WHAT IS THE PRICE ELASTICITY OF HOUSING DEMAND?

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I. Conceptual Framework

DISAGREEMENT about the responsiveness of housing demand to variations in relative prices persists, despite extensive empirical analyses. Two factors underlie this disagreement: the multidimensional character of housing makes direct observation of prices (as distinct from expenditures) impossible; and, the significant search, transactions, and moving costs associated with changing dwellings imply that, at any instant, a given household's consumption may deviate significantly from its utility maximizing level in a static equilibrium. While a number of ingenious attempts have been made to circumvent these problems, each is quite indirect and relies upon strong, and untestable, assumptions (cf. Mayo (1978)). This paper provides direct estimates of price elasticities, based upon an explicit model of housing consumption dynamics and utilizing the experimental manipulations of housing prices incorporated in the Housing Allowance Demand Experiments.[1] While the data are limited to two years of longitudinal data and pertain only to low income renters, they nevertheless permit the direct estimation of this key parameter of housing demand.

This analysis focuses on the price responsiveness of households, but clearly other changes in household circumstances (such as in income or family size) affect desired housing consumption. In fact, given the limited longitudinal data, information about other demand adjustments provides valuable insights into consumption dynamics. Price changes can be viewed as but one of a variety of exogenous influences on housing demand.

A complete structural model of housing demand would consider the joint influence of household preferences, relocation costs, and prices on search and moving behavior and, conditional on this, their subsequent influence on housing consumption. However, both household preferences and relocation costs are generally unobserved, and estimation of such a complete model is simply beyond our current capabilities. We concentrate upon the more modest goal of modelling the reduced form relationship between housing consumption and housing stock disequilibrium (defined below).

Consumption dynamics are represented by variants of a linearized stock adjustment process. This formulation is based on the simple observation that adjustments will generally be a monotonic function of the magnitude of disequilibrium in housing consumption. As indicated by past work (Hanushek and Quigley, 1979), this is both a convenient and powerful characterization of short run dynamics.

Two basic formulations of consumption dynamics are considered. Let H_t^d represent the "desired," or static equilibrium, quantity of housing demanded by a given household, and let H_t be the actual (observed) housing consumption at time t. In the simplest form, households are assumed, on average, to close the gap between desired and equilibrium housing consumption at a constant rate α, so that

$$H_{t+1} = \alpha[H_{t+1}{}^d - H_t] + \phi H_t \tag{1}$$

where ϕ is one plus the rate of relative price increase during the interval.[2] This formulation,

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[1] Alternative approaches to this problem can also be found in Friedman and Weinberg (1978).

[2] While the H's refer to quantities, only consumption expenditures measured in current prices can be measured. Unit prices in the initial period are arbitrarily normalized to one, and ϕ indicates changes in relative prices over time.

Given the large fixed cost component to searching and moving, individual households would not be expected to make a series of marginal adjustments to equilibrium but instead would be more likely, given a decision to adjust, to close substantially the gap. Thus, this relationship is best thought of as the reduced form consumption relationship that incorporates both adjustment decisions (searching and movhowever, does not allow for differences in behavioral responses occasioned by different patterns of equilibrium changes. Since the principal method of changing housing consumption is through searching and moving, households may be more responsive in any period to contemporaneous changes in equilibrium demand than to initial disequilibrium. This possibility is considered by decomposing the level of disequilibrium into its time components with the hypothesis that $\gamma > \beta$:[3]

$$H_{t+1} = \beta[H_t{}^d - H_t] + \gamma[H_{t+1}{}^d - H_t{}^d] + \phi H_t. \quad (2)$$

Now consider a household for which housing prices are exogenously reduced by some proportion η $(0 \leq \eta < 1)$. The new equilibrium housing demand, $\tilde{H}_{t+1}{}^d$, resulting from the price change is, by definition,

$$\tilde{H}_{t+1}{}^d = H_{t+1}{}^d(1 + \epsilon\eta) \quad (3)$$

where ϵ is the price elasticity of demand for residential housing. Substitution into (1) and (2) yields

$$H_{t+1} = \alpha[H_{t+1}{}^d - H_t] + \alpha\epsilon\eta H_{t+1}{}^d + \phi H_t, \quad (4)$$

and

$$H_{t+1} = \beta[H_t{}^d - H_t] + \gamma[H_{t+1}{}^d - H_t{}^d] + \beta\epsilon\eta H_t{}^d + \gamma\epsilon\eta[H_{t+1}{}^d - H_t{}^d] + \phi H_t. \quad (5)$$

