Three Essays on Household Finance

by

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To my parents and sister, for their encouragement and unconditional support.

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ABSTRACT

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Chair: John Laitner

This dissertation studies household saving and investment decisions in a variety of circumstances. Every individual faces various types of risk such as housing, labor income, and longevity risk. My dissertation focuses on the combined effects of such risks on household saving and investment behavior.

The first chapter of the dissertation investigates the effects of housing and labor income risk on household stock investment behavior. Housing market risk is geographically heterogeneous in that house price growth rate and its correlations with stock return and local labor growth rate vary widely across regions. In the presence of housing market risk, which is not easily diversifiable due to a special characteristic of houses as a residence, households adjust their stock share according to local housing market risk. 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 suggests that housing market risk exerts more influence on household portfolio choice when it is combined with labor income risk.

In the second chapter, the effect of retirement on portfolio choice is examined. The conventional wisdom suggests that, when labor income is reduced, households should hold

more safe assets in their portfolios after retirement. However, little theoretical consensus has been reached and empirical evidence has been scarce to evaluate this argument. This chapter provides empirical evidence that the retirement has a causal effect on portfolio choice. The household level panel data and the instrumental variable approach are used to deal with endogeneity problem and identify the casual effect of retirement. The result shows that the retirement causes a 5-7 percent increase in risky shares in households portfolio.

The third chapter examines the cash-out mortgage refinancing behavior and its effect on portfolio rebalancing. Owing to the expansion of mortgage market and low mortgage interest rate in the early 2000s, households cashed out a large amount of home equity. Cashed-out households reduce their home equity actively, thus rebalancing their portfolios. This rebalancing effect, however, is offset due to aggressive investments in other real estate. As households increased their real estate holdings using cashed-out home equity, they enjoyed a greater leveraging effect in real estate investment during the booming housing market, while household portfolios became more vulnerable to housing market risk.

CHAPTER I

Geographic Heterogeneity in Housing Market Risk and Portfolio Choice

1.1 Introduction

The effect of housing on portfolio choice has 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 them 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 that the correlation between house price growth rate and labor income growth rate has, on average, a dominant effect on portfolio choice. The main contribution of this paper is to shed light on the effects of local housing and labor market conditions on household finance. To the best of my knowledge, this paper is the first to examine the joint effect of local housing market risk and labor income risk 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, and individuals, whether they rent or own, need a place to live. The role of housing asset as a residence renders housing market risk hard to avoid and not readily diversifiable. 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 vary greatly across regions. The 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. When an aggregate demand shock occurs, house prices respond more sensitively to the shock in areas with low housing supply elasticity. Such response causes the volatility of house price growth rate to increase. In other words, 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. While stock prices and labor income directly affect housing demand, the shift in demand is reflected in the house prices to a greater extent in areas with low housing supply elasticity. House price is thus more positively correlated with stock price and labor income 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 high positive correlation, 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 measure of local housing market risk. This identification strategy offers an important advantage over the use of conventional risk measures 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 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 effect only 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, that face 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 local housing market risk exerts less influence on portfolio choice. This finding suggests that the effect of the correlation between house price and labor income dominates 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 current housing share and housing preference. Therefore, on average, the sole effect of housing risk is indeterminate. When house price is positively correlated with labor income, however, every household faces an additional consideration of liquidity constraints. For instance, when labor income drops unexpectedly, households usually try to borrow to smooth their consumption. Due to the positive correlation, however, home equity is reduced together with labor income. In such an event, households lose one of the most important borrowing channels. Experiencing an unexpected labor income drop and losing home equity concurrently, households in the low supply elasticity areas may suffer more from negative aggregate shocks. Considering the 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 is true with households that move to low-risk areas. This result remains significant 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. It also examines 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.

1.2 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 region to region. My 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 across region, and these regional variations can be explained largely by local housing supply elasticity.

1.2.1 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 1.1.A shows the distribution of the estimated standard deviations. As the figure shows, there is a considerable variation 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 1.1.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 et al.*, 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 et al.*, 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.

$$\widehat{\sigma}_{h,i} = \tau_0 + \tau_1 HSE_i + \epsilon_i \tag{1.1}$$

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 1.2 confirms the negative relationship between the volatility of house price growth rate and housing supply elasticity.

1.2.2 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).[1] 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.[2] Therefore, it stands to reason that the correlation between stock return and local 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 et al.*, 1992; *Kimball*, 1993; *Guiso et al.*, 1996; *Viceira*, 2001; *Gomes and Michaelides*, 2003; *Benzoni et al.*, 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 it 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

[1] 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.

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

local labor income growth rate.

$$\Delta \ln(Q_{s,i,t}) = \varepsilon_{s,i}\Delta \ln(P_{i,t}) + u_{i,t} \tag{1.2}$$

$$\Delta \ln(Q_{d,i,t}) = \varepsilon_{d}\Delta \ln(P_{i,t}) + \varepsilon_d^S \Delta \ln(S_t) + \varepsilon_d^Y \Delta \ln(Y_{i,t}) + v_{i,t} \tag{1.3}$$

where Q_s and Q_d are the quantities of housing supplied and demanded, 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 (1.2), 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 (1.3). 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 assume to vary across regions as subscript i indicates 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.

$$\Delta \ln(P_{i,t}) = \frac{\varepsilon_d^S}{\varepsilon_{s,i} - \varepsilon_d}\Delta \ln(S_t) + \frac{\varepsilon_d^Y}{\varepsilon_{s,i} - \varepsilon_d}\Delta \ln(Y_{i,t}) + \frac{v_{i,t} - u_{i,t}}{\varepsilon_{s,i} - \varepsilon_d} \tag{1.4}$$

where the term $\frac{v_{i,t}-u_{i,t}}{\varepsilon_{s,i}-\varepsilon_d}$ is independent of $\Delta \ln(S_{i,t})$ and $\Delta \ln(Y_{i,t})$ by construction. Equation (1.4) 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 $\Delta \ln(Y_t)$:

$$\beta_i^S = \beta_0^S + \beta_1^S \frac{1}{\varepsilon_{s,i}} \quad (1.5)$$

$$\beta_i^Y = \beta_0^Y + \beta_1^Y \frac{1}{\varepsilon_{s,i}} \quad (1.6)$$

where β_i^S and β_i^Y are coefficients on $\Delta \ln(S_t)$ and $\Delta \ln(Y_t)$, respectively. Based on these assumptions, the equation (1.4) can be rewritten as follows.

$$\Delta \ln(P_{i,t}) = \beta_0^S \Delta \ln(S_t) + \beta_1^S \left[\frac{1}{\varepsilon_{s,i}} \times \Delta \ln(S_t) \right] + \beta_0^Y \Delta \ln(Y_{i,t}) + \beta_1^Y \left[\frac{1}{\varepsilon_{s,i}} \times \Delta \ln(Y_{i,t}) \right] + z_{i,t} \quad (1.7)$$

where the error term $z_{i,t}$ is independent of $\Delta \ln(S_{i,t})$ 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 (1.7). 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 1.2 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 positive. 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.[3] 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.

1.3 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 at period $t+1$ as follows.

$$\max_{\alpha,C,H} E_0 \left[\frac{(C_{t+1}^{1-\theta} H_{t+1}^{\theta})^{1-\gamma}}{1-\gamma} \right] \tag{1.8}$$

[3] *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.

s.t.

$$X_{t+1} = W_t(1+R_{p,t+1}) + Y_{t+1} + P_{t+1}H_t \qquad (1.9)$$

$$X_{t+1} = C_{t+1} + P_{t+1}H_{t+1} \qquad (1.10)$$

$$R_{p,t+1} = \alpha R_{s,t+1} + (1-\alpha)R_f \qquad (1.11)$$

where 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 service, which has the log-normal distribution, $p_{t+1} = \log(P_{t+1}) \sim N(\mu_p, \sigma_p^2)$.[4] 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.[5]

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 (1.9) 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.

$$x_{t+1} - y_{t+1} = \log\left[\exp\{w_t + r_{p,t+1} - y_{t+1}\} + \exp\{h_t + p_{t+1} - y_{t+1}\} + 1\right] \qquad (1.12)$$

$$x_{t+1} - y_{t+1} \approx k + \rho_A(r_{p,t+1} - r_p) + \rho_B(y_{t+1} - y) + \rho_C(p_{t+1} - p) \qquad (1.13)$$

$$x_{t+1} \approx k' + \rho_A r_{p,t+1} + (\rho_B + 1)y_{t+1} + \rho_C p_{t+1} \qquad (1.14)$$

[4] 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.

[5] *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.

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

$$\rho_A = \frac{\exp\{w_t + r_p - y\}}{1 + \exp\{w_t + r_p - y\} + \exp\{h_t + p - y\}} \tag{1.15}$$

$$\rho_B = \frac{-\exp\{w_t + r_p - y\} - \exp\{h_t + p - y\}}{1 + \exp\{w_t + r_p - y\} + \exp\{h_t + p - y\}} \tag{1.16}$$

$$\rho_C = \frac{\exp\{h_t + p - y\}}{1 + \exp\{w_t + r_p - y\} + \exp\{h_t + p - y\}} \tag{1.17}$$

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

$$V(X_{t+1}) = \frac{\left((1-\theta)^{1-\theta}\theta^{\theta}\right)^{1-\gamma}}{1-\gamma}\left(\frac{X_{t+1}}{P_{t+1}^{\theta}}\right)^{1-\gamma} \tag{1.18}$$

The maximization problem (1.8) 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

$$\alpha = \frac{E\left[r_{t+1} - r_f\right] + \frac{1}{2}\sigma_s^2}{\gamma\rho_A\sigma_s^2} - \frac{\gamma\rho_C + \theta(1-\gamma)}{\gamma\rho_A}\frac{\sigma_{ps}}{\sigma_s^2} - \frac{(\rho_B + 1)}{\rho_A}\frac{\sigma_{ys}}{\sigma_s^2} \tag{1.19}$$

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.

$$\begin{aligned}
\rho_A &= \frac{\exp\{w_t + r - y\}}{1 + \exp\{w_t + r - y\} + \exp\{h_t + p_h - y\}} \\
&= \frac{\exp\{w_t + r\}}{\exp\{y\} + \exp\{w_t + r\} + \exp\{h_t + p_h\}} \\
&\approx \frac{W(1+R)}{Y + W(1+R) + P_H H}
\end{aligned} \tag{1.20}$$

The right hand side of equation (1.20) 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, house price volatility is more likely to negatively affect 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 (1.19).

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 region.[6] To examine how the variation

[6]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} ($\frac{\partial \rho_{py}}{\partial \beta} > 0$).

in β affects portfolio allocation, I rewrite the optimal stock share (α) as follows based on assumption 1.

$$\alpha \quad = \quad \frac{E\left[r_{t+1}-r_f\right]+\frac{1}{2}\sigma_s^2}{\gamma\rho_A'\sigma_s^2}-\frac{\gamma\rho_C'+\theta(1-\gamma)}{\gamma\rho_A'}\frac{\sigma_{ps}}{\sigma_s^2}-\frac{(\rho_B'+1)}{\rho_A'}\frac{\sigma_{ys}}{\sigma_s^2} \tag{1.21}$$

where

$$\rho_A' \quad = \quad \frac{\exp\left\{w_t+r_p-y\right\}}{1+\exp\left\{w_t+r_p-y\right\}+\exp\left\{h_t+p-y\right\}} \tag{1.22}$$

$$\rho_B' \quad = \quad \frac{-\exp\left\{w_t+r_p-y\right\}+(\beta-1)\exp\left\{h_t+p-y\right\}}{1+\exp\left\{w_t+r_p-y\right\}+\exp\left\{h_t+p-y\right\}} \tag{1.23}$$

$$\rho_C' \quad = \quad \frac{-(1/\beta)\exp\left\{w_t+r_p-y\right\}+(1-1/\beta)\exp\left\{h_t+p-y\right\}}{1+\exp\left\{w_t+r_p-y\right\}+\exp\left\{h_t+p-y\right\}} \tag{1.24}$$

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.

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

The 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.

1.4 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.

1.4.1 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 part 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.[7] 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 remain 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 few 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

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

80;[8,9] 2) Households whose financial liquid asset is greater than \$10,000; 3) Households that own their main residence;[10] 4) Households whose main residence is located in the Metropolitan Statistical Areas (MSAs) for which measures of housing supply elasticity by Saiz (2010) are available. Table 1.1 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 1.1 in the appendix. The final sample represents 189 MSAs.[11]

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

[8]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.

[9]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.

[10]Since this paper studies the effect of housing assets on portfolio choice, I only focus on the homeowners. In the robustness test, I consider the risky investment behavior of households that rent their residence.

[11]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.

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 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.[12]

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

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

Summary Statistics

Table 1.3 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,

[12] 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.

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 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 1.4 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.

1.4.2 Identification Strategy

To identify the regional variation in housing market risk, I use the housing supply elasticity as a measure of 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 used as a measure of local housing market risk that households in a specific region face.

Although conventional risk measures such as volatility of housing return can be used as measure of local housing market risk, 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. For example, households in areas where housing supply elasticity is low expect that future house price can be volatile even if they have experienced stable housing market over last five.

Additionally, I distinguish the joint effect of housing and labor income risks from the effect only 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.

$$\alpha_{i,t} = \beta_0 + \beta_1 HSE_i + \beta_2 Retired_{i,t} + \beta_3 (HSE_i \times Retired_{i,t}) + \gamma X_{i,t} + \epsilon_{i,t} \tag{1.25}$$

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.

1.4.3 Results

1.4.3.1 Baseline regression

Table 1.5 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, 0.008, implies a corresponding difference in stock share of 1.7 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 0.015, than that for retired group, at 0.002, 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, showing 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 correlates strongly 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.

1.4.3.2 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.[13] Table 1.6 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.

[13]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 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.

1.4.3.3 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 according to home equity shares.[14] 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 1.7 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 0.012 for this group, compared to 0.008 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. Additionally, for the lowest home equity share group, the coefficient on housing supply elasticity remains statistically significant even after retirement, while the coefficient

[14] 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.

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 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.

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, Proposition 2 in Section 3 states that 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 affect 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.

1.4.3.4 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,[15] 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 1.8 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

[15] *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.

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 1.9.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 1.9.B. The marginal effect of housing supply elasticity increases from 0.02 to 0.048 as the LTV ratio increases from 0.4 to 0.8. This result 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, because the leveraged position in housing investment amplifies the effect of housing market risk, greater sensitivity is exhibited by households that hold mortgages.

1.4.4 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. Of course, 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 1.10 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.

1.4.5 Robustness Check

1.4.5.1 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, 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 1.11, 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 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.

1.4.5.2 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 1.12. 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.[16]

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 1.12 show how housing market risk affects stock shares of self-employed households. As can be seen in the table,

[16]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.

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 1.12. 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.

1.4.5.3 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.[17] 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.[18] I test the baseline regression model substituting *household retirement* for *head retirement*. Table 1.13 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.

1.5 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

[17]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.

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

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 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.

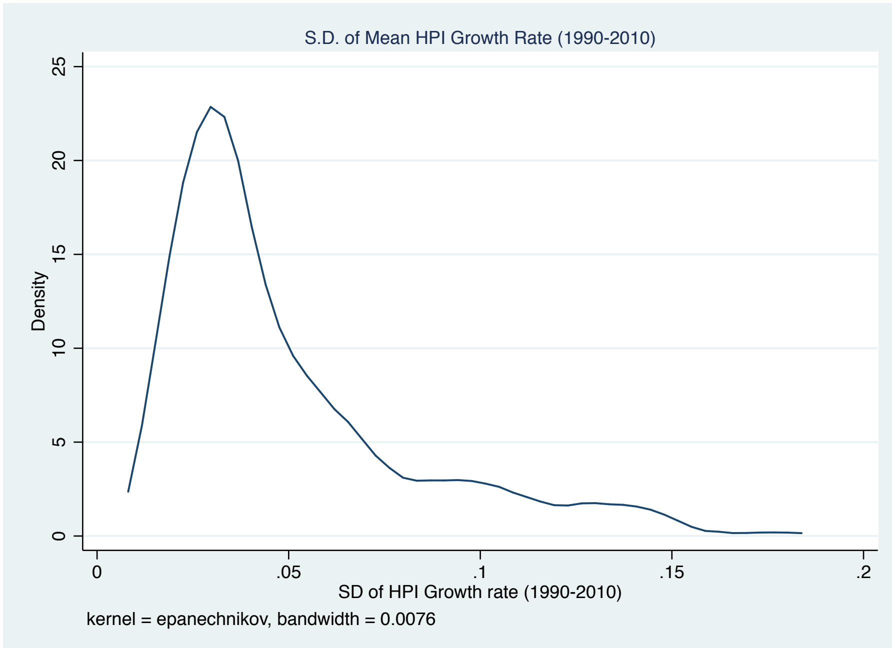
Although the main findings in this paper are robust from various perspectives, some limitations warrant further development. First, this paper does not distinguish the effect of the volatility of house price growth rate on portfolio choice from the effect of the correlation of house price growth rate 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.

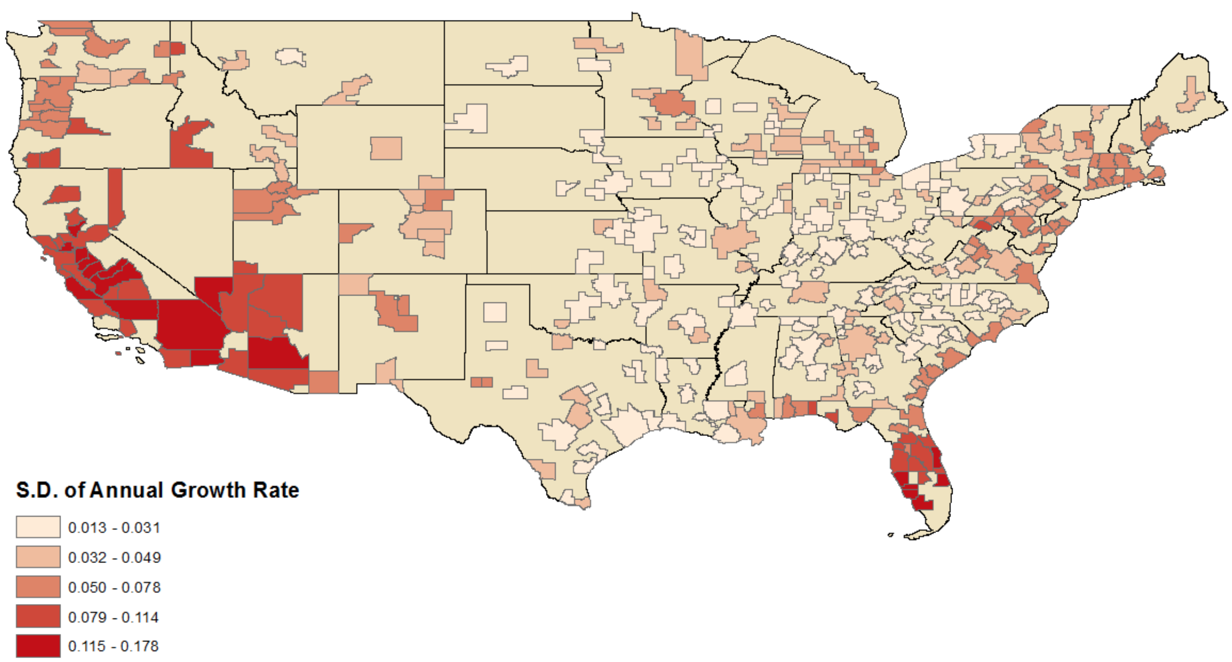
Notwithstanding some limitations, this paper introduces a new perspective that enhances our understanding of heterogeneity in household portfolio choice. Although households have relatively easy access to global financial market owing to globalization and advancement in technology, local economic conditions 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.

Figure 1.1: 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

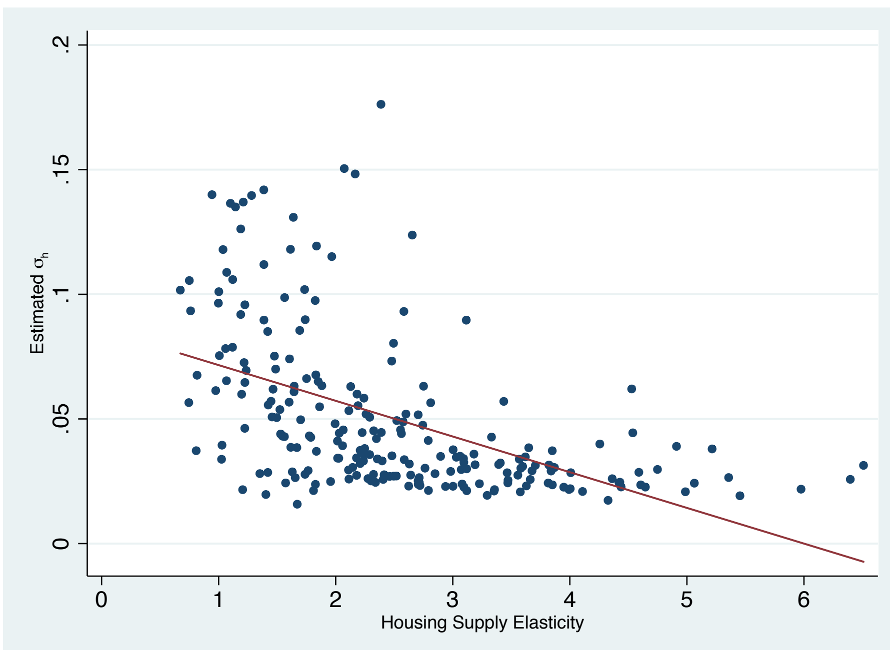


B. Map of the United States with Standard Deviation of Annual House Price Growth Rate



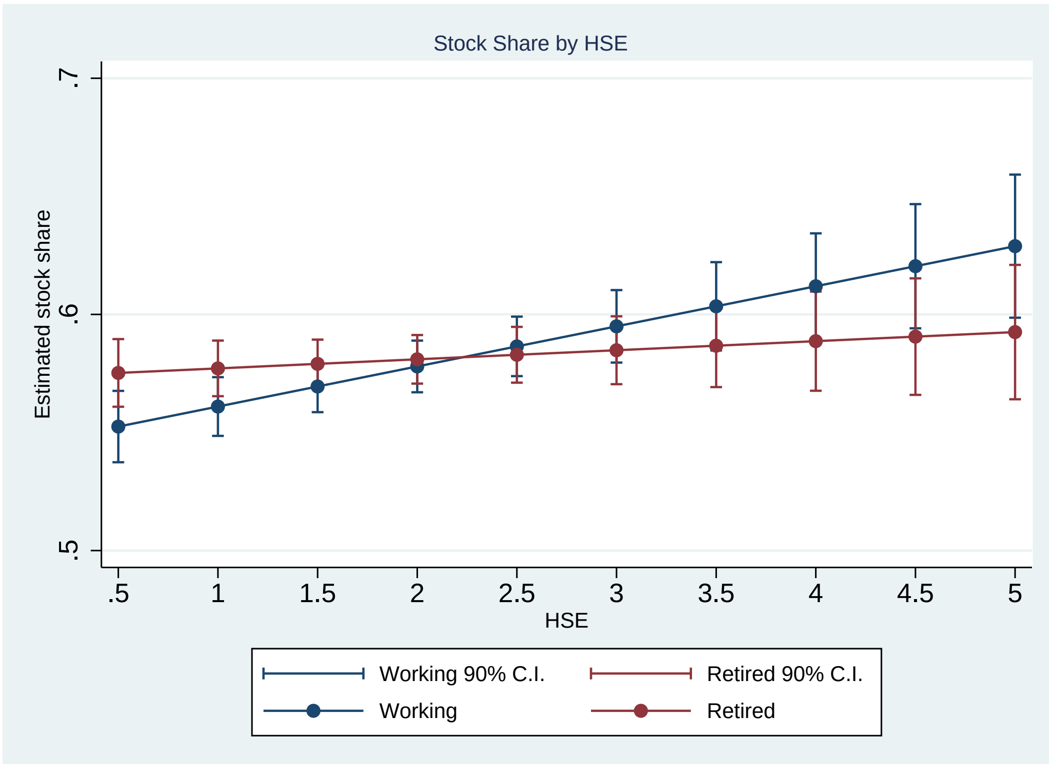
Notes: This figure is based on the standard deviation of average annual growth rate of the House Price Index (HPI) for MSAs from 1990 to 2010. The HPI is provided by the Federal Housing Finance Agency (FHFA).

