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Following a Panel of Stayers: Length of Stay, Tenure Choice and Housing Demand

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Abstract

This study continues the author's research on demand by housing "stayers". Most consumers do not move routinely in response to small changes in income or housing price, so the "own-rent" and "move-stay" decisions are modeled as multi-period optimization in the presence of transactions costs. Length of stay is also modeled. The empirical section uses the American Housing Survey to provide a panel of household stayers for a metropolitan area. Results indicate that income and value-rent measures in different years have separable and significant impacts on housing demand. Estimated full income elasticities are between 0.35 and 0.40.

Key words: Housing demand; tenure choice; length of stay.

1. *Optimizing over Many Periods*

In a series of studies, Goodman and collaborators have examined housing demand as a multi-period optimization. Most recently, the author attempted a limited analysis of a panel of housing stayers – those who had been in a dwelling unit for four years or more – looking at their housing demand and tenure choice as functions of multiple measures of prices and incomes. He found that multiple measures provided additional insights into the estimation of demand for a group who do not adjust their housing consumption.

This study broadens the previous one in several ways. First, it extends the panel from eight to twelve years, allowing more moving, and providing additional measures of income and price. Second, in the previous work, Goodman treated length of stay as exogenous to the model – here the author introduces hazard analysis to his model to ascertain the determinants of length of stay. Third, this paper broadens the earlier definition of expected demand, to provide a measure that attempts to bridge the micro- and the macroeconometric literatures reporting demand elasticity.

After a brief review of the literature, the study provides a discrete time multi-period consumer optimization model with transactions costs. It then proposes a general econometric framework for estimating the model, and presents a database that has been created and enlarged from the American Housing Survey (AHS). The primary finding is that in a multi-period model, the impacts of incomes and price variables from different periods are separable and significant. Length of stay has measurable and important effects.

2. *Multiple Period Frameworks*

Goodman [10, 11] derives a model in which the transactions costs of changing dwellings are essentially infinite. The two period framework, while useful for exposition, ignores the decisions on how long to stay, and how often to move. Goodman [12] links the static housing demand model to mobility analysis and considers a multi-period model that shows the equilibrium conditions, demonstrates that they are unique, and presents comparative statics.

Models of transactions costs in adjusting activity levels are not new. Hu [17] considers the appropriate adjustments to capital stock when the transactions costs are large. In housing analysis, Muth [20] examines moving costs in the context of long-term housing expenditures. Amundsen [2] considers the optimal numbers of moves when a consumer has perfect foresight, and can access perfect capital markets. He shows how the number of moves is related to moving costs, income, and preferences for housing, and he demonstrates, under simplified conditions, that the moves are equally spaced.[1]

These models do not address several aspects of housing analysis. The first is consumer choice under imperfect capital markets. The permanent income hypothesis suggests that consumers can easily borrow against future earnings, but "real life lenders" are not so accommodating. The considerable literature on liquidity constrained borrowing suggests major capital market imperfections, particularly early in peoples' earning lives.

The second aspect involves linkages between demand and mobility. Most models view consumers either as purchasing housing services in equilibrium, or as moving when out of equilibrium. How are the two linked, and what indicators can be used to predict mobility?

Third, consumers' utility functions may change over time, particularly with respect to life cycle variables such as family size, number of children, or retirement. A discrete time model permitting parameterization of the relative demands for housing and other goods allows a more realistic characterization of the path of housing consumption.

Consider a consumer optimizing over *T* periods, over housing consumption h_t (with price p_t) and consumption of all other goods c_t (with price 1). The transactions cost of moving each period is m_t. Assuming perfect capital markets, annual income y_t, interest rate r, and rate of time preference ρ, if the consumer, at time 0, plans to move each period, the optimization problem is:

$$L^* = \sum_{t=1}^{t=T}(1+\rho)^{t-1}U^t(h_t, c_t) + \lambda\left[\sum_{t=1}^{t=T}\left(\frac{y_t}{(1+r)^{t-1}} - \frac{p_t h_t}{(1+r)^{t-1}} - \frac{c_t}{(1+r)^{t-1}} - \frac{m_t}{(1+r)^{t-1}}\right)\right]. \quad (1)$$

Without perfect capital markets the problem is:

$$L^{**} = \sum_{t=1}^{t=T}(1+\rho)^{t-1}U^t(h_t, c_t) + \sum_{t=1}^{t=T}\lambda_t(y_t - p_t h_t - c_t - m_t). \quad (1')$$

1. Ai et al. [1], Edin and Englund [6], and Henderson and Ioannides [16] conduct empirical studies treating moving costs.

Staying in the same unit for *T* more periods permits the consumer to save moving costs, while incurring immobility (in terms of foregone utility) costs, making the problem:

$$L^* = \sum_{t=1}^{t=T}(1+\rho)^{t-1}U^t(\overline{h}\ ,c_t) + \lambda\left[\sum_{t=1}^{t=T}\left(\frac{y_t}{(1+r)^{t-1}} - \frac{p_t\overline{h}}{(1+r)^{t-1}} - \frac{c_t}{(1+r)^{t-1}}\right)\right]. \quad (2)$$

or:

$$L^{**} = \sum_{t=1}^{t=T}(1+\rho)^{t-1}U^t(\overline{h}\ ,c_t) + \sum_{t=1}^{t=T}\lambda_t(y_t - p_t\overline{h}\ - c_t). \quad (2')$$

Given the multi-dimensional vector of incomes, prices, and preferences, the consumer solves for:

1. number of stays (alternatively number of moves), *k*,
2. length of each stay (alternatively, number of periods between moves), $S_k = (T_k - T_{k-1})$, with $\sum_k S_k = T$,
3. housing consumed during each stay, $\overline{h}^k$,
4. non-housing consumption during each period, c_t.

