Geographic Heterogeneity in Housing Market Risk and Portfolio Choice

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Abstract

The U.S. housing market is heterogeneous in that house price dynamics vary greatly across regions, the housing supply elasticity being the main explanator. Households are exposed to completely different housing market risk, depending on the location of the main residence. This paper examines how geographic heterogeneity in housing market risk affects household portfolio allocations. Using the restricted version of the Health and Retirement Study (HRS) data with detailed geographic information, I find that households in areas with low housing supply elasticity tend to hold less stock in their portfolios. This tendency, however, weakens after retirement when labor income risk disappears.

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1 Introduction

The effect of housing on portfolio choice has long been examined from various perspectives (e.g., Grossman and Laroque, 1990; Flavin and Yamashita, 2002; Cocco, 2005; Yao and Zhang, 2005). While those studies find the effect of housing on household portfolio choice to be significant, most of the previous studies have considered housing as a homogeneous asset, that is, every household expects housing investment to be associated with the same return and volatility. Depending on the housing location, however, households are exposed to totally different housing market risk. If such regional variation in housing market risk prevails, do household portfolio choices vary across regions?

In this paper, I show that households in areas where the housing market risk is higher tend to respond by holding less stock in their portfolios, although this tendency weakens after retirement when labor income risk disappears. This finding is explained by focusing on three aspects of housing market risk: the volatility of house price growth rate, the correlation between house price growth rate and stock return, and the correlation between house price growth rate and labor income growth rate. While housing market risk varies significantly across regions, I find the correlation between house price growth rate and labor income growth rate to have, on average, a dominant effect on portfolio choice. The main contribution of this paper is to shed light on the joint effects of local housing and labor market risks on household portfolio choice.

Household optimal portfolio allocation varies with housing market risk due to the special characteristics of housing investment. Housing assets play a dual role as investments and illiquid durable consumption goods. The role of housing asset as a residence renders housing market risk hard to avoid and not readily diversifiable because individuals, whether they rent or own, need a place to live. Furthermore, adjusting housing investment incurs significant cost because housing asset is indivisible and relocation involves both pecuniary and non-pecuniary costs. The housing market risk, therefore, dictates that households allocate their portfolio strategically so as to maintain an optimal level of overall risk to their total wealth.

The location of the primary residence, to a large extent, determines the housing market risk to which a household is exposed. Unlike other investments such as stocks and bonds, house prices are greatly affected by such region-specific factors as local population growth, local income growth, and land constraints. Thus, house price dynamics and attendant housing market risk differ substantially from region to region. Consequently, choice of the location of the primary residence exposes a household to that area's region-specific housing market risk.

Regional variation in housing market risk is largely explained by housing supply elasticity. In areas where housing supply elasticity is low, house price growth rate is more volatile as the house prices respond more sensitively to a shock in such areas when an aggregate demand shock takes place. That is, low housing supply elasticity amplifies the effect of aggregate shocks on house prices. The amplifying effect of housing supply elasticity, in turn, affects how house price growth rate is correlated with stock return and labor income growth rate. House price is more positively correlated with stock price and labor income in areas with low housing supply elasticity since a shift in housing demand is reflected in house prices to a greater extent in such areas.

Using Metropolitan Statistical Area (MSA) level house price and labor income data, and nationwide stock price index, I do confirm that house price growth rate is more volatile, and is more strongly and positively correlated with stock return and local labor income growth rate where housing supply elasticity is low. Because of the high volatility and the positive correlations, households in these areas are exposed to higher housing market risk.

Given that housing market risk varies significantly across regions, especially with housing supply elasticity, I empirically test how this regional variation in housing market risk affects household portfolio choice using two identification strategies. First, I use housing supply elasticity as a proxy for the local housing market risk. This identification strategy offers an important advantage over the use of conventional risk measures such as volatility of housing return as explanatory variables. Conventional risk measures only partially portray future housing market risk as they are based on historical data, and easily tainted by temporary economic shocks. Housing supply elasticity, on the other hand, is the principal cause of fundamental mechanism by which future housing market risk is determined, and seldom changes over time since it is determined mainly by intrinsic geographic characteristics. Housing supply elasticity thus better represents the local housing market risk in the sense that the portfolio allocation is determined mostly by future expectation on housing market risk, not by the past performance nor temporary changes in the housing market.

Secondly, retirement status is used as an identifier of labor income risk. Retirement is usually characterized by the absence of participation in the labor market. Labor income uncertainty is not of a concern to retirees who derive their income mostly from social security benefits, pension plans, and annuities. In this sense, retirement status is a good proxy for labor income risk. Using these two identifiers, I am able to distinguish the sole effect of housing risk from the combined effect of housing and labor income risk.

Empirical analysis finds that households located in areas with low housing supply elasticity, facing higher housing market risk, hold less stock in their portfolios. After retirement, however, the difference in stock shares between high-risk and low-risk areas diminishes as the labor income risk is no longer much of a concern. Empirical finding also suggests that the effect of correlation between house price and labor income is a dominant factor in explaining households's portfolio choice.

Owing to the special characteristics of housing assets as durable consumption goods, house price volatility and its correlation with stock price affect households differently depending on their housing preference and current housing share, and hence the effect of the volatility and the correlation with stock price on portfolio choice is, on average, indeterminate. On the other hand, house price is positively correlated with labor income, and the correlation between house price and labor income always negatively affects the portfolio choice. When labor income drops unexpectedly, households usually try to borrow in order to smooth their consumption. Due to the positive correlation, home equity is reduced together with labor income, making households lose one of the most important borrowing channels, and hence the liquidity. Experiencing an unexpected labor income drop and losing home equity concurrently, households in the low supply elasticity areas would suffer more from negative aggregate economic shocks. Given this additional risk from liquidity constraints, it is optimal for households in such areas to hold relatively less stock shares in liquid assets, especially when they are employed.

Portfolio rebalancing behavior of relocating households also indicates that households respond to housing market risk by adjusting their stock shares. The housing market risk to which households are exposed changes significantly when they move to other MSA. Measuring change in housing market risk by the difference in housing supply elasticities before and after moving, I examine whether a change in housing market risk causes a corresponding change in household portfolio allocation. From relocating household sample, I find that households tend to reduce their stock shares when they move to areas where housing market risk is higher. The opposite obtains with households that move to low-risk areas. This result remains the same even after controlling for other post-moving status changes including change in wealth, income, and housing share.

The effect of housing assets on portfolio choice has been examined from various perspectives. Grossman and Laroque (1990) examine optimal consumption and portfolio allocation when consumption takes the form of illiquid durable goods such as housing assets. While they reject the consumption-based capital asset pricing model (CCAPM) because of the illiquidity of durable goods, they confirm that the standard one-factor capital asset pricing model (CAPM) holds even in the presence of illiquid durable consumption goods. On the other hand, Cocco (2005) uses a life cycle model in which households generate utility from both non-durable consumption goods and housing services, to show that housing plays an important role in determining the composition of a household's portfolio. Yao and Zhang (2005) also examine the effect of housing assets on portfolio choice using a life cycle model. However, they allow households to choose to rent instead of owning a house. In their model, households that rent tend to invest more in stocks. Flavin and Yamashita (2002) use a mean-variance efficiency framework to show the optimal portfolio choice of homeowners with different home equity shares in total wealth.

While the literature finds the importance of the housing asset in household investment decisions both empirically and theoretically, these studies do not consider a variation in housing market characteristics across regions, driven mainly by geographic constraints. This paper explores how variation in local housing market risk affects household portfolio choice, and whether the effect of labor income risk on portfolio choice is altered as the relationship between labor income risk and house price dynamics varies across regions. Drawing on empirical evidence based on household level data and supporting theoretical background, this paper demonstrates that geographic variation in housing market risk significantly affects household portfolio choice.

The rest of this paper is organized as follows. In section 2, I examine the geographic heterogeneity in US housing market and the role of housing supply elasticity in explaining the geographic heterogeneity. In section 3, I build a two-period stylized model to understand the effect of housing market risk on portfolio allocations. Section 4 provides empirical evidence on how variation in housing market risk affects household portfolio choice. Section 5 concludes.

2 Housing Market Heterogeneity and Heterogeneous Background Risk

In this section, I examine whether the geographic heterogeneity in housing market risk prevails and housing supply elasticity plays a role in explaining the regional variations. The housing asset is risky in the sense that house price is volatile and correlated with prices of other assets such as stock and human capital. Since housing demand and supply are largely affected by region-specific factors such as local labor income, local population growth and land constraints, house price dynamics and attendant housing market risk varies greatly from region to region. In this paper, the examination of geographic heterogeneity in housing market risk takes into account three risk measures related to housing assets: volatility of housing return, correlation between housing return and stock return, and correlation between housing return and labor income growth rate. Metropolitan Statistical Area (MSA) level data show that these three risk measures vary substantially across regions, and these regional variations can be explained largely by local housing supply elasticity.

2.1 Regional Variation in Volatility of House Price Growth Rate

The volatility of the return on housing asset is an important factor that characterizes housing asset as a risky investment. To examine how housing market risk varies across regions, I first focus on the regional variation in standard deviations of house price growth rate. Using Metropolitan Statistical Area (MSA) level House Price Index (HPI) by Federal Housing Finance Agency (FHFA), I estimate standard deviations of house price growth rate for 228 MSAs from 1990 to 2010. Figure 1.A shows the distribution of the estimated standard deviations. As the figure shows, there is a considerable dispersion in the standard deviations across MSAs. To illustrate the regional variation in the standard deviation, these statistics are put on the map of the United States in Figure 1.B. As can be seen in the figure, households have experienced totally different house price dynamics depending on the location of their residence.

The regional variation in house price dynamics can be explained largely by local housing supply elasticity (Saiz, 2010). Since housing supply elasticity is determined mainly by land scarcity and zoning regulation, which seldom change over time but vary greatly across regions, it has been widely used as a proxy for local house price dynamics in the literature (Mian and Sufi, 2009, 2010, 2011; Mian, Rao, and Sufi, 2013; Chetty and Szeidl, 2010). House price volatility is also closely related to housing supply elasticity. When there is an aggregate demand shock, house prices change in response to this shock. However, the extent to which house price responds to the aggregate demand shock varies with housing supply elasticity. In areas where housing supply elasticity is low, house price is more sensitive to the aggregate demand shock. That is, the effect of aggregate shocks on house prices is amplified in areas where housing supply elasticity is low, rendering house price more volatile in such areas (Glaeser, Gyourko, and Saiz, 2008).

Using the estimated standard deviation of house price growth rate and housing supply elasticity by Saiz (2010), I examine the relationship between volatility of house price growth rate and housing supply elasticity in the following regression.

$$\widehat{\sigma}_{h,i} = \tau_0 + \tau_1 HSE_i + \epsilon_i \tag{1}$$

where HSE_i indicates housing supply elasticity in MSA i and $\widehat{\sigma}_{h,i}$ is the estimated standard deviation of housing price growth rate. The estimated coefficient on housing supply elasticity, $\hat{\tau}_1$, is -0.010 with standard error 0.001. The negative coefficient on housing supply elasticity implies that the volatility of house price growth rate decreases with housing supply elasticity so that in areas where housing supply elasticity is low, households are more likely to experience high volatility of house price growth rate. Figure 2 confirms the negative relationship between the volatility of house price growth rate and housing supply elasticity.

2.2 Correlation between Housing Return and Other Asset Returns

For stockholders, housing assets are risky not only because house price growth rate is volatile, but also it is correlated with stock returns. Since stocks are traded in nationwide markets, region-specific factors that affect local house prices usually do not influence stock prices, especially market index such as the Standard & Poor's 500 (S&P 500).[3] On the contrary, the stock return shocks can affect local housing demand, and the change in local housing demand is reflected in local house price but in different magnitude depending on local housing supply elasticity.[4] Therefore, it stands to reason that the correlation between stock return and local

[3]The stock price of a company whose operations are closely related to local economy can be affected by region-specific shocks. If stock investors prefer to hold stocks of locally specialized company, their portfolios are vulnerable to region-specific shocks (Coval and Moskowitz, 1999). However, in this paper, I assume that households holds aggregate level stock index so that their portfolios are free of region-specific shocks.

[4]Poterba (2000) briefly summarizes evidence on the link between stock prices and real estate.

house price growth rate varies across regions.

Household portfolio choice is also affected by the correlation between house price growth rate and labor income growth rate. The effect of labor income uncertainty on household saving and portfolio decision is examined from various perspectives in the literature (Bodie, Merton, and Samuelson, 1992; Kimball, 1993; Guiso, Jappelli, and Terlizzese, 1996; Viceira, 2001; Gomes and Michaelides, 2003; Benzoni, Collin-Dufresne, and Goldstein, 2007; Polkovnichenko, 2007; Lynch and Tan, 2011). While the effects of labor income risk and housing market risk on the portfolio choice are important on their own, how these two background risks are correlated to each other also matters when we consider the effect of these background risks on portfolio choice. Moreover, since the labor income varies considerably across regions and directly affects local housing demand, it is worthwhile to examine the regional variation in the correlation between house price growth rate and labor income growth rate.

