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TAX SUBSIDIES TO OWNER-OCCUPIED HOUSING: AN ASSET-MARKET APPROACH*

JAMES M. POTERBA

Inflation reduces the effective cost of homeownership and raises the tax subsidy to owner occupation. This paper presents an asset-market model of the housing market and estimates how changes in the expected inflation rate affect the real price of houses and the equilibrium size of the housing capital stock. Simulation results suggest that the accelerating inflation of the 1970s, which substantially reduced homeowners' user costs, could have accounted for as much as a 30 percent increase in real house prices. Persistent high inflation rates could lead ultimately to a sizable increase in the stock of owner-occupied housing.

During the housing boom of the 1970s, the real price of owner-occupied houses rose by 30 percent. The rate of new construction activity reached record-breaking highs in 1977 and 1978, before the credit crunch of 1979 curtailed new starts. While it is impossible to isolate a single "cause" of the boom, the coincidence of high inflation rates and the tax deductibility of nominal mortgage payments was one factor that made homeownership more attractive. Rising inflation rates push up nominal interest rates, increasing the homeowner's interest charges, and lead to large nominal capital gains on houses. Because of the tax system, however, an increase in the inflation rate reduces the real cost of homeownership. Homeowners are permitted to deduct mortgage interest payments from their taxable income, and under current law imputed rental income is not taxed. A variety of tax provisions, such as exemption of housing capital gains for the elderly, make capital gains from homeownership essentially untaxed. Owner occupants therefore gain on balance: while receiving the full value of their home's appreciation, they bear only a fraction of the higher interest payments.

Many studies have documented the recent decline in homeownership costs.¹ The effective cost of owner-occupation was ac-

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1. Examples include Diamond [1980], Dougherty and Van Order [1982], Viliani [1981], Hendershott and Hu [1981], Hendershott and Shilling [1981], and Hendershott [1980], among others. DeLeeuw and Ozanne [1979] use a present-value-of-investment approach in studying the same effects.

tually negative during the 1970s for some high tax bracket individuals. Surprisingly, the consequences of this sharp user cost decline have received little attention.² In this paper I develop and estimate an asset-market model of the owner-occupied housing market. The model can be used to analyze the impact of inflation and tax policy on the relative price of houses and on the size of the housing capital stock. My goal is to measure both the long- and the short-run consequences of a user cost change similar to that caused by inflation rates in the last decade.

A rational home buyer should equate the price of a house with the present discounted value of its future service stream. The value of future services, however, will depend upon the evolution of the housing stock, since the marginal value of a unit of housing services declines as the housing stock expands. The immediate change in house prices depends upon the entire expected future path of construction activity. As often happens in asset-market models, only one set of expectations is consistent with the eventual return to a steady state. The assumption that the buyers and sellers of houses possess perfect foresight ties the economy to this stable transition path and makes it possible to calculate the short-run change in house prices which results from a user cost shock.

I should emphasize at the outset that my study focuses on the price of housing *structures*, not the composite good comprising both structures and land which many people think of as "a house." The Census Bureau collects data on both land and structure costs, and then applies hedonic techniques to compute a price index for a constant quality structure. I use this structures price series throughout the paper. Land prices have also increased substantially in the last fifteen years; USDA data on agricultural land prices suggest real appreciation of over 50 percent. However, a complete model of the housing sector, treating land and houses separately, is beyond the present investigation.

My study is divided into four sections. The first presents a capital-theoretic model of the housing sector. I follow Kalchbrenner [1973], Kearl [1975, 1979], and Sheffrin [1979] in distinguishing between the market for existing houses and the market for new construction. The second section analyzes the long-run con-

2. Hendershott's [1980] study examined the response of new construction, and Buckley and Ermisch [1979] investigated the steady-state effects of user cost changes in Britain. Neither study combined the supply and demand sides of the housing market, and both ignored the transition from one steady state to another.

sequences of a user cost change and explains how the perfect foresight assumption restricts the initial price change. In the third section I explore the theory's implications for empirical models of residential construction activity. I estimate a quarterly model of aggregate investment in one-family owner-occupied structures, and compare the results with those from previous housing studies. The final section describes perfect foresight "simulations" that illustrate the impact of user cost changes on house prices and building activity.

The results suggest that absent other inflation-induced distortions in the housing market,³ as much as a 30 percent increase in the real price of owner-occupied structures could be attributed to the user cost decline of the late 1970s. They highlight the role of inflation in determining the tax subsidy to owner occupation and indicate that the substantial changes in the inflation rate which have been experienced in the early 1980s may dramatically affect the desirability of homeownership.

I. THE THEORETICAL FRAMEWORK

The desired quantity of housing services HS^d depends upon the real rental price R of those services: $HS^d = f(R)$, $f_R < 0$. The flow supply of services HS^s is produced by the stock of housing structures H according a production relationship, $HS^s = h(H)$. The stock of houses⁴ is fixed in the short run, so the equilibrium rental equates the demanded quantity of services with the existing service flow: $HS^s = HS^d$. The market-clearing rental can be represented as $R = R(h(H))$, $R' < 0$, where R is the inverse demand function for housing services. To simplify my exposition, I shall write $R(H)$ for the marginal rental value of services generated by a housing stock H .

Individuals consume housing services until the marginal value of these services equals their cost. To formalize this condition, I shall make several assumptions: (i) all structures depreciate at a constant rate δ , and require maintenance and repair expenditures

3. The user cost is not the only channel by which inflation affects the housing market. The structure of fixed nominal payment mortgage instruments can induce other distortions: the "effective duration" of the mortgage is reduced, and liquidity-constrained consumers may find initial nominal payment requirements prohibitive. These effects have been extensively discussed in Kearl [1979] and Schwab [1982]. Resolving whether user cost or mortgage instrument effects are more significant is an important empirical issue, but it is beyond the present paper.

