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A GENERAL EQUILIBRIUM MODEL OF HOUSING, TAXES, AND PORTFOLIO CHOICE

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ABSTRACT

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 as 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.

A simulation of taxes on owner housing raises welfare not only by re-allocating capital, but also because government takes part of the risk from individual properties and diversifies it away. Measures to disallow property tax or mortgage interest deductions do not help share this risk. Simulations of actual tax reform indicate a small shift from rental to owner housing, and welfare gains from re-allocating risk.

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1. Introduction

Government has no single policy toward housing. Rather, it affects the equilibrium amounts of owner-occupied and rental housing through an amalgam of policies such as: direct subsidies for low-income housing, deductions allowed under the personal income tax, the progressive personal rate structure, the relative taxation of other goods and assets, and the effect of monetary policy on interest rates. Of particular interest have been the effects of tax rules on the residential capital stock and tenure choice, that is, whether to own or rent.

Personal tax rules favor owner housing by exempting the imputed net rental income. Tax rules also have favored rental housing to some extent through accelerated depreciation allowances. An important indirect benefit to housing capital is the additional corporate tax on other uses of capital. 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 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 non-negative 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 2x2x2=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.

We do not attempt to review the many previous studies that have addressed these issues, as excellent recent reviews are available in Rosen (1985), Olsen (1987), and Smith, Rosen and Fallis (1988). However, it is important to point out the unique features of our model. The current paper makes four contributions relative to existing literature.

First, some of the existing literature treats owner-occupied and rental housing as consumption goods whose relative prices are affected by tax rules (e.g. King, 1980, or Rosen and Rosen, 1980). Other papers treat housing as an investment whose relative return is affected by tax rules (e.g., Feldstein, 1980, Summers, 1981, or Poterba, 1984). None of this literature considers housing as both consumption and investment.[1] In our model, both the consumption decision and investment decision are part of utility maximization where the owning household is constrained to consume the same amount of housing as it has in its portfolio. Given this constraint, the model searches for the quantity of owner-occupied housing that maximizes utility. It then calculates utility for the same household as a renter and compares the two. It also compares utility with and without holding each of the other risky assets.

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

[1] Exceptions are the theoretical model of Henderson and Ioannides (1983), and the simulation model of Hendershott and Won (1989).

the 1983 Survey of Consumer Finances, weighted to represent the U.S. economy.[2] 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 8 different asset holding regimes. For each trial price vector we therefore evaluate the supplies and demands of 28,624 household types.

Third, some of the existing literature estimates parameters econometrically to perform partial equilibrium simulations of policy changes (e.g. King, 1983). General equilibrium efforts typically 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. Here, we push forward the integration of these techniques. Econometric methods are used to estimate important tax parameters, to estimate some consumer preference parameters, and to estimate a logit model used to calculate probabilities that a household falls into each of the 8 regimes. Overall consistency is still ensured by calibration for other parameters.

Fourth, all models necessarily abstract from many of the complicated features of tax law,[3] but the detail here is extreme. The corporate sector has asset-specific depreciation rules, nominal interest deductions, a 46 percent statutory rate in our base year (1983), and a ten percent credit for equipment. In the household sector, regression

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[2] 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.

[3] 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, Shoven, and Whalley, 1983).

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 take the standard deduction, and remaining taxable income is applied to the statutory rate schedule 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, so the tax function is evaluated for each regime of each household at each trial price vector.[4]

Despite these contributions, limitations remain. Transfers are lump sum, as we do not model direct housing subsidies. We concentrate on the allocation of capital among asset types, with no intertemporal framework that could allow a change in the total stock of capital. There are no capital market imperfections, and only stylized international capital flows that can affect domestic rates of return. We do not separately consider tax-free municipal debt. The equilibrium wage is endogenous, but labor supply is fixed. The model assumes perfect competition, no externalities, and constant returns to scale with zero excess profits.

The next section explains the household sector in some detail, and it is followed by briefer descriptions of the production sector, tax calculations, parameter estimation, the government sector, equilibrium conditions, and the data used. 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

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[4] Other models may contain some, but not all, of these four important features. For example, Hendershott and Won (1989) 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.

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. We also simulate the effects of more practical reforms such as removal of deductions for property taxes or for mortgage interest paid. Finally, we simulate the effects of the Tax Reform Act of 1986.

Our results emphasize the special features of our model. First, we show very disaggregate results where households in different situations have different incentives. 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 while low-bracket groups want more. The overall outcome depends on relative numbers and wealth. In our model, full taxation of owner housing would only reduce its total quantity by 3 to 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 that levels the playing field between owner and rental housing. 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 undiversifiable risk of owners' individual returns. This welfare effect has not been previously noted.