The following simplified relationships between the quantity (Q) and price (P) of housing are used to examine how local house price growth rate is correlated with stock return and local labor income growth rate.

$$\Delta \ln(Q_{s,i,t}) = \varepsilon_{s,i} \Delta \ln(P_{i,t}) + u_{i,t} \tag{2}$$

$$\Delta \ln(Q_{d,i,t}) = \varepsilon_{d} \Delta \ln(P_{i,t}) + \varepsilon_{d}^{S} \Delta \ln(S_{t}) + \varepsilon_{d}^{Y} \Delta \ln(Y_{i,t}) + v_{i,t} \tag{3}$$

where Q_s and Q_d are the quantities of housing supplied and demanded, P is price of housing, S is stock price, Y is labor income, ε_s and ε_d are the price elasticities of housing supply and demand, ε_d^S and ε_d^Y are the elasticities of housing demand with respective to stock price and labor income, and i indicates MSA. In the housing supply equation (2), I assume housing supply to be explained by house price and an unobservable factor, $u_{i,t}$, which affects local housing supply, but is not correlated with local house price. Housing demand, on the other hand, is determined by housing price as well as stock price and labor income, as shown in the housing demand equation (3). The term $v_{i,t}$ is a factor that affects housing demand other than house price, stock price, and labor income. Among various elasticities, only the price elasticity of housing supply is assumed to vary across regions as indicated by subscript i in the equations.

To represent house price growth rate as a function of stock return and labor income growth rate, I use the equilibrium condition, $\Delta\ln(Q_{s,i,t}) = \Delta\ln(Q_{d,i,t})$, which draws the following equation.

$$\Delta\ln(P_{i,t}) = \frac{\varepsilon_d^S}{\varepsilon_{s,i} - \varepsilon_d}\Delta\ln(S_t) + \frac{\varepsilon_d^Y}{\varepsilon_{s,i} - \varepsilon_d}\Delta\ln(Y_{i,t}) + \frac{v_{i,t} - u_{i,t}}{\varepsilon_{s,i} - \varepsilon_d} \tag{4}$$

where the term $\frac{v_{i,t}-u_{i,t}}{\varepsilon_{s,i}-\varepsilon_d}$ is independent of $\Delta\ln(S_t)$ and $\Delta\ln(Y_{i,t})$ by construction. Equation (4) reveals the relationship between local house price growth rate ($\Delta\ln(P_{i,t})$) and stock return ($\Delta\ln(S_t)$), and local labor income growth rate ($\Delta\ln(Y_{i,t})$). Notable in this equation is that the coefficients on $\Delta\ln(S_t)$ and $\Delta\ln(Y_{i,t})$ vary across region i due to the housing supply elasticity ($\varepsilon_{s,i}$) in each coefficient. More specifically, the coefficients are inversely related to the housing supply elasticity in region i. To incorporate this relationship in the panel regression model, I assume the following functional form of the coefficients on $\Delta\ln(S_t)$ and $\Delta\ln(Y_{i,t})$:

$$\beta_i^S = \beta_0^S + \beta_1^S\frac{1}{\varepsilon_{s,i}} \tag{5}$$

$$\beta_i^Y = \beta_0^Y + \beta_1^Y\frac{1}{\varepsilon_{s,i}} \tag{6}$$

where β_i^S and β_i^Y are coefficients on $\Delta\ln(S_t)$ and $\Delta\ln(Y_{i,t})$, respectively. Based on these assumptions, the equation (4) can be rewritten as follows.

$$\begin{aligned}\Delta\ln(P_{i,t}) &= \beta_0^S\Delta\ln(S_t) + \beta_1^S\left[\frac{1}{\varepsilon_{s,i}} \times \Delta\ln(S_t)\right] + \beta_0^Y\Delta\ln(Y_{i,t}) + ...\\ &\quad \beta_1^Y\left[\frac{1}{\varepsilon_{s,i}} \times \Delta\ln(Y_{i,t})\right] + z_{i,t}\end{aligned} \tag{7}$$

where the error term $z_{i,t}$ is independent of $\Delta\ln(S_t)$ and $\Delta\ln(Y_{i,t})$. To estimate the coefficients

β_0^S, β_1^S, β_0^Y, and β_0^Y, house price growth rate ($\Delta \ln(P_{i,t})$) is regressed on stock return, stock return interacted with the inverse of housing supply elasticity, labor income growth rate, and labor income growth rate interacted with the inverse of housing supply elasticity.

I use the MSA-level quarterly house price index by the FHFA as local house price (P_i), S&P 500 Index as stock price (S), and MSA-level average wage data by the Quarterly Census of Employment and Wages (QCEW) as local labor income (Y_i). I use the panel data of 228 MSA samples from 1990Q1 to 2010Q4 (228×84) to estimate the coefficients β_0^S, β_1^S, β_0^Y, and β_0^Y from equation (7). While the concurrent response of house price growth rate with respect to stock return and labor income growth rate is important, the effect of lagged variables should also be considered to reflect the sluggish response of house price to changes in stock return and labor income growth rate in the previous periods. Table 1 reports the estimated coefficients on current stock return and labor income growth rate as well as those on the lagged variables. To estimate the aggregate effect of all coefficients, I report the aggregated coefficient based on Dimson (1979) approach. In the baseline case without lagged variables, all coefficients are positive, meaning that both stock return and labor income growth rate positively affect local house price growth rate. The positive coefficients on interaction terms imply that the positive effect of stock return and labor income growth rate on house price growth rate is strengthened as housing supply elasticity decreases. Although including the lagged variables increases the magnitude of the aggregate coefficients, the direction of the effect remains the same. Stock return and labor income growth rate thus positively affect house price growth rate even in the presence the effect of lagged variables.

In this section, I find the volatility of house price growth rate and its correlation with stock return and local labor income growth rate to vary across regions, and this regional variation to be largely explained by housing supply elasticity. In areas with low housing supply elasticity, house price growth rate is more volatile, and more positively correlated with stock return and local labor income growth rate than in areas with high housing supply elasticity.[5] Therefore, households in areas with low housing supply elasticity are exposed to higher housing market risk than those in areas with high housing supply elasticity.

3 Stylized Two-period Model

In this section, I build a stylized two-period model following Campbell and Viceira (2002) and Chetty and Szeidl (2010). This model provides basic intuition on how the volatility of house price and the extent to which house price correlates with other uncertainties affects household portfolio choice.

Model Set-up. In this model, households are endowed with housing assets H_t and liquid financial assets W_t at period t. Households allocate liquid financial assets into risky stocks and risk-free bonds to maximize the utility, which is a function of non-durable consumption (C_{t+1}) and housing consumption (H_{t+1}) at $t+1$:

$$\max_{\alpha,C,H} E_0\left[\frac{(C_{t+1}^{1-\theta}H_{t+1}^{\theta})^{1-\gamma}}{1-\gamma}\right] \tag{8}$$

s.t.

$$X_{t+1} = W_t(1+R_{p,t+1}) + Y_{t+1} + P_{t+1}H_t \tag{9}$$

$$X_{t+1} = C_{t+1} + P_{t+1}H_{t+1} \tag{10}$$

$$R_{p,t+1} = \alpha R_{s,t+1} + (1-\alpha)R_f \tag{11}$$

where θ measures the relative preference for housing consumption over non-durable consumption, γ is the coefficient of relative risk aversion, Y_{t+1} is labor income at $t+1$, which has the log-normal distribution, $y_{t+1} = \log(Y_{t+1}) \sim N(y, \sigma_y^2)$, and P_{t+1} is the unit price of housing

[5]Glaeser et al. (2008) show that house price is more volatile in areas in which housing supply elasticity is low. Harter-Dreiman (2004) studies how housing supply elasticity explains the relationship between local house price and local labor income dynamics.

service, which has the log-normal distribution, $p_{t+1} = \log(P_{t+1}) \sim N(p, \sigma_p^2)$.[6] The gross rate of return on risk-free assets is $1 + R_f = \exp(r_f)$ and the gross rate of return on risky stock is $1 + R_s = \exp(r_s)$, where $r_{s,t+1} = \log(1 + R_{s,t+1}) \sim N(\mu_s, \sigma_s^2)$. Portfolio return $R_{p,t+1}$ is determined by the risk-free rate R_f, return on risky stock R_s, and portfolio allocation α. In this model, short sales are not allowed (i.e. $0 \leq \alpha \leq 1$). Additionally, I assume that households can move at no cost to make the solution of this problem analytically tractable.[7]

Log-linear Approximate Solution. To find an approximate analytical solution for this maximization problem, I use the log-linear approximate method following Campbell (1993) and Campbell and Viceira (1999, 2001). I first take log of equation (9) after dividing both sides of the equation by Y_{t+1}, and then take a first-order Taylor expansion of the right-hand-side around $r_{p,t+1} = E[r_{p,t+1}] \equiv r_p$, $y_{t+1} = E[y_{t+1}] \equiv y$ and $p_{t+1} = E[p_{t+1}] \equiv p$. This provides the following log-linearized budget constraint.

$$x_{t+1} - y_{t+1} = \log\left[\exp\{w_t + r_{p,t+1} - y_{t+1}\} + \exp\{h_t + p_{t+1} - y_{t+1}\} + 1\right] \tag{12}$$

$$x_{t+1} - y_{t+1} \approx k + \rho_A(r_{p,t+1} - r_p) + \rho_B(y_{t+1} - y) + \rho_C(p_{t+1} - p) \tag{13}$$

$$x_{t+1} \approx k' + \rho_A r_{p,t+1} + (\rho_B + 1)y_{t+1} + \rho_C p_{t+1} \tag{14}$$

where k and k' are constants, and $\rho_{i\in\{A,B,C\}}$ are as follows.

$$\rho_A = \frac{\exp\{w_t + r_p - y\}}{1 + \exp\{w_t + r_p - y\} + \exp\{h_t + p - y\}} \tag{15}$$

$$\rho_B = \frac{-\exp\{w_t + r_p - y\} - \exp\{h_t + p - y\}}{1 + \exp\{w_t + r_p - y\} + \exp\{h_t + p - y\}} \tag{16}$$

$$\rho_C = \frac{\exp\{h_t + p - y\}}{1 + \exp\{w_t + r_p - y\} + \exp\{h_t + p - y\}} \tag{17}$$

As this model assumes no moving cost, households allocate total wealth at $t + 1$ into non-

[6] House price at t being assumed to be 1, log house price at $t + 1$, p_{t+1}, can be interpreted as house price growth rate.

[7] Chetty and Szeidl (2010) also assume no moving cost, but in their paper, households move only with exogenous moving shock at the probability of θ. Probability $1 - \theta$ is interpreted as the commitment on the current home.

durable consumption goods and housing service according to housing preference θ.

$$\begin{aligned} C_{t+1} &= (1-\theta)X_{t+1} \\ P_{t+1}H_{t+1} &= \theta X_{t+1} \end{aligned}$$

Then the utility function can be represented as a function of X_{t+1}

$$V(X_{t+1}) = \frac{\left((1-\theta)^{1-\theta}\theta^{\theta}\right)^{1-\gamma}}{1-\gamma}\left(\frac{X_{t+1}}{P_{t+1}^{\theta}}\right)^{1-\gamma} \tag{18}$$

The maximization problem (8) can be rewritten as follows.

$$\max_{\alpha} E_0\left[V(X_{t+1})\right]$$

s.t.

$$X_{t+1} = W_t(1+R_{p,t+1}) + Y_{t+1} + P_{t+1}H_t$$

$$R_{p,t+1} = \alpha R_{s,t+1} + (1-\alpha)R_f$$

The solution for this maximization problem is derived in Appendix A. It is given by

$$\alpha = \frac{E\left[r_{t+1}-r_f\right]+\frac{1}{2}\sigma_s^2}{\gamma\rho_A\sigma_s^2} - \frac{\gamma\rho_C+\theta(1-\gamma)}{\gamma\rho_A}\frac{\sigma_{ps}}{\sigma_s^2} - \frac{(\rho_B+1)}{\rho_A}\frac{\sigma_{ys}}{\sigma_s^2} \tag{19}$$

where σ_{ps} is the covariance between house price and stock return and σ_{ys} is the covariance between labor income and stock return.

Comparative statistics. Based on the analytical solution for optimal stock share described above, I examine how household portfolio choice is affected by the volatility of house price and its correlation with stock price and labor income. Similar to the approach in Campbell and Viceira (2002), I first consider the effect of a mean-preserving increase in the variance of house price on the optimal stock share.

Proposition 1. When $\rho_A > 1/\gamma$, a mean-preserving increase in the variance of log house price (σ_p^2) reduces stock share.

$$\left.\frac{\partial \alpha_t}{\partial \sigma_p^2}\right|_{E[P_{t+1}]=\bar{P}} < 0 \quad \text{when } \rho_A > 1/\gamma$$

Proof. See the appendix.

To interpret this result, I rewrite ρ_A as follows.

$$\begin{aligned}
\rho_A &= \frac{\exp\{w_t + r - y\}}{1 + \exp\{w_t + r - y\} + \exp\{h_t + p_h - y\}} \\
&= \frac{\exp\{w_t + r\}}{\exp\{y\} + \exp\{w_t + r\} + \exp\{h_t + p_h\}} \\
&\approx \frac{W(1+R)}{Y + W(1+R) + P_H H}
\end{aligned} \tag{20}$$

The right hand side of equation (20) represents the ratio of the expected value of liquid financial asset to total wealth. If we assume the risk aversion parameter, γ, to be the same across individuals, it is more likely that house price volatility negatively affects stock shares of those who put a relatively large portion of their total wealth into financial assets. If financial assets represent a relatively small portion of total wealth, whether the effect of house price volatility is negative depends on other conditions, such as the relative risk aversion coefficient and current stock share.

