A National Bureau of Economic Research Conference Report

Hoynes, Hilary and Daniel McFadden. "The Impact of Demographics on Housing and Non-Housing Wealth in the United States," in *The Economic Effects of Aging in the United States and Japan*, edited by Michael D. Hurd and Naohiro Yashiro. University of Chicago Press: Chicago, 1997, pages 153-194.

The Economic Effects of Aging in the United States and Japan

Edited by Michael D. Hurd and Naohiro Yashiro

The University of Chicago Press

Chicago and London

7 The Impact of Demographics on Housing and Nonhousing Wealth in the United States

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7.1 Introduction

Equity in housing is a major component of household wealth in the United States. Demographic impacts on housing prices can have potentially large effects on the welfare of households that anticipate using their equity when they are old to finance consumption and insure against risks of major medical costs. Mankiw and Weil (1989) and McFadden (1994a) have argued that population aging in the United States in the coming three decades is likely to induce substantial declines in housing prices, resulting in capital losses for current homeowners. McFadden argues that the welfare impact of these capital losses is small if they are anticipated and savings rates adjust to optimize life-cycle consumption. However, the impact near the end of life of some cohorts could be large if they have failed to adjust savings behavior to compensate for demographically induced losses in housing wealth. This paper examines further the question of whether households anticipate demographic impacts on housing prices and adjust their savings behavior in response.

Section 7.2 summarizes the evidence on the relationship between demographics and behavior of the housing market. Section 7.3 contains an analysis of life-cycle savings behavior using data from the Panel Study of Income Dynamics and examines the question of whether savings rates are correlated with capital gains rates. Zero correlation corresponds to complete behavioral offset, with each increase in savings due to capital gains offset by a reduction in savings from other channels. High correlation corresponds to a failure to anticipate price changes or to adjust savings behavior in response. Section 7.4 concludes.

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7.2 Demographics and the Housing Market

7.2.1 Background

Over the period 1900–1990, McFadden (1994a) finds for the United States a correlation of 0.966 between real constant-quality housing stock and population.[1] This suggests that the force of demographics is a leading determinant of housing demand, even though adjustments in household formation and dissolution, housing consumption in square meters per person, and dwelling quality in response to income and price may be important at the margin.

New construction is a relatively small proportion of the housing stock: real gross investment has averaged 5.3 percent of the real housing stock over 1900–1990. Consequently, the short-run price elasticity of supply of dwellings is relatively low, even though new construction is fairly responsive to price. Then demographic trends that affect housing demand should induce substantial, and largely forecastable, movements in housing prices. The correlation of population and housing prices was 0.883 over 1900–1990.

We shall review the standard theory of the housing market and identify the role of demographic factors in determining stocks and prices. For completeness, we begin by developing the standard consumer model of housing demand and deriving the conventional formula for the user cost of housing. A comparative statics analysis of this model identifies qualitatively the linkage between housing prices and demand. We use the following notation:

π	Cost of living index
d	Dummy variable: one for owner, zero for renter
R	Nominal rental rate per unit of constant-quality housing
P	Nominal purchase price per unit of constant-quality housing
m	Marginal income (and capital gains) tax rate
τ	Property tax rate
δ	Maintenance (or depreciation) rate
θ	Share of purchase mortgaged
r	Mortgage interest rate (nominal)
r'	After-tax interest rate, $r' \equiv (1 - m)r$
μ	Operating cost rate for owned housing, $\mu \equiv (\theta r + \tau)(1 - m) + \delta$
A	Nominal financial assets of the consumer (debt if negative)
W	Nominal wealth
Y	Nominal income

1. The GNP Residential Investment Deflator is assumed to be a valid measure of nominal constant-quality housing price. Residential Investment, deflated by this measure, is then accumulated at a depreciation rate of 2.687 percent to obtain real constant-quality housing stock. The depreciation rate is chosen so that the series is commensurate with the Department of Commerce series on Value of Net Stocks of Residential Structures. The Residential Investment Deflator, divided by the total GNP Implicit Price Deflator, is taken as the measure of the price of constant-quality housing. Details of the construction and sources are given in McFadden (1994a).

g	Real consumption of goods other than housing
h	Real consumption of constant-quality housing units
$\mathring{P}$	Capital gains rate, $\mathring{P} \equiv (P_2 - P_1)/P_1$
α	Consumer's expected capital gains rate
σ^2	Consumer's variance of capital gains rate

Consider for simplicity a consumer who is endowed with initial (after-tax) wealth W_1, lives one period, and then leaves a bequest W_2 in the following period. The consumer must decide on levels of consumption of housing units (h) and goods other than housing (g), and on whether to rent ($d = 0$) or own ($d = 1$). Assume the consumer's utility function has the form

$$\mathcal{U} = U(g, h) + \mathbf{E}\, V(W_2/\pi_2), \tag{1}$$

where U is the utility of current consumption, V is the utility of bequests, and the expectation is taken with respect to future housing prices, which are unknown when consumption decisions must be taken. Although we shall not do so in this paper, it is possible to interpret V as a valuation function, which may depend on age, health, and mortality risk, and to allow U to depend on age and health. Then equation (1) will be the term entering Bellman's equation for the consumer's dynamic stochastic program. We make the following assumptions on U, V, and beliefs about future prices:

1. U is strictly concave and nondecreasing, with $\nabla_g U(0, h) = +\infty$, $\nabla_h U(g, 0) = +\infty$, and $\nabla_h U(g, +\infty) = 0$.
2. Housing and nonhousing consumption are normal goods; that is, $\nabla_g(\nabla_g U/\nabla_h U) \leq 0$ and $\nabla_h(\nabla_g U/\nabla_h U) \geq 0$.
3. V is a constant relative risk aversion utility function; that is, $V(w) = -Ce^{-\kappa w}$, where C and κ are positive parameters.
4. All variables except $\mathring{P}$ are in the consumer's initial information set $\mathcal{I}$, and given this information the consumer believes that $\mathring{P}$ has a normal distribution with mean α and variance σ^2.

The consumer's budget constraint in the first period is

(2) $0 = W_1 + (1 - m)Y_1$	Initial after-tax wealth and after-tax income
$- \pi_1 g$	Nonhousing expenditures
$- (1 - d)Rh$	Housing expenditures if renter
$- dh\{(1 - \theta)P_1$ $+ P_1[(\theta r + \tau)(1 - m) + \delta]\}$	Out-of-pocket housing expenditures if owner
$- A_1$	Financial assets purchased

Line four of equation (2), out-of-pocket housing expenditures, is composed of the down payment $(1 - \theta)P_1 h$, mortgage interest $r\theta P_1 h$, property taxes $\tau P_1 h$, maintenance or depreciation $\delta P_1 h$, and an offset $m(r\theta + \tau)P_1 h$ arising from the deductability of mortgage interest and property taxes from income subject to income taxes. Using the definition of μ, line four can be written compactly as $-dhP_1(1-\theta+\mu)$. The second period budget constraint is

(3) $0 = [1+(1-m)r]A_1$	Financial assets with after-tax interest
$+\,dh[P_2-\theta P_1-m(P_2-P_1)]$	Housing equity net of capital gains tax
$-\,W_2$	Bequest

For simplicity, we assume that financial assets are held as savings accounts (resp. consumer loans) that carry the mortgage interest rate r, and that interest income (resp. expense) is taxed (resp. deducted) at the marginal rate m. Then the first line of equation (3) gives financial assets in the second period after taxes. The second line of equation (3) gives the cash received from sale of a house in period 2, less repayment of mortgage principal $(P_2-\theta P_1)h$ and taxes on nominal capital gains $m(P_2-P_1)h$, which are assumed to be taxed at the same rate as ordinary income. Using the definitions of r' and $\mathring{P}$, this constraint can be written compactly as

$$0 = (1+r')A_1 + dhP_1[1-\theta+(1-m)\mathring{P}] - W_2.$$

Combining equations (2) and (3) to eliminate A_1 gives an intertemporal budget constraint,

$$(4)\quad \begin{aligned} W_2 &= dhP_1[1-\theta+(1-m)\mathring{P}] + [1+r']\{W_1+(1-m)Y_1 \\ &\quad -\pi_1 g-(1-d)Rh-dhP_1(1-\theta+\mu)\} \\ &= (1+r')[W_1+(1-m)Y_1-\pi_1 g-(1-d)Rh] \\ &\quad - dhP_1[(1+r')\mu+r'(1-\theta)-(1-m)\mathring{P}]. \end{aligned}$$

Substituting equation (4) into equation (1) and taking the expectation gives the objective function

$$(5)\quad \begin{aligned} \mathcal{U} &= U(g,h) - C\cdot\exp\left\{-\frac{\kappa}{\pi_2}\left[\omega-(1+r')\pi_1 g\right.\right. \\ &\quad \left.\left. -(1-d)(1+r')Rh - dhP_1c - P_1^2h^2d\frac{q}{2}\right]\right\}, \end{aligned}$$

where

$$\begin{aligned} \omega &= (1+r')[W_1+(1-m)Y_1], \\ q &= \kappa\sigma^2(1-m)^2/\pi_2, \\ c &= (1+r')\mu + r'(1-\theta) - (1-m)\alpha \approx (1-m)(r+\tau) \\ &\quad + \delta - (1-m)\alpha. \end{aligned}$$

Then ω is total initial wealth, q is a risk penalty associated with the uncertainty about future house prices, and c is the *expected user cost of housing per dollar purchased*. The last form of c is obtained using the approximation $r'\mu \approx 0$. The first-order conditions for maximization of expression (5) are

$$(6)\quad \nabla_g U = (1+r')\kappa\frac{\pi_1}{\pi_2}\mathcal{V},$$

$$(7)\quad \nabla_h U = \frac{\kappa}{\pi_2}[(1+r')R(1-d) + dP_1c + dhP_1^2q]\mathcal{V},$$

where

$$\begin{aligned} \mathcal{V} &\equiv C\cdot\exp\left\{-\frac{\kappa}{\pi_2}\left[\omega-(1+r')\pi_1 g\right.\right. \\ &\quad \left.\left. -(1-d)(1+r')Rh - dhP_1c - P_1^2h^2d\frac{q}{2}\right]\right\}. \end{aligned}$$

A consumer whose utility U does not depend on tenure d will choose to own if $P_1c' < R$, where $c' = c + P_1hq/2$, and rent otherwise. If all consumers are identical, then equilibrium in a market in which both purchased and rental housing appear requires that prices and rents adjust so that $R = P_1c'$. On the other hand, if there is a distribution of beliefs, or even a distribution of wealth and income that induces a distribution of c', then the split between owning and renting will be determined by the proportion of consumers with c' satisfying $P_1c' < R$, with R and P_1 adjusting to clear the purchase and rental markets. Of course, if there is a distribution of tastes for tenure entering U, or of degrees of risk aversion κ, this will split the population between owners and renters even if all consumers have common beliefs.

The marginal utility of additional housing is positive. Then when faced with negative c, corresponding to a high rate of positive capital gains, the consumer will choose $d = 1$ and a high level of h, financing the purchase by borrowing financial assets at the after-tax rate $(1-m)r$. Risk aversion will, however, keep $h \le -2c/P_1q$. The market will respond to this increase in the demand for purchases by increasing P_1. This arbitrage opportunity implies that very large anticipated capital gains over very short periods will be squeezed out by the market. Similarly, large anticipated capital losses should induce a shift to rental housing, which lowers P_1 and squeezes out some of the capital losses. In practice, consumers are additionally constrained with respect to the proportion of a housing purchase they can mortgage and with respect to financing down payments with borrowed money, and there are substantial transactions costs associated with moves between rental and owner housing or in changing housing consumption levels in owner-occupied housing. These will further limit the scope for arbitrage by consumers and leave the possibility of modest anticipated capital gains and losses that are not arbitraged away. From the last form of the definition of c, the user cost of housing does not depend on equity versus debt financing (θ), a consumer equivalent of the Modigliani-Miller theorem.

A comparative statics analysis of the impact of income and prices on consumer decisions can be carried out given the assumptions below equation (1), plus the following assumptions:

5. The elasticities of g and h with respect to ω are less than one.
6. The elasticity of h with respect to R (for renters) or P_1 (for owners) is less than one in magnitude.
7. The elasticity of substitution between g and h is at most one.
8. The degree of relative risk aversion is less than two.

