The Effect of Housing on Portfolio Choice*

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Abstract

We show that characterizing the effects of housing on portfolios requires distinguishing between the effects of home equity and mortgage debt. We isolate exogenous variation in home equity and mortgages by using differences across housing markets in house prices and housing supply elasticities as instruments. Increases in property value (holding home equity constant) reduce stockholding, while increases in home equity wealth (holding property value constant) raise stockholding. The stock share of liquid wealth would rise by 1 percentage point – 6% of the mean stock share – if a household were to spend 10% less on its house, holding fixed wealth.

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I. Introduction

Houses are the largest assets owned by most households, but the impact of housing on financial markets remains unclear. Many models predict that housing tends to reduce the demand for risky assets because it increases a household's exposure to risk and illiquidity (Grossman and Laroque 1990, Brueckner 1997, Flavin and Yamashita 2002, Chetty and Szeidl 2007). But empirical studies have not found a systematic relationship between housing and portfolios in practice (Fratantoni 1998, Heaton and Lucas 2000, Yamashita 2003, Cocco 2005).

This paper reconciles the theory with the data. We first show using a simple model that it is critical to separate the effects of property value from the effects of home equity to characterize the effects of housing on portfolios. We then show empirically that exogenous increases in mortgage debt induce substantial reductions in the share of liquid wealth held in stocks, while exogenous increases in home equity wealth raise stock ownership. Our empirical findings differ from those of prior studies both because we separate the effects of mortgage debt and home equity wealth and because we account for the endogeneity of housing choice in our empirical analysis.

We structure our empirical analysis using a stylized two-period model of portfolio choice that incorporates both the illiquidity and price risk effects of housing. Our model is a stylized version of richer models of housing and portfolio choice (Cocco 2005, Yao and Zhang 2005, Vestman 2012). We use it to characterize the distinct effects of *exogenous* changes in property value and home equity, generating predictions about the causal impact of these variables. We show that increases in property value (holding home equity wealth fixed) generally reduce the stock share of liquid wealth by increasing illiquidity, increasing exposure to risk, and reducing the present value of lifetime wealth. In contrast, increases in home equity (holding property value fixed) *raise* the stock share of liquid wealth with CRRA preferences through a wealth effect. Since property value is the sum of mortgage debt and home equity, increases in mortgage debt (holding home equity fixed) are equivalent to increases in property value, and also reduce stockholding. The main lesson from the model is that distinguishing between property value and home equity is critical when studying the causal effect of housing on portfolios.

Based on this result, we turn to investigate the effects of property value and home equity wealth on portfolios empirically. As emphasized by Cocco (2005) and Vestman (2012), both portfolios and housing are endogenous choices that are affected by unobserved factors such as future labor income or preferences. Thus one cannot identify the causal effect of housing on portfolios using cross-sectional variation across households. We address this endogeneity problem using a series of three research designs.

We begin with a research design that instruments for property values and home equity using current and year-of-purchase home prices in the individual's state, calculated using repeat-sales indices. The current house price index is naturally a strong predictor of property values. However, the current house price also creates variation in a household's wealth: increases in house prices increase home equity wealth. To isolate the causal effect of owning a more expensive house while holding wealth fixed, we exploit the second instrument – the average house price at the time of purchase. Individuals who purchase houses at a point when prices are high tend to have less home equity and a larger mortgage. We control for aggregate shocks and cross-sectional differences across housing markets by including state and year fixed effects, thereby exploiting only differential within-state variation for identification.

We implement this cross-sectional IV strategy using microdata on housing and portfolios for 80,392 households from the Survey of Income and Program Participation (SIPP) panels spanning 1990 to 2008. We use two-stage-least-squares specifications to estimate the effect of property value and home equity on the share of liquid wealth that a household holds in stocks. We find that housing has a large effect on the share of stockholdings. A $10,000 increase in property value (holding fixed home equity wealth) causes the stock share of liquid wealth to fall by 0.6 percentage points ($275), or 3.9% of mean stockholdings in the sample. This estimate is stable and statistically significant with $p < 0.05$ across a broad range of specifications. In contrast, a $10,000 increase in home equity (holding fixed total property value) increases the stock share of liquid wealth by 4.3% through a wealth effect.[1]

Our first research design suffers from two potential confounds that could lead to biased estimates. The first is omitted variable bias: state-level house price fluctuations may be correlated with other factors such as local labor market conditions that directly impact portfolio choice. The second is selection due to the endogeous timing of housing purchases: for example, people who buy houses when prices in their state are relatively high may have different risk preferences from those who buy when prices are lower, potentially generating a spurious correlation between stock shares and house price indices. We address these two concerns using two refinements of the research design, each of which exploits a subset of the variation used for identification in the first design.[2]

Our second research design – which constitutes the central identification strategy of the paper – addresses omitted variable bias by isolating variation in house prices driven by supply constraints. Here, we instrument for property values and home equity using the current and year-of-purchase *national* average of house prices interacted with the *state* housing supply elasticity, as measured by Saiz (2010) based on land availability and regulations. Intuitively, fluctuations in the national housing market generate larger price fluctuations in states with inelastic housing supply, generating differential variation in house prices across states over time. This strategy yields estimates that are similar to the first design. We estimate that

[1]To facilitate comparison between samples with different rates of stock market participation and hence different mean stock shares of liquid wealth, we report results in both percentages and percentage points throughout the paper.

[2]Although the refined designs rely on weaker identification assumptions, we start with the first design because it exploits all the variation in average house prices rather than a narrow subset of the variation, demonstrating that the effects of housing on portfolio choice that we document hold quite broadly.

a \$10,000 increase in property value causes a reduction in the stock share of liquid wealth of approximately 4%, while a \$10,000 increase in home equity (holding fixed total property value) raises the stock share by 4.8%. The elasticity of the stock share of liquid wealth with respect to outstanding mortgage debt is -0.2, while the elasticity with respect to home equity wealth is 0.3. These portfolio changes are driven by both the extensive and intensive margins: changes in mortgage debt and home equity wealth induces changes in both the probability of owning any stocks and the amount of stocks held conditional on stock ownership.

Our third research design addresses selection effects by using panel data to study how portfolios for a given household change around the purchase of a house. We test whether individuals who buy a larger house reduce their stock share of liquid wealth more than those who buy smaller houses. We again instrument for the change in property value using the state-level house price index at the time of home purchase. This panel strategy complements the cross-sectional approaches in two ways. First, it provides evidence that households actively change the composition of their financial portfolios depending upon the amount they invest in a house. Second, it further mitigates concerns about the endogeneity of housing choices by permitting household fixed effects. Because the SIPP is a short panel, we observe portfolio shares both before and after home purchase for only 6,912 households. For this subset of households, we find that a \$10,000 increase in the price of the house leads to a 5.2% reduction in the stock share of liquid wealth in the year after home purchase, again similar to the estimates from the first two designs. This finding shows that stockholders primarily sell stocks (rather than bonds) to finance down payments. Although this strategy does not eliminate all potential sources of bias – specifically, time-varying unobservables – the fact that controlling for time-invariant selection effects (using panel data) has little impact on the results suggests that any remaining confounds are likely to be modest. Taken together, the three research designs show that mortgage debt has a robust negative effect on risk taking in financial portfolios over both short and long horizons.

The magnitudes of the impact of housing on financial portfolios can be assessed by considering various counterfactuals. First, suppose households have the same level of home equity wealth but spend 10% less on their house, so property value is 10% lower. The estimates from our the second (preferred) research design imply that the stock share of portfolios would be approximately 1 percentage point higher in this scenario. Given the mean level of liquid wealth in our sample of \$44,090 (in 1990 dollars), this translates into a \$441 increase in stockholdings per household on average. While this may appear to be a small change in absolute terms, it constitutes a 6% increase in the stock share of liquid wealth relative to the sample mean because many households do not hold any stocks. Among households that participate in the stock market, the predicted increase in the stock share from spending 10% less on housing is 5.3 percentage points. As an alternative counterfactual, suppose households have no mortgage debt and no home equity wealth. The net impact of having no housing wealth or liabilities would be an increase in the mean stock share of 4.2 percentage points (26%), or $1,850. Among stockholders, the share of liquid wealth held in stocks would increase by 19.7 percentage points.[3] Finally, as another metric, a one standard deviation increase in mortgage debt reduces the stock share of liquid wealth by 4.1 percentage points (26%). This is similar to the impact of a one standard deviation decrease in log financial wealth on stock shares (Calvet, Campbell, and Sodini 2007).

Our estimates of the effect of housing on portfolios are larger and more robust than previous estimates. Fratantoni (1998) finds an elasticity of stock share with respect to mortgage debt of -0.15. In contrast, Heaton and Lucas (2000), Cocco (2005), and Yao and Zhang (2005) show that in cross-sectional OLS regressions in which property value is included as a covariate, the stock share is *positively* associated with mortgage debt. In related work, Yamashita (2003) finds an elasticity of stock share with respect to property value of approximately -0.1 (in a specification that does not include mortgage debt). Yamashita uses age, family size, home tenure, and aggregate housing returns as instruments for mortgage debt; unfortunately, these instruments are unlikely to be valid because standard models (e.g. Cocco 2005) generate direct relationships between all of these variables and portfolio choice, independent of the housing channel. Consistent with these prior studies, we also find that OLS estimates in our data are often wrong-signed and are sensitive to covariates. Our IV estimates are less sensitive to specification because they are driven by variation that is orthogonal to most household-level determinants of portfolios and because we systematically separate the effects of mortgage debt and home equity. The robustness of these results is underscored by a recent study by Fougere and Poulhes (2014), who replicate our analysis using data on French households and confirm that when one isolates exogenous variation in these variables, mortgage debt and home equity have significant, opposite-signed effects on portfolio shares.

The link between housing and financial decisions that we document here has implications for several issues. For example, our results suggest that increases in leverage due to the easing of credit in the U.S. (Mian and Sufi 2011) may have increased households' risk aversion in the 2000s. This may have indirectly contributed to the stock market decline in the late 2000s by reducing the potential demand for stocks after a decrease in prices. Our results also suggest that levered homeownership—by increasing risk aversion—amplifies the welfare cost of risk. Policies which restrict or insure risks that homeowners are exposed to could therefore generate significant welfare gains.

The remainder of the paper is organized as follows. The next section presents a portfolio choice model, analyzes its comparative statics with respect to housing, and quantifies the impacts one should expect using numerical simulations. Section 3 describes the data. Section 4 presents the empirical results. Section 5 concludes.

[3] If the wealth taken out of housing were invested in other assets (e.g., financial assets) so that total wealth remained fixed, the stock share of liquid wealth would likely rise even further.

II. Theoretical Predictions

In this section, we develop a stylized two period model of portfolio choice in the presence of housing. Our objective is to demonstrate the distinct effects of property value and home equity on household portfolios. Because our interest is in the causal effect of these variables, we treat property value and home equity as exogenous in the model.[4] Our model is thus a simpler version of the rich models in Cocco (2005), Yao and Zhang (2005) and Vestman (2012), who endogenize housing and explore the joint evolution of housing and portfolios, but do not study the distinct impacts of exogenous changes in property value and home equity. Because our model is analytically tractable, it provides a simple way to characterize the mechanisms underlying these impacts. In particular, our model captures several mechanisms identified in the literature, including illiquidity (Grossman and Laroque 1990, Chetty and Szeidl 2007), home price risk (Flavin and Yamashita 2002), hedging effects (Sinai and Souleles 2005), and diversification effects (Yao and Zhang 2005).[5]

Model setup. We build on Cocco's (2005) model of housing and portfolio choice, but make a number of simplifying assumptions—most importantly, that households can only move at exogenous random dates—to obtain an (approximate) analytic expression for portfolio shares. A household endowed with a house H_0, mortgage debt M_0, and liquid wealth L_0 makes a financial portfolio investment decision in $t = 0$. Consumption takes place in $t = 1$, and the household maximizes

$$E_0 \frac{\left[C_1^{1-\mu} H_1^{\mu}\right]^{1-\gamma}}{1-\gamma} \tag{1}$$

where C_1 is adjustable (e.g., food) consumption and H_1 is housing consumption. As in Campbell and Cocco (2003), we assume that moves in $t = 1$ are exogenous. With probability θ the household stays in the current house ($H_1 = H_0$), while with probability $1 - \theta$ it moves, and chooses H_1 optimally. One interpretation of this assumption is that the household only moves in response to life-changing events such as marriage or childbirth which are perceived to be exogenous when making a portfolio decision. In this model, θ measures the strength of housing commitment.

