May, 1989

The General Equilibrium Effects of Inflation on Housing Consumption and Investment

James Berkovec, *University of Virginia*
Don Fullerton, *University of Illinois at Urbana-Champaign*

The General Equilibrium Effects of Inflation on Housing Consumption and Investment

By JAMES BERKOVEC AND DON FULLERTON*

Traditional models of housing and taxation find that inflation raises the cost of business capital, reduces the cost of homeownership, and shifts capital toward owner-occupied housing. Results from theoretical (Martin Feldstein, 1982) and econometric (Lawrence Summers, 1981) models suggest that inflation raises the net return to housing. In a general equilibrium model with multiple consumers, Patric Hendershott and Shen Cheng Hu (1983) simulate the amount of the shift toward housing. In a partial-equilibrium model with housing supply, James Poterba (1984) finds that a large fraction of housing price appreciation can be explained by its preferential tax treatment with inflation.

In general, the cost of business capital rises because of historical cost depreciation, FIFO inventory accounting, and the taxation of nominal capital gains. The cost of housing falls, essentially because nominal interest payments are deducted while capital gains are untaxed.

In this paper, we show that these conclusions do not necessarily hold. We use a very disaggregate general equilibrium model of household portfolio choice. Inflation does not raise the cost of business capital in this model, despite nominal depreciation and capital gains taxes, because the greater interest deductions at the 46 percent corporate rate outweigh the combined taxation of household nominal interest receipts. In the "open economy" model, where the real interest rate is fixed by international flows of debt, inflation actually reduces the net cost of funds and thus the corporate cost of capital. High tax brackets are still encouraged to own housing, but low brackets shift into bonds. Aggregate housing does *not* increase with inflation in this model.

The model assumes perfect markets in a single period with fixed labor, fixed wealth, constant returns to scale production, and no excess profits. It makes four important contributions, however. First, any owner-occupied housing in a portfolio is constrained to match that household's consumption of housing services in utility. Second, rather than rely on 10 or 20 "representative" consumers, we calculate preference parameters for each of 3,578 observations from the 1983 *Survey of Consumer Finances* and evaluate supplies and demands for each household at each trial price vector. Third, we integrate econometric estimation of parameters with calibration methods that insure overall consistency of the benchmark equilibrium. Fourth, we model the actual 1983 tax law including detailed provisions of the corporate tax system, estimation of each household's adjusted gross income, endogenous decisions to itemize deductions, determination of each household's tax bracket at each iteration, and calculation of tax paid from the schedule.

These contributions turn out to be important for our results. In the "closed economy" version of our model, inflation helps the poor by raising the real interest rate and hurts the rich by reducing their real after-tax

†*Discussants*: Roger H. Gordon, University of Michigan; Jonathan Eaton, University of Virginia; John B. Shoven, Stanford University.

*Department of Economics, University of Virginia, Charlottesville, VA 22901. This paper was written while Fullerton was an Olin Senior Fellow at the NBER. We are grateful for support from HUD grant H-5798RG, and for help from David Crowe, Roger Gordon, Jon Jones, Joon-Kyu Park, and Jon Skinner.

returns. The same relative effects appear in the open economy version. Also, tenure choice in our logit model is determined primarily by income and demographic factors, while the amount of housing is affected by taxes and relative returns. This distinction is important for an increase in the rate of inflation, because the greater number of households in low tax brackets causes a slight *decrease* in the total number of owner-occupants, while the greater wealth in high tax brackets leads to a slight *increase* in the total amount of owner housing.

I. The Model

Each household allocates its fixed wealth to a vector of assets A, including positive or negative riskless debt D and nonnegative amounts of risky corporate equity E, rental housing R, and owner housing OH. The vector of net returns is $r=(r_D, r_E, r_R, r_0)$. Following Joel Slemrod (1982) and Roger Gordon and Slemrod (1983), consumers maximize

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

using labor and capital income plus transfers minus taxes, where H is housing services, C is other (corporate) consumption, β is a parameter of risk aversion, and σ^2 is the variance of income. This variance is calculated from $A'\Sigma A$, where Σ is a prespecified variance-covariance matrix that is affected by taxes. Observed rental holdings do not follow a strict mean-variance framework, so we add a household specific intercept γ to rental holdings. Also, because the typical taxpayer holds only a subset of these assets, we consider the choice among eight "regimes," with and without holding each of the three risky assets. The household first chooses the best allocation of wealth and consumption within each regime, and then it chooses the regime with the highest overall utility:

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

subject to an income constraint on spending $C+P_H H$, a wealth constraint on A, and where δ_i represents transaction cost or other reason to neglect particular assets in regime i. Note that the choice among regimes includes the choice about whether to owner-occupy. First-order conditions are used to solve for demands in the four renter regimes, but the extra constraint that $H=OH$ prevents analytical solution in the four owner regimes. 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.