The directions of change expected under assumptions 1–8 are summarized in table 7.1. The impact of P_1 in this table does not take into account indirect effects arising because P_1 affects consumer beliefs about capital gains. The first row of the table is constructed under the assumption that across consumers there is a continuous distribution of beliefs about capital gains rates and that this distribution divides the population into owners and renters. The expected capital gains rate α is reinterpreted as characterizing the location of this distribution. Details of the construction of the table are given in the appendix.

Define the *ex ante expected savings rate* of the consumer to be $s^e = (W_2^e - W_1)/Y_1$, and the *ex post realized savings rate* to be $s = (W_2 - W_1)/Y_1 \equiv s^e + (1 - m)dhP_1(\mathring{P} - \alpha)/Y_1$. From table 7.1, the ex ante savings rate should fall when P_1 rises and rise when α rises, other things being equal. This effect can be reversed if consumers believe that α is higher when P_1 is higher. Define $\psi = (1 - m)dhP_1/Y_1$, and let $\alpha^r = \mathbf{E}_{P_1\mathcal{I}}\mathring{P}$ denote the statistical expectation of $\mathring{P}$, given initial information. Then $s = s^e + \psi(\mathring{P} - \alpha)$, implying that $\mathbf{E}_{\mathring{P}|\mathcal{I}}s = s^e + \psi(\alpha^r - \alpha)$ and $s - \mathbf{E}_{P|\mathcal{I}}s = \psi(\mathring{P} - \alpha^r)$. In the population, the ex post savings rate satisfies

$$(8)\qquad \begin{aligned}\mathrm{Cov}(s, P_1) &= \mathbf{E}_{\mathcal{I}}\{s^e + \psi(\alpha^r - \alpha)\}(P_1 - \mathbf{E}_{\mathcal{I}}P_1)\\ &= \mathbf{E}_{\mathcal{I}}s^e(P_1 - \mathbf{E}_{\mathcal{I}}P_1) + \mathbf{E}_{\mathcal{I}}\psi(\alpha^r - \alpha)(P_1 - \mathbf{E}_{\mathcal{I}}P_1)\end{aligned}$$

$$(9)\qquad \begin{aligned}\mathrm{Cov}(s, \mathring{P}) &= \mathbf{E}_{\mathcal{I}}\{s^e + \psi(\mathring{P} - \alpha^r) + \psi(\alpha^r - \alpha)\}\\ &\quad (\mathring{P} - \alpha^r + \alpha^r - \mathbf{E}_{\mathcal{I}}\alpha^r)\\ &= \mathbf{E}_{\mathcal{I}}s^e(\alpha^r - \mathbf{E}_{\mathcal{I}}\alpha^r) + \mathbf{E}_{\mathcal{I}}\psi\cdot\mathrm{Var}(\mathring{P}|\mathcal{I})\\ &\quad + \mathbf{E}_{\mathcal{I}}\psi(\alpha^r - \alpha)(\alpha^r - \mathbf{E}_{\mathcal{I}}\alpha^r).\end{aligned}$$

If consumer expectations α do not depend on P_1 and rational expectations α^r are uncorrelated with P_1, then the first term in equation (8) should be negative from table 7.1 and the second term should be zero, so that $\mathrm{Cov}(s, P_1) < 0$. If consumer expectations α are positively correlated with P_1, then the first term in equation (8) can be positive; the second term will reinforce this if rational expectations are more positively correlated with P_1 than beliefs and will offset this otherwise. The first term in equation (9) is nonnegative from table 7.1, provided consumer expectations are nonnegatively correlated with rational expectations. The second term is positive. The third term is zero if expectations are rational and positive if consumer beliefs exhibit "regression to the mean," positively correlated with rational expectations but with smaller deviations from the mean. If the correlation of P_1 and $\mathring{P}$ is low, then the slope coefficients

Table 7.1 Comparative Statics of Housing Demand

Quantity	Income Y_1	Rental Rate R	Housing Price P_1	Capital Gains Rate α
Share of owners ($d = 1$)	+	+	−	+
If renter				
Nonhousing consumption (g)	+	?	0	0
Housing consumption (h)	+	−	0	0
Financial assets (A_1)	+	−	0	0
Expected bequest (W_2^e)	+	−	0	0
If owner				
Nonhousing consumption (g)	+	0	?	?
Housing consumption (h)	+	0	−	+
Financial assets (A_1)	+	0	−	−
Expected bequest (W_2^e)	+	0	−	+

in a regression of s on one, P_1, and $\mathring{P}$ will have the signs of $\mathrm{Cov}(s, P_1)$ and $\mathrm{Cov}(s, \mathring{P})$, respectively. The magnitude of the coefficient of $\mathring{P}$ will be relatively small if capital gains are largely anticipated, so that the conditional variance of $\mathring{P}$ is small and the "bias" $\alpha - \alpha^r$ has a low correlation with α^r. If consumers are naive in forming expectations, believing that $\mathring{P}$ is more positively correlated with P_1 than is the case, this will make the coefficient of P_1 less positive and have relatively little effect on the coefficient of $\mathring{P}$.

We have argued that arbitrage by consumers, achieved by varying the level of housing consumption and by moving between rental and owner housing, should limit but not eliminate anticipated capital gains. The behavior of supply will also affect the transmission of demographic trends into housing prices. Poterba (1984), Topel and Rosen (1988), and McFadden (1994a) have found aggregate supply of new housing to be quite price-elastic, with elasticities around 2. Further, real housing investment has averaged 5.3 percent of real constant-quality stocks over the period 1900–1990, and the elasticity of stocks with respect to price is quite low, about 0.11. Then, one would expect short-run changes in housing demand to induce substantial short-run variations in housing prices. However, developers do have some control over the timing of completion and marketing of new houses, giving them some arbitrage opportunities when there are large anticipated capital gains or losses.

We conclude from this analysis that rational consumers should display behavioral response to anticipated capital gains, although arbitrage will limit the magnitude of these gains. If consumers expect no correlation between initial information and future price changes, so that there are no anticipated capital gains, then comparative statics suggests that ex post savings rates are likely to be negatively correlated with initial housing prices and correlated dollar for dollar with ex post realized capital gains. On the other hand, if arbitrage does not eliminate anticipated capital gains, and these are forecastable in part from initial housing prices and other information, then ex post savings can be positively correlated with initial house prices. Further, there may be some behavioral offset to the savings these capital gains are expected to generate.

7.2.2 Demographics and Housing Consumption

An empirical examination of demographics and housing consumption can be made using U.S. census public-use samples of 0.1 percent of the population, which give household size and age composition, status as a renter or owner, and owner-reported dwelling value. McFadden (1994a) analyzes the 1940, 1960, 1970, and 1980 census samples, adapting a model suggested by Mankiw and Weil (1989):

$$V_{ht} = \sum_{j=0}^{J} \alpha_{jt} K_{jht} + \varepsilon_{ht}, \tag{10}$$

where h indexes households, t indexes year, $j = 0, \ldots, J$ indexes five-year age cohorts, V_{ht} is stated dwelling value, K_{jht} is the number of persons in cohort j in household h, α_{jt} is the imputed housing consumption of individuals in cohort j in year t, and ε_{ht} is a disturbance. This model applies to homeowners. To correct for bias due to self-selection between owning and renting, a probit model is first estimated for tenure choice, using observations on both owners and renters:

$$\Pr(\text{Owner}) = \Phi(\gamma_0 + \gamma_1 y_{ht} + \gamma_2 y_{ht}^2 + \sum_{j=0}^{J} \beta_{jt} K_{jht}), \tag{11}$$

where y_{ht} is real household income. Then, an inverse Mills ratio is calculated from this probit equation and added to equation (10) to absorb the nonzero conditional expectation of ε_{ht} induced by selection. Figure 7.1, adapted from McFadden (1994a), plots the coefficients from the selection-adjusted regressions, *relative to the age 40–44 cohort,* for each census year. These profiles are remarkably stable between 1960 and 1980. The profile for 1940 shows less relative housing consumption for the cohorts between ages 25 and 39 than is observed in the later censuses. This is almost certainly attributable to the lack of consumer confidence and shortage of liquidity during the Great Depression, when these cohorts might normally have been rapidly increasing their housing consumption. This figure provides empirical justification for an assumption that the relative housing consumption profile will remain stable in the future. Figure 7.2 gives the 1970 profile, which will be used for further computation, with 95 percent confidence bounds. The profile is quite precisely determined except for the very old, where sample sizes are small.

McFadden (1994a) summarizes U.S. census data on population by sex and five-year age cohort in census years from 1900 through 1990, using *Current Population Reports* and contemporaneous life tables to interpolate in the early part of the century. He then uses the *cohort-component* projection procedure, combined with 1989 U.S. census "midrange" assumptions on fertility, mortal-

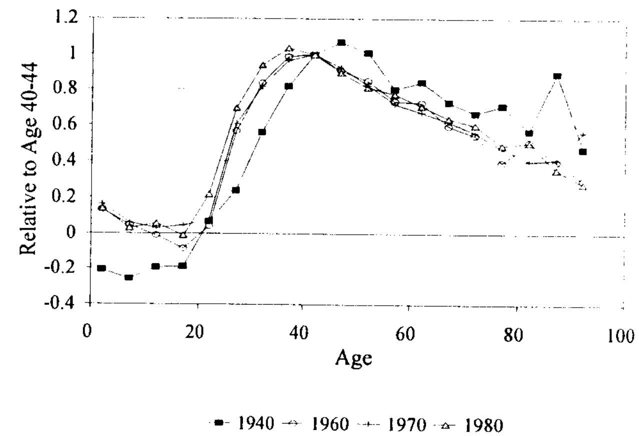

Fig. 7.1 Housing consumption
Source: McFadden (1994a).

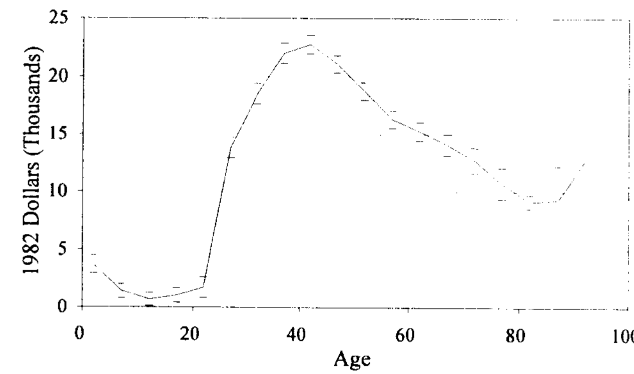

Fig. 7.2 1970 Housing consumption (with 95 percent confidence bounds)
Source: McFadden (1994a).

ity, and immigration, to project population by age cohort in the coming century. Figure 7.3 shows historical and projected population and *housing-consumption-equivalent* population, in which each age cohort is scaled to its equivalent numbers of age 40–44 persons using the coefficients from figure 7.2. Qualitatively, the equivalent population curve shows relatively steady growth from the beginning of the century until about 1975, rises more rapidly from 1975 to 1990 as the post–World War II baby boomers formed households and acquired houses, and is forecast to rise much more slowly after 1990, becoming essentially flat after 2020.