Both formulations explicitly recognize lagged responses to exogenous stimuli. From equation (4), the long run response to a price change is the price elasticity times the price change, $\epsilon\eta$, but on average only 100α per cent of this response will be observed in the first period. In equation (5) the observed response to an experimental change in housing prices is $\gamma\epsilon\eta$ after one period and $(\gamma + \beta - \beta\gamma)\ \epsilon\eta$ after two periods, even though the long run response is again $\epsilon\eta$.

Estimation of this model requires longitudinal information on the actual housing consumption of households (H_t), their equilibrium demands for given incomes, preferences and initial prices $(H_t{}^d)$, and the price reduction (η).

II. Empirical Analysis

Data from the Housing Allowance Demand Experiment, which provided housing subsidies to a sample of low income, renter households in Phoenix and Pittsburgh, allow estimation of the housing adjustment models in equations (4) and (5). This analysis concentrates upon 586 households in Phoenix and 799 households in Pittsburgh. Of these, 302 in Phoenix and 424 in Pittsburgh were randomly assigned to treatment groups receiving experimental reductions in rental payments (η) that ranged from 0.2 to 0.6 (i.e., rent subsidies of 20% to 60%); the remainder were assigned to control groups that received no subsidy.[4] Detailed longitudinal information about household characteristics and housing consumption was collected at the beginning of the experiment and annually for two subsequent years.

The empirical implementation involves specifying the equilibrium demands of individual households (H^d) in each period and then estimating the dynamic responses and price elasticity parameters. Direct estimation of equilibrium demands was used instead of more common substitution of exogenous demand determinants into the dynamic relationships for two reasons: practical limitations imposed by the complicated adjustments in equation (5) (particularly given the limited longitudinal data); and the lack of separate identification of changes in relative prices (ϕ) with substitution.[5]

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ing) and actual consumption choices. For present purposes, the focus on expected aggregate behavioral responses is sufficient, although information about the distribution of outcomes across individual households requires more detailed analysis of structural moving relationships (see Hanushek and Quigley (1978)).

[3] Note that $[H_{t+1}{}^d - H_t] \equiv [H_t{}^d - H_t] + [H_{t+1}{}^d - H_t{}^d]$.

[4] Receipt of subsidy did not depend upon any specific housing consumption choices. The experimental payments were actually received for one full year after the period examined here, and experimental households knew that they would receive assistance in obtaining other subsidies after completion of the experiment—thus minimizing effects of the limited duration of the experiment. (Other treatment groups receiving income subsidies similar to a negative income tax are not analyzed here.) Sample median incomes were 0.5–0.6 of each SMSA's median income.

Since the experimental group is small relative to the entire housing market, there would be no perceptible supply responses, and the price elasticity is therefore identified.

[5] Errors in estimating equilibrium demands may affect the subsequent estimation of the demand relationships. However, in the simplest model (equation (4)) the problems with using instruments for equilibrium demands are the same as those encountered in direct substitution when equilibrium demands are stochastically related to the exogenous variables. Moreover, as discussed below, it is possible to assess

In competitive markets where households face the same prices, contract rents (standardized for landlord provision of utilities and appliances) provide an unambiguous measure of the quantity of housing services actually consumed.[6] Assuming that households recently making relocation decisions consume their utility maximizing quantity of housing services (H^d), equilibrium demand functions at initial housing prices for each housing market are then estimated by regressing expenditures on income, assets, family size, position in the life cycle, and other demographic characteristics for recent mover households.[7] These estimates, presented and discussed elsewhere (Hanushek and Quigley, 1979), are consistent with expectations and prior research estimates, but, importantly, they indicate systematic differences between the two housing markets. All previous investigations of price elasticities that utilized price variations across housing markets have assumed that the demand relationships are the same across areas—an assumption that does not appear warranted.