Proposition 2. Portfolio share decreases in the covariance between house price and stock return (σ_{ps}) if and only if $\rho_C > \frac{\gamma-1}{\gamma}\theta$

Proof. It is straightforward from equation (19).

In this proposition, ρ_C can be interpreted as the share of housing asset in total wealth, as shown in the following approximation.

$$\begin{aligned}
\rho_C &= \frac{\exp\{h_t + p - y\}}{1 + \exp\{w_t + r_p - y\} + \exp\{h_t + p - y\}} \\
&\approx \frac{PH}{Y + W(1+R_P) + PH}
\end{aligned}$$

The condition $\rho_C > \frac{\gamma-1}{\gamma}\theta$ implies that the correlation between house price and stock price has a negative effect on portfolio choice when the share of housing assets in total wealth is relatively larger than the housing preference θ. The housing preference determines the amount of housing service that households consume in the second period. Households endowed with a relatively small amount of housing assets in the first period need to purchase more housing services in the second period, depending on their housing preferences. In this case, households are born to take a short position in future house price. If stock price is positively correlated with house price, stocks provide a hedge against the short position. The correlation between house price and stock price thus positively affects stock share.

In the previous section, the correlation between house price and labor income is shown to vary across regions. I consider the effect of the correlation between house price and labor income in this model by assuming the following linear relationship between labor income and house price.

Assumption 1. $p_{t+1} = \beta y_{t+1} + \psi_{t+1}$ where y_{t+1} and ψ_{t+1} are independent.

In this assumption, β can be interpreted as the sensitivity of house price to labor income, which, as shown in the previous section, varies across regions.[8] To examine how the variation in β affects portfolio allocation, I rewrite the optimal stock share (α) as follows based on assumption 1.

$$\alpha = \frac{E\left[r_{t+1} - r_f\right] + \frac{1}{2}\sigma_s^2}{\gamma\rho'_A\sigma_s^2} - \frac{\gamma\rho'_C + \theta(1-\gamma)}{\gamma\rho'_A}\frac{\sigma_{ps}}{\sigma_s^2} - \frac{(\rho'_B + 1)}{\rho'_A}\frac{\sigma_{ys}}{\sigma_s^2} \tag{21}$$

[8]From this linear relationship, the correlation between house price and labor income can be represented as follows. $\rho_{py} = Corr(p_{t+1}, y_{t+1}) = \frac{Cov(\beta y_{t+1} + \psi_{t+1}, y_{t+1})}{\sigma_p \sigma_y} = \beta\frac{\sigma_y}{\sigma_p}$. Therefore, high β means high correlation between house price and labor income ρ_{py} ($\frac{\partial \rho_{py}}{\partial \beta} > 0$).

where

$$\rho'_A = \frac{\exp\{w_t + r_p - y\}}{1 + \exp\{w_t + r_p - y\} + \exp\{h_t + p - y\}} \tag{22}$$

$$\rho'_B = \frac{-\exp\{w_t + r_p - y\} + (\beta - 1)\exp\{h_t + p - y\}}{1 + \exp\{w_t + r_p - y\} + \exp\{h_t + p - y\}} \tag{23}$$

$$\rho'_C = \frac{-(1/\beta)\exp\{w_t + r_p - y\} + (1 - 1/\beta)\exp\{h_t + p - y\}}{1 + \exp\{w_t + r_p - y\} + \exp\{h_t + p - y\}} \tag{24}$$

The equation for optimal share now contains β terms. From this modified equation, we can understand the effect of the correlation between labor income and house price on portfolio choice.

Proposition 3. Portfolio share decreases with the sensitivity of house price to labor income (β).

Proof.

$$\frac{\partial \alpha}{\partial \beta} = -\frac{1}{\beta^2}(1 + \frac{\exp\{h_t + p\}}{\exp\{w_t + r_p\}}) - \frac{\exp\{h_t + p\}}{\exp\{w_t + r_p\}} < 0$$

Proposition 3 implies that the stock share in financial assets decreases as the correlation between house price and labor income increases. When house price is positively correlated with labor income, background risk becomes higher and households need to reduce the risk in financial wealth to maintain overall risk to their total wealth.

In sum, the correlation between house price and labor income always negatively affects household portfolio choice, whereas the effects of the volatility of house price and the correlation between house price and stock price vary with other conditions, especially the share of housing asset in total wealth. This is mainly due to the special characteristic of housing asset as durable consumption goods. Households drive utility directly from housing assets. Therefore, owning a house is not necessarily associated with higher risk exposure even in the presence of volatility of house price as it protects households from uncertainty in future housing consumption (Sinai and Souleles, 2005; Paciorek and Sinai, 2012). For households that plan to upsize their homes, stock investments compensate for the funds required for new home purchase when stock price is positively correlated with house price. The role of housing market risk in household portfolio choice can thus vary significantly depending on housing preference and current housing share in total wealth.

4 Empirical Analysis

This section provides empirical evidence on how households respond to region-specific housing market risk. I use two identification strategies to distinguish the sole effect of housing risk from the combined effect of housing and labor income risk. First, housing supply elasticity is used to identify the region-specific housing market risk. Second, I use retirement status as an indicator of labor income risk to examine the combined effect of housing and labor income risks on portfolio choice.

4.1 Data

The main data set used in this paper is the Health and Retirement Study (HRS) data with geographical information. The HRS is a longitudinal panel data set that surveys more than 26,000 individuals over the age of 50 biennially since 1992. I use the restricted version of the HRS data to obtain geographic information. Geographic information includes location of main residence, birth place, and distance of relocation when households move. One characteristic that distinguishes the HRS from other survey data is the abundance of the elderly in the sample. For example, whereas the HRS survey targeted heads of household age 50 and older, the Panel Study of Income Dynamics (PSID), another longitudinal survey, tracks individuals in all age groups every year or every other year. My focus on elderly households reflects the greater importance of local housing market risk to that group. According to the US Census, the moving rate decreases with age and stabilizes after late 40s. Additionally, homeownership rates for elderly households are relatively high. Taking these two stylized facts into consideration, local housing market risk exerts a greater influence on older homeowners who have invested a large portion of their wealth in housing assets and are less likely to move. Another important benefit of the HRS data is that it includes a relatively large number of retired households. Using retired households, that no longer have labor income risk, as a control group, I am able to examine how the effect of housing market risk on portfolio choice varies with the presence of labor income risk.

Sample Selection

For the main analysis, I use the HRS data from the 1998 through 2010 waves. In 1998, a significant change in sample composition took place in the HRS. First, the "original" HRS data was merged with the Asset and Health Dynamics Among the Oldest-Old (AHEAD) data.[9] Second, two new cohorts, namely the Children of the Depression (1924-1930) cohort and the War Babies (1942-1947) cohort, were newly added. Because of these modifications, the sample size of the HRS changed significantly in 1998. Since this paper often uses a change in household wealth or income level by comparing samples between two consecutive surveys, I focus on the survey periods over which sample size remains relatively stable.

Although the HRS has surveyed more than 26,000 individuals, not all of them are relevant to this study. For example, the main focus of this paper being household portfolio allocation in the liquid financial wealth, households with little liquid assets are irrelevant to this study. Including irrelevant households in the sample impedes examination of the real effect of household portfolio allocation. To avoid bias induced by irrelevant sample households and ensure comparability with results reported in the literature, I restrict the sample based on the following criteria: 1) Married or single household with the head aged between 50 and 80;[10,11] 2) Households whose financial liquid asset is greater than $10,000; 3) Households that own their main residence;[12] 4) Households whose main residence is located in the Metropolitan

[9] The "original" HRS has collected data in 1992, 1994, and 1996, while the AHEAD has collected in 1993 and 1995.

[10] Although I include both married and single households, I exclude the household in which the marital status of head has been changed. The reason I exclude this sample is that the marital status change by itself causes a significant change in household portfolio, misleading the effect of other factors on portfolio choice.

[11] The HRS does not provide the definition of household head. I define household head as a member of household whose earning is the highest among members throughout survey periods.

[12] Since this paper studies the effect of housing assets on portfolio choice, I only focus on the homeowners.

Statistical Areas (MSAs) for which measures of housing supply elasticity by Saiz (2010) are available. Table 13 in the Appendix shows the sample size after each selection criteria is applied.

Geographical Distribution

To study geographic heterogeneity in housing market characteristics effectively, sample needs to be widely distributed across regions. Although the HRS was not designed to represent all areas of the United States, the sample is relatively well distributed, having been collected from more than 300 MSAs. In the main analysis, I match the HRS data with housing supply elasticity information by Saiz (2010). Since Saiz (2010) provides housing supply elasticity information for 269 MSAs, after matching with this information, I end up with 269 MSA samples. The number of MSAs is further reduced after applying for the sample selection criteria described above. The coverage of MSA after applying each sample selection criteria is summarized in Table 13 in the appendix. The final sample represents 189 MSAs.[13]

Variable Definitions

Household portfolio choice, the main focus of the present study, usually refers to the decision regarding the portion of household liquid wealth to put into stocks, or risky investments. In this paper, I define liquid financial wealth as the sum of cash, checking, saving or money market accounts, stocks and mutual funds, and bonds, subtracted by other debts including credit card debt and personal loans but excluding mortgage and home equity loan. Stock share is calculated by dividing the total amount of stocks and mutual funds by liquid financial wealth. Alternatively, I consider stock shares in total wealth, which counts liquid wealth as well as the net value of business, IRA accounts, value of main residence and other real estate, minus mortgage and home equity loan.

The relative portion of housing assets in total wealth is an important factor in examining the effect of the housing asset on portfolio choice. Since home purchase is usually financed

In the robustness test, I consider the risky investment behavior of households that rent their residence.

[13] Because the size of MSAs vary greatly, the sample size for each area also is different from each other. However, there is no significant variation over survey years within the same MSA.

by mortgage, both total value of house and home equity are taken into account in estimating the relative portion of housing assets in total wealth. Housing share and home equity share in total wealth are defined as follows.[14]

$$HousingShare = \frac{\text{Value of Housing Asset}}{\text{Total Wealth}+\text{Remaining Mortgage Balance}+\text{Home Equity Loan}}$$

$$HomeEquityShare = \frac{\text{Value of Housing Asset} - \text{Remaining Mortgage Balance} - \text{Home Equity Loan}}{\text{Total Wealth}}$$

Summary Statistics

Table 2 summarizes the financial status of the sample used in the study. As shown in Section 2, housing market risk varies considerably with housing supply elasticity. To understand the effect of regional variation in housing market risk on household asset holdings and composition, I report summary statistics for three groups with different housing supply elasticity: low, medium, and high housing supply elasticity groups. Average housing supply elasticity for low, medium, and high groups is 1.029, 1.836, and 3.191, respectively. Additionally, the effect of age on household asset holdings is illustrated by reporting summary statistics for three age groups: age between 51 and 60, between 61 and 70, and between 71 and 80.

Considerable variations is observed in summary statistics across the housing supply elasticity groups. On average, the low housing supply elasticity group is wealthier and earns more income than the high housing supply elasticity group. Mean values of housing assets, liquid assets, and stock assets for the low housing supply elasticity group are also higher than those for the high housing supply elasticity group. Most notably, the mean value of the housing asset is approximately 83 percent higher for the low housing supply elasticity group (269,000 in 2000 dollars) than for the high housing supply elasticity group (147,000 in 2000

[14] In the HRS, the value of housing asset is estimated based on the question: "What is its present value? I mean, what would it bring if it were sold today?". Since this value is self-estimated housing value, it may be different from the market value of the house. In analyzing the effect of housing asset on portfolio choice, however, the self-estimated value of house is as good as any other measures.

dollars). Households hold significant amount of stocks, on average, 71,000 in 2000 dollars for the whole sample and 126,000 in 2000 dollars among stock market participants. Regional variation among groups is less significant for average stock holdings than for the value of housing assets and total wealth.

Household asset holdings also vary with age. Interestingly, the average value of the housing asset decreases with age, while average values of liquid assets and stock assets increases with age. No significant difference in home equity level is observed across age groups, however. This pattern of decreasing house value is observed across all housing supply elasticity groups. Since households usually downsize their homes and pay off their mortgages as the homeowners grow older, the average value of the housing asset decreases with age, but the home equity remains unchanged.

To better understand household asset composition, Table 3 summarizes the share of assets in total wealth or liquid financial wealth. Households, on average, put almost 40 percent of their total wealth into home equity. There is a significant difference in home equity shares across regions: low housing supply elasticity group holds 43 percent of total wealth in housing, while average home equity share of high housing supply elasticity group is 36.4 percent. The share of liquid asset holdings of low housing supply elasticity group (25.9 percent), on the other hand, is lower than the share of high housing supply elasticity group (31.8 percent). No significant difference in stock shares in financial liquid assets is observed between two groups.

In sum, the summary statistics show that household asset holdings and composition vary across regions and age groups. Between households in areas with low and high housing supply elasticity, we observe significant differences in total wealth and income level, but not in stock shares. Given that wealth and income levels generally affect household stock investment, the absence of significant differences in stock shares between these two regions is noteworthy and warrants further investigation. The following empirical analysis explores how housing market risk might explain the findings inferred from the summary statistics.