Equivalent population has a correlation of 0.964 with real constant-quality housing stock over the period 1900–1990 and a correlation of 0.904 with housing prices measured by the GNP implicit price deflator. Further evidence on the correlation of changes in equivalent population and housing prices is obtained by examining 112 metropolitan statistical areas (MSAs) and primary

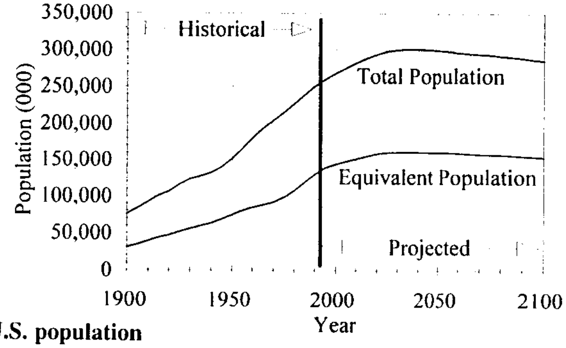

Fig. 7.3 U.S. population
Source: McFadden (1994a).

metropolitan statistical areas (PMSAs) during the decade of the 1980s. We use American Chamber of Commerce Researchers Association (ACCRA) data on prices of "standard 3 bedroom, 2 bath one-family houses suitable for a mid-management level owner" (ACCRA 1992). These data are obtained from quarterly surveys of homebuilders, mortgage bankers, appraisers, and savings and loan officers. Respondents were asked for sales prices of new homes meeting the criteria above and an additional list of detailed specifications. If no new homes meeting the specifications were marketed, then recent resale homes were asked for. A drawback of these prices is that they are not representative of the total housing market and may not be accurate for low-income consumers. Missing quarters are imputed by interpolation. In some cases, missing observations in are imputed by the following method: The National Association of Realtors *Home Sales* and *Home Sales Yearbook* provide data on median sales prices of resale one-family homes by year and MSA (National Association of Realtors 1990). For all MSAs where both the ACCRA and Realtors series are available, we form the ratio of their (unweighted) means in each year. Then we deflate the Realtors series using these ratios and use this deflated series to fill in missing observations in the ACCRA series. The effect of the deflation is to remove quality changes in the Realtors series that are held constant in the ACCRA series. The final extended ACCRA series is then in nominal dollars and is substantially but not completely adjusted to remove quality changes. The housing price data show substantial variation across MSAs. Figure 7.4 shows the distribution of rates of price changes, deflated by the CPI, from 1984 to 1989; the observations on which this distribution is based are weighted by MSA population. Some perspective on the consistency of these prices is provided by comparing them with median house values in the MSAs in census years. There is a mismatch in years (1984–89 for ACCRA, 1980–90 for the census), with some significant macroeconomic changes in the nonoverlapping period. Also, the census values are not quality-adjusted. Figure 7.5 shows a scatter plot of the two price series, along with a fit of census price changes to ACCRA price changes. There is considerable scatter, and a few MSAs, such

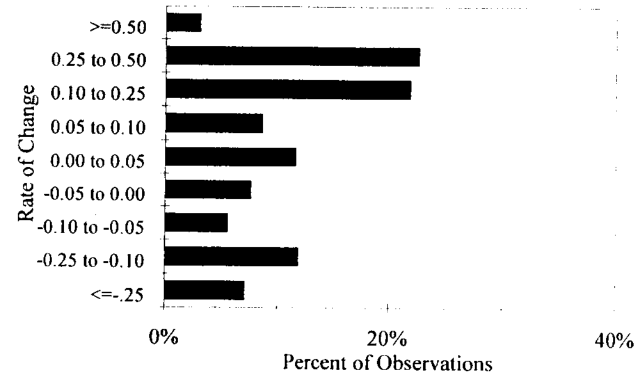

Fig. 7.4 ACCRA housing prices (frequency of 1984–89 rate of change)
Source: Authors' tabulation.

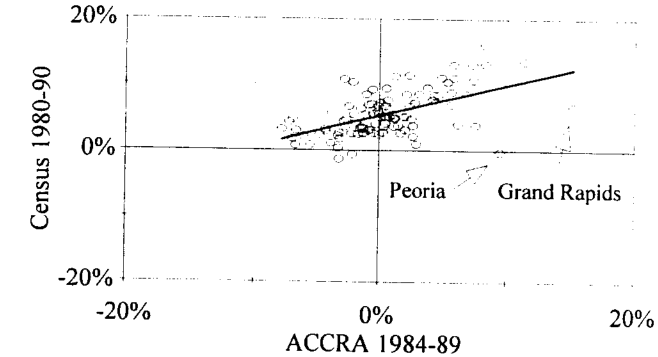

Fig. 7.5 MSA housing prices (annual rates of change)
Source: Authors' tabulation.

as Peoria, Grand Rapids, York, and Lancaster, are outliers. Nevertheless, the correlation of the two variables is 0.56.

Equivalent population for each MSA is approximated by applying the cohort-size-weighted average coefficients from figure 7.2 to the population age segments 0–18, 19–64, and 65+. For 1970, these age distributions were not available by MSA, so the corresponding age distribution in the state containing the MSA was used. Changes in equivalent population are quite forecastable in the short run, even at the MSA level. A regression of the rate of equivalent population change in 1980–90 on the rate of equivalent population change in 1970–80, plus a constant and the rate of change of real median prices in 1970–80, gives a multiple correlation coefficient of 0.407, with the lagged equivalent population change providing most of the explanatory power. The correlation of 1970–80 equivalent population change and 1980–90 equivalent population change is 0.618.

Figure 7.6 gives the scatter plot for the rates of change in real housing prices

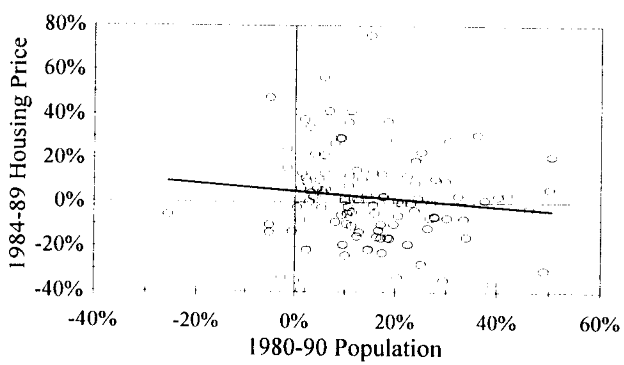

Fig. 7.6 Population and housing prices (rates of change)
Source: Authors' tabulation.

over 1984–89 and population over 1980–90. The figure also shows a regression through these points:

(12)

$$\log(\text{Price}_{89}/\text{Price}_{84}) = \underset{(0.029)}{0.050} - \underset{(0.146)}{0.175} \cdot \log\left(\text{Equiv. pop.}_{90}/\text{Equiv. pop.}_{80}\right).$$

Our comparative statics analysis suggests that price changes and population changes should be positively correlated in the market, even when the population change is fully anticipated. Unanticipated changes in population should have a stronger positive impact since they will not have increased initial prices via reduced user cost, which increases initial demand. However, the regression does not show the expected positive correlation between housing price change and equivalent population change and suggests instead that population changes are fully anticipated and actively arbitraged away. However, there are also several econometric reasons the regression might fail to exhibit the expected effects, including variations in income growth or economic conditions across MSAs that are omitted from the model, speculative "bubbles" in prices that increase variance and produce outliers, or measurement problems related to the definition of MSA boundaries and the distribution of home sales within each MSA. In addition, there may be self-selection between homeowners and renters that is related to population growth, and there may be endogeneity of population growth, which may respond to price differentials. Examination of the scatter plot suggests that there are outliers. However, a least absolute deviations regression that reduces the influence of outliers does not change the coefficients substantially.

Extending this analysis, we ask whether housing price changes are predictable from initial information on housing price levels (which may be correlates of past population growth) and the rate of change in population growth. The regression

(13)

$$\log\left(\frac{\text{Price}_{89}}{\text{Price}_{84}}\right) = \underset{(1.328)}{0.098} + \underset{(0.202)}{0.188} \cdot \log\left(\frac{\text{Equiv. pop.}_{90}}{\text{Equiv. pop.}_{80}}\right) - \underset{(0.183)}{0.472} \cdot \log\left(\frac{\text{Equiv. pop.}_{80}}{\text{Equiv. pop.}_{70}}\right) - \underset{(0.075)}{0.112} \cdot \log\left(\frac{\text{Median price}_{80}}{\text{Median price}_{70}}\right) + \underset{(0.117)}{0.011} \cdot \log(\text{Price}_{84})$$

has $R^2 = 0.108$, indicating that the initial information embodied in historical housing prices and current population growth has little predictive power but that past population growth does have some predictive power.

A second implication of the housing market model is that as a result of arbitrage the *level* of housing prices should be higher in markets where population growth is higher. To test this, we regress 1984 price on the rates of population change in 1970–80 and 1980–90 and on the 1970–80 rate of housing price change:

(14)

$$\log(\text{Price}_{84}) = \underset{(0.070)}{11.296} + \underset{(0.169)}{0.372} \cdot \log\left(\frac{\text{Equiv. pop.}_{90}}{\text{Equiv. pop.}_{80}}\right) - \underset{(0.156)}{0.072} \cdot \log\left(\frac{\text{Equiv. pop.}_{80}}{\text{Equiv. pop.}_{70}}\right) + \underset{(0.064)}{0.040} \cdot \log\left(\frac{\text{Median price}_{80}}{\text{Median price}_{70}}\right).$$

This regression indicates that initial price is positively related to future population growth but is not related to past rates of price change or population growth. This suggests that demographic effects are largely translated by arbitrage into initial prices, and consumers are primarily affected through these price changes rather than through capital gains.

Sharper, and somewhat different, results are obtained when the rate of growth of median house values, as reported by the census, is used instead of the ACCRA measure:

(15)

$$\log\left(\frac{\text{Median price}_{90}}{\text{Median price}_{80}}\right) = \underset{(1.076)}{1.042} + \underset{(0.282)}{0.893} \cdot \log\left(\frac{\text{Equiv. pop.}_{90}}{\text{Equiv. pop.}_{80}}\right) + \underset{(0.105)}{0.018} \cdot \log(\text{Price}_{80})$$

$$- 1.116 \cdot \log\left(\frac{\text{Equiv. pop.}_{80}}{\text{Equiv. pop.}_{70}}\right)$$
$$(0.264)$$
$$- 0.531 \cdot \log\left(\frac{\text{Median price}_{80}}{\text{Median price}_{70}}\right).$$
$$(0.111)$$

This regression has $R^2 = 0.35$, suggesting that real housing price changes *are* forecastable. Contemporaneous population growth has predictive power and is positively correlated with price changes. The effect of lagged price change is negative, suggesting that the market overshoots. Measurement error in census data should be modest but if present could also explain the last effect. The negative sign on past population growth rates also suggests a market cycle, with "spurts" of past population growth that are uncorrelated with current population growth possibly leading to "overbuilding," which creates downward pressure on market prices.

Since there is moderately good agreement between the ACCRA and census prices, it is surprising that regressions (13) and (15) are substantially different. In further analysis, we will use the ACCRA prices, which match the dates of the savings data to be analyzed. For the critical question of behavioral response in savings, we will repeat the analysis using the apparently more forecastable census prices.

The pattern of results for MSAs with census median house prices is confirmed by an analysis of changes in population and housing prices across states. We use the median of owner-reported dwelling values by state, not quality-adjusted, from the 1970, 1980, and 1990 U.S. censuses. We use state equivalent population, constructed in the same way as the MSA equivalent populations. The regressions analogous to (14) and (15) are

$$\log(\text{Price}_{80}) = \underset{(0.103)}{10.813} + \underset{(0.510)}{1.849} \cdot \log\left(\frac{\text{Equiv. pop.}_{90}}{\text{Equiv. pop.}_{80}}\right) \tag{16}$$
$$- \underset{(0.469)}{1.080} \cdot \log\left(\frac{\text{Equiv. pop.}_{80}}{\text{Equiv. pop.}_{70}}\right)$$
$$+ \underset{(0.304)}{1.083} \cdot \log\left(\frac{\text{Median price}_{80}}{\text{Median price}_{70}}\right),$$

$$\log\left(\frac{\text{Median price}_{90}}{\text{Median price}_{80}}\right) = - \underset{(1.317)}{2.391} + \underset{(0.481)}{1.580} \cdot \log\left(\frac{\text{Equiv. pop.}_{90}}{\text{Equiv. pop.}_{80}}\right) \tag{17}$$
$$+ \underset{(0.122)}{0.258} \cdot \log(\text{Price}_{80})$$

$$- 1.187 \cdot \log\left(\frac{\text{Equiv. pop.}_{80}}{\text{Equiv. pop.}_{70}}\right)$$
$$(0.413)$$
$$- 0.985 \cdot \log\left(\frac{\text{Median price}_{80}}{\text{Median price}_{70}}\right).$$
$$(0.286)$$

Equation (16) has $R^2 = 0.336$. Initial prices appear to be related to future population growth, indicating that arbitrage occurs. The terms involving equivalent population can be rearranged into the form

$$0.769 \cdot \log\left(\frac{\text{Equiv. pop.}_{90}}{\text{Equiv. pop.}_{80}}\right) + 1.080 \cdot \left\{\log\left(\frac{\text{Equiv. pop.}_{90}}{\text{Equiv. pop.}_{80}}\right) - \log\left(\frac{\text{Equiv. pop.}_{80}}{\text{Equiv. pop.}_{70}}\right)\right\}.$$

Then initial price is positively related to the rate of change of future population and to the rate of acceleration of equivalent population.