Third, partial measures that disallow deductions for property taxes or for payments of mortgage interest 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.

2. The Household Sector

We wish to specify utility as a function of housing services, H, expected consumption, C, and the vector of asset holdings, A. This vector consists of debt holdings, D, corporate equity, E, rental property, R, and owner-occupied housing, OH. There is no saving, and wealth is fixed. Following Slemrod (1982), we can use a simple Cobb-Douglas combination of C and H together with a negative term for risk:

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

All of 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 stock holdings. The variance of income is $\sigma^2 = A'\sum A$, where $\sum$ is the after-tax variance-covariance matrix of asset returns. 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 when 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 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 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 A = (D, E, R, OH) is effectively augmented by (E_G, R_G, O_G), to reflect the ownership of 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.

A second implementation problem is that many households hold rental property in amounts that would not be predicted by a strict portfolio model. Possible explanations are that individuals have special cost advantages, 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.

The third 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 asset, there are 8 asset combinations or "regimes." The term δ_i represents transactions cost or other reason 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:

$$\max_{i=1,8} \left[\max_{C_i,H_i,A_i} [\, U_i(C_i,H_i,A_i) + \delta_i] \right] \qquad (2)$$

subject to budget constraints (suppressing the index for regimes):

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

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

where Y is income, $\bar{Y}$ is after-tax labor income and transfers, 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. The household has fixed labor, L, that earns the equilibrium wage, w. The vector 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.

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 first order conditions:

$$\frac{\partial U}{\partial H} = 0 = (1-\alpha)(C/H)^{\alpha} - P_H\alpha(C/H)^{(\alpha-1)} \tag{4a}$$

$$\frac{\partial U}{\partial E} = 0 = \alpha(C/H)^{(\alpha-1)}(r_E-r_D) - 2\beta[\sum_{EE}E+\sum_{ER}\gamma R+Z_E] \tag{4b}$$

$$\frac{\partial U}{\partial R} = 0 = \alpha(C/H)^{(\alpha-1)}(r_R-r_D) - 2\beta\gamma[\sum_{RE}E+\sum_{RR}\gamma R+Z_R] \tag{4c}$$

where $\sum_{ij}$ refers to the ij^{th} element of the variance-covariance matrix, and where $Z_i = \sum_{iE_G}E_G + \sum_{iR_G}R_G + \sum_{iO_G}O_G$ (for i = E, R) refer to risk returned by 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 where E and/or R are 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:

$$\frac{\partial U}{\partial H} = 0 = (1-\alpha)(C/H)^{\alpha} - (P_H+r_D-r_O)\alpha(C/H)^{(\alpha-1)} - 2\beta[\sum_{OE}E+\sum_{OR}\gamma R+\sum_{OO}H+Z_O] \tag{5a}$$

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

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

where $Z_i = \sum_{iE_G}E_G + \sum_{iR_G}R_G + \sum_{iO_G}O_G$, for i = E, R, O. This non-linear

set of equations does not have a simple analytical solution, but it can be solved numerically given specific parameter values. Thus we iterate for the utility maximizing amount of housing for each of the four owner regimes, for each household, for each trial price vector.

3. The Production Sector

One unit of rental housing services is produced from one unit of capital allocated to R, just as owner housing services are produced from OH. The corporate output is produced competitively 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 which 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.

4. Taxation

The model includes a social security tax, a personal income tax, and a corporate income tax. The first of these is by far 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. Following Hall and Jorgenson (1967), the cost of capital or pretax rate of return is then:

$$r_C = (r_C^*+d)(1-k-uz)/(1-u) - d \qquad (8a)$$

where

$$r_C^* = [(r_E^*+\pi) + b(r_D^*+\pi)(1-u)]/(1+b) - \pi \quad . \qquad (8b)$$

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 2 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. Using 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 these 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 starts with 195,000 tax returns for 1983, exactly matches social security numbers for some additional information about those households, and statistically matches each household with observations in other data sets in order to assign non-tax data such as house value, rent paid, and asset holdings. They impute missing data such as itemizable deductions for nonitemizers. The Treasury's Office of Tax Analysis was willing to help us take advantage of their merges and imputations by running some regressions on their file using right-hand

variables that are also available in our survey. In all, twenty variables were determined to appear in both files.[5] Using their full sample, 24 separate OLS regressions were used: to "predict" adjusted gross income (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 twenty 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:

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

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

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

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

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

Of corporate equity, in (9b), a fraction e is financed by retained

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[5] These include wages and salaries, business income, non-taxed income, interest, dividends, capital gains, rental income, various transfers, pensions, age, sex, number of dependents, IRA and Keogh accounts, mortgage and other interest paid, and rent paid or house value.

earnings. The return on these investments is received as capital gains subject to rate g, a fraction of r 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^*. The investor receives nominal riskfree depreciation allowances that are discounted at the nominal riskfree 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:

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

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 yields an expression much like that for corporations in (8a) above. We then solve for the net return to obtain equation (9c).[6]

Finally, for owner-occupied housing, the rental return r_O^* is not taxed, while maintenance and depreciation are not deducted. Property taxes are deductible if the homeowner is an itemizer, as indicated when

[6] 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. Rather than enter the debate about the tax advantages of "churning," 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 equations (9c) or (10).

the dummy variable I is equal to one.[7]

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 is multiplied by $[e(1-g)+(1-e)(1-\tau)]$. Each row and each column involving rental housing is multiplied by $(1-\tau)/(1-\tau z)$ as in (9c). For owner housing, neither returns nor variances are 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).

5. Parameter Selection and Estimation

A number of parameters must be chosen to represent the base year,

[7] 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.

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, while the Appendix provides sources and discussion of our procedures.

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, where 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 using New York Stock Exchange data for 1960-1986 presented in Ibbotson and Siegel (1983). 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 Ibottson and Siegel.

The social security tax is ten 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 ten percent investment tax credit for equipment. These and other tax parameters are described in the Appendix.

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. Equity investors are assumed to diversify fully, as described in the Appendix, but housing investors do not. Certainly owner-occupants must hold a single investment in a single region of the country.[8]

Finally, the variances of government holdings of assets through tax receipts are calculated from the variance-covariance matrix of the underlying equity and real estate investments. Government cannot further diversify equity, so that 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 and can be reduced by pooling across individuals. We assume the government can diversify away all regional and intra-regional variation, leaving only the national component. When we simulate the effects of a tax on owner-housing like that on rental housing, we again assume that subnational risk is diversified and only national-level risk is returned through O_G.

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 consumer 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 $\sum$. For households 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

[8] We recognize that homeowners can in principle 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.

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 and/or γ were estimated using regressions on other household characteristics over the households where β and γ were identified. The value of α is always obtainable from observed C and H in (4a) or (5a).

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.

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 faces a set of 8 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 say that 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 logit analysis.

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.

6. The Government Sector and Equilibrium Conditions

We provide a simple treatment of government to help close the model in a way that ensures 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 model is 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 sample is less than the total initial consumption demand for rental housing. Thus we assign the difference to a government holding of rental housing that is then held fixed across all simulations. Government has no owner housing.

The government receives initial levels of revenue from social security taxes, corporate taxes, personal taxes, and from the market return on their holdings of rental housing. They must pay interest on their use of debt at the market rate, and they make 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.

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. With any change in tax rules, however, government revenue would change. We then abstract from the effects of public deficits or spending changes by assuming that government scales some other tax parameter so as to be able to meet all initial demand levels with a balanced budget. In results below, all personal rates and the statutory corporate rate are multiplied by the same scalar. This scalar must be determined endogenously along with rates of return to each asset.

Government risks (E_G, R_G, O_G) also act like prices in the sense that they must be known for households to set their portfolios, and yet are determined by aggregate portfolios. Thus the search for an equilibrium iterates on seven endogenous "prices": the market return to debt r_D^*, the market return to equity r_E^*, the rental rate for housing (used for both r_R^* and r_O^*), the tax scalar, and the three government risks (E_G, R_G, O_G). We then use equation (9) to solve for net rates of return to each household, equation (8) to obtain the cost of corporate capital, (7a) for corporate capital demand, and (7b) to solve for the wage. Next we calculate asset demands and housing consumption in each of the 8 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.[9]

Equilibrium is attained when the net supply of debt by households matches demand by corporations and government, the supply of equity by households matches the demand by corporations, the supply of rental

[9] The evaluation of aggregate demands takes about an hour of CPU 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 x 5 = 40 hours of CPU. In the simulations with no mortgage interest deductions, the kink in the budget constraint requires multiple evaluations and can take over 100 hours.

housing by households and government matches the demand by households, government revenue matches expenditures, and risks received from government match the amounts generated by taxation of household portfolios. The calculations ensure that each household's demand equals its own supply of owner housing, and Walras' Law ensures demand equals supply for corporate output. In addition to this closed economy model, we provide results for a stylized open economy model described below.