In the competitive corporate sector, output is produced according to

$$(3) \qquad C=\varphi K_C^{\rho}L^{1-\rho}+\mu,$$

where K_C is the sum of corporate equity and debt, in fixed proportions, L is total labor supply, and μ is a random element with mean zero. Given that L is fixed, we can solve for capital demand and the equilibrium wage.

Taxes include a flat 10 percent payroll tax on business use of labor, and a corporate tax at rate u (=.46) on income from five assets including equipment, structures, land, inventories, and intangibles. Each asset depreciates at exponential rate d and receives allowances with present value z. Following Robert Hall and Dale Jorgenson (1967), the cost of capital is

$$(4a) \qquad r_C=(r_C^*+d)(1-k-uz)/(1-u)-d$$

$$(4b) \qquad r_C^*=\left[(r_E^*+\pi)+b(r_D^*+\pi)(1-u)\right]/(1+b)-\pi$$

where k (=.1) is an investment tax credit for equipment, b (=.5) is the debt-equity ratio, π is the rate of inflation, r_E^* is the real return to equity, and r_D^* is the real market interest rate. Fullerton and Andrew Lyon (1988) provide parameter values as well as weights for the five assets.

The *Survey of Consumer Finances* provides much information on asset holdings, but no data on personal taxes. We found 20 income and demographic variables that appeared both in this survey and in the Treasury Department's individual tax file, an extensive elaboration of 195,000 actual tax returns that includes imputations for house value, rent paid, itemizable deductions of nonitemizers, and other information. The Treasury was able to run 24 ordinary least square regressions for us, using the 20 selected variables to predict adjusted gross income 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 Tax Reform Act of 1986. (See our 1988 paper for more detail on the model and the 1986 Act.)

For each household in our sample, we apply the Treasury coefficients to obtain AGI and itemizable deductions. The latter is compared to the standard deduction, and the remaining tax base is applied to the statutory rate brackets to determine the marginal rate τ and actual tax paid. The four real net rates of return for that household are then:

$$\text{(5a)} \quad r_D = (r_D^* + \pi)(1-\tau) - \pi$$

$$\text{(5b)} \quad r_E = (r_E^* + \pi)[e(1-g)+(1-e)(1-\tau)] - \pi$$

$$\text{(5c)} \quad r_R = [(r_R^* - m - t_p)(1-\tau) - \pi g]/(1-\tau z) - d$$

$$\text{(5d)} \quad r_0 = r_0^* - m - d - t_p(1 - I\tau)$$

where e ($=.5$) is the fraction of corporate earnings retained, g ($=.2\tau$) is the effective rate on accrued capital gains, m ($=.01$) is maintenance, and t_p ($=.018$) is property tax. For the landlord, rental income after maintenance and property taxes is subject to rate τ, while purely nominal capital gains are taxed at rate g. For the owner, imputed rents are untaxed, capital gains are untaxed, and property taxes are deducted by itemizers ($I=1$).

We use Treasury coefficients and all initial asset holdings for taxable income in the base case, but equations (5) govern changes in simulation. In the variance-covariance matrix, each row and each column involving equity is multiplied by $[e(1-g)+(1-e)(1-\tau)]$; those involving rental housing are multiplied by $(1-g)/(1-\tau z)$; and those for owner housing are unaffected by taxes. We use Newton's algorithm to solve for r_D^*, r_E^*, r_R^*, and a tax scalar used in the simulations to adjust marginal tax rates by just enough to keep all government activities fixed with a balanced budget. The rent r_R^* is also used for r_0^*, and the wage derives from equation (3).

The initial real interest rate and inflation rate are each set at 5 percent. Based on Roger Ibottson and Laurence Siegel (1983), we set the real return to equity at 12 percent. The assumed rent is 11 percent, yielding 7.2 percent after maintenance, depreciation, and property tax. Our 1988 paper provides the variance-covariance matrix and describes how each household's holdings are used to solve for its α, β, and γ. The δ_i are assumed to be functions of exogenous variables such as wealth, age, and household size. These parameters are estimated by a logit model which is used to predict regime probabilities for each household as a function of the exogenous variables and of U_i calculated from equation (1). These probabilities are then used in the simulations. That is, each household is weighted by regime probabilities as well as by corrected sample weights. The probabilities in the benchmark equilibrium aggregate to a 62 percent homeownership rate overall, with a range from 38 percent for households with incomes under \$5,000 per year to 89 percent for those over \$200,000 per year.