4.2 Identification Strategy

To identify the regional variation in housing market risk, I use the housing supply elasticity as a proxy for local housing market risk. As shown in Section 2, in areas where housing supply elasticity is low, households are exposed to higher housing market risk in the sense that 1) housing return is more volatile, and 2) housing return is more positively correlated with stock return and labor income growth rate. On the contrary, in areas where housing supply elasticity is high, housing market risk is relatively low. Moreover, because the geographic constraint is a main determinant of housing supply elasticity, it rarely changes over time. Therefore, housing supply elasticity can be a good proxy for local housing market risk that households in a specific region face.

Conventional risk measures based on historical data can be easily tainted by temporary economic shock and may misrepresent true nature of local housing market condition. On the other hand, local housing supply elasticity, which is mainly determined by geographic characteristics, is the principal cause of fundamental mechanism by which future housing market risk is determined, and therefore, better explains the intrinsic housing market risk to which households in specific areas are exposed.

Additionally, I distinguish the joint effect of housing and labor income risks from the sole effect of housing risk using retirement status as a proxy for labor income risk. Labor income risk is unavoidable as long as individuals participate in labor market. However, after retirement, individuals no longer worry about an uncertainty in labor income. Retirement income, generally in the form of social security and pensions, being stable and unaffected by aggregate economic conditions, the risk associated with a positive correlation between housing and labor income risk disappears after retirement.

Using housing supply elasticity and retirement status as independent variables, I estimate the effect of housing market risk and labor income risk jointly in the following regression equation.

$$\alpha_{i,t} = \beta_0 + \beta_1 HSE_i + \beta_2 Retired_{i,t} + \beta_3 (HSE_i \times Retired_{i,t}) + \gamma X_{i,t} + \epsilon_{i,t} \tag{25}$$

where $\alpha_{i,t}$ is the stock share of individual i at time t, HSE_i is the housing supply elasticity of the region where individual i resides, $Retired_{i,t}$ is the retirement status of individual i, and X is a set of demographic characteristics that include race, education, religion, and the number of children. I use this regression equation to test whether household stock shares vary with housing market risk and working status, conditional on stock market participation. In the regression, β_1 can be interpreted as the combined effect of the volatility of housing return, the correlation between housing and stock returns, and the correlation between house return and labor income growth rate. On the other hand, $\beta_1 + \beta_3$ measures the effect of housing risk after eliminating labor income risk.

4.3 Results

4.3.1 Baseline regression

Table 4 presents the result of the baseline regression. The first column reports the result of baseline regression without interaction terms for the full sample. The coefficient on housing supply elasticity is positive and statistically significant, meaning that the average stock share of households in areas with high housing supply elasticity is higher than the share in areas with low housing supply elasticity. This result holds after controlling for other variables such as income, wealth level, and demographic characteristics. As reported in the summary statistics, average housing supply elasticities in low and high groups are 1.029 and 3.191, respectively. Since the difference in housing supply elasticity between two groups is 2.162, the coefficient on housing supply elasticity, 0.009, implies a corresponding difference in stock share of 1.9 percent, on average. I also run the same regression for working household samples and retired household samples separately. Column (2) and (3) are results for working group and retired group, respectively. The coefficients on housing supply elasticity are positive for both cases, but higher for the working group, at 0.016, than that for retired group, at 0.005, and statistically significant only for the former. In column (4), I interact the housing supply elasticity with retirement status to check how the marginal effect of housing market risk on risky share changes after retirement. The coefficient on the interaction term is negative and statistically significant, indicating that the positive effect of housing supply elasticity on portfolio choice becomes weaker after retirement. This result is consistent with results with separate samples. That is, households respond to housing market risk less sensitively after retirement.

This baseline regression model shows that households reduce stock share in presence of high housing market risk, but the effect of housing market risk on portfolio choice is weakened after retirement. To interpret this result, I focus on the role of labor income risk. As the literature points out, labor income flows serve as "bond like" riskless assets and crowd riskless assets out of portfolio, especially when labor income is less correlated to stock return. In areas with low housing supply elasticity, however, labor income strongly correlates with housing return, which amplifies background risks. This effect weakens the role of labor income as a substitute for safe assets. Because labor income is correlated with neither stock return nor housing return in areas with high housing supply elasticity, its role as a hedge against stock market risk is unimpaired in such areas. Households in areas with high housing supply elasticity, when they no longer have labor income, reduce stock shares as the crowding out effect of labor income disappears.

4.3.2 Controlling for the Effect of Home Equity Share

Households in areas with low housing supply elasticity are exposed to higher housing market risk. On the other hand, the average house price level and growth rate are also high in areas with low housing supply elasticity (Saiz, 2010). In the long run, homeowners in these areas have experienced higher appreciation in the value of their homes, while housing expenses such as mortgage debt payment and implicit cost of housing have also been high. Because of high growth rates and high commitments, housing assets account for a greater portion in household finance in low housing supply elasticity areas. The relative importance of housing assets in total wealth can affect household stock investment decision, which is distinguished from the effect of house price volatility and its correlation with other asset prices. To control for the effect of high commitment, I include the home equity share in total wealth as a control variable in the baseline regression.[15] Table 5 presents results of the regression with home equity share as a control variable. As can be seen in the table, the home equity share in total wealth negatively affects stock share in liquid financial wealth. Households that allocate relatively more wealth to their houses tend to decrease stock shares. This effect is significant for all specifications. Even after controlling for the effect of home equity share on portfolio choice, however, the coefficient on housing supply elasticity remains significant. This result confirms that household responds to the magnitude of risk in the housing asset as well as the relative share of housing asset in their total wealth.

4.3.3 Regression by Home Equity Share

The two-period stylized model in Section 3 shows that the home equity share has a significant effect on how housing market risk affects portfolio allocation. Depending on the portion of home equity in total wealth, the volatility of house price growth rate and its correlation with stock return can affect stock share either negatively or positively. In this section, I examine how the effect of housing market risk on portfolio choice varies with home equity share. I first rank all households by home equity shares, and divide the sample into quartile groups

[15] Here, home equity share is the portion of home equity (house value - remanning mortgage balance - home equity loan) in total wealth, while stock share is the portion of stock assets in total liquid assets. Although stock share is not directly related to home equity share in this set up, there could be a concern about a systemic relationship between home equity share and stock share. Considering this issue, I instead use home equity to income ratio as a measure of the relative importance of the housing asset in household finance. Even using this alternative measure as control variable, the effect of housing supply elasticity on stock share remains significant.

according to home equity shares.[16] To examine how the effect of housing supply elasticity (i.e., housing market risk) on stock share varies with home equity share, I interact these quartile groups with housing supply elasticity as in the following regression model.

$$\alpha_{i,t} = \beta_0 + \beta_1 HSE_i + \beta_2 (HSE_i \times HomeEquityShareGroup_{i,t}) + \gamma X_{i,t} + \epsilon_{i,t}$$

where $HomeEquityShareGroup$ is an indicator for the home equity share quartile groups and other variables are the same as in the baseline regression.

Table 6 reports the result of this regression by working status. Column (1), (2), and (3) report results for entire sample, working group, and retirees, respectively. For the entire sample, the coefficient on housing supply elasticity remains statistically significant only when it is interacted with the lowest home equity share quartile group; the magnitude of the coefficient increases to 0.013 for this group, compared to 0.009 in the baseline case in which the effect of home equity share is not considered. For the working group sample, housing supply elasticity has the strongest effect on portfolio choice in the lowest home equity share group. Furthermore, for the lowest home equity share group, the coefficient on housing supply elasticity remains statistically significant even after retirement, while the coefficient of housing supply elasticity is not statistically significant for retirees in the baseline regression.

Overall, for households whose home equity share is low, housing market risk exerts more influence on portfolio choice. In the baseline regression, the effects of the volatility of house price growth rate and its correlation with stock return are not significant because the result only shows the average effect over home equity share. However, when the effect of home equity share is taken into account, we observe a significant effect of those two risk factors on portfolio choice for households with low home equity share.

[16] For this grouping, I consider the households with home equity share between 0 and 1. Since home equity is the value of house subtracted by mortgage amount, the home equity share cannot exceed 1 unless total non-housing wealth is negative. Similarly, the home equity share cannot be less than 0 unless home equity is negative. After grouping, each home equity share quartile group has home equity share 0 to 0.25, 0.25 to 0.5, 0.5 to 0.75, and 0.75 to 1, respectively.

Proposition 1 in Section 3 states that the volatility of house price is more likely to affect stock shares negatively when the portion of financial assets in total wealth is relatively large. Since low home equity share means high financial shares by construction, Proposition 1 is consistent with the finding that the effect of housing market risk is more significant for households with low home equity share. On the other hand, as stated in Proposition 2 in Section 3, when current home equity share is relatively lower than future housing preference, the positive correlation between house price and stock return can positively affect stock share. This is because households need more housing assets in the future and, due to the positive correlation, stocks provide a hedge against the short position in housing assets. The regression result by home equity share group appears inconsistent with Proposition 2. However, considering the fact that most of households in this study is likely to downsize their homes as the head of household gets older, the positive correlation between house price growth rate and stock return affects stock shares negatively even though the current home equity share is small. Most homeowners in this study possess the excess amount of home equity in the sense that they are more likely to downsize home in the future. Since this excess amount that they sell in the future acts as risky investment, the positive correlation between house price growth rate and stock return has a negative effect on stock share regardless of home equity share. Therefore, the difference in the effect of housing market risk on portfolio choice among home equity share groups is driven mainly by the effect of volatility of house price growth rate.

4.3.4 Effect of Mortgage

Housing investment has a leverage effect since most households finance home purchases with mortgages. Leveraged positions in housing assets amplify housing market risk because the effects of house price volatility and its correlation with other asset prices are multiplied by the leverage ratio (i.e. $1/(1 - LTV ratio)$). For example, for a household that purchases a house with a 25 percent down payment and 75 percent mortgage, a five percent increase in house value provides a 20 percent return on the net investment in the housing asset. Flavin and Yamashita (2002) show, based on simulation results using a mean-variance efficiency framework, that a mortgage has a significant effect on household portfolio choice.

In this paper, however, the effect of mortgage is not crucial since a large portion of households in the HRS data has already paid off their mortgages and the loan-to-value(LTV) ratio is relatively low for households that still hold mortgages. In the sample used for the main analysis, the portion of mortgage holder is 36.1 percent and an average LTV ratio of mortgage holders is 35.3 percent. While the portion of mortgage holders and average LTV ratio are relatively low compared to young households,[17] the effect of mortgage is still not negligible. On that account, I examine the influence of leverage on the effect of housing market risk on portfolio choice.

Table 7 presents the result of baseline regression by mortgage status. Comparing the coefficient on housing supply elasticity in Column (1) and Column (4), we can find, for the full sample, that mortgage holders are twice as sensitive as non-mortgage holders to housing market risk. For the working sample, mortgage holders are 50 percent more sensitive to housing market risk than non-mortgage holder, while for the retiree group, the housing supply elasticity does not significantly affect portfolio allocation for mortgage holders as well as non-mortgage holders.

I further analyze the leverage effect by testing whether the effect of housing market risk on portfolio choice varies with the LTV ratio. To this end, I interact the LTV with housing supply elasticity and regress stock share on this interaction term. Table 8.A shows that the interaction term has positive and statistically significant coefficient, which implies that the effect of housing market risk increases with the LTV ratio. To interpret the effect of this interaction term more precisely, I estimate the marginal effect of housing supply elasticity at different LTV ratios as shown in Table 8.B. The marginal effect of housing supply elasticity increases from 0.021 to 0.037 as the LTV ratio increases from 0.4 to 0.8. This result

[17] Flavin and Yamashita (2002) estimate the household mortgage holdings using the PSID data. Average LTV ratio of households whose head is age of between 18 and 30 is around 80 percent.

supports the idea that households respond to the leverage effect of mortgage borrowing. In sum, although the effect of housing market risk exists for both mortgage holders and non-mortgage holders, greater sensitivity is exhibited by households that hold mortgages because the leveraged position in housing investment amplifies the effect of housing market risk.