Equation (17) has $R^2 = 0.581$, so housing price changes appear to be forecastable, with current and lagged equivalent population growth and lagged price changes all significant. The directions of the effects are the same as were found in the MSA data. Again, the effects of equivalent population changes can be reinterpreted as positive response to contemporaneous equivalent population growth (with a coefficient of 0.393) and to the rate of acceleration of equivalent population (with a coefficient of 1.187).

The analysis above with ACCRA prices suggests that demographic effects are largely anticipated and arbitraged away in the housing market so that initial prices embody current information about forecastable trends. Because there are essentially no surprises in population growth over a decade, even at the MSA level, there is no significant correlation of ex post population change and ex post price change. However, using census prices, there appears to be evidence for a substantial forecastable component in housing prices. We have indicated several possible sources of differences in the two price series but have not identified any key features that would lead to the differences in fitted regressions using the two different sources. If the market is not perfectly efficient and there is substantial forecastability, then there is at least scope for a behavioral response that would mitigate some of the adverse effects of demographic changes that are expected to weaken the housing market and reduce real capital gains.

Over the 40-year horizon facing a 30-year-old prospective home buyer, birth rates and consequent changes in equivalent population are not so highly forecastable, and one would expect to see a significant positive correlation of ex post population changes and ex post price changes. These conclusions have several implications for life-cycle savings behavior. First, if arbitrage eliminates most forecastable capital gains, then there is little room for demographics to influence savings behavior except via its impact on initial prices. In the long run, the demographic effects may contain innovations that will result in ex post capital gains, but since these are not forecastable, they cannot alter savings behavior. Then most demographic change should have relatively little ex ante impact on behavior, with the consequence that the effects of demographics on market prices should translate directly into changes in welfare, particularly as a result of unanticipated changes late in life.

7.3 Wealth, Expectations, and Savings

7.3.1 Background

In this section we explore the role of ex post measures of capital gains in the housing market on household savings decisions. Equity in housing has traditionally represented a major component of household wealth in the United States. Feinstein and McFadden (1989), Venti and Wise (1990), and McFadden (1994b) have found that housing equity represents more than 50 percent of total wealth in the population over age 65. Housing wealth has increased with age, at least in the past decade, except for the very old, but extraction of equity becomes an important resource after age 75. The trend of rising house prices that has typified the U.S. market for past decades, as noted by McFadden (1994a), has translated into increases in wealth for current cohorts of elderly homeowners. However, Mankiw and Weil (1989) and McFadden (1994a) have argued that population aging in the United States in the coming three decades is likely to result in a reversal of these trends in housing prices. McFadden (1994a) finds that a potential implication of this reversal is capital losses accompanied by nontrivial welfare losses for younger cohorts of current homeowners. However, if households can anticipate changes in housing prices, and if they adjust their *nonhousing* savings accordingly, welfare losses in retirement could be mitigated. The empirical question that we examine in this section is how household savings decisions are affected by capital gains in housing.

Section 7.2 presented a simple two-period model of consumption and savings. An implication of that model is that consumers should show some savings behavior response to the level of housing prices, essentially because housing demand is inelastic, housing consumption cannot be reduced sufficiently to reduce equity, and compensating adjustments in financial savings are not fully offsetting. Another implication is that ex ante savings rates should respond positively to a change in beliefs that increases expected capital gains. Ex post savings rates, which incorporate realized capital gains, will reflect this dependence in addition to the dependence built into the accounting. However, if capital gains cannot be forecast from current information, including demographic trends, then only the accounting dependence will be observed. The results in section 7.2 suggest that this may indeed be the case. This should be seen most clearly by examining the rate of savings for assets other than housing equity.

Of course, if consumers are irrational in their beliefs and fail to use available information, then a behavioral response may be absent even if capital gains are in principle forecastable.

Recent data from the Panel Study of Income Dynamics (PSID) provides an excellent source for the analysis of savings among elderly households. Comprehensive data on housing and nonhousing wealth was collected in 1984 and 1989 for over 7,000 households. We use this wealth data to form measures of real savings rates over the five-year period. Data on average housing prices by MSA are used to form ex post real capital gain rates over the 1984–89 period, which are then matched to each household in the PSID based on their county of residence. If consumers can predict changes in housing prices *and* have full behavioral offset in savings, then we would expect to see very low correlation between changes in area housing prices and savings rates. However, if individuals are naive in forming expectations or do not adjust savings, then we would expect to see a positive correlation between ex post savings rates and ex post capital gains in housing, as suggested by equations (8) and (9) derived from the two-period model.

The MSA-level regression results in section 7.2 present somewhat mixed evidence concerning the degree to which capital gains in housing are forecastable based on current information, including demographics. In view of these results, the household-level savings regressions in this section use both sources of housing price data, those from ACCRA and from the census.

We present estimates of the effect of changes in housing prices on total, housing, and nonhousing savings rates. These regressions contain controls for age of head, health status, demographic characteristics such as marital status, race, education, and sex of head, and income and initial wealth.

7.3.2 Data and Definitions

The data used for our analysis of the determinants of household savings are drawn from the PSID, a longitudinal data set collected by the Institute for Social Research (ISR) at the University of Michigan, which began in 1968 with a sample of about 5,000 households containing 18,000 individuals. All members (and descendants) of these original survey families have been reinterviewed annually such that by the twenty-second year of the panel, more than 38,000 individuals have participated or are currently participating in the survey. All estimates presented here are based on the 1968–89 (or Wave XXII) sample of the PSID.

The PSID contains a detailed accounting of wealth for all survey households in 1984 and 1989. Using these data, we construct measures of net worth in 1984 and 1989 that include home equity (house value less remaining principal), other real estate equity, financial assets (savings accounts, money market accounts, CDs, treasury bills, mutual funds, stocks, and bonds), business equity, and vehicle equity, less household debt. In an assessment of quality of wealth estimates from survey data, Curtin, Juster, and Morgan (1989) found that the PSID provides wealth data that is "of surprisingly high quality, relative to the quality obtainable with much more intensive survey methods and higher costs per case" (477). In addition to the wealth data, the PSID contains data on health status, demographic variables, family composition, household income, and state and county of residence. The demographic data used in this analysis includes age, education, marital status, sex, and race of the head of household.

We limit the sample to include those households that had stable family compositions over the 1984–89 period. Primarily, we seek to exclude those families where there was a divorce, marriage, or remarriage during the five-year period. We choose to limit our analysis to these intact households because a major change in family composition, such as marriage or divorce, could have a large impact on the savings rate over this period that is not necessarily attributable to life-cycle savings behavior. There are a total of 7,114 households in the 1989 sample of the PSID, of which 4,719 satisfy our definition of an intact family. We further limit the sample by excluding families where the head of household was less than 30 years old and dropping observations with missing data on demographic variables, resulting in a sample with 4,360 observations.[2]

The PSID data are augmented with data on changes in housing prices by MSA from two different sources. The first source comes from ACCRA and covers the period 1984–89; the second source is the decennial census and covers the years 1980–90.[3] The ACCRA data are attractive because they measure constant-quality housing price for the same period that the PSID savings rate is measured. The census data represent owner-reported house value. Both sources of data are available at the MSA or PMSA level. Because the PSID identifies county of residence, not MSA, we merge the housing price data with the PSID data using a Census Bureau file that maps counties into MSAs. About 27 percent of the households in our sample live in counties that are not part of one of the 112 PMSAs or MSAs represented in the ACCRA data. In addition, price data were not available for the entire 1984–89 period for all of the MSAs. The resulting number of observations with data on area housing prices from ACCRA is 2,427.[4] Capital gains from housing are measured by the logarithm of the ratio of real housing prices in 1989 to real housing prices in 1984.

The dependent variable in the regressions is real savings rate over the five-

2. Our sample selection is designed to identify those households where there was no change in the head or spouse over the five-year period. The one exception is that we include those households where the head or spouse died between 1984 and 1989 but the surviving spouse did not remarry. Those households with no change in the head or spouse represent almost 98 percent of the observations in our data set. Overall, in the PSID, over 70 percent of the households in the 1989 sample had no change in the head or spouse between 1984 and 1989. We do not limit the sample to homeowners because one of the implications of the model in section 7.2 is that it may be optimal to change ownership status in response to anticipated capital gains or losses.

3. Both sources of housing price data are described in more detail in section 7.2.2.

4. We are able to assign housing price data to 2,694 of the 4,360 observations in the intact sample. The sample is reduced further to 2,427 observations by dropping those households that move out of the county during the five-year period 1984–89.

year period 1984–89. The savings rate is defined as the difference between real wealth in 1989 and real wealth in 1984 divided by the sum of real income over the period 1984–88,[5]

$$s = \frac{W_{89} - W_{84} / p_{84}}{\sum_{t=1984}^{1988} Y_t / p_t}.$$

In order to explore the effect of capital gains in housing on savings, we split total savings into its housing and nonhousing components. Wealth in each of the years can be easily separated into equity in housing and all nonhousing wealth. Housing wealth includes equity in the home and all other real estate equity, while nonhousing wealth includes financial assets (liquid assets, stocks, and bonds), business equity, and vehicle equity, less household debt. Using these wealth measures, the total savings rate over the period is separated into housing savings and nonhousing savings rates.

Summary statistics for the sample of all intact families from the PSID are provided in table 7.2. Table 7.3 provides descriptive statistics for the subsample with housing price data. In order to minimize the impact of outliers in savings rates, we drop observations in the top and bottom 2.5 percent of the total savings rate distribution.[6] The final sample sizes are 4,142 for all intact families and 2,331 for the sample of intact households with area housing price data.[7] Table 7.2 shows that mean wealth (in 1989 dollars) increased from $72,647 in 1984 to $95,707 in 1989. The real savings rate averaged 7.3 percent, about equally split between housing and nonhousing savings. The average age of the head of household in 1989 was 49, and over 1,180 families had a head over the age of 60. The health status variable is self-reported health status of the head in 1984. The values range from 1 (excellent) to 5 (very poor). Over half of the sample reports health to be excellent or very good. Sixty-three percent of the households are married couple households, and about 72 percent are headed by men. The sample of households in MSAs have slightly higher wealth, savings rates, and income. They are older and more likely to be single, black, and headed by a female. Average housing price (in 1989 dollars) increased from

5. The wealth data correspond to the years 1984 and 1989. To create the savings rate, we divide by total (real) income received in the period between the wealth assessments. This corresponds to income received in 1984–88. In the PSID, income received in calendar year t is reported in survey year $t + 1$. Therefore, total income is the real sum of income from calendar years 1984–88, or survey years 1985–89.

6. Trimming the data in this way drops observations with savings rates of less than −118 percent or more than 133 percent. There seem to be a few extreme outliers in the data, such as a savings rate of over 10,000 percent, and the estimates are sensitive to the exclusion of these outliers. Other than dropping these extreme outliers, the results are not sensitive to the amount of trimming of the data.

7. Note that these sample counts are for the ACCRA housing price data. The sample sizes are somewhat smaller for the census housing price data because of data availability.

Table 7.2 **Descriptive Statistics: Full Sample of Intact Households, 1984–89**

Statistic	Mean	Standard Deviation	Median	Minimum	Maximum
Total wealth 1984[a]	72,647	174,684	27,569	−216,200	5,752,500
Housing wealth 1984	39,081	78,008	16,708	−28,046	2,252,400
Nonhousing wealth 1984	33,565	130,267	7,208	−273,960	5,633,100
Total wealth 1989	95,707	235,097	36,675	−107,400	7,460,000
Housing wealth 1989	50,572	94,727	21,500	−100,000	2,270,000
Nonhousing wealth 1989	45,135	182,374	9,500	−126,800	6,675,000
Total savings rate 1984–89	0.073	0.321	0.027	−1.147	1.326
Housing savings rate 1984–89	0.039	0.255	0.000	−2.326	2.228
Nonhousing savings rate 1984–89	0.034	0.244	0.008	−1.873	1.946
Real income 1984–89	174,533	166,017	143,110	2,657	4,251,000
Age[b]	47.8	15.3	46	30	97
Health status 1984	2.528	1.182	2	1	5
Married	0.633				
Male	0.719				
Black	0.357				
Education <8	0.147				
Education 9–11	0.176				
Education 12	0.313				
Education 13–15	0.185				
Education ≥16	0.179				
N	4,142				

Source: Authors' tabulations from the 1989 PSID. See text for definition of sample.
[a]All dollar amounts are in 1989 dollars.
[b]Unless otherwise specified, all demographic characteristics are for the head of household in 1989.