Figure 1.2: Standard Deviation of Annual House Price Growth Rate and Housing Supply Elasticity



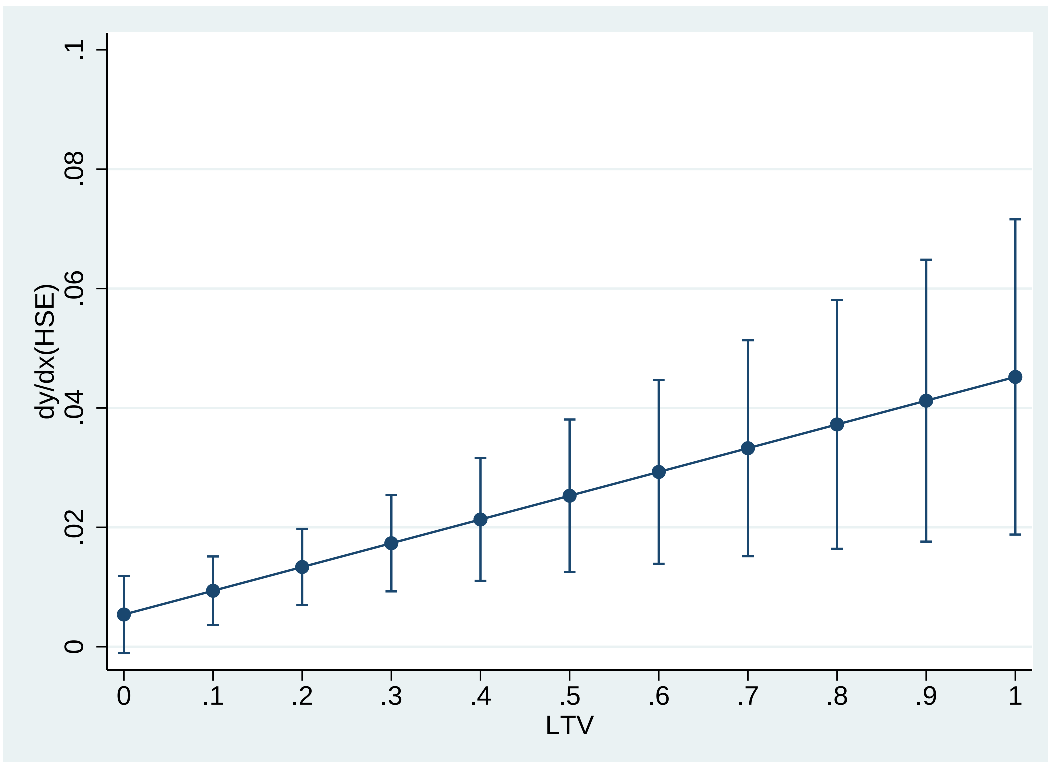
Notes: This figure is based on the standard deviation of average annual growth rate of the House Price Index (HPI) for 228 MSAs from 1990 to 2010 and housing supply elasticity by Saiz (2010). The HPI is provided by the Federal Housing Finance Agency (FHFA).

Figure 1.3: Estimated Stock Shares by Housing Supply Elasticity



Notes: This figure plots the estimated stock shares by housing supply elasticity for working and retired groups. Error bars indicate the 90 percent confidence intervals.

Figure 1.4: Marginal Effect of Housing Supply Elasticity on Portfolio Choice by LTV Ratio



Notes: The figure present the marginal effect of housing supply elasticity on portfolio choice by loan-to-value (LTV) ratio. Error bars indicate the 90 percent confidence intervals.

Table 1.1: 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

Table 1.2: 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 1.3: 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 1.4: 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	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
(Cond. on	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
Participation)	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 1.5: Regression of Stock Share on Housing Supply Elasticity (Baseline)

Dependent. Var. Stock Share	(1) All	(2) Working	(3) Retired	(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 1.6: Regression of Stock Share on Housing Supply Elasticity (HES Controlled)

Dependent. Var.	(1)	(2)	(3)	(4)
Stock Share	All	Working	Retired	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 1.7: Regression of Stock Share on Housing Supply Elasticity by Home Equity Share Group

Dep. Var. Stock Share	(1) All	(2) Working	(3) Retired
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 1.8: 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 1.9: Effect of LTV on the Relationship between HSE and Stock Share (with or without mortgage)

A. Regression with LTV Interaction term.

	All	Working	Retiree	All	Working	Retiree
	(1)	(2)	(3)	(1)	(2)	(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 1.10: 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 1.11: Robustness Check I (Stock and Other Real Estate Share)

Dep. Var. Share of Stock and Other Real Estate	All (1)	Working (2)	Retiree (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 1.12: 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 1.13: Robustness Check III (Household Retirement Status)

	All	Working	Retiree	Interaction
	(1)	(2)	(3)	(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
Demographic 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

CHAPTER II

Retirement and Portfolio Choice

2.1 Introduction

Baby Boomers are beginning to constitute a large portion of the aging population, and as a result of their increased life expectancy, the financial sustainability of the U.S. social security system is being significantly challenged. Given this challenge, understanding portfolio choices of retirees, especially during the transition into retirement, has drawn increasing attention. The portfolio choices of retirees are of interest because they not only affect asset composition and returns, but also other economic decisions such as consumption and pension benefits. Understanding portfolio choice is therefore of great importance in formulating and implementing policies associated with retirement benefits. Conventional wisdom suggests that when retirees anticipate that there will be a substantial decrease in income after retirement, they will reduce their risk portfolio holdings when transitioning into retirement, shifting portfolio composition from risky assets to relatively safe ones. However, this argument is not fully supported by either empirical or theoretical evidence in economic studies. Whether and how this occurs remains a matter of debate. Though there are extensive theoretical studies about portfolio choice over the life cycle, the effect of retirement on portfolio choice, or retirement effects, remains ambiguous.[1] From an empirical perspective, the retire-

[1] The seminal works of *Samuelson* (1969) and *Merton* (1969, 1971) suggests that in a frictionless market, retirement status is irrelevant to the portfolio choice. *Bodie et al.* (1992) show that, with non-tradable

ment effect, to the best of our knowledge, is under-explored.[2] Since individuals' portfolio choices after retirement will affect retirees' income flows, consumption and other economic decisions that are highly correlated to pension and retirement policies, it is worth exploring emipirical evidence as to whether and how retirement may affect an individual's portfolio choice. To fill this gap in the literature, the goal of this paper is to empirically establish the causal effect of retirement on portfolio choice and to provide some possible explanations for this causal effect.

Modeling and estimating models with endogenous retirement decisions pose economic and econometric challenges. To solve this endogeneity problem, we use data from the Health Retirement Study (HRS), a national longitudinal survey, and adopt the instrumental variable approach. We use two sets of instruments for retirement status: historical expected retirement status and eligibility age indicators of retirement benefits (especially, Social Security benefits). Using these instruments, we find that retirement causes a discrete jump in risky share holding by roughly 5-7 percentage points. This increase accounts for one fourth of the increase in risk asset holdings provided that the average risky share is 20.2 percentage points in our sample. This finding suggests that there exists a positive and sizable retirement effect on portfolio choice towards risky assets, which cannot be easily explained by the theories in existing studies.[3] In addition, we find substantial heterogeneous retirement effects across wealth levels and mortgage holdings but no significant heterogeneity on pension holdings. In terms of wealth, the retirement effect is strongest among individuals in the top one-third of wealthy households in our sample, while little effect is found for the individuals in the bottom one-third of poor households. In terms of mortgage, non-mortgage holders exhibit a larger positive retirement effect on portfolio choice than mortgage holders. No significant

labor income, individuals tend to hold more risky assets while working than after retirement. On the other hand, Viceira (2001) shows that, with a large correlation between stock market risk and labor market risk, portfolio choice can be riskier after retirement than prior to retirement. A detailed discussion on this stream of literature will be provided later.

[2] A partial list includes *Heaton and Lucas* (2000), *Horneff et al.* (2007), and *Addoum* (2013).

[3] For example, *Samuelson* (1969) posits that retirement is uncorrelated to portfolio choice; *Bodie et al.* (1992) predict a decrease in risky asset holdings right after retirement; *Cocco et al.* (2005) argue for a smooth increase in the risky asset share after retirement.

difference is found for pension holders versus non-pension holders.

Motivated by these counterintuitive findings, we further propose and test four separate hypotheses that may explain portfolio choice behaviors: 1) *The risk tolerance hypothesis* states that provided risk tolerance is negatively correlated with risky asset holdings, when retirement itself increases risk tolerance, risky asset holdings will increase;[4] 2) *The time spending hypothesis* suggests that, having more time after retirement to be allocated to analyzing or tracking risky assets like stocks can increase risky asset holdings. An alternative scenario under the same hypothesis could be that an increase in utility drawn from additional time working on risky assets could also increase risky asset holdings; 3) *The life expectancy hypothesis* states that retirement results in a pessimistic view of life expectancy which leads to an increase in risky asset holdings. Specifically, people after retirement stop working and may not feel to be as capable and active as before and may become pessimistic about their life expectancy, resulting in an increase in risky asset holdings. In particular, an increase (decrease) in life expectancy may cause an increase (reduction) in savings and consequently, decrease (increase) the relative risky shares in the portfolio, as predicted by *Cocco and Gomes* (2012); 4) *The bequest motive hypothesis* states that retirement weakens the bequest motive and thus increases an individual's risky asset holding. To be specific, a weaker bequest motive increases the speed at which wealth is drawn down, and thus decreases the wealth to labor income ratio. In turn, this will potentially result in an increase in risky portfolio choice, as predicted by *Cocco et al.* (2005). Though our results indicate that all four explanations can contribute to the retirement effect on portfolio choice, to some extend, we predict that the risk tolerance and time spending hypotheses are likely the main driving forces.[5]

Within the existing literature, our paper is more closely related to two main streams of studies. The first stream discusses household portfolio choice under the life-cycle framework.

[4]This is consistent with *Canner et al.* (1997), who argue that risk tolerance is negatively correlated to risky asset allocation.

[5]Our analysis only captures the net effects from retirement and explanations proposed here are just possibilities. Structurally decomposing contributions from different channels would be an interesting topic for future study.

Of relevance here are the seminal papers by *Samuelson* (1969) and *Merton* (1969, 1971). From there, follow-up studies have developed in two directions. Some studies do not explicitly model retirement based on life-cycle and instead only generally discuss portfolio choice over time (*Calvet et al.*, 2009; *Campbell*, 2006; *Heaton and Lucas*, 2000). Other studies have focused on the effects of demographic and behavioral characteristics on portfolio choice, such as age (*Ameriks and Zeldes*, 2004), health (*Rosen and Wu*, 2004; *Edwards*, 2008), lifetime experience of volatility (*Malmendier and Nagel*, 2011; *Appendino*, 2013), the expectation of future borrowing constraints (*Guiso et al.*, 1996), optimism about investment decisions (*Dominitz and Manski*, 2007; *Puri and Robinson*, 2007) and financial literacy (*Lusardi and Mitchell*, 2007; *Van Rooij et al.*, 2011).

There also exist a few papers that explicitly model retirement, either exogenously (*Viceira*, 2001; *Campbell et al.*, 2001; *Cocco et al.*, 2005; *Gomes and Michaelides*, 2005) or endogenously (*Bodie et al.*, 1992, 2004; *Farhi and Panageas*, 2007; *Dybvig and Liu*, 2010) and focus on the discussion on retirement transitions. For example, *Cocco et al.* (2005) build up an exogenous retirement model and predict that at retirement individuals may smoothly adjust their risk portfolio holdings upwards. *Farhi and Panageas* (2007) endogenize an irreversible retirement choice and show a larger portion of risky assets prior to retirement. Among these, *Gomes and Michaelides* (2005) provide theoretical predictions that are close to our empirical findings. They use the Epstein-Zin utility function and include a fixed entry cost for risky investment as well as risk aversion heterogeneities in their model. They find that with certain parameters, there can be a non-smooth shift in risky share at the exogenous retirement age of 65. While *Gomes and Michaelides* (2005) provide a possible scenario of portfolio choice changes close to retirement age, very little explanation for this jump is offered. From an empirical perspective, *Addoum* (2013) is the most relevant work on retirement portfolio choice. This work focuses on the correlation between retirement and portfolio choice by discussing relative bargaining power between husband and wife within household rather than establishing causal effects. In *Addoum* (2013), the author finds a negative correlation between retirement and risky portfolio choice, which is the opposite of our results. Also, the author finds a positive retirement effect of wives and a negative retirement effect of husbands, which are different from ours, too. However, this paper focuses on the retirement effect interacted with marital status and only discusses the correlation between retirement and portfolio choices. Our paper contributes to the literature by empirically establishing a positive causality of retirement on portfolio choice and further discussing and testing possible explanations for this retirement effect. In addition, different from *Addoum* (2013), which only considers observations with positive risky shares, our analysis uses unconditional sample and includes all observations. By doing so, our analysis is able to capture the household transition from non-risky asset holders to risky asset holders and vice versa and avoids the sample selection issue.[6]

Our paper is also related to another stream of studies, which concentrate on other aspects of economic behavior rather than on portfolio choice around retirement. Some studies in this area discuss the "retirement consumption puzzle," i.e. a downward shift of consumption at retirement (*Modigliani and Brumberg*, 1954; *Friedman*, 1957; *Heckman*, 1974; *Bernheim et al.*, 2001; *Haider and Stephens Jr*, 2007; *Battistin et al.*, 2009).[7] Other studies consider saving behavior (*Papke*, 2004), housing (*Yogo*, 2009), pension and annuitization (*Brown*, 2001) and health care (*Hurd and McGarry*, 1997). Our paper will complement previous studies by empirically discussing household investment behavior during the retirement phase.

The remainder of this paper is organized as follows. Section 2 presents our empirical methodology, discussing our benchmark specification and identification strategy. Section 3 discusses data issues and variable definitions. Section 4 presents our main results of the retirement effect on portfolio choice. Section 5 investigates four possible hypotheses to explain the retirement effect. Section 6 conducts several robustness checks, and then Section 7 concludes.

[6] In the data, we find that households which experience such transitions are not rare and count for approximately 20 percent of all households.

[7] *Attanasio* (1999) and *Hurst* (2008) provide excellent reviews on this topic.

2.2 Empirical Methodology

2.2.1 Benchmark

We estimate the retirement effect on household portfolio choice. To this end, following a panel regression approach, we consider the benchmark regression as follows:

$$Riskyshare_{it} = \beta_0 + \beta_1 HHretire_{it} + \boldsymbol{\gamma}'\boldsymbol{X}_{it} + \delta_i + \eta_t + \varepsilon_{it} \tag{1}$$

where the dependent variable, $Riskyshare_{it}$, is household i's risky share at wave t, which is measured as the value of risky assets divided by the value of total financial assets. The key variable of interest, $HHretire_{it}$, is the head of household i's retirement status dummy at wave t. $\boldsymbol{X}_{it}$ contains sets of 1) household characteristics; 2) household head's characteristics; and 3) spouse's characteristics, for household i at wave t, under different specifications. Household fixed-effects, δ_i, captures time-invariant factors that are correlated to risk portfolio choice. η_t represents the wave fixed-effects and ε_{it} is the time-varying unobserved disturbance. We are focusing on the retirement effect on risk portfolio choice, which is captured by β_1.

Note that the benchmark specification can estimate the average retirement effect, but it cannot provide enough information to help us distinguish between two competing sources for retirement effects. More specifically, we cannot separate the effects in terms of 1) those who switched from non-risky-asset buying to risky-asset buying after retirement (extensive margin) or 2) those who owned risky assets before and increase their risky asset holdings after retirement (intensive margin). To separate these possible features, we conduct two additional exercises. To test the extensive margin effect, we use a stock market participation indicator as the dependent variable to run a panel logistic regression model with a similar setting to Equation (1). To test the intensive margin effect, we follow Equation (1) by restricting our sample to households with positive risky shares in order to determine whether risky asset holders increase their risky share after retirement. The results together with ones for the benchmark regression will be discussed in Section 3.

2.2.2 Identification Strategy

To establish the causal effect of retirement, we need to solve the endogeneity problem. Two sources of endogeneity could bias the estimate of the coefficient β_1: 1) omitted variable bias and 2) reverse causality. More specifically, omitted variable endogeneity occurs when unobserved factors like preference and life style simultaneously affect the retirement decision and portfolio choice. Simultaneous endogeneity occurs when portfolio choice decisions reversely affect retirement decisions.

To address the endogeneity issue, we use the instrumental variable approach, which commonly requires two restrictions: 1) the relevance restriction, which requires that the instrumental variables are correlated to the endogenous variable, namely the household head's retirement status ($HHretire_{it}$); and 2) the exclusion restriction, which requires that the instrumental variable we use is uncorrelated to the error term ε_{it}, directly. To satisfy these two restrictions, we consider two sets of instrumental variables for retirement status.

The first instrument we use, following *Haider and Stephens Jr* (2007), is the subjective expected retirement status. We construct this subjective expected retirement status by comparing the expected retirement age reported in the 1992 wave to the actual age in the following waves. If the expected retirement age is smaller than the actual age, then the expected retirement status is classified as "retired". Otherwise, the status is "not retired". Based on the rational expectation argument, information known at time t is uncorrelated with the expectation errors between period t and future periods $t+1$, $t+2$, and so forth, i.e. the instrument is uncorrelated with the error term in Equation (1). Meanwhile, the actual retirement is just a revised decision based on new and unexpected changes under rational expectation assumption, which is highly correlated to self-reported retirement expectations in previous waves.[8]

[8]The first-stage regression in Table D.4 in Appendix ensures that the subjective retirement expectation is highly predictive of subsequent retirement behavior. For robustness, though not reported here, we construct an alternative expected retirement status by using the lagged expected retirement age instead of using only the expected retirement age from the 1992 wave. The results are qualitatively the same.

Following *Bonsang et al.* (2012), we use two indicators as the second set of instruments: 1) whether an individual pass the minimum age to claim early retirement benefit, and 2) whether an individual pass the minimum age to claim full retirement benefit. Specifically, age 62 is the minimum age at which Social Security benefits can be partially claimed, i.e. early retirement,[9] and the age at which individuals can claim full Social Security benefits varies by different birth cohort.[10] These two age thresholds are minimum age requirements for claiming partial and full social security benefits, respectively, and consequently they are highly correlated to retirement decisions. The first-stage regression in Table D.4 in Appendix confirms our conjecture. In terms of the exclusion restriction, since these two age thresholds are set by the government exogenously and are not affected by individuals, we argue that these age thresholds are relatively exogenous, and are not correlated to the error terms.[11]

2.3 Data Description

The data used in this paper is from the Health and Retirement Study (HRS), a longitudinal survey that collects detailed information on the US population over the age of 50.[12] More specifically, we use the RAND HRS Data file, a cleaned and processed version of the HRS data. RAND HRS data contain 26,000 household observations with detailed information on demographics, health, income, wealth, and retirement status. The main advantage of this data is that it includes 7,700 households, with at least one respondent of each household born between 1931 and 1941, who has retired or is expected to retire during the survey period

[9] 75 percent Social Security benefits can be claimed at age 62 and the proportion increases overtime until when full benefits can be claimed.

[10] Note that the normal retirement age is set to increase to age 67 over a 22-year period, which affects people born on or after January 2nd, 1938. Table D.3 in Appendix shows the normal retirement age for the different cohorts used for our empirical analysis

[11] If the error term contains factors that affect an individual's life expectancy, the exclusion restriction may not necessarily hold.

[12] In terms of representativeness, although the HRS was designed to represent the US population over the age of 50, to address the research regarding racial and ethnic disparities, the HRS has oversampled Black and Hispanic populations. In this study, we do not adjust the sample regarding race and ethnicity, rather a subsample of only the white population is examined. The results, though not reported, are qualitatively the same as our main results.

(1992-2010).