By substituting relevant household income and demographic characteristics for each time period, household and time specific instruments for desired consumption (i.e., $H_0{}^d$, $H_1{}^d$, and $H_2{}^d$) are constructed from the equilibrium demand functions. These estimates, combined with actual rent expenditures in each period adjusted for tenure discounts, allow direct estimation of the price elasticity of housing demand—estimation that is free from the most stringent assumptions and data problems encountered by indirect methods.[8]

III. Empirical Results—Adjustment and Price Elasticity Estimates

Table 1 presents coefficient estimates for households in the Phoenix and Pittsburgh housing markets, replicated in two successive one-year intervals for the same sample of households. Assuming that the errors are normally distributed, the estimates are obtained by maximum likelihood techniques incorporating the nonlinear constraints on parameters.

Standard covariance tests suggest little difference in the estimated parameters in the two time periods and that the basic adjustment behavior of those households receiving experimental housing price reductions is no different from the behavior of control households who are unaffected by the experiment.[9] The simple adjustment coefficient (α) indicates that, on average, 19% of the gap between desired housing consumption and observed initial consumption is closed in each one-year period in Pittsburgh. In Phoenix, where the average mobility rate of households is higher, the results suggest that 35% of the gap is closed in any year. In both housing markets, ϕ is significantly greater than one, indicating modest increases in relative prices. The rate of inflation in housing prices is consistently greater in Phoenix than in Pittsburgh.

Based upon the simple adjustment model, equation (4), the estimated price elasticity of demand is -0.64 in Pittsburgh and -0.45 in Phoenix. These are estimates of the long run

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the importance of such problems in the extended models (equation (5)). Some attempts at using self-reported "satisfaction" indexes as instruments for housing disequilibrium were also made, but these crude instruments yielded unsatisfactory results.

[6] A significant housing price gradient would imply that households face differing prices, but this does not appear to be a problem in the cities analyzed here. For Phoenix and Pittsburgh, Merrill (1977) tests for equality of coefficients between central city and suburbs in hedonic price equations. In Pittsburgh, coefficient equality cannot be rejected; in Phoenix, the hypothesis can be rejected, although the estimated prices are very similar and the standard error of estimate changes only slightly with stratification. Independent analysis of Pittsburgh for the NBER Urban Simulation Model (reported in private correspondence by Gregory Ingram) provides no evidence of price gradients. Finally, Muth (1969) found estimated population gradients for Pittsburgh to be insignificantly different from zero at the 0.10 level (and to have the third smallest point estimate for the 46 areas he analyzed).

[7] All households, regardless of subsequent assignments to treatment groups, that moved within 12 months of enrollment ($t = 0$) are assumed to be in equilibrium and included in the estimation. This is consistent with the assumed microbehavior in footnote 2.

[8] Landlord cost savings from long term occupancy (resulting from both reduced redecorating costs and lower vacancy rates) would be expected to be reflected, at least partially, in reduced rents. (See, for example, previous estimates by Kain and Quigley (1975) and Schafer (1979).) Here, measured expenditures are normalized to new occupants (consistent with the estimated equilibrium demands) by using the estimated tenure coefficients from the Phoenix and Pittsburgh hedonic price equations of Merrill (1977). These tenure discounts grow to 10% in Pittsburgh and 19% in Phoenix for more than 10 years of occupancy.

[9] For Phoenix, the hypothesis of coefficient equality across time periods is rejected in the simpler model at the 5% level. However, in the more complex model, time period equality of coefficient is not rejected. Since $\eta = 0$ for the control households, the relevant test is for equality of α's, β's, γ's and ϕ's across samples in each time period. This simply confirms the random assignment of households to treatment groups.

TABLE 1.—ESTIMATES OF STOCK ADJUSTMENT MODELS OF HOUSING CONSUMPTION FOR EXPERIMENTAL AND CONTROL HOUSEHOLDS[a]