$114,000 in 1984 to $130,952 in 1989, representing a increase of 9.2 percent. Figure 7.4 shows that there is large variation in the housing growth rate over this period. Over 50 percent of the sample had real growth between 10 and 50 percent, while about a third of the sample had capital losses.

7.3.3 Life-Cycle Savings and Wealth

The PSID data show large differences in the level and composition of wealth and savings by age of head of household. Figure 7.7 provides estimates for mean wealth in 1989 by age of head of household, and figure 7.8 plots median

Table 7.3 **Descriptive Statistics: Intact Households with MSA Housing Prices, 1984–89**

Statistic	Mean	Standard Deviation	Median	Minimum	Maximum
Total wealth 1984[a]	74,477	207,399	24,956	−216,200	5,752,500
Housing wealth 1984	41,455	90,802	14,321	−13,128	2,252,400
Nonhousing wealth 1984	33,022	156,676	6,564	−273,960	5,633,100
Total wealth 1989	100,922	283,206	35,000	−72,579	7,460,000
Housing wealth 1989	54,154	105,730	20,000	−71,319	2,270,000
Nonhousing wealth 1989	46,768	227,404	8,153	−126,800	6,675,000
Total savings rate 1984–89	0.080	0.311	0.026	−1.131	1.326
Housing savings rate 1984–89	0.046	0.244	0.000	−1.577	1.736
Nonhousing savings rate 1984–89	0.034	0.218	0.008	−1.873	1.489
Real income 1984–89	183,245	193,901	147,380	2,657	4,251,000
MSA housing price 1984	114,356	26,481	106,371	67,980	212,996
MSA housing price 1989	130,952	53,422	107,680	74,875	344,670
log(HPRY89/ HPRY84)	0.092	0.218	0.063	−0.361	0.758
Age[b]	49.9	14.8	47	30	97
Health status 1984	2.540	1.178	2	1	5
Married	0.586				
Male	0.674				
Black	0.433				
Education <8	0.132				
Education 9–11	0.186				
Education 12	0.317				
Education 13–15	0.195				
Education ≥16	0.170				
N	2,331				

Source: Authors' tabulations from the 1989 PSID. See text for definition of sample.
[a]All dollar amounts are in 1989 dollars.
[b]Unless otherwise specified, all demographic characteristics are for the head of household in 1989.

wealth by age of head of household.[8] Mean wealth rises steeply from ages 30–34 to ages 60–64, an increase from $34,000 to $160,000. Wealth falls to about $100,000 for ages 75 and over. Median wealth also follows this hump-

8. Means by five-year age class are fairly precisely estimated because cell sizes average 200–350. The exception is the oldest age group (85+), which is imprecisely estimated because sample size is 47.

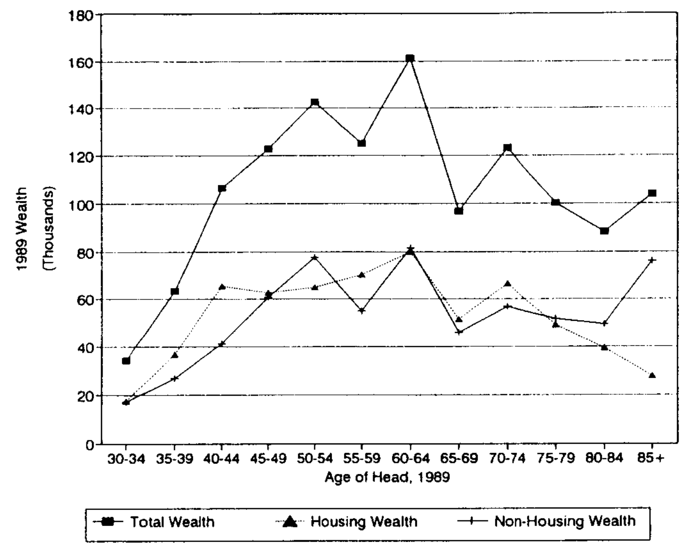

Fig. 7.7 Mean wealth by age of head of household
Source: Authors' tabulation from the 1989 PSID.

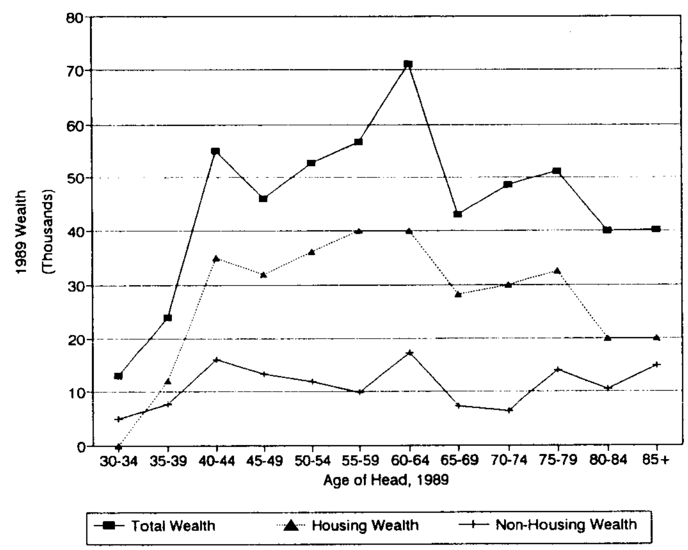

Fig. 7.8 Median wealth by age of head of household
Source: Authors' tabulation from the 1989 PSID.

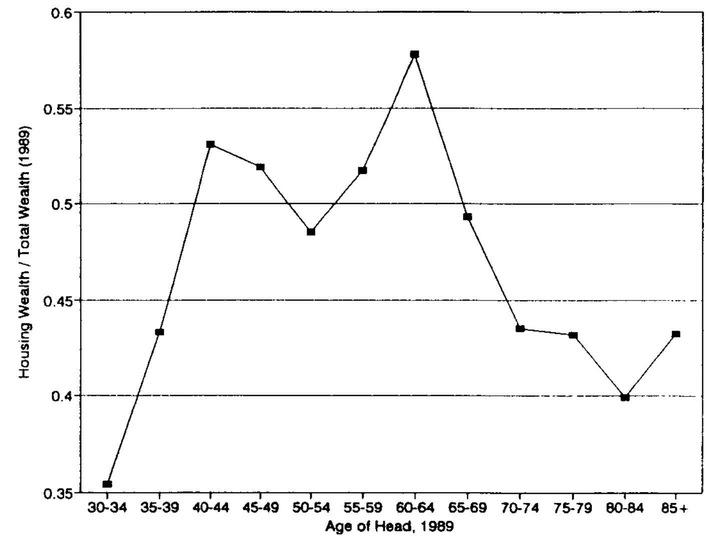

Fig. 7.9 Housing wealth as a percentage of total wealth by age of head of household
Source: Authors' tabulation from the PSID.

shaped pattern, but because of the highly skewed nature of wealth, the levels are consistently lower. Median wealth rises from $13,020 for households with heads aged 30–34 to $70,000 for those aged 60–64, then falls to about $40,000–$50,000 for those aged 70 and over.[9]

Figures 7.7 and 7.8 also plot the housing and nonhousing components of household wealth. The hump-shaped pattern for wealth is particularly apparent for housing wealth, but it is not apparent for nonhousing wealth. Median housing wealth falls from $40,000 among those aged 55–64 to $20,000 for those aged 80 and over. At the same time, median nonhousing wealth remains fairly constant over this age range.

Housing wealth represents the single most important part of total household wealth among families in the United States. Among our sample of intact families in the PSID data, housing wealth represents, on average, over half of total wealth. As shown in figure 7.9, the relative importance of housing wealth varies dramatically over the life cycle. Among younger families homeownership is low; housing wealth peaks as a percentage of total wealth at ages 60–64 and then decreases. Housing wealth as a percentage of total wealth increases from about 35 percent among the youngest cohort to a high of over 55 percent for

9. Because we are only using one year of wealth data, these age effects of wealth could also be generated by cohort effects. That is, those aged 80–84 in the data also belong to the same birth cohort. These data do not allow for the separate identification of age effects and cohort effects. For an analysis of financial wealth holdings by age and birth cohort, see Attanasio (1993).

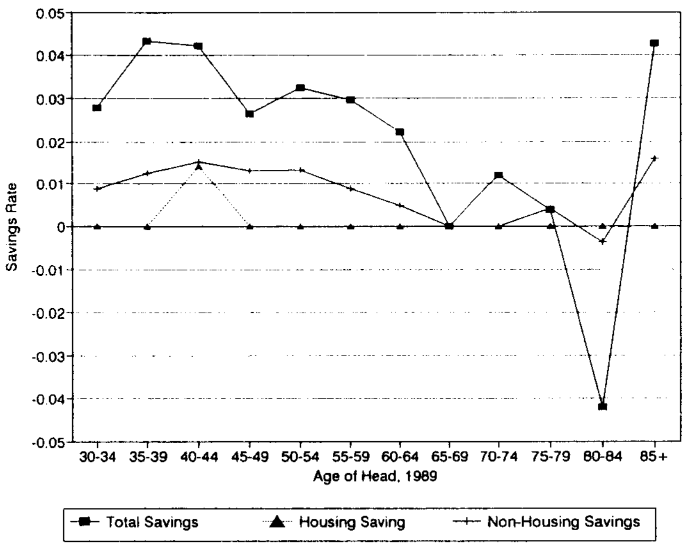

Fig. 7.10 Mean five-year savings rate by age of head of household in 1989
Source: Authors' tabulation from the 1984–89 PSID.

those aged 60–64, then falls to about 40 percent of total wealth for those in the oldest cohorts.

Figure 7.10 summarizes the life-cycle pattern of total, housing, and nonhousing savings rates over the period 1984–89. Between the ages of 35 and 60, the total savings rate averages about 9 percent of real income over the five-year period. After age 60, the savings rate decreases to about 5 percent and eventually turns negative only at the highest age levels. Housing savings follows this same pattern, with lower savings rates among the elderly. Nonhousing savings, however, remain more steady over the life cycle.

7.3.4 Savings Rates and Capital Gains in Housing

This section investigates the effect of changes in housing prices on five-year savings rates using a sample of intact families from the PSID. As described above, the savings rate data correspond to the period 1984–89. The housing price data refer to price changes for the MSA that the family resides in. The ACCRA housing price data cover the years 1984–89, while the census data cover the years 1980–90.