7. Data

The data for this analysis comes from the 1983 Survey of Consumer Finances (SCF). This survey contains asset 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.

Due to 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 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.[10] 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 is impossible to display fully, but it is summarized in Table 2.[11] 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

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[10] 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.

[11] 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 2. This allocation represents the starting point for any simulation.

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 SCF, 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 5.1 percent of households have 0.2 percent of wealth, while the top 1.5 percent of households have 31.0 percent of wealth.

The next three rows of Table 2 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 2 then shows rent paid and the consumption of the corporate output, averaged over all households in each group. The standard deviation of consumption (SD cons) indicates the overall riskiness of the group's portfolio. The next row is the calculated tax paid, using Treasury coefficients and actual tax schedules. The marginal tax rate averages .004 for the first group, which means that most households are untaxed while 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 2, 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 7.2 percent. With taxes the net returns are given by equations (9), so the top income group gets only 4.5 percent on rental housing but 8.1 percent on owner housing. Because the 10 percent nominal interest rate is taxed by almost half, before subtracting 5 percent inflation, the net return to debt is near zero.

At the bottom of Table 2, "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 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 38 percent to 96 percent across the income groups, averaging 62 percent overall. These calculated percentages closely reflect actual homeownership characteristics.

8. Simulation Results

We consider four tax changes in this model, as summarized in Table 3. Each is discussed below. Tables with all new allocations are available, but it is easier to interpret tables indicating the change in household decisions. Using the average of households in each income group, Tables 4-7 show the ratios of key variables in each simulation to

their values in the initial equilibrium.

In the closed economy, with no international capital flows, the equilibrium interest rate depends upon changes in both demand and supply of debt. In the middle panel of Table 3, we also perform 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 somewhat stylized, as debt is perfectly mobile while equity and housing must still be owned domestically. In the third panel of Table 3, we test the sensitivity of results to a respecification in which the benchmark equilibrium gross return to housing is not 11 percent but 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.

First, 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 while 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 particular reason to owner-occupy, but the estimated δ_i terms imply that some households have a preference for owning their own home.

Table 3 shows that this "level" treatment of housing raises much extra tax revenue and allows all statutory rates to be scaled down by 10 percent. 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 3 indicate that this general pattern is repeated in the open economy model and when the risk premium for housing is greater.

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, Rosen, and Holtz-Eakin, 1984). The combined effect depends on the individual's risk aversion and tax rate, as seen in the more detailed results of Table 4.

To see the effects of the marginal tax rate most clearly, 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 their marginal tax rate falls to .443, their real net interest rate doubles to .002, calculated as (.043+.05)(1-.443)-.05. Their net return to owner housing falls to 64 percent of its former value. This group is induced to increase their supply of debt 28 percent, as shown at the top of that column. It is their overall wealth which leads to the increase in the aggregate supply of debt that drives down the market interest rate.

Table 4 also shows that this bracket holds 23 percent less owner housing (even though they are constrained to purchase 23 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) only reduces their probability of owning by 0.1 percent. This result highlights the importance of separating tenure

choice from the amount of owner-occupied housing. The logit model implies that the tenure decision 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, 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 bracket is untaxed, their real net interest rate falls from 5 to 4.3 percent. Their ratio of new debt holdings to old debt holdings is 1.285, which indicates that they increase their negative position (from -$1,114 to -$1,431 per household). They buy more equity and rental housing, and since they are unaffected by the taxation of owner housing, they also buy 4 percent more owner housing. Their probability of owning only increases by .8 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 4 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 of 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.[12] Table 4 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 .8999 (from Table 3), the top-bracket rate changes from .492 to .443 while the bottom-bracket rate of zero is unaffected.

The bottom-right entry indicates, however, that the average household in the economy would gain by $380 per year. This "efficiency gain" is 1.05 percent of the average household's economic income ($36,276, in Table 2). 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 (SD cons) 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

[12] The reported equivalent variations are based on the logit formula, where the interpretation is that 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, where the interpretation is that each household really represents many households in the U.S. economy that actually enter all eight regimes in proportions given by the probabilities. Differences can arise because, while relative utility affects the regime chosen, households do not necessarily choose the regime with the highest utility. However, the alternative equivalent variations are always very close to the reported ones.

government to pool the risk of owners who are inherently unable to diversify. This result highlights the importance of treating owner 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 where all of 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 .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 4 are interesting. 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 ten 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 case indicate a similar pattern.