At $t = 0$ the household can invest in a riskfree financial asset with return $1 + R_f = \exp(r_f)$ and a risky asset with return $1 + R = \exp(r)$, where r is normally distributed with mean μ_r and variance σ_r^2. The only choice variable at $t = 0$ is α, the share of the risky asset out of liquid wealth. Let $R_p = \alpha R + (1 - \alpha) R_f$ denote the household's financial return, and assume that short sales constraints restrict $\alpha \in [0, 1]$. Home prices are $P_0 = 1$ and $P_1 = \exp(p_1)$,

[4] Correspondingly, in the empirical analysis we use an instrumental variables strategy that exploits variation in property value and home equity which is exogenous to the household's choices.

[5] The text presents a highly stylized model that highlights the key qualitative results in the simplest setting. In the Appendix, we show using numerical simulations that with plausible parametrizations, our key comparative statics remain robust to realistic extensions including fixed moving costs, stock market participation costs, labor income risk, and dynamics.

where p_1 is normal with mean μ_p and variance σ_p^2. The correlation between home price growth and stock returns is $\rho = \text{corr}[p_1, r]$.

The household chooses α to maximize (1) subject to the budget constraint

$$C_1 + P_1 H_1 = (1 + R_p)\, L_0 + Y_1 + P_1 H_0 - (1 + R_m)\, M_0$$

where R_m is the mortgage rate and Y_1 is labor income, which for now we assume is deterministic. Let the (risk-adjusted) present values of mortgage debt, labor income, liquid wealth, home value, and lifetime wealth be denoted by $M = M_0 (1 + R_m) / (1 + R_f)$, $Y = Y_1 / (1 + R_f)$, $L = L_0$, $PH = P_0 H_0$, and $W = L + Y + PH - M$. Note in particular that PH stands for market value of the house in the initial period.

Optimal portfolio shares. We derive an approximate equation for the optimal stock share α using log-linearization. Optimization yields the log-linear Euler equation

$$\mu_r - r_f + \frac{\sigma_r^2}{2} = \theta^* \cdot \text{cov}\left[r, -v'_{nm}\right] + (1 - \theta^*) \cdot \text{cov}\left[r, -v'_m\right], \tag{2}$$

where v'_{nm} and v'_m are the log marginal utilities of wealth in $t = 1$ in the "no move" and "move" states of the world and the weight

$$\theta^* = \frac{1}{1 + \frac{1-\theta}{\theta} \frac{\mu^{\mu(1-\gamma)} (1-\mu)^{-\mu-\gamma+\mu\gamma}}{(PH/W)^{\mu(1-\gamma)} (1-PH/W)^{-\mu-\gamma+\mu\gamma}}}. \tag{3}$$

The intuition for (2) is that the agent optimizes by trading off the expected gain from investing in the risky asset with the additional fluctuation in marginal utilities he bears as a result of the investment. The additional risk is measured by the covariance of the market return with marginal utilities, weighted by θ^*. The weight θ^* can be interpreted as a marginal-utility-adjusted probability of not moving, analogous to a state-price density. When the housing share of lifetime wealth PH/W equals the optimal share μ, equation (3) implies that $\theta^* = \theta$. But when $PH/W > \mu$, we have $\theta^* > \theta$: since the household starts with too much housing and too little adjustable consumption, the marginal utility of wealth is—on average—relatively higher in the no-move state, explaining the larger weight θ^*.

An approximation for the optimal portfolio share can be derived from the Euler equation using standard methods (see e.g., Campbell and Viceira 2002):

Proposition 1: *Letting $\gamma^c = \mu + \gamma - \gamma\mu$, the optimal share of stocks out of liquid wealth at $t = 0$ is, to a log-linear approximation,*

$$\alpha = \frac{\mu_r - r_f + \sigma_r^2/2}{\sigma_r^2 \left[\theta^* \gamma^c \frac{L}{W-PH} + (1 - \theta^*)\, \gamma \frac{L}{W}\right]} + cov[p_1, r] \cdot (1 - \theta^*) \frac{\mu\,(\gamma - 1) - \gamma \frac{PH}{W}}{\sigma_r^2 \left[\theta^* \gamma^c \frac{L}{W-PH} + (1 - \theta^*)\, \gamma \frac{L}{W}\right]}. \tag{4}$$

The proof is in the Appendix. To see the intuition for the expression, first consider the case in which house prices do not covary with stock prices ($\text{cov}[p_1, r] = 0$). In this case, the second term drops out and (4) has an interpretation analogous to a familiar "myopic" rule: the numerator measures the expected excess return of stocks, while the denominator equals stock market risk σ_r^2 multiplied by effective risk aversion over liquid wealth. Because housing is a fixed commitment, risk aversion is the weighted average $\theta^*\gamma^c L/(W - PH) + (1 - \theta^*)\,\gamma \cdot (L/W)$. When the consumer is free to move ($\theta = \theta^* = 0$), this term simplifies to $\gamma L/W$, yielding the classic Merton (1969) formula adjusted for the fact that stocks are measured as a share of liquid rather than total wealth. When the consumer can never adjust housing ($\theta = \theta^* = 1$), effective risk aversion is $\gamma^c L/(W - PH)$. This is different from γ for two reasons. First, because the agent cannot move, shocks are concentrated on adjustable consumption $W - PH$ and hence have an amplified effect on marginal utility (Chetty and Szeidl 2007). Second, because H_1 does not adjust, curvature is determined by $(1 - \mu)(1 - \gamma)$ in (1), generating the γ^c term.

Finally, when $\text{cov}[p_1, r] \neq 0$, home price risk generates a hedging demand for stocks, reflected in the second term in (4). This term is also affected by the strength of the housing commitment θ through θ^*. When $\theta = \theta^* = 1$, the home is never sold, and hence home price risk does not affect behavior (Sinai and Souleles 2005).

Comparative statics. Equation (4) allows us to trace the impact on the stock share of an exogenous change in total wealth W of which home equity is a component, and in property value PH. In these comparative statics we hold fixed all other parameters, including liquid wealth L. Exogenous increases in W generally increase α^*. Intuitively, with CRRA utility, the household seeks to maintain a constant share of its wealth in risky assets; thus an exogenous increase in wealth, such as home equity (holding fixed property value) induces the household to buy stocks. This force is related to the diversification effect emphasized by Yao and Zhang (2005), and is captured by the terms involving W in the denominator in (4). An increase in wealth also reduces θ^*; because the no-move state is typically riskier, this additional effect generally acts to further raise α^*.

Exogenous increases in property value PH reduce α^* through three channels. First, for a given W, increasing PH implies that a larger share of wealth is "tied up" in housing, making marginal utility higher and more sensitive to shocks in the no-move state. This effect arises from an increase in effective risk aversion $\gamma^c L/(W - PH)$ in the denominator of (4) and by a higher weight θ^* on the no-move state. Second, when $\text{cov}[p_1, r] > 0$, a higher PH results in greater exposure to home price risk, which has a negative effect on hedging demand. Third, holding fixed home equity, a higher property value means higher mortgage debt. If the mortgage rate exceeds the risk free rate ($R_m > R_f$), increased mortgage payments reduce lifetime wealth W, resulting in lower stockholdings in (4). This logic suggests that it is critical to distinguish changes home equity from changes in property value to uncover the effects of housing on portfolio choice.

Calibration. To make the comparative statics explicit, we turn to present numerical results. We first choose values for the model parameters. For parameters related to life-cycle portfolio choice, we follow Cocco, Gomes, and Maenhout (2005): we set $R_f = 0.02$, $ER = 0.06$, and $\sigma = 0.157$ per annum, and let $\gamma = 10$. Concerning housing, we set the relative preference for housing at $\mu = 0.2$ (Yao and Zhang 2005), and the parameters of home prices and mortgage at $\mu_p = 0.016$, $\sigma_p = 0.062$, and $R_m = 0.04$ (Cocco 2005). Both Cocco and Yao and Zhang assume a zero correlation between housing and the stock market; we report results with both $\rho = 0$ and $\rho = 0.1$.

We set the time horizon of our model to be 10 years to represent an investment horizon over which housing commitments are likely to be important.[6] Cocco (2005) estimates a five-year moving probability of 24.4%, which implies that the probability of not moving over ten years is 57%. We therefore use $\theta = 0.55$ as our baseline. We set liquid wealth $L_0 = \$44,000$, home value $P_0H_0 = \$130,000$ and mortgage $M_0 = \$54,000$, the approximate sample means in our data (see Table IIa below). Cocco, Gomes, and Maenhout (2005, Figure 3b) report that the present value of future labor income is approximately 5 times current financial wealth for households in their late forties and early fifties; hence we set $Y_1 = 5L_0$.

Numerical results. To complement the approximate formulas, we report results based on the exact numerical solution of the model. These simulations provide a way to verify that the approximate solution in (4) accurately captures the comparative statics.[7] Table I shows optimal portfolio shares as a function of property value and home equity, holding fixed liquid wealth and other model parameters. Home equity is defined as property value minus mortgage due.[8] Panel A demonstrates that increases in property value P_0H_0 (holding fixed home equity wealth) reduce the optimal share of stocks. For example, when the probability that the household does not move is $\theta = 0.55$ and the correlation between housing and returns is $\rho = 0$, increasing property value from $\$130,000$ to $\$140,000$ results in a reduction in stock share from 69.1% to 63.2%, or by about 8.5%. Panel B considers the effect of changes in home equity wealth (holding fixed property value). For the same parameters, an increase in home equity from $\$76,000$ to $\$86,000$, while holding home value fixed at $\$130,000$, increases the stock share from 69.1% to 74.6%, or by about 8%. We observe qualitatively similar effects for

[6] In the Appendix we report results from a dynamic model that features a 20 year horizon. We also verified that our qualitative results are robust to having a 15 year horizon in the static and correspondingly a 30 year horizon for the dynamic model.

[7] The quality of the approximation is high for short horizons but deteriorates slightly over longer horizons. For example, the average absolute difference between the numerical and the approximate solution across all the parameter values considered in Table I for a one-year horizon is only 0.05 percentage points. With a five year horizon, the mean error grows to 0.30 percentage points and for ten years it is 1.96 percentage points. Despite these deviations, the approximate solution shows the same patterns as the numerical results.

[8] Formally, we measure home equity as $P_0H_0 - M_0$. Since the mortgage rate exceeds the riskfree return ($R_m > R_f$) this measure of home equity does not equal the contribution of housing to household wealth as measured in present value terms, which equals $P_0H_0 - M_0(1 + R_m)/(1 + R_f)$. We use the former definition because it is simpler, can be implemented empirically without information on R_m and R_f, and is the most common colloquial definition of "home equity."

other parameter values.

Our results confirm the theoretical predictions of the model, and highlight the importance of distinguishing between property value and home equity when evaluating the impact of housing on portfolio choice. We now turn to empirically assess these predictions.

III. Data and Sample Definition

We estimate the effects of housing on portfolio choice using data from eight Survey of Income and Program Participation panels that began in years 1990-2008. Each SIPP panel tracks 15,000 to 45,000 households over a period of 2-3 years, collecting information on income, assets, and demographics. During the first four panels, asset data were only collected once; in the last four panels, asset data were collected once per year, permitting a panel analysis of changes in portfolios. The main advantages of the SIPP relative to other commonly used datasets on financial characteristics such as the Survey of Consumer Finances are its large sample size and detailed information about covariates such a complete housing history and geographic location.

We obtain quarterly data on average of housing prices by state from 1975-2011 using the repeat sales index constructed by the Federal Housing Finance Agency (FHFA). Calhoun (1996) provides a detailed description of the construction of the FHFA index, which has been widely used in studies of housing markets (see e.g., Himmelberg, Mayer, and Sinai 2005).[9] We obtain land topology-based measures of housing supply elasticity by state from Saiz (2010).[10] Saiz predicts housing supply elasticities using data on physical and regulatory constraints (land availability and use regulations), providing a convenient index of the supply constraints in each housing market.

The eight SIPP panels together contain information on 197,858 unique households, of which 117,497 are homeowners, whom we define as individuals with positive property value and positive home equity.[11] 89,144 of these households bought their current house after 1975 and therefore have FHFA data for the year of home purchase, which is required for our instrumental variable analysis. We exclude an additional 7,449 households whose reported liquid wealth by our definition is zero, making their portfolio shares ill defined. 1,273 households live in small

[9] FHFA is the successor to OFHEO, which originally started to compile and publish this widely used index. We use FHFA price indices rather than other popular measures such as Case-Shiller indices because Case-Shiller data are available only starting in 2000 for selected metro areas. Unfortunately, geographic information below the state level is not available for more than two-thirds of the observations in our sample. Although the two indices differ in the way they treat appraisals and the set of loans they consider, Leventis (2007) reports a correlation of 0.98 between the FHFA and Case-Shiller indices for markets where both measures are available.

[10] We aggregate the MSA-level statistics reported by Saiz (2010, Table 6) to the state level by taking population-weighted means across MSAs within each state. For MSAs that cross state boundaries, we use the population in the MSA within each state, calculated from Census statistics on county population.