Table 7.4A presents parameter estimates for regressions where the dependent variable is the total savings rate.[10] Model (1) relates savings rates to age

10. For each of the models reported in this section, the dependent variable is the savings rate multiplied by 100.

Table 7.4A Parameter Estimates for Savings Rate Regressions Where Dependent Variable = Total Savings Rate: Capital Gains in Housing for 1984–89

	Model							
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	−2.117	−5.864	−1.982	−157.838	−151.100	−147.397	−137.785	−134.940
	(6.320)	(6.664)	(8.742)	(36.849)	(41.933)	(42.293)	(42.235)	(42.198)
Age	0.472	0.407	0.347	0.265	0.115	0.034	−0.061	−0.195
	(0.247)	(0.249)	(0.331)	(0.330)	(0.352)	(0.362)	(0.358)	(0.359)
Age²/100	−0.519	−0.363	−0.339	−0.267	−0.133	−0.060	0.026	0.210
	(0.225)	(0.226)	(0.306)	(0.305)	(0.325)	(0.334)	(0.332)	(0.332)
Married		4.102	4.541	4.410	4.581	4.547	3.628	2.390
		(1.751)	(2.198)	(2.190)	(2.275)	(2.276)	(2.305)	(2.299)
Black		−1.363	−1.182	−1.460	−1.029	−1.045	−0.561	−0.476
		(1.155)	(1.441)	(1.437)	(1.541)	(1.542)	(1.551)	(1.544)
Male		1.420	3.311	3.375	3.730	3.778	3.488	2.982
		(1.879)	(2.306)	(2.297)	(2.386)	(2.387)	(2.385)	(2.365)
Education 9–11		−1.029	−2.984	−2.841	−3.123	−3.156	−3.151	−2.592
		(1.800)	(2.307)	(2.298)	(2.411)	(2.413)	(2.408)	(2.390)
Education 12		1.330	−2.268	−2.135	−2.271	−2.336	−2.585	−2.238
		(1.703)	(2.209)	(2.200)	(2.309)	(2.311)	(2.309)	(2.295)
Education 13–15		3.665	−2.378	−2.672	−2.276	−2.353	−2.892	−2.837
		(1.912)	(2.461)	(2.452)	(2.592)	(2.596)	(2.601)	(2.586)
Education ≥16		8.932	4.713	4.304	3.809	3.807	2.218	1.014
		(2.004)	(2.655)	(2.647)	(2.815)	(2.816)	(2.886)	(2.887)

(continued)

Table 7.4A (continued)

	Model							
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Health status		−1.132	−1.473	−1.518	−0.776	−0.763	−0.505	−0.352
		(0.495)	(0.631)	(0.628)	(0.663)	(0.664)	(0.672)	(0.668)
log(HPYR89/ HPRY84)[a]			22.800	18.628	20.529		19.910	19.930
			(2.905)	(3.048)	(4.111)		(4.113)	(4.077)
log(HPRY84/ 100,000)[a]				13.651	13.256	13.108	12.326	11.940
				(3.136)	(3.622)	(3.636)	(3.637)	(3.621)
log(POP80/ POP70)[b]					2.357	2.439	1.819	3.764
					(6.135)	(6.141)	(6.131)	(6.086)
log(HPRY80/ HPRY70)[c]					−1.180	−1.120	−0.801	−0.364
					(2.626)	(2.630)	(2.628)	(2.606)
log(HPRY89/ HPRY84 * Age ≤40						24.556		
						(5.834)		
log(HPRY89/ HPRY84) * Age 41–60						18.923		
						(6.417)		
log(HPRY89/ HPRY84) * Age >60						18.241		
						(5.547)		
Real income 1984–89[d]							1.122	3.789
							(0.459)	(0.627)
Housing wealth 1984[d]								−1.555
								(0.855)
Nonhousing wealth 1984[d]								−3.161
								(0.554)
Adjusted R^2	0.0027	0.0276	0.0621	0.0693	0.0631	0.0626	0.0654	0.0825
N	4,142	4,142	2,331	2,331	1,996	1,996	1,996	1,996

Note: Based on authors' tabulations from the 1989 PSID. See text for description of sample selection. The dependent variable is the real savings rate over the five-year period 1984–89, which is calculated by dividing the change in real wealth by real income over the five-year period. All specifications include controls for age, sex, race, education, marital status, and health status of the head of household. All dollar amounts are in 1989 dollars. Standard errors are in parentheses.

[a]ACCRA data for constant-quality housing prices.

[b]Population by MSA from decennial census.

[c]Median home value (not quality-adjusted) from decennial census by MSA.

[d]In 100,000 dollars.

Table 7.4B Parameter Estimates for Savings Rate Regressions Where Dependent Variable = Total Savings Rate: Capital Gains in Housing for 1980–90

	Model		
Variable	(1)	(2)	(3)
Constant	−8.281	−106.709	−106.659
	(9.262)	(22.048)	(23.046)
Age	0.177	0.142	0.093
	(0.349)	(0.348)	(0.351)
Age²/100	−0.194	−0.169	−0.114
	(0.323)	(0.321)	(0.325)
Married	5.355	5.440	4.527
	(2.270)	(2.258)	(2.276)
Black	−1.901	−1.349	−1.583
	(1.506)	(1.501)	(1.522)
Male	3.158	3.212	4.016
	(2.381)	(2.368)	(2.387)
Education 9–11	−2.685	−2.502	−2.672
	(2.412)	(2.398)	(2.415)
Education 12	−1.765	−1.854	−1.881
	(2.296)	(2.283)	(2.307)
Education 13–15	−1.108	−1.918	−2.186
	(2.574)	(2.565)	(2.590)
Education ≥16	5.448	4.572	4.330
	(2.793)	(2.783)	(2.805)
Health status 1984	−0.745	−0.725	−0.777
	(0.662)	(0.659)	(0.661)
log(HPRY90/HPRY80)[a]	13.832	16.154	15.577
	(1.890)	(1.937)	(2.542)
log(HPRY80/100,000)[a]		9.113	9.322
		(1.855)	(2.073)
log(POP80/POP70)[b]			0.076
			(6.152)
log(HPRY80/HPRY70)[a]			−0.511
			(2.866)
Adjusted R^2	0.0582	0.0688	0.0663
N	2,045	2,045	2,024

Note: See table 7.4A note.
[a]Median home value (not quality-adjusted) from decennial census by MSA.
[b]Population by MSA from decennial census.

of head of household, and the results imply a hump-shaped age profile. As shown in figure 7.10, the savings rate decreases with age beginning at about age 45. Model (2) considers a larger set of demographic variables. Savings rates are found to be higher for married couples and those families whose head of household is nonblack or male. However, neither sex nor race of head of household is found to significantly affect savings rates. Higher education levels (education of the head) are associated with higher rates of savings. Self-

reported health of the head in 1984 is associated with lower levels of savings. This is consistent with the evidence in Attanasio and Hoynes (1995), where lower levels of household wealth are associated with higher levels of mortality risk. Controlling for these demographic variables shifts out the age profile for savings rates. The parameter estimates in model (2) imply that savings rates are maximized at age 56 and decline after.

The next three models add capital gains in housing prices for the MSA of residence to the savings rate regression.[11] These housing price data correspond to 1984–89 and are from ACCRA. The housing price variable is constructed as the logarithm of the ratio of real housing prices in 1989 to real housing prices in 1984. The estimates in model (3) imply that an increase in the growth rate of real housing prices of 10 percentage points will lead, on average, to an increase in the total savings rate of 2.28 percentage points, or an increase of 37 percent. What does this suggest for the amount of behavioral offset that households are engaging in? At mean levels of income and wealth, an additional real increase of 10 percentage points in home value (with no offsetting change in savings) will lead to an increase in the savings rate of 3.10 percentage points. If individuals are, in fact, forming correct expectations about changes in housing prices, then these estimates suggest that they are making (at the most) very minor changes to their nonhousing savings.

This result can also be seen by considering the effect of capital gains in housing on housing and nonhousing savings rates. Parameter estimates for the housing savings rate regressions are presented in table 7.5A, while the nonhousing savings rate estimates are in table 7.6A.[12] Consider the estimates for model (3) in tables 7.5A and 7.6A. Changes in area housing prices have the same effect on the housing savings rate as was found for the total savings rate. For nonhousing savings, capital gains in housing are associated with both small and statistically insignificant changes in nonhousing savings.

The model presented in section 7.2 suggests that savings rates should be correlated with the initial level of housing prices, as well as with the growth rate. Model (4) adds the logarithm of the 1984 housing price to the regressions. Increases in initial housing prices are associated with increases in the total and

11. Note that the sample size is reduced by half when we include the MSA-level housing price data in the specification. As described in section 7.3.2, this is because of incomplete price data and because about a quarter of the PSID sample does not live in an MSA. Estimates not reported here suggest that there are not large differences in the role of demographic variables among these two samples. Because of the smaller sample, however, the precision of the estimates generally is reduced.

12. The effects of demographic variables on housing and nonhousing savings rates are similar to the results summarized for the total savings rate equation. Notable differences are that health status in 1984 is more important in determining changes in nonhousing as compared to housing wealth. If poor health leads to low savings rates because of an increase in medical costs, reductions in nonhousing wealth would be expected because of the highly illiquid nature of housing wealth. In addition, housing savings is found to peak at an earlier age compared to total savings rates. Model (2) implies that housing savings rates begin to decline at age 49, compared to age 56 for total savings.

Table 7.5A **Parameter Estimates for Savings Rate Regressions Where Dependent Variable = Housing Savings Rate: Capital Gains in Housing for 1984–89**

	Model							
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	−10.132	−11.288	−6.512	−155.981	−163.530	−161.486	−163.888	−181.460
	(5.004)	(5.313)	(6.859)	(28.855)	(33.692)	(33.982)	(33.985)	(34.071)
Age	0.679	0.618	0.465	0.387	0.393	0.337	0.397	0.521
	(0.196)	(0.198)	(0.259)	(0.258)	(0.282)	(0.291)	(0.288)	(0.290)
Age²/100	−0.729	−0.629	−0.487	−0.418	−0.430	−0.377	−0.434	−0.499
	(0.178)	(0.181)	(0.240)	(0.239)	(0.261)	(0.268)	(0.267)	(0.268)
Married		3.658	4.827	4.701	4.656	4.639	4.682	4.825
		(1.396)	(1.725)	(1.715)	(1.828)	(1.829)	(1.855)	(1.856)
Black		0.655	0.754	0.488	0.557	0.540	0.545	0.046
		(0.921)	(1.131)	(1.125)	(1.238)	(1.239)	(1.248)	(1.247)
Male		0.371	0.677	0.739	1.234	1.267	1.240	1.250
		(1.498)	(1.809)	(1.799)	(1.917)	(1.918)	(1.919)	(1.909)
Education 9–11		−3.282	−4.386	−4.248	−4.659	−4.674	−4.658	−4.135
		(1.435)	(1.810)	(1.799)	(1.937)	(1.938)	(1.938)	(1.930)
Education 12		−0.949	−3.509	−3.381	−3.960	−3.997	−3.952	−3.237
		(1.357)	(1.733)	(1.723)	(1.855)	(1.857)	(1.858)	(1.853)
Education 13–15		1.517	−2.361	−2.643	−2.677	−2.716	−2.661	−1.895
		(1.524)	(1.931)	(1.920)	(2.082)	(2.086)	(2.093)	(2.088)
Education ≥16		2.667	−1.802	−2.194	−2.014	−2.011	−1.971	−1.200
		(1.598)	(2.083)	(2.073)	(2.262)	(2.263)	(2.322)	(2.331)
Health status 1984		−0.485	−0.780	−0.824	−0.458	−0.447	−0.466	−0.594
		(0.395)	(0.495)	(0.492)	(0.533)	(0.533)	(0.541)	(0.540)
log(HPRY89/ HPRY84)[a]			22.536	18.535	15.609		15.626	16.016
			(2.279)	(2.387)	(3.303)		(3.310)	(3.292)
log(HPRY84/ 100,000)[a]				13.092	13.825	13.762	13.850	14.916
				(2.456)	(2.910)	(2.921)	(2.927)	(2.924)
log(POP80/POP70)[b]					−4.802	−4.778	−4.787	−3.458
					(4.929)	(4.934)	(4.933)	(4.914)
log(HPRY80/ HPRY70)[c]					−0.590	−0.562	−0.600	−0.150
					(2.110)	(2.113)	(2.115)	(2.104)
log(HPRY89/ HPRY84) * Age ≤40						18.507		
						(4.687)		
log(HPRY89/ HPRY84) * Age 41–60						13.725		
						(5.156)		
log(HPRY89/ HPRY84) * Age >60						14.426		
						(4.457)		
Real income 1984–89[d]							−0.030	0.743
							(0.370)	(0.506)
Housing wealth 1984[d]								−3.341
								(0.690)
Nonhousing wealth 1984[d]								−0.322
								(0.448)
Adjusted R^2	0.0082	0.0196	0.0572	0.0683	0.0600	0.0595	0.0597	0.0704
N	4,142	4,142	2,331	2,331	1,996	1,996	1,996	1,996

Note: See table 7.4A note.

[a]ACCRA data for constant-quality housing prices.

[b]Population by MSA from decennial census.

[c]Median home value (not quality-adjusted) from decennial census by MSA.

[d]In 100,000 dollars.