Our primary sample draws from the 1992 wave to the 2010 wave in HRS. In order for our results to be comparable to those in the literature, we restrict our sample based on the following four criteria: 1) a household with the head between ages 50 and 80;[13] 2) households not reporting self-employment; 3) households where retirement status is known; 4) households with a risky share measure between 0 and 1. More detailed sample selection procedures can be found in Table D.1 in Appendix.

2.3.1 Variable Definitions

Retirement Status

Retirement status is the key variable of interest in our analysis. To measure the retirement status of each individual, we use the self-reported retirement status in the HRS, which is constructed from the survey question *"At this time do you consider yourself to be completely retired, partly retired, or not retired at all?"*. For the main analysis, we classify respondents who self-reported "completely retired" as retirees.[14] The portion of retirees by age is given in Figure 2.1. As the figure illustrates, the portion of retirees increases significantly between ages 62 and 65, which is closely related to the eligibility age for Social Security retirement benefits.[15]

Risky Shares

We define risky shares as the net value of stocks, mutual funds, and investment trusts divided by total financial assets. Total financial assets are the sum of checking and saving accounts; money market funds; certificates of deposit (CD); government saving bonds; treasury bills; corporate, municipal, government, and foreign bonds; and other savings after

[13]We define the head of a household as the member who earns the most over the entire survey period.

[14]As an alternative measure of retirement, we treat both the completely and the partly retired groups as retirees. The results are robust

[15]Other retirement measures constructed from a labor force participation question are constructed and tested as robustness check in Section 6. The results are qualitatively the same

subtracting other debts such as credit card balances, medical debts, and life insurance policy loans. Financial assets do not include main residence, other real estate, vehicles, businesses, and Individual Retirement Account (IRA) and Keogh plans.

A caveat of the risky share measure in our main analysis is that, due to data limitation, we do not include IRA account when calculating the risky share. Because the IRA assets account for a sizable fraction of retirement assets, excluding them may lead to a less precise risky share measure. However, the HRS did not collect information about IRA account until the 2000 wave. Even in the waves of 2000, 2002 and 2004, only limited information regarding to the portion of stock investments in IRA accounts was collected in roughly three categories *"Mostly or All Stocks, Mostly or All Interest Earning, and Evenly Split"*. The exact portion of stocks in IRA assets has only been collected since the 2006 wave. To verify that our results are not driven by the construction of the risky share measure, we analyze a subsample since 2006 by including the IRA account when measuring the risky share and the results are qualitatively similar and are reported in Section 6.

Expected Retirement Status

We construct the expected retirement status by following *Haider and Stephens Jr* (2007). We first extract the expected retirement age information for each individual in the initial 1992 wave and then compare this expected retirement age to the actual age in the following waves. If an individual's expected retirement age is lower than the actual age in a given wave, we define this individual's expected retirement status as "expected to be retired." Otherwise, if an individuals's expected retirement age is higher than the actual age, we label the expected retirement status as "expected not to be retired."[16]

[16] As a robustness check, instead of using the expected retirement age reported in 1992 wave, we also define an alternative expected retirement status by using the expected retirement age asked in one wave prior. Though not reported here, the results are qualitatively the same.

Indicators for Early Retirement and Normal Retirement

We define the indicator "early retirement" as 1 if an individual's actual age is greater or equal to 62 and the other indicator "normal retirement" as 1 if an individual's actual age is greater or equal to the minimum age for claiming the full social security benefit, following *Bonsang et al.* (2012).

Measure of Risk Tolerance

The risk tolerance measures are constructed from the experimental survey questions regarding to job choices following *Barsky et al.* (1997). Specifically, in the 1992 wave, the risk tolerance is set using the four following levels, listed from least to most risk-averse:

- 1. *"R would take a job with even chances of doubling income or cutting it in half."*
- 2. *"R would take a job with even chances of doubling income or cutting it by a third."*
- 3. *"R would take a job with even chances of doubling income or cutting it 20%."*
- 4. *"R would take or stay in the job that guaranteed current income given any of the above alternatives."*

Based on the series of questions, the HRS classifies each individual into four different risk tolerance groups, from the most risk tolerant (scored as 1) to the least risk tolerant (scored as 4). These questions are not asked in the 1994 and 1996 waves. From the 1998 wave forward, additional questions are asked that allow two more categories:

- 1a. *"Less risk-averse than 1 above: R would take a job with even chances of doubling income or cutting it by 75%."*
- 4a. *"Between categories 3 and 4 above: R would take a job with even chances of doubling income or cutting it by 10%."*

These additional categories are used to define an alternative 6-category risk tolerance measure. We use both the 4 and 6 categories risk tolerance measures in our analysis.

Following the Stock Market

Stock market participation is costly. Time allocation is one type of cost that investors incur when they participate in the stock market and we conjecture that reducing working hours allows households to devote more time to stock market and investment decisions. To capture this, we construct a measure for following the stock market. The HRS provides the amount of time allocated to stock market using the question: *"How closely do you follow the stock market: very closely (1) , somewhat (2) , or not at all (3)?"* since the 2002 wave. We use the answers to this question as a categorical measure for the frequency of following the stock market.

Life Expectancy

As discussed in *Puri and Robinson* (2007), individuals, who have higher self-reported life expectancies than the standard, are more likely to invest in stocks. We want to test whether the retirement effect is driven by a change in an individual's life expectancy. To do so, we define the life expectancy measures from two self-reported questions in the HRS.

- 1. *"The probability of living to age 75"*
- 2. *"The probability of living to age 85"*

We use these two reported probabilities directly as our life expectancy measures.

Probability of Leaving Bequest

Although some economists are skeptical about the effect of the bequest motive on saving decisions (*Hurd* (1989); *Dynan et al.* (2002); *Cagetti* (2003)), it is more common to assume that investors with high bequest motives are likely to save more, and that this behavior in turn leads an individual's portfolio choice towards more risk (*Cocco et al.* (2005); *Rosen and Wu* (2004)). To test whether the bequest motive changes around retirement, which can potentially explain the positive change in risky share, we use survey questions regarding to the probability of leaving a bequest to construct bequest incentive measures. Beginning in the 1994 wave, the HRS asked the following question

- 1. *"What are the chances that you [or your (husband/wife/partner)] will leave an inheritance totaling* $10,000 *or more?"*

If the respondent reports that probability of leaving a bequest of $10,000 or more is larger than zero, he or she is further asked

- 2. *"What are the chances that you [or your (husband/wife/partner)] will leave an inheritance totaling* $100,000 *or more."*

If the reported probability to the first question is zero, respondents are asked

- 3. *"What are the chances that you (and your (spouse/partner)) will leave any inheritance?"*

We use these reported probabilities as our three measures for bequest motives.[17]

Other Control Variables

We use other demographic characteristics and financial status as control variables. One characteristics is age, which is one of the most important demographic characteristics in portfolio choice. The relationship between age and portfolio choice has previously been reported in portfolio choice literature (*Ameriks and Zeldes*, 2004). We include age and age squared terms as control variables to distinguish the age effect from the effect of retirement. In addition to age, such as education, health status, ethnicity, religion, region of residence, size of household, which may affect the portfolio choice, are also controlled.

Classic portfolio theory assumes non-CRRA utility function and no labor income risk so that optimal portfolio share should be constant regardless of income and wealth level

[17]Keep in mind that the first question is an "unconditional" measure and the last two are "conditional" measures, where the second question measures a even stronger bequest motive than that from the first question and the last question is a weaker measure than that from the first question.

(*Merton* (1969); *Samuelson* (1969)). However, many studies have shown that level of income and wealth are important factors that affect an individual's portfolio decision (*Cohn et al.* (1975); *Donkers and Van Soest* (1999); *Guiso et al.* (2003); *Peress* (2004)). In light of these studies, we control the effect of financial status on the portfolio decision, using income level, wealth level, pension information, and mortgage status as control variables.[18]

2.3.2 Summary Statistics

Table 2.1 shows the summary statistics according to the retirement status of household head.[19] Part I of the table presents demographic characteristics, and part II summarizes the financial status. The average age of retirees is 9 years older than that of non-retirees. A further difference is that retirees are less educated and less healthy than non-retirees. These differences are statistically significant. In terms of financial status, the average dollar value of total financial wealth for retirees is almost 50 percent larger than for non-retirees. After retirement, the income of the former is reduced by 42 percent from an average of $41,000 to $23,800. While most of the summary statistics are consistent with conventional wisdom, the risky shares show an opposite pattern. Stock share of financial assets for retirees is 2.8 percent higher than that of non-retirees, which amounts to almost a 15 percent increase. This difference in stock share is statistically significant, but the difference in combined stock share in financial and IRA assets between the two groups is not statistically significant. The subjective measure of risk tolerance is also reported in the last two rows, but the difference is not statistically significant. Other risky shares such as stock shares, and other real estate shares in total assets are also higher for retirees than for non-retirees.

To understand household asset composition in detail, we summarize the value of each asset and its portion in total household wealth in Table 2.2. As shown, the housing asset constitutes the largest portion of total wealth, while the second largest is financial assets,

[18] All wealth and income data are deflated by the consumer price index (CPI) into 2000 dollars.

[19] In this table, we only report some important variables to our analysis. The detailed summary statistics can be found in Table D.2 in Appendix.

which are 19.6 percent of total assets. We also compare the asset composition of retirees and non-retirees. As shown in Table 2.2, there is no change in relative importance of each asset before and after retirement. However, the portion of each asset varies. The portions of relatively liquid assets, including financial, stock, and IRA assets increases, while the portion of illiquid assets such as home equity, transportation, business, and other real estate decrease. In particular, the portion of financial assets shows the largest increase in both level and ratio.

2.4 Main Results

This section presents the main results of this paper. We will first discuss the results of retirement effect on portfolio choice from the benchmark specification. After establishing the overall retirement effect, we will further explore whether the retirement effect comes from intensive margin, i.e. individuals who do not hold risky assets before retirement tend to hold risky assets after retirement, or from extensive margin, i.e. risky asset holders increase their risky portfolios after retirement. In addition, we also investigate potential heterogeneities in terms of wealth, mortgage holdings, and pension holdings.

2.4.1 Benchmark Result

In this subsection, we will discuss the overall pattern of retirement effects identified in the data. First, we present the rough pattern of how portfolio choice varies with age in Figure 2.2. The risky share increases between age 62 and age 67, where the portion of retirees increases dramatically. To distinguish the age effect from the retirement effect, we also draw the fitted line based on estimated risky share of non-retiree by age. Since the fitted line is not affected by the retirement effect, the gap between the fitted line and the real risky share can be partially explained by the retirement effect.

To further explore retirement effects, controlling for other factors that could also affect portfolio choice, we consider the regression analysis that we described in Section 2. The results are summarized in Table 2.3. Column 1 provides estimates using the panel regression. Columns 2 to 4 report the estimates using a different set of instruments.[20] Columns 5-8 correspond to Columns 1-4, but include more control variables that capture the spouse's demographic characteristics, like age, square of age, and self-reported health status. Standard errors are all clustered at the household level. Table 2.3 shows that the retirement effect is quite striking and robust across different specifications. The benchmark specification in Column 1 shows that retired individuals invest approximately 1.3 percentage points more in risky shares, accounting for about 7.7% of the average risky share holdings. Taking into account that the estimates in Column 1 might be biased due to endogeneity issues, Columns 2-4 show that when the instrumental variables are used, the retirement effect increases to about 4.4-6.7 percentage points across different specifications. This accounts for 26% to 40% of the average risky shares. According to these results, retirement status has a huge impact on risky portfolio choices.[21]

Besides the positive retirement effect, we also find that control variables exhibit the effects, as we expected. Households with more wealth or higher income invest more in risky assets, which is consistent with predictions from *Calvet et al.* (2009). Over time, however, older individuals, in general, invest in risky assets, though this trend reverses at later ages beginning around 77, consistent with findings in *Campbell et al.* (2001) and *Cocco et al.* (2005). Larger households invest less in risky assets, while households with more children have a higher percentage of risky shares in their portfolios. Though the sign of the coefficient is negative, self-reported health status has no significant impact on risk portfolio choice[22]. This differs from the findings in *Rosen and Wu* (2004), who find that health exhibits negative

[20]The first-stage regression results of our instrumental variables are reported in Table D.4 in Appendix. All three instrumental variables we use in this paper are, both economically and statistically, significantly correlated to the actual retirement status.

[21]Because risky shares are nonnegative, we also estimate Tobit regression models. As shown in Table D.5 in Appendix, the results are robust across different specifications. We can observe that individuals after retirement tend to increase their potential risky share holdings by 5.4 percentage points in the panel regression specification and 6.5 to 12.6 percentage points in different IV specifications. The results without controlling for the spouse's characteristics exhibit a similar pattern.

[22]For the robustness check, we also run the regression without controlling for the health status of head or spouse. The results are similar to the benchmark table.

effects on risk portfolio choice. The difference between our results and those of *Rosen and Wu* (2004) might be due to different sampling periods and sample selection rules. While the sample for the benchmark analysis includes both married and single households, marital status changes during survey periods due to various reasons such as marriage, divorce, and death of spouse. Marital status change may affect risky investment behavior. To controlling for the effect of marital status change, we include the dummy for marital status change: households that change martial status are indicated as "1" and households that remain the same are indicated as "0". The results show that marital status change does not affect the risky share significantly.[23]

2.4.2 Extensive Margin vs. Intensive Margin

In the previous subsection, we have found that there is a positive retirement effect on risky portfolio choice. In this subsection, we further investigate whether this retirement effect is driven by an extensive margin or intensive margin, as we introduced in Section 2. To explore this, we use the rich data provided by the HRS.

To test extensive margin, we first define a risky asset holding indicator. We classify households as risky asset holders if they hold any positive risky assets, and non-risky asset holders if they do not hold any. Though this definition does not distinguish stock holdings from mutual fund holdings, it is still a good approximation of household risky asset market participation. We then run the panel logit regression with the indicator of risky asset holders as a dependent variable. The results are shown in Column 1 of Table 2.4. As can be seen in the table, households are more likely to invest in the stock market after retirement than before. This finding is statistically significant at the 1% level. By calculation, the marginal effect of retirement is 1.8 percent. Part of the retirement effect can be attributed to the fact that some households become risky asset investors after retirement.

[23]In addition to the marital status change, we also include marital status, whether single or married, as control variable. Including marital status as control variable instead of marital status change does not change the effect of retirement on stock share.

To test intensive margin, we first focus on households with only positive risky assets. The result is reported in Column 2 of Table 2.4, which does not show any significant statistical difference. However, as we know, restricting our analysis only on conditional sample may incur sample selection problem, which could be problematic. To deal with this issue, we further conduct the Heckman selection model under a panel data setting. The result is shown in Column 3 of Table 2.4. It is shown that after dealing with the sample selection issue, households increase 1.7 percent risky shares after retirement and this effect is statistically significant. It indicates that the increase in intensive margin also contributes to the retirement effect we found in the benchmark results.

In short, we find that this retirement effect comes from both extensive margin and intensive margin. In other words, retirees who refrained from buying risky assets before retirement tend to buy them after retirement, and those who held risky assets before retirement increase the share after retirement. We do not try to decompose and quantify each effect in this paper, but this would be an interesting investigation for future studies.

2.4.3 Heterogeneities

We may expect the retirement effect to be heterogeneous across different characteristics. Here, we explore the potential heterogeneities regarding 1) wealth; 2) mortgage holding; and 3) pension holding.

2.4.3.1 Heterogeneities by Wealth

Among all possible characteristics, the retirement effect is more likely to be different across wealth levels. Intuitively speaking, individuals from households with a limited budget can allocate money only to support themselves, and may not be able to buy any risky assets. In light of this constraint, changes in portfolio choice are less likely to occur after retirement. In contrast, for individuals from wealthier households, who have more flexibility in allocating money towards different portfolio choices, changes in the portfolio choice are more likely to occur after retirement. Taking this into account, we will explore the possible heterogeneity across different wealth levels.

We split each wave sample evenly into three groups according to wealth: high, medium, and low. We first plot the average risky shares of the three groups in relation to retirement status across different ages. As illustrated in Figure 2.3, in the high wealth group, retirees in general have larger risky share holdings than do non-retirees. For this group, the pattern is robust across different ages. The medium and low wealth groups, on the other hand, do not exhibit any substantial difference between retirees and non-retirees.

To examine the heterogeneity across wealth levels, we also conduct regression analyses, including both panel regression and IV panel regression as before.[24] The results are summarized in Table 2.5. The low wealth group is omitted as a reference group in all specifications. Column 1 provides the results in simple panel regression. The result shows that the retirement effect can be attributed mainly to the high wealth group, where the coefficient on the interaction term of the high wealth group indicator and the retirement indicator is positive, although results in Column 2 and 4 are only statistically significant.

2.4.3.2 Heterogeneity by Mortgage Holdings

Like wealth, the retirement effect is also likely to be heterogenous in terms of mortgage holdings. The idea is that since mortgage holders need to pay back their mortgages even after retirement, mortgage holders 1) may not have enough money to invest in risky assets and 2) may not be willing to invest more in risky assets, which would mean bearing more risk. If this is the case, we expect that the retirement effect for mortgage holders will be smaller than that for non-mortgage holders.

Here we consider two measures to examine the heterogeneous retirement effects. For the first measure, we classify households with any mortgage as mortgage holders and the rest

[24]When we conduct an instrumental variables regression analysis for specifications with retirement-wealth interactions, we instrument these interactions by interactions between our instrumental variables and wealth indicators. Similar settings are adopted for other heterogeneity tests.

as non-mortgage holders. We define this dummy variable as the first measure of mortgage holding. For the second measure, we use the natural log of mortgage reported in the HRS data as a continuous measure of mortgage holdings.

Table 2.6 provides the regression similar to Table 2.5. Columns 1 to 4 report the results using the first measure and Columns 5 to 8 report the results using the second measure. As shown in Table 2.6, the coefficient of the interaction term between the mortgage dummy and the retirement status dummy is negative, though it is statistically significant only for non-IV specification. Based upon these coefficients, we calculate that the retirement effect on risky share holdings for non-mortgage holders is 1.4 percentage points higher in the panel regression and 0.8-2.2 percentage points higher in the IV setting than for mortgage holders. Similar patterns can be found by using the second measure.

2.4.3.3 Heterogeneity by Pension Holdings

Pension holdings is another factor that could possibly lead to the heterogeneous retirement effect. The constant benefit flow from pension could have different impact on pension holders and non-pension holders for their investment choices, and in turn influence the retirement effect differently across pension holders and non-pension holders.

Here, in order to examine heterogeneity retirement effect across pension holding, we consider one pension measure to classify the household into pension holders and non-pension holders. More specifically, we classify households as pension holders if they report any type of patterned benefit and the rest as non-pension holders.[25] We interact the pension dummy with retirement status as an additional variable. Table 2.7 shows that there is no significant difference between pension holders and non-pension holders, except the result in Column 3.[26] This indicates that differences in retirement income flows cannot explain the retirement effect. Ideally, we would also explore heterogeneity across different pension schemes. However, since

[25] From our definition, pension holder indicator is time invariant, thus it is automatically omitted in our panel regression.

[26] This is also evidence that the retirement effect is not driven by differences in post-retirement income flows due to different retirement benefit schemes.

there is limited information in HRS, we will leave this for future study.

2.5 Possible Explanations for the Retirement Portfolio Choice Puzzle

The previous section has established that there exists a sizable retirement effect on household risky asset investment. This result is very robust across different specifications and cannot be explained by existing theories. In this section, we further propose and test four possible explanations for this positive retirement effect. One caveat, these represent only four out of many possible explanations.[27]

2.5.1 Changes in Risk Tolerance

Many factors, like age, wealth, health status, and working status, can affect risk tolerance. Now, provided that risk tolerance is positively correlated to risky asset holdings (*Canner et al.*, 1997), when retirement itself increases risk tolerance, the increased risk tolerance boosts the chance that individuals will invest more in risky assets. More specifically, before retirement, individuals encounter many other uncertainties, including employment uncertainty, labor income uncertainty, and so forth. Given these uncertainties, individuals have lower risk tolerance and so maintain fewer risky asset holdings. In contrast, after retirement, those work-related uncertainties disappear, prompting individuals to be more risk tolerant and invest more in risky assets.

To test this risk tolerance hypothesis, we employ the risk tolerance measure proposed by *Barsky et al.* (1997), which is constructed from a series of hypothetical questions on the comparison of a job with a fixed wage to jobs with wage uncertainties. More specifically, this measure is defined into two categorical variables: a categorical variable from 1 to 4, and a categorical variable from 1 to 6. Note that the smaller the number, the more risk

[27] For example, tax concerns might be another possible channel, which we do not discuss here due to a lack of data.

tolerant the households. Since both measures are categorical variables, we consider both the ordered logit regression and the panel regression. The results of the ordered logit regression are reported in Columns 1 and 3 and the results of the panel regression are presented in Columns 2 and 4 in Table 2.8.[28] Across all specifications using different measures, we can observe that households have a higher risk tolerance after retirement than before retirement, which is consistent to our conjecture above.

Although the cardinal proxy for risk tolerance provides the evidence that the risk preference shifts after retirement, using this cardinal proxy to study household behavior raises issues including measurement error problem (*Kimball et al.*, 2008). To overcome these issues, *Kimball et al.* (2008) develop an imputation method. Following their imputation methodology, we impute the relative risk tolerance for retirees and non-retirees separately under the assumption that the risk preference would change after retirement. Table 2.9 shows the result of regressions of imputed risk tolerance measures on retirement status. As first and second columns of the table show, imputed risk tolerance and log risk tolerance measures become higher after retirement. Similarly, households have a lower risk aversion coefficient after retirement. The results with imputed risk tolerance measures also confirm that households become more risk tolerant after retirement.

2.5.2 Time Spending

Next, we consider how the availability of more time, associated with retirement, might drive the retirement effect. As we know, individuals have more time after retirement for keeping track of risky asset markets and they might even gain utilities during the trading process of risky assets. If this is the case, individuals would be likely to invest more in the risky assets once they have more time after retirement.

[28]Since 2000, the HRS surveyed these income gamble questions to the individuals less than age 65. Thus, our samples contain only about 15% of respondents above 65 for the four-category risk measure, and 19% above 65 for the six-category risk measure. To deal with the possible bias caused by this sample selection, we conduct the same analysis using the subsample before survey year 2000. The result with the subsample, which is reported in Table D.6 in Appendix B, shows the similar pattern, although the statistical significance is reduced due to a substantial drop in the sample size.