4. Houses are assumed to be homogeneous, so new construction is qualitatively the same as the existing housing stock.

equal to a fraction κ of current value;⁵ (ii) structures incur property tax liabilities at a rate μ ; (iii) all individuals face a marginal income tax rate θ , may deduct property taxes from taxable income, and may borrow or lend any amount at a nominal interest rate i . The one-period cost of housing services from a "unit structure" with real price Q is ωQ , where ω is the sum of after-tax depreciation, repair costs, property taxes, mortgage interest payments, and the opportunity cost of housing equity, minus the capital gain (at rate π_H) on the housing structure.⁶

$$(1) \quad \omega = [\delta + \kappa + (1 - \theta)(i + \mu) - \pi_H].$$

Homeowners equalize the marginal cost and marginal benefit of housing services, setting $R(H) = Q\omega$.⁷

The *nominal* house price inflation rate π_H equals the sum of overall inflation (π) and *real* house price inflation π_Q , where $\pi_Q = \dot{Q}/Q = \pi_H - \pi$. To study real price changes, I rewrite the asset-market equilibrium condition as

$$(2) \quad \dot{Q} = -R(H) + \nu Q,$$

where $\nu = \delta + \kappa + (1 - \theta)(i + \mu) - \pi$. For a given initial stock of houses H and real house price Q , (2) determines the expected real capital gain needed to induce individuals to hold the entire housing stock. The $\dot{Q} = 0$ locus is the demand curve for houses when investors expect no real capital gains; it defines the structures prices that are consistent with full ownership of the housing stock and constant real house prices.

Asset-market equilibrium may also be explored by arguing that the price of a house must equal the present discounted value of its net future service flow. The arbitrage condition (2) is the primitive concept, and the present-value relation can be derived from it. A house's net service value $S(t)$ is its real rental service

5. The assumption that maintenance is a constant fraction of home value implicitly recognizes that many of the inputs to maintenance, including copper pipe, gravel, and lumber, are also assets whose relative prices are affected by inflation. Other inputs, such as the homeowner's time, are of a different character, and maintenance might be treated proportional to the physical size of the house. This alternative assumption would reduce the effect of inflation on house prices, though sample simulations showed the effect to be small.

6. If the opportunity cost of funds i_0 is different from the cost of borrowing i_B , then the loan-to-value ratio L on the housing purchase enters the problem. The user cost in (1) becomes

$$(1') \quad \omega' = \delta + \kappa + (1 - \theta)[Li_B + (1 - L)i_0 + \mu] - \pi_H.$$

7. Throughout this discussion, risk and uncertainty play no role in determining the asset market equilibrium. A more complete model would recognize the importance of portfolio considerations in the home purchase decision.

value minus depreciation, tax, and maintenance costs: $S(t) = R(H(t)) - [(1 - \theta)\mu + \delta + \kappa] Q(t)$. The equation for the evolution of real house prices may be rewritten as $\dot{Q}(t) = -S(t) + [(1 - \theta)i - \pi]Q(t)$. Subject to the transversality condition that restricts the value of housing structures' services to grow at a rate less than the discount rate, this differential equation is solved by

$$(3) \quad Q(t) = \int_t^{\infty} S(z) e^{-[(1 - \theta)i - \pi](z - t)} dz.$$

A house's real price equals the present value of its future net service flow discounted at the homeowner's real after-tax interest rate.⁸

I have described the demand for existing structures. The market for new construction, which determines the amount of gross residential investment, is the second part of the housing sector. I assume that the homebuilding industry is perfectly competitive and that the industry's supply depends on its output price, the real price of housing structures. Gross investment I equals the industry's output: $I = \psi(Q)$ with $\psi' > 0$. This specification of the investment function requires some explanation. Some authors (for example, Muth [1960]), have argued that in the long run the housing structures supply curve is perfectly elastic. If this were so, the steady state price of structures would be determined only by construction costs, which are assumed independent of the level of construction. By comparison, the two-sector monetary growth model described by Foley and Sidrauski [1971] implicitly argues that the production possibility frontier between houses and other goods is not flat. Provided that any factor, such as lumber or the individuals who are skilled as construction workers, is in limited supply, a rise in construction demand will increase the equilibrium price of structures.

Combining the gross investment function $\psi(Q)$ with the accounting identity for the net change in the housing stock \dot{H} yields an expression for net investment:

$$(4) \quad \dot{H} = I - \delta H = \psi(Q) - \delta H.$$

8. If interest and inflation rates vary through time, then equation (3) becomes

$$(3') \quad Q(t) = \int_t^{\infty} S(z) \exp\left(-\int_t^z \rho(x) dx\right) dz,$$

where $\rho(t) = (1 - \theta)i(t) - \pi(t)$.

A long-run steady state is defined by a constant housing stock, $\dot{H} = 0$.⁹ The steady state houses price is therefore $Q^* = \psi^{-1}(\delta H^*)$, where H^* is the equilibrium stock of structures.

My omission of land is most apparent in this discussion of flow supply. To treat land properly, we must specify the relationship between inputs of land and structures and output of housing services. Information on this "housing service production function" is almost impossible to obtain. It is also difficult to measure the elasticity of supply of residential land. Although this parameter is crucial in determining the model's response to user cost shocks, there is little agreement concerning its numerical magnitude. These difficulties led me to focus only on structures in my empirical analysis, but in the appendix I discuss how land could be added to the theoretical model.

II. THE ANALYTICS OF USER COST CHANGES

The model may be used to analyze a reduction in user costs induced by an increase in the rate of expected inflation, and to describe its ultimate consequences for the housing market. First, consider the consequences for the housing market steady state. Higher inflation rates reduce homeowners' user costs because while nominal mortgage interest payments are tax deductible, the capital gains from house appreciation are essentially untaxed.¹⁰ Differentiating the user cost expression yields $d\omega/d\pi = (1 - \theta)di/d\pi - d\pi_H/d\pi$. Real house prices are constant in the steady state, so $d\pi_H = d\pi$. An increase in the overall inflation rate will reduce the steady state user cost of housing, $d\omega/d\pi < 0$, if $di/d\pi < 1/(1 - \theta)$. Plausible values for the average marginal in-

9. In a growing economy, the ratio of H to real income must be constant. H must therefore grow at a rate $n + \eta_y g$, where n is the rate of population growth, g the rate of growth of real income per capita, and η the income elasticity of demand for housing services. In the calculations of Section IV, I allow for income growth by defining $\delta^* = \delta + n + \eta_y g$ and requiring $\dot{H} = \psi(Q) - \delta^* H$.