[11] 4.66% of households with positive property value report zero or negative home equity. We exclude these individuals in our baseline analysis because we use log home equity as an independent variable in some specifications and wish to retain a fixed sample across all specifications.

states that are masked in the SIPP, while another 30 households report holding a negative amount in stocks; we exclude these households as well. These exclusions leave us with 80,392 homeowners in our cross-sectional analysis sample.

Table IIa reports summary statistics for the cross-sectional analysis sample.[12] In the cross-sectional sample, homeowners own houses that are worth approximately $130,000 on average in 1990 dollars. The average amount of home equity—defined as property value minus mortgage—is $77,000 and the average outstanding mortgage is $54,000. The average household head is 49 years old and has lived in his current house for 9.2 years. Mean total wealth (which includes liquid wealth, home equity, wealth in retirement accounts, and other illiquid assets such as cars) is $187,320.[13]

We define liquid wealth as the sum of assets held in stocks, bonds, checking, and savings accounts, excluding retirement accounts. We exclude retirement accounts from our definition of liquid wealth because households typically incur significant penalties to withdraw money from retirement accounts prior to retirement. Moreover, the SIPP does not contain data on portfolio allocations within retirement accounts, so we cannot study changes in portfolio choice behavior within these accounts. Mean liquid wealth is $44,000, but this distribution is skewed; the median level of liquid wealth is only $5,900.[14]

Households hold on average 16% of their liquid wealth in the form of stocks in taxable (non-retirement) accounts and 84% in "safe" assets (bonds, checking, and savings accounts). The relatively small fraction of wealth held in stocks reflects the fact that only 29% of the households in the data hold stocks outside their retirement accounts, consistent with Vissing-Jorgensen (2003).

Panel data on portfolio shares are available for households in the 1996, 2001 and 2008 SIPP panels.[15] In these panels, data on portfolio shares were collected annually, giving us information on assets and homeownership between 3 to 4 times per household. We form our panel analysis sample using the 6,912 observations for which we observe a purchase of a new house within the panel and have data on portfolio shares both before and after this home purchase.[16]

Table IIb reports summary statistics for the sample we use in the panel analysis. Homeowners in the panel sample generally have similar characteristics to those in the cross-sectional

[12]See Appendix Table I for summary statistics for the full SIPP sample.

[13]Total wealth is gross household wealth measured on the survey. It includes financial assets as well as all real estate (including second homes), cars, and private business equity. Debts are not subtracted from the total wealth measure.

[14]Skewness and outliers do not affect the results reported below. Trimming outliers (e.g. by excluding the top and bottom 1% of households by wealth or property value) has virtually no effect on our 2SLS estimates. This is because the distribution of predicted housing values generated by the instruments is not skewed. There are few outliers in the fitted values from the first stage.

[15]Data for the 2004 panel is technically available, but only two waves do not fulfill the criterion of our research design to include both pre- and post-purchase values.

[16]When we include these households in the cross-sectional sample, we only use data from the first year in which assets are observed. Hence, each observation in the cross-sectional sample is for a unique household.

sample, with three exceptions. First, they have less home equity and more mortgage debt, as expected for new home buyers. Second, they are slightly less wealthy, consistent with being younger on average. Finally, they hold more stocks in their portfolios. This is because the panel sample spans 1996-2011, a period with higher stock ownership than the early 1990s.

IV. Empirical Analysis

We estimate the impacts of property value and home equity using the following linear specification for portfolio shares:

$$\text{stock share}_i = \text{const} + \beta_1 \text{property value}_i + \beta_2 \text{home equity}_i + \gamma X_i + \varepsilon_i \tag{5}$$

where X_i denotes a vector of controls, including components of total wealth such as liquid wealth and income. Home equity, defined as property value minus the outstanding mortgage debt, measures the contribution of housing to total wealth. Table I in Section 2 shows that our model predicts $\beta_1 < 0$ and $\beta_2 > 0$.[17] The error term ε captures other sources of heterogeneity in portfolios. These may include entrepreneurial risk (Heaton and Lucas 2000), investment mistakes (Odean 1999, Calvet, Campbell and Sodini 2007), heterogeneity in risk aversion γ (Vestman 2012), or measurement error in income (Cocco 2005).

Some of the effects captured by the error term may be correlated with property value, creating bias in OLS estimates of β_1 and β_2. For instance, Cocco (2005) emphasizes biases due to unobserved labor income, which affects both the stock share and property value. Suppose that $Y_1 = Y_1^{\text{obs}} + Y_1^{\text{un}}$ where only Y_1^{obs} is observed to the econometrician. Since higher lifetime wealth generates higher stockholdings, ε is positively related to Y^{un}. If households with higher future labor income own larger houses, property value is also positively related to Y^{un}, and hence the OLS estimate of β_1 is biased upward. Indeed, Cocco (2005, Table 6) runs cross-sectional OLS regressions using simulated data from his model and finds a *positive* effect of mortgage debt on stockholdings, caused by omitting future labor income from the regression. Such endogeneity problems make it essential to isolate variation in property value and home equity that is orthogonal to ε in order to identify β_1 and β_2.

We divide our empirical analysis into four sections. First, we confirm that estimating (5) using OLS in our data yields results that are similar to those of prior studies. We then identify the causal impacts of mortgage debt and home equity wealth on portfolios by using three different research designs to estimate (5): variation in mean house prices, variation in local housing supply constraints, and changes in portfolio shares around home purchase in panel

[17] An alternative specification is to normalize the housing variables by liquid wealth. We show that our results are robust to such a specification, but opt to use levels in our baseline model for two reasons. First, when liquid wealth is imperfectly measured and close to zero for some observations, normalizing by it introduces large outliers in the independent variables of interest. Second, our simulations show that one should find a relationship between the stock share and levels of property value and home equity wealth.

data.

A. OLS Estimates

Previous studies have estimated OLS regressions of portfolio shares on property values, mortgage debt, and home equity with various control vectors and obtained mixed results. To ensure that the differences between our findings and theirs are not driven by differences in data or sample definitions, we begin by estimating similar specifications in our sample.

Column 1 of Table III reports OLS estimates of a regression of the stock share of liquid wealth on property value and home equity wealth without any covariates.[18] Consistent with the findings of Heaton and Lucas (2000), Cocco (2005), and Yao and Zhang (2005), we find that an increase in property value (mortgage debt) is *positively* associated with the stock share of liquid wealth, contrary to the model's predictions. This is presumably because individuals with larger properties tend to be wealthier or face less background risk and these omitted factors induce them to hold more stocks.

In column 2, we attempt to account for some of these factors by including controls for household income and private business wealth; household head's education, number of children, and age; and a 10 piece linear spline in liquid wealth to control flexibility for a household's level of wealth. The inclusion of these covariates reduces the coefficient on property value by approximately 80%, but it remains positive in sign.

In column 3, we exclude households with zero mortgage debt, who constitute 25% of homeowners in the sample, as in Fratantoni (1998). This change in sample specification makes the coefficient on property value negative but statistically insignificant, consistent with Fratantoni's findings. Importantly, Fratantoni is not able to control for location as the SCF does not contain geographic information. Once indicators for state of residence are included, the correlation between property values and stock shares is no longer negative, though still insignificant, as shown in Column 4 of Table III.

These OLS results echo the instability of estimates found in prior studies. Moreover, they indicate that the endogeneity of housing choices is likely to bias the effect of property value on stock shares upward. These findings motivate our focus on formulating research designs that isolate "exogenous" variation in mortgage debt and home equity that is plausibly orthogonal to other unobserved determinants of portfolios.

B. Research Design 1: Mean House Prices

Our first research design exploits two instruments to generate variation in home equity and property value: the average price of houses in the individual's state in the current year (the year in which portfolios are measured) and the average price of houses in the individual's

[18] We report conventional (unclustered) standard errors. Standard errors clustered by state-year cells are typically within +/-5% of the unclustered standard errors across all of the specifications reported in the paper.

state in the year that he bought his house. The intuition for this identification strategy is illustrated in Figure I, which plots average real home prices in California from 1975 to 2009 using the FHFA data. Consider a hypothetical experiment involving a set of individuals who buy identical houses and only pay the interest on their mortgage (so that debt outstanding does not change over time). As a baseline, consider individual A who buys a house in 1985 and whose portfolio we observe in 2000.

Now compare this individual to individual B who buys the same house in 1990 and whose portfolio we also observe in 2000. Individuals A and B have the same current property value, but individual B is likely to have less home equity and a larger mortgage, because home prices were higher in 1990 than 1985. Intuitively, since individual B is buying the same house at a higher price, he needs a bigger mortgage; and because he enjoys less home price appreciation than A, he will end up with lower home equity in 2000. Now consider a second experiment, comparing panel C to A. Individual C buys the same house in 1985, but we observe his portfolio in 2005. This individual has the same mortgage debt as individual A (under the assumption that individuals only pay interest to service their debt), but has higher home equity and wealth at the time we observe his portfolio. Together, the two experiments (instruments) allow us to separately identify the causal effects of mortgages and home equity on portfolios.

In practice, our implementation of this strategy differs from the hypothetical examples above in two ways. First, we include state, current year, year of house purchase, and age fixed effects in our regression specifications. Thus, we identify β_1 and β_2 in (5) purely from differential changes in house prices across states for individuals who bought houses in the same year and have identical home tenures. Second, unlike in the hypothetical example, individuals buy smaller houses when prices are high and reduce their mortgage debt over time by paying more than mortgage interest. The first stage effects of the house price indices on mortgage and home equity account for these effects.

Identification Assumptions. The key identification requirement for this research design is that changes in average state house prices are orthogonal to unobserved determinants of portfolio decisions ε_i in (5) conditional on our control vector. In evaluating the validity of this assumption, it is important to note that the fixed effects we include rule out several omitted variable biases that one may be concerned about. For example, fluctuations in interest rates and credit standards at the national level would affect both average house prices and portfolio choices directly. Our inclusion of current year fixed effects eliminates such confounds. Similarly, differences in portfolio choice correlated with an individual's year of home purchase or home tenure cannot create biases because our specifications include year of purchase fixed effects.[19] Likewise, the inclusion of state fixed effects accounts for potential biases that may emerge from static differences across housing markets.

Despite the fact that the most plausible confounds are accounted for by the fixed effects,

[19]By including both year of purchase and current year fixed effects, we control non-parametrically for home tenure.

there are two remaining potential threats to the validity of the research design. First, fluctuations in state housing markets may be correlated with other factors – such as the strength of local labor markets – that directly affect portfolio choice. Second, the orthogonality condition could be violated via selection effects, due to the endogenous timing of housing purchases. For example, people who buy houses when prices in their state are relatively high may have different risk preferences from those who buy when prices are lower, potentially generating a spurious correlation between stock shares and house price indices. We address these two concerns in the next two subsections using two refinements of the research design, each of which exploits a subset of the variation used for identification here. Although these subsequent designs rely on weaker identification assumptions, we begin by exploiting all the variation in average house prices to demonstrate that the effects of housing on portfolio choice that we document hold quite broadly, rather than only for a narrow subset of the variation in house prices.[20]

Results. The first three columns of Table IV report first stage regressions of mortgage, home equity, and property value (mortgage plus home equity) on the two instruments. These specifications include state, year of purchase, current year, and age fixed effects as covariates. These first-stage effects remain similar when we include the following vector of "full controls," which we use to evaluate robustness of each of our specifications below: household income, household head's education, number of children, the state unemployment rate in the current year, private business wealth, and a ten piece linear spline for liquid wealth.

Column 1 of Table IV shows that higher current house prices strongly predict higher property values, with a t-statistic of 40. Conditioning on current prices, higher house prices at the time of purchase predict slightly lower current property values, confirming that individuals purchase smaller houses if they buy at times when prices are relatively high. Column 2 shows that higher current prices strongly predict higher home equity, showing that much of the increase in property value comes from higher home equity, as expected. Higher prices at the time of purchase strongly predict lower home equity, with a t-statistic of 18. Conversely, column 3 shows that higher prices at the time of purchase predict much larger mortgages. Higher current prices also predict (to a smaller extent) larger mortgages, an effect that may be driven by refinancing – when current prices are high, individuals tap into their home equity.[21]

Columns 4-7 of Table IV report two-stage least squares estimates of β_1 and β_2 in (5),

[20]Prior research has found that fluctuations in house prices are driven by several factors, including supply constraints, construction costs, momentum effects, and macroeconomic conditions (see e.g., Case and Shiller 1989, Glaeser et al. 2005, Glaeser et al. 2008, Gyourko et al. 2013). Some of these factors, such as supply constraints, are less likely to violate the exclusion restriction by directly affecting portfolio choice than other factors, such as macroeconomic conditions.