To test this hypothesis, we use one measure, tracking the stock market, in HRS. This measure is drawn from the question "How closely do you track the stock market: very closely, somewhat closely and never." The value of this measure is assigned as 1, 2 or 3, respectively. A smaller number means more closeness. We again use the ordered logit regression and the results appear in Column 5 of Table 2.8. We find that retirement does increase the closeness of tracking the stock market, which supports the time spending hypothesis.

2.5.3 Life Expectancy

As suggested by *Cocco and Gomes* (2012), individuals who have a longer life expectancy plan for a longer horizon, and accordingly they will allocate more of their assets to saving, switching their portfolio towards a lower risk. If retirement changes an individual's perception about her life expectancy, then this could possibly affect her portfolio choice. To be specific, it is possible that when an individual is working, she feels healthy and capable. Once retired, she may feel less healthy and less capable, thus reducing her life expectancy. This pessimistic view on life expectancy after retirement would potentially lead to a decrease in savings and an increase in risky assets.

To determine whether the retirement effect could occur in response to changes in anticipated life expectancy, we examine whether retirement decreases anticipated life expectancy across different levels of optimism. Here we use the self-reported probability of living to ages 75 and 85 as subject life expectancy to test this hypothesis. The results are given in columns 6 and 7 of Table 2.8. As shown, on average, individuals tend to perceive a lower life expectancy after retirement. In particular, retirement decreases the individual's expectation of living to age 75 by 0.8 percent, and the individual's expectation of living to 85 by 5.4 percent. Such results support the conclusion that the retirement effect could be caused by a decrease in retiree anticipated life expectancy, though not all of them are not all statistically significant.

2.5.4 Bequest Motives

We may also expect that retirement could weaken bequest motives, which in turn might increase the probability that households invest in more risky assets.[29] When individuals are employed, they may consider themselves in a better financial situation, giving them a stronger bequest motive. Once retired, individuals would experience a sudden loss of labor income and may view themselves less capable than before. In particular, this view of weaker self may weaken the bequest motive. If this is the case, changes in bequest motive may be another possible explanation for the retirement effect.

Bequest motives in the HRS are measured using a sequence of questions. Individuals were firstly asked whether they intend to leave a bequest of $10K or above and the probability of doing so. If the probability of leaving a bequest of $10K is positive, then individuals were asked whether they intend to leave a bequest of $100K or above and the probability. However, if the probability of leaving a bequest of $10K is zero, individuals were asked whether they want to leave any bequest and with what probability. We treat each of these questions as a different measure of bequest motives. We regress these three measures of bequest motives on retirement. The results are shown in Columns 8 to 10 of Table 2.8. A relatively weaker bequest motive is found after retirement though it is not statistically significant except for the question of leaving any. Although the evidence is relatively weak, these findings suggest that a weaker bequest motive is also a possible explanation that leads to an increase in risky share holding after retirement.

2.6 Robustness

In this section, we will present various robustness checks including: 1) adopting an alternative risky share definition by incorporating IRA accounts; 2) using an alternative retirement status which classifies partial retirement as "retired"; 3) including both the household

[29] *Cocco et al.* (2005) argue that people with stronger bequest motive draw down their wealth more slowly and this, in turn, results in a lower risky share.

head's retirement status and the spouse's retirement status simultaneously; 4) excluding another possible explanation of market-driven passive asset holdings; 5) further exploring the potential non-linear effect of age, income, and wealth; 6) conducting a placebo test by artificially assigning "forced retirement age;" 7) distinguishing the short-term versus long-term retirement effect by examining the retirement effect interacted with retirement durations.

2.6.1 Alternative Risky Share Definition

In the previous sections, we focused on the risky share measure defined by the ratio of risky assets (stocks and mutual funds) to total financial assets, where financial assets do not include retirement accounts. One may argue that when making portfolio choice decisions, individuals will not only take their non-retirement financial assets into account, but also consider their retirement accounts, in their total assets. To address this concern, we use an alternative risky share measure by including the IRA account and its respective portion in stocks. This new risky share measure is defined as (stocks + mutual funds + IRA stocks)/ (financial assets+IRA).[30] The new results are summarized in Table 2.10. It shows that the retirement effect maintains and this effect is quantitatively similar to the results obtained using our initial risky share definition. In other words, our results are robust to risk portfolio measure both with and without taking into account the retirement account.

2.6.2 Alternative Retirement Definition

In Section 4 and Section 5, we used self-reported retirement status and only treat individuals as retired if they report "fully-retired." Although there is no formal verification of an individual's retirement status, there are a set of alternative measures that can be used for robustness checks. We will present the results with different retirement measures in Table 2.11. In Column 1, we use the same measure as in Section 4 and Section 5. In Column 2, we

[30] Since the HRS only includes IRA account information since 2000, and only precise asset allocation information from the 2006 wave samples; using the new risky share measure will make our sample size much smaller than our original definition.

define a new retirement status by including both fully-retired and partially-retired individuals as retirees. In Columns 3 and 4, we build up the retirement measures from a question about labor force participation. This question is "What is your current labor force status: working, unemployment, not in labor market, disabled, partially retired, fully retired?". To define retirement status, we exclude individuals who are either "not in labor market" or "disabled" from our sample. Similar to the retirement definitions used in Columns 1 and 2, we classify an individual as a retiree if he reports labor force participation as "fully-retired". In Columns 3 and in Column 4, we classify an individual as a retiree if he reports labor force participation as either "fully retired" or "partially retired". As shown in Table 2.11, the retirement effect is robust to different retirement status definitions.

2.6.3 Spouse's Retirement Status

Another concern about the retirement effect stems from the fact that men and women differ with respect to their risk aversion, which affects their investment decisions (*Barber and Odean*, 2001; *Addoum*, 2013). To address this concern, we estimate the retirement effect by including both male household heads' retirement status and their spouses' retirement status in our estimation equation at the same time. Table 2.12 shows that the positive retirement effect is only driven by the household head's retirement status. The spouse's retirement negatively contributes to portfolio choice although the coefficients are not significant for all specifications.[31] These results indicate potential gender differences in portfolio choice during the transition into retirement, which was evaluated by *Addoum* (2013). However, our results based on unconditional samples are opposite to his results from samples with positive risky shares.

[31] In the instrumental variable estimations, we construct the spouse's expected retirement status and age indicators as IVs for the spouse's retirement status in the same spirit as instruments defined for the household head's retirement status.

2.6.4 Passive Holdings

Passive holdings occur when the stock market crashes and stock prices decline sharply. In this scenario, individuals with stock holdings might be reluctant to sell their stocks at such low prices. When this happens at the same time as retirement, this confounding effect of passive holding might be misinterpreted as the retirement effect. To distinguish the retirement effect from the passive holding effect, we firstly control the wave fixed-effects in our regression. Additionally, we conduct subsample regressions which drop the observation in the 2008 to 2010 waves to avoid the potential passive holding effect caused by the 2008-2009 crisis. These results, displayed in Table 2.13, do not show any significant difference from those obtained by using the full sample, which suggests that the retirement effect is not driven by the crisis.[32]

2.6.5 High Order Effects in Age, Income and Wealth

Age, income, and wealth may affect risky share holding nonlinearly. Though we controlled for age, income, wealth in both linear and square terms, this might not be sufficient to capture the high order effects if any.[33] To explicitly exclude this possibility, we use different specifications to add further higher order terms in our regression by using age, age square, age cubic and age quadratic terms, log of income, log income square, log of wealth and log wealth square. As shown in Table 2.14, after controlling these high order terms, our retirement effect still maintains.

2.6.6 Placebo Test

Since HRS data is constructed solely from self-reported answers to survey questions, there might be some potential reporting errors. More specifically, imagine that when individuals tend to misreport their retirement status, the retirement effect we obtained in the previous

[32]For the internet bubble crisis of early 2000, we also conduct a similar subsample test by restricting our sample up to the 2000 wave. The results are qualitatively similar.

[33]We also use specification with log terms

section might be driven by some unobserved factors that determine *reported* retirement status rather than *actual* retirement status. To address this issue, we conduct some placebo tests. We artificially set "fixed" retirement ages, above which people will be labeled as "retirees". Under each specification, we set a fixed retirement age, which are 62 to 70 in Column 1 to Column 9, respectively. If the retirement effect is not driven by other unobserved factors that may affect the reported retirement status, we should not expect significant retirement effects from our placebo tests. The results are reported in Table 2.15. We find that this "artificial" retirement is only effective when set at age 65, the minimum legal age for full retirement benefits, by which the portion of retirees is increased rapidly. The placebo tests in Table 14 indicate that our results are not driven by other potential factors and thus indirectly support our main findings of the retirement effect on the portfolio choice.

2.6.7 Retirement Duration

In the benchmark panel regression, we show that retirees hold larger risky shares in their portfolios than non-retirees do. Although this result is statistically significant and remains valid with various specifications, there is one limitation to this panel regression. This panel regression with a retirement dummy only shows that the overall risky share throughout retirement is higher than the risky share before retirement, which is silent about how risky share changes by retirement duration. To overcome this limitation and test how risky share changes by retirement duration, we conduct an additional regression of the risky share on retirement duration dummies. The retirement duration is defined by the period between the interview year and the retirement year. For example, for retirees who participated in the 2010 wave survey and reported that she/he had retired in year 2009, the retirement duration is 1 year in the 2010 wave. Because the HRS is a longitudinal survey, we can also estimate the retirement duration for individuals who are not retired in a particular survey wave, but report being retired in a later wave. In this case, the retirement duration is negative. This duration dummy regression tells us how the risky share changes over time after retirement.

The regression equation to be estimated is:

$$Riskyshare_{it} = \beta_0 + \sum_{k=-4}^{15} \beta_{1k} D_{ikt} + \boldsymbol{\gamma}' \boldsymbol{X}_{it} + \eta_i + \epsilon_{it}$$

where D_{ikt} is a dummy variable that indicates whether individual i has been retired for k years in year t (a retirement duration dummy), and other specifications are the same as in the benchmark regression. In this analysis, we restrict our sample to individuals whose retirement duration is between -5 and 15, and we omit the dummy for the retirement duration -5 to make these individuals the control group.

Figure 2.4 plots the coefficient β_{1k} and its 95% confidence intervals. As can be seen in the figure, there is a distinct jump between the retirement duration 0 and 1. After the jump, the coefficients remain relatively stable. In other words, individuals increase their risky share at retirement and maintain that increased risky share at the beginning of retirement and throughout the retirement. On the other hand, coefficients prior to retirement are all insignificant. This result strengthens our hypothesis that retirement causes a discrete jump in risky share holdings.

2.7 Conclusion

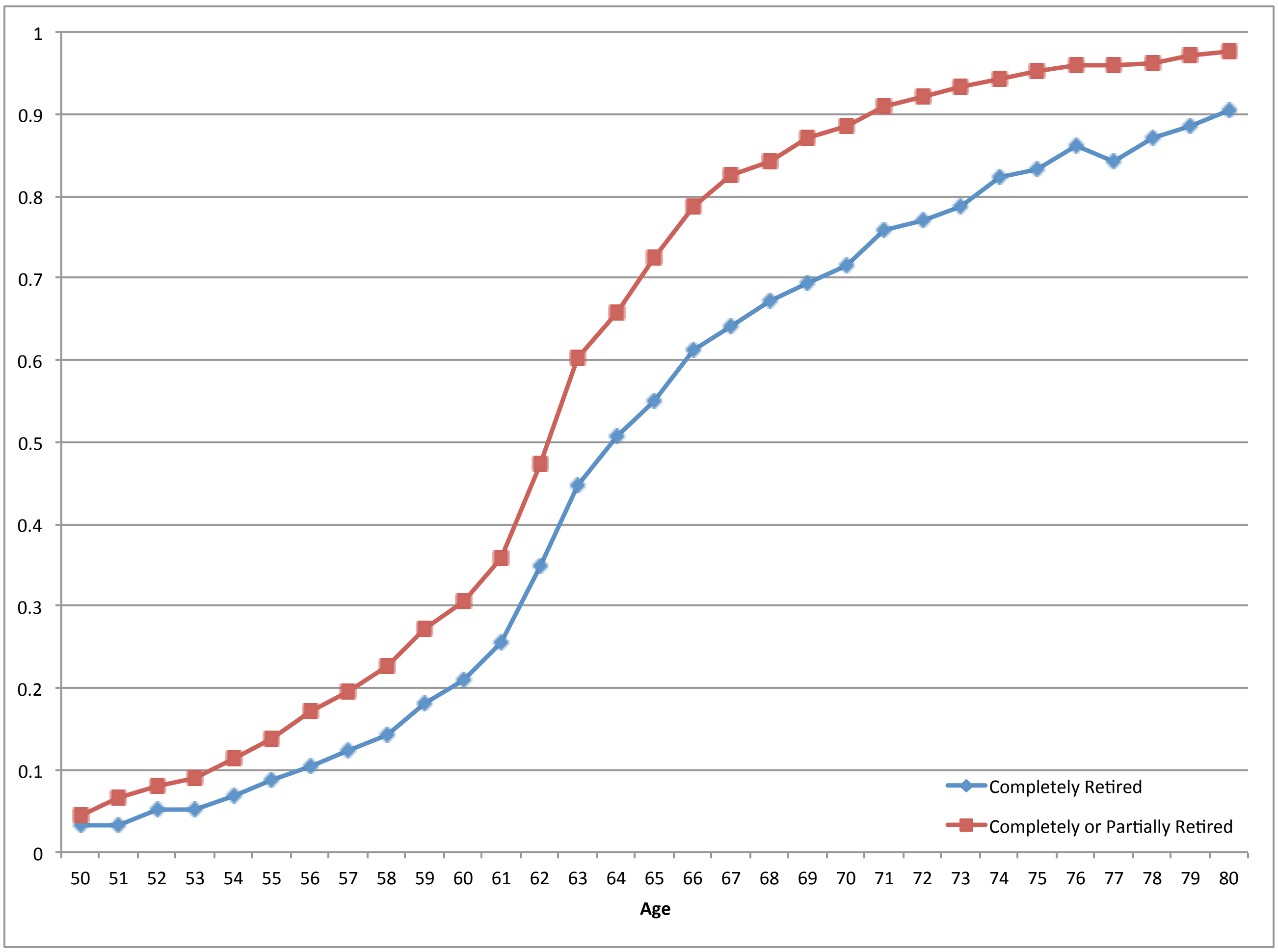
To sum up, our paper first explores the positive causal effect of retirement on risky asset holdings, after correcting the endogeneity bias associated with retirement status. We find that retirement leads to approximately a 5.4-6.7 percentage point increase in the risky shares of household's portfolio holdings, accounting for approximately one fourth of the increase in risk asset holdings. In addition, from the estimation distinguishing retirement duration, we find that this increase mainly occurs right after the retirement and then maintains over time. These results support positive increase pattern of risky asset holding over time periods as predicted by a stream of theories, but are not consistent with the smoothed transition pattern as suggested by these theories.[34]

To further explore this retirement effect on portfolio choices, we then propose and test four possible hypotheses that could explain this sizable shift due to retirement. We show that this retirement effect can be associated with four possible scenarios: 1) higher risk tolerance, 2) more time to track risky asset markets, 3) perception of shorter life expectancy, and 4) lower bequest motives, the first two of which are stronger and more robust. One caveat is that we cannot distinguish these scenarios simultaneously.

There are several possible directions that we will explore in further work. First, we will develop a sensible theoretical model that could reconcile such a large positive retirement effect. Second, as retirement is associated with decreased income risk, it is also worth discussing how the decrease in income risk affects portfolio choice. Thirdly, we try to find the richer data that could allow us to distinguish four channels proposed above simultaneously.

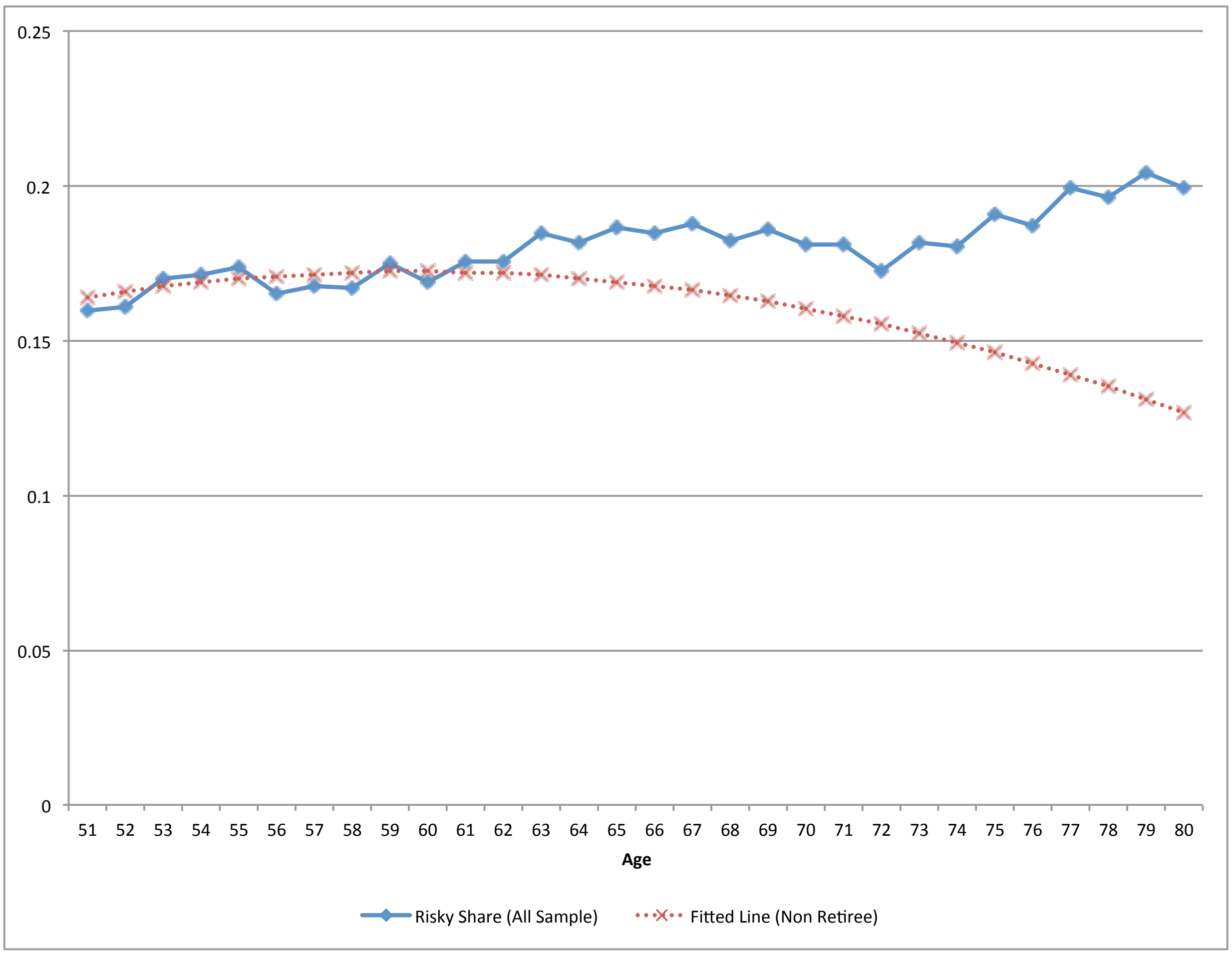
[34]This stream of literature includes *Viceira* (2001), *Cocco et al.* (2005), *Gomes and Michaelides* (2005) and *Cocco and Gomes* (2012).

Figure 2.1: Retirement Age



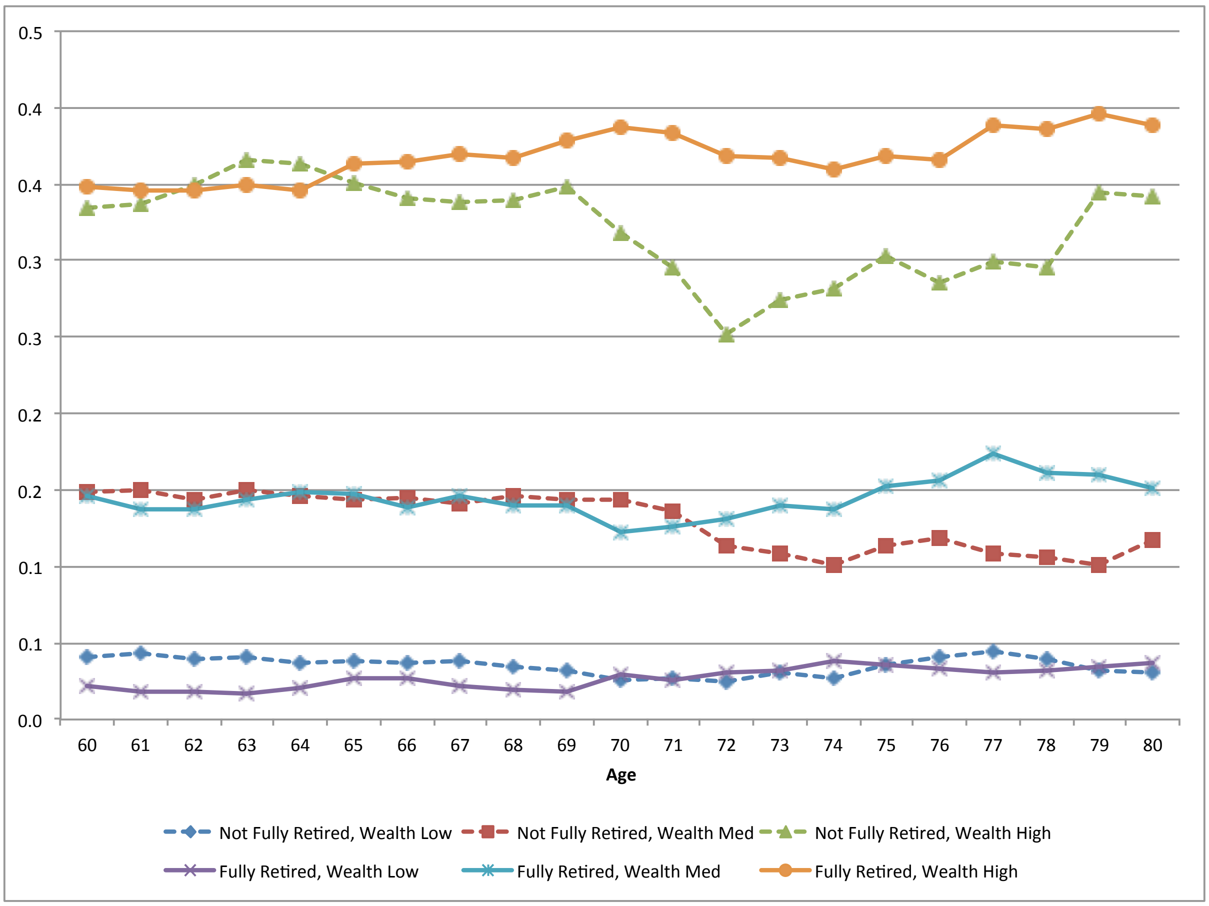
Notes: This graph is based on the aggregate samples in the HRS from the 1992 wave to the 2010 wave. To identify the retirement status, the self-reported retirement status is used.