Finally in Table 4, we show effects on "horizontal equity" within each group, that is, the fraction of households with an equivalent variation that is more that $1, (win), less than -$1 (lose), or in between (draw). Although the lowest two income groups have negative average equivalent variations, over sixty percent of these households still gain. And although the highest income group has a huge positive average gain, 20 percent of those households still lose. These results highlight the importance of maintaining sample diversity.

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 3 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 $87, much smaller than the $380 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 $87 is only the standard Harberger efficiency gain from increasing the tax on an untaxed asset.

Table 5 shows more detailed results, where again high-bracket households shift out of housing and into holding debt. They gain an average of $5,363, primarily via tax rate reduction. The lowest-income bracket again experiences a lower cost of borrowing and increases their 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, due to the importance of owner housing in their portfolios. The percentages of winners and losers reflect the relative numbers of owner-occupants in each group.

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 homogenous. 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 re-arrange their affairs in order to draw down any taxable debt holdings before borrowing at a non-deductible interest rate.

Table 3 indicates that this reform would have very little impact. It reduces the real interest rate only from .05 to .0493, and it raises only enough revenue to scale down marginal tax rates by 2.2 percent. The average equivalent variation is only $32 per household. Like 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, at a cost given by the after-tax interest rate, before borrowing at the market interest rate.

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, 1989).

Table 6 has more detailed results for this simulation, where the fifth row shows that no income group changes their holdings of owner housing in either direction by more than one percent. The first six income groups lose, on average, while 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 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 only be accomplished 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.

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 (TRA), 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 TRA eliminated the second-earner deduction, income averaging, the capital gains exclusion, state sales tax deductions, some individual retirement accounts, 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 adjusted gross income 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). We also capture the phantom 33 percent rate bracket and the extent to which it depends on the number of exemptions.[13]

Table 3 indicates that the real interest rate falls from 5 to 3.7 percent, while the rate 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 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 7 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, while top-bracket taxpayers shift into holding debt (because rate reduction increases their net return from .001 to .009). The top-bracket

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[13] Changes to income still can push any household into a different bracket, where the new marginal tax rate is used in equations (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.

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 only falls by 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 to 30 percent predicted by partial equilibrium rental project models.[14]

In our model, the Tax Reform Act increases the number of homeowners at all income levels, and by 1.7 percent overall. It increases owner housing by 2 percent. The substantial rate reduction increases utility most in the highest income bracket, and overall by an average of $342 per household. This efficiency gain results primarily from a re-allocation of portfolios and risk-bearing, as it does not include changes in labor/leisure choices, compliance, or firms' asset 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.

9. 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

[14] 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 via 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.

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 of 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 to 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 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, while tax factors help determine the size of each owner-occupied house.

Table 1

Selected Parameter Values

Parameter		Value
r_D^*	real return to debt	.05
r_E^*	real return to equity	.12
r_R^*	real rental rate	.11
t_{ss}	social security tax rate	.10
t_p	property tax rate	.018
b	debt/equtiy 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
π	inflation rate	.05
ρ	capital share in production	.1182
ϕ	scale parameter in production	1.1996

corporate assets:

	weight	k	d	d'(83)	d'(86)
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	∞	∞

variance-covariance matrix, $\sum$:

	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

Table 2

Average Values of Key Variables by Group

Economic Income Groups($1983)	(1) 0-5K	(2) 5-10K	(3) 10-20K	(4) 20-30K	(5) 30-50K	(6) 50-100K	(7) 100-200K	(8) 200K+	(9) Total
Number	169	416	788	613	743	406	153	290	3578
Weighted Num	4077.	10119.	19205.	15195.	18446.	9806.	1854.	1160.	79862.
Wealth	3080.	11822.	28751.	40693.	67654.	136712.	477105.	1835725.	86472.
Types of Income									
Labor	599.	2325.	9155.	18668.	30086.	50091.	90008.	298399.	25603.
Transfers	2254.	3018.	2457.	1711.	1389.	1402.	3280.	4376.	2047.
Economic	3709.	7432.	14866.	24517.	38342.	65738.	134911.	471170.	36276.
Asset Holdings									
Debt	-1114.	236.	5745.	5549.	9875.	22821.	149940.	530263.	18679.
Equity	491.	1579.	2648.	3905.	5806.	13313.	76542.	695461.	16462.
Rental	316.	1167.	2538.	4347.	7428.	19283.	78633.	338523.	12429.
Owner	3386.	8840.	17818.	26890.	44540.	81289.	171973.	271395.	38898.
Uses of Income									
Rent	871.	1286.	1654.	1654.	1641.	1171.	893.	394.	1469.
Corp Good	2463.	5067.	10376.	17496.	26746.	43436.	77416.	261689.	23702.
(SD Cons)	1.	2.	3.	4.	7.	13.	33.	140.	8.
Tax Paid	3.	107.	874.	2407.	5051.	12182.	37678.	179192.	6822.
Marg Tax Rate	0.004	0.044	0.135	0.208	0.278	0.378	0.468	0.492	0.206
Real Net Returns									
Debt	0.050	0.046	0.036	0.029	0.022	0.012	0.003	0.001	0.029
Equity	0.120	0.114	0.103	0.093	0.085	0.072	0.060	0.057	0.094
Rental	0.071	0.070	0.066	0.063	0.061	0.057	0.053	0.052	0.063
Owner	0.072	0.072	0.072	0.073	0.075	0.078	0.080	0.081	0.074
Summary Stats									
Utility	4.568	8.131	14.505	20.873	30.384	46.147	80.940	180.301	25.906
Logit Sur	1.610	1.896	2.063	2.217	2.518	3.196	4.449	8.197	2.436
Home Prob	0.377	0.450	0.509	0.601	0.713	0.841	0.903	0.956	0.616