[21]Refinancing does not affect our 2SLS estimates because it rescales both the first-stage and reduced-form coefficients by the same amount. Refinancing could affect liquid wealth; we account for this channel by conditioning on liquid wealth using a flexible spline in many of our specifications. Note that in a heterogeneous population, our IV strategy will estimate a local average treatment effect that applies to individuals who do not fully refinance their mortgages when property values go up.

where home equity and property value are instrumented using the two FHFA price indices. In column 4, we estimate the model including current year, year of purchase, age, and state fixed effects. The null hypothesis that changes in property value have a positive effect on financial portfolios is rejected with $p < 0.01$. The point estimate of the property value coefficient implies that a \$10,000 increase in an individual's mortgage debt reduces his stock share of liquid wealth by 0.62 percentage points (\$275 at the sample mean). Given a mean stock share in the analysis sample of 16%, this is equivalent to a 3.9% reduction in the stock share of liquid wealth. The elasticity of the stock share of liquid wealth with respect to mortgage debt is approximately -0.2 at the sample mean mortgage debt of \$53,000.

The estimate of the home equity coefficient in column 4 implies that a \$10,000 increase in home equity raises the stock share by 0.68 percentage points (4.3%) when total property value is held fixed, which we interpret as a wealth effect. The mean home equity in the sample is approximately \$77,000, implying an elasticity of stock share of liquid wealth with respect to home equity wealth of approximately 0.3.

Column 5 of Table IV replicates column 4 with the fixed effects and the full set of covariates: liquid wealth spline, private business wealth, education, income, number of children, and the state unemployment rate. The estimate of the property value coefficient is barely affected by controls, unlike the OLS estimates in Table III.[22] Since controlling for these observables has little impact on the estimate, one can be more confident that biases due to omitted unobservables are not driving the results.

In column 6, we estimate a model analogous to column 4 using logs instead of levels for the independent variables. We instrument for log(property value) and log(home equity) with the logs of the two FHFA price indices. We retain the stock share in levels on the left hand side because of the large number of individuals with 0 stock shares in our sample. Consistent with the previous results, the estimates reveal that increases in property value significantly reduce the share of stocks in liquid wealth, and increases in home equity wealth increase stock shares.

Column 7 reports estimates from a specification analogous to column 5 except the endogenous regressors are also defined as shares of liquid wealth, like the dependent variable. We replace property value by the ratio of property value to liquid wealth and home equity by the ratio of home equity to liquid wealth. We then use the level of the two FHFA price indices as in column 4 as instruments for these ratios. This specification effectively tests whether households with a large amount of mortgage debt to liquid wealth hold safer portfolios using a different functional form to account for variation in wealth. One weakness of this specification is that it introduces substantial outliers, as there are many households with near-zero liquid wealth. To reduce noise from these outliers, we exclude observations with ratios of property

[22]Some of the controls in this specification—e.g., liquid wealth—are themselves endogenous to home purchase. The similarity of the results when these controls are excluded suggests that their endogeneity is unlikely to be a significant source of bias.

value or home equity to liquid wealth above 20. The resulting estimates are consistent with those obtained previously, but less precisely estimated because of the instability of the ratios.

Threats to Identification. We now return to the two threats to identification discussed above: state-level omitted variable biases and selection effects. To evaluate these concerns, it is useful to understand the reduced-form relationships underlying the two-stage-least-squares estimates above. Two reduced-form relationships drive the 2SLS results in Table IV. First, individuals who buy houses when housing prices are relatively high in their state hold less stocks in subsequent years. Second, homeowners' stock shares do not vary substantially with contemporaneous housing prices. The first finding tells us that households with higher mortgage debt and lower home equity have lower stock shares. To determine which channel is responsible for the reduction in stockholding, we use the second finding, which shows that fluctuations in home equity have no effect on stock shares. This leads us to conclude that increases in mortgage debt reduce stockholding, as shown in Table IV.

The first threat to a causal interpretation of the two reduced-form relationships is that fluctuations in current home prices are correlated with portfolios through omitted variables. For instance, house prices may be related to local economic conditions that directly affect portfolio choice. Such effects are unlikely to be responsible for our findings, for two reasons. First, controlling for observable measures of the local business cycle by using state unemployment rates and current household income has little effect on the estimates. Second, any remaining omitted variables (e.g. expectations of future labor income) are likely to bias the estimated effect of current house prices on stock shares upward. If individuals are unobservably wealthier when house prices are high in their area, their stock shares should rise because higher income individuals tend to hold more stocks. This would work *against* our second reduced-form result that fluctuations in property value have no effect on portfolios.

The second threat to identification is that fluctuations in house prices at the time of purchase are correlated with portfolios because of selection effects. Individuals who buy houses when house prices are relatively high may have different risk preferences. Such selection bias is also likely to be modest in our setting for the same two reasons. Controlling for observables has little impact on the estimates, indicating that selection on observables is minimal. And again, we expect such selection biases to work against our findings: those who are willing to buy a house when prices are relatively high are presumably *less* risk averse (Shore and Sinai 2010). This would work against our first reduced form finding that individuals who buy when prices are high (and thus have more mortgage debt) have *safer* portfolios.

These arguments suggest that the results in Table IV are unlikely to be driven by omitted variable and selection biases, but they are not definitive. In the next two subsections, we develop two refinements of this identification strategy that address these problems more directly. The first isolates variation in house prices driven by supply constraints, which is more credibly orthogonal to omitted variables that may affect portfolio choice. The second uses panel data to directly account for selection effects.

C. Research Design 2: Variation in Housing Supply Elasticities

Our second research design exploits national house prices interacted with local housing supply elasticities to generate variation in home equity and property value.[23] To understand the intuition for this strategy, consider two states, one with an inelastic housing supply (e.g. California) and another with highly elastic housing supply (e.g. Kansas). When there is an aggregate demand shock for housing at the national level, there is little adjustment in the supply of housing in California, so prices covary strongly with the national prices. However, in Kansas, most of the adjustment takes place on the supply margin and local house prices are much more stable. More generally, aggregate demand shocks for housing (which we measure using national house prices) have larger impacts on house prices in states with low housing supply elasticities, generating differential variation in house prices across states (Mian and Sufi 2009). The key advantage of this source of variation is that it avoids the potential for omitted variable bias due to local economic shocks because the variation is driven purely by *national* demand shocks, and the direct effect of such national shocks are accounted for by our year fixed effects.

To implement this strategy, we instrument for mortgage debt and home equity with current and year-of-purchase *national* house prices interacted with the *state* housing supply elasticity. The housing supply elasticity is taken from Saiz (2010), who constructs predicted elasticities using measures of local physical and regulatory constraints.[24]

As above, we include current and year of home purchase fixed effects as well as state fixed effects in all regression specifications. These fixed effects absorb the level effects of national price shocks and differences in the state housing supply elasticity. The inclusion of state fixed effects rules out the concern that differences in the housing supply elasticity are correlated with other factors that directly affect portfolios, such as differences in wealth or economic conditions. In particular, by including state fixed effects, we are effectively asking whether the larger *fluctuations* in property value (relative the state mean) observed in less elastic cities lead to larger fluctuations in stockholding (relative to the state mean).

Results. Columns 1-3 of Table V report first stage regressions of property value, home equity, and mortgage debt on these two instruments. The specifications in columns 1-3 include state, year of purchase, current year, and age fixed effects as covariates. As above, the first-stage estimates are unaffected by the inclusion of additional controls. Column 1 shows that higher

[23]We thank the associate editor for suggesting this approach.

[24]We use the housing supply elasticity at the state rather than a more local level because states are the finest geographic unit we observe in the SIPP data. Although housing supply elasticities vary across cities within states, our state-level analysis can be interpreted as simply collapsing the local means to a higher level of aggregation. This coarsening leads to a loss of efficiency (as we lose information on the within-state variance) but does not affect the consistency of our estimates, since the remaining variation at the state level still would satisfy the same orthogonality condition that holds at the local level.

national prices in the current year have significantly smaller effects on property values in states with highly elastic housing supply. Column 2 shows that higher national prices also have smaller effects on home equity in more elastic housing markets, as expected. Higher national prices at the time of purchase reduce home equity by a smaller amount in areas with elastic housing supply. Conversely, column 3 shows that higher prices at the time of purchase have smaller impacts on mortgage debt in elastic markets. All of these first-stage effects are highly significant, although the t statistics are somewhat smaller than in the first research design because this strategy exploits a narrower source of variation.

Columns 4-6 of Table V report two-stage least squares estimates of β_1 and β_2 in (5), where home equity and property value are instrumented using the two national price indices interacted with state housing supply elasticity. In column 4, we estimate the model including current year, year of purchase, age, and state fixed effects. The point estimate of the property value coefficient implies that a \$10,000 increase in an individual's mortgage reduces his stock share of liquid wealth by 0.6 percentage points. A \$10,000 increase in home equity increases his stock share by 0.8 percentage points.

Column 5 of Table V replicates column 3 with the full set of covariates in addition to the fixed effects. Including the full set of controls does not have a statistically significant impact on the coefficient estimates. The magnitudes of the coefficients are quite similar to the corresponding coefficients from the first research design in column 5 of Table IV, although slightly less precisely estimated because the first-stage has less power.

In column 6, we replicate the levels specification with the controls in column 5, but restrict the sample to individuals with more than \$100,000 of total wealth. The objective of this specification is to assess whether the effects we have identified are also present among high-wealth households, whose behavior may be most relevant for financial market aggregates. The point estimate of the property value and home equity coefficients are slightly larger in magnitude than those in the full sample. Housing remains an important determinant of portfolio choice even for wealthier households.

Counterfactuals. To interpret the magnitude of these effects, it is helpful to consider some counterfactuals. First, suppose that households had the same level of home equity wealth and financial wealth, but spent 10% less on their houses. Given that mean property value is \$130,257 in this sample (Table IIa), the estimates from column 5 imply that the stock share of portfolios would be $7.58 \times 0.130257 = 0.99$ percentage points higher on average in this scenario. This is a 6% increase relative to the mean stock share of 16%.[25]

Second, suppose households had no mortgage debt and no home equity wealth. Based on the mean level of property value and home equity wealth (\$76,572), the net impact of having no housing wealth or liabilities on the stock share of liquid wealth would be $7.58 \times 1.30257 - 7.37 \times 0.76572 = 4.23$ percentage points, a 26% increase. If the wealth taken

[25]These counterfactuals apply to the average household in the population, pooling those who hold stocks and those who do not. We present counterfactuals for the subset of stockholders below.

out of housing were invested in other assets (e.g., financial assets) so total wealth remained fixed, the stock share of liquid wealth would likely rise even further because the portfolio share of stocks tends to rise with liquid wealth (Calvet, Campbell, and Sodini 2007).

Because property value is the sum of mortgage debt and home equity, our estimates of β_1 and β_2 imply that an increase in home equity holding fixed *mortgage debt* does not have a significant effect on portfolio allocations. This is because the wealth effect of having more home equity is cancelled out by the effect of owning a more expensive house. It is therefore crucial to disentangle the two components of property value in order to uncover the effects of housing on portfolios. It follows that the demand for risky assets will not covary with current house price fluctuations (because they affect both wealth and property values simultaneously), but will covary negatively with outstanding mortgage debt.

Extensive and Intensive Margin Response. In columns 7 and 8, we decompose the effects of housing on stock shares into stock market participation decisions (whether to own any stocks) and intensive margin changes in portfolio allocations (how much money to invest in stocks conditional on owning stocks). Column 7 replicates column 5, replacing the dependent variable with an indicator for owning stocks. A \$10,000 increase in an individual's mortgage is estimated to reduce his probability of owning stocks by 1.4 percentage points, relative to a mean of 29%. Increases in home equity wealth increase the probability of stock market participation by a slightly smaller magnitude.

Column 8 isolates the intensive margin response – the change in stock shares conditional on participating in the stock market. This column reports estimates of a two-stage Tobit specification. This model is analogous to the two-stage-least-squares estimates, but corrects for the fact that some individuals are non-participants using a Tobit specification where the stock share is left censored at 0.[26] The estimates imply that a \$10,000 increase in mortgage debt reduces stock shares for stock market participants by 3.3 percentage points relative to a base of 54.6%. Home equity changes again have similar effects in the opposite direction.

We can use the estimates in Column 8 to consider the same counterfactuals as we did above for the subset of stockholders. Among stockholders, mean property value is \$159,501 and home equity is \$97,731. Hence, if households in this sample were to spend 10% less on housing, they would increase the stock share of their portfolio by $33.39 \times 0.159501 = 5.33$ percentage points. This is a 9.8% increase relative to the mean stock share of 54.6% among stockholders. The net impact of having no housing wealth or liabilities on the stock share of liquid wealth would be $33.39 \times 1.59501 - 34.32 \times 0.97731 = 19.71$ percentage points, a 36.1% increase. The percentage changes in stockholding under these counterfactuals are similar to those in the full sample, but naturally the magnitudes of the changes in portfolio shares are larger among the subset of households that hold stocks.

[26]Estimating a 2SLS model only on the subsample of stock market participants yields biased estimates because changes in home equity and mortgages affect stock market participation rates, generating selection effects.