Figure 2.2: Risky Share by Age



Notes: This graph is based on the aggregate samples in the HRS from the 1992 wave to the 2010 wave. The risky share is the share of total value of stock in financial assets. To reduce the noise in the data, moving average (with ± 1 age window) is used. Non-retiree sample is used to estimate the fitted line, which shows the patter of risky share by age. The formula for the fitted line is $RiskyShare = -0.2226 + 0.0132 * Age - 0.0001 * Age^2$.

Figure 2.3: Risky Share by Age and Wealth Group



Notes: This graph is based on the aggregate samples in the HRS from the 1992 wave to the 2010 wave. The risky share is the share of total value of stock in financial assets. The wealth group is based on the total value of household assets including financial assets and housing assets. To identify the retirement status, the self-reported retirement status is used.

Figure 2.4: Coefficients of the Retirement Duration in the Risky Share Regression

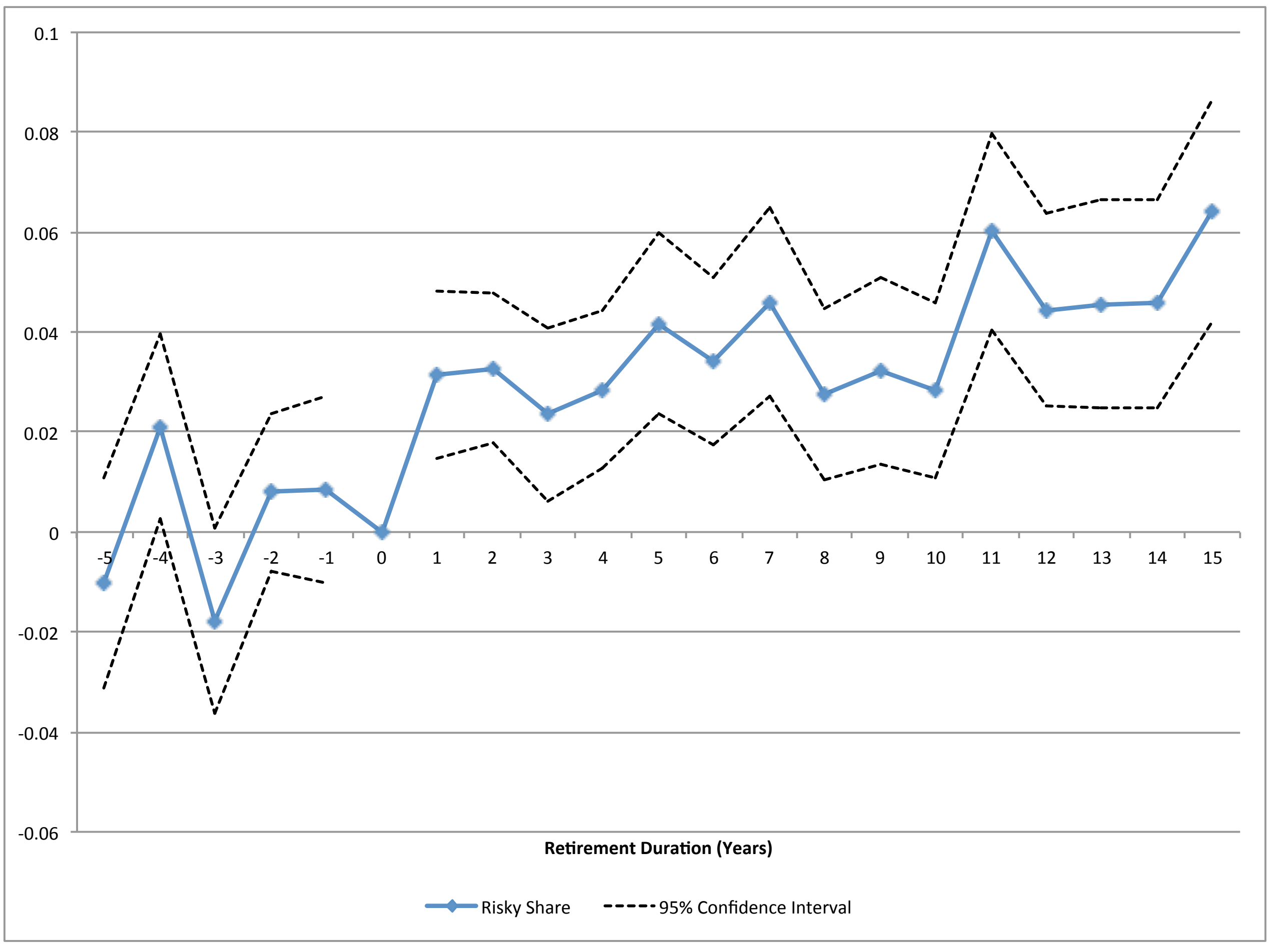


Table 2.1: Summary Statistics

Variables	Non Retired Mean	Non Retired S.D.	Retired Mean	Retired S.D.	Difference Mean	Difference S.D.
Part I. Demographic Characteristics						
Age						
Head	60.2	6.43	69.6	6.45	-9.41	.044***
Spouse	58.7	7.77	66.8	7.77	-8.17	.060***
Size of Household	2.48	1.20	2.15	0.99	.336	.008***
Number of Children	3.09	1.96	3.21	2.08	-.120	.014***
Year of Schooling						
Head	13.2	2.93	12.5	3.13	.625	.021***
Spouse	12.7	2.87	12.3	2.67	.391	.022***
Self-Reported Health Status (Head)						
Head						
1:Poor/Fair, 0:Excellent/VeryGood/Good	.142	.349	.308	.462	-.166	.003***
1:Poor/Fair/Good, 0:Excellent/VeryGood/Good	.459	.498	.631	.483	-.171	.003***
Spouse						
1:Poor/Fair, 0:Excellent/VeryGood/Good	.207	.405	.245	.430	-.037	.003***
1:Poor/Fair/Good, 0:Excellent/VeryGood/Good	.513	.500	.553	.497	-.040	.004***
Part I. Financial Status						
Wealth ($10,000; 2000 Dollars)						
Total Asset	26.6	31.6	33.05	35.34	-6.41	.227***
Total Asset Excluding 2nd Residence	25.4	29.9	31.6	33.5	-6.20	.215***
Total Financial Asset	6.07	11.2	9.13	13.8	-3.06	.085***
Total Stock Asset	2.32	5.82	3.40	7.06	-1.08	.085***
Income ($10,000; 2000 Dollars)						
Total Income of Household	6.21	4.01	3.86	3.08	2.35	.025***
Total Income of Head	3.66	1.93	2.17	1.49	1.49	.012***
Total Income of Spouse	1.03	1.12	.683	.804	.344	.007***
Risky Share						
Stock Share in Financial Asset	.168	.305	.192	.322	-.024	.002***
Stock Share in Financial and IRA Asset	.231	.336	.233	.339	-.002	.003
Subjective Measure of Risk Tolerance						
1: Least Risk Averse; 4: Most Risk Averse	3.31	1.05	3.28	1.09	.028	.017
1: Least Risk Averse; 6: Most Risk Averse	4.64	1.49	4.70	1.55	-.058	.030

Notes: Wealth and income data are winsorized at the top 5 percent and bottom 5 percent level. The asterisk in the last column report the significance of t-test. The significant level is as follows.
*** Significant at the 1 percent level, ** Significant at the 5 percent level,* Significant at the 10 percent level.

Table 2.2: Summary of Household Assets

	Value of Assets ($1,000)					Composition of Assets				
	Mean	S.D.	Median	Min	Max	Mean	S.D.	Median	Min	Max
Total										
IRA	39.4	70.3	0.0	0.0	240	0.099	0.156	0.000	0.000	1.000
Stock	29.4	67.5	0.0	0.0	250	0.057	0.119	0.000	0.000	1.000
Financial Asset	78.5	132.4	17	-7.0	490	0.209	0.268	0.134	-1.000	1.000
Home Equity	103.0	98.4	75	0.0	350	0.419	0.296	0.384	0.000	1.000
Transportation	14.0	12.7	10	0.0	45	0.105	0.161	0.050	0.000	1.000
Business	5.4	21.4	0.0	0.0	100	0.013	0.058	0.000	0.000	0.996
Other Real Estate	15.5	42.2	0.0	0.0	170	0.038	0.106	0.000	0.000	1.000
Total Assets	322.6	372.6	179.5	0.0	1398	1.000	1.000	1.000	1.000	1.000
Non-retirees										
IRA	33.4	63.7	0.0	0.0	240	0.095	0.156	0.000	0.000	1.000
Stock	23.8	60.0	0.0	0.0	250	0.052	0.116	0.000	0.000	1.000
Financial Asset	62.5	116.6	12	-7.0	490	0.179	0.257	0.108	-1.000	1.000
Home Equity	94.7	94.5	69	0.0	350	0.429	0.296	0.402	0.000	1.000
Transportation	14.2	12.5	10	0.0	45	0.119	0.166	0.061	0.000	1.000
Business	6.3	22.8	0.0	0.0	100	0.016	0.067	0.000	0.000	0.996
Other Real Estate	15.6	42.0	0.0	0.0	170	0.043	0.115	0.000	0.000	1.000
Total Assets	284.7	347.1	152.0	0.0	1398	1.000	1.000	1.000	1.000	1.000
Retirees										
IRA	46.5	76.8	0.0	0.0	240	0.103	0.157	0.000	0.000	1.000
Stock	36.0	74.7	0.0	0.0	250	0.063	0.123	0.000	0.000	1.000
Financial Asset	97.2	146.5	25.5	-7.0	490	0.242	0.276	0.175	-1.000	1.000
Home Equity	112.8	101.9	87	0.0	350	0.408	0.295	0.360	0.000	1.000
Transportation	13.8	13.0	10.0	0.0	45	0.090	0.152	0.040	0.000	1.000
Business	4.4	19.5	0.0	0.0	100	0.009	0.046	0.000	0.000	0.745
Other Real Estate	15.3	42.6	0.0	0.0	170	0.032	0.095	0.000	0.000	0.999
Total Assets	366.4	395.5	220.0	0.0	1398	1.000	1.000	1.000	1.000	1.000

Notes: All asset values are winsorized at bottom 5 percent and top 5 percent level and deflated into 2000 Dollars. We classify the samples into two groups, Retirees and Non-retirees, based on the self-reported retirement status of household head. Households whose head reports *completely retired* are classified into Retirees while households whose head reports *partially retired or not retired* are classified into Non-retirees.

Table 2.3: Benchmark Table

	I				II			
	Panel	**IV1**	**IV2**	**IV3**	**Panel**	**IV1**	**IV2**	**IV3**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Head Completely Retired	0.013***	0.054**	0.044**	0.067***	0.015***	0.054**	0.052**	0.073***
	[0.003]	[0.022]	[0.019]	[0.019]	[0.004]	[0.024]	[0.022]	[0.021]
Head Age	-0.005*	-0.003	-0.009**	-0.002	-0.006*	-0.002	-0.011**	-0.001
	[0.003]	[0.006]	[0.004]	[0.006]	[0.003]	[0.007]	[0.004]	[0.007]
Head Age Square	0.000	-0.000	0.000*	-0.000	0.000*	0.000	0.000*	-0.000
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Head Self-Reported Health	-0.000	0.002	-0.001	0.003	0.001	0.004	-0.000	0.004
(1:Poor/Fair, 0:Excellent/VeryGood/Good)	[0.003]	[0.005]	[0.003]	[0.005]	[0.004]	[0.006]	[0.004]	[0.006]
Household Size	-0.003**	-0.002	-0.003*	-0.002	-0.005**	-0.000	-0.004**	-0.000
	[0.001]	[0.002]	[0.001]	[0.002]	[0.002]	[0.003]	[0.002]	[0.003]
Number of Children	0.005***	0.003	0.005***	0.003	0.009***	0.009***	0.010***	0.010**
	[0.002]	[0.003]	[0.002]	[0.003]	[0.003]	[0.004]	[0.003]	[0.005]
ln(Household Income+1)	0.027***	0.038***	0.032***	0.041***	0.030***	0.042***	0.036***	0.045***
	[0.002]	[0.005]	[0.003]	[0.005]	[0.003]	[0.006]	[0.004]	[0.006]
ln(Household Wealth+1)	0.008***	0.008***	0.008***	0.008***	0.009***	0.009***	0.009***	0.009***
	[0.000]	[0.001]	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Change Marital Status	0.005	0.011	0.003	0.011	-0.014	0.030	-0.010	0.031
	[0.007]	[0.011]	[0.007]	[0.011]	[0.024]	[0.039]	[0.025]	[0.039]
Spouse Age Square					-0.000	-0.000*	-0.000	-0.000
					[0.000]	[0.000]	[0.000]	[0.000]
Spouse Self-Reported Health					-0.000	-0.008	-0.001	-0.008
(1:Poor/Fair, 0:Excellent/VeryGood/Good)					[0.003]	[0.005]	[0.003]	[0.005]
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	86276	35444	81245	34826	65750	27888	61930	27421
R-square	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
F-Statistics	62.79	37.23	61.56	36.91	46.94	31.77	45.93	31.25
First Stage F-Statistics		608.92	392.03	282.39		600.45	384.03	278.98
Endogeneity Test Statistics		3.56	2.53	8.30		2.50	2.76	7.57
p-value		0.06	0.11	0.00		0.11	0.10	0.01

Notes: The dependent variable is a stock share in total financial assets. Both panel and IV regression results are reported. Standard errors are in parentheses. 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 2.4: Extensive and Intensive Margin Analysis

	Panel Logit	Panel Conditional on Participation	Panel Conditional on Participation (Heckman Selection Model)
	(1)	(2)	(2)
Head Completely Retired	0.155***	0.006	0.017*
	[0.048]	[0.007]	[0.010]
Head Age	-0.106	-0.018***	-0.027***
	[0.000]	[0.006]	[0.008]
Head Age Square	0.001**	0.000	0.000*
	[0.000]	[0.000]	[0.000]
Head Self-Reported Health	-0.005	0.007	0.007
(1:Poor/Fair, 0:Excellent/VeryGood/Good)	[0.054]	[0.009]	[0.009]
Household Size	-0.085***	-0.001	-0.008
	[0.024]	[0.004]	[0.006]
Number of Children	0.169***	0.017**	0.030***
	[0.047]	[0.007]	[0.010]
ln(Household Income+1)	0.464***	-0.005	0.031
	[0.034]	[0.005]	[0.021]
ln(Household Wealth+1)	0.726***	0.014***	0.075**
	[0.031]	[0.005]	[0.034]
Change Marital Status	0.065	-0.028	-0.022
	[0.331]	[0.049]	[0.049]
Spouse Age	0.026		
	[0.039]		
Spouse Age Square	-0.000	0.000	0.000
	[0.000]	[0.000]	[0.000]
Spouse Self-Reported Health	0.029	-0.007	-0.005
(1:Poor/Fair, 0:Excellent/VeryGood/Good)	[0.053]	[0.008]	[0.008]
Year Fixed Effect	Yes	Yes	Yes
Household Fixed Effect	Yes	Yes	Yes
Observations	28851	23954	23954
Chi-square	1739.72		
Wald p-value	0.00		
R-squared		0.02	0.02
F-Statistics		11.73	11.36

Notes: The dependent variable for the Logit Regression is the probability of participating in stock market. For the intensive margin analysis, the stock share conditional on stock market participation is used as a dependent variable. In the Logit Regression, sample with no within household variation are dropped (29,436 observations). Standard errors are in parentheses. 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 2.5: Heterogeneity - Wealth

	Panel	IV1	IV2	IV3
	(1)	(2)	(3)	(4)
Head Completely Retired	0.008	0.016	0.056**	0.041
	[0.006]	[0.030]	[0.023]	[0.026]
Household Wealth High	0.108***	0.078***	0.105***	0.076***
	[0.006]	[0.011]	[0.008]	[0.011]
Household Wealth Medium	0.042***	0.021**	0.047***	0.022**
	[0.005]	[0.009]	[0.007]	[0.009]
Head Completely Retired × Wealth High	0.011	0.043**	0.005	0.038**
	[0.007]	[0.020]	[0.014]	[0.018]
Head Completely Retired × Wealth Medium	-0.005	0.024	-0.020	0.020
	[0.007]	[0.019]	[0.013]	[0.018]
Household Characteristics	Yes	Yes	Yes	Yes
Head Characteristics	Yes	Yes	Yes	Yes
Spouse Characteristics	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Household Fixed Effect	Yes	Yes	Yes	Yes
Observations	65750	27888	61930	27421
R-square	0.03	0.03	0.03	0.03
F-Statistics	64.47	34.51	61.74	33.62
Endogeneity Test Statistics		4.63	5.08	11.19
p-value		0.20	0.17	0.01

Notes: The dependent variable is the stock share in financial assets. Standard errors are in parentheses. 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 2.6: Heterogeneity - Mortgage

	Panel	IV1	IV2	IV3	Panel	IV1	IV2	IV3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Head Fully Retired	0.020***	0.066***	0.050**	0.073***	0.024***	0.057**	0.059***	0.074***
	[0.004]	[0.022]	[0.020]	[0.019]	[0.005]	[0.025]	[0.022]	[0.022]
Head Fully Retired × Mortgage Holder	-0.014**	-0.022	-0.014	-0.008				
	[0.006]	[0.016]	[0.012]	[0.015]				
Mortgage Holder	0.009**	0.013*	0.012**	0.011				
	[0.004]	[0.007]	[0.006]	[0.007]				
Head Fully Retired × ln(Mortgage Value)					-0.002***	-0.004***	-0.002**	-0.003**
					[0.001]	[0.001]	[0.001]	[0.001]
ln(Mortgage Value)					0.001	0.002**	0.001**	0.002**
					[0.000]	[0.001]	[0.001]	[0.001]
Household Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Head Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spouse Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	65308	27716	61476	27252	59191	24505	55227	24042
R-square	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02
F-Statistics	46.87	29.30	44.70	28.69	44.92	28.23	42.73	27.55
Endogeneity Test Statistics		3.46	2.55	8.50		4.27	3.54	5.47
p-value		0.18	0.28	0.01		0.12	0.17	0.06

Notes: The dependent variable is the stock share in financial assets. Standard errors are in parentheses. 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 2.7: Heterogeneity - Pension

	Panel	IV1	IV2	IV3
	(1)	(2)	(3)	(4)
Head Completely Retired	0.011*	0.061*	0.083***	0.078***
	[0.007]	[0.034]	[0.029]	[0.030]
Head Completely Retired × Pension Holder	0.004	-0.007	-0.037**	-0.008
	[0.007]	[0.022]	[0.019]	[0.020]
Household Characteristics	Yes	Yes	Yes	Yes
Head Characteristics	Yes	Yes	Yes	Yes
Spouse Characteristics	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Household Fixed Effect	Yes	Yes	Yes	Yes
Observations	65750	27888	61930	27421
R-square	0.02	0.03	0.02	0.02
F-Statistics	49.64	30.79	47.65	30.28
Endogeneity Test Statistics		2.86	6.97	8.61
p-value		0.24	0.03	0.01

Notes: The dependent variable is the stock share in financial assets. Standard errors are in parentheses. 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 2.8: Channel Test

	Risk Tolerance				Following	Life Expectancy Living		Probability of Leaving Bequest		
	4 Cat.		6 Cat.		Stock Market	To Age 75	To Age 85	10K+	100K+	Any
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Head Completely Retired	-0.205***	-0.199***	-0.115**	-0.342***	-0.277***	-0.008	-0.058***	-0.330	0.435	-1.336***
	[0.048]	[0.055]	[0.057]	[0.108]	[0.045]	[0.007]	[0.011]	[0.399]	[0.667]	[0.421]
Household Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Head Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spouse Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household Fixed Effect	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15904	15904	9954	9954	18576	36700	38215	56459	31016	31418
Pseudo R-square	0.01		0.01		0.07					
Chi-square	204.51		219.69		1271.08					
R-squared						0.04	0.05	0.01	0.02	0.02
F-Statistics						46.43	60.07	24.14	23.89	12.30

Notes: This table shows the result of testing 4 possible explanations for increasing risky share after retirement. As shown in the first row in the table, the dependent variables are the subjective risk tolerance measure, time allocation to stock market, self-reported life expectancy, and probability of leaving bequest, respectively. In the column (1), (3), and (5), the ordered logic regression is used. The panel regression is used in the other columns. Standard errors are in parentheses. 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 2.9: Channel Test - Imputed Risk Tolerance Measure

	Risk Tolerance	Log Risk Tolerance	Risk Aversion
	(1)	(2)	(3)
Head Completely Retired	0.007**	0.030*	-0.206*
	[0.004]	[0.016]	[0.120]
Household Characteristics	Yes	Yes	Yes
Head Characteristics	Yes	Yes	Yes
Spouse Characteristics	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Household Fixed Effect	Yes	Yes	Yes
Observations	12770	12770	12770
R-square	0.02	0.02	0.02

Notes: As shown in the first row in the table, the dependent variables are the imputed risk tolerance measure, the imputed log risk tolerance measure, and the imputed risk aversion coefficient, respectively. Standard errors are in parentheses. 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 2.10: Robustness - Alternative Risk Measure