	Pittsburgh						Phoenix					
Coefficient	0→1		1→2		Pooled Time Periods		0→1		1→2		Pooled Time Periods	
α	0.223 (7.65)		0.155 (6.23)		0.185 (9.79)		0.407 (10.01)		0.273 (7.61)		0.352 (13.02)	
β		0.213 (7.24)		0.145 (5.80)		0.181 (9.56)		0.402 (9.02)		0.259 (7.09)		0.330 (11.87)
γ		0.466 (4.23)		0.444 (3.46)		0.376 (4.86)		0.462 (4.26)		0.534 (3.77)		0.512 (6.38)
ϵ	−0.573 (3.07)	−0.278 (2.75)	−0.689 (2.71)	−0.693 (2.68)	−0.642 (4.13)	−0.359 (3.36)	−0.484 (2.90)	−0.427 (2.49)	−0.385 (1.80)	−0.374 (1.71)	−0.453 (3.53)	−0.409 (3.65)
ϕ	1.028 (2.71)[b]	1.022 (2.06)[b]	1.036 (3.77)[b]	1.030 (3.12)[b]	1.033 (4.70)[b]	1.032 (4.79)[b]	1.085 (5.02)[b]	1.084 (4.95)[b]	1.058 (3.75)[b]	1.053 (3.43)[b]	1.074 (6.39)[b]	1.067 (5.94)[b]
R^2	0.582	0.585	0.700	0.702	0.648	0.649	0.535	0.535	0.695	0.697	0.610	0.613
Sample Size												
Control	375	375	361	361	736	736	284	284	243	243	527	527
Experimental	424	424	407	407	831	831	302	302	265	265	567	567
Parameter Equality												
Experimental & Control	0.292[c]	0.893[c]	0.043[c]	1.796[c]			0.863[c]	0.571[c]	1.039[c]	0.977[c]		
Time Periods					1.278[c]	2.031[c]					4.114[c]	2.399[c]
$\beta = \gamma$		5.240[d]		5.493[d]		6.434[d]		0.297[d]		3.770[d]		6.214[d]

[a] t-statistics are in parentheses.
[b] t-statistics are calculated on null hypothesis that parameter equals one; i.e., that there were no changes in the relative prices of housing and other goods.
[c] F-statistics.
[d] t-statistics.

responsiveness of housing consumption to exogenous price changes; i.e., the responses observed after all households had fully adjusted to the changed housing prices. The short run elasticities—those which would be observed after one year of altered prices—are, however, considerably less. While a 10% reduction in housing prices would lead eventually to a 6.4% increase in housing consumption in Pittsburgh, only a 1.2% increase is actually observed after one year. Similarly, in Phoenix only a 1.6% increase in housing consumption (from a 10% rent reduction) is observed after the first year, even though a 4.5% increase is expected in the long run.

Table 1 also presents the maximum likelihood estimates of the expanded adjustment model, equation (5), which distinguishes between initial levels of disequilibrium in housing consumption and changes in equilibrium demands. Again the model is replicated in two successive one-year intervals for the same sample of households in each market.[10] Covariance tests indicate no differences in adjustment behavior for experimental and control households and no differences between time intervals.

The estimated price elasticities in the more general formulation of equation (5) are −0.36 in Pittsburgh and −0.41 in Phoenix. These estimates imply a somewhat less elastic response than found in the simpler models (and implicitly that achieving housing consumption goals through rent subsidies could be quite expensive). The estimates of equation (5) also strongly suggest significant differences in the short run responsiveness of housing consumption to current changes in equilibrium demands and to initial levels of disequilibrium.

One concern throughout this estimation is the potential for biases arising from the inaccuracy in estimation of equilibrium demands and problems in distinguishing adjustment lags from serial correlation in housing demands. Measured household characteristics explain roughly 40% of the variation in equilibrium demands. If unmeasured factors determining demand are uncorrelated with the observed exogenous variables, the parameters of the equilibrium demand functions are, of course, unbiased, but the estimated equilibrium demand for individual households will contain errors. The expanded adjustment model (equation (5)) provides some insight into the importance of this problem. A portion of the residual variation undoubtedly reflects systematic, but unmeasured, differences in household