D. *Research Design 3: Portfolio Changes Around Home Purchase*

Our third identification strategy directly addresses concerns about selection by examining changes in portfolio shares within a household. Do individuals who buy more expensive houses reduce their stockholdings by a larger amount from the year before to the year after home purchase? We answer this question using the small subsample of households for whom we (1) observe a home purchase within our data and (2) observe portfolio shares both before and after home purchase. Note that this sample includes both individuals who transition from renting to owning and individuals who bought a new house within our sample frame. As discussed in Section 3, this panel sample includes much fewer households than the cross-sectional analysis sample because the SIPP tracks households for only 3 years and relatively few households buy a house within that window.

Define $\Delta x = x_{t+1} - x_{t-1}$ for an individual who buys a new house in year t. We estimate a version of (5) in first differences:

$$\Delta \text{stock share}_i = \alpha + \beta_1 \Delta \text{property value}_i + \beta_2 \Delta \text{total wealth}_i + \gamma \Delta X_i + \Delta \varepsilon_i \qquad (6)$$

This estimation strategy complements the preceding research designs by addressing selection directly. If our results are driven by selection effects, individuals who buy houses when prices are high would hold more conservative portfolios even *before* they buy their houses and we would not find $\beta_1 < 0$ in (6).

To account for the endogeneity of the size of the house one purchases, we instrument for Δproperty value using the state house price index in the year of home purchase.[27] Because we only observe portfolio shares over two to three years, there is little difference between house prices at the time of purchase and the point at which we observe portfolio shares. Therefore, we cannot separately instrument for the effects of changes in wealth (via home equity) on portfolios as in the preceding cross-sectional specifications. Instead, we control for the change in total wealth in (6) directly. To the extent that this approach fails to adjust adequately for the impacts of changes in wealth, our estimate of β_1 in the panel design will be biased toward zero because it captures not only the impacts of having more mortgage debt but also the impacts of having more wealth.

In practice, we find that controlling for the change in wealth has little impact on our estimate of β_1 because local house prices are not strongly correlated with changes in total wealth from the year before to the year after purchase. Intuitively, an individual who buys a house in a more expensive market ends up with less liquid wealth but similar total wealth after the house purchase. As a result, the IV estimate of β_1 in (6) is effectively identified from changes in property value that are orthogonal to changes in total wealth.[28]

[27]Unfortunately, there is insufficient power to use the house price elasticities in our second design as instruments in this panel analysis.

[28]In our stylized model, we consider variation in property value holding liquid wealth fixed. In our panel

Results. Columns 1-3 of Table VI document the first-stage effects of the state house price index on changes in property value, home equity, and mortgage debt in a regression that includes state and age fixed effects as well a control for the change in total wealth. To reduce the influence of outliers, we exclude 65 households who report changes in total wealth of more than 1 million dollars in these specifications; we show below that this exclusion has no effect on our estimate of β_1 but does affect the estimated wealth effects. The estimates show that individuals who buy houses in higher priced markets spend more on their houses. Most of the increase comes from taking on more mortgage debt rather than making a bigger downpayment to build home equity.

Columns 4-6 report 2SLS estimates of the effect of changes in property value on the stock share of liquid wealth. In column 4, we include state, age, and year fixed effects and the change in total wealth as controls. A \$10,000 increase in property value is estimated to reduce the stock share by 1.3 percentage points in this specification. This estimate is statistically significant with $p < 0.01$. A \$10,000 increase in wealth is estimated to increase stock shares by 0.6 percentage points. Reassuringly, this estimate is quite similar to the estimated impacts of home equity wealth on the stock share from our first two identification strategies.

Note that the results in column 4 are not just a mechanical consequence of the fact that people reduce their liquid wealth to make a down payment when buying a house (presumably by selling stocks). Since the dependent variable in the regression is the stock share of liquid wealth, the result is that people sell stocks in greater proportion than bonds when they buy a house, which is a choice rather than a mechanical consequence of making a downpayment.

Column 5 shows that controlling for education, number of children, state unemployment rate, and the change in household income does not affect the results significantly. These results allay concerns that our estimates of the effect of housing on stock shares may be biased by changes in local economic conditions that are correlated with changes in house prices.

Column 6 shows that the estimated impact of changes in property value on the stock share of liquid wealth remains unchanged when the outliers with wealth changes of more than 1 million dollars are included. Not surprisingly, however, these outliers substantially attenuate the estimated effect of wealth on portfolio shares. Finally, column 7 replicates column 5, replacing the dependent variable with an indicator for owning stocks. A \$10,000 increase in an individual's mortgage is estimated to reduce his probability of owning stocks by 1.2 percentage points relative to a baseline stock ownership rate of 36% in this sample.

In sum, the panel analysis confirms that the difference in portfolios between individuals who buy when house prices are high and low emerges immediately *after* home purchase,

research design, liquid wealth falls when individuals buy a house. This leads to an additional effect on the stock share of liquid wealth due to a reduction in the denominator (Yao and Zhang 2005). This additional effect works to increase the stock share of liquid wealth, working against our theoretical prediction. Our empirical analysis is therefore a stronger test of our theoretical prediction, in that it asks whether the negative effect of housing on the stock share of liquid wealth (driven by the mechanism we highlight in this paper) is stronger than the opposing effect due to the reduction in liquid wealth.

directly addressing concerns about time-invariant selection bias. Although other forms of selection – based on time-varying unobservables – could still bias the estimates, the similarity and robustness of the estimates from the three research designs suggest that such effects are likely to be weak, and that mortgage debt has a robust negative effect on risk taking in financial portfolios over both short and long horizons.

V. Conclusion

This paper has characterized the causal effect of housing on portfolio choice. We find robust evidence that an increase in property value (i.e., mortgage debt), holding wealth fixed, reduces a household's propensity to participate in the stock market and reduces the share of stocks in the portfolio conditional on participation. The estimated elasticity of the share of liquid wealth allocated to stocks with respect to mortgage debt is -0.2. Increases in home equity wealth while holding property value fixed increase stockholding. The estimated elasticity of the stock share of liquid wealth with respect to home equity is 0.3.

These results hold in a research design that exploits all the available variation in mean house prices across states as well as refined designs that exploit the portion of variation that projects onto differences in housing supply elasticities and control for selection effects by examining changes in portfolios around the purchase of a house. Although each of the three designs is not necessarily definitive in itself, the stability of the results across the different sources of variation makes it quite unlikely that the results are driven by confounding factors.

Our results imply that the interaction between housing and financial markets could have important consequences for the macroeconomy. For instance, in the 2000s, there was a substantial increase in levels of mortgage debt as well as an increase in the illiquidity of housing as many individuals postponed selling their homes. Our findings suggest that each of these factors increased households risk aversion, potentially exacerbating the decline in financial markets by reducing the demand for stocks even at low prices. In future work, it would be interesting to explore whether such interactions are consistent with historical fluctuations in housing and asset prices using calibrated general equilibrium models.

Our analysis is consistent with the hypothesis that the illiquidity of housing amplifies household risk aversion. An interesting avenue for future research would be to explore whether fluctuations in the liquidity of housing markets over time induce changes in financial portfolios. It is also important to analyze whether the commitment of having to make mortgage payments – a "cash commitment" that arises from liquidity constraints – or the commitment of being unable to adjust housing consumption easily is what amplifies risk aversion.[29] Depending upon which mechanism is more important, reducing transaction costs in the housing and

[29] Such an analysis would require variation in mortgage payments that is orthogonal to property value, perhaps arising from differences in the term structure of loans.

mortgage markets could raise welfare both directly and by allowing households to bear more risk in their financial portfolios.

References

Brueckner, J.K. (1997). "Consumption and Investment Motives and the Portfolio Choices of Homeowners," *Journal of Real Estate Finance and Economics*, 15(2): 159–80.

Calvet, L.E., Campbell, J.Y. and Sodini, P. (2007). "Down or Out: Assessing the Welfare Costs of Household Investment Mistakes," *Journal of Political Economy*, 115(5): 707–747.

Campbell, J. Y. and Cocco, J. F. (2003). "Household Risk Management and Optimal Mortgage Choice," *Quarterly Journal of Economics* 118:1449-1494.

Campbell, J. Y. and Cocco, J. F. (2007). "How Do House Prices Affect Consumption? Evidence from Micro Data," *Journal of Monetary Economics* 54:591-621.

Campbell, J. Y. and Viceira, L. M. (2002) *Strategic Asset Allocation: Portfolio Choice for Long Horizon Investors*, Oxford University Press.

Case, K. E. and Shiller, R. J. (1989). "The Efficiency of the Market for Single Family Homes," *American Economic Review*, 79(1) : 125-137.

Chetty, R. and Szeidl, A. (2007). "Consumption Commitments and Risk Preferences," *Quarterly Journal of Economics* 122(2): 831-877.

Cocco, J. (2005). "Portfolio Choice in the Presence of Housing," *Review of Financial Studies* 18, 535–567.

Cocco, J. F., Gomes F. J. and Maenhout P. J. (2005) "Consumption and Portfolio Choice over the Life Cycle," *Review of Financial Studies* 18, 491-533.

Davidoff, Thomas (2010). "Home Equity Commitment and Long-Term Care Insurance Demand," *Journal of Public Economics* 94(1), 44-49.

Davis, J. S., F. Kubler and P. Willen (2006) "Borrowing Costs and the Demand for Equity over the Life Cycle," *Review of Economics and Statistics* 88, 348-362.

Flavin, M. and Yamashita, T. (2002). "Owner-Occupied Housing and the Composition of the Household Portfolio," *American Economic Review*, 92(1): 345–362.

Fougere, D. and M. Poulhes. (2014) "The Effect of Housing on Portfolio Choice: A Reappraisal Using French Data." CREST Working Paper.

Fratantoni, M.C. (2001). "Homeownership, Committed Expenditure Risk, and the Stockholding Puzzle," *Oxford Economic Papers*, 53(2): 241–59.

Fratantoni, M.C. (1998). "Homeownership and Investment in Risky Assets," *Journal of Urban Economics*, 44(1): 27–42.

Glaeser, E. L., Gyourko, J. and Saiz. A. (2008). "Housing Supply and Housing Bubbles, " *Journal of Urban Economics*, 64(2) : 198-217.

Glaeser, E. L., Gyourko, J. and Saks, R. E. (2005). "Why Have Housing Prices Gone Up ? " *American Economic Review*, 95(2) : 329-333.

Grossman, S. J. and Laroque, G. (1990). "Asset Pricing and Optimal Portfolio Choice in the Presence of Illiquid Durable Consumption Goods," *Econometrica* 58, 25–51.

Gyourko, J., Mayer, C. and Sinai, T. (2013). "Superstar Cities," *American Economic Journal : Economic Policy*, 5(4) : 167-99.

Heaton J. and Lucas, D.J. (2000). "Portfolio Choice in the Presence of Background Risk," *Economic Journal* 110(460): 1-26.

Himmelberg, C., Mayer, C., and Sinai, T. (2005). "Assessing High House Prices: Bubbles, Fundamentals, and Misperceptions," *Journal of Economic Perspectives* 19(4): 67-92.

Merton, R. C. (1969). "Lifetime Portfolio Selection Under Uncertainty: The Continuous Time Case," *Review of Economics and Statistics* 51, 247-257.

Mian, A. and Sufi, A. (2009). "'The Consequences of Mortgage Credit Expansion: Evidence from the U.S. Mortgage Default Crisis," *Quarterly Journal of Economics* 124, 1449–1496.

Mian, A. and Sufi, A. (2011). "House Prices, Home Equity Based Borrowing, and the U.S. Household Leverage Crisis," *American Economic Review* 101, 2132-2156.

Odean, T. (1999). "Do Investors Trade Too Much?" *American Economic Review*, 89(5): 1279–1298

Piazzesi, M., Schneider, M. and Tuzel, S. (2007). "Housing, Consumption and Asset Pricing," *Journal of Financial Economics*, 83(3): 531–569.

Saiz, A. (2010). "The Geographic Determinants of Housing Supply," *Quarterly Journal of Economics*, 125(3): 1253-1296.

Shore, S. and Sinai, T. (2010). “Commitment, Risk, and Consumption: Do Birds of a Feather Have Bigger Nests?” *Review of Economics and Statistics*, 92(2), 408–424.

Sinai, T. and Souleles, N.S. (2005). “Owner-Occupied Housing as a Hedge Against Rent Risk,” *Quarterly Journal of Economics,* 120(2): 763–789.

Smith, L., Rosen, K., and Fallis, G. (1988). “Recent Developments in Economic Models of Housing Markets,” *Journal of Economic Literature,* 26(1): 29-64.

Vestman, Roine (2012). ”Limited Stock Market Participation Among Renters and Home Owners,” Working paper, Stockholm Institute for Financial Research.