Table 7.5B Parameter Estimates for Savings Rate Regressions Where Dependent Variable = Housing Savings Rate: Capital Gains in Housing for 1980–90

Variable	Model (1)	(2)	(3)
Constant	−14.962	−107.416	−102.791
	(7.414)	(17.608)	(18.425)
Age	0.452	0.419	0.307
	(0.280)	(0.278)	(0.281)
Age²/100	−0.488	−0.464	−0.353
	(0.259)	(0.257)	(0.260)
Married	5.676	5.756	5.507
	(1.817)	(1.803)	(1.820)
Black	−0.104	0.415	0.423
	(1.205)	(1.199)	(1.217)
Male	0.357	0.408	0.763
	(1.906)	(1.891)	(1.908)
Education 9–11	−4.102	−3.930	−4.179
	(1.930)	(1.915)	(1.931)
Education 12	−3.298	−3.382	−3.688
	(1.837)	(1.823)	(1.845)
Education 13–15	−1.461	−2.223	−2.557
	(2.060)	(2.048)	(2.071)
Education ≥16	−0.931	−1.754	−2.048
	(2.236)	(2.223)	(2.242)
Health status 1984	−0.341	−0.321	−0.382
	(0.530)	(0.526)	(0.529)
log(HPRY90/HPRY80)[a]	12.945	15.126	14.316
	(1.512)	(1.547)	(2.032)
log(HPRY80/100,000)[a]		8.560	8.472
		(1.481)	(1.658)
log(POP80/POP70)[b]			−3.194
			(4.918)
log(HPRY80/HPRY70)[a]			0.472
			(2.292)
Adjusted R^2	0.0515	0.0664	0.0638
N	2,045	2,045	2,024

Note: See table 7.4A note.

[a]Median home value (not quality-adjusted) from decennial census by MSA.

[b]Population by MSA from decennial census.

housing savings rates but have no significant effect on nonhousing savings. A 10 percent increase in initial housing prices increases the (total) savings rate by 1.4 percentage points, an increase of about 17 percent. Finally, model (5) includes past measures of population and price changes for the MSA. Neither of these variables affect household savings.

The savings regressions presented above assume that the behavioral re-

Table 7.6A Parameter Estimates for Savings Rate Regressions Where Dependent Variable = Nonhousing Savings Rate: Capital Gains in Housing for 1984–89

Variable	Model (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	8.015	5.424	4.529	−1.858	12.429	14.089	26.103	46.520
	(4.821)	(5.118)	(6.245)	(26.429)	(29.919)	(30.181)	(30.086)	(29.927)
Age	−0.207	−0.211	−0.118	−0.122	−0.277	−0.303	−0.458	−0.716
	(0.189)	(0.191)	(0.236)	(0.237)	(0.251)	(0.258)	(0.255)	(0.255)
Age²/100	0.210	0.266	0.148	0.151	0.297	0.317	0.461	0.710
	(0.172)	(0.174)	(0.218)	(0.219)	(0.232)	(0.238)	(0.236)	(0.235)
Married		0.445	−0.286	−0.291	−0.075	−0.092	−1.054	−2.436
		(1.345)	(1.570)	(1.571)	(1.623)	(1.624)	(1.642)	(1.630)
Black		−2.018	−1.937	−1.948	−1.586	−1.584	−1.106	−0.522
		(0.887)	(1.030)	(1.031)	(1.099)	(1.100)	(1.105)	(1.095)
Male		1.049	2.634	2.637	2.497	2.511	2.248	1.732
		(1.443)	(1.647)	(1.647)	(1.702)	(1.703)	(1.699)	(1.677)
Education 9–11		2.253	1.402	1.407	1.536	1.519	1.507	1.543
		(1.382)	(1.648)	(1.648)	(1.720)	(1.722)	(1.715)	(1.695)
Education 12		2.278	1.240	1.246	1.689	1.660	1.367	1.000
		(1.308)	(1.578)	(1.578)	(1.647)	(1.649)	(1.645)	(1.628)
Education 13–15		2.148	−0.017	−0.029	0.401	0.362	−0.231	−0.942
		(1.469)	(1.758)	(1.759)	(1.849)	(1.852)	(1.852)	(1.834)
Education ≥16		6.264	6.515	6.498	5.823	5.817	4.189	2.214
		(1.539)	(1.897)	(1.898)	(2.008)	(2.010)	(2.056)	(2.047)
Health status 1984		−0.647	−0.692	−0.694	−0.318	−0.316	−0.039	0.242
		(0.380)	(0.450)	(0.451)	(0.473)	(0.474)	(0.479)	(0.474)
log(HPRY89/HPRY84)[a]			0.264	0.093	4.920		4.285	3.915
		(2.705)	(2.186)	(2.933)		(2.930)	(2.892)	
log(HPRY84/100,000)[a]				0.559	−0.570	−0.654	−1.524	−2.977
				(2.249)	(2.584)	(2.595)	(2.591)	(2.568)

(continued)

Table 7.6A (continued)

Variable	Model (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(POP80/POP70)[b]					7.159	7.216	6.607	7.222
					(4.377)	(4.382)	(4.367)	(4.316)
log(HPRY80/HPRY70)[c]					−0.591	−0.558	−0.201	−0.214
					(1.874)	(1.877)	(1.872)	(1.848)
log(HPRY89/HPRY84) * Age ≤40						6.049		
						(4.163)		
log(HPRY89/HPRY84) * Age 41–60						5.198		
						(4.579)		
log(HPRY89/HPRY84) * Age > 60						3.815		
						(3.959)		
Real income 1984–89[d]							1.152	3.046
							(0.327)	(0.444)
Housing wealth 1984[d]								1.786
								(0.606)
Nonhousing wealth 1984[d]								−2.840
								(0.393)
Adjusted R^2	0.0001	0.0118	0.0206	0.0202	0.0152	0.0142	0.0208	0.0471
N	4,142	4,142	2,331	2,331	1,996	1,996	1,996	1,996

Note: See table 7.4A note.
[a]ACCRA data for constant-quality housing prices.
[b]Population by MSA from decennial census.
[c]Median home value (not quality-adjusted) from decennial census by MSA.
[d]In 100,000 dollars.

Table 7.6B **Parameter Estimates for Savings Rate Regressions Where Dependent Variable = Nonhousing Savings Rate: Capital Gains in Housing for 1980–90**

Variable	Model (1)	(2)	(3)
Constant	6.681	0.706	−3.868
	(6.670)	(15.972)	(16.657)
Age	−0.274	−0.276	−0.214
	(0.252)	(0.252)	(0.254)
Age²/100	0.294	0.295	0.239
	(0.233)	(0.233)	(0.235)
Married	−0.321	−0.316	−0.980
	(1.635)	(1.635)	(1.645)
Black	−1.797	−1.764	−2.006
	(1.084)	(1.088)	(1.100)
Male	2.801	2.804	3.253
	(1.715)	(1.715)	(1.725)
Education 9–11	1.417	1.428	1.507
	(1.737)	(1.737)	(1.746)
Education 12	1.534	1.528	1.807
	(1.653)	(1.654)	(1.668)
Education 13–15	0.353	0.304	0.371
	(1.854)	(1.858)	(1.872)
Education ≥16	6.379	6.326	6.378
	(2.011)	(2.016)	(2.027)
Health status 1984	−0.404	−0.403	−0.395
	(0.477)	(0.477)	(0.478)
log(HPRY90/HPRY80)[a]	0.887	1.028	1.261
	(1.361)	(1.403)	(1.837)
log(HPRY80/100,000)[a]		0.553	0.850
		(1.344)	(1.498)
log(POP80/POP70)[b]			3.270
			(4.446)
log(HPRY80/HPRY70)[a]			−0.983
			(2.072)
Adjusted R^2	0.0172	0.0168	0.0164
N	2,045	2,045	2,024

Note: See table 7.4A note.
[a]Median home value (not quality-adjusted) from decennial census by MSA.
[b]Population by MSA from decennial census.

sponse to a given change in capital gains is constant across all households. Because older homeowners are closer to retirement and possibly more likely to be considering selling their homes in the near future than younger homeowners, it is possible that the behavioral response would differ with the age of the household head. Model (6) interacts the change in housing prices with dummies for age of the household head. Our results show no significant differences in the responses of households with heads less than age 40, between ages 40 and 60, and over age 60.[13]

Further, we find that adding controls for household wealth and income does not change the conclusions about the role of capital gains in housing. Models (7) and (8) in tables 7.4A, 7.5A, and 7.6A show that higher household income and lower initial wealth are associated with higher savings rates. The results for wealth, however, appear to be spurious: initial housing wealth is significantly negatively correlated with housing savings, while initial nonhousing wealth is significantly negatively correlated with nonhousing savings rates.

These savings regressions imply that households are not engaging in any behavioral offset in response to changes in housing prices. However, if capital gains cannot be forecast from current information, then we would not expect to see the households engaging in any offsetting behavior. The results in section 7.2 suggest that, when the ACCRA data are used, housing prices are not forecastable from current information, including demographics. However, the census data imply that these gains are not arbitraged away and housing prices are forecastable from demographics. Tables 7.4B, 7.5B, and 7.6B present estimates for models that use the census price data to reconsider the issue of behavioral offset.

Model (1) in tables 7.4B, 7.5B, and 7.6B includes the full set of demographic variables and the growth rate in housing prices over 1980–90. The housing price variable is constructed as the logarithm of the ratio of real housing prices in 1990 to real housing prices in 1980. Results using the census data have the same implications about offsetting behavior as we found with the ACCRA housing price data. Increases in capital gains in housing have a large and positive effect on both total and housing savings. The results in table 7.6B, however, show that there is no effect of changes in capital gains in housing prices on nonhousing savings. These results are robust to the addition of 1980 housing price (model [2]) as well as measures of past growth in population and housing prices (model [3]).

If households can perfectly predict capital gains in housing *and* they offset this change by fully adjusting nonhousing savings rates, then we would expect to see zero correlation between changes in housing prices and total savings rates and negative correlation between changes in housing prices and nonhousing savings rates. We find neither. There are several hypotheses, however, that are consistent with our findings: Expectations about capital gains in housing prices may not play any role in savings decisions; that is, even if consumers had perfect foresight about changes in housing prices, they do not change their savings rates to try to achieve some target total savings over the period. Alternatively, expectations play a role but households are "naive" in forming these expectations; that is, they may not be using all available information (e.g., forecastable components of housing price changes such as demographic trends) to form expectations about changes in housing prices.

13. We considered several specifications for the interaction between age and price change (e.g., various other dummy variable interactions and an age polynomial), and in each case there were no significant age effects.

7.4 Concluding Remarks

Housing equity represents an important part of household wealth in the United States. Steady gains in housing prices over the last several decades have generated large potential gains in household wealth among homeowners. Mankiw and Weil (1989) and McFadden (1994a) have argued that the population aging in the United States is likely to induce substantial declines in housing prices, resulting in capital losses for future elderly generations. However, if households are able to anticipate these housing price changes and they modify their nonhousing savings decisions, then potential losses may be mitigated.

We use data on housing prices and demographic trends for 112 metropolitan statistical areas to investigate whether housing prices are forecastable from current information. We then estimate housing savings rate equations using data on five-year savings rates from the Panel Study of Income Dynamics. We use data from two different sources to examine the effect of demographics on housing prices, and in future research we intend to use alternative data sources to further examine this important issue.

While our results are mixed with respect to the forecastability of housing prices, we found no evidence that households were changing their nonhousing savings in response to expectations about capital gains in housing. This lack of adjustment could result in large welfare losses to current homeowners and large intergenerational equity differences.

Appendix

Comparative Statics for the Housing Demand Model

This appendix analyzes the comparative statics of housing demand and savings in the two-period model. Assumptions will be stated when they are first used, starting with the following basic assumptions:

1. U is strictly concave and nondecreasing with $\nabla_g U(0, h) = +\infty$, $\nabla_h U(g, 0) = +\infty$, and $\nabla_h U(g, +\infty) = 0$.

2. Housing and nonhousing consumption are normal goods; that is, $\nabla_g(\nabla_g U/\nabla_h U) \leq 0$ and $\nabla_h(\nabla_g U/\nabla_h U) \geq 0$.

3. V is a constant relative risk aversion utility function; that is, $V(w) = -Ce^{-\kappa w}$, where C and κ are positive parameters.