4.4 Relocation and Portfolio Adjustment

The result of the baseline regression is statistically significant and robust in various specifications. However, there could be potential selection bias issues since the location of residence is closely related to other factors such as job and demographic distribution and income and wealth level, all of which can affect portfolio allocation. If this is the case, portfolio choice could be driven mainly by other characteristics of households in a specific region. To consider the effect of other demographic and financial characteristics on portfolio choice, I include various control variables in the baseline analysis. In addition, I deal with these potential selection bias issues more carefully by focusing on individual level variation in housing market risk. Housing market risk exposure may change significantly when individuals move to other states or MSAs, and this change affects their portfolio choice. For example, household that moves from Houston, where housing price is relatively stable, to a more volatile area like San Francisco, might adjust its portfolio choice in response to the change in housing market risk. Using samples of households for which the location of main residence changes between two survey years, I examine how households change their portfolio choice when their housing market risk exposure changes. By focusing on the effect of individual level variation in housing market risk, I control for the effect of individual-specific characteristics on portfolio choice. Portfolio choice can be affected by other changes in individual status following relocation, such as increased housing share, changes in income and wealth level, and job status change. Therefore, I test the effect of changes in housing market risk on portfolio choice after controlling for these effects using the following regression equation.

$$\Delta\alpha_{i,t} = \beta_0 + \beta_1 \Delta HSE_{i,t} + \beta_2 OtherEvents_{i,t} + \epsilon_{i,t}$$

where $\Delta\alpha_{i,t}$ is a change in stock share of household i between $t-1$ and t, $\Delta HSE_{i,t}$ is a change in housing supply elasticity of household i after moving, and $OtherEvents_{i,t}$ indicates change in home equity share, total wealth, total income, and retirement status. I run this regression for households that move to another MSA (between two survey years) that results in a significant change in their exposure to housing market risk. Table 9 presents the result of this regression. Each column reflects different control variables. For all specifications, the coefficients on change in housing supply elasticity are positive and statistically significant, which means that households increase stock shares when they move from a low to a high supply elasticity area. These results are unaltered and remain statistically significant even after controlling for change in home equity share, wealth, and income level. Since households are more likely to move to other areas at retirement, I also consider the effect of retirement on change in portfolio choice. The effect of retirement event on portfolio choice is, however, not statistically significant. All things considered, change in housing supply elasticity is the dominant factor that affects stock share change. Households respond actively to a change in housing market risk, and adjust stock shares depending on the degree of housing market risk exposure.

4.5 Robustness Check

4.5.1 Alternative Definition of Risky Share

I consider stock and housing as two most important risky investments for average households. However, households can invest in other types of risky assets like other real estate and business. The portion of investment in other real estate including recreation home and rental property is non-negligible. For the sample used in the main analysis, 22.3 percent of households possess other real estate, and for these households, average shares of other real estate in total wealth is 19.8 percent. Since households that bear additional risk from other real estate investment may reduce stockholdings accordingly, stock share in financial assets does not correctly measure the risk exposure of households that hold other real estate. To consider the additional risk exposure brought by other real estate investment, I define the risky share as the portion of stocks and other real estates in total non-housing wealth and examine whether this alternatively defined risky share also responds to housing market risk. Table 10, which reports the results of the regression using this alternative definition of risky share as a dependent variable, shows the coefficient on housing supply elasticity to be positive and statistically significant for the full sample and working group sample. While the magnitude of coefficients is slightly lower than those in the baseline regression, in which stock share in financial wealth is used as a dependent variable, the overall effect of housing supply elasticity on risky investment behavior remains the same. This result confirms that households respond to housing market risk by adjusting the portion of other real estate as well as the portion of stock asset.

4.5.2 Alternative Sample Selection

Renters

Renters, although they do not hold housing assets, are exposed to housing market risk in the sense that they take short position in future housing services. Since rent price is interconnected with house price, the volatility of house price renders renters' future consumption uncertain. However, the positive correlations between house price growth rate and stock return, and between house price growth rate and labor income growth rate provide a hedge against future rent expense. During housing market boom, for example, renters are expected to spend more on rent payment, but the increased rental expenditure is partially offset by increased labor income or stock return due to the positive correlations. Since the volatility of house price growth rate and its correlation with stock return and labor income growth rate exert effects in different directions, the effect of regional variation in housing market risk on portfolio choice is tentative. To examine renters' portfolio choice in the presence of heterogeneous housing market risk, I run the baseline regression using samples that rent their main residence. Results are presented in the first three columns in Table 11. As can be seen, the coefficient on housing supply elasticity is not statistically different from zero, regardless of working status. That is, renting households do not respond sensitively to regional variation in housing market risk.[18]

Self-employed Household

As Heaton and Lucas (2000) point out, proprietary business wealth plays an important role in household portfolio choice. Income from proprietary business is riskier than wage income since proprietary business income is more highly correlated with stock returns. Additionally, investment in proprietary business crowds out the opportunity for investment in common stock. Proprietary business wealth thus substitutes for common stock holdings such that households that own their own business tend to hold less stock. To consider the substitution effect of proprietary business investment, I focus on self-employed households that drive income primarily from their own business. Column (4) to (6) in Table 11 show how housing market risk affects stock shares of self-employed households. As can be seen in the table, there is no significant relationship between local housing market risk and stock share of self-employed households. When proprietary businesses are also considered as risky investments, however, the risky investment behavior of self-employed households also respond to local housing market risk as shown in Column (7) to (9) in Table 11. In other words, households in areas where housing market risk is high tend to increase the portion of safe assets in their non-housing wealth that includes proprietary business wealth as well as financial wealth.

[18] The majority of the HRS sample with financial wealth greater than 10,000 dollars own homes. The smaller sample size could be one possible reason for statistical insignificancy. In the further studies to be conducted with the younger sample, in which the proportions of homeowners and renters are not significantly different, I plan to compare the risky investment behavior of homeowners and renters in the presence of heterogeneous housing market risk.

4.5.3 Spouse Retirement Status

The main result of this paper indicates that retirement status of household head has a significant effect on how regional variation in housing market risk affects household portfolio choice. The presence of labor income risk explains this result. However, for married households in which both household head and spouse earn labor income, the labor income of spouse may constitute a non-trivial portion of household total labor income.[19] In this case, the retirement status of spouse can also affect household portfolio choice. To take the effect of spouse retirement into consideration, I define *household retirement* as a status in which both head and spouse are retired.[20] I test the baseline regression model substituting *household retirement* for *head retirement*. Table 12 reports the result. As the table shows, even using *household retirement* instead of *head retirement*, the effect of housing supply elasticity on portfolio choice is almost the same as in the baseline regression.

5 Conclusion

Housing market risk is difficult to avoid and not readily diversifiable because the house plays a dual role as an investment and a place of residence. Household exposure to housing market risk varies with the location of the main residence. In the presence of heterogeneous housing market risk, households can strategically adjust their portfolio allocations so as to maintain an optimal level of overall risk to their total wealth. This paper examines how heterogeneity in housing market risk affects household portfolio choice by focusing on three aspects of housing market risk: 1) volatility of house price growth rate, 2) the correlation between house price growth rate and stock return, and 3) the correlation between housing

[19]Since this paper defines head of household as the member whose labor income is higher than any other member throughout the survey period, labor income of head is always higher than that of spouse. Working status of household head is thus more important to household portfolio choice. For some households, however, the difference in labor income between household head and spouse is insignificant, in which case spouse's labor income may represent a considerable proportion of total household income.

[20]For single households and married households in which the spouse has no labor income, *head retirement* status is the same as *household retirement* status.

price growth rate and labor income growth rate. These three aspects of housing market risk vary greatly across regions and this regional variation is explained largely by local housing supply elasticity. Empirical evidence shows that households respond to these variations in housing market risk and adjust their portfolio allocation accordingly. In areas with low housing supply elasticity, housing market risk is higher and households tend to hold less stock in their financial wealth. This tendency becomes weaker after retirement, emphasizing the importance of the correlation between housing and labor income risks. Portfolio rebalancing behavior in response to changes in housing market risk also confirms that households consider the housing market risk differently depending on the location of their main residence.

Although the main findings in this paper are robust from various perspectives, some limitations warrant further development. First, this paper does not distinguish the effect of the volatility of house price growth rate on portfolio choice from the effect of the correlation of house price growth rate and stock return, while the effect of the correlation between housing and labor income risks is identified using retirement status as an indicator of labor income risk. Since both the volatility of house price growth rate and its correlation with stock return decrease with housing supply elasticity, it is difficult to identify these two risk measures when we focus on the regional variation and use housing supply elasticity as an indicator of the regional variation. Further studies could use the estimated volatility and correlation coefficient to examine the effect of each factor on portfolio choice.

Secondly, this paper does not consider the effect of idiosyncratic labor income risk. This paper uses the correlation between local house price growth rate and local labor income growth rate as a measure of combined risk of housing and labor income. However, the correlation between these two risks can vary significantly across individuals as well as regions. For example, people who work in the public sector, labor income is less correlated with aggregate economic conditions and house price dynamics, even if they live in areas where housing supply elasticity is low. In this case, the combined effect of housing and labor income risk does not significantly affect household portfolio choice. Using individual level income data in the HRS, the effect of idiosyncratic labor income risk and its relationship with local housing market risk can be further examined.

Notwithstanding some limitations, this paper introduces a new perspective that enhances our understanding of heterogeneity in household portfolio choice. Although households have relatively easy access to global financial market owing to globalization and advancement in technology, local economic conditions are still the most important consideration in household financial decisions. Without considering the impact of local economy on household financial decision, our understanding of household investment behavior would be much limited. This paper offers a clue to the importance of local economic conditions in household finance.

References

Benzoni, L., P. Collin-Dufresne, and R. S. Goldstein. 2007. Portfolio Choice over the Life-Cycle when the Stock and Labor Markets are Cointegrated. *The Journal of Finance* 62:3. 9

Bodie, Z., R. C. Merton, and W. F. Samuelson. 1992. Labor supply flexibility and portfolio choice in a life cycle model. *Journal of economic dynamics and control* 16:427–449. 9

Campbell, J. Y. 1993. Intertemporal Asset Pricing without Consumption Data. *The American Economic Review* 83:487–512. 13

Campbell, J. Y., and L. M. Viceira. 1999. Consumption and Portfolio Decisions When Expected Returns Are Time Varying. *Quarterly Journal of Economics* 114. 13

Campbell, J. Y., and L. M. Viceira. 2001. Who Should Buy Long-Term Bonds? *American Economic Review* pp. 99–127. 13

Campbell, J. Y., and L. M. Viceira. 2002. *Strategic asset allocation: portfolio choice for long-term investors*. Oxford University Press. 12, 14

Chetty, R., and A. Szeidl. 2010. The effect of housing on portfolio choice. Tech. rep., National Bureau of Economic Research. 7, 12, 13

Cocco, J. F. 2005. Portfolio choice in the presence of housing. *Review of Financial studies* 18:535–567. 2, 5

Coval, J. D., and T. J. Moskowitz. 1999. Home bias at home: Local equity preference in domestic portfolios. *The Journal of Finance* 54:2045–2073. 8

Dimson, E. 1979. Risk measurement when shares are subject to infrequent trading. *Journal of Financial Economics* 7:197–226. 11

Flavin, M., and T. Yamashita. 2002. Owner-occupied housing and the composition of the household portfolio. *American Economic Review* pp. 345–362. 2, 5, 29

Glaeser, E. L., J. Gyourko, and A. Saiz. 2008. Housing supply and housing bubbles. *Journal of Urban Economics* 64:198–217. 8, 12

Gomes, F., and A. Michaelides. 2003. Portfolio choice with internal habit formation: A life-cycle model with uninsurable labor income risk. *Review of Economic Dynamics* 6:729–766. 9

Grossman, S., and G. Laroque. 1990. Asset pricing and optimal portfolio choice in the presence of illiquid durable consumption goods. *Econometrica* 58:25–52. 2, 5

Guiso, L., T. Jappelli, and D. Terlizzese. 1996. Income risk, borrowing constraints, and portfolio choice. *The American Economic Review* pp. 158–172. 9

Harter-Dreiman, M. 2004. Drawing inferences about housing supply elasticity from house price responses to income shocks. *Journal of Urban Economics* 55:316–337. 12

Heaton, J., and D. Lucas. 2000. Portfolio choice and asset prices: The importance of entrepreneurial risk. *The journal of finance* 55:1163–1198. 33

Kimball, M. S. 1993. Standard risk aversion. *Econometrica: Journal of the Econometric Society* pp. 589–611. 9

Lynch, A. W., and S. Tan. 2011. Labor income dynamics at business-cycle frequencies: Implications for portfolio choice. *Journal of Financial Economics* 101:333–359. 9

Mian, A., K. Rao, and A. Sufi. 2013. Household Balance Sheets, Consumption, and the Economic Slump. *The Quarterly Journal of Economics* 128:1687–1726. 7

Mian, A., and A. Sufi. 2010. Household Leverage and the Recession of 2007–09. *IMF Economic Review* 58:74–117. 7

Mian, A., and A. Sufi. 2011. House Prices, Home Equity-Based Borrowing, and the US Household Leverage Crisis. *American Economic Review* 101:2132–56. 7

Mian, A. R., and A. Sufi. 2009. The Consequences of Mortgage Credit Expansion: Evidence from the US Mortgage Default Crisis. *The Quarterly Journal of Economics* 124:1449–1496. 7

Paciorek, A., and T. Sinai. 2012. Does home owning smooth the variability of future housing consumption? *Journal of Urban Economics* 71:244–257. 17

Polkovnichenko, V. 2007. Life-cycle portfolio choice with additive habit formation preferences and uninsurable labor income risk. *Review of Financial Studies* 20:83–124. 9

Poterba, J. M. 2000. Stock market wealth and consumption. *The Journal of Economic Perspectives* pp. 99–118. 8

Saiz, A. 2010. The geographic determinants of housing supply. *The Quarterly Journal of Economics* 125:1253–1296. 7, 8, 20, 25

Sinai, T., and N. S. Souleles. 2005. Owner-Occupied Housing as a Hedge Against Rent Risk. *Quarterly Journal of Economics* 120. 17