Goodman [12] demonstrates that the multi-period equilibrium within each stay is summarized by equation (3), whether or not perfect capital markets exist.

$$\sum_{t=1}^{t=T} MU_t^y\ (MRS_t - p_t) = 0. \quad (3)$$

with the weighted (by the marginal utility of income MU_t^y) sum of the differences between the marginal rate of substitution (*MRS*) and the price ratio over the multi-period stay equaling 0. Each period's income and housing price, as well as the prices of other goods, and other sociodemographic characteristics, influence the quantity of housing purchased during the *entire stay*, even for households that do not move. [2]

3. An Econometric Framework

Goodman [9, 10] defines expected housing quantity as:

Expected *Q* = Expected Owner *Q* + Expected Renter *Q*

$$H(Q) = t\ Q_o + (1 - t)\ Q_r \quad (4)$$

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2. Equilibrium values of MU_t^y and MRS_t differ depending on whether capital markets are perfect.

where t was a tenure choice probability, and t, Q_o and Q_r were functions of income y.

Goodman then totally differentiated it to get a “full elasticity” with respect to income and got:

$$\eta_y^* = \frac{(1-t)\eta_{Q_r y} Q_r}{H(Q)} + \frac{t\eta_{Q_o y} Q_o}{H(Q)} + [1 - \frac{Q_r}{H(Q)}]\eta_{ty} \quad (5)$$

In this paper, I propose the following framework:

Expected Q = Expected Owner-stayer Q + Expected Renter-stayer Q +

Expected Owner-mover Q + Expected Renter-mover Q

$$H(Q) = k_o^s Q_o^s + k_r^s Q_r^s + k_o^m Q_o^m + k_r^m Q_r^m$$

where:

Q_o^s = housing demand for owner-stayers Q_o^m = housing demand for owner-movers

Q_r^s = housing demand for renter-stayers Q_r^m = renter demand for renter-movers

and k_o^s, k_r^s, k_o^m and k_r^m are probabilities of being in one of the four (tenure choice, mover-stayer) cells, recognizing that $k_o^s + k_r^s + k_o^m + k_r^m = 1$.

If we totally differentiate this new term, and concentrate on $k_o^s Q_o^s$, we get:

$$\eta_y^* = \frac{dH}{dy}\frac{y}{H} = k_o^s \frac{dQ_o^s}{dy}\frac{y}{Q_o^s}\frac{Q_o^s}{H} + k_o^s \frac{Q_o^s}{H}\frac{dk_o^s}{dy}\frac{y}{k_o^s} + \text{ similar terms for } k_r^s, k_o^m \text{and } k_r^m .$$

Then:

$$\eta_y^* = \frac{dH}{dy}\frac{y}{H} = k_o^s \frac{Q_o^s}{H}\left[\frac{dQ_o^s}{dy}\frac{y}{Q_o^s} + \frac{dk_o^s}{dy}\frac{y}{k_o^s}\right] + \text{ similar terms for } k_r^s, k_o^m \text{and } k_r^m .$$

or:

$$\eta_y^* = \frac{dH}{dy}\frac{y}{H} = k_o^s \frac{Q_o^s}{H}\left[E_{Q_o^s y} + E_{k_o^s y}\right] + \text{ similar terms for } k_r^s, k_o^m \text{and } k_r^m . \quad (6)$$

The first term in brackets describes what happens to those who are mover-stayers, the “standard” demand elasticity. Adding the second term (the change in probability of being in the mover-stayer category) shows what happens if one examines the mover-stayer category over time. This may provide a linkage between the cross-section work (which separates out categories carefully) and the time-series work (which generally doesn't).

4. Hazard Analysis

One of the major features of a model of stayers involves length of stay, which is jointly determined with prices, income, and preferences. Goodman (2002) models length of stay as endogenous, yet it is important to address its role.

The goal is to characterize the length of the observed stay, denoted by *T*. The cumulative distribution of *T* is:

$$F(t) = \int_0^t f(s)ds = Prob\ (T \leq t), \tag{7}$$

where *s* represents length of stay, and *f(s)* is a probability density function (PDF). The survival function *S (t)* is the probability that a stay will still be in progress at length *t*.:

$$S\ (t) = 1 - F\ (t) = Prob\ (T > t), \tag{8}$$

To address the probability that the stay will end in the next interval, $\Delta\, t$, define hazard rate $\lambda(t) = f(t)/S(t)$ as the instantaneous rate of termination for a stay still in progress at length *t*.

The functions also provide estimates of the median lengths of estimated durations. Both the *hazard* function and the *survival* function (from Equation 8) provide important episode-related information. The hazard function indicates whether one can expect the length of stay to end with higher or lower probability as duration increases.

Most standard statistical software provides distributions including exponential, Weibull, lognormal and log-logistic. Following Peng, Dear and Denham [21] these distributions are subsets of the generalized *F* distribution with the following density function and survival function:

$$f(t; s_1, s_2) = (s_1 e^w / s_2)^{s_1} (1 + s_1 e^w / s_2)^{-(s_1 + s_2)} B(s_1, s_2)^{-1} / (t\sigma), \tag{9}$$

$$S(t; s_1, s_2) = \int_0^{s_2 (s_2 + s_1 e^w)^{-1}} x^{s_2 - 1} (1 - x)^{s_1 - 1} B(s_2, s_1)^{-1} dx\,, \tag{10}$$

where $w = (\log t - \mu)/\sigma$. Also, $-\infty < \mu < \infty$, $\sigma > 0$, s_1, $s_2 > 0$, and *B* is the beta function.

This function subsumes most common alternatives, including the following special cases:
Weibull if $s_1 = 1$, $s_2 \to \infty$, Lognormal if $s_1, s_2 \to \infty$
Exponential if $s_1 = 1$, $s_2 \to \infty$, $\sigma = 1$, Log-logistic if $s_1 = s_2 = 1$
Extended generalized gamma (EGG) if $s_1 \to \infty$ or $s_2 \to \infty$.