4. All variables except $\mathring{P}$ are in the consumer's initial information set $\mathcal{I}$ and given this information the consumer believes that $\mathring{P}$ has a normal distribution with mean α and variance σ^2.

Using the budget constraint equations (2) and (3) to eliminate A_1, one has

(A1) $$W_2 = dhP_1[1 - \theta + (1 - m)\mathring{P}] + [1 + r']\{W_1 + (1 - m)Y_1 - \pi_1 g - (1 - d)Rh - dhP_1(1 - \theta + \mu)\}.$$

For notational shorthand, define

$$W_2^e = dhP_1[1 - \theta + (1 - m)\alpha] + [1 + r']\{W_1 + (1 - m)Y_1 - \pi_1 g - (1 - d)Rh - dhP_1(1 - \theta + \mu)\},$$

$$\omega = (1 + r')[W_1 + (1 - m)Y_1],$$

$$c = (1 + r')[1 - \theta + \mu] - [1 - \theta + (1 - m)\alpha],$$

$$q = \kappa\sigma^2(1 - m)^2/\pi_2,$$

$$\mathsf{V} = \exp\left\{-\frac{\kappa}{\pi^2}\left[\omega - (1 + r')\pi_1 g - (1 - d)(1 + r')Rh - dhP_1 c - P_l^2 h^2 d\frac{q}{2}\right]\right\}.$$

Then W_2^e is the consumer's expected final wealth, ω is total initial wealth, c is the user cost of housing, q is a risk penalty, and V appears in the expression for expected utility of bequests:

(A2) $$\mathbf{E}\,V(W_2/\pi_2) = -C \cdot \mathsf{V}.$$

Substituting this expression into the consumer's objective function gives the problem

(A3) $$\max_{h,g} U(g, h) - C \cdot \mathsf{V}.$$

The first-order conditions for this unconstrained problem are

(A4) $$\nabla_g U = b_g C \cdot \mathsf{V}, \quad \nabla_h U = b_h C \cdot \mathsf{V},$$

where

$$(\nabla_g \mathsf{V})/\mathsf{V} = b_g \equiv (1 + r')\kappa\frac{\pi_1}{\pi_2},$$

$$(\nabla_h \mathsf{V})/\mathsf{V} = b_h \equiv \frac{\kappa}{\pi_2}[(1 + r')R(1 - d) + dP_1 c + dhP_l^2 q].$$

Similarly,

$$(\nabla_\omega \mathsf{V})/\mathsf{V} = b_\omega \equiv -\kappa/\pi_2,$$

$$(\nabla_R \mathsf{V})/\mathsf{V} = b_R \equiv (1 + r')\frac{\kappa}{\pi_2}(1 - d)h,$$

$$(\nabla_{P_1} \mathsf{V})/\mathsf{V} = b_{P_1} \equiv \frac{\kappa}{\pi_2}dh[c + qhP_1],$$

$$(\nabla_\alpha \mathsf{V})/\mathsf{V} = b_\alpha \equiv -1(1 + r')\frac{\kappa}{\pi_2}(1 - m)dhP_1.$$

Define the matrix

$$\mathsf{M} \equiv \begin{bmatrix} \nabla_{gg}U - b_g^2 C \cdot \mathsf{V} & \nabla_{gh}U - b_g b_h C \cdot \mathsf{V} \\ \nabla_{hg}U - b_h b_g C \cdot \mathsf{V} & \nabla_{hh}U - b_h^2 C \cdot \mathsf{V} - \frac{\kappa}{\pi_2} dP_l^2 qC \cdot \mathsf{V} \end{bmatrix}.$$

Note that M is the sum of

$$\begin{bmatrix} \nabla_{gg}U & \nabla_{gh}U \\ \nabla_{hg}U & \nabla_{hh}U \end{bmatrix},$$

which is negative definite, and

$$\begin{bmatrix} 0 & 0 \\ 0 & -\frac{\kappa}{\pi_2} dP_l^2 qC \cdot \mathsf{V} \end{bmatrix} - \begin{bmatrix} b_g \\ b_h \end{bmatrix} \begin{bmatrix} b_g & b_h \end{bmatrix} C \cdot \mathsf{V},$$

which is negative semidefinite. Hence, det M > 0, and

$$\mathsf{M}^{-1} = \frac{1}{\det_{\mathsf{M}}} \begin{bmatrix} \nabla_{hh}U - b_h^2 C \cdot \mathsf{V} - \frac{\kappa}{\pi_2} dP_l^2 qC \cdot \mathsf{V} & -\nabla_{gh}U + b_g b_h C \cdot \mathsf{V} \\ -\nabla_{gh}U + b_g b_h C \cdot \mathsf{V} & \nabla_{gg}U - b_g^2 C \cdot \mathsf{V} \end{bmatrix}.$$

Define the vectors

$$\mathsf{A}_\omega = \begin{bmatrix} b_g b_w \\ b_h b_w \end{bmatrix}, \quad \mathsf{A}_{P_1} = \begin{bmatrix} b_g b_{P_1} \\ b_h b_{P_1} + \frac{\kappa d}{\pi_2}(c + 2hP_1 q) \end{bmatrix},$$

$$\mathsf{A}_R = \begin{bmatrix} b_g b_R \\ b_h b_R + \frac{\kappa}{\pi_2}(1 + r')(1 - d) \end{bmatrix}, \quad \mathsf{A}_\alpha = \begin{bmatrix} b_g b_\alpha \\ b_h b_\alpha - \frac{\kappa d}{\pi_2} P_1 (1 - m) \end{bmatrix}.$$

The derivatives needed for comparative statics analysis are obtained by differentiating the first-order conditions:

$$\mathsf{M}\begin{bmatrix} d_g \\ d_h \end{bmatrix} = C \cdot \mathsf{V}\left\{\mathsf{A}_\omega d\omega + \mathsf{A}_{P_1} dP_1 + \mathsf{A}_R dR + \mathsf{A}_\alpha da\right\}.$$

First, income/wealth effects satisfy

$$\begin{bmatrix} \partial g/\partial\omega \\ \partial h/\partial\omega \end{bmatrix} = \frac{b_\omega C \cdot \mathsf{V}}{\det \mathsf{M}} \begin{bmatrix} b_g \nabla_{hh}U - b_h \nabla_{hg}U - b_g \cdot \frac{\kappa}{\pi_2} \cdot dP_l^2 q C \cdot \mathsf{V} \\ -b_g \nabla_{gh}U + b_h \nabla_{gg}U \end{bmatrix}.$$

The terms $b_g \nabla_{hh}U - b_h \nabla_{hg}U \le 0$ and $b_h \nabla_{gg}U - b_g \nabla_{gh}U \le 0$ by normality, along with $b_\omega < 0$, imply that g and h are increasing in ω. Let $\varepsilon(g, x) = \partial\log(g)/$

$\partial \log(x)$ denote the elasticity of a variable g with respect to a variable x. The following assumption appears to be supported empirically:

5. The elasticities of g and h with respect to ω are less than one.

This assumption implies

$$\omega \frac{\partial A_1}{\partial \omega} = \frac{\omega}{1 + r'} - \pi_1 g \varepsilon(g, \omega) - [(1 - d)(1 + r')Rh + dhP_1(1 - \theta + \mu)]\varepsilon(h, \omega) \geq A_1,$$

and for α such that expected net equity $1 - \theta + (1 - m)\alpha$ is positive,

$$\omega \frac{\partial W_2^e}{\partial \omega} = \omega - (1 + r')\pi_1 g \varepsilon(g, \omega) - dhP_1[1 - \theta + (1 - m)\alpha]\varepsilon(h, \omega) \geq W_2 .$$

Second, increasing R has no effect on owners and for renters satisfies

$$\begin{bmatrix} \partial g/\partial R \\ \partial h/\partial R \end{bmatrix} = \frac{1}{\det M} \begin{bmatrix} b_R(b_g \nabla_{hh} U - b_h \nabla_{hg} U) - \frac{\kappa}{\pi_2}(1 + r')\{b_g b_h C\cdot V - \nabla_{gh} U\} \\ b_R(-b_g \nabla_{gh} U + b_h \nabla_{gg} U) - \frac{\kappa}{\pi_2}(1 + r')\{b_g^2 C\cdot V - \nabla_{gg} U\} \end{bmatrix} .$$

Then $\partial h/\partial R < 0$. The cross-price effect $\partial g/\partial R$ is negative if g and h are not very substitutable, and the income effect dominates. The effect of increasing R on financial assets, and hence on savings, is negative if h is inelastic with respect to R and the cross-price effect of R on g is weak.

Third, increasing P_1 has no effect on renters and for owners satisfies

$$\begin{bmatrix} \partial g/\partial P_1 \\ \partial h/\partial P_1 \end{bmatrix} = \frac{1}{\det M} \begin{bmatrix} b_{P_1}(b_g \nabla_{hh} U - b_h \nabla_{hg} U) - \frac{\kappa}{\pi_2}(c + 2hP_1 q)\{b_g b_h C\cdot V - \nabla_{gh} U\} \\ b_{P_1}(-b_g \nabla_{gh} U + b_h \nabla_{gg} U) - \frac{\kappa}{\pi_2}(c + 2hP_1 q)\{b_g^2 C\cdot V - \nabla_{gg} U\} \end{bmatrix} .$$

Then $\partial h/\partial P_1 < 0$. The cross-price effect $\partial g/\partial P_1$ is negative if g and h are not very substitutable, and the income effect dominates. The effects of increasing P_1 on financial assets and final expected wealth satisfy

$$\partial A_1/\partial P_1 = -h[1 + \varepsilon(h, P_1)](1 - \theta + \mu) - \pi_1 \partial g/\partial P_1 ,$$
$$\partial W_2^e/\partial P_1 = -h[1 + \varepsilon(h, P_1)]c - (1 + r')\pi_1 \partial g/\partial P_1 .$$

If h is inelastic with respect to P_1 and the cross-price effect of P_1 on g is weak, then $\partial A_1/\partial P_1$ is negative and $\partial W_2^e/\partial P_1$ is small negative.

Fourth, increasing α has no effect on renters and for owners satisfies

$$\begin{bmatrix} \partial g/\partial \alpha \\ \partial h/\partial \alpha \end{bmatrix} = \frac{1}{\det M} \begin{bmatrix} b_\alpha(b_g \nabla_{hh} U - b_h \nabla_{hg} U) - \frac{\kappa}{\pi_2}(1 - m)P_1\{b_g b_h C\cdot V - \nabla_{gh} U\} \\ b_\alpha(-b_g \nabla_{gh} U + b_h \nabla_{gg} U) - \frac{\kappa}{\pi_2}(1 - m)P_1\{b_g^2 C\cdot V - \nabla_{gg} U\} \end{bmatrix} .$$

When risk aversion is moderate, the leading terms will dominate, and $\partial g/\partial \alpha$ and $\partial h/\partial \alpha$ will both be positive. The effect of α on W_2^e satisfies

$$\partial W_2^e/\partial \alpha = hP_1(1 - m) + (1 + r')\partial A_1/\partial \alpha + P_1[1 - \theta + (1 - m)\alpha]\partial h/\partial \alpha .$$

This expression is positive when risk aversion is moderate.

The preceding analysis assumed that the P_1 and α varied independently. In practice, the consumer will use the initial information, including P_1, in forming expectations. If the consumer is rational, this dependence will reflect the statistical dependence of $\mathring{P}$ on P_1. If the consumer is irrational, having for example naive expectations that past rates of increase in prices reflected in P_1 will continue, this will also make α positively dependent on P_1. A strong positive dependence of α on P_1 will result in positive total effects of increasing P_1 on A_1 and W_2^e.

The analysis to this point has dealt with a single consumer, who is either an owner or a renter. Now consider a population of consumers, identical except for heterogeneity in beliefs about expected capital gains; that is, α has a distribution over the population. If supplies of rental and owner housing are fixed, then prices adjust to equilibrate demand and supply, with consumers with high α becoming owners. The comparative statics of demand are then as follows: An increase in R, and under usual circumstances a decrease in P_1 or a shift upward in the α of each consumer, will increase the utility of owning and lead at the margin to moves from renting to owning. If supplies are completely inelastic, this increase in demand for owning will be offset by a combination of increasing R and decreasing P_1.

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