Finally, the government in this model collects taxes, provides lump sum transfers to each household, provides rental housing, uses debt, and buys some corporate output. Each of these amounts is fixed in the simulations. The government's rental housing is set as the original difference between household ownership and household demand; its debt is set as the original difference between household supply and corporate demand; its purchases are set as the original difference between tax revenue and other expenses.

II. Results

In the base case, untaxed households earn 10 percent nominal interest before 5 percent inflation, while top bracket households earn 5 percent after-tax before 5 percent inflation (for a zero real net return). Still, owner housing constitutes the largest asset for all income groups up to the top ($200,000/year) group, which holds more equity and rental housing.

Table 1 shows selected results from the closed economy model where the 5 percent inflation was changed to zero or 10 percent, with no other changes in parameters or tax rules. These simulations give some indication of the effects of inflation through a given tax system, and the zero inflation simulations indicate the effects of a policy change to complete indexation.

Most results are expressed as ratios of the simulated value to the base value, so the first row indicates that no inflation (or full indexation) would reduce the real interest rate received by untaxed households by 45 percent, and that an increase from 5 to 10 percent inflation would increase their real return by 57 percent. Since untaxed households receive the actual market returns which are shown at the bottom of the table, these percentages correspond to real interest rates of .0275, .05, and .0796, for inflation rates of zero, 5, and 10 percent, respectively. Since inflation increases the real return to debt without a big effect on other assets, it increases the capital income and utility of low-bracket households.

At the other end of the income scale, inflation reduces the real net interest rate from .014 at no inflation to −.010 at 10 percent inflation. The table shows that the real net rate of return for top-bracket households falls for all four assets (but it falls least for owner-occupied housing). Inflation reduces their capital income and utility. Thus the first general result we wish to emphasize is that moderate inflation seems to have a progressive effect in the redistribution of capital income. (The wage rate does not change very much, but we have not modeled other effects such as sticky wages, transfers, or prices.)

TABLE 1—NET RATES OF RETURN AND ASSET HOLDINGS, REPORTED AS RATIO TO THEIR VALUES IN THE BASE CASE (Closed Economy Model)

	Inflation Rates (Percent)		
	0	5	10
A. *Net Rates of Return*			
1. Zero Bracket			
Debt	0.552	1.0	1.574
Equity	1.026	1.0	0.975
Rental	1.039	1.0	0.989
Owner	1.037	1.0	0.995
2. Top Bracket			
Debt	+.014[a]	0.0[a]	−.010[a]
Equity	1.240	1.0	0.736
Rental	1.469	1.0	0.697
Owner	1.032	1.0	0.999
B. *Asset Holdings*			
1. Zero Bracket			
Debt	0.003	1.0	2.194
Equity	1.441	1.0	0.481
Rental	1.820	1.0	0.262
Owner	1.056	1.0	0.909
Homeowner Prob	1.017	1.0	0.959
2. Top Bracket			
Debt	1.628	1.0	0.313
Equity	1.012	1.0	0.981
Rental	0.742	1.0	1.277
Owner	0.894	1.0	1.146
Homeowner Prob	1.000	1.0	0.999
3. Total			
Debt	1.022	1.0	0.975
Equity	1.046	1.0	0.948
Rental	0.953	1.0	1.065
Owner	0.991	1.0	1.006
Homeowner Prob	1.003	1.0	0.979
C. *Market Prices*[a]			
r_D	.0275	.0500	.0796
r_E	.1229	.1200	.1177
r_R	.1126	.1100	.1097
r_C	.1029	.1059	.1095
Tax Scaler	1.0134	1.0000	1.0321
Wage Rate	1.0037	1.0000	.9957

[a]These results reported in levels, not ratios.

In the closed economy model, the effect of inflation on the nominal interest rate ($\partial i/\partial \pi$) must be greater than one in order to maintain a real after-tax interest rate. Empirical estimates suggest that interest rates rise only point-for-point with inflation, however. To capture this alternative, we model a stylized "open" economy where the real interest rate is fixed at 5 percent by international flows of debt (Ingemar Hansson and Charles Stuart, 1986). Equity and housing returns still vary, as they must be owned domestically. Our first result about the progressive effect of inflation is also clear in the open economy version of our model.

The bottom of the table for the closed economy indicates that inflation raises the corporate cost of capital (r_C) only slightly. We capture the effect of historical cost depreciation, but this effect was overestimated in models with only depreciable assets such as equipment and structures. The weight on these assets is reduced here by the addition of inventories, land, and intangibles. We use only LIFO inventory accounting, assuming that firms would minimize taxes, and we include the taxation of purely nominal capital gains. In this model, these tax-increasing effects of inflation are almost completely offset by the tax-reducing effect that nominal interest is deducted at the corporation's 46 percent rate and included by households at much lower rates. If firms were allowed to increase their debt-equity ratio, we might expect the cost of capital to fall. In the open economy model, fixed real interest rates mean that inflation actually reduces the cost of finance and cost of capital. Thus our second general point is that inflation does not necessarily raise the cost of business capital. It does not even increase the relative return to homeowning for low-tax brackets, although it does increase the relative return to homeowning for high-tax brackets.