From here we estimate the length of stay *log T*, where *W* is an error term:

$$log\ T = X'\beta + \sigma W, \quad \text{or} \quad T = exp\ (log\ T) = e^{X'\beta} e^{\sigma W} \qquad (11)$$

5. Sequential Bivariate Probit

Testing the theoretical model presents challenges. One would desire to follow a panel of households over time, seeing some move, possibly several times, and some stay. The theoretical model does not explicitly model tenure choice, so any empirical housing work must address issues of owning as opposed to renting, particularly regarding the roles of moving and transactions costs.

The database covers households in the Detroit metropolitan area in 1981, 1985, 1989, and 1993. We begin with a sample of 1981 households:

1. Were they owners or renters?
2. Did they stay in the dwelling unit from one year to the next?
3. Conditional on parts 1 and 2, how much housing did they own or rent during the period that they remained in the sample?

Estimating consumer behavior suggests a joint relationship between housing tenure (own/rent) and the move/stay decision. The two are related – Shelton [23] and others since have modeled the economic factors that lead renters to shorter (implicitly more likely to move in any time interval) housing tenures than owners.

For any given year, a bivariate probit model (Catsiapis and Robinson [4], Ermisch [7], Greene [15], Maddala [19]) can be used to estimate the joint relationship for housing tenure *f* and the probability of staying *g*. Variable $f = 1$ if and only if the household owned, with $f = 0$ referring to renter housing. Variable $g = 1$ if and only if the household "stays," with $g = 0$ otherwise.[3] Goodman [13] estimates this relationship for 1989 demand, conditional on the household's being in

3. Strictly speaking, *f* and *g* are continuous latent variables and the observable dichotomous ones are defined relative to these variables' crossing the zero threshold or not.

the sample in 1981 and 1985. This is analogous to comparing staying costs (in foregone utility) with moving costs.

$$\underline{\text{Owners}}:\ f = \mu_Y Y + \mu_P(\frac{P_o}{P_r}) + \mu_V(\frac{V}{R}) + \sum \mu_D D + \mu_L L + \varepsilon_f . \tag{11a}$$

$$\underline{\text{Stayers}}:\ g = \alpha_Y Y + \sum \alpha_\sigma \sigma + \sum \alpha_D D + \alpha_L L + \varepsilon_g . \tag{11b}$$

The correlation of ε_f and ε_g is denoted by ρ.

The current project is more ambitious. Figure 1 follows a panel of all households (owners and renters) who started in the 1981 panel. For all of these households, I estimate length of stay, as of 1981. Subsequent to 1981 these households either moved or stayed. For the movers, I estimate demand based on the 1981 values of incomes, prices and demographics, providing fractions that moved, and demand elasticities, to be applied to equation (6).

(Figure 1 – Selection Model)

For 1985, the process is repeated. Again for all of the remaining households, I re-estimate 1985 length of stay (which must now be at least 4 years). Again, subsequent to 1985 these households either moved or stayed, and I estimate demand based on the 1981 and 1985 values of incomes, prices, and demographics. The process is repeated for 1989 (similar to Goodman [13]), with three rounds of information on prices and incomes, and for 1993, with four rounds of price and income information.

This leads to following set of full elasticities, using equation (6). To account for the panel nature of the sample, I add parameters s_o^s, s_r^s, s_o^m, and s_r^m that indicate the share of the categories estimated as of 1981, 1985, 1989, and 1993, and are related to the mover-stayer decision. Hence:

$$H(Q) = s_o^s k_o^s Q_o^s + s_r^s k_r^s Q_r^s + s_o^m k_o^m Q_o^m + s_r^m k_r^m Q_r^m =$$

$$\sum_{j=81,85,89,93} s_{o,j}^s k_{o,j}^s Q_{oj}^s + \sum_{j=81,85,89,93} s_{r,j}^s k_{r,j}^s Q_{rj}^s + \sum_{j=85,89,93} s_{o,j}^m k_{o,j}^m Q_{oj}^m + \sum_{j=85,89,93} s_{r,j}^m k_{r,j}^m Q_{rj}^m$$

or:

$$\eta_y^* = \frac{dH}{dy}\frac{y}{H} = \sum_{j=81,85,89,93} \frac{s_o^s k_o^s Q_o^s}{H}\left[E_j^{Q_o^s y} + E_j^{k_o^s y} + E_j^{s_o^s y}\right] + \sum_{j=81,85,89,93} \frac{s_r^s k_r^s Q_r^s}{H}\left[E_j^{Q_r^s y} + E_j^{k_r^s y} + E_j^{s_r^s y}\right] +$$

$$\sum_{j=85,89,93} \frac{s_o^m k_o^m Q_o^m}{H}\left[E_j^{Q_o^m y} + E_j^{k_o^m y} + E_j^{s_o^m y}\right] + \sum_{j=85,89,93} \frac{s_r^m k_r^m Q_r^m}{H}\left[E_j^{Q_r^m y} + E_j^{k_r^m y} + E_j^{s_r^m y}\right] \quad (6')$$

6. Full Model

A seven-equation model is used to address these questions. The first two equations establish instruments to be used for permanent income (actually one equation each for owner and renter) and housing price (again, one equation each for owner and renter). The third equation estimates length of stay in the dwelling. The fourth and fifth equations jointly estimate tenure choice (owner-renter status) and mover-stayer status. The sixth and seventh equations estimate owner and renter housing demand respectively, conditional on staying in the same dwelling unit.

Permanent income estimates follow the cross-sectional method proposed by Goodman and Kawai [14], as return r_h on human capital vector $\boldsymbol{H}$ and return r_n on nonhuman capital vector $\boldsymbol{N}$:

$$Y^P = r_h\boldsymbol{H} + r_n\boldsymbol{N}. \quad (13)$$

Substituting equation (13) into the identity that current income Y equals the sum of its permanent (Y^P) and transitory (Y^T) components, or $Y = Y^P + Y^T$, yields:

$$Y = r_h\boldsymbol{H} + r_n\boldsymbol{N} + Y^T. \quad (14)$$

Here, predicted value of the regression on human capital variables including age, education, gender, and race, and nonhuman capital variables including financial assets, is taken as permanent income. The residual is treated as transitory income Y^T.