10. Several factors motivate the choice of zero as an effective capital gains tax rate. First, housing capital gains are untaxed whenever the proceeds are invested in another home. The U. S. Savings League [1979] reports that 78 percent of all home sellers purchase another house immediately. The percentage who were unable to reinvest their full capital gain because of "trading down" to a smaller house is unfortunately not known. Second, the first \$100,000 of capital gains is tax exempt when the house seller is over sixty-five, regardless of reinvestment. Finally, the small fraction of sellers who are taxed pay taxes when their gain is realized and not when it accrues, reducing the effective tax rate still further.

come tax rate of homeowners, between 0.25 and 0.5,¹¹ imply that inflation shocks will reduce the user cost if nominal interest rates rise by less than one and one-third percentage points for every one point increase in the inflation rate.

Inflation's effect on nominal interest rates is an unresolved issue. While theoretical analyses predict values of $di/d\pi$ that are greater than one, empirical findings point to a value less than or equal to unity. Feldstein and Summers [1978] and Summers [1982] discuss these questions in some detail. The complex institutional arrangements that have governed mortgage interest rates in the period under consideration, in particular the regulated nature of the savings and loan industry, make it unlikely that the mortgage rate behaves according to standard term-structure theories. While these institutional considerations suggest that the expected inflation rate may not be of direct relevance to the mortgage market, regression evidence provides a useful *description* of the joint evolution of mortgage and inflation rates.

I performed simple tests to measure the responsiveness of the nominal short-term commercial paper rate, and the nominal mortgage interest rate, to expected inflation. A time series for inflationary expectations was formed using a "rolling ARMA" technique.¹² The short rate was regressed against the one-period forecast inflation rate, and the mortgage rate against a discounted fifteen-year forecast inflation rate. The regression results for the period 1960–1980 are summarized below:

$$(5a) \quad R_{\text{mortgage}} = 4.14 + 1.10\pi_{\text{long}}^e + 0.65u_{-1} \quad \begin{array}{l} \bar{R}^2 = 0.92 \\ D.W. = 1.29 \end{array}$$

(0.64) (0.15) (0.23)

$$(5b) \quad R_{\text{short}} = 2.82 + 0.82\pi_{\text{short}}^e + 0.53\hat{u}_{-1} \quad \begin{array}{l} \bar{R}^2 = 0.59 \\ D.W. = 1.40 \end{array}$$

(1.31) (0.24) (0.29)

11. The NBER TAXSIM file shows that average marginal tax rate of individuals who claimed mortgage interest deductions in 1977 was 27 percent. However, only 50 percent of homeowners deduct mortgage payments. The marginal tax rate on some mortgage interest payments is therefore zero. This simple argument is misleading, however, since not all homeowners have mortgages. More importantly, the marginal tax rate facing the individual *spending* the marginal housing dollar may be quite different from the average marginal tax rate of current homeowners. Since the appropriate tax rate is ambiguous, I present simple calculations below, assuming that $\theta = 0.25$ and $\theta = 0.35$.

12. For each year between 1960 and 1980, an ARMA (1,1) model was fitted to the preceding ten years of inflation data. The estimated inflation rate process was then used to forecast inflation rates for the next fifteen years. The short-term expected inflation rate was defined as the one-period ahead forecast, and the expected long-term inflation rate was computed using the procedure of Feldstein and Summers [1978], discounting future forecasts at 8 percent per year.

The hypothesis that $di/d\pi = 1$ cannot be rejected in either case; I impose this value in the simulations below.

While long-term mortgage interest rates are important, the *short-term* interest rate enters the arbitrage equation for houses. Absent risk, the one-period return on houses must equal the return on alternative assets, and this is the short-term interest rate.¹³ Changes in the long-term interest rate affect the housing market, not by raising today's user cost, but because they convey information about expected future user costs. If the expected short-term interest rate in some future period rises, today's nominal long-term interest rate will also rise. Investors must expect the arbitrage condition to hold even when short rates, hence user costs, are high. One way to enforce asset-market equilibrium would be for house prices to fall sharply in the period when the short rate rises, and to rebound in the next period. However, investors who foresaw this event would enjoy large capital gains when house prices returned to their previous level. The assumption of rational expectations precludes these anticipated excess returns. The price of structures *today*, and the interim path of housing investment, will therefore adjust to guarantee that the arbitrage equation holds. An increase in the long-term interest rate therefore depresses house prices today and reduces housing capital intensity, but it is not relevant for measuring today's user cost. Earlier studies of user costs based on mortgage rates, for example, Hendershott [1980] and Dougherty and Van Order [1982], may have measured the real cost of homeownership incorrectly.

To understand the dynamics of the housing market, we need to analyze the differential equations that govern Q and H . These equations, shown below, are drawn on a phase diagram in Figure I:

$$\begin{aligned} (6) \quad \dot{H} &= \psi(Q) - \delta H \\ \dot{Q} &= -R(H) + \nu Q. \end{aligned}$$

Point A is an initial steady state (H^*, Q^*) . The figure depicts the effect of a reduction in user costs, leading to a greater housing service demand at each real price Q . Real house prices and the quantity of housing capital thus increase, leading to the new steady state position that is labeled B .

13. A second argument for the importance of the short rate is that there are individuals for whom the relevant margin is deciding whether to purchase a house this period or next. The short-term interest rate on mortgages is the relevant interest rate for these marginal individuals.