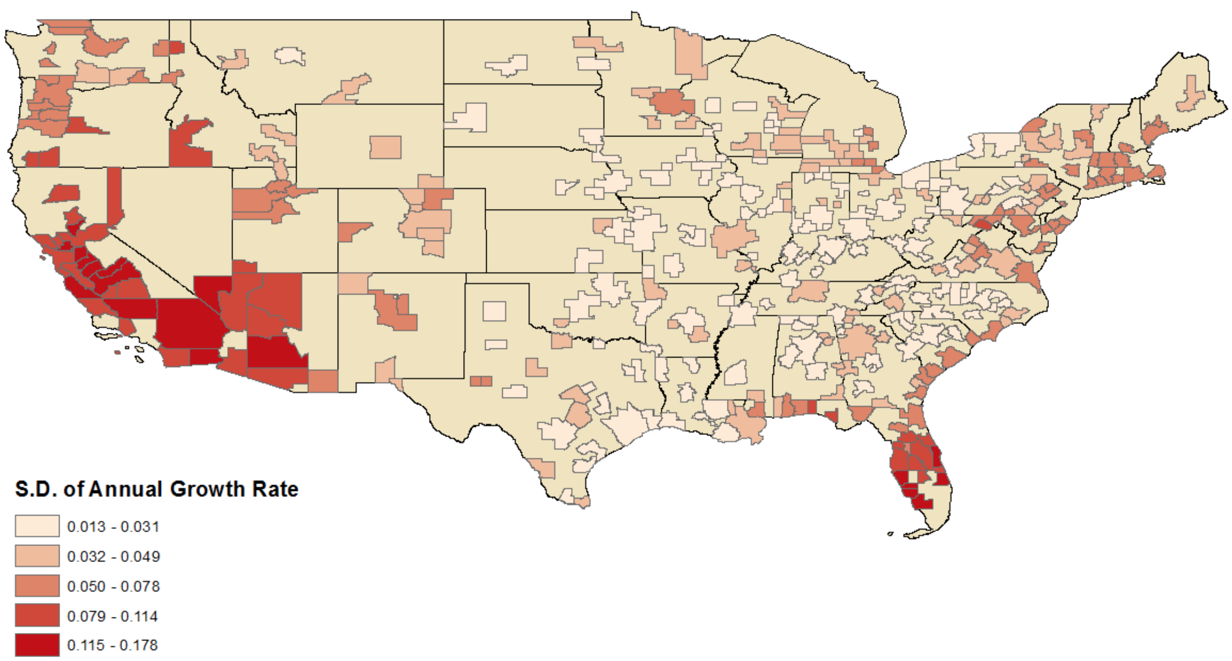
Viceira, L. M. 2001. Optimal Portfolio Choice for Long-Horizon Investors with Nontradable Labor Income. *The Journal of Finance* 56:433–470. 9

Yao, R., and H. H. Zhang. 2005. Optimal consumption and portfolio choices with risky housing and borrowing constraints. *Review of Financial Studies* 18:197–239. 2, 5

Figure 1: Standard Deviation of Annual House Price Growth Rate of MSAs from 1990 to 2010

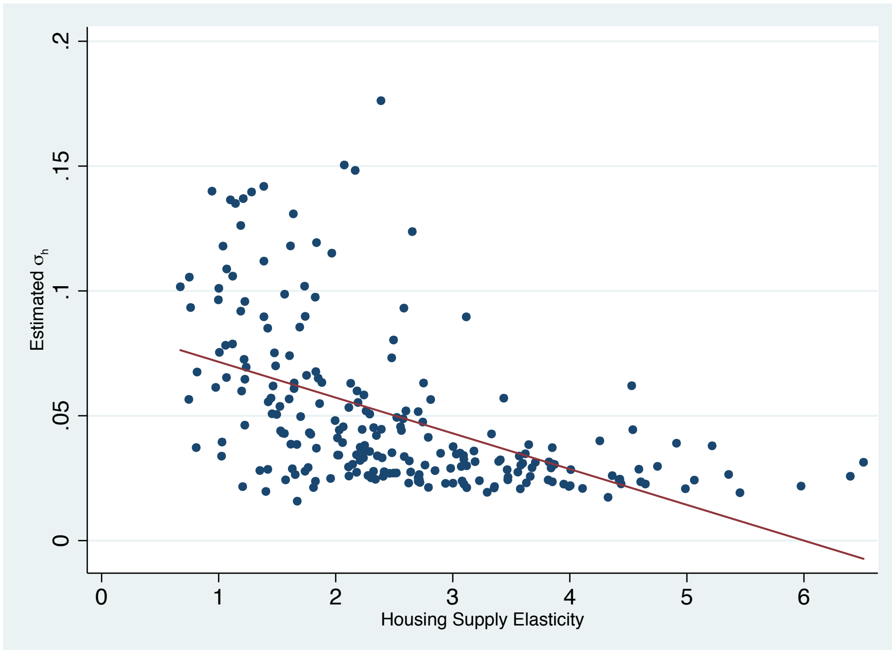
A. Distribution of Standard Deviation of Annual House Price Growth Rate

B. Map of the United States with Standard Deviation of Annual House Price Growth Rate



Notes: This figure is based on the standard deviation of average annual growth rate of the House Price Index (HPI) for MSAs from 1990 to 2010. The HPI is provided by the Federal Housing Finance Agency (FHFA).

Figure 2: Standard Deviation of Annual House Price Growth Rate and Housing Supply Elasticity



Notes: This figure is based on the standard deviation of average annual growth rate of the House Price Index (HPI) for 228 MSAs from 1990 to 2010 and housing supply elasticity by Saiz (2010). The HPI is provided by the Federal Housing Finance Agency (FHFA).

Table 1: Regression of house price growth rate on stock return and labor income growth rate

The table shows the coefficients of regression of house price growth rate ($\Delta \ln P$) on current and lagged series of stock return ($\Delta \ln S$) and labor income growth rate ($\Delta \ln Y$). The coefficients on stock return and labor income growth rate interacted with inverse of housing supply elasticity are also reported (β_1^S and β_1^Y, respectively). Newey-West standard errors are reported in parentheses.

	Lag			
	$k=0$	$k=1$	$k=2$	Aggregated Coefficients
$\hat{\beta}_0^S(k)$	0.013			0.013
	(0.006)			
	0.010	0.005		0.016
	(0.005)	(0.005)		
	0.014	-0.016	0.040	0.038
	(0.005)	(0.005)	(0.005)	
$\hat{\beta}_1^S(k)$	0.049			0.049
	(0.011)			
	0.010	0.044		0.054
	(0.011)	(0.010)		
	0.009	0.019	0.048	0.075
	(0.012)	(0.009)	(0.011)	
$\hat{\beta}_0^Y(k)$	0.010			0.010
	(0.004)			
	0.016	0.016		0.032
	(0.004)	(0.004)		
	0.014	0.019	0.015	0.048
	(0.005)	(0.005)	(0.005)	
$\hat{\beta}_1^Y(k)$	0.023			0.023
	(0.007)			
	0.034	0.048		0.082
	(0.007)	(0.009)		
	0.039	0.058	0.040	0.137
	(0.009)	(0.011)	(0.010)	

Table 2: Summary Statistics - Household Asset Value

		All				By Age Groups											
						51-60				61-70				71-80			
	HSE	Mean	s.d.	Med	Obs.	Mean	s.d.	Med	Obs.	Mean	s.d.	Med	Obs.	Mean	s.d.	Med	Obs.
Total Wealth																	
	Low	701	744	454	4,915	675	692	428	1,058	729	783	479	1,975	686	722	449	1,861
	Med.	635	681	413	4,862	597	635	410	1,158	671	707	438	1,959	617	679	389	1,731
	High	495	610	302	4,908	458	558	289	990	511	643	306	2,113	496	598	305	1,791
	All	610	686	385	14,685	580	638	375	3,206	634	718	397	6,047	600	673	378	5,383
Value of House																	
	Low	269	188	210	4,891	301	199	240	1,053	276	189	214	1,959	242	175	192	1,858
	Med.	221	158	176	4,865	242	161	204	1,159	227	164	178	1,961	199	148	157	1,731
	High	147	103	123	4,935	164	111	132	997	150	107	125	2,127	133	90	116	1,797
	All	212	162	160	14,691	237	171	191	3,209	216	165	162	6,047	192	149	150	5,386
Home Equity																	
	Low	224	166	180	4,835	227	174	179	1,036	227	167	180	1,939	219	160	178	1,839
	Med.	181	136	144	4,817	173	132	137	1,142	185	142	145	1,941	183	133	149	1,720
	High	121	90	100	4,875	115	96	94	980	123	93	100	2,097	122	83	104	1,784
	All	175	141	136	14,527	173	145	130	3,158	177	143	135	5,977	175	136	137	5,343
Liquid Assets																	
	Low	194	285	82	4,930	173	261	68	1,067	182	265	79	1,985	220	318	98	1,857
	Med.	199	280	88	4,862	160	229	70	1,154	205	284	90	1,966	217	304	96	1,728
	High	172	253	76	4,916	153	250	64	996	169	257	72	2,112	185	250	87	1,794
	All	188	274	82	14,708	162	246	68	3,217	185	269	80	6,063	207	292	94	5,379
Stock Assets																	
	Low	73	131	7	4,789	69	124	11	1,040	71	128	7	1,937	77	138	5	1,791
	Med.	76	134	9	4,728	71	127	9	1,136	82	139	12	1,915	71	133	5	1,664
	High	65	121	5	4,816	59	108	8	974	65	120	5	2,067	68	130	4	1,762
	All	71	129	7	14,333	66	121	9	3,150	72	129	8	5,919	72	134	4	5,217
Stock Assets																	
(Cond. on	Low	128	152	63	2,712	113	142	50	636	124	149	60	1,100	144	161	80	963
Participation)	Med.	130	155	68	2,739	119	147	55	675	137	157	76	1,144	130	156	70	915
	High	119	143	56	2,637	102	126	48	559	120	141	62	1,124	127	154	58	949
	All	126	150	63	8,088	112	139	50	1,870	127	150	65	3,368	134	157	68	2,827
Income																	
	Low	82	74	58	4,942	113	83	91	1,055	84	73	61	1,989	61	60	42	1,878
	Med.	84	77	60	4,851	116	89	91	1,147	85	76	61	1,951	61	60	43	1,739
	High	73	68	52	4,903	102	76	83	987	74	69	53	2,109	54	55	38	1,793
	All	79	73	56	14,696	111	83	88	3,189	81	73	58	6,049	59	59	41	5,410

Note: This table provides summary statistics for household asset values. Based on the housing supply elasticity (HSE) of the areas where households reside, sample is divided into three groups: low, medium, and high elasticity areas. Summary statistics are reported by housing supply elasticity group and age group. Asset values are in thousands of constant-year 2000 dollars.

Table 3: Summary Statistics - Household Asset Composition

		All				By Age Groups: 51-60				61-70				71-80			
	HSE	Mean	s.d.	Med	Obs.	Mean	s.d.	Med	Obs.	Mean	s.d.	Med	Obs.	Mean	s.d.	Med	Obs.
House Share in Total Wealth	Low	0.554	0.340	0.499	4,901	0.639	0.386	0.571	1,030	0.561	0.350	0.493	1,976	0.498	0.285	0.462	1,875
	Med.	0.506	0.320	0.440	4,844	0.584	0.365	0.491	1,134	0.491	0.320	0.423	1,957	0.473	0.276	0.423	1,739
	High	0.460	0.306	0.398	4,883	0.541	0.359	0.467	973	0.458	0.307	0.387	2,105	0.417	0.257	0.368	1,791
	All	0.507	0.324	0.444	14,628	0.589	0.372	0.512	3,137	0.502	0.329	0.433	6,038	0.463	0.275	0.418	5,405
Home Equity Share in Total Wealth	Low	0.430	0.224	0.412	4,837	0.443	0.221	0.436	1,035	0.419	0.224	0.395	1,940	0.433	0.224	0.416	1,842
	Med.	0.397	0.219	0.365	4,821	0.393	0.217	0.363	1,141	0.380	0.217	0.350	1,951	0.420	0.222	0.388	1,715
	High	0.364	0.212	0.330	4,876	0.350	0.207	0.315	979	0.361	0.211	0.327	2,101	0.374	0.215	0.340	1,782
	All	0.397	0.220	0.369	14,534	0.396	0.218	0.372	3,155	0.386	0.218	0.356	5,992	0.409	0.222	0.381	5,339
Liquid Assets Share in Total Wealth	Low	0.259	0.193	0.212	4,774	0.236	0.181	0.192	1,037	0.241	0.183	0.194	1,935	0.291	0.208	0.249	1,781
	Med.	0.287	0.202	0.242	4,715	0.260	0.192	0.214	1,124	0.280	0.197	0.238	1,913	0.312	0.211	0.271	1,665
	High	0.318	0.205	0.282	4,767	0.297	0.200	0.244	960	0.305	0.200	0.264	2,048	0.346	0.210	0.318	1,747
	All	0.288	0.202	0.244	14,256	0.264	0.192	0.215	3,121	0.276	0.195	0.231	5,896	0.317	0.211	0.280	5,193
Stock Share in Financial Assets	Low	0.333	0.371	0.143	4,956	0.360	0.377	0.223	1,057	0.329	0.368	0.147	1,997	0.321	0.369	0.100	1,881
	Med.	0.341	0.375	0.156	4,861	0.348	0.379	0.166	1,139	0.359	0.382	0.200	1,965	0.318	0.362	0.114	1,743
	High	0.318	0.370	0.091	4,891	0.336	0.377	0.138	974	0.326	0.374	0.103	2,108	0.299	0.361	0.057	1,795
	All	0.331	0.372	0.130	14,708	0.348	0.378	0.175	3,170	0.337	0.375	0.147	6,070	0.313	0.364	0.091	5,419
Stock Share in Financial Assets (Cond. on Participation)	Low	0.573	0.314	0.625	2,879	0.583	0.316	0.641	653	0.566	0.315	0.610	1,160	0.574	0.313	0.628	1,053
	Med.	0.578	0.318	0.625	2,872	0.584	0.322	0.645	678	0.590	0.321	0.652	1,194	0.558	0.310	0.588	994
	High	0.574	0.317	0.616	2,712	0.586	0.317	0.625	559	0.590	0.312	0.649	1,165	0.546	0.321	0.563	982
	All	0.575	0.316	0.623	8,463	0.584	0.318	0.641	1,890	0.582	0.316	0.638	3,519	0.560	0.315	0.594	3,029

Note: This table provides summary statistics for household asset composition. Based on the housing supply elasticity (HSE) of the areas where households reside, sample is divided into three groups: low, medium, and high elasticity areas. Summary statistics are reported by housing supply elasticity group and age group.