Housing prices are estimated with hedonic price equations following the formula:

$$\log V = \nu_0^o + \sum \nu_0^o x_k + \nu_G^o G + u^o \quad (15a)$$

$$\log R = \nu_0^r + \sum \nu_0^r x_k + \nu_G^r G + u^r \quad (15b)$$

where V (R) = the value (rent) of the dwelling unit, depending on vector X of housing attributes, and location G. House and rent price indices are calculated over geographic areas G for standardized bundles X^* such that $P_o^G = V(X^*, G)$ and $P_r^G = R(X^*, G)$.

The specification of tenure choice (11a) follows Goodman [9]. All else equal, increased income Y and length of stay L are likely to predict owner housing, and the D terms such as household size, age, gender or race of head may reflect tastes. Goodman distinguishes between the owner-renter price ratio P_o/P_r, and the value-rent ratio V/R. For comparable dwelling units with attributes X^*, an increase (decrease) in $P_o(X^*)/P_r(X^*)$ is expected to predict renter (owner) status.

In contrast V/R is derived to reflect expected housing investment returns – high (low) V/R is expected to predict owner (renter) status for specific dwelling units (Goodman [9]). Through a well-specified function, one can reconstruct any renter (owner) unit as if it were owned (rented). Since hedonic coefficients can be interpreted as the sums of replacement costs (Rosen [22]) and quasi-rents (Kain and Quigley [18]), a set of high quasi-rents for a specific bundle suggests a market-indicated expectation for capital gain. Holding relative prices for standardized units constant, the value-rent ratio compares units for investment potential.

Specification of stayer equation (11b) follows the theoretical derivation of equations (2) and (3), which indicate that differences over time in explanatory variables such as income and housing price may impose higher staying costs. The σ terms refer to "spreads" of incomes, prices, and value-rent ratios, variables D referring to sociodemographic variables that may reflect tastes, and L refers to length of stay in the residence. Since it is postulated that owners are more likely to stay, the simultaneity between housing tenure and probability of staying is estimated in correlation ρ between f and g.

Conditional on "staying" in the 1993 sample, for example, owner and renter housing demand are:

$$q^{own} = [\sum_{i=1}^{4} \eta_{yi}^{P} Y_i^P + \eta_{pi}P_{oi} + \eta_{vi}(V/R)] + \sum_{k} \eta_{kD}D_k + \eta_f\lambda_f + \eta_g\lambda_g + \varepsilon_o \qquad (16a)$$

$$q^{rent} = [\sum_{i=1}^{4} \delta_{yi}^{P} Y_i^P + \delta_{pi}P_{ri}] + \sum_{k} \delta_{kD}D_k + \delta_f\lambda_f + \delta_g\lambda_g + \varepsilon_r \qquad (16a)$$

As derived from the theoretical model, multiple measures of income, housing price, and value-rent ratio are included for each of the three years. Variables λ_f and λ_g refer to the selection adjustments derived from equations (11a) and (11b).

Since variables such as income are used in several stages of the estimation it is important to show how they are used to calculate marginal impacts and elasticities. Because relatively few renters in the sample stay in the same unit for more than twelve years, the analysis concentrates on the demand of owner-stayers. Expected housing demand is the probability of being an owner-stayer multiplied by the amount of housing demanded by those who are owner-stayers. Following Greene, identify the tenure choice regression as *f* and the mover-stayer regression as *g*. Then let vector $\mathbf{x} = \mathbf{x}_f \cup \mathbf{x}_g$ and let $\boldsymbol{\beta}'_f \mathbf{x}_f = \boldsymbol{\gamma}'_f \mathbf{x}$, and $\boldsymbol{\beta}'_g \mathbf{x}_g = \boldsymbol{\gamma}'_g \mathbf{x}$.[4]

The bivariate probability reflecting owner-stayer status is:

$$\text{Prob } [f = 1, g = 1] = \Phi_b\left[\boldsymbol{\gamma}'_f \mathbf{x}, \boldsymbol{\gamma}'_g \mathbf{x}, \rho\right], \tag{17}$$

and the expected housing demand (ED) for owner-stayers is:

ED = [Prob. of observing an owner-stayer] [Demand by owner-stayers]

$$= \boldsymbol{\Phi}_b\left[\boldsymbol{\gamma}'_f \mathbf{x}, \boldsymbol{\gamma}'_g \mathbf{x}, \rho\right]\left[q_i^{own} \mid q_i^{own} \text{ is observed}\right]$$

$$= \boldsymbol{\Phi}_b\left[\boldsymbol{\gamma}'_f \mathbf{x}, \boldsymbol{\gamma}'_g \mathbf{x}, \rho\right]\left[\boldsymbol{\eta}'\mathbf{x}_i + \eta_{\lambda_f}\lambda_f + \eta_{\lambda_g}\lambda_g\right]. \tag{18}$$

Equation (18) leads to two elasticities of interest. The first is the conditional elasticity of owner-stayers, which (following Greene) consists of two components. The direct effect of variable *x* on the mean of q_i^{own} is η. In addition a variable such as income *Y*, which appears in one or more probability equations, will influence q_i^{own} through its presence in λ_f and λ_g.[5] The effect of a 1% income increase on q_i^{own}, for example, is:

$$\Delta q_i^{own} = \left[\boldsymbol{\eta}'\mathbf{x}_i^{(Y=1.01Y_0)} + \eta_{\lambda_f}\lambda_f^{(Y=1.01Y_0)} + \eta_{\lambda_g}\lambda_f^{(Y=1.01Y_0)}\right] - \left[\boldsymbol{\eta}'\mathbf{x}_i^{(Y=Y_0)} + \eta_{\lambda_f}\lambda_f^{(Y=Y_0)} + \eta_{\lambda_g}\lambda_g^{(Y=Y_0)}\right] \tag{19}$$

The derived percentage change in Δq_i^{own} thus represents the income elasticity.