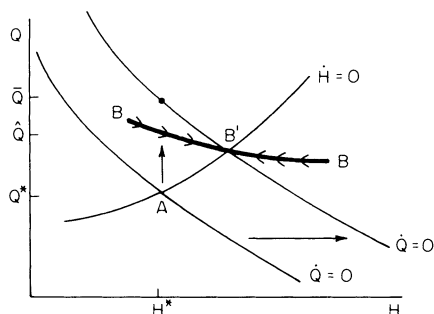


FIGURE I

The Effects of a User Cost Reduction

The housing model exhibits the “saddlepoint stability” property frequently found in asset-market models with rational expectations. Begg [1982] and Sheffrin [1983] discuss these models in some detail. If a steady state is disturbed, there is a unique path (the “stable arm”) along which the system will return to a steady state. It is the only path that satisfies the transversality condition. The housing stock at the time of the shock is fixed at H^* , so the real price of houses must adjust to reach the stable arm at (H^*, \hat{Q}) . From this point, as the system moves along path BB' to point B , the housing stock will grow and the real price will decline.

The figure allows a comparison of the price response under perfect foresight (\hat{Q}) with the response when agents expect the housing stock to remain fixed. Housing stock adjustments accommodate the user cost change, and fixing the housing stock reduces the system’s ability to react to shocks. The fixed- H case is tantamount to assuming a vertical $\dot{H} = 0$ locus, and in this situation, prices move to \bar{Q} . This is the case that I label “static expectations.” The substantial difference between \bar{Q} and \hat{Q} in the simulations reported below shows how any analysis that neglects expectations of future housing construction will overstate the housing price responses.

III. CALIBRATING THE MODEL

Estimates of the housing inverse demand function and the construction supply equation are needed to estimate the housing market’s response to changes in the inflation rate. For a number

of reasons, the inverse demand function is difficult to estimate from time-series data. Accurate measurement of the user cost requires measuring expected house price inflation, which is inherently unobservable. Further difficulties arise from the need to aggregate across individuals with different marginal tax rates and therefore different housing user costs.¹⁴ I chose not to estimate the housing demand function, but relied upon previous cross-sectional research. I approximated $R(H)$ as

$$(7) \quad \log Q\omega = \log R(H) = \alpha_0 + \alpha_1 \log H.$$

The coefficient α_1 is the reciprocal of the price elasticity of housing service demand. While there have been many attempts to estimate housing demand questions, Rosen's [1979] is noteworthy for its inclusion of tax-adjusted user costs. His results suggest a housing price elasticity of about minus one and an income elasticity near 0.75. I employ these values in the simulations below.¹⁵

My empirical work centered on estimating the investment supply function. The asset-market model predicts that the new construction flow depends primarily on the real price of owner-occupied houses. While several recent studies of corporate investment, including Abel [1980] and Summers [1981a], have applied this asset-market framework, most residential investment research still combines the notion of a "desired residential capital stock" with a stock-adjustment model for dynamic response. My investigation breaks from that tradition. I approximated the investment supply function $\psi(Q)$ by allowing the level (or rate) of investment-good production INV to depend on the real price of houses Q_t , the real price of alternative construction projects QN_t , and the prevailing wage in the construction industry W_t :

$$(8) \quad INV_t = \beta_0 + \beta_1 \cdot Q_t + \beta_2 \cdot QN_t + \beta_3 \cdot W_t + \varepsilon_t.$$

14. Kearl [1979] estimated what he interpreted as a structural price equation allowing for the full effect of inflationary distortions operating through mortgage instruments. He did not, however, impose the restriction that $\log(Q \cdot \omega)$ should appear on the left-hand side of the equation. The theory determines only the product $Q \cdot \omega$. Kearl also neglected the role of investors' expectations and used the mortgage rate instead of the short-term interest rate in defining the user cost. Manchester [1983] attempted to overcome the difficulty with measuring expectations by using instrumental variables. However, there has not yet been any attempt to estimate a housing demand model by imposing the restrictions that are implied by the assumption of rational expectations.

15. Most studies have estimated the demand for housing structures with land, and may not provide estimates of the elasticity of demand for structures alone. However, the fact that the land-to-value ratio for houses has remained almost constant over the past two decades suggests that the elasticity of demand for structures may therefore be approximated by the house price demand elasticity.

In the reported equations below, *INV* will be measured both as the level of real investment in structures and as the ratio of real structures investment to GNP.

The construction model was estimated on quarterly time series data for the United States for the period 1974–1982. The real value of new one-family housing construction put in place, *INV*, was provided by the Bureau of Economic Analysis. The real house price series *Q* is an unpublished Census Bureau price index for a constant-quality new house, divided by the personal consumption deflator. One factor that is not considered by the Census Bureau in computing house prices is the interest cost of keeping a house “on the market.” However, there was substantial variation in the average time-on-the-market for new houses during my data period. Market residence time is important because the interest costs of holding an unsold house are a major cost to builders and other house-sellers. Since variations in interest rates and selling times affect the attractiveness of undertaking new construction, I adjusted the price series for interest costs by defining the effective real price Q_R as $Q_{Rt} = Q / \prod_{i=1}^T (1 + r_{t-i})$ where r_i is the one-month commercial paper rate and T is the average number of months on the market for houses that were sold at t . The *QN* index, the price of alternative outputs, was measured as the nonresidential structures deflator from the National Income and Product Accounts, divided by the consumption deflator. Finally, the average hourly earnings of construction workers *W* was obtained from *Employment and Earnings*.

The comparison between the Census Bureau's real house price series and my “adjusted” series is shown in Table I. The number of months that new houses spend on the market has varied between 2.5 and 5.4 in the post-1963 period. When combined with movements in the nominal interest rate, this implies that the ratio of the effective price to the nominal price received by a seller has varied between 0.99 and 0.95. Unadjusted structures prices rose 35.7 percent between 1970 and 1979, while the adjusted series shows only a 34 percent increase. There was also a clear decline in the real price of structures after 1979. Neither series reflects the full decline in “effective” real house prices of late due to the rapid increase in seller-financing at below market interest rates.