Table 4: Regression of Stock Share on Housing Supply Elasticity (Baseline)

Dependent. Var. Stock Share	(1) All	(2) Working	(3) Retiree	(4) Interaction
Housing Supply Elasticity (HSE)	0.009***	0.016***	0.005	0.017***
	(0.004)	(0.005)	(0.005)	(0.005)
Head Retired				0.029*
				(0.016)
Head Retired × HSE				-0.013*
				(0.007)
Head Age	-0.008	0.017	-0.006	-0.002
	(0.009)	(0.014)	(0.022)	(0.009)
Head Age^2	0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Household Size	-0.009	-0.012*	-0.003	-0.008
	(0.005)	(0.007)	(0.009)	(0.006)
Head Health Status	-0.021*	-0.017	-0.025*	-0.023*
	(0.012)	(0.023)	(0.015)	(0.012)
Ln(Household Income)	-0.029***	-0.016**	-0.041***	-0.028***
	(0.005)	(0.008)	(0.009)	(0.006)
Ln(Total Wealth)	0.057***	0.053***	0.067***	0.059***
	(0.005)	(0.007)	(0.007)	(0.005)
Demographic Char. Controlled	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Observations	6,026	2,909	3,117	6,026
R-squared	0.037	0.034	0.046	0.040

Notes: Dependent variable for this analysis is a stock share in total financial assets. Housing supply elasticity is measured by matching the location of main residence and the estimates provided by Saiz (2010). Head retired is a binary indicator for retirement status of household head. Retirement status is based on self-reported working status. Household size is the number of members in household. Head health status is a binary indicator that has value "0" when head is relatively healthy and "1" otherwise. Demographic characteristics controlled include race, education, and religion of the head and the number of children in household. All standard errors are clustered at the household level.

*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level

Table 5: Regression of Stock Share on Housing Supply Elasticity (Home Equity Share Controlled)

Dependent. Var. Stock Share	(1) All	(2) Working	(3) Retiree	(4) Interaction
Housing Supply Elasticity (HSE)	0.006*	0.012**	0.003	0.014***
	(0.004)	(0.005)	(0.005)	(0.005)
Head Retired				0.028*
				(0.016)
Head Retired × HSE				-0.013*
				(0.007)
Home Equity Share	-0.069***	-0.084**	-0.049	-0.069***
	(0.023)	(0.033)	(0.035)	(0.024)
Head Age	-0.008	0.017	-0.005	-0.001
	(0.009)	(0.014)	(0.022)	(0.009)
Head Age^2	0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Household Size	-0.007	-0.011	-0.001	-0.006
	(0.006)	(0.007)	(0.009)	(0.006)
Head Health Status	-0.022*	-0.020	-0.025*	-0.024*
	(0.012)	(0.024)	(0.015)	(0.012)
Ln(Household Income)	-0.029***	-0.017**	-0.042***	-0.029***
	(0.005)	(0.008)	(0.009)	(0.006)
Ln(Total Wealth)	0.049***	0.045***	0.060***	0.052***
	(0.005)	(0.008)	(0.009)	(0.006)
Demographic Char. Controlled	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Observations	5,998	2,893	3,105	5,998
R-squared	0.038	0.037	0.046	0.041

Notes: Dependent variable for this analysis is a stock share in total financial assets. Home equity share is the share of home equity in total wealth. Housing supply elasticity is measured by matching the location of main residence and the estimates provided by Saiz (2010). Head retired is a binary indicator for retirement status of household head. Retirement status is based on self-reported working status. Household size is the number of members in household. Head health status is a binary indicator that has value "0" when head is relatively healthy and "1" otherwise. Demographic characteristics controlled include race, education, and religion of the head and the number of children in household. All standard errors are clustered at the household level. *** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level

Table 6: Regression of Stock Share on Housing Supply Elasticity by Home Equity Share Group

Dep. Var. Stock Share	(1) All	(2) Working	(3) Retiree
Housing Supply Elasticity (HSE)	-0.013	-0.011	-0.016
	(0.011)	(0.017)	(0.017)
HSE × Home Equity Share High (0.5 to 0.75)	0.008	0.014	0.000
	(0.007)	(0.009)	(0.011)
HSE × Home Equity Share Low (0.25 to 0.5)	0.002	0.011*	-0.007
	(0.005)	(0.007)	(0.007)
HSE × Home Equity Share Lowest (0 to 0.25)	0.013***	0.018***	0.011**
	(0.004)	(0.006)	(0.005)
Head Age	-0.008	0.017	-0.005
	(0.009)	(0.014)	(0.022)
Head Age^2	0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)
Household Size	-0.008	-0.012	-0.001
	(0.005)	(0.007)	(0.009)
Head Health Status	-0.021*	-0.017	-0.023
	(0.012)	(0.023)	(0.015)
Ln(Household Income)	-0.029***	-0.016**	-0.041***
	(0.005)	(0.008)	(0.009)
Ln(Total Wealth)	0.052***	0.049***	0.059***
	(0.005)	(0.007)	(0.008)
Demographic Char. Controlled	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	6,018	2,905	3,113
R-squared	0.038	0.034	0.048

Notes: Dependent variable for this analysis is a stock share in total financial assets. Home equity share is the share of home equity in total wealth. Housing supply elasticity is measured by matching the location of main residence and the estimates provided by Saiz (2010). Head retired is a binary indicator for retirement status of household head. Retirement status is based on self-reported working status. Household size is the number of members in household. Head health status is a binary indicator that has value "0" when head is relatively healthy and "1" otherwise. Demographic characteristics controlled include race, education, and religion of the head and the number of children in household. All standard errors are clustered at the household level. *** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level

Table 7: Regression of Stock Share on HSE by Mortgage Status

	Without Mortgage			With Mortgage		
	All	Working	Retiree	All	Working	Retiree
	(1)	(2)	(3)	(4)	(5)	(6)
Housing Supply Elasticity (HSE)	0.008*	0.014*	0.006	0.016**	0.021***	0.009
	(0.004)	(0.007)	(0.005)	(0.007)	(0.008)	(0.013)
Head Age	-0.024*	0.014	-0.034	0.004	0.001	0.076*
	(0.013)	(0.020)	(0.024)	(0.016)	(0.023)	(0.044)
Head Age^2	0.000*	-0.000	0.000	-0.000	-0.000	-0.001*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Household Size	-0.011	-0.015	-0.006	-0.008	-0.013	0.012
	(0.007)	(0.012)	(0.010)	(0.008)	(0.009)	(0.018)
Head Health Status	-0.021	-0.008	-0.025	-0.021	-0.032	-0.01
	(0.013)	(0.031)	(0.016)	(0.023)	(0.037)	(0.034)
Ln(Household Income)	-0.038***	-0.018	-0.054***	-0.022***	-0.025**	-0.024*
	(0.007)	(0.011)	(0.011)	(0.008)	(0.012)	(0.014)
Ln(Total Wealth)	0.076***	0.070***	0.081***	0.034***	0.041***	0.040***
	(0.006)	(0.010)	(0.008)	(0.008)	(0.010)	(0.015)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Chars. Controlled	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.048	0.051	0.052	0.027	0.021	0.051
No. of Obs.	3,881	1,442	2,439	2,145	1,467	678

Notes: Dependent variable for this analysis is a stock share in total financial assets. Mortgage status is based on the self-reported remaining mortgage balance. Housing supply elasticity is measured by matching the location of main residence and the estimates provided by Saiz (2010). Head retired is a binary indicator for retirement status of household head. Retirement status is based on self-reported working status. Household size is the number of members in household. Head health status is a binary indicator that has value "0" when head is relatively healthy and "1" otherwise. Demographic characteristics controlled include race, education, and religion of the head and the number of children in household. All standard errors are clustered at the household level.

*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level

Table 8: Effect of LTV on the Relationship between HSE and Stock Share (with or without mortgage)

A. Regression with LTV Interaction term.

	All (1)	Working (2)	Retiree (3)	All (1)	Working (2)	Retiree (3)
Housing Supply Elasticity (HSE)	0.010***	0.016***	0.005	0.005	0.010	0.005
	0.004	0.005	(0.005)	(0.004)	(0.006)	(0.005)
Loan-to-Value Ratio (LTV)	0.050**	0.064**	0.033	-0.017	-0.003	0.029
	0.020	0.025	0.037	(0.036)	(0.048)	(0.068)
HSE × LTV				0.040**	0.037*	0.003
				(0.017)	(0.022)	(0.035)
Head Age	-0.006	0.017	-0.004	-0.006	0.017	-0.004
	(0.009)	(0.014)	(0.022)	(0.009)	(0.014)	(0.022)
Head Age^2	0.000	-0.000	0.000	0.000	-0.000	0.000
	(0.000)	0.000	(0.000)	(0.000)	(0.000)	(0.000)
Ln(Household Income)	-0.032***	-0.020**	-0.043***	-0.032***	-0.020**	-0.043***
	(0.006)	(0.008)	(0.009)	(0.006)	(0.008)	(0.009)
Ln(Total Wealth)	0.060***	0.057***	0.068***	0.060***	0.057***	0.068***
	(0.005)	(0.007)	(0.007)	(0.005)	(0.007)	(0.007)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Demogrpahic Chars. Controlled	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.038	0.036	0.046	0.039	0.037	0.046
No. of Obs.	6,004	2,895	3,109	6,004	2,895	3,109

Notes: Dependent variable for this analysis is a stock share in total financial assets. LTV is estimated by dividing remaining mortgage balance by the self-reported value of main residence. Housing supply elasticity is measured by matching the location of main residence and the estimates provided by Saiz (2010). Head retired is a binary indicator for retirement status of household head. Retirement status is based on self-reported working status. Demographic characteristics controlled include race, education, health status, and religion of the head and the number of children in household. All standard errors are clustered at the household level.

*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level

B. Marginal effect of Housing Supply Elasticity on Stock Share by LTV ratio

	At LTV										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
HSE	0.005	0.009	0.013	0.017	0.021	0.025	0.029	0.033	0.037	0.041	0.045
Std. Err.	(0.004)	(0.003)	(0.004)	(0.005)	(0.006)	(0.008)	(0.009)	(0.011)	(0.013)	(0.014)	(0.016)
t stat	1.37	2.68	3.44	3.54	3.41	3.26	3.13	3.02	2.94	2.87	2.82

Table 9: Regression of Change in Stock Share on Change in Housing Supply Elasticity

Dep. Var. ΔStock Share	(1)	(2)	(3)	(4)	(5)	(6)
ΔHousing Supply Elasticity (HSE)	0.033*	0.033*	0.032*	0.034**	0.038**	0.102***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.034)
ΔHSE × Head Retired						-0.088**
						(0.040)
ΔHome Equity Share		-0.035	-0.027	-0.034	-0.028	
		(0.073)	(0.073)	(0.077)	(0.077)	
ΔTotal Wealth			-0.001	-0.001		-0.001*
			(0.001)	(0.001)		(0.001)
ΔHousehold Income				0.007		0.003
				(0.011)		(0.012)
Head Retiring					0.042	
					(0.063)	
Head Retired						0.049
						(0.051)
Head Age	0.053**	0.053**	0.052**	0.051**	0.047*	0.039
	(0.023)	(0.023)	(0.024)	(0.024)	(0.024)	(0.024)
Head Age^2	-0.000**	-0.000**	-0.000**	-0.000**	-0.000*	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ln(Household Income)	0.004	0.003	0.002	-0.007	-0.002	-0.006
	(0.025)	(0.025)	(0.025)	(0.033)	(0.027)	(0.031)
Ln(Total Wealth)	-0.040*	-0.038	-0.032	-0.034	-0.030	-0.026
	(0.023)	(0.024)	(0.025)	(0.026)	(0.025)	(0.027)
Demographic Char. Controlled	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	283	283	283	283	243	256
R-squared	0.094	0.095	0.098	0.096	0.148	0.077

Notes: Dependent variable for this analysis is a change in stock share in total financial assets. Home equity share is the share of home equity in total wealth. Housing supply elasticity is measured by matching the location of main residence and the estimates provided by Saiz (2010). Head retired is a binary indicator for retirement status of household head. Retirement status is based on self-reported working status. Household size is the number of members in household. Head health status is a binary indicator that has value "0" when head is relatively healthy and "1" otherwise. Demographic characteristics controlled include race, education, and religion of the head and the number of children in household. All standard errors are clustered at the MSA level.