Table 3

Summary Simulation Results

A. Closed Economy	Base Values	Level Housing	No Pr. Tax Deduction	No Mort. Int. Deduction	1986 Law
r_D^*	.0500	.0429	.0450	.0493	.0367
r_E^*	.1200	.1238	.1214	.1209	.1166
r_R^*	.1100	.1057	.1076	.1087	.1053
r_C	.1059	.1040	.1042	.1059	.1072
Tax Scalar	1.0000	.8999	.9569	.9779	1.1430
Wage Rate	1.0000	1.0024	1.0022	1.0001	.9984
EV per Household ($)		380.	87.	32.	342.
Percentage with Gains (%)		72.	67.	52.	60.

B. Open Economy	Base Values	Level Housing	No Pr. Tax Deduction	No Mort. Int. Deduction	1986 Law
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
EV per Household ($)		503.	169.	42.	544.
Percentage with Gains (%)		81.	66.	59.	37.

C. Closed Economy Start with $r_R^* = .14$	Base Values	Level Housing	No Pr. Tax Deduction	No Mort. Int. Deduction	1986 Law
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
EV per Household ($)		382.	76.	6.	307.
Percentage with Gains (%)		70.	67.	54.	58.

Table 4
Tax Owner Like Rental, Level Housing (Closed Economy, r_R^*=.11)

Simulated/Base Ratios for Key Variables

Economic Income Groups($1983)	(1) 0-5K	(2) 5-10K	(3) 10-20K	(4) 20-30K	(5) 30-50K	(6) 50-100K	(7) 100-200K	(8) 200K+	(9) Total
Economic Incm	0.990	0.990	0.994	0.997	0.996	0.992	0.982	0.979	0.991
Asset Holdings									
Debt	1.285	-4.354	0.561	0.431	0.644	0.938	1.138	1.277	1.013
Equity	1.158	1.205	1.248	1.236	1.256	1.194	1.021	0.942	1.030
Rental	1.286	1.363	1.330	1.236	1.176	1.105	0.970	0.872	1.026
Owner	1.044	1.058	1.058	1.045	1.016	0.961	0.884	0.766	0.973
Uses of Income									
Rent	0.987	0.983	0.977	0.976	0.989	1.000	1.042	1.082	0.984
Corp Good	0.989	0.987	0.995	1.001	1.000	0.999	1.003	1.034	1.004
(SD Cons)	1.052	1.054	1.029	1.003	0.980	0.956	0.937	0.967	0.977
Tax Paid	0.935	0.974	0.971	0.974	0.996	1.019	1.004	0.940	0.978
Marg Tax Rate	1.043	1.045	0.970	0.938	0.948	0.940	0.920	0.900	0.947
Real Net Returns									
Debt	0.858	0.848	0.843	0.849	0.830	0.814	0.910	2.197	0.843
Equity	1.031	1.030	1.038	1.052	1.058	1.079	1.121	1.153	1.049
Rental	0.940	0.940	0.945	0.951	0.954	0.962	0.976	0.985	0.950
Owner	0.938	0.917	0.869	0.826	0.769	0.697	0.647	0.638	0.815
Fraction of Group									
Win	0.699	0.633	0.715	0.820	0.776	0.598	0.577	0.802	0.722
Lose	0.260	0.349	0.277	0.173	0.210	0.397	0.410	0.193	0.267
Draw	0.041	0.017	0.008	0.007	0.013	0.005	0.012	0.006	0.011
Summary Stats									
Home Prob	1.008	1.006	1.016	1.018	1.010	1.004	0.999	0.999	1.011
Equiv Var	-36.	-80.	66.	231.	292.	212.	811.	15142.	380.