The specification in (8) is inadequate for two reasons. First, it ignores the fact that residential building has often been affected by credit rationing. While full treatment of the rationing problem

TABLE I
REAL HOUSE PRICES 1963-1982

Year	Real house price, no market-time adjustment	Average number of months on market	Adjustment factor	Real house price, adjusting for time on market
1963	0.960	3.542	0.991	0.969
1964	0.950	3.758	0.990	0.957
1965	0.959	3.767	0.989	0.966
1966	0.970	3.858	0.987	0.975
1967	0.974	3.225	0.989	0.981
1968	0.989	3.242	0.988	0.995
1969	1.019	4.025	0.983	1.020
1970	1.000	3.417	0.982	1.000
1971	1.012	2.783	0.989	1.019
1972	1.039	3.075	0.990	1.048
1973	1.071	4.575	0.980	1.069
1974	1.068	5.100	0.970	1.055
1975	1.093	4.550	0.973	1.083
1976	1.132	3.617	0.985	1.134
1977	1.208	3.508	0.987	1.214
1978	1.288	3.992	0.982	1.287
1979	1.357	4.750	0.970	1.340
1980	1.354	5.392	0.956	1.318
1981	1.357	5.158	0.955	1.319
1982	1.316	3.917	0.963	1.290

Sources. Column 1, U.S. Bureau of the Census, Construction Reports C-27, and National Income Accounts for Personal Consumption Deflator. Column 2, U.S. Bureau of Census, Construction Reports C-30. Columns 3 and 4, own calculations. See text for description.

requires a formal disequilibrium model, as in Fair and Jaffee [1972], I follow a second-best course and add a measure of credit availability to (8):

$$(8a) \quad INV_t = \beta_0 + \beta_1 \cdot Q_t + \beta_2 \cdot QN_t + \beta_3 \cdot W_t + \beta_4 \cdot CREDIT_t + \varepsilon_t.$$

Two alternative measures of credit rationing are employed below. The first, *CREDIT1*, is a distributed lag on the net deposit inflow to savings and loan institutions. *CREDIT2* is an indicator variable for periods that Brayton [1979] defined as "credit rationed." Similar variables have been employed in many previous housing studies.

The second problem that (8) does not recognize is that building a house takes time. Construction decisions must be based upon

expectations of the prices that will prevail several months in the future. To model this, I replaced the price variables in (8a) with their expected one-quarter ahead values and estimated the model by instrumental variables, using lagged values of Q_t and QN_t as instruments for expected future prices. This approach to estimating rational expectations models was suggested by McCallum [1976]. Since my equations displayed second-order residual autocorrelation,¹⁶ they were estimated using a variant of Fair's [1970] method. However, only values of the price variables lagged more than two periods were used as instruments; this avoids the criticism of Flood and Garber [1980].

Estimates of the investment model are shown in Table II, which reports two basic specifications. In the first the dependent variable is the ratio of investment of one-family residences to GNP. Since most adjustment-cost theories of investment suggest that the *rate* of investment relative to the economy's total output or its capacity for producing investment goods is determined by the real price of structures, most of my reported equations focus on this specification. Alternative "traditional" equations in which the level of investment is the dependent variable were also tried and reported.¹⁷ My model of structures investment differs from many previous studies of construction behavior because it deemphasizes such demand variables as disposable income or demographic trends. I argue that the asset price of houses is a sufficient statistic for these demand side forces, and that the flow of new construction should therefore depend only upon the real house price.

The estimation results provide support for the asset-market theory outlined in Section I. In the best-fitting equations, the estimated elasticities of the rate of new construction with respect to real house prices range between 0.5 and 2.3, depending upon model specification.¹⁸ Models with *CREDIT*1, the savings inflow variables, fit measurably better than those with the credit ra-

16. The common-factor restrictions imposed by my AR(2) error structure were never rejected at the 95 percent confidence level. See Sargan [1980] for further discussion of common factor tests.

17. Specifications involving the ratio of housing investment to the net housing capital stock were also estimated, as were models in which the level of investment was deflated by the total number of construction workers at the previous construction boom. I also estimated models for housing starts. Similar results obtained from all of these models, suggesting some robustness of the findings.

18. These findings can be compared with results of earlier studies that included real house prices in residential investment functions. Kearl [1979] found a supply price elasticity of about 1.6 for new investment, and Huang [1973] reported an elasticity of nearly two for housing starts.

TABLE II
RESIDENTIAL INVESTMENT EQUATIONS

Equation	Dependent variable	Inst. var.	Constant	Real house prices	Nonresidential construction deflator	Real construction wage	<i>CREDIT1</i>	<i>CREDIT2</i>	ρ_1	ρ_2	D.W.	P.S.T	SSR	R^2
(1)	<i>I/G</i>	No	0.462 (0.165)	0.520 (0.310)	-1.340 (0.292)	-0.205 (0.381)	3.17 (0.40)	—	1.14 (0.12)	-0.41 (0.12)	1.99	0.876	1,087	0.967
(2)	<i>I/G</i>	No	0.086 (0.089)	0.556 (0.377)	-1.140 (0.510)	0.617 (0.744)	—	-0.004 (0.023)	1.48 (0.11)	-0.58 (0.11)	1.99	1.300	1,901	0.944
(3)	<i>I/G</i>	Yes	0.434 (0.173)	1.000 (0.473)	-1.803 (0.411)	0.051 (0.385)	3.02 (0.40)	—	1.08 (0.13)	-0.39 (0.13)	2.01	1.092	1,139	0.966
(4)	<i>I/G</i>	Yes	0.019 (0.106)	2.265 (0.995)	-2.725 (0.837)	1.242 (0.844)	—	-0.012 (0.024)	1.38 (0.13)	-0.48 (0.14)	2.13	1.379	2,448	0.941
(5)	<i>I</i>	No	0.260 (0.136)	0.686 (0.367)	-1.091 (0.320)	0.049 (0.412)	3.73 (0.46)	—	1.08 (0.12)	-0.36 (0.12)	2.01	0.59	1,413	0.953
(6)	<i>I</i>	No	0.019 (0.086)	0.702 (0.441)	-0.889 (0.683)	0.866 (0.904)	—	-0.008 (0.023)	1.46 (0.11)	-0.54 (0.11)	1.86	1.64	2,536	0.941
(7)	<i>I</i>	Yes	0.169 (0.159)	1.324 (0.548)	-1.642 (0.442)	0.377 (0.431)	3.39 (0.47)	—	1.04 (0.13)	-0.35 (0.13)	2.04	0.65	1,490	0.952
(8)	<i>I</i>	Yes	0.009 (0.131)	2.963 (1.470)	-3.131 (1.171)	1.045 (1.178)	—	0.019 (0.029)	1.34 (0.14)	-0.39 (0.14)	2.20	1.64	3,454	0.940