*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level

Table 10: Robustness Check I (Stock and Other Real Estate Share)

Dep. Var.	All	Working	Retiree
Share of Stock and Other Real Estate	(1)	(2)	(3)
Housing Supply Elasticity (HSE)	0.006***	0.015***	-0.001
	(0.003)	(0.004)	(0.004)
Head Age	-0.029***	-0.005	-0.034*
	(0.008)	(0.011)	(0.018)
Head Age^2	0.000***	0.000	0.000**
	(0.000)	(0.000)	(0.000)
Household Size	-0.024***	-0.022***	-0.024***
	(0.004)	(0.006)	(0.007)
Head Health Status	0.002	-0.005	0.003
	(0.010)	(0.018)	(0.012)
Ln(Household Income)	-0.013***	-0.013*	0.004
	(0.005)	(0.007)	(0.007)
Ln(Total Wealth)	0.040***	0.035***	0.047***
	(0.004)	(0.006)	(0.006)
Year Fixed Effect	Yes	Yes	Yes
Demogrpahic Chars. Controlled	Yes	Yes	Yes
R-squared	0.035	0.025	0.040
No. of Obs.	6,025	2,908	3,117

Notes: Dependent variable for this analysis is a stock share in total financial assets. Housing supply elasticity is measured by matching the location of main residence and the estimates provided by Saiz (2010). Head retired is a binary indicator for retirement status of household head. Retirement status is based on self-reported working status. Household size is the number of members in household. Head health status is a binary indicator that has value "0" when head is relatively healthy and "1" otherwise. Demographic characteristics controlled include race, education, and religion of the head and the number of children in household. All standard errors are clustered at the household level.

*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level

Table 11: Robustness Check II (Alternative Sample Selection)

	Renters			Self-employed					
				Share of Stock in Financial Wealth			Share of Stock and Business in Non-housing assets		
	All	Working	Retiree	All	Working	Retiree	All	Working	Retiree
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Housing Supply Elasticity (HSE)	-0.022	0.010	-0.041	0.012	0.012	-0.006	0.024**	0.024**	0.070
	(0.023)	(0.048)	(0.030)	(0.011)	(0.011)	(0.048)	(0.010)	(0.010)	(0.055)
Head Age	0.020	0.184***	-0.155	0.015	0.016	0.033	-0.047*	-0.054*	-0.000
	(0.044)	(0.066)	(0.103)	(0.030)	(0.033)	(0.152)	(0.027)	(0.030)	(0.160)
Head Age^2	0.000	-0.001*	0.001	-0.000	-0.000	-0.000	0.000	0.000*	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Household Size	-0.008	-0.008	-0.013	-0.007	-0.010	0.099	-0.006	-0.010	0.049
	(0.011)	(0.020)	(0.016)	(0.016)	(0.016)	(0.084)	(0.013)	(0.013)	(0.069)
Head Health Status	0.025	0.159**	0.004	-0.036	-0.020	-0.079	-0.037	-0.008	0.041
	(0.024)	(0.065)	(0.030)	(0.039)	(0.046)	(0.149)	(0.037)	(0.042)	(0.126)
Ln(Household Income)	-0.009	-0.002	-0.071	-0.005	0.000	0.062	-0.008	-0.018	0.090
	(0.021)	(0.032)	(0.038)	(0.014)	(0.015)	(0.079)	(0.014)	(0.015)	(0.069)
Ln(Total Wealth)	0.030*	-0.003	0.068***	0.018	0.020	-0.002	0.032**	0.044***	-0.051
	(0.016)	(0.028)	(0.023)	(0.013)	(0.015)	(0.043)	(0.013)	(0.014)	(0.053)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Chars. Controlled	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	-0.014	0.033	0	0.011	0.001	0.101	0.025	0.032	-0.019
No. of Obs.	322	130	192	719	655	64	719	655	64

Notes: Dependent variable for column (1) to (6) is a stock share in total financial assets. Dependent variable for column (7) to (9) is the share of stock and business assets in total non-housing assets. Housing supply elasticity is measured by matching the location of main residence and the estimates provided by Saiz (2010). Renters are households that do not own their main residence. Household size is the number of members in household. Head health status is a binary indicator that has value "0" when head is relatively healthy and "1" otherwise. Demographic characteristics controlled include race, education, health status, and religion of the head and the number of children in household. All standard errors are clustered at the household level.

*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level

Table 12: Robustness Check III (Household Retirement Status)

	All (1)	Working (2)	Retiree (3)	Interaction (4)
Housing Supply Elasticity (HSE)	0.009***	0.016***	0.003	0.017***
	(0.004)	(0.005)	(0.005)	(0.005)
Household Retired				0.031*
				(0.016)
HSE × Household Retired				-0.014**
				(0.007)
Head Age	-0.008	0.009	-0.017	-0.001
	(0.009)	(0.013)	(0.023)	(0.009)
Head Age^2	0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Household Size	-0.009	-0.010	-0.004	-0.008
	(0.005)	(0.007)	(0.010)	(0.006)
Head Health Status	-0.021*	-0.020	-0.024	-0.023*
	(0.012)	(0.021)	(0.016)	(0.012)
Ln(Household Income)	-0.029***	-0.016**	-0.045***	-0.028***
	(0.005)	(0.008)	(0.009)	(0.006)
Ln(Total Wealth)	0.057***	0.053***	0.068***	0.060***
	(0.005)	(0.006)	(0.008)	(0.005)
Year Fixed Effect	Yes	Yes	Yes	Yes
Demogrpahic Chars. Controlled	Yes	Yes	Yes	Yes
R-squared	0.037	0.036	0.045	0.040
No. of Obs.	6,026	3,315	2,711	6,026

Notes: Dependent variable for this analysis is a stock share in total financial assets. Housing supply elasticity is measured by matching the location of main residence and the estimates provided by Saiz (2010). Household retired is a binary indicator that has value "1" when both head and spouse are retired and "0" otherwise. Retirement status is based on self-reported working status. Household size is the number of members in household. Head health status is a binary indicator that has value "0" when head is relatively healthy and "1" otherwise. Demographic characteristics controlled include race, education, health status, and religion of the head and the number of children in household. All standard errors are clustered at the household level.
*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level

Appendix

A. Solving maximization problem

The first order condition with respect to α for the maximization problem is as follows.

$$E\left[V'(W_{t+1})(R_{s,t+1} - R_f)\right] = 0 \tag{26}$$

where

$$V'(W_{t+1}) = \left((1-\theta)^{1-\theta}\theta^{\theta}\right)^{1-\gamma} W_{t+1}^{-\gamma} P_{t+1}^{\theta(\gamma-1)} \tag{27}$$

We can rewrite the first-order condition (24) as follows.

$$\begin{aligned}
E\left[V'(W_{t+1})(1+R_{s,t+1})\right] &= E\left[V'(W_{t+1})(1+R_f)\right] \\
E\left[\exp\left\{\log V'(W_{t+1}) + \log(1+R_{s,t+1})\right\}\right] &= E\left[\exp\left\{\log V'(W_{t+1}) + \log(1+R_f)\right\}\right] \\
E\left[\exp\left\{v'(w_{t+1}) + r_{s,t+1}\right\}\right] &= E\left[\exp\left\{v'(w_{t+1}) + r_f\right\}\right] \qquad (28)
\end{aligned}$$

Let $x_{t+1} = v'(w_{t+1}) + r_{s,t+1}$ and $y_{t+1} = v'(w_{t+1}) + r_f$. Taking a second-order Taylor expansion around $x_{t+1} = E\left[x_{t+1}\right]$ and $y_{t+1} = E\left[y_{t+1}\right]$ provide the following equation.

$$\exp\left\{E[x_{t+1}]\right\}\left(1 + \frac{1}{2}Var[x_{t+1}]\right) = \exp\left\{E[y_{t+1}]\right\}\left(1 + \frac{1}{2}Var[y_{t+1}]\right) \tag{29}$$

Taking a first-order Taylor expansion around zero

$$E[x_{t+1}] + \frac{1}{2}Var[x_{t+1}] = E[y_{t+1}] + \frac{1}{2}Var[y_{t+1}] \tag{30}$$

Rewriting the equation (16) in terms of $v'(w_{t+1})$, $r_{s,t+1}$, and r_f

$$\begin{aligned}
E[v'(w_{t+1}) + r_{s,t+1}] + \frac{1}{2}Var[v'(w_{t+1}) + r_{s,t+1}] &= E[v'(w_{t+1}) + r_f] + \frac{1}{2}Var[v'(w_{t+1}) + r_f] \\
E[r_{s,t+1} - r_f] + \frac{1}{2}Var[r_{s,t+1}] &= -Cov(v'(w_{t+1}), r_{s,t+1}) \qquad (31)
\end{aligned}$$

From equation (2) and (7), the equation (29) can be rewritten as follows

$$\begin{aligned} E\left[r_{s,t+1}-r_f\right]+\frac{1}{2}\sigma_s^2 &= -Cov(\xi-\gamma w_{t+1}-(1-\gamma)\theta p_{t+1}, r_{s,t+1}) \\ &\approx -Cov(-\gamma\rho_A r_{p,t+1}-\gamma(\rho_B+1)y_{t+1}-\gamma\rho_C p_{t+1}-(1-\gamma)\theta p_{t+1}, r_{s,t+1}) \\ &= \gamma\rho_A\alpha\sigma_s^2+(\gamma\rho_C+\theta(1-\gamma))\sigma_{ps}+\gamma(\rho_B+1)\sigma_{ys} \end{aligned}$$

Therefore, optimal risky share in the presence of labor income and housing assets is

$$\alpha = \frac{E\left[r_{t+1}-r_f\right]+\frac{1}{2}\sigma_s^2}{\gamma\rho_A\sigma_s^2}-\frac{\gamma\rho_C+\theta(1-\gamma)}{\gamma\rho_A}\frac{\sigma_{ps}}{\sigma_s^2}-\frac{(\rho_B+1)}{\rho_A}\frac{\sigma_{ys}}{\sigma_s^2} \tag{32}$$

where

$$\begin{aligned} \frac{\gamma\rho_C+\theta(1-\gamma)}{\gamma\rho_A} &= \left(\frac{\theta(1-\gamma)}{\gamma}-\frac{1}{\beta}\right)+\frac{\theta(1-\gamma)}{\gamma}\frac{\exp\{y\}}{\exp\{w_t+r_p\}}+\left(\frac{\theta(1-\gamma)}{\gamma}-\frac{1}{\beta}+1\right)\frac{\exp\{h_t+p\}}{\exp\{w_t+r_p\}} \\ \frac{(\rho_B+1)}{\rho_A} &= \beta+\exp\{\bar{y}-h_t-\bar{p}\} \end{aligned}$$

B. Proof of the proposition 1

From the log-normality condition, mean and variance of house price P_{t+1} can be represented by

$$E[P_{t+1}] = e^{p+\frac{1}{2}\sigma_p^2} \tag{33}$$

Form the equation (16) and the mean-preserving assumption, we can derive the linear relationship between p and σ_p^2 as follows.

$$p = K-\frac{1}{2}\sigma_p^2 \tag{34}$$

where K is a constant term. Taking derivatives of stock share α_t in the equation (15) with respect to σ_p^2 provides the following expression.

$$\frac{d\alpha_t}{d\sigma_p^2} = \frac{d\alpha_t}{d\rho_A}\left[\frac{d\rho_A}{dp}\frac{dp}{d\sigma_p^2} + \frac{d\rho_A}{dr_p}\frac{dr_p}{d\alpha_t}\frac{d\alpha_t}{d\sigma_p^2}\right] \tag{35}$$

Therefore,

$$\frac{d\alpha_t}{d\sigma_p^2} = \frac{\frac{d\alpha_t}{d\rho_A}\frac{d\rho_A}{dp}\frac{dp}{d\sigma_p^2}}{1 - \frac{d\alpha_t}{d\rho_A}\frac{d\rho_A}{dr_p}\frac{dr_p}{d\alpha_t}} \tag{36}$$

Then, a sufficient condition for making $\frac{d\alpha_t}{d\sigma_p^2}$ negative is

$$\frac{dr_p}{d\alpha_t} = \left(E\left[r_{t+1} - r_f\right] + \frac{1}{2}\sigma_s^2\right)\left(1 - \frac{1}{\gamma\rho_A}\right) > 0 \tag{37}$$

because $\frac{d\alpha_t}{d\rho_A} = -\frac{1}{\rho_A}\alpha_t < 0$, $\frac{d\rho_A}{dp} < 0$, $\frac{d\rho_A}{dr_p} = \rho_A(1-\rho_A) > 0$, and $\frac{dp}{d\sigma_p^2} = -\frac{1}{2} < 0$. In other words, if $\gamma > 1/\rho_A$, the optimal stock share is decreasing in the house price volatility.

C. Sample Selection

Table 13: Sample Size and Geographical Distributions

Selection Criteria	Sample Size	Number of MSA covered
Single or Married without change marital status	45,478	241
Household head age between 50 and 80	35,845	232
Financial liquid wealth more than 10,000 dollars	17,223	204
Homeowners	14,857	186
Stockowners	8,317	161