	(1)	(2)
Head Completely Retired	0.063***	0.023**
	[0.006]	[0.010]
Household Characteristics	Yes	Yes
Head Characteristics	Yes	Yes
Spouse Characteristics	Yes	Yes
Year Fixed Effect	Yes	Yes
Household Fixed Effect	No	Yes
Observations	18459	18459
R-square	0.17	0.01
F-Statistics	239.65	11.30

Notes: The dependent variable is the stock share in financial and IRA assets. Standard errors are in parentheses. 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 2.11: Robustness - Alternative Definition of Retirement

	Self-Reported Retirement Status		Labor Force Status	
	Completely	Completely/Partially	Completely	Completely/Partially
	(1)	(2)	(3)	(4)
Head Retired	0.015***	0.013**	0.011**	0.013**
	[0.004]	[0.004]	[0.004]	[0.004]
Household Characteristics	Yes	Yes	Yes	Yes
Head Characteristics	Yes	Yes	Yes	Yes
Spouse Characteristics	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Household Fixed Effect	Yes	Yes	Yes	Yes
Observations	65750	65750	64636	64636
R-squared	0.02	0.02	0.02	0.02
F-Statistics	46.94	46.68	46.67	46.63

Notes: The dependent variable is the stock share in financial asset. In the first two columns, the retirement dummy is created using the self-reported retirement status. In the last two columns, the retirement dummy is created using the labor force status, and the unemployed and the disabled groups are excluded. Standard errors are in parentheses. 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 2.12: Robustness - Retirement Status of Spouse

	Panel	IV1	IV2	IV3
	(1)	(2)	(3)	(4)
Head Completely Retired	0.017***	0.106**	0.059*	0.076*
	[0.005]	[0.046]	[0.031]	[0.041]
Spouse Completely Retired	0.003	-0.070	-0.059**	-0.052
	[0.004]	[0.055]	[0.029]	[0.044]
Household Characteristics	Yes	Yes	Yes	Yes
Head Characteristics	Yes	Yes	Yes	Yes
Spouse Characteristics	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Household Fixed Effect	Yes	Yes	Yes	Yes
Observations	52435	52435	47467	13472
Endogeneity Test Statistics		3.72	4.71	2.32

Notes: The dependent variable is the stock share in financial assets. Standard errors are in parentheses. 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 2.13: Robustness - Non Crisis Sample

	(1)	(2)
Head Completely Retired	0.015***	0.015***
	[0.004]	[0.004]
Household Characteristics	Yes	Yes
Head Characteristics	Yes	Yes
Spouse Characteristics	No	Yes
Year Fixed Effect	Yes	Yes
Household Fixed Effect	Yes	Yes
Observations	70588	54162
R-square	0.01	0.01
F-Statistics	50.73	36.08

Notes: The dependent variable is the stock share in financial assets. Standard errors are in parentheses. 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 2.14: Robustness - Including High Order Terms

	(1)	(2)
Head Completely Retired	0.009***	0.010***
	[0.004]	[0.004]
Head Age	0.066	0.274
	[0.282]	[0.330]
Head Age^2	-0.002	-0.007
	[0.007]	[0.008]
Head Age^3	0.000	0.000
	[0.000]	[0.000]
Head Age^4	-0.000	-0.000
	[0.000]	[0.000]
ln(Household Income+1)	0.034***	0.027***
	[0.005]	[0.006]
ln(Household Income+1)^2	0.006***	0.001
	[0.002]	[0.002]
ln(Household Wealth+1)	0.048***	0.055***
	[0.002]	[0.002]
ln(Household Wealth+1)^2	0.004***	0.004***
	[0.000]	[0.000]
Household Characteristics	Yes	Yes
Head Characteristics	Yes	Yes
Spouse Characteristics	No	Yes
Year Fixed Effect	Yes	Yes
Household Fixed Effect	Yes	Yes
Observations	86276	65750
R-squared	0.03	0.03

Notes: The dependent variable is the stock share in financial asset. Standard errors are in parentheses. 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 2.15: Placebo Test

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\boldsymbol{I}$(Age of Head $\geq$ 62)	0.004								
	[0.004]								
$\boldsymbol{I}$(Age of Head $\geq$ 63)		0.006							
		[0.004]							
$\boldsymbol{I}$(Age of Head $\geq$ 64)			0.005						
			[0.004]						
$\boldsymbol{I}$(Age of Head $\geq$ 65)				0.010**					
				[0.004]					
$\boldsymbol{I}$(Age of Head $\geq$ 66)					0.006				
					[0.004]				
$\boldsymbol{I}$(Age of Head $\geq$ 67)						0.004			
						[0.004]			
$\boldsymbol{I}$(Age of Head $\geq$ 68)							0.002		
							[0.005]		
$\boldsymbol{I}$(Age of Head $\geq$ 69)								-0.002	
								[0.005]	
$\boldsymbol{I}$(Age of Head $\geq$ 70)									-0.008
									[0.005]
Household Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Head Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spouse Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	65750	65750	65750	65750	65750	65750	65750	65750	65750
R-squared	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
F-Statistics	46.59	46.66	46.54	46.67	46.48	46.41	46.39	46.44	46.53

Notes: The dependent variable is the stock share in financial asset. Standard errors are in parentheses. 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.

CHAPTER III

Cash-out Refinancing as a Tool for Portfolio Rebalancing

3.1 Introduction

During the housing market boom in early 2000s, U.S. households experienced a significant appreciation in their home value and a remarkable drop in mortgage interest rate at the same time (Figure 3.1). Because of the increased home value and low interest rates, homeowners had a great incentive to refinance their mortgages and pull out some portion of their home equity during this period. As shown in Figure 3.2, the mortgage refinancing increased dramatically since 2001, and the total amount of refinanced mortgage was almost twice as much as the amount of new origination. In particular, a significant amount of money has been cashed out from home equity through mortgage refinancing during this period (Figure 3.3). Total home equity cashed out has dramatically increased from 2001 and reached its peak at 2006, right before the mortgage crisis. This huge amount of money from cashed-out home equity would have been transferred to consumption or any other types of assets including risky and risk-free assets. The usage of this cashed-out home equity is important in understanding household saving and investment decision and macroeconomic dynamics during this period. In this paper, I examine how households used this cashed-out home equity during 2000s with a particular focus on asset reallocation.

For many homeowners, the housing asset accounts for the largest portion of their total assets, and therefore, variations in house value can significantly affect household consumption as well as saving and investment decision. In the literature, the effect of housing asset on consumption has been examined from various perspectives. The wealth effect caused by an appreciation in house value increases household consumption (*Case et al.*, 2005; *Campbell and Cocco*, 2007; *Bostic et al.*, 2009; *Carroll et al.*, 2011). Additionally, change in house value has effect on household borrowing constraint, which results in change in consumption (*Cooper*, 2009, 2013). The effect of housing asset on household saving and investment decision also has been examined in many studies. A large investment in housing asset can crowd out the opportunity in investment in other assets. Household portfolio choice can also be affected by homeownership status, the share of housing asset, and mortgage debt (*Flavin and Yamashita*, 2002; *Cocco*, 2005; *Yao and Zhang*, 2005; *Chetty and Szeidl*, 2010). These studies conclude that housing assets affect household consumption and saving decision directly or indirectly.

The effect of cash-out refinancing on household consumption and savings is more direct and immediate because households actively and voluntarily engage in the transaction. Previous studies have focused on the direct effect of cash-out refinancing on consumption. *Hurst and Stafford* (2004) show that liquidity-constrained homeowners use their home equity to smooth their consumption by refinancing their mortgages. Their perspective is supported by the data from the Panel Study of Income Dynamics (PSID), showing how an unemployment shock is related to the propensity to refinance and reduce home equity, controlling for other variables such as household income, demographics, and the present value of financial gain to refinance. On the other hand, *Chen et al.* (2013) use macro level data to describe the relationship between cash-out refinancing and consumption smoothing motive at the aggregate level. They conclude that the portion of households that increase their mortgage balance as they refinance is related to macro variables including interest rate, industrial production, and income growth. However, considering the dramatic increase in the amount of home equity cashed out during the housing market boom in the early 2000s, it is likely that the cashed-out money was transferred to other asset accounts besides consumption.

In this paper, I examine how households use the funds from cash-out refinancing based on household level micro data from the Panel Study of Income Dynamics (PSID). I particularly focus on cash-out refinancing behavior of financially unconstrained households. During the housing market boom and burst in 2000's, these households cashed out a large amount of money relative to their income and wealth. These households, although they pulled out a large amount of home equity, were not likely to increase their consumption, and less probable to invest in stocks and IRA accounts. Instead, they used the cashed-out home equity to invest in other real estate such as second home and rental properties, and improved their main residence. In other words, the financially unconstrained households cashed out home equity and used this fund to invest aggressively in real estate market, increasing the portion of real estate in their total wealth.

Cash-out refinancing is an important tool for households to adjust the share of home equity in total wealth. The mortgage gives homeowners a chance to adjust home equity not only at the time of home purchase, but also throughout the period of home ownership. The house is differentiated from other assets because of its role as a residential unit. Homeowners can enjoy the benefit of living in that dwelling and investing in it at the same time. On the other hand, unlike other assets, homes cannot be divided so that homeowners cannot easily realize a gain when their house price rises. Homeowners face only two choices: sell the home or keep the home. Therefore, realizing a gain implies that they need to find another place to live, which involves relatively large transaction costs such as taxes, realtor fees, and the cost of relocating. Even though homeowners cannot easily sell or buy their houses due to various frictions, they instead use mortgage refinancing to adjust the portion of the housing asset in their total portfolio. While many have studied the role of mortgage in facilitating home ownership, few have explored the potential of mortgages to act as a tool for controlling home equity levels in what, for most people, is their greatest asset. As house prices rise dramatically during housing market boom, housing assets are likely to take more portion in households' total wealth. In that case, households can increase a mortgage balance so as to decrease the portion of home equity in total wealth. In other words, the cash-out refinancing can be used as the tool for rebalancing home equity share in total assets.

Using the PSID data, this paper finds that during the housing market boom, cashed-out households more actively reduced the home equity share responding to passive increase in home equity share. However, an investment in other real estate increased the share of real estate in total wealth, which offsets the rebalancing effect of cash-out refinancing. Investing in other real estate using cased-out home equity makes households enjoy a greater leverage effect on real estate investment, but vulnerable to the shock in real estate market. That is, the cash-out refinancing did not effectively reduce the exposure to housing market risk and rather encouraged speculative households to invest more aggressively in housing market. Therefore, cashed-out households that invested in other real estate experienced a greater appreciation in the value of total wealth during the housing market boom, while they suffered more from the drop in asset value during the financial crisis.

Much research has been done on the effect of housing asset on households saving and investment decision (*Flavin and Yamashita*, 2002; *Cocco*, 2005; *Yao and Zhang*, 2005; *Chetty and Szeidl*, 2010). However, most of the previous studies focus on how households adjust the stock share in the presence of housing assets, while the possibility that households can adjust their home equity share by changing the leverage in housing investment are overlooked. This paper focuses on the role of cash-out refinancing as a tool for adjusting home equity share. *Calvet et al.* (2009) examine households' portfolio rebalancing behavior using detailed Swedish data. They show that households negatively respond to passive stock share change to restore the previous stock share. However, they only consider the stock share in financial asset. This paper extends the concept of portfolio rebalancing to home equity share rebalancing. Cashed-out households negatively respond to the passive increase in home equity share. However, due to the increase in other real estate share, the rebalancing effect is offset, while the leverage effect is magnified. By examining the active rebalancing behavior in real estate investment, this paper contributes to heighten our understanding in the effect of housing investment and mortgage on household finance and macroeconomics dynamics, especially during the housing market boom and burst in 2000's.

This paper is organized as follows. Section 2 describes the data that are used for analysis in detail. In section 3, I summarize the cash-out refinancing statistics in 2000's. Section 4 examines the usage of cashed-out home equity. In section 5, I examine how households rebalance their home equity share using cash-out refinancing. Section 6 provides the discussion of this paper and section 7 concludes the paper.

3.2 Data Description

In this paper, I use the Panel Study of Income Dynamics (PSID) data from 1999 to 2011 to examine households' cash-out refinancing behavior. During this period, the PSID surveyed more than 8,000 households every two years, and collected a wide range of data including assets, income, expenditure, and household demographic information. Particularly, the PSID provides detailed information on housing assets and mortgages such as current value of house, original and remaining mortgage balance, mortgage interest and payment, and refinancing status.

I choose the period between 2001 and 2011 because 1) housing market experienced large bubble and burst during this period, 2) mortgage origination and refinancing increased dramatically, along with the expansion of mortgage market, and 3) total home equity cashed out increased considerably since 2001. An additional advantage using the PSID data during this period is that the PSID began to produce biennial and relatively well-balanced panel data, which more thoroughly detailed expenditures. The panel characteristic of the PSID is crucial to this study since most analyses in this study use the change of individual household characteristics, which can be estimated by comparing data of each household in two consecutive surveys.[1]

[1] For example, the amount of increased mortgage debt can be calculated by subtracting previous mortgage

As the focus of this paper is on the variation of households' characteristics, only households that participated in two consecutive surveys are included in the sample. Among this sample, I exclude households that rent their main residence unit. These households are excluded since the major concern in this study is the usage of home equity through mortgage borrowing. After this selection criteria, I obtain 27,977 sample.[2] In the following subsections, I describe the main items that are employed in the analysis in detail.

The value reported in this paper is nominal. Because the PSID does not report the exact date (or year) of each transaction between surveys, it is not possible to accurately estimate an inflation adjusted value of each transaction. For example, an active stock investment reported in 2009 survey can occur right after 2007 survey, or right before 2009 survey, or during 2008. Because active investments are important in this paper, I use nominal values instead of inflation adjusted value.

3.2.1 Key Variables

Assets

The PSID contains several household asset items including house, various financial assets, and retirement accounts. In the PSID, the total households wealth is defined as follows.

$$\begin{aligned} TotalWealth &= HomeEquity + Fam/Business + Checking/Saving + Stock \\ &\quad + OtherAssets + Vehicles + Annuities + OtherRealEstate - Debt \end{aligned}$$

Additionally, in this paper, total financial asset is defined as follows.

$$TotalFinancialAsset = Checking/Savings + Stock + Bonds - Debt$$

balance from current balance. Using this mortgage balance change and moving status, I can identify whether households cashed out their home equity between two survey periods.

[2]Since this paper uses sample from surveys from 2001 to 2011, 4,666 household samples are observed in every survey year on average, although there is a variation in sample size over years. For example, in 2001, the sample size is at lowest, 4,406, while in 2007, it is at highest, 4,767.

Table 3.1 shows summary statistics of household total wealth and financial wealth by survey year. The average value of total wealth increased by 55 percent from 2001 to 2007, but decreased by 15 percent from 2007 to 2011. On the other hand, the average total financial wealth increased only by 17 percent from 2001 to 2007, and decreased by 12 percent from 2007 to 2011. In other words, the financial wealth is relatively stable during this period, while the total wealth, which includes home equity and other real estate, is more volatile.

Mortgage

The PSID provides detailed mortgage data, including monthly mortgage payments, remaining mortgage balances, contract years, mortgage rates, and whether a mortgage was refinanced or newly originated. Total amount of mortgage balance is the sum of 1st mortgage and 2nd mortgage. The concept of the mortgage is comprehensive in the PSID. All types of loans that use a house as collateral are considered as a mortgage. Because the PSID is a well balanced panel data, the change in mortgage balance of each household can easily be traced, which in turn allows us to determine whether there has been a cash-out. However, the data on mortgages or loans for a second home or other real estate is not provided in the PSID. Table 3.1 shows that the average mortgage balance is 60,034 dollar in 2001 and 86,150 in 2007. During this period, the average balance increased by 44 percent. Interestingly, even after mortgage market crisis in 2007, the average mortgage balance increased to 87,464 in 2011.

Income

I use total household income to analyze the effect of income on household consumption and investment decisions. The PSID provides detailed income data for each household, including wage, transfer income, and social security income. Not included in the data are the gains from selling assets such as houses, vehicles, stocks, and bonds. As can be seen in Table 3.1, an average household's total income increased constantly from 2003 to 2009 with average growth rate 7.5 percent. However, an average income decreased by 3.7 percent from 2009 to 2011.

Expenditure

Historically, the PSID has gathered information about food consumption and housing expenditures. In 1999, the survey began to include more questions regarding household expenditures such as food consumption, transportation expense, utility expense, education, health spending, and mortgage and loan payments. According to *Li et al.* (2010), this new, more detailed expenditure data covers more than 70 percent of expenditures reported in the Consumer Expenditure Survey. The richness of the expenditure data is important for my analysis since, in the literature, the consumption smoothing is considered as one of the most important motive for the cash-out. I compile total expenditure data for each household to examine the consumption smoothing motive of cash-out refinancing. However, housing expenditures such as mortgage payments and property tax payments are excluded as those expenditures are directly related to mortgage balance. Table 3.1 shows that an average non-durable good consumption increased rapidly from 2001 to 2007. Households reduce their expenditure after 2007 although the average (and median) income did not decrease during this period.

Demographic Information

In addition to various financial information, I also use the demographic information on each household, including the age of head, year of education, marital status, and family composition. Because these factors affect households' financial decision, I use these demographic information as control variables in the most of the analysis.

3.3 Cash-out Refinancing in 2000's

In this section, I summarize the general characteristics of cash-out refinancing during the housing market boom and burst in 2000's. Additionally, I examine what triggered cash-out refinancing during this period.

3.3.1 Definition of Cash-out Refinancing

Cash-out refinancing refers to a mortgage refinance transaction in which the homeowner increases the mortgage balance so that the new balance is greater than the previous mortgage balance plus closing costs. In their report of cash-out refinance share, Freddie Mac defines cash-out refinance as "the refinancing of a mortgage with at least a 5% greater loan amount than the previous unpaid mortgage balance." On the other hand, Freddie Mac and Fannie Mae's credit policy guidelines for lenders define a cash-out refinance loan as "one that is either used to extract home equity (that is, the borrower receives a cash payment from the refinance settlement) or is used to pay off an existing second lien (for example, a home equity line of credit or home equity loan) that was not used in the purchase of the home." Because the PSID asks no direct question about cash-out refinancing and does not collect information about the purchase of a new main residence, cash-out refinancing transactions are difficult to identify. To overcome this problem, I use other information in the PSID such as move-in year, ownership status and change in mortgage balance. Move-in year and ownership status are important to distinguish the cash-out refinancing from the mortgage balance change caused by new home purchase. In this paper, the cash-out mortgage refinancing is defined as an increase in mortgage balance without a move into a new home between two survey periods. Given this perspective, the concept of cash-out refinancing is more comprehensive in this paper. For example, I consider the origination of a new home equity loan, which results in a total mortgage balance increase, as a cash-out refinancing, even though a household has not refinanced their first mortgage.

3.3.2 Cash-out Refinancing Statistics

I summarize cash-out refinancing statistics in the PSID from 2001 to 2011 in Table 3.2. Part I in Table 3.2 shows the percentage of cashed-out households among homeowners and mortgage holders. The percentage of cashed-out households among homeowners was at lowest, 22.1 percent in 2011, and at highest, 29.3 percent in 2003. This percentage reached 39.7 percent when the sample was restricted to homeowners with a positive mortgage balance. To check whether the cash-out refinancing prevails only among financially constrained household, I divide sample into two groups: households with financial assets less than 10,000 dollars and more than 10,000 dollars, and calculate the portion of cashed-out households by the two groups. Throughout all survey years, the portion of cashed-out households with less than 10,000 dollars was higher than with more than 10,000 dollars. However, the relatively large number of households with financial assets more than 10,000 dollars also cashed out during this period. On average, more than 30 percent of mortgage holders that had more than 10,000 dollars in their financial assets cashed out during this period.

I also estimate the amount of cashed-out home equity during this period. The average amount of cashed-out home equity increased from $24,635 in 2001 to $40,482 in 2007. This amount varies with the financial status of households. Overall, households that held more than 10,000 dollars in financial assets pulled out the larger amount of money from their home equity. For example, in 2007, households with more than 10,000 dollars in their financial assets cashed out 49,544 dollars on average, while 36,195 dollars were cashed out from home equity of households with less than 10,000 dollars in their financial assets. These statistics show that the cash-out refinancing was relatively widespread during this period regardless of household financial status, and the amount of cash-out was not negligible.

Portion of Home Equity Cashed-out

For the better understanding of the relative magnitude of cashed-out home equity in household accounts, I summarize the portion of home equity cashed out in various household accounts in Table 3.3. The amount of cashed-out home equity takes about 17 percent of total house value on average with a large variation across years. The cashed-out home equity takes more than 45 percent of total household income on average, and in 2007 survey, the amount takes the largest portion compared to household total income, 51.7 percent. I also compare the amount of cashed-out home equity with total nondurable consumption. The cashed-out amount takes more than twice of total nondurable consumption on average. From the estimated result in this table, we understand that the amount of home equity cashed-out takes non-negligible portion in household total wealth, income, and consumption. Therefore, the cashed-out home equity may affect not only consumption but also household asset composition.

Loan-to-value (LTV) Ratio

Cash-out refinancing, which increases mortgage balance, results in the change in the LTV ratio. Most homeowners expect decreasing LTV ratio over time because monthly mortgage payment reduces the mortgage balance gradually and nominal value of house usually increases in the long run. On the other hand, the LTV ratio can increase when households increase mortgage balance through refinancing and house prices decrease. The LTV ratio is a key factor when we consider the effect of housing asset on household financial decision. For example, the LTV ratio affects household consumption through borrowing constraint channel (*Cooper*, 2013), and is also closely related to the mortgage default decision (*Elul et al.*, 2010). Figure 3.4 plots the LTV ratio throughout survey years by cash-out refinancing status. As the figure shows, the LTV ratio has fluctuated over time. The LTV ratio tends to be high during recession, while it decreases during booming periods. The LTV ratio also varies with the cash-out status. The LTV ratio of households that cashed out home equity was higher than the ratio of households that did not cash out. The difference in LTV ratio between cashed-out and non cashed-out households was 2 to 5 percents. I also calculate the change in the LTV ratio between two survey periods, which is described in Figure 3.5. As expected, after cashing out home equity, the LTV ratio increased, while households that did not cash out home equity experienced a decrease in the LTV ratio. After the cash-out, the LTV ratio increased by 5 to 15 percent on average. Considering that housing assets take a large portion in household total wealth, 5 to 15 percent increase in LTV ratio can have a significant effect on household asset composition.