Vissing-Jorgensen, A. (2003), “Perspectives on Behavioral Finance: Does “Irrationality” Disappear with Wealth? Evidence from Expectations and Actions,” *NBER Macroeconomics Annual,* 139-194.

Yamashita, T. (2003). “Owner-Occupied Housing and Investment in Stocks: An Empirical Test,” *Journal of Urban Economics*, 53(2): 220–237.

Yao, R. and Zhang, H. (2005). “Optimal Consumption and Portfolio Choices with Risky Housing and Borrowing Constraints,” *Review of Financial Studies*, 18(1), 197-239.

Yogo, M. (2006). “A Consumption-based Explanation of Expected Stock Returns,” *Journal of Finance*, 61(2): 539–58.

Appendix

A.1 Proofs

Proof of Proposition 1. Let $W_1 = L_0(1 + R_p) + P_1 H_0 - M_1 + Y_1$. If the household can move, the optimal consumption bundle satisfies $C_1 = (1-\mu)W_1$ and $P_1 H_1 = \mu W_1$, implying that utility in this state is

$$V_m(W_1) = \frac{\left[\mu^{\mu}(1-\mu)^{1-\mu}\right]^{1-\gamma}}{1-\gamma} \cdot \left(\frac{W_1}{P_1^{\mu}}\right)^{1-\gamma}. \tag{7}$$

If the household cannot move, the consumption bundle is $C_1 = W_1 - P_1 H_0$ and $H_1 = H_0$, and hence utility is

$$V_{nm}(W_1) = \frac{H_1^{\mu(1-\gamma)}}{1-\gamma} \cdot (W_1 - P_1 H_0)^{(1-\mu)(1-\gamma)}. \tag{8}$$

We then define $V(W) = V_m(W)$ if the household moves and $V_{nm}(W)$ otherwise. The first order condition of the problem implies

$$E\left[(R - R_f) \cdot V'(W_1)\right] = 0.$$

We can write this as

$$\begin{aligned} & \theta \cdot E\left[(1+R) \cdot V'_{nm}(W_1)\right] + (1-\theta) \cdot E\left[(1+R) \cdot V'_m(W_1)\right] \\ = \;& \theta \cdot E\left[(1+R_f) \cdot V'_{nm}(W_1)\right] + (1-\theta) \cdot E\left[(1+R_f) \cdot V'_m(W_1)\right] \end{aligned}$$

where both sides are positive. To log-linearize each side separately, first introduce the notation that $V^{0\prime}_{nm}$ and $V^{0\prime}_m$ are the marginal utilities in the two states in the realization in which both the agent's financial return and home price growth equal $1 + R_f$. Now take logs of the left hand side and use a first order approximation, around the point at which both the stock return and home price growth equal $1 + R_f$, to obtain

$$\begin{aligned} & \log\left[\theta \cdot E\left[(1+R) \cdot V'_{nm}(W_1)\right] + (1-\theta) \cdot E\left[(1+R) \cdot V'_m(W_1)\right]\right] \\ \approx \;& k + \theta^* \left[\log E\left[(1+R) \cdot V'_{nm}(W_1)\right] - \log\left[(1+R_f) V^{0\prime}_{nm}\right]\right] \\ & + (1-\theta^*) \left[\log E\left[(1+R) \cdot V'_m(W_1)\right] - \log\left[(1+R_f) V^{0\prime}_m\right]\right] \end{aligned}$$

where

$$\theta^* = \frac{\theta V^{0\prime}_{nm}}{\theta V^{0\prime}_{nm} + (1-\theta) V^{0\prime}_m}.$$

An analogous formula holds for the right hand side of the first order condition, with the same constants. Using the approximation $\log E \exp(z) \approx Ez + \sigma_z^2/2$ which is exact when z is a normal random variable, we then obtain

$$Er - r_f + \frac{\sigma_r^2}{2} \approx \theta^* \cdot \operatorname{cov}\left[r, -v'_{nm}\right] + (1-\theta^*) \cdot \operatorname{cov}\left[r, -v'_m\right]$$

as in the text. To compute θ^*, let W_1^0 denote wealth in $t = 1$ in the no-move state when both the financial return and home price growth equal $1 + R_f$; and let $P_1^0 = 1 + R_f$ denote the corresponding home price. Substituting into (7) and (8) yields

$$\begin{aligned} \frac{V^{0\prime}_{nm}}{\left(W_1^0\right)^{-\gamma}} &= \frac{1-\mu}{\left(W_1^0\right)^{-\gamma}} H_0^{\mu(1-\gamma)} \left(W_1^0 - P_1^0 H_0\right)^{-\mu-\gamma+\mu\gamma} = \left(\frac{H_0}{W_1^0}\right)^{\mu(1-\gamma)} (1-\mu) \left(1 - \frac{P_1^0 H_0}{W_1^0}\right)^{-\mu-\gamma+\mu\gamma} \\ \frac{V^{0\prime}_m}{\left(W_1^0\right)^{-\gamma}} &= \left[\mu^\mu (1-\mu)^{1-\mu}\right]^{1-\gamma} \left(P_1^0\right)^{-\mu(1-\gamma)} \end{aligned}$$

which imply, after some calculations, equation (4) in the text.

Now note that $V'_{nm}(W_1)$ is proportional to $(L_0(1+R_p) + Y_1 - M_1)^{-\mu-\gamma+\gamma\mu}$. Let $L_0(1+R_p) +$

$Y_1 - M_1 = L_1$, which we can log-linearize as

$$l_1 \approx k' + \eta_1 (l + r_p) + \eta_2 (y + r_f) + (1 - \eta_1 - \eta_2)(m + r_f)$$

where k' is a constant, lowercase letters denote the logs of L, Y and M defined in the text, and

$$\eta_1 = \frac{L}{L + Y - M} \text{ and } \eta_2 = \frac{Y}{L + Y - M}.$$

$V'_m(W_1)$ is proportional to $W_1^{-\gamma} P_1^{(\gamma-1)\mu}$. We can log linearize $W_1 = L_0(1 + R_p) + P_1 H_0 + Y_1 - M_1$ as

$$w_1 \approx k' + (1 - \rho)\eta_1 (l + r_p) + (1 - \rho)\eta_2 (y + r_f) + (1 - \rho)(1 - \eta_1 - \eta_2)(m + r_f) + \rho p_1$$

where k'' is a different constant and $\rho = PH/(L + PH + Y - M)$ is the housing share in wealth W.

Substituting these expressions into $V'_{nm}(W_1)$ and $V'_m(W_1)$ and then in the Euler equation yields

$$Er - r_f + \frac{\sigma_r^2}{2} \approx (1 - \theta^*)\gamma \cdot \left[(1 - \rho)\eta_1 \cdot \alpha\sigma^2 + (\rho - (1 - 1/\gamma)\mu)\operatorname{cov}[r, p_1]\right] + \theta^*\gamma^c\eta_1\alpha\sigma^2$$

and hence

$$\alpha \approx \frac{Er - r_f + \sigma^2/2 + (1 - \theta^*)(\mu(\gamma - 1) - \gamma\rho)\operatorname{cov}[r, p_1]}{\theta^*\gamma^c \cdot \sigma^2\eta_1 + (1 - \theta^*)\gamma \cdot \sigma^2\eta_1(1 - \rho)}$$

which gives (4) as desired.

A.2 Robustness of Theoretical Results to Model Extensions

In this section, we assess the robustness of the comparitive statics to incorporating additional features into the stylized model.

A.2.1 Static Extensions

Here we extend the model to incorporate (1) fixed adjustment costs, which permit households to move at any time by paying a cost, (2) stock market participation costs, and (3) labor income risk. Because these features make the model analytically intractable, we use numerical methods to characterize the relationship between housing and portfolios. We discuss our numerical approach in Appendix A.3 below.

Fixed adjustment costs. We begin by relaxing the assumption that households can only move at random, exogenous dates. A more realistic assumption is that households can move at any time by paying a fixed cost. Let λ denote the size of this fixed cost as a share of property value. Smith, Rosen, and Fallis (1988) estimate the monetary component of moving costs to be approximately $\lambda = 0.1$. We consider values of $\lambda = 0.1$ and $\lambda = 0.2$, the latter of which captures other utility costs of moves (e.g., the need to change a child's school). Panel A of Appendix Table IIa reports results analogous to those in Table I from this model. The direction of comparative statics are generally the same, although the property value effects are smaller in magnitude, as should be expected given that housing is a weaker commitment in this model.

One interesting feature of the fixed cost model is that the comparative statics of interest change sign for some parameter values. For instance, when $\lambda = 0.2$ and $\rho = 0$, increasing home value from $\$110,000$ to $\$120,000$ *increases* the stock share from 82.6% to 83.8%. Such non-monotonicities in risk preferences in the presence of fixed costs were first observed by Grossman and Laroque (1990) and more extensively documented by Yao and Zhang (2005). The intuition is that households who are relatively close to the boundary of their inaction region have a gambling motive: by holding more stocks, they can increase the probability of buying their "ideal" house. For households who are on the margin of moving, this mechanism can sometimes overpower the three forces that act toward reducing α^*. Appendix Table IIa shows that for most parameter values, the other three forces dominate. However, the fact that the model can sometimes produce a positive relationship implies that the average effect of property value on the stock share is ultimately an empirical question.

Income risk. Next, we consider the effects of labor income risk by allowing labor income Y_1 to be stochastic. Because the household must repay the exogenously fixed mortgage (i.e., there is no default), labor income must be bounded from below for the model to be well-defined. We thus assume that $Y_1 = Y_1^s + Y_1^r$ where both terms are non-negative. Y_1^s is a safe (deterministic) component of labor income, while Y_1^r is a lognormal random variable. In keeping with the earlier parametrization, we assume $EY_1 = Y_1^s + EY_1^r = 5L_0$. We set (somewhat arbitrarily) the safe share of expected labor income to be 60%: $Y_1^s = 3L_0$ and $EY_1^r = 2L_0$. We assume that Y_1^r and P_1 are jointly lognormal, and set $Var\left[\log\left(Y_1^r\right)\right]$ and $Cov\left[\log\left(Y_1^r\right), \log\left(P_1\right)\right]$ to match the standard deviation of $\log(Y_1)$ and the correlation between $\log(Y_1)$ and $\log(P_1)$. We calibrate $\log(Y_1)$ to the annual standard deviation of 0.13 for labor income growth as used by Yao and Zhang (2005). For the correlation between $\log(Y_1)$ and $\log(P_1)$, we consider both zero (as a benchmark) and 0.55 (as in Cocco, 2005). As above, we assume $\theta = 0.55$ and $\rho = 0$.

Panel B of Appendix Table IIa shows that introducing labor income risk reduces the stock share. Intuitively, these shocks increase background risk and hence reduce the risk appetite of investors. However, the predictions about the effect of property value and home equity are again unchanged in sign and remain similar in magnitude. The correlation between labor income and home prices has small effects on portfolio shares. This is likely because home price risk (ρ) itself has small effects. Intuitively, house prices only matter in the event of a move, and even then, much of the money invested in the previous house is used to purchase the new house, providing a natural hedge against house price risk (Sinai and Souleles 2005).

Participation costs. Finally, we consider the effect of incorporating stock-market participation costs. We extend our baseline model by assuming that the household must pay a fixed cost F at $t = 0$ if it wishes to hold any stocks. Vissing-Jorgensen (2003) estimates that, when allowing for cross-sectional variation in fixed costs, a cost distribution with median cost of \$350 per year (in 1982-84 prices) can explain the pattern of non-participation in 1994. Converting this median estimate to 1990 prices (the units we use to measure wealth and home value in our empirical analysis) and computing the present value of paying this amount every year for ten years to reflect the investment horizon, we obtain an estimate of $F = \$4,207$. Panel C of Appendix Table IIa reports optimal portfolios in the presence of this cost with $\theta = 0.55$ and $\rho = 0$. To demonstrate the novel effects of participation costs, in this panel we look at a wider range of housing values by using a step size of $\$20,000$ for both property value and home equity. The table shows an active extensive margin: for example, as property value increases from $\$150,000$ to $\$170,000$, the household changes the stock share from 61.4% to zero. Intuitively, a higher property value leads the household to reduce the stock share, but the fixed cost of participation outweighs the benefit of investing a small amount in stocks, inducing the household to exit the stock market entirely. We observe a similar effect when home equity wealth falls from $\$56,000$ to $\$36,000$. These extensive margin responses amplify the effects of housing on portfolio shares, but the qualitative predictions of the model remain similar.

A.2.2 Dynamic Extensions

The model we have analyzed thus far is effectively static: there is a single decision about portfolio choice, and all uncertainty is resolved in a single period. We now consider three extensions that make the model dynamic: (1) consumption in the initial period, (2) persistent uncertainty, and (3) a bequest motive. To isolate the effect of these changes, we consider each separately.