Notes. Standard errors are shown in parentheses. All equations are estimated on quarterly data, 1964:1–1982:2. A full data appendix is available on request. Six lagged values of *CREDIT1* are included in the model; only the sum of their coefficients is reported. *P.S.T.* is a post sample predictive test as described by Davidson *et al.* (1978). Variable means: *I/G* = 1.012; *I* = 1.011; real house prices = 1.011; real nonresidential deflator = 1.060; wages = 1.116; *CREDIT1* = 0.129; and *CREDIT2* = 0.214. Equations (3), (4), (7), and (8) are estimated by instrumental variables.

tioning dummy variable. An increase in the real price of nonresidential buildings also has a depressing effect on new housing investment. This "cross-price" elasticity varies substantially between equations, ranging from -0.9 to -1.8 . The estimates in the best-fitting equations are at the upper end of that range. The importance of nonresidential structures prices supports the view that construction resources may be used to produce several different outputs, with the choice being based on their relative prices. It may suggest that expansionary public works projects could depress housing construction by drawing resources into non-residential building.

The *CREDIT* terms play an important part in each of the reported equations. Both measures of credit availability enter with their predicted signs, although the *CREDIT2* dummy variable is often insignificant. The long-run impact of a one dollar inflow to savings and loans is over a three-dollar increase in the total value of new construction. Hendershott [1980] commented that this effect seems implausibly large, although large credit effects were also reported by Jaffee and Rosen [1979].¹⁹ The three-for-one effect might be justified in several ways. First, if all funds at S&L's are loaned, then a one dollar deposit should lead to $1/L$ dollars worth of new construction, where L is the loan-to-value ratio on new homes, currently about 0.8. Second, if savings and loans receive deposit inflows at times when other mortgage-granting institutions also receive inflows, my credit variable does not measure the full increase in the pool of loanable funds. This argument cuts both ways: if money is being drawn *away* from other lenders, my variable overstates the case.

The one failing of the investment models is the poor performance of the real construction wage variable. Although it has a negative coefficient in one equation, it usually has a positive coefficient that is not statistically significant. Other measures of construction costs, including the lumber price index and the wholesale price index for construction materials, also had positive coefficients when included in the model. Treating the cost variables as endogenous, and using lagged wage or costs as instrumental variables, did not affect these results. Dropping the wage variable had little effect on the other coefficients.

19. Jaffee and Rosen [1979] estimate the *number* of new homes that will be built if another dollar is deposited at a savings and loan. Multiplying their estimate by the average value of a new home suggests \$1.40 worth of new construction for each \$1.00 added to the savings and loans.

My results point to several different effects of credit market instruments on the housing market. In addition to the usual credit rationing effects, there is evidence of a small short-term interest rate effect operating through the expected present value of future house prices. For the parameter values which I have estimated, a two-percentage-point increase in the nominal interest rate reduces construction activity by about 1 percent.

The asset-market model also provides new insight on *how* credit rationing affects the housing market. Past studies that related construction activity to the difference between the desired and the existing housing stock omitted the important asset-market equilibrium condition. They concluded that credit availability determined the quantity of housing services demanded, since the credit variables entered the new construction equation. A competing (but not exclusive) hypothesis was suggested by Fair [1972], who argued that *builders* are the actors who are most affected when credit is tight.

The asset-market approach allows us to distinguish between the "demand effect rationing" (rationing reduces the desired quantity of housing services) and "supply effect rationing" (rationing leaves builders unable to construct their desired number of new homes) hypotheses. Demand effect rationing should affect the market for new and existing structures in the same way. It has an effect on the asset market for houses and therefore should reduce the real price of structures. Construction activity should decline in response to the price signal from the asset market; however, if the asset price is a sufficient statistic for the demand forces affecting the housing market, there should be *no additional effect* from placing credit rationing variables in the investment supply equation. Supply effect rationing, however, should have its principal effect in reducing new building. It could even increase the equilibrium price of existing houses by curtailing the growth of the housing stock, which raises the expected future rental value of existing structures. Under the "supply effect" hypothesis, the real price of houses should not annihilate the credit rationing variables. The strong credit rationing effects in my construction models are presumptive evidence for validity of the "supply effect" hypothesis. They do not constitute a rejection of the demand effect model; that can only come from evidence on how rationing affects house prices.

Table III shows the percentage change in the value of new construction and the real price of houses between the quarter

TABLE III
SUPPLY VERSUS DEMAND EFFECT RATIONING

Rationing period	Change in residential investment	Change in real house prices
60:1-60:3	- 16.9 percent	- 0.8 percent
66:3-67:2	- 13.1 percent	- 0.5 percent
69:2-70:1	- 24.9 percent	0.0
73:3-75:1	- 38.5 percent	- 0.9 percent
Mean quarterly change (full sample)	5.4 percent	1.9 percent

Notes. Periods of rationing determined by Brayton [1979]. Change in residential investment is the largest percentage difference between constant dollar single-family investment in the quarter before the rationed period and a quarter during the rationed period. A similar calculation yields the change in real house prices.

before each recent credit crunch began and the worst quarter during that crunch. Brayton [1979] has identified the periods of credit rationing during the past two decades by studying the supply of mortgage funds. He defines a quarter as "credit rationed" when the growth rate of mortgage fund supply over two quarters falls by more than two percentage points relative to its growth rate over the preceding four quarters. The rationing ends when the growth rate returns to 1 percent below the initial four-quarter growth rate. While the level of investment falls substantially during each period of credit restriction, real house prices have never fallen by as much as 1 percent. These findings constitute substantial support for Meltzer's [1974] claim that credit rationing affects the flow supply of new construction, not the demand for houses.