3.3.3 Determinants of Cash-out

Cash-out refinancing decision can be affected by various factors including the house price growth rate, the difference between original mortgage rates and current market rates, the LTV ratio, the remaining mortgage period, income, and wealth. I examine what triggers household cash-out refinancing decision among these factors. To this end, I run the Probit regression with cash-out refinancing status as a dependent variable. Table 3.4 shows the result of the Probit regression. Based on the assumption that households with a different level of financial assets have a different motivation in cash-out, I report the result for households with financial asset less than 10,000 dollars and more than 10,000 dollars separately. As column (1) and (2) in Table 3.4 shows, for both financially constrained and unconstrained households, most of the factors listed in the table have significant effects on the cash-out refinancing decision. However, the income growth rates do not significantly affect the cash-out refinancing decision for both financially constrained and unconstrained households. One difference between financially constrained and unconstrained groups is that the existence in other debt only significantly affects cash-out refinancing decision for financially unconstrained households.

To understand the effect of each factor listed above on cash-out refinancing decision more precisely, I estimate the marginal effect of each explanatory variable. The LTV ratio affects the cash-out decision more significantly for financially constrained households. For example, when the LTV ratio decreases from 0.8 to 0.6, financially constrained households are about 9 percent more likely to cash out, while financially unconstrained households are

5.2 percent more likely to cash out. The mortgage rate for the first loan affects the cash-out decision more significantly for financially unconstrained households. Increasing the difference between the original rate and the current rate from 1 to 2 percent, financially constrained households are 1.5 percent more likely to cash out, while financially unconstrained households are 2.3 percent more likely to cash out. Interestingly, previous home equity share is another important determinant of cash-out refinancing. For example, when the previous home equity share increases from 0.5 to 0.8, the likelihood of cashing out increases by 1.1 percent and 2.5 percent for financially constrained and unconstrained households, respectively. That is, households consider the portion of home equity in total wealth when they decide to cash out. The existence of 2nd mortgage is another concern when households decide to cash out. However, the 2nd mortgage rate does not significantly affect the cash-out decision for both groups as column (4) and (5) show. Overall, various factors affect household cash-out refinancing decision, while financially constrained and unconstrained households respond differently to each factor.

3.4 Usage of Cashed-out Home Equity

According to the recent cash-out refinance report by Freddie Mac, the total cashed-out home equity in 2006, right before financial crisis, was $320 billion, which was more than 10 times greater than the amount in 2000. Examining the usage of this large amount of cashed-out home equity is crucial for understanding economic phenomena during the housing market boom and burst. In this section, I examine where this cashed-out home equity was used, particularly focusing on cash-out refinancing behavior of financially unconstrained households.[3]

[3] In this section, I define the financially unconstrained households as households with financial assets more than 10,000 dollars.

Likelihood of Increasing in Consumption

Cash-out refinancing accompanies real money transaction, and this money should be consumed or go into one of their asset accounts. I first test whether financially unconstrained households use the cashed-out home equity to increase consumption level. To this end, I create the indicating variables whether households increase consumption more than 10 percent and 20 percent compared to previous survey year, and use these indicators to run Probit regression to examine the probability of increasing in consumption is related to cash-out refinancing. Column (1) and (2) in Table 3.5 report the results of Probit regression. As can been seen, the cash-out event has no significant relationship with an increase in consumption, while other factors including change in income level and age are closely related to an increase in consumption level.

Likelihood of Investing in Other Assets

Households should put their cashed-out home equity into one of their asset accounts unless they consume all of the additional borrowing. Using Probit regressions, I examine which accounts households are more likely to invest in. I generate dummy variables which indicate whether net investment in a specific asset is positive. The PSID asks detailed questions regarding their investment activity. For instance, questions regarding stock investment are as follows.

"Did you buy more or sell more–that is, on balance, did you put money into stocks, mutual funds, or investment trusts, take money out of them, or put about as much in as you took out?"

"About how much did you (or anyone in your family living there) put in or take out?"

Using these specific questions on the investment in each asset account, I estimate whether the net investment in each asset is negative or positive. Using these estimated variables, I run Probit regressions to find that the cashed-out households are more probable to invest in specific accounts including stock, IRA, and other real estate. Column (3)-(5) in Table

3.5 describe the result of Probit regressions. The cash-out event reduces the probability of investing in stock and IRA accounts with statistically significances at 0.5% and 0.1% level, respectively. The probability of investing in other real estate, on the other hand, increases when households cash-out their home equity. Additionally, Column (6) shows that cashed-out households are more likely to use the money to repair their home. That is, households pull out home equity and reinvest in home, which increases the value of house. In sum, households that cashed-out home equity are less likely to invest in stocks or IRA accounts, but they are more likely to reinvest in their house and/or invest in other real estate. To investigate the usage of cash-out home equity in more detail, I examine the relationship between the amount of cashed-out home equity and net investment in stocks, IRA accounts, other real estate, and home repairs.

Cashed-out Home Equity and Net Investment in Other Assets

The amount of cashed-out home equity is related to the amount of net investment in a certain asset if households use the cashed-out home equity to invest in other assets. To study the relationship between net investment and the amount of cashed-out home equity, I run the following regression model for cashed-out households.

$$NI_{OtherAssets,t} = \beta_0 + \beta_1 AmountCashedOut_t + \beta_2 Z_t + \epsilon_t \qquad (3.1)$$

where $NI_{OtherAssets}$ is a net investment in other assets, $AmountCashedOut$ is a total amount of cashed-out home equity, and Z is a set of other control variables. Table 3.6 shows the result of the regressions for stock, IRA, other real estate, and home repair. Column (1) shows that the net investment in stock is negatively related to the amount of cashed-out home equity. As households pull out larger amount of money from home equity, the net investment in stock is reduced. On the other hand, there is no significant relationship between the net investment in IRA and the cashed-out amount. Other real estate investment and home repair expense are positively and statistically significantly related to the amount of cashed-out home equity, which is consistent with the result of Probit regression above. More specifically, since households that cashed-out and invested in other real estate pulled out $71,728 from home equity on average from 2001 to 2007, $32,421 dollars were invested in other real estate. If we assume that the LTV ratio for other real estate investment is 75 percent, cashed-out households can invest in other real estates with total value 130,000 dollars approximately.[4] As households invest in other real estate using cashed-out home equity, households take a greater leverage position in real estate market, which makes their portfolio performance more responsive to house price fluctuations.

Home Equity Share and Real Estate Share after Cashing-out

The previous results show that cashed-out households are more probable to invest in other real estate and the amount of cashed-out home equity is related to the net investment in other real estate. In addition, I examine whether the investment behavior of cashed-out households affects the asset composition so that the exposure to housing market risk changes through cash-out refinancing. I first estimate the participation rate in other real estate investment and the share of other real estate in total wealth by cash-out status. Figure 3.6 shows that the share of other real estate for cashed-out households increases rapidly compared to non cashed-out households before 2007, while there is no certain pattern in the participation rate. This figure is consistent with the result of the previous analysis, that is, cashed-out households use their home equity to invest more aggressively in real estate market.[5]

[4] The PSID does not provide the LTV ratio for other real estate investment. I, instead, use the average LTV ratio from 2001 to 2007 based on the conventional single family mortgage data from the Federal Housing Finance Agency.

[5] Since Figure 3.6 shows the simple difference in average real estate share between cashed-out and non-cashed out households for every survey year, I cannot track the long-term effect of cash-out refinancing, and there could be a selection bias issue. In the following section, I focus on individual level variations to control for individual level characteristics.

3.5 Cash-out Refinancing and Home Equity Rebalancing

Cash-out refinancing affects household asset composition. First of all, households can reduce the share of home equity in total wealth as they increase the debt against house. Secondly, the cashed-out home equity can increase the share of other assets in total wealth if households use the cashed-out money to save or invest in other assets. In this section, I examine how households rebalance their portfolio including home equity through cash-out refinancing.

3.5.1 Change in Home Equity Share

The portion of home equity in total household wealth varies across time because of variation in house value, mortgage balance, and non-housing wealth. Table 3.7.A shows the change in home equity share in total wealth over the survey periods. As can be seen, throughout the survey period, home equity share was decreasing, while home equity share decreased more rapidly after the financial crisis in 2008. Home equity share was decreasing over time even during the housing market boom because most homeowners held mortgages against their home and paid off the mortgage balance gradually and the portion of other assets in total wealth increased over time as homeowners kept saving and investing in other asset. The change in home equity share is also summarized by cash-out status in Table 3.7.A. The change in home equity share has a negative value for both cashed-out and non cashed-out households. However, the magnitude is significantly higher for cashed-out homeowners. It is because the home equity share decreases more rapidly as homeowners increase mortgage balance through cash-out refinancing.

Passive and Active Change in Home Equity Share

A change in home equity share is composed of passive and active changes. The fluctuation in house price causes passive change in home equity share, while households change their home equity share actively by adjusting mortgage balance and increasing (or decreasing) other asset accounts. By decomposing active and passive changes in home equity share, we can understand how households actively respond to passive change in home equity share. I decompose the passive and active change in home equity share using current and previous self-reported house value, mortgage balance, and non-housing wealth. The passive ($\theta^P_{H,t}$) and active ($\theta^A_{H,t}$) change in home equity share are defined as follows.[6]

$$\Delta\theta^P_{H,t} = \theta^P_{H,t} - \theta_{H,t-1}$$

$$\Delta\theta^A_{H,t} = \theta_{H,t} - \theta^P_{H,t}$$

where $\theta_{H,t}$ and $\theta_{H,t-1}$ are the home equity share in total wealth at t and $t-1$, respectively. $\theta^P_{H,t}$ is the passive home equity share, which is estimated as follows.

$$\theta^P_{H,t} = \frac{P_t H_t - Mortgage_{t-1} - Repair_t}{P_t H_t - Mortgage_{t-1} - Repair_t + W^P_{t-1}}$$

where P_t is a house price per unit at t, H_t is number of unit invested in house at t, $Mortgage_{t-1}$ is a total mortgage at $t-1$, $Repair_t$ is a repair expense on house between t and $t-1$, and W^P_{t-1} is the value of total non-housing wealth at $t-1$. Since current mortgage balance reflects homeowner's active response to house price change, the previous mortgage balance is used for calculating passive home equity share. Additionally, the home repair expense is subtracted because the home repair can significantly increase the value of house, which is considered as an active investment on the house. Therefore, passive home equity share only captures the change in home equity share caused by the change in value of house.

Using this definition, I estimate the passive and active change in home equity share for each survey year as in Table 3.7.B and Table 3.7.C. The passive change in home equity share was positive from 2001 to 2007, but turned into negative after 2009. There was a significant

[6] When I estimate the passive and active change in home equity share, I confine sample to households which do not move and resize their home in order to concentrate on the role of mortgage refinancing in portfolio rebalancing.

difference in the passive share change between cashed-out and non cashed-out households. For example, the passive change in home equity share of cashed-out households in 2007 was 0.053, which is more than twice of the passive change of non cashed-out households, 0.025. This pattern explains that cashed-out households experienced more appreciation in house value so that they had more incentive to pull out the home equity during the housing market boom. Based on this basic finding regarding the passive and active change in home equity share, I examine home equity rebalancing behavior in detail below.

3.5.2 Home Equity Share Rebalancing

Every household has their own optimal portfolio choice based on their risk preference and socio-economic condition such as income, wealth, age, and family composition. Because asset price fluctuates frequently, households should rebalance their portfolio to maintain the optimal share of each asset. *Calvet et al.* (2009) study portfolio rebalancing behavior using Swedish data and show that households negatively response to passive change in stock share. In other words, households tend to restore their previous optimal position as they actively adjust their risky share. However, this study only considers the rebalancing of stock share in financial asset, as most studies regarding optimal portfolio share usually do. The role of house in household's portfolio should not be underestimated since house, on average, takes the largest portion in homeowner's total asset, even after subtracting mortgage debt. Particularly, during the housing market boom and burst in 2000's, the portfolio share of each asset can be significantly affected by house price fluctuation. Several papers examine the effect of home equity on portfolio choice. In general, these studies conclude that a homeownership or an investment in housing asset reduces a stock share due to a substitution effect. This substitution effect results from the fact that households consider a house as a risky asset. Therefore, homeowners are expected to respond to house price change as well as stock price change in order to maintain their optimal portfolio share. However, households are more likely to be passive regarding home equity share change because resizing house involves large transaction costs including realtor fee, taxes, and moving expense. Additionally, because a house directly affects households' utility as durable goods consumption, the resizing decision is more complicated than any other investment. Consequently, household is reluctant to adjust their home equity share actively in the presence of various frictions. However, as mortgage markets grow remarkably, households can change home equity share actively without change their house size. The net equity on housing asset is determined by house value subtracted by mortgage debt. Households reduce home equity share as they borrow mortgage more against a house while paying monthly mortgage bill increases home equity share. That is, households can rebalance their home equity share more aggressively as they cash-out from their home equity.

Following the methodology in *Calvet et al.* (2009), I examine how households actively adjust home equity share especially using the cash-out refinancing. Particularly, I use the following rebalancing regression as *Calvet et al.* (2009) use to examine the stock share rebalancing behavior.

$$\Delta\theta^{A}_{H,t} = \beta_0 + \beta_1 \Delta\theta^{P}_{H,t} + \beta_2(\theta_{H,t-1} - \overline{\theta_{H,t-1}}) + \epsilon_t$$

where $\theta^{A}_{H,t}$ and $\theta^{P}_{H,t}$ are the active and passive change in home equity share between t and $t-1$, $\theta_{H,t-1}$ is the home equity share at $t-1$, and $\overline{\theta_{H,t-1}}$ is the average home equity share at $t-1$. The regression coefficient β_1 shows how actively homeowner rebalance their home equity share responding to passive home equity share change. I run this regression before 2007 and after 2007 separately, and report the results in the first two columns in Table 3.8. The coefficient on the the passive home equity change in the column (1) is -0.601, which means that households, whose average passive home equity change is 0.032, reduce their home equity actively by 0.019 before 2007. After 2007, households, whose average passive home equity share change is -0.036, increase their home equity actively by 0.029. Column (3) to (6) in Table 3.8 report the result of the regression for cashed-out and non-cashed-out households separately. As shown in the table, before 2007, the cashed-out households respond more aggressively to the passive change in home equity share. Cashed-out households, whose average passive home equity share change is 0.049, reduce home equity shares by 0.031, while non cashed-out households, whose average is 0.027, reduce the home equity share by 0.015. On the other hand, after 2007, non cashed-out households respond more aggressively to a decrease in passive home equity share. The passive changes in home equity shares for cashed-out and non cashed-out households are -0.043 and -0.034 on average after 2007. Therefore, they reduce home equity share by 0.025 and 0.030, respectively, on average. As home equity share increases rapidly during the booming housing market, households tend to reduce their home equity share actively. This rebalancing behavior appears more strongly among cashed-out households, whose average home equity increases more than the average of non cash-out households. That is, they reduce home equity share more aggressively responding to an increase in home equity share through cash-out refinancing.

3.5.3 Real Estate Share Rebalancing

Households are exposed to housing market risk as they own home and invest in other real estate. Even though homeowners' total wealth increases during housing market boom, due to the role of housing asset as durable goods, it is difficult to enjoy real gain from housing investment unless they reduce the size of their main residence. Instead, households, which expect high return on housing market, can purchase other real estate such as second home and rental properties to earn realizable gain from real estate investment. In that case, households are exposed to an additional real estate market risk. To examine households' real exposure to real estate market, I introduce a real estate share, which is the sum of home equity share and other real estate share. In the previous section, I find that households that cash out their home equity are more likely to invest in other real estate. This investment increases a real estate share, while the cash-out reduces it. The home equity rebalancing regression above shows that cashed-out households reduce home equity share more aggressively. However, it is unclear whether households reduce the real exposure to real estate market as they cash-out because they can invest in other real estate using cashed-out home equity. I run a real estate share rebalancing regression to find how households actively change a real estate share responding to the passive change in real estate share. To this end, I first define passive real estate share as follows.

$$\theta^P_{R,t} = \frac{P_tH_t - Mortgage_{t-1} - Repair_t + RealEst_t - NI_{RealEst,t}}{P_tH_t - Mortgage_{t-1} - Repair_{t-1} + RealEst_t - NI_{RealEst,t} + W^P_{NonRealEst,t-1}}$$

where $RealEst_t$ is a net value of other real estate at t, $NI_{RealEst,t}$ is a net investment in other real estate between t and $t-1$, and $W^P_{NonRealEst,t-1}$ is the value of total non-real estate wealth at $t-1$, and definitions for other variables are the same as for the passive home equity share. Since the PSID only provides the net value of other real estate, I cannot distinguish the effect of mortgage balance change from asset value change for other real estate. Instead, I use the amount of net investment in other real estate to rule out the effect of active change. Definitions of the passive real estate change ($\Delta\theta^P_{R,t}$) and the active real estate change ($\Delta\theta^A_{R,t}$) are similar as for home equity.

Using these passive and active real estate change, I run the real estate share rebalancing regression as follows.

$$\Delta\theta^A_{R,t} = \beta_0 + \beta_1\Delta\theta^P_{R,t} + \beta_2(\theta_{R,t-1} - \overline{\theta_{R,t-1}}) + \epsilon_t$$

where $\Delta\theta^A_{R,t}$ and $\Delta\theta^P_{R,t}$ are the active and passive change in real estate share between t and $t-1$, $\theta_{R,t-1}$ is the real estate share at $t-1$, and $\overline{\theta_{R,t-1}}$ is the average real estate share at $t-1$. Table 3.9 shows the result of the regression. Column (1) and (2) show that the coefficients on the passive real estate change before and after 2007 are both negative, -0.440 and -0.393, respectively. Since the average passive change in real estate share before and after 2007 were 0.010 and -0.079, households reduced real estate share by 0.004 before 2007, but increased the share by 0.031 after 2007. The difference in real estate share rebalancing behavior between cashed-out and non cashed-out households is reported in Column (3)-(6). Interestingly, there is no significant difference in coefficients on passive real estate change between cashed-out and non cashed-out households, which is distinguished from the result of home equity share rebalancing regression in the previous section. Non cashed-out households, whose passive real estate share is increased by 0.038 on average, reduce 66.7 percent of the increase. Cashed-out households, which reduce their home equity share more aggressively, respond less actively to real estate share change. On average, the real estate share of cash-out households is increased by 0.044 and they actively reduce the share by 0.021. This result supports the idea that cashed-out households use their home equity to invest in other real estate. Cashed-out households seem to decrease their home equity more aggressively, however, because of increasing in other real estate share, their exposure to real estate market is not reduced in fact. After all, this real estate rebalancing behavior makes cashed-out households exposed more in housing market risk compared to the non cashed-out households.

3.6 Discussion

This paper provides evidence that the cashed-out home equity, which dramatically increased during the housing market boom in 2000's, was partly used for investing in other real estate.[7]. Cash-out refinancing makes households enable to decrease the home equity share, but increase the leverage ratio at the same time. Households enjoy greater leverage effect on real estate investment by investing in other real estate using cashed-out home equity. However, the increased leverage position to real estate market makes households vulnerable to housing market risk. Table 3.10 compares the average returns on total wealth by cash-out and other real estate investment status before and after the financial crisis. Before the financial crisis, households that cashed-out and invested in other real estate experienced the greatest appreciation in their total wealth. However, after the financial crisis, their total wealth decreased

[7]Since the analysis of this paper is based on survey data, the aggregate effect of cash-out refinancing cannot be estimated precisely. However, owing to the national representativeness of sample in the PSID data, the finding in this paper helps us understand the effect of cash-out refinancing on our aggregate economy.

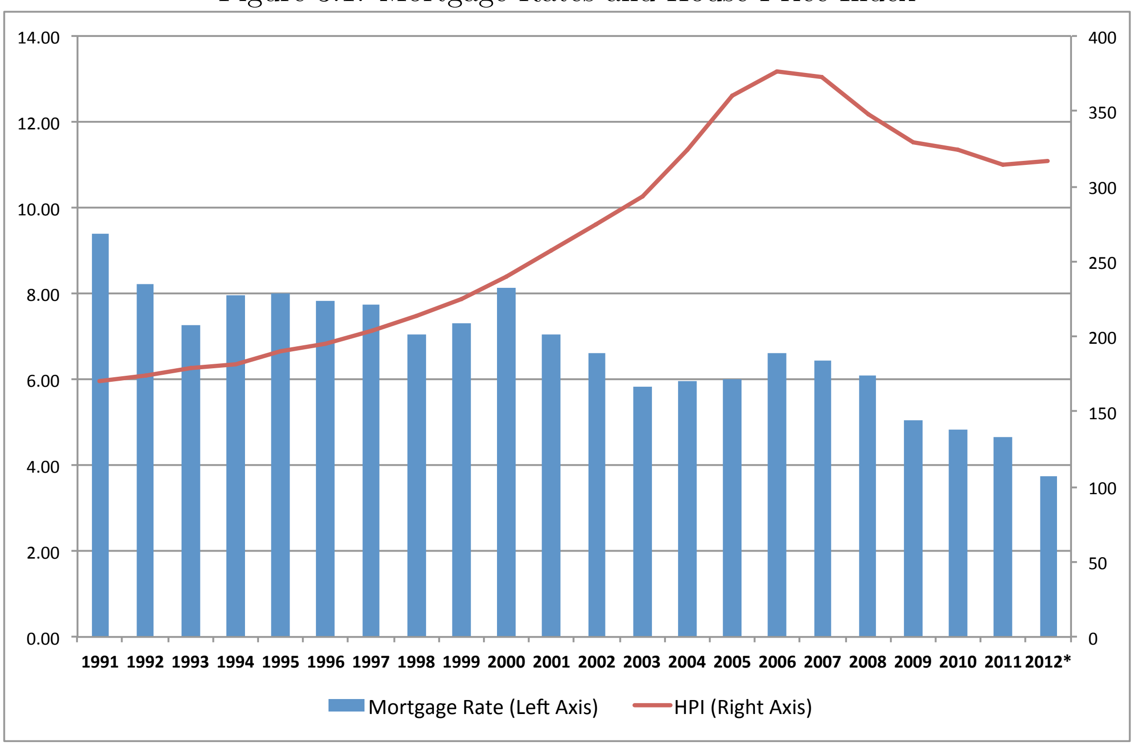
the most. This summary statistics partially support the idea that households that invested in other real estate using cashed-out home equity experienced a large appreciation in asset value, but suffered more when housing market crashed during the financial crisis.