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4. As a result of these transformations, $\boldsymbol{\gamma}'_f$ contains all the nonzero elements of $\boldsymbol{\beta}'_f$ and possibly some zeros in the positions of variables in **x** that appear only in the other equation; $\boldsymbol{\gamma}'_g$ is defined similarly (Greene [15, P. 851]).

5. Greene signs $\dfrac{\partial E[y_i \mid z_i^* > 0]}{\partial x_{ik}}$ in a conventional probit model, where *z** is the selection parameter and *y* is the dependent variable conditional on selection. He writes “it is quite possible that the magnitude, sign, and statistical significance of the [full] effect might all be different from those of the estimate of [the direct effect] β…” [15, P. 928-9]. In an e-mail to the author, Greene indicated that $\dfrac{\partial E[y_i \mid f_i^*, g_i^* > 0]}{\partial x_{ik}}$ is exceedingly difficult to sign, but calculating the incremental impacts depends only on the ability to evaluate λ_f and λ_g at incremental levels of the explanatory variables.

The second elasticity relates to changes in explanatory variables on the entire expected demand (ED) expression. An income increase, for example, may affect the probability of being an owner-stayer as well as the conditional elasticity of owner-stayers. Starting with equation (18):

Pct. Δ ED = Pct. Δ [Prob. of observing owner-stayer] + Pct. Δ [Demand by owner-stayers]

The impact of variable *x* on the probability of being an owner-stayer is:

$$\frac{\partial \Phi_b}{\partial x} = \phi(w_f)\Phi\left[\frac{w_g - \rho w_f}{\sqrt{1-\rho^2}}\right]\gamma_f + \phi(w_g)\Phi\left[\frac{w_f - \rho w_g}{\sqrt{1-\rho^2}}\right]\gamma_g \quad (20)$$

where γ_f and γ_g are the coefficients from the tenure choice and the mover-stayer equations respectively. The impact on demand by owner-stayers comes from equation (14). This "expected value" formulation may provide insights into comparing microeconometric demand specifications with earlier specifications that look at aggregate expenditures over time.

From the theoretical model it follows that one should model a permanent increase in income (for example) as one-dollar increase in each of the three years. Similar effects, using multiple measures of housing price or value-rent ratio, can be derived for other "economic" variables. Estimating separate significant coefficients for income in different years within the same equation would provide separate effects over time, as predicted by the theoretical model.

7. Sample

The American Housing Survey (AHS) provides details on both the dwelling units and the households within them that are not available in other databases.[6] Moreover, the methods developed are replicable on AHS databases for other metropolitan areas.

It is essential to show how the household database was constructed because the AHS follows dwelling units (each with a unique identification number) rather than individuals. One cannot assume without additional information that the same household is occupying the dwelling unit. Although other studies have utilized the panel nature of the dwelling units, it is unknown whether any have attempted to take advantage of the panel nature of the households.

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6. This feature contrasts with a database like the Panel Survey on Income Dynamics (PSID) that is explicitly panel, but which contains only limited housing data, and even less geographic detail.

Due to confidentiality concerns the AHS does not provide geographic identifiers on its publicly available files. As a result, dwelling unit location within a metropolitan area is limited to central city, suburb, or county indicators. For example, all houses in the city of Detroit have the identical unit price for a given year, and identical unit prices four, eight, and twelve years later.[7]

Detroit MSA surveys were available for 1973, 1977, 1981, 1985, 1989, and 1993. Because of survey procedure changes, the study was limited to 1981, 1985, 1989, and 1993. Some dwelling units were rotated out of the survey, so the demand analyses used only households from dwelling units included in all four. Thus households outside of Wayne, Macomb, and Oakland Counties (the three counties in 1981) were not used. With no reason to believe that units were systematically rotated out of the sample, there is no reason to assume selection bias.

The fundamental criterion for matching indicated when the household had moved into the unit. Suppose 1981 Household A (HA) had lived there since 1978. Looking at the same house in 1985, if the 1985 household had also lived there since 1978, and matched on age of household head and other consistency criteria, it was assumed that this was HA for both 1981 and 1985, and that HA had been there for 7 years. The process was repeated for the 1989 and the 1993 panels.[8]

If HA is also identified for 1989, then it is indicated as having lived in the dwelling unit for 11 years (since 1978). If, however, in looking at the same dwelling unit for 1989, the current household has been there since 1987, two assumptions are made:

1. HA moved from the dwelling unit in 1987.
2. Household B (HB) moved into the dwelling unit in 1987.

Thus, it is assumed that HA lived in the dwelling unit for 9 years (from 1978 to 1987). Household B (HB) enters the sample, having lived in the dwelling unit for 2 years.

(Table 1 – Descriptive Values for Multi-Year Models)

One of the major premises is that households continue to live in the same unit, consuming roughly the same quantity of housing. Even with "perfect" measurement, housing quantity may

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7. Unit prices do change from period to period. Inclusion of additional metropolitan areas in this estimation process would presumably alleviate lack of price variation.
8. The entire set of matching criteria and procedures are available from the author on request.

change within the same unit due to renovation or depreciation.

Housing quantity is calculated by dividing estimated value by the price of housing estimated from equations (8a) and (8b), yielding (for four years) q_{81}, q_{85}, q_{89} and q_{93}. Since this process of calculating housing quantity does not constrain q_{81}, q_{85}, q_{89}, and q_{93} to equal each other, the arithmetic average of the four is used as housing quantity.

The main multi-year demand analyses were based on a sample of 1,099 households who started in the 1981 sample, and whose dwelling unit remained in the sample through 1993. In 1981 benchmark, approximately 18 percent of sample households were black, and about 64% of the households were married. Mean age of the household head was 47.2 years, and the mean household length of stay was 11.75 years. Summary measures of income and price are discussed below.