IV. SIMULATION RESULTS

This section uses the parameter estimates described above to compute the impact of changes in the inflation rate and tax policy on the housing market. I used an algorithm for solving nonlinear rational expectations models to find the "perfect foresight path" by which the housing market moves from one equilibrium to another.²⁰ I report both the initial price adjustment at the time

20. The algorithm is described in Lipton, Poterba, Sachs, and Summers [1982]. A full description of the procedure used here is available from the author on request. Simulations assume constant wages, nonresidential structures prices, and set the house price supply elasticity at unity. A more complete discussion may be found in Poterba [1980].

of the policy change as well as the steady-state changes in the stock of structures and real house prices. Convergence to the steady state may take several decades, so these results indicate the consequences of persistent high inflation rates or otherwise favorable tax treatment of houses. While a change in the inflation rate that is expected to be temporary has a smaller effect on house prices, the consequences may still be quite substantial. A ten-year period of elevated inflation rates was calculated to produce a housing price change two-thirds as large as a permanent inflation shock.

Simulations are reported in Table IV assuming marginal income tax rates of 25 and 35 percent. I consider the impact of an unanticipated, permanent inflation shock from 0 to 2 percent, 0 to 5 percent, 0 to 8 percent, or 3 to 9 percent. The last shock is roughly comparable to the actual movement in expected inflation rates during the 1970s. Note that the effect of a shock depends both upon its size and upon the initial rate of inflation. A constant size inflation shock has a larger effect at higher inflation rates because the initial user cost is lower, meaning the shock causes a larger *percentage* reduction in housing user costs.

A 5 percent inflation, introduced into an economy with previously stable prices, causes real house prices to jump by 13.6 percent in the 25 percent tax rate case. The steady state change in real house prices is smaller, just over half the size of the initial adjustment. The inflation shock also leads to between a 15 and a 25 percent change in the long-run stock of housing structures, depending upon the marginal tax rate. The 3 to 9 percent shock induces as much as a 43 percent growth of the equilibrium housing capital stock. By comparison, if the tax system were indexed for inflation and did not treat inflation-induced increases in the nominal interest rate in the same fashion as changes in the real interest rate, equilibrium housing capital intensity would be unaffected by the rate of inflation. These results are dramatic, and suggest that failure to adapt the tax code to a period of rising prices can have very large effects on the intersectoral allocation of capital. These results, when coupled with findings that inflation depresses the real return to corporate capital,²¹ may imply a larger change in the relative size of the residential and nonresidential capital stocks.

21. Feldstein [1980] and Summers [1981b] describe the effects of inflation and the tax system on corporate profitability.

TABLE IV
UNEXPECTED INFLATION SHOCK SIMULATIONS

	Change in inflation rate			
	0-0.02	0-0.05	0-0.08	0.03-0.09
<u>$\theta = 0.25$ case</u>				
Static expectations price change	8.3	23.8	44.4	35.3
Perfect foresight price change	5.1	13.6	23.4	18.7
Steady-state price change	2.7	7.4	13.1	10.6
Steady-state capital change	5.5	15.3	27.8	22.3
<u>$\theta = 0.35$ case</u>				
Static expectations price change	13.0	40.2	84.8	71.2
Perfect foresight price change	7.7	21.3	38.7	32.3
Steady-state price change	4.2	12.0	22.8	19.7
Steady-state capital change	8.5	25.2	50.5	43.1

All reported changes are percentage movements from initial equilibrium. Assumed exogenous parameter values are $\delta = 0.015$, $\mu = 0.02$, $\kappa = 0.02$, $\delta^* = 0.04$, real rate of interest $r = 0.02$. Further information is reported in the Appendix.

The results in Table IV also allow a comparison of the change in real house prices under static expectations and perfect foresight. In the static case with a 25 percent marginal tax rate, an inflation shock from 3 to 9 percent leads to a 35.3 percent price increase. The rational expectations jump, 18.7 percent, is only about half of the static expectations change. This substantial divergence suggests the importance of using explicitly dynamic models with forward-looking expectations when studying policies that affect capital accumulation and asset prices.

Large changes in the long-run equilibrium capital stock cause immediate increases in the rate of gross residential investment. The "standard" 3 to 9 percent shock raises residential construction by 20 percent in the years immediately following the shock. The computed transition path also provides information about the time required to reach the new equilibrium. In my calculations the housing stock is within 1 percent of its new long-run equilib-

rium value within 40 years. The time required for movement halfway to the equilibrium value is about 11 "years."

The simulation approach described here can be used to study a wide range of complex policy changes that have their effect on the housing market exclusively through the user cost. Calculations for an economy with a constant 10 percent inflation rate and 25 percent marginal tax rate show that eliminating mortgage interest deductibility provisions would change the user cost from 4 percent to 7 percent, leading to an immediate fall of 26 percent in real house prices. In the long run the stock of housing capital would decline by 29 percent. The fact that changes in the tax law will have important effects on the relative value of different household portfolio assets is often ignored in policy debates. Removing mortgage interest deductibility, if it reduced real house prices by 26 percent, would imply a net wealth decline of 545 billion 1980 dollars for the household sector. This is 13 percent of household net worth, and the most substantial effects would probably be upon highly levered homeowners for whom a sharp decline in real house prices could lead to severe financial distress.