The middle part of the table indicates that untaxed households nearly eliminate their interest bearing assets at no inflation, and double them at high inflation. Equity and rental holdings are reduced the most at high inflation. Because of the incentive to hold bonds, the number of homeowners in this bracket falls by 4 percent while the amount of owner housing falls by 9 percent. Thus low-income groups do not experience the incentive effect of inflation discussed for high-bracket groups in most of the literature. Whether inflation increases owner housing becomes an empirical question that depends on the relative number and wealth of households in each tax situation. It also becomes important to measure carefully the actual marginal tax rates they face.

Our model includes 3,578 weighted individual households, each with specific asset holdings, adjusted gross income, and marginal tax rate. We cannot show disaggregate results here, but the table shows the two extremes. In the 50 percent marginal rate bracket, when inflation reduces all real net returns *except* that of owner housing, households reduce bond holdings dramatically. They would like to switch most capital into owner housing as an asset, but they are constrained in this model to consume an equal amount of housing services. This constraint turns out to be important, because it limits the high-bracket shift into owner housing. Thus they add more rental housing to portfolios and increase owner housing by only 15 percent (when inflation increases to 10 percent). The next part of the table indicates that low and high tax brackets offset each other in such a way that none of the four assets change much in total. The third general point we wish to emphasize is that inflation does *not* increase the capital allocated to owner housing in this model. However, it does increase owner housing by 10 percent in the open economy version of our model.

Our estimation of the logit model reveals that households are more likely to shift in and out of equity or rental housing than they are to shift in and out of homeownership. As might be expected, income and demographic characteristics are the major determinants of tenure choice. The fourth main point of our paper, revealed in the table, is that taxes have a small effect on homeownership rates but more effect on housing per owner (but housing prices are held fixed in this model). This distinction is missed by Harvey Rosen and Kenneth Rosen (1980) and others who estimate the effect of relative price changes on homeownership rates only.

Finally, our model emphasizes the importance of using individual households and their separate amounts of wealth. When inflation increases from 5 to 10 percent, low-bracket households shift out of owner housing while high-bracket households shift into owner housing. The sheer number of low-bracket households causes a *decrease* in the total number of owners, while the wealth of the high-bracket households leads to a slight *increase* in the amount of owner housing.

REFERENCES

Berkovec, James and Fullerton, Don, "A General Equilibrium Model of Housing, Taxes, and Portfolio Choice," mimeo., 1988.

Feldstein, Martin, "Inflation, Tax Rules, and the Accumulation of Residential and Nonresidential Capital," *Scandinavian Journal of Economics*, No. 2, 1982, *84*, 293–311.

Fullerton, Don and Lyon, Andrew B., "Tax Neutrality and Intangible Capital," *Tax Policy and the Economy*, 1988, *2*, 63–88.

Gordon, Roger and Slemrod, Joel, "A General Equilibrium Simulation Study of Subsidies to Municipal Expenditures," *Journal of Finance*, May 1983, *38*, 585–94.

Hall, Robert and Jorgenson, Dale W., "Tax Policy and Investment Behavior," *American Economic Review*, June 1967, *57*, 391–414.

Hansson, Ingemar and Stuart, Charles, "The Fisher Hypothesis and International Capital Markets," *Journal of Political Economy*, December 1986, *94*, 1330–37.

Hendershott, Patric H. and Hu, Shen Cheng, "The Allocation of Capital Between Residential and Nonresidential Uses: Taxes, Inflation and Capital Market Constraints," *Journal of Finance*, June 1983, *38*, 795–812.

Ibbotson, Roger G. and Siegel, Laurence, "The World Market Wealth Portfolio," *Journal of Portfolio Management*, Winter 1983, *9*, 5–17.

Poterba, James M., "Tax Subsidies to Owner-Occupied Housing: An Asset-Market Approach," *Quarterly Journal of Economics*, November 1984, *94*, 729–52.

Rosen, Harvey S. and Rosen, Kenneth T., "Federal Taxes and Homeownership: Evidence from Time Series," *Journal of Political Economy*, February 1980, *88*, 59–75.

Slemrod, Joel, "Tax Effects on the Allocation of Capital Among Sectors and Among Individuals: A Portfolio Approach," NBER Working Paper No. 951, 1982.

Summers, Lawrence H., "Inflation, the Stock Market, and Owner-Occupied Housing," *American Economic Review Proceeding*, May 1981, *71*, 429–34.