Consumption in the initial period. To allow for consumption and savings decisions in the initial period, suppose that at $t = 0$ the household can freely choose adjustable consumption C_0. Housing consumption is restricted to be equal to the housing endowment H_0. Preferences are now given by

$$\frac{\left[C_0^{1-\mu} H_0^{\mu}\right]^{1-\gamma}}{1-\gamma} + \delta E_0 \frac{\left[C_1^{1-\mu} H_1^{\mu}\right]^{1-\gamma}}{1-\gamma}.$$

We also assume that the household receives initial income Y_0 in period zero. We set $\theta = 0.55$ and $\rho = 0$, use an annual discount factor of 0.96, and set Y_0 such that the household with property value $\$130,000$ and home equity $\$76,000$ saves exactly the same amount (\$44,000) as the exogenous starting level of liquid wealth we used in the static model above. This gives $Y_0 = \$215,468$, which is slightly lower than Y_1.

Panel A of Appendix Table IIb shows that the qualitative effects of property value and home equity in this setting are the same as in the static case. However, the stock share is now more sensitive to changes in property value and home equity. This is because of the additional margin of savings. For example, when higher property value increases future risk, the household not only reduces the dollars it invests in stocks (as in the baseline model), but also saves more, further lowering the share of stocks in liquid wealth.

Persistent uncertainty. To consider the effects of multi-period uncertainty, we now introduce a third period into the baseline model. In $t = 0$, the household makes a portfolio decision as in the baseline version of the model. In $t = 1$, it repays its outstanding mortgage, earns labor income Y_1, moves houses with (exogenous) probability $(1 - \theta)$, consumes, and makes a new portfolio decision. In $t = 2$, the household earns labor income Y_2, moves with independent probability $(1 - \theta)$, and consumes. We assume that each period lasts ten years. We set $Y_1 = 4L_0$, $Y_2 = 3L_0$, $\theta = 0.55$, and $\rho = 0$. The annual discount factor is 0.96.

Panel B of Appendix Table IIb shows that in this environment with persistent uncertainty, the effects of property value and home equity, though larger in magnitude, are once again qualitatively similar to the baseline specification. Thus, the results of the one-period model with a ten year horizon continue to serve as a useful benchmark.

Bequests. Finally, we address the concern that the household cannot monetize the house at the end of $t = 1$ in our baseline model by introducing a bequest motive. Following Cocco (2005), we assume that the household bequeaths the house as well as any unconsumed savings (S_1) to its offspring, who derive CRRA utility from the total market value of these assets. Thus implicitly we assume that death is a move-inducing event. Similarly to Cocco (2005), total utility from the perspective of $t = 0$ is given by

$$E_0 \frac{\left[C_1^{1-\mu} H_1^{\mu}\right]^{1-\gamma}}{1-\gamma} + \delta E_0 \frac{\left[P_1 H_1 + S_1\right]^{1-\gamma}}{1-\gamma}.$$

Panel C of Appendix Table IIb reports the results from this specification. The qualitative results remain similar, but now the stock share responds less to changes in property value and home equity. One force that explains this pattern is that bequest utility is bounded from below due to the presence of housing. Intuitively, because parents know that their children will have the house even if they cannot bequeath any financial assets, they are less sensitive to changes in risk.

A.3 Numerical methodology

In each specification, we use the same numerical techniques as Cocco (2005) to solve the model.[30] The idea is use backward induction and compute continuation values over grids. We approximate the state and choice variables using equal-spaced grids, and the probability

[30] We thank Joao Cocco for sharing his code for solving the model in Cocco, Gomes, and Maenhout (2005).

density functions of shocks with three-point Gaussian quadratures. In the static specifications, both with random moves and fixed costs, and with and without labor income risk, we compute realized utility over each gridpoint in the state space and then expected utility using numerical integration for each choice of α. To compute utilities for points which do not lie on the grid, we use cubic spline interpolation. In the dynamic model, we perform the same exercise in the last period for each consumption and portfolio decision, and use the resulting optimal continuation values to solve for the optimal portfolio in the initial period. Using a seven-point Gaussian quadrature instead does not affect the results.

TABLE I
Numerical Results from Stylized Model

Panel A: Impacts of property value on stock share of liquid wealth
(When home equity = $76,000)

θ	ρ	Property value				
		$110,000	$120,000	$130,000	$140,000	$150,000
0.55	0	80.2%	74.8%	69.1%	63.2%	57.4%
0.55	0.1	79.2%	73.9%	68.4%	62.7%	57.1%
0.35	0	83.6%	78.3%	72.3%	66.0%	59.5%
0.35	0.1	81.9%	76.7%	71.0%	64.9%	58.8%
0	0	95.1%	93.6%	92.0%	90.3%	88.6%
0	0.1	90.8%	88.5%	86.2%	83.8%	81.3%

Panel B: Impacts of home equity wealth on stock share of liquid wealth
(When property value = $130,000)

θ	ρ	Home equity				
		$56,000	$66,000	$76,000	$86,000	$96,000
0.55	0	58.0%	63.5%	69.1%	74.6%	80.1%
0.55	0.1	57.5%	62.9%	68.4%	73.8%	79.2%
0.35	0	60.5%	66.4%	72.3%	78.1%	83.8%
0.35	0.1	59.5%	65.3%	71.0%	76.6%	82.1%
0	0	83.3%	87.7%	92.0%	96.4%	100.0%
0	0.1	77.2%	81.7%	86.2%	90.7%	95.1%

Notes: Each cell lists the optimal share of liquid wealth invested in stocks (α^*) for a different combination of parameters. θ denotes the probability that the household does not move and measures the strength of housing commitments. ρ denotes the correlation coefficient between the (log) stock return and (log) home price growth, and measures the degree of home price risk.

TABLE IIa
Summary Statistics for SIPP Cross Sectional Anaysis Sample

	Mean (1)	Median (2)	Standard Deviation (3)
Demographics:			
Age (years)	48.73	47	14.11
Years of education	13.66	13	2.77
Number of children	0.64	0	1.03
Household Income ($)	48,677	39,871	42,120
Housing:			
Property value ($)	130,257	103,567	95,113
Mortgage ($)	53,685	42,345	54,509
Home tenure (years)	9.21	7	7.38
Wealth:			
Total wealth ($)	187,320	101,334	700,338
Liquid wealth ($)	44,090	5,909	661,134
Home equity ($)	76,572	51,784	77,987
Equity in other real estate ($)	16,680	0	70,585
Vehicle equity ($)	6,406	4,884	7,586
Business equity ($)	11,864	0	73,189
Retirement accounts ($)	30,456	3100	62,046
Portfolio Allocation:			
Percent of households holding stock	29.32%	0.00%	45.52%
Stock share (% of liquid wealth)	16.02%	0.00%	30.40%
Safe assets share (% of liquid wealth)	83.98%	100.00%	30.40%
Number of observations		80,392	

Notes: This table includes all household heads (reference persons) in the 1990-2008 SIPP panels who purchased houses in or after 1975 and for whom house price index information is available, which is the estimation sample for the cross-sectional analysis. All monetary values are in real 1990 dollars. Home tenure is defined as numbers of years living in current house. Income is total family income: labor income plus all other forms of income plus transfers. Total wealth is gross household wealth measured on the survey. It includes financial assets as well as all real estate (including second homes), cars, and private business equity. Debts are not subtracted from the total wealth measure. Safe assets consist of bonds, checking accounts, and savings accounts. Liquid wealth is defined as the the sum of safe assets and stockholdings.

TABLE IIb
Summary Statistics for SIPP Panel Analysis Sample

	Mean (1)	Median (2)	Standard Deviation (3)
Demographics:			
Age (years)	43.53	40	13.70
Years of education	14.07	13	2.60
Number of children	0.98	1	1.16
Household Income ($)	53,134	42,980	46,858
Housing:			
Property value ($)	133,871	109,832	96,323
Mortgage ($)	79,235	70,747	62,069
Home tenure (years)	1.29	1.00	0.45
Wealth:			
Total wealth ($)	139,886	70,873	200,633
Liquid wealth ($)	35,464	5,573	98,333
Home equity ($)	54,985	31,381	73,038
Equity in other real estate ($)	12,010	0	55,737
Vehicle equity ($)	5,673	4,558	7,606
Business equity ($)	8,045	0	60,832
Retirement accounts ($)	21,059	0	49,968
Portfolio Allocation:			
Percent of households holding stock	36.31%	0.00%	48.09%
Stock share (% of liquid wealth)	22.52%	0.00%	35.27%
Safe assets share (% of liquid wealth)	77.48%	100.00%	35.27%
Number of observations		6,912	

Notes: This table includes the subset of household heads in the 1996 to 2008 SIPP panels for whom we observe wealth both before and after the year of home purchase, which is the estimation sample for the panel analysis. All monetary values are in real 1990 dollars. Home tenure is defined as numbers of years living in current house. Income is total family income: labor income plus all other forms of income plus transfers. Total wealth is gross household wealth measured on the survey. It includes financial assets as well as all real estate (including second homes), cars, and private business equity. Debts are not subtracted from the total wealth measure. Safe assets consist of bonds, checking accounts, and savings accounts. Liquid wealth is defined as the the sum of safe assets and stockholdings.

TABLE III
OLS Regression Estimates

Dependent Variable.:	Stock Share			
	(%)	(%)	(%)	(%)
	(1)	(2)	(3)	(4)
Property value	4.43	0.75	-0.37	0.13
(x $100K)	(0.19)	(0.19)	(0.22)	(0.23)
Home equity	1.51	-1.35	-0.71	-0.81
(x $100K)	(0.24)	(0.23)	(0.30)	(0.30)
current year, purch. year and age FE's		x	x	x
state FE's		x		x
liquid wealth spline		x	x	x
other controls		x	x	x
Observations	80,392	80,392	60,520	60,520

Notes: Standard errors in parentheses. Specifications 2-4 include fixed effects for the household head's age, current year (year in which portfolio allocations and current property value are measured), and year of home purchase. These specifications also include a 10-piece linear spline for liquid wealth, and the following other controls: income, private business wealth, education, number of children, and state unemployment rate in current year as well as year of home purchase. Specifications 2 and 4 include state fixed effects. The dependent variable is dollars held in stocks divided by liquid wealth. All specifications are estimated using OLS. Specifications 1 and 2 use the entire cross-sectional sample; specifications 3 and 4 restrict the sample to those with positive mortgage debt.

TABLE IV
Research Design 1: Variation in State House Prices

	First Stage (OLS)			Two-Stage Least Squares			
Dependent Variable:	Prop Val	Home Equity	Mortgage	Stock Share			
						Logs	Shares
	($)	($)	($)	(%)	(%)	(%)	(%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Property value				-6.23	-7.45		
(x $100K)				(2.46)	(2.18)		
Home equity				6.81	6.80		
(x $100K)				(2.84)	(2.46)		
Log property value						-37.39	
(x $100K)						(14.37)	
Log home equity						18.34	
(x $100K)						(7.84)	
Property val/iq wealth							-7.88
(x $100K)							(3.10)
Home eq/liq wealth							7.98
(x $100K)							(3.19)
FHFA state house price	346.00	300.58	45.42				
index in current year	(8.39)	(7.11)	(4.70)				
	[41.23]	[42.27]	[9.67]				
FHFA state house price	-43.87	-155.14	111.27				
index in year of purchase	(9.11)	(7.73)	(5.10)				
	[4.81]	[20.08]	[21.81]				
state, curr. year, purch. year and age FE's	x	x	x	x	x	x	x
other controls					x	x	x
Observations	80,392	80,392	80,392	80,392	80,392	80,392	42,196

Notes: Standard errors in parentheses and t-statistics in square brackets. All specifications include fixed effects for the household head's state of residence, age, current year (year in which portfolio allocations and current property value are measured), and year of home purchase. Specifications 5-7 include these fixed effects, a 10-piece linear spline for liquid wealth, and the following other controls: income, private business wealth, education, number of children, and state unemployment rate in current year as well as year of home purchase. In column 1, the dependent variable is property value in the current year; in 2, it is home equity in the current year; and in 3, it is total outstanding mortgage debt in the current year. The dependent variable in specifications 4-7 is dollars held in stocks divided by liquid wealth. Specifications 1-3 are estimated using OLS; 4-7 are estimated using two-stage least squares. Instruments for property value and home equity are the current-year and year of purchase FHFA state price indices in specification 4-7. In specification 6, we instrument for the logs of these variables with the logs of the price indices. In specification 6, the endogenous regressors are in logs. In specification 7, the endogenous regressors are the ratio of property value to liquid wealth and the ratio of home equity to liquid wealth; households for whom either of these ratios exceed 20 are excluded in this specification. Coefficients for specifications 4-7 can be interpreted as percentage point effect of a $100,000 change in property value and home equity.