Another proposal that is frequently advanced calls for the taxation of the imputed rent from owner-occupation. In this scenario the arbitrage condition for asset-market equilibrium becomes $(1 - \theta)R(H)/Q = \omega$. Simulations assuming a marginal tax rate of 25 percent, for which the user cost rises from 4 percent to $5\frac{1}{3}$ percent, suggest that this policy change would reduce real house prices by 13 percent in the short run. The stock of owner-occupied housing would decline by one-sixth in the new steady state. The comparison between these changes and those for eliminating mortgage deductibility shows how substantial the effects of inflation, interacting with the tax system, can be: the real subsidy to homeowners that results from interest deductibility is now greater than that from the failure to tax-imputed rental income.

V. CONCLUSIONS

This study has used a dynamic model of the housing sector to study inflation's effect on the tax subsidy to owner occupation. Simulation results suggest that the tax provisions for mortgage interest deductibility, in tandem with rising inflation rates, could explain most of the 30 percent increase in real structures prices during the 1970s. Empirical results from a residential investment equation based on an asset-market model of the housing sector, in which the principal driving force behind new construction is

the real price of houses, demonstrated this model's power in explaining housing investment.

The model provides important insights into the functioning of the housing market. Provisional evidence suggests that while credit rationing has a large impact on the flow supply of new construction, its impact on the underlying demand for housing services is minimal. The price variable that I suggest drives builder behavior is the expected present value of receipts from selling a house. When nominal interest rates are high, or the average time that houses spend on the market is long, this present value declines. This "present value" effect is a direct mechanism by which nominal interest rates affect building activity.

The present study has overlooked many important issues involving the tax system's effect on the housing market. For example, I have not addressed the question of tenure choice. There is substantial evidence that the share of the population that owns a home is responsive to the relative prices of rental and owner-occupied accommodation. The recently increased attractiveness of homeownership should therefore be reflected in a shift out of rental housing, and this demand effect should be considered.²² I have also sidestepped the joint nature of housing services and the essential role of land. While the model that I outline in the appendix takes a first step, much more investigation, and particularly empirical work, is required. Finally, the model outlined here is explicitly partial equilibrium. It does not address the central question of how the equilibrium rate of return on housing and other assets is determined. Issues such as the riskiness of housing investment and the relative tax treatment of residential and non-residential capital, which arise in the general equilibrium setting, merit further study.

APPENDIX: THE HOUSING MODEL WITH LAND AND STRUCTURES

The body of this paper has ignored the interaction between structures and land. In this appendix I shall set out the model with land, for a special case, and demonstrate how the results

22. Weiss [1978] presents a neat theoretical model of the effect of taxes on homeownership, and Hendershott and Shilling [1981] look at the effects of changing user costs and rents. Neither study has treated the problem in a dynamic setting. Titman [1982] argued that conventional wisdom about the effect of inflation on homeownership rates may be misguided, because the desirability of being a landlord rises even more rapidly than the appeal of homeownership. His model suggests that inflation discourages owner occupation. This theoretical controversy underscores the need for further empirical research.

would be affected. I assume a Cobb-Douglas production function for housing services,

$$(A.1) \quad h = H^\alpha L^{1-\alpha},$$

and a constant elasticity inverse demand curve for these services,

$$(A.2) \quad R = h^{1/\eta} = H^{\alpha/\eta} L^{(1-\alpha)/\eta},$$

where η is the elasticity of demand for housing services. The two steady state asset-market equilibrium conditions are

$$(A.3) \quad R_H = (\alpha/\eta) H^{(\alpha-\eta)/\eta} L^{(1-\alpha)/\eta} \\ = [(1-\theta)(i+\mu) + \delta + \kappa - \pi] Q_H = \omega_H Q_H$$

and

$$(A.4) \quad R_L = (1-\alpha)/\eta H^{\alpha/\eta} L^{[(1-\alpha-\eta)/\eta]} \\ = [(1-\theta)(i+\mu)] Q_L = \omega_L Q_L.$$

Note that land has no maintenance or depreciation costs. In addition, there are supply functions for land and structures, which shall be written as

$$(A.5) \quad L = \psi(Q_L), \quad \gamma_1 = d \log L / d \log Q_L$$

$$(A.6) \quad H = \rho(Q_H), \quad \gamma_2 = d \log H / d \log Q_H.$$

Taking logs of (A.3) and (A.4), differentiating, and substituting using (A.1), (A.5), and (A.6) yields the following equation system for the effects of inflation on structure and land prices:

$$(A.7) \quad \begin{bmatrix} \gamma_2 \alpha - \eta(1 + \gamma_2) & \gamma_1(1 - \alpha) \\ \gamma_2 \alpha & \gamma_1(1 - \alpha) - \eta(1 + \gamma_1) \end{bmatrix} \begin{bmatrix} \hat{Q}_H \\ \hat{Q}_L \end{bmatrix} \\ = \begin{bmatrix} -\eta\theta\pi / \omega_H \\ -\eta\theta\pi / \omega_L \end{bmatrix} \hat{\pi},$$

where a caret denotes percentage change. The resulting steady-state price changes are therefore

$$(A.8) \quad \frac{d \log Q_H}{d \log \pi} = -\frac{\eta\theta\pi}{\Delta} \left[\frac{-\gamma_1(1-\alpha)(\delta+\kappa) - \eta(1+\gamma_1)\omega_L}{\omega_L\omega_H} \right]$$

$$(A.9) \quad \frac{d \log Q_L}{d \log \pi} = -\frac{\eta\theta\pi}{\Delta} \left[\frac{\gamma_2\alpha(\delta+\kappa) - \eta(1+\gamma_2)\omega_H}{\omega_L\omega_H} \right],$$

with $\Delta = -\eta [\gamma_2\alpha + \gamma_1(1 - \alpha) + \gamma_1\gamma_2 - \eta(1 + \gamma_1)(1 + \gamma_2)] > 0$. Both expressions are positive for $(\delta + \kappa)$ sufficiently small. As the supply elasticity for structures becomes large, however, $d \log Q_H/d \log \pi$ approaches zero. These expressions allow us to answer questions about how much of an inflation shock will be capitalized in land and how much in houses. Further empirical work to parameterize these models clearly remains to be done.

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