8. Results

a. Income and Price

For permanent income, separate owner and renter regressions were estimated for each year for *all* households in the AHS database (rather than simply those who were who stayed in the same unit) that year. The estimating regression is:

$$Wage\ Income = Y - r_n\boldsymbol{N} = r_0 + r_1(AGE) + r_2\ (EDUC) + r_3\ (DEM) + u, \quad (14')$$

where $r_n\boldsymbol{N}$ nets out nonwage returns to nonhuman capital. Parameters r_1 refer to a cubic function of age of household head, r_2 to levels of education (high school, some college, college degree, graduate work), and r_3 to demographic variables such as gender, race, marital status, and presence of a second worker. The regressions (available from the author on request) were estimated in nominal (1981, 1985, 1989, or 1993) dollars; all results were subsequently deflated to real (1982-4) dollars.

A criticism of equation (14′) is that error u may contain systematic components attributable to unmeasured skills or effort. These components cannot be identified in cross-sectional regressions, but can be estimated for households for whom there is more than one observation. For households in the sample for two, three, or four years, $\bar{u}_2 = (\hat{u}_{81} + \hat{u}_{85})/2$, $\bar{u}_3 = (\hat{u}_{81} + \hat{u}_{85} + \hat{u}_{89})/3$, or $\bar{u}_4 = (\hat{u}_{81} + \hat{u}_{85} + \hat{u}_{89} + \hat{u}_{93})/4$ was calculated, as appropriate. Systematic effects $\bar{u}_2$, $\bar{u}_3$, or $\bar{u}_4$

were then added to fitted values $\hat{u}$ of equation (14′) for each year as permanent income and subtracted from $\hat{u}$ as transitory income.

Returning to Table 1, mean sample real income increased from $23,590 in 1981 to $41,440 for those that remain in 1993. Permanent real income rose similarly, from $21,910 in 1981 to $31,710 in 1993. Households who were in the sample for all four periods had mean annual real transitory income of $10,220.

Housing prices and value-rent ratios were derived from hedonic price regressions estimated in semi-log form (Thibodeau [24]). Separate regressions were estimated by year, and for differing tenures, but geographic submarkets were modeled solely with binary variables. The 1980s saw considerable population loss in the City of Detroit relative to the rest of the metropolitan area, and this is indicated by steep house price discounts 32.2%, 46.1%, 49.4%, and 53.6%) for the four years.

Renter hedonic price regressions were also estimated for 1981, 1985, 1989, and 1993. Detroit rents were not as steeply discounted, although they were 18.2%, 17.1%, 22.5%, and 22.2% less than surrounding areas, in the four years respectively.

The price indices used the arithmetic mean of owner and renter bundles as X^*. Indices P_o and P_r apply the Duan [5] "smearing" factor $s = \frac{\sum \exp(\hat{e}_i)}{n}$, where $\hat{e}_i = y_i - x_i\hat{\beta}$ refers to estimated residuals, to retransform semi-log estimates from equations (8a) and (8b):

$$P_o^G = s_o \exp(\nu_0^o + \sum \nu_k^o x_k^* + \nu_G^o G),\ P_r^G = s_r \exp(\nu_0^r + \sum \nu_k^r x_k^* + \nu_G^r G). \qquad (21)$$

Value-rent ratios for individual units are created by statistically matching owner units with renter units with the same characteristics using equations (15a) and (15b). Because the vectors of coefficients were allowed to vary by dwelling unit, there was considerably more variation in value-rent ratios than in housing prices.

Both owner and renter prices (per unit) remained constant in real terms over the 12 year period. The Detroit metropolitan area was in a "zero-growth" state during that time period, and whatever growth that was occurring, for the most part occurred in outlying counties that were not covered by the AHS for the entire 12 year period. The relative prices and relative value-rent ratios, are consistent with generally accepted industry norms of the value reflecting 10 to 12 years of monthly rents.

b. Duration Models

Table 2 presents the duration models for each of the four years, 1981, 1985, 1989, and 1993. The models are specified with the variables that were appropriate at the time. From the nature of the optimizing process, it seems appropriate also to include the "spread" variables to indicate deviation from single-period equilibrium. For the households (still) in the sample, it would seem that the larger spreads would be related to shorter stays (i.e. negative signs), and increased probabilities of moving.

(Table 2 – Duration Results)

The Weibull distribution is presented for the four years. Across these years it provided the most reliable, although not always the best fitting (by likelihood ratio tests).[9] Households had a minimum length of residence of 1 year in 1981, 5 years, in 1985, 9 years in 1989, and 12 years in 1993.

Greene shows that the Weibull survival function $S(t) = e^{-(\lambda t)^p}$ yields hazard function $H(t) = \lambda p(\lambda t)^{p-1}$, so *p* greater (less) than 1, indicates increasing (decreasing) hazard, or positive (negative) duration dependence. Thus for each of the four years, the stay is more likely to end, the longer that it is at time *t*.

Permanent income has a mixed impact. It has a positive impact on length of stay in 1981, but negative impacts the next three years. Transitory income has similar impacts. One might expect a negative impact on length of stay if transactions costs are fixed, or if they rise more slowly than the cost of the housing bundle, as they would become a smaller proportion of a larger income.

Housing price has important impacts. For three of the four years (1985 excepted), the more

9. For 1981 the Weibull distribution had the highest log-likelihood value. For 1985 and 1989 the log-logistic distribution had the highest value, and for 1993 the log-normal distribution had the highest value. Since the differences were not large, and since the Weibull distribution is easy to interpret, it is used here. The gamma and generalized-F distributions did not converge.

expensive owner housing is relative to renter housing, the shorter the length of stay. Similarly, value-rent ratio has a positive (and significant impact on each length of stay). This is consistent with the premise that the better the investment the housing is, the longer people stay in it.