Table 5

Eliminate Property Tax Deduction (Closed Economy, r_R^*=.11)

Simulated/Base Ratios for Key Variables

Economic Income Groups($1983)	(1) 0-5K	(2) 5-10K	(3) 10-20K	(4) 20-30K	(5) 30-50K	(6) 50-100K	(7) 100-200K	(8) 200K+	(9) Total
Economic Incm	0.993	0.992	0.995	0.998	0.996	0.994	0.988	0.990	0.994
Asset Holdings									
Debt	1.210	-1.798	0.799	0.720	0.867	1.044	1.083	1.102	1.012
Equity	1.103	1.107	1.120	1.117	1.125	1.088	1.020	0.992	1.027
Rental	1.265	1.205	1.142	1.108	1.067	1.033	0.975	0.951	1.010
Owner	1.029	1.028	1.027	1.023	1.002	0.965	0.930	0.883	0.980
Uses of Income									
Rent	0.989	0.987	0.984	0.984	0.985	0.993	1.030	1.040	0.986
Corp Good	0.992	0.991	0.998	1.003	1.003	1.002	1.003	1.016	1.004
(SD Cons)	1.032	1.033	1.026	1.020	1.010	0.998	0.989	0.999	1.006
Tax Paid	0.939	0.945	0.956	0.963	0.979	1.000	0.997	0.973	0.982
Marg Tax Rate	0.989	0.945	0.957	0.960	0.968	0.969	0.966	0.957	0.964
Real Net Returns									
Debt	0.899	0.899	0.896	0.890	0.874	0.835	0.636	0.317	0.888
Equity	1.012	1.014	1.019	1.024	1.027	1.035	1.049	1.063	1.023
Rental	0.966	0.968	0.971	0.974	0.975	0.979	0.985	0.989	0.973
Owner	0.966	0.965	0.959	0.947	0.919	0.883	0.863	0.858	0.935
Fraction of Group									
Win	0.683	0.600	0.676	0.813	0.716	0.473	0.403	0.655	0.670
Lose	0.265	0.371	0.307	0.183	0.271	0.503	0.597	0.345	0.313
Draw	0.052	0.029	0.017	0.005	0.013	0.024	0.000	0.000	0.017
Summary Stats									
Home Prob	1.006	1.005	1.010	1.011	1.008	1.003	0.999	0.999	1.007
Equiv Var	-24.	-60.	1.	84.	72.	-90.	-161.	5368.	87.

Table 6

Eliminate Mortgage Interest Deduction (Closed Economy, $r_R^* = .11$)

Simulated/Base Ratios for Key Variables

Economic Income Groups($1983)	(1) 0-5K	(2) 5-10K	(3) 10-20K	(4) 20-30K	(5) 30-50K	(6) 50-100K	(7) 100-200K	(8) 200K+	(9) Total
Economic Incm	0.999	0.998	0.999	1.000	0.999	0.998	0.996	0.996	0.998
Asset Holdings									
Debt	1.036	0.588	0.921	0.834	0.909	0.970	1.037	1.061	1.000
Equity	1.031	1.036	1.060	1.073	1.059	1.035	0.979	0.981	1.001
Rental	0.969	0.964	1.004	1.039	1.027	1.028	0.973	0.950	0.988
Owner	1.010	1.009	1.016	1.017	1.008	0.996	0.989	0.991	1.003
Uses of Income									
Rent	0.997	0.996	0.982	0.968	0.964	0.986	1.038	0.952	0.977
Corp Good	0.999	0.998	0.998	0.998	0.998	0.999	1.002	1.009	1.000
(SD Cons)	1.007	1.005	1.008	1.007	1.003	0.999	0.990	0.989	0.999
Tax Paid	1.098	1.065	1.033	1.026	1.020	1.007	0.992	0.981	0.999
Marg Tax Rate	1.106	1.045	1.002	1.000	1.000	0.989	0.981	0.978	0.997
Real Net Returns									
Debt	0.986	0.982	0.984	0.982	0.978	1.002	1.168	1.914	0.984
Equity	1.008	1.014	1.045	1.085	1.129	1.176	1.161	1.143	1.078
Rental	0.983	0.996	1.041	1.096	1.151	1.187	1.139	1.110	1.085
Owner	0.982	0.983	0.983	0.984	0.984	0.983	0.982	0.982	0.983
Fraction of Group									
Win	0.683	0.512	0.426	0.452	0.503	0.661	0.854	0.974	0.519
Lose	0.202	0.377	0.500	0.515	0.477	0.333	0.142	0.026	0.431
Draw	0.115	0.111	0.074	0.033	0.020	0.005	0.003	0.000	0.049
Summary Stats									
Home Prob	1.003	1.005	1.019	1.021	1.015	1.004	0.997	1.001	1.013
Equiv Var	-1.	-13.	-21.	-54.	-98.	-89.	342.	5161.	32.

