax reform does not greatly affect the choice between renting and owning, so it is interesting that the overall equivalent variation is almost as large as that from the level treatment of housing. In the open-economy model, it is even larger.

X. Conclusion

The effects of taxes on tenure choices and housing stocks are complicated by nontaxation of imputed net rents of owners, depreciation allowances for landlords, relative taxation of corporate capital, deductions for property taxes, deductions for nominal interest paid, a graduated personal rate structure, diversity of household preferences, the constraint of consuming as much owner housing as is invested, and general equilibrium feedback effects on relative rates of return. This paper describes the first attempt to address all these issues.

We use 3,578 individual households from the Survey of Consumer Finances, establish behavioral parameters for each, calculate marginal tax rates and taxes paid from detailed provisions of the tax code, and simulate the general equilibrium effects of changes in tax rules. The removal of implicit benefits to owner-occupied housing was found to decrease the stock of owner housing by only 3–6 percent because the "rate of return effect," which discourages owner housing, is largely offset by the "variance effect," which encourages owner housing by sharing the risk among owners who are otherwise unable to diversify. While high-bracket taxpayers shift out of owner housing, low-bracket groups buy more. The number of homeowners actually rises.

Partial reforms that affect only the deductibility of property taxes or mortgage interest affect incentives in the same direction but have much smaller efficiency gains because they do not allow the government to help spread risk. The Tax Reform Act of 1986 affects incentives in the opposite direction and increases owner housing relative to rental housing. Therefore the potential gains from taxing owner housing are, if anything, larger in the current context than in the 1983 benchmark used here. Finally, we note that demographic characteristics are primary determinants of tenure choice, whereas tax factors help determine the size of each owner-occupied house.

Appendix

Sources for Selected Parameters

For residential property, King and Fullerton (1984) estimate a state and local property tax rate of 1.8 percent. For the corporate sector, they estimate .5 for the debt/equity ratio. They also discuss taxation of retained earnings and capital gains. The fraction of equity investment financed by retained earnings compared to new share issues is observable, but the parameter e represents the fraction for marginal equity and is inherently unobservable. We use .5 for this parameter in order to be consistent with other studies that apply a capital gains rate and a dividend tax rate to equal fractions of corporate earnings. King and Fullerton derive an effective accrued capital gains rate that is about half the statutory rate on realizations, so the 60 percent exclusion in 1983 implies that the effective rate is always 20 percent of the household's full marginal rate. That is, $f = .2$ and $g = f\tau$.

The four types of real corporate investment are listed in panel B of table 1 with information from Fullerton and Lyon (1988). Column 1 provides weights for the five assets. The investment tax credit is 10 percent for equipment in 1983 and zero for all other assets. Economic depreciation rates d vary from zero to 21.5 percent. To measure the effect of accelerated depreciation allowances, Fullerton and Lyon convert complicated actual allowances into exponential rates d' that have the same present value when discounted at a nominal after-tax interest rate to account for inflation. The discount rate for the firm is $r_D = (r_D^* + \pi)(1 - u)$, and the present value of allowances for each asset is just $z = d'/(d' + r_D)$. The table indicates that allowances for equipment are most accelerated, but intangible assets are deducted immediately ($z = 1$).

Using these parameters for the 1983 tax law in equations (8) provides .1059 for r_C, the required pretax return or cost of capital in the corporate sector. To calculate total capital used in the corporate sector, K_C, we add over all households' corporate equity, multiply by .5 to get corporate debt, and sum. Corporate expenditures on capital are $r_C K_C$. We add over all households' labor income and multiply by $1 + t_{ss}$ to get wL, corporate expenditures on labor. The share ρ is then $r_C K_C/(wL + r_C K_C)$. Finally, for the corporate sector, we define a unit of output to cost one dollar. Zero excess profits imply that $C = r_C K_C + wL$, and the production function in equation (6) implies that the scale parameter ϕ must be calculated as $(r_C K_C + wL)/K_C^{\rho} L^{1-\rho}$.

Finally, panel C of table 1 shows the variance-covariance matrix, Σ. Debt is assumed to be riskless. A series of real returns from equity was compiled from Ibbotson and Siegel (1983) and used to calculate a stock market variance for 1960–80. The resulting value of 252.03 was used as the expected variance of equity returns. The use of the variance of the index as the variance for an individual's equity investment assumes that individuals all hold a diversified "market" portfolio. Although this may be a good assumption for stocks, it is not reasonable to assume perfect diversification for real estate investments. Rental real estate can be diversified through the use of partnerships and real estate funds, but most rental properties still are individually held.

The variances of real estate returns are calculated using several data sources. A national series of owner-occupied housing prices for 1960–86 was computed using the constant quality structures index (mostly single-family houses, from the Bureau of the Census, ser. C-27). This index has a 2.57 percent per year standard deviation. A hedonic price series for owner-occupied housing in 22 cities for 1974–83 was taken from Pollakowski (1991). This series was used to create an estimate of regional variability around the national average. The regional standard deviation of owner-occupied prices calculated from this index was 4.95 percent. Another data source is used for the additional variability of individual house prices around the regional level. Case and Shiller (1989) compute price indices for four areas, looking at actual sales data. The data suggest that the intraregional standard deviation of housing prices is about 6 percent. The total variance of owner-occupied housing is the sum of national, regional, and intraregional effects. The sum of variances is 67.1, shown in panel C of table 1, for a standard deviation of 8.26 percent per year.

Rental housing presumably shares some price risk with owner-occupied housing, but it has two additional effects. On the one hand, landlords may be able to diversify to some degree. On the other hand, they face additional risk from vacancies or tenant-specific depreciation. In the absence of any good information about these effects, we assume that they cancel at the regional and intraregional levels. Thus, for the subnational components of rental housing variability, we use the same figures as those for owner-occupied housing. The national variability of rental returns was computed from the U.S. residential real estate investment data of Ibbotson and Seigel. The total variance of 66.7 is close to that of owner-occupied housing.

Covariance terms in table 1 are calculated using the data series from stock returns, residential real estate, and the constant quality structures index. We assume that regional variations of owner-occupied and rental housing are perfectly correlated. The overall correlation coefficient is .39, so the covariance is 26.2. The measured correlation of stock returns and rental housing is .096, and the correlation of stock and owner housing is .047.

Finally, we deal here with the value of defined benefit pension plans. We use survey responses about expected future pension benefits to measure implied pension wealth. Vested benefits are discounted at real rates until retirement and then at nominal rates until an assumed date of death. A similar calculation is performed for pension benefits currently being received. Social security wealth is ignored since social security is treated as a pure tax and transfer plan.

The defined benefit pension wealth must then be allocated between debt and equity. One approach would look at the relative holdings of actual corporate pension funds, but this information is irrelevant to the portfolio problem of a household that is promised future pension benefits. The household may perceive some riskiness about this promise, but the degree is somewhat arbitrary. It may depend on the performance of the fund, the riskiness of the firm, and the ordering of claims. For this reason, we treat 20 percent of this wealth as equity and 80 percent as debt. All income from pension wealth is tax-free. Because the model has only one time period and no net saving, the household is assumed to recognize and spend all such income in the current period.

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