The spread variables (for permanent income, transitory income, price ratio, and value rent ratio) have mixed results. The income terms are all insignificant. The price terms have mixed impacts. Increased spread in the value-rent ratio has the expected negative impact on length of stay for all three years; increased owner-renter price ratio has a negative impact for two of the three years.

Regarding sociodemographics impacts, black households have systematically shorter stays across all four years. Married households have longer lengths of stay for 1981 and 1985, and shorter lengths of stay for 1989 and 1993. The age impacts are significantly nonlinear, increasing the lengths of stay at a decreasing rate, although they are always positive.

c. Bivariate Selection

This section follows a panel of households, to determine their transition from one sample to the next. Figure 2 presents the set of transitions from a sample of 1,099 households (76.6% owner) in 1981 to 356 households that remained by 1993. Of the original 829 identifiable owners, 28.7%, or 238 moved between 1981 and 1985. Of the original 258 identifiable renters, 62.0%, or 160 moved between 1981 and 1985. These percentages are consistent with long-standing estimates of owner and renter mobility. The tall bar in 1985 is comprised of the 1981 total less the moving owners, and renters. Subsequent years are treated similarly with 12 of the 1,099 original households classified as “missing” with respect to tenure choice. The final estimates in 1993 describe a sample of 329 owner-stayers, and 27 mover-stayers.

(Figure 2 – Transition to Stayer Status)

Three sequential bivariate probit models are estimated, indicating: (1) 1981 tenure and 1985 stayer status; (2) 1985 tenure and 1989 stayer status; and (3) 1989 tenure and 1993 stayer status. Since all of the remaining 1993 households are stayers, the final equation is a conventional probit model looking at tenure choice.

(Table 3 – Bivariate Probit Regressions)

One can make several observations about the sequential mover-stayer estimates. Looking at Table 3, the 1981 and 1985 models are the strongest, probably because sample attrition (more renters move) leads to smaller sample sizes for the 1989 and 1993 models. For 1981 the model correlations are positive and significant with $\rho_{81} = 0.272$ and $\rho_{85} = 0.229$; $\rho_{89} = -0.007$ and is not statistically significant.

For the tenure choice equations, both permanent and transitory incomes have significant and substantive importance. Interestingly, the transitory component for the stayers has a larger impact than the permanent component in all three regressions in which it is used (it is omitted in 1989 to allow convergence). In all four years married households are more likely to own; black households have mixed impacts from year to year.

This study confirms a finding from the author's most recent work regarding age and home-ownership. Most previous work, including the author's own, prior to Goodman [13] found age to be positively related to ownership. Here, as with Goodman [13], controlling for length of stay in the residence, older residents are more likely to rent. This seemingly unusual finding can be interpreted by adding the quadratic impacts of the age coefficients (which are slightly negative) to the impact of length of stay in the residence. As with Goodman [13], older households with shorter stays in the unit are more likely to rent. Those with longer stays are more likely to own.

The second part of the bivariate probit analysis examines the determinants of "staying." In addition to incomes, prices, and sociodemographic variables such as age, race, gender, and marital status, the theoretical model implied that changes in the "economic" variables were likely to increase staying costs (in terms of foregone utility), holding moving costs constant. After several specifications, squared difference of income, price ratio (owner-renter) and value-rent ratio were chosen such that for variable *z*, over *n* periods, $\text{PCH}_z = \sum_{k=1}^{n} \frac{(z_k - \bar{z})^2}{n}$.

Controlling for tenure, length of stay is significantly related to stayer status in all four regressions. Age enters all three of the equations quadratically, and significantly. However, the age impact evaluated at the mean, while positive for 1981 and 1985, is negative for 1989. This suggests that following a cohort over time, the households that preferred to stay at younger ages, prefer to move as they reach age 60 (the mean age for the 1993 sample).

The "spread" variables, indicating variations in incomes, prices, and tastes, give mixed results. Increased permanent income spread for 1985 and 1989 imply mover status, consistent with the model, although the coefficients are not significant. Similarly, variation in the value-rent ratio for 1985 and 1989 is also related to moving, but again without statistical significance.

d. Demand regressions

This section examines the demand equations that are estimated, corrected for selection into the sample. The selection process provides owner sample sizes of 235, 170, 86, and 329 for the four years, respectively; it provides renter sample sizes of 154, 54, 16, and 27. Due to the small renter sample sizes, interpretation of rental results will be more tentative than the owner results.

The selection adjustments are important for all four years of owner regressions. The stayer adjustment is statistically significant for 1981 and 1985, with the tenure choice adjustment significant for 1989 and 1993. The tenure choice adjustment is significant for renters for 1981, but not for the other years. This is almost certainly due to small sample size (which increases the standard error) since the coefficient orders of magnitude are roughly similar to 1981. For the owner regressions, the selection adjustments are positively related to quantity demanded. [10]

(Table 4 – Tests of Multi-Year Models)

One important investigation regards the appropriate specification of multiple year variables for the regressions. In Table 4, I concentrate here on the 1989 stayers, with potentially three income, price, and value-rent terms, and the 1993 stayers with potentially four income, price and value-rent terms. These tests involve using only the 1989 coefficients (for 1989) or only the 1993

10. These findings are similar to those of Ermisch [7]. He found that, given observed attributes, owner-occupiers are more likely to be stayers, and that households with unobserved attributes that make them more likely to move (stay) have lower (higher) housing demand, while households with unobserved traits that increase their probability of owning have higher housing demand.

coefficients for 1993, and comparing the fit using either *F*-tests. Both tests significantly reject the hypothesis that current year's quantities are explained solely by current year's parameters.[11]

For example in Table 4a, the permanent income coefficient for 1989 alone is 0.00579. When entered separately the 1981, 1985, and 1989 coefficients are 0.00630, 0.00382, and 0.00079 respectively. When the coefficients are constrained to be constant, the constrained coefficient of 0.00352 is significant and gives a permanent income elasticity (0.00352, multiplied by three) that is about twice as large as the single year's elasticity.