TABLE V
Research Design 2: Variation in Housing Supply

	First Stage (OLS)			Two-Stage Least Squares				Two-step Tobit
Dependent Variable:	Prop Val	Home Eq	Mortg	Stock Share			Stock Holder	Stock Share
						High-Wlth		
	($)	($)	($)	(%)	(%)	(%)	(%)	(%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Housing Supply Elasticity x U.S. FHFA in current year	-165.41	-148.23	-17.18					
	(5.59)	(4.75)	(3.12)					
	[29.58]	[31.23]	[5.51]					
Housing Supply Elasticity x U.S. FHFA in year of purch.	22.25	70.23	-47.98					
	(5.32)	(4.51)	(2.97)					
	[4.18]	[15.56]	[16.18]					
Property value (x $100K)				-6.48	-7.58	-11.03	-14.24	-33.39
				(3.09)	(2.68)	(4.33)	(3.86)	(8.70)
Home Equity (x $100K)				7.74	7.37	11.41	13.16	34.32
				(3.71)	(3.16)	(5.63)	(4.56)	(10.23)
state, age, year FE's	x	x	x	x	x	x	x	x
other controls					x	x	x	x
Observations	80,088	80,088	80,088	80,088	80,088	40,354	80,088	80,088

Notes: Standard errors in parentheses and t-statistics in square brackets. The housing supply elasticity is from Saiz (2010, Table 6), who constructs predicted elasticity measures by MSA and state using measures of land availability and usage regulations. We measure national house prices in our sample using the mean of the FHFA index in each year. Specifications 1-3 report OLS estimates of the first-stage effect of the housing supply elasticity interacted with national house prices in the current year and the year of purchase. The dependent variables are property value, home equity, and mortgage debt in the current year. Specifications 4-7 report 2SLS estimates using the two interactions of the housing supply elasticity with national prices as instruments for property value and home equity. Specification 8 is estimated as a Tobit model with endogenous regressors using Newey's two-step estimator. The dependent variable in specifications 4-6 is dollars held in stocks divided by liquid wealth. The dependent variable in specification 7 is an indicator for holding stocks. All specifications include fixed effects for the household head's state of residence, age, current year (year in which portfolio allocations and current property value are measured), and year of home purchase. Specifications 5-8 include these fixed effects, a 10-piece linear spline for liquid wealth, and the following other controls: income, private business wealth, education, number of children, and state unemployment rate in the current year. Coefficients in columns 4-8 can be interpreted as percentage point effect of a $100,000 change in property value and home equity. Specification 6 restricts the sample to individuals with total wealth above $100,000.

TABLE VI
Research Design 3: Portfolio Changes around Home Purchase

	First Stage (OLS)			Two-Stage Least Squares			
Dependent Variable:	Δ Prop Val	Δ Home Eq	Δ Mortg	Δ Stock Share			Δ Stock-holder
	($)	($)	($)	(%)	(%)	(%)	(%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FHFA state house price index in year of purchase x (year of purchase = 1998)	648.29 (69.23) [9.36]	31.22 (50.01) [0.62]	601.96 (52.22) [11.53]				
FHFA state house price index in year of purchase x (year of purchase = 2002)	471.38 (42.85) [11.00]	125.07 (30.95) [4.04]	336.88 (32.32) [10.42]				
FHFA state house price index in year of purchase x (year of purchase = 2010)	136.04 (37.40) [3.64]	-50.17 (27.01) [1.86]	179.69 (28.21) [6.37]				
Δ Property value (x $100K)				-12.77 (3.88)	-11.64 (4.06)	-11.76 (4.02)	-12.14 (4.56)
Δ total wealth	0.20 (0.01)	0.21 (0.00)	-0.01 (0.01)				
Δ total wealth (x $100K)				6.17 (0.84)	5.88 (0.86)	0.82 (0.09)	6.10 (0.96)
state, age, year FE's	x	x	x	x	x	x	x
other controls					x	x	x
Observations	6,912	6,912	6,912	6,912	6,912	6,977	6,912

Notes: Standard errors in parentheses and t-statistics in square brackets. Specifications 1-3 report OLS estimates of the first-stage effect of the house price index in the year of purchase on the change in property value, home equity, and mortgage debt from the year before to the year after home purchase. These effects are allowed to vary across the three SIPP panels used for the analysis (the 1996 panel, with modal year of purchase = 1998; the 2001 panel, with modal year of purchase = 2002; and then 2008 panel, with modal year of purchase = 2010). Specifications 4-6 report 2SLS estimates of the effect of changes in property value and total wealth on changes in the stock share of liquid wealth using these instruments. The dependent variable in specification 7 is an indicator for holding stocks. All specifications include fixed effects for state of residence and age and also control for the change in total wealth from the year before to the year after home purchase. Specifications 5-7 also include the following other controls: change in income from year before to year after home purchase as well as education, number of children, and the state unemployment rate. All specifications except 6 omit 65 households whose reported wealth changed by more than 1 million dollars in magnitude to reduce the influence of outliers.

APPENDIX TABLE I
Summary Statistics for SIPP Full Sample

	Mean	Median	Standard Deviation
	(1)	(2)	(3)
Demographics:			
Age (years)	49.53	47	16.97
Years of education	12.75	12	3.06
Number of children	0.56	0	1.01
Household Income ($)	34,769	25,990	35,005
Housing:			
Property value ($)	73,168	49,747	91,592
Mortgage ($)	27,456	0.00	46,993
Home tenure (years)	15.13	11	13.89
Wealth:			
Total wealth ($)	115,428	44,364	494,883
Liquid wealth ($)	27,671	2,066	456,717
Home equity ($)	46,739	19,373	71,360
Equity in other real estate ($)	10,618	0.00	55,621
Vehicle equity ($)	4,696	2,985	6,631
Business equity ($)	7,491	0.00	57,976
Retirement accounts ($)	17,258	0.00	47,153
Portfolio Allocation:			
Percent of households holding stock	19.18%	0.00%	39.37%
Stock share (% of liquid wealth)	12.26%	0.00%	28.17%
Safe assets share (% of liquid wealth)	87.74%	100.00%	28.17%
Number of observations		197,858	

Notes: This table includes all household heads (reference persons) in the 1990-2008 SIPP panels. All monetary values are in real 1990 dollars. Home tenure is defined as numbers of years living in current house. Income is total family income: labor income plus all other forms of income plus transfers. Total wealth is gross household wealth measured on the survey. It includes financial assets as well as all real estate (including second homes), cars, and private business equity. Debts are not subtracted from the total wealth measure. Safe assets consist of bonds, checking accounts, and savings accounts. Liquid wealth is defined as the the sum of safe assets and stockholdings.

APPENDIX TABLE IIa
Static Extensions of the Stylized Model

Panel A: Fixed adjustment costs

λ	ρ	Property value				
		$110,000	$120,000	$130,000	$140,000	$150,000
0.2	0	82.6%	83.8%	84.1%	82.8%	80.8%
0.2	0.1	81.0%	80.6%	80.0%	78.2%	75.3%
0.1	0	91.6%	90.5%	88.6%	86.6%	84.6%
0.1	0.1	88.0%	86.0%	83.5%	80.9%	78.2%
		Home equity				
		$56,000	$66,000	$76,000	$86,000	$96,000
0.2	0	76.3%	80.3%	84.1%	87.5%	90.4%
0.2	0.1	71.9%	76.1%	80.0%	83.4%	86.8%
0.1	0	79.8%	84.2%	88.6%	93.0%	97.2%
0.1	0.1	74.5%	79.0%	83.5%	88.0%	92.4%

Panel B: Labor income risk

corr(y_1,p_1)	Property value				
	$110,000	$120,000	$130,000	$140,000	$150,000
0	53.2%	47.0%	40.9%	35.0%	29.3%
0.55	53.4%	47.3%	41.1%	35.2%	29.4%
	Home equity				
	$56,000	$66,000	$76,000	$86,000	$96,000
0	29.5%	35.1%	40.9%	46.7%	52.6%
0.55	29.6%	35.3%	41.1%	47.0%	52.9%

Panel C: Participation cost in stock market

fixed cost	Property value				
	$90,000	$110,000	$130,000	$150,000	$170,000
$4,207	97.4%	86.7%	74.3%	61.4%	no stocks
	Home equity				
	$36,000	$56,000	$76,000	$96,000	$116,000
$4,207	no stocks	62.0%	74.3%	86.4%	98.4%

Notes: Each cell lists the optimal share of liquid wealth invested in stocks (α*) for a different combination of parameters in alternative models. In Panel A, λ is the share of home value that must be paid as a fixed cost when moving. In Panel B, corr(y1, p1) is the correlation between log of period 1 labor income and log of period 1 house prices. In Panel C, 'fixed cost' is cost that has to be paid if the household wants to participate in the stock market.

APPENDIX TABLE IIb
Dynamic Extensions of the Stylized Model

Panel A: Consumption in initial period

Y_0		Property value				
		$110,000	$120,000	$130,000	$140,000	$150,000
$215,468		100.0%	84.2%	69.1%	57.7%	48.8%
		$31,345	$37,551	$44,000	$50,545	$57,219
		Home equity				
		$56,000	$66,000	$76,000	$86,000	$96,000
$215,468		49.0%	57.7%	69.1%	84.6%	100.0%
		$57,717	$50,837	$44,000	$37,156	$30,507

Panel B: Persistent uncertainty

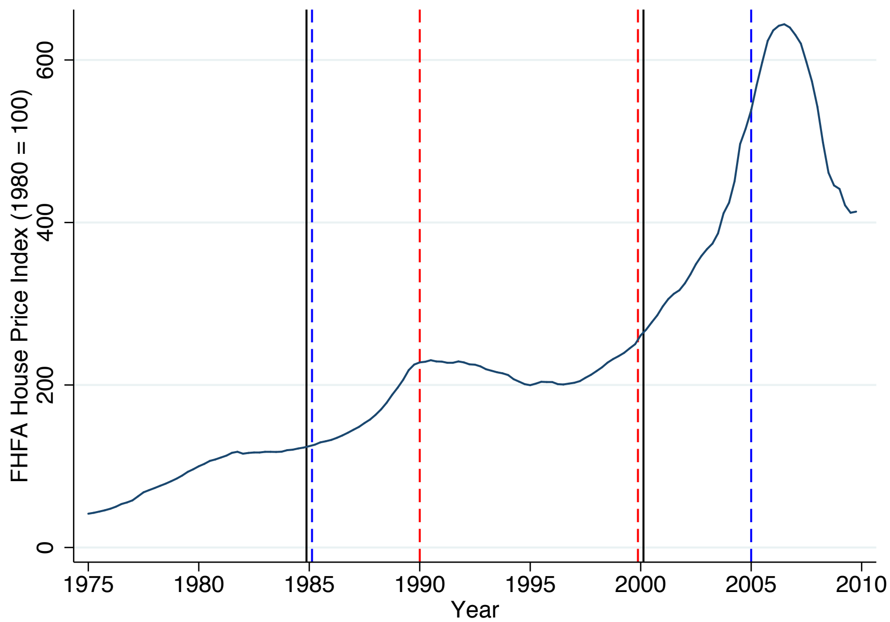
θ	ρ	Property value				
		$110,000	$120,000	$130,000	$140,000	$150,000
0.55	0	98.5%	90.8%	76.1%	58.7%	46.9%
		Home equity				
		$56,000	$66,000	$76,000	$86,000	$96,000
0.55	0	47.6%	59.3%	76.1%	90.7%	98.7%

Panel C: Bequests

θ	ρ	Property value				
		$110,000	$120,000	$130,000	$140,000	$150,000
0.55	0	100.0%	97.8%	93.5%	86.3%	75.8%
0.55	0.1	93.0%	90.2%	85.9%	80.2%	71.0%
		Home equity				
		$56,000	$66,000	$76,000	$86,000	$96,000
0.55	0	78.9%	87.0%	93.5%	99.4%	100.0%
0.55	0.1	73.4%	80.4%	85.9%	91.6%	96.9%

Notes: Each cell lists the optimal share of liquid wealth invested in stocks (α*) for a different combination of parameters in alternative models. In Panel A, below the stock shares, we also display the amount of wealth invested in stocks and bonds. In Panel A, Y_0 is period 0 income. In Panel B and C, θ denotes the probability that the household does not move and measures the strength of housing commitments; ρ denotes the correlation coefficient between the (log) stock return and (log) home price growth, and measures the degree of home price risk.

FIGURE I
Real House Prices in California, 1975-2009



NOTE–This figure illustrates the concept underlying our identification strategies by plotting the FHFA real housing price index in California from 1975 to 2009. The solid black lines correspond to an individual who buys a house in 1985 and whose portfolio is observed in 2000. The dashed red lines show an individual who buys the same house in 1990 instead of 1985, and has approximately $100,000 more mortgage debt when observed in 2000 as a result. The dashed blue lines mark an individual who buys in 1985 and is observed in 2005. This individual has approximately $175,000 more home equity than the first individual.