Table 7

Tax Reform Act of 1986 (Closed Economy, r_R^*=.11)

Simulated/Base Ratios for Key Variables

Economic Income Groups($1983)	(1) 0-5K	(2) 5-10K	(3) 10-20K	(4) 20-30K	(5) 30-50K	(6) 50-100K	(7) 100-200K	(8) 200K+	(9) Total
Economic Incm	0.978	0.975	0.984	0.991	0.988	0.981	0.961	0.937	0.974
Asset Holdings									
Debt	1.603	-7.696	0.315	-0.011	0.346	0.710	1.129	1.519	0.991
Equity	1.254	1.289	1.343	1.379	1.396	1.257	0.981	0.821	0.980
Rental	1.862	1.779	1.635	1.466	1.261	1.095	0.845	0.661	0.970
Owner	1.081	1.077	1.079	1.078	1.050	1.017	0.967	0.867	1.022
Uses of Income									
Rent	0.966	0.958	0.941	0.933	0.913	0.890	0.924	1.083	0.930
Corp Good	0.973	0.972	0.985	0.992	0.990	0.987	0.989	1.043	0.997
(SD Cons)	1.063	1.068	1.052	1.040	1.021	1.003	0.964	0.915	0.990
Tax Paid	0.625	0.834	0.936	0.969	0.985	0.977	0.922	0.801	0.902
Marg Tax Rate	0.808	0.879	0.949	0.934	0.904	0.855	0.779	0.651	0.890
Real Net Returns									
Debt	0.734	0.730	0.700	0.679	0.670	0.710	1.587	11.022	0.707
Equity	0.973	0.977	0.979	0.988	1.008	1.062	1.178	1.338	1.000
Rental	0.934	0.931	0.918	0.912	0.911	0.917	0.944	0.998	0.919
Owner	0.934	0.934	0.929	0.921	0.907	0.901	0.915	0.902	0.919
Fraction of Group									
Win	0.682	0.597	0.646	0.661	0.593	0.423	0.565	0.745	0.604
Lose	0.300	0.396	0.343	0.326	0.398	0.570	0.435	0.255	0.386
Draw	0.018	0.007	0.011	0.014	0.009	0.007	0.000	0.000	0.010
Summary Stats									
Home Prob	1.022	1.016	1.023	1.023	1.017	1.010	1.004	1.001	1.017
Equiv Var	-56.	-134.	-58.	19.	-132.	-451.	416.	30860.	342.

Appendix: Sources for Selected Parameters

The rates of return to debt, equity, and housing are set at 5, 12, and 11 percent, respectively, as described in the text. The housing sectors require assumptions about maintenance, depreciation, and rental rates as percent of property values. Maintenance expenditures were set at one percent of value as were depreciation rates for rental and owner-occupied housing. The state and local property tax on residential property is 1.8 percent, as estimated by King and Fullerton (1984).

For the corporate sector, King and Fullerton (1984) provide .5 for the debt/equity ratio. They also discuss taxation of retained earnings and capital gains. We can observe the fraction of equity investment financed by retained earnings, compared to new share issues, 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 (1984) 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 $g = fr$.

The four types of real corporate investment are listed in Table 1 with information from Fullerton and Lyon (1988). The first column 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 implies 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, Table 1 shows the variance-covariance matrix, $\sum$. Debt is assumed to be riskless. A series of real returns from equity was compiled from Ibbotson and Siegel and used to calculate a stock market variance for 1960-1986. 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

1960-1986 was computed using the constant quality structures index (mostly single family houses, from the Bureau of the Census, Series 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 1974-1983 was taken from Pollakowski (1987). 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 (1988) compute price indices for four areas, looking at actual sales data, which suggest that the intra-regional standard deviation of housing prices is about 6 percent. The total variance of owner-occupied housing is the sum of national, regional, and intra-regional effects. The sum of variances is 67.1, shown in 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 intra-regional levels. Thus, for the subnational components of rental housing variability, we use the same figures as for owner-occupied housing. 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, as 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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