Looking at all of the demand regressions in Table 5, the owner income terms enter separately and significantly for all four years. A single income term is used for 1981, separate terms for 1985, and constrained coefficients for 1989 and 1993. The resulting income elasticities (particularly for 1985, 1989, and 1993) are quite similar, at 0.407, 0.349, and 0.377 respectively.

(Table 5 – Owner and Renter Demand)

The owner price effects were the correct sign for 1985, 1989 and 1993. (Goodman [13] had similar problems with 1981 prices). Again constraining the elasticities to be the same across years, the price elasticities for 1985, 1989, and 1993 were -0.196, -0.107, and -0.289 for the three years respectively.

One might argue that the 1993 regression provides the best test of the multi-year optimization model. It shows an R^2 of 0.548 and has the smallest standard error of the four years. Both permanent and transitory income have significant impacts. There is a significant price elasticity, and the value rent ratio is positively related to quantity demanded as expected. The owner-renter selection is also significant, although it is noted that over 90 percent of the households are owner households.

9. Expected Demand and Full Elasticities

This section examines the full elasticities that accompany an increase in income. These

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11. For 1989, $F_{8, 66} = 2.165$, with the critical (5%) value of 2.082. For 1993, $F_{12, 305} = 2.532$ with a critical (5%) value of 1.784. The 1993 estimates are also significant at the 1% level (critical value of 2.243) due in part to the larger sample size.

include impacts on length of stay, tenure choice and owner-stayer status, in addition to the impact of income on quantity demanded holding all of them constant. Returning to equation (6′):

$$\eta_y^* = \frac{dH^s}{dy}\frac{y}{H^s} = \sum_{j=81,85,89,93} \frac{s_o^s k_o^s Q_o^s}{H^s}\left[E_j^{Q_o^s y} + E_j^{k_o^s y} + E_j^{s_o^s y}\right] + \sum_{j=81,85,89,93} \frac{s_r^s k_r^s Q_r^s}{H^s}\left[E_j^{Q_r^s y} + E_j^{k_r^s y} + E_j^{s_r^s y}\right] \quad (6'')$$

since we cannot follow movers. Table 6 provides a worksheet that traces the impacts of a permanent 1 percent income increase.

(Table 5 – Full Elasticities and their Components)

Table 5 begins with baseline values of owner and renter percentages f and the percentage of stayers, which starts as 1.0 in 1981. The 1981 housing quantity is calculated as a weighted average of the four owner (or renter) regressions. Measure *E(Q)* weights housing quantity by percentages of owners and renters, and *H(Q)* weights *E(Q)* by the percentage of stayers, here 1.0.

The 1985 housing quantity omits those households that moved between 1981 and 1985, so while *E(Q)* may rise with income, *H(Q)* falls due to sample attrition. The 1989 and 1993 baseline measures are calculated similarly.

From equation (6″), the impact of a one percent increase in income is related to elasticities in percent owner *f*, percent stayer *g*, and share *s*. There are major changes in probability of owning/renting, and smaller changes in the probability of staying in the house. Changes in sample shares are calculated in the table, but since they are small, their elasticities are not shown. The impact of income on length of stay, and then on the owner-stayer decision, is also calculated, but again not shown in the table.

Table 6, part c, shows the full impact of a 1 percent increase in income, and its component parts. The partial impacts vary from 0.228 in 1989 to 0.435 for 1985 quantity. The full elasticity for stayers is 0.312.

As important as the measurements, is the conceptual interpretation of the numerous impacts of variables on observed housing demand. Income and household age are seen to have complicated impacts on length of stay, tenure choice, the mover-stayer decision, and on quantity demanded.

10. Conclusions

This article continues a line of research in which the explicit mover-stayer decision is modeled as an equilibrium decision. The American Housing Survey has been processed to provide a 12-year data panel for which there are very good household and unmatched housing data.

This study adds to previous work by explicitly modeling length of stay in the dwelling unit. Careful analysis of length of stay allows researchers to distinguish between effects that are related to age, and those that are related to housing tenure, and the decision to move or stay.

As with earlier work, that looked at demand at a single time, these results indicate that income and value-rent measures in different years have separable and significant impacts on housing demand. For individual groups of stayers, the conditional income elasticities provide values between 0.23 and 0.38. Price impacts on demand are less helpful, in part because of difficulties in measuring housing price using the AHS in a single metropolitan area, even over a period of twelve years. However, the four-period average price elasticities are plausible.

Renter data also provide useful results in looking at tenure choice and mover-stayer behaviors. The demand results are circumscribed by the fact that renter mobility yields very small samples of long-term stayers, and accompanying unstable parameter and standard error estimates.

When the panels are combined, the full income elasticity is slightly higher than 0.35, although elasticities for individual years are as high as 0.56. Increased income, leading to the choice of owner-rather than renter housing, increases housing demand separately from the impacts of tenure-specific income increases.

From a policy perspective the separable income impacts help to interpret key features of demand side programs such as housing vouchers that have been proposed to address problems of adequate housing for the poor. As Goodman [10] notes, repeated analyses using individual data have generally found income elasticities to be less than +1.0 and most of the analyses from the Experimental Housing Allowance Program (EHAP) project found them to be closer to 0 than to +1.0. The general appraisal was that the EHAP experiments were too short in duration, that the income subsidies were not necessarily viewed as permanent, and that moving costs might constrain adjustment.[12]

The estimates presented here, for both owner and renter demand, verify criticisms that single year income measures tend to underestimate responsiveness to income changes. Indeed, for longer-staying households, a one-year income increase, even if fully expected, would provide a very small impact on housing demand unless it became permanent. For income subsidies and/or vouchers to influence housing demand, they must be expected, and they must be long-term.

12. Bradbury - Downs [3] and Friedman - Weinberg [8] provide excellent EHAP summary volumes.

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