[10] In estimating equation (5), it must be recognized that $\eta = 0$ for all households at the beginning of the experiment. Thus, for the first interval (0 → 1) the estimated model is

$$(N-1)\ H_1 = \beta\,[H_0^d - H_0] + \gamma\,[H_1^d - H_0^d] + \gamma\epsilon\eta\, H_1^d + \phi H_0$$

and for the second interval (1 → 2), the estimated model is

$$(N-2)\ H_2 = \beta\,[H_1^d - H_1] + \gamma\,[H_2^d - H_1^d] + \gamma\epsilon\eta\,[H_2^d - H_1^d] + \beta\epsilon\eta\, H_1^d + \phi H_1.$$

tastes and other factors that remain stable over time. When changes in equilibrium demands are considered, any time invariant household factors will be eliminated, and, in the extreme, the error variance for this term will be zero. Thus, it is logical to expect biases in γ to be less severe than those in β, and this may partially explain why estimates of β are smaller than those for γ. However, since the price discount was not in effect at enrollment, the form of the estimation (as explained in footnote 10) differs across the two periods, and any biases from inaccurate measurement and serial correlation of demands would differ across the two intervals. The finding of coefficient equality for the two periods thus offers considerable support for this explicit model of household dynamics.

For the simple models of stock adjustment, the 95% confidence interval for the price elasticity of housing demand is (−0.33 to −0.95) for Pittsburgh households and is (−0.20 to −0.71) for Phoenix households. For the expanded models the confidence intervals are (−0.22 to −0.54) and (−0.19 to −0.63) in Pittsburgh and Phoenix, respectively. Although the long run elasticity estimates obtained from the expanded models are smaller, the latter models suggest a more rapid temporal response to price variation.

By way of comparison, Muth (1971) estimates the price elasticity from the production function for new housing and reports three estimates of the price elasticity with 95% confidence intervals of (−0.51 to −0.99). Polinsky and Ellwood (1977), using an identical methodology, report two estimates, with a confidence interval of (−0.56 to −0.86). Again, these studies are for national samples of households and are confined to the purchasers of new single detached, FHA insured housing. This more direct analysis suggests that renters are somewhat less responsive to price variation and that responses do vary across housing markets.

The evolution of consumption responses to price changes depends not only upon the demand elasticity and adjustment parameters but also upon the supply elasticity. As shown in table 2, which describes the interaction of these factors, the response to a price reduction will be smaller with less elastic supply. For example, with a supply elasticity of 1.0, a 10% price reduction will elicit only a 3% to 4% increase in housing consumption over the long run, and, at the end of five years, only 60% to 90% of this eventual increase will be realized. The estimates thus suggest inelastic responses to price reductions and ones that evolve rather slowly over time.

TABLE 2.—PERCENTAGE CHANGE IN HOUSING CONSUMPTION FROM A 10% REDUCTION IN HOUSING PRICES AS A FUNCTION OF DEMAND AND SUPPLY PRICE ELASTICITIES[a]

	Demand Elasticity			
	Pittsburgh		Phoenix	
Adjustment Period/ Supply Elasticity (δ)	Simple Adjustment $\epsilon = -.642$	Expanded Adjustment $\epsilon = -.359$	Simple Adjustment $\epsilon = -.453$	Expanded Adjustment $\epsilon = -.409$
A. After one year				
supply elasticity 0.2	0.75%	0.81%	0.89%	1.02%
0.4	0.92%	1.01%	1.14%	1.38%
0.6	0.99%	1.10%	1.26%	1.55%
1.0	1.06%	1.19%	1.33%	1.73%
∞	1.19%	1.35%	1.60%	2.09%
B. After five years				
supply elasticity 0.2	1.35%	1.13%	1.34%	1.30%
0.4	2.03%	1.57%	2.00%	1.92%
0.6	2.44%	1.81%	2.40%	2.28%
1.0	2.91%	2.05%	2.86%	2.69%
∞	4.11%	2.58%	4.01%	3.69%
C. After full adjustment				
supply elasticity 0.2	1.53%	1.28%	1.39%	1.34%
0.4	2.46%	1.89%	2.12%	2.02%
0.6	3.10%	2.25%	2.58%	2.43%
1.0	3.91%	2.64%	3.12%	2.90%
∞	6.42%	3.59%	4.53%	4.09%

[a] Calculations based upon estimated adjustment models of demand in table 1, assuming constant supply elasticities. Entries are obtained by substitution along the uncompensated demand curve, i.e., entries in the table are $\delta\hat{\epsilon}_\tau/\delta - \hat{\epsilon}_\tau$ where δ is the supply elasticity and $\hat{\epsilon}_\tau$ is the responsiveness of demand to price change after period τ ($\hat{\epsilon}_1 = \alpha\epsilon$, $\hat{\epsilon}_\infty = \epsilon$).

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