As the literature points out, a variation in leverage and collateral constraints are important factors that explain asset prices and macroeconomic dynamics (*Kiyotaki and Moore*, 1997; *Bernanke et al.*, 1999; *Geanakoplos*, 2010). Additionally, many studies find evidence that the excessive credit supply caused by mortgage market expansion is associated with the rapid increase in house price (*Coleman et al.*, 2008; *Wheaton and Nechayev*, 2008; *Glaeser et al.*, 2010; *Pavlov and Wachter*, 2011; *Brueckner et al.*, 2012). This paper provides evidence that a dramatic increase in cash-out refinancing was related to an aggressive investment in real estate market, which is another channel that amplifies the leverage effect. By examining this relationship further in detail, we can understand the housing market bubble and burst in 2000's more precisely.

3.7 Conclusion

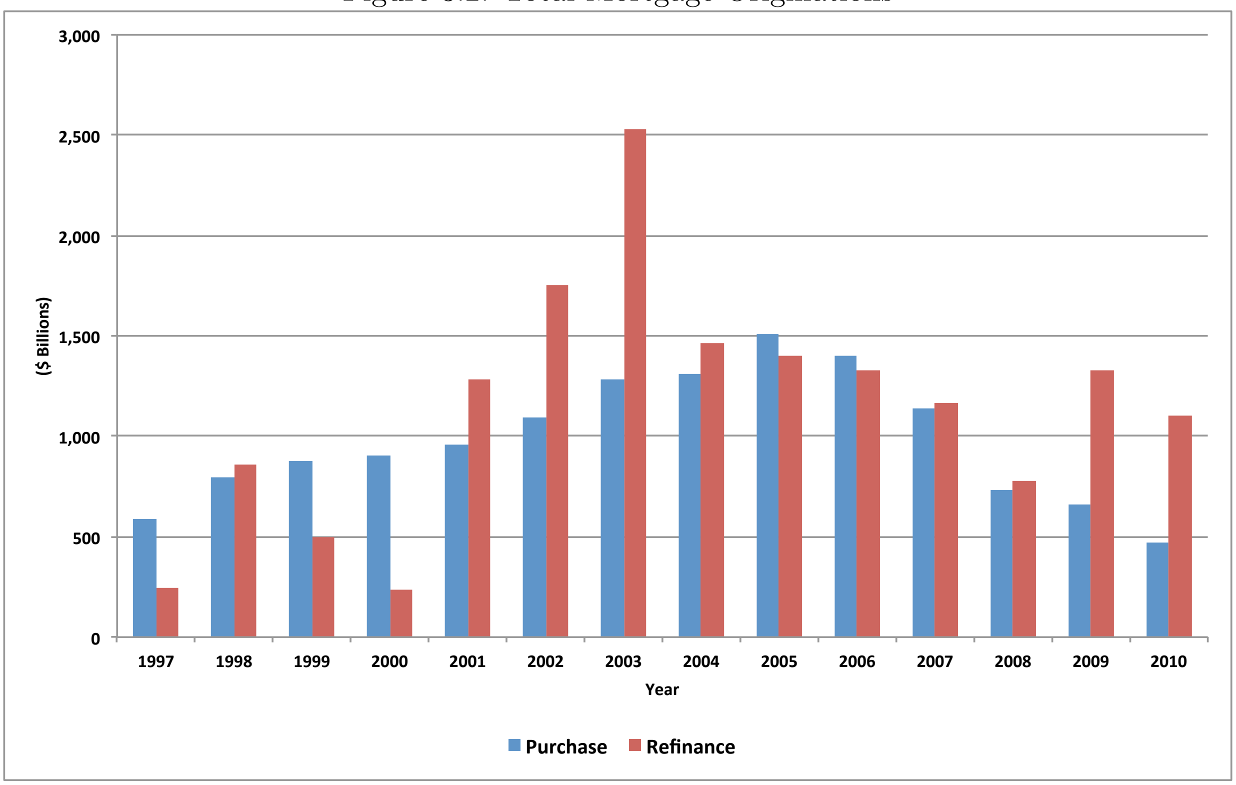
For most homeowners, their housing asset accounts for the largest portion of their total assets. As the mortgage market expands and housing value increases, households have more opportunities to extract a home equity. Since household consumption and investment decisions are one of the most important influence on our economy, it is important to examine how households use their home equity. The relation between household consumption and cash-out refinancing has been examined previously, especially for financially constrained households. However, the cash-out refinancing motive for financially unconstrained households was not considered even though the amount they cashed-out were not negligible. I find that financially unconstrained households also cashed out large amount of home equity during the housing market boom in early 2000s, and were probable to use their home equity to increase their investment in other real estate. Households whose share of home equity in their total assets is lower than other wealthy households have an incentive to participate more in the housing or real estate market to increase an exposure to real estate market. Before the mortgage market crisis, housing market looked solid as well as profitable. Therefore, prior to the crisis, increasing the share of real estate seemed reasonable if investment opportunity existed. However, this over-investment based on expansion of mortgage market finally resulted in the housing market collapse and households that aggressively invested in real estate market using their home equity were suffering from decreasing values of the largest portion of their portfolio.

Figure 3.1: Mortgage Rates and House Price Index



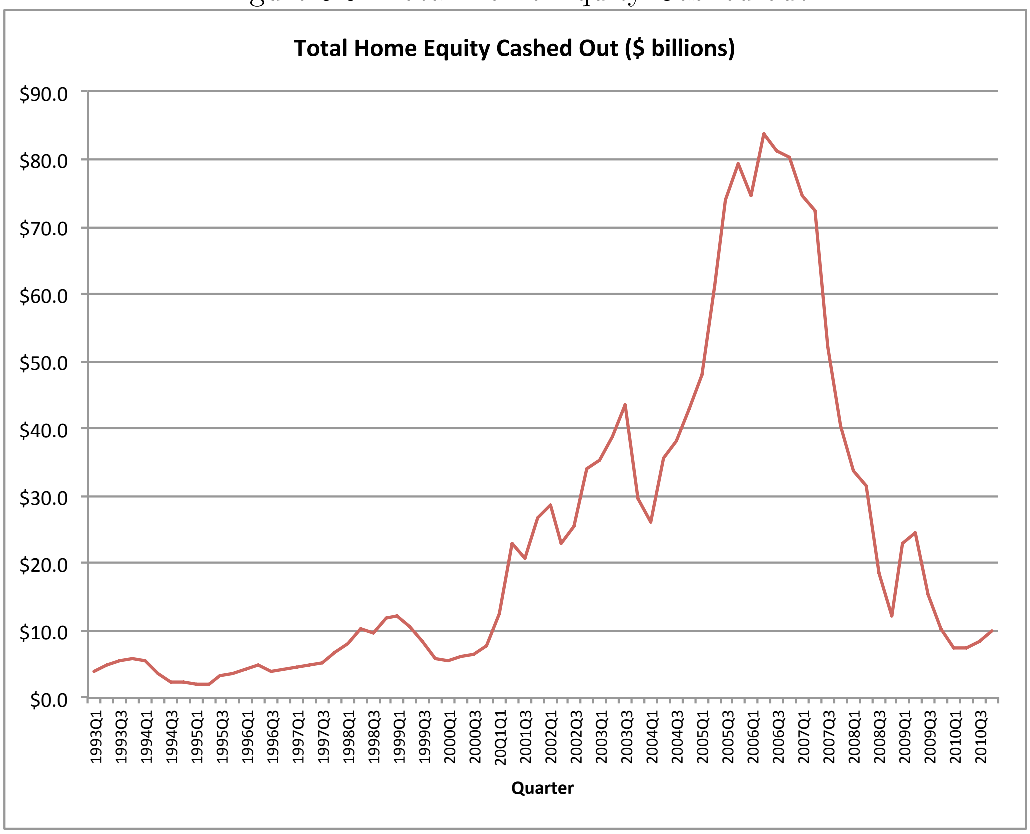
Note: Mortgage interest rates and house price index are from Federal Housing Finance Agency.

Figure 3.2: Total Mortgage Originations



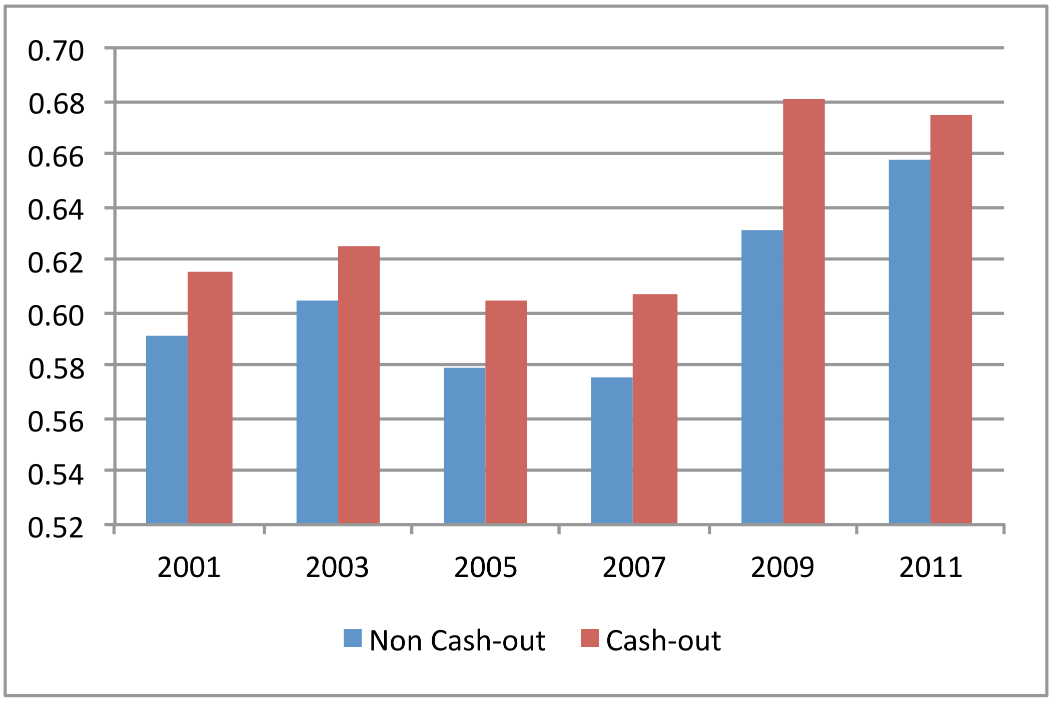
Note: Mortgage originations data is from the National Data Book published by U.S. Census Bureau.

Figure 3.3: Total Home Equity Cashed-out



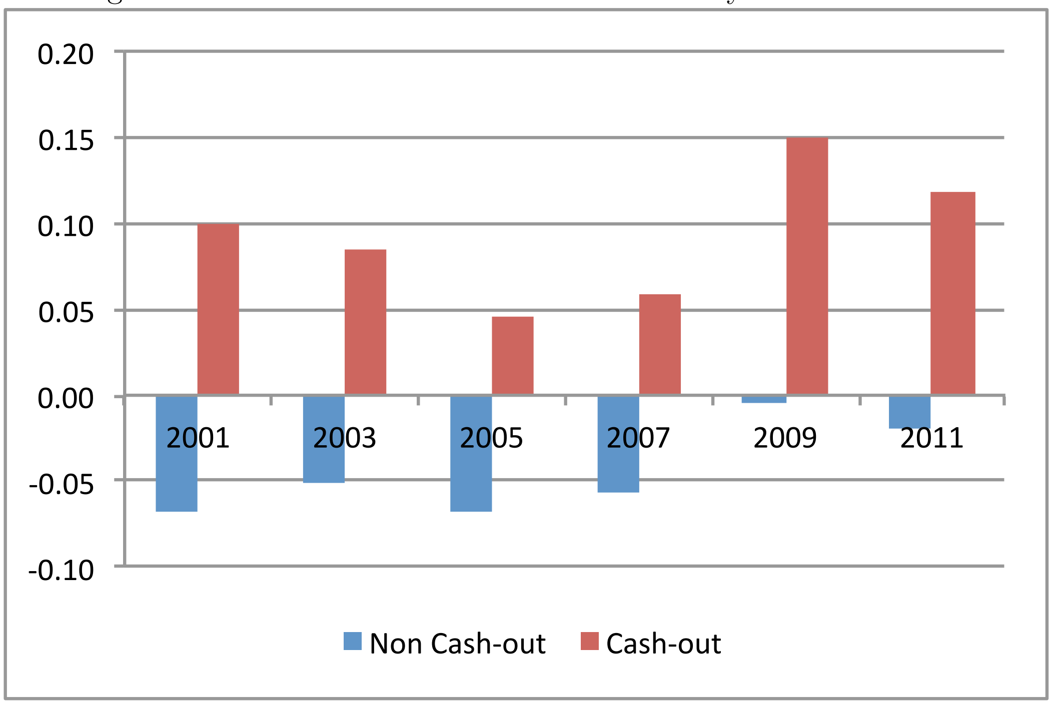
Note: This graph is based on the Cash-Out Refinance Report by Freddie Mac. Total home equity cashed-out represents the total amount homeowners extracted through the refinance of prime, first-lien conventional mortgages. It does not consider the refinance of FHA loans, VA loans, or subprime mortgages.

Figure 3.4: Average Loan-to-Value Ratio by Cash-out Status



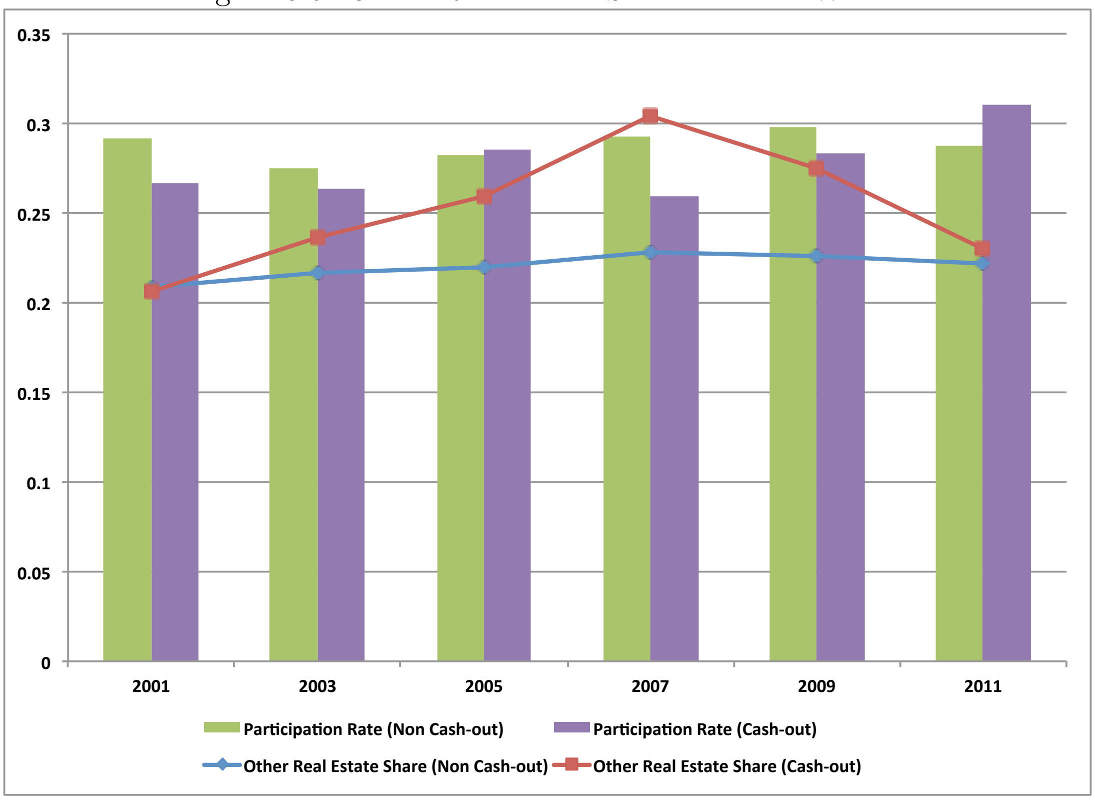
Note: This graph is based on the author's estimation using the PSID from 1999 to 2011. The LTV ratio is estimated by dividing total mortgage amount by self-reported house value. Total mortgage amount includes 1st and 2nd mortgage balance as well as home equity loan.

Figure 3.5: Difference in Loan-to-Value Ratio by Cash-out Status



Note: This graph is based on the author's estimation using the PSID from 1999 to 2011. The LTV ratio is estimated by dividing total mortgage amount by self-reported house value. Total mortgage amount includes 1st and 2nd mortgage balance as well as home equity loan.

Figure 3.6: Other Real Estate Share in Total Wealth



Note: This graph is based on the author's estimation using the PSID from 1999 to 2011. The participation rate implies the portion of households that hold other real estate including second home and rental property among entire sample. Other real estate share is estimated by dividing the value of other real estate share by the value of total wealth, conditional on participation.

Table 3.1: Summary Statistics

	Year						
	2001	2003	2005	2007	2009	2011	Total
Total Wealth							
Mean	203,702	212,865	272,027	315,576	275,616	266,892	258,480
S.D.	281,903	298,950	383,782	452,972	431,126	411,961	385,267
Median	96,550	99,500	124,000	143,000	117,000	110,000	114,000
1st Quartile	36,850	37,550	46,100	51,500	38,000	36,200	41,000
3rd Quartile	247,600	259,400	330,750	373,000	322,000	309,400	305,000
Total Non-housing Wealth							
Mean	127,000	124,702	154,716	180,856	166,215	165,345	153,473
S.D.	231,057	233,164	296,435	347,273	344,895	331,136	302,800
Median	32,300	32,000	34,501	39,000	34,000	31,100	33,500
1st Quartile	6,500	6,000	6,500	7,400	5,392	5,000	6,000
3rd Quartile	138,500	126,750	159,500	182,500	161,000	160,375	154,000
Total Financial Assets							
Mean	43,834	40,711	46,361	51,162	46,402	44,820	45,580
S.D.	106,928	99,477	120,581	132,910	127,485	129,859	120,373
Median	3,000	4,000	3,000	3,500	3,000	2,000	3,000
1st Quartile	-500	-600	-1,500	-2,000	-3,500	-4,000	-1,999
3rd Quartile	35,500	36,000	35,000	40,000	40,000	33,000	36,000
House Value							
Mean	133,942	155,572	199,212	227,488	206,063	190,342	185,948
S.D.	99,470	120,082	165,975	181,636	154,511	140,195	149,967
Median	110,000	125,000	150,000	175,000	165,000	150,000	145,000
1st Quartile	65,000	75,000	86,000	98,000	100,000	90,000	83,000
3rd Quartile	175,000	200,000	250,000	300,000	270,000	250,000	250,000
Mortgage							
Mean	60,034	70,103	78,680	86,150	91,062	87,464	79,030
S.D.	65,647	75,415	83,948	90,969	94,028	93,166	85,274
Median	45,000	52,000	58,900	63,000	69,000	65,000	57,946
1st Quartile	0	0	0	0	0	0	0
3rd Quartile	94,000	110,000	125,000	140,000	150,000	142,418	125,000
Total Income							
Mean	67,304	66,940	72,180	78,501	83,122	80,085	74,800
S.D.	49,577	46,005	50,783	55,903	57,769	55,628	53,193
Median	56,000	56,489	60,930	66,255	71,000	68,050	63,015
1st Quartile	33,000	34,000	36,135	39,000	42,156	39,400	37,000
3rd Quartile	87,700	89,000	94,600	101,532	107,285	105,700	98,031
Total Non-durable Consumption							
Mean	13,566	13,920	15,938	17,500	17,200	18,289	16,099
S.D.	7,763	8,023	9,115	9,683	9,674	10,062	9,282
Median	11,827	12,148	13,810	15,434	15,228	16,482	14,080
1st Quartile	8,445	8,536	9,793	10,880	10,585	11,260	9,720
3rd Quartile	16,596	17,240	19,840	21,920	21,400	23,070	20,140

Note: The number is reported in nominal US dollars. All values are winsorized at bottom 1 percent and top 1 percent level.

Table 3.2: Cashed-out Refinancing Statistics

I. Portion of Cashed-out Households

	Year						
	2001	2003	2005	2007	2009	2011	Total
Homeowners	0.253	0.293	0.274	0.262	0.257	0.221	0.260
Mortgage Holders	0.345	0.397	0.370	0.356	0.345	0.306	0.354
Homeowners & Financial Asset less than 10,000	0.292	0.314	0.296	0.304	0.287	0.241	0.289
Homeowners & Financial Asset more than 10,000	0.194	0.260	0.241	0.200	0.210	0.187	0.216
Mortgage Holders & Financial Asset less than 10,000	0.371	0.397	0.371	0.383	0.358	0.312	0.365
Mortgage Holders & Financial Asset more than 10,000	0.298	0.398	0.367	0.308	0.322	0.294	0.332

II. Amount of Total Home Equity Cashed-out

		Year						
		2001	2003	2005	2007	2009	2011	Total
Total	Mean	24,635	27,790	35,014	40,482	39,303	30,273	32,996
	S.D.	29,866	32,471	47,959	52,330	66,954	45,526	47,645
	Obs.	815	1,066	980	928	874	760	5,423
Financial Asset less than 10000	Mean	21,776	25,228	27,462	36,195	33,594	25,418	28,399
	S.D.	25,623	28,757	34,499	46,477	55,994	39,628	39,981
	Obs.	556	654	610	630	557	496	3,503
Financial Asset more than 10000	Mean	30,772	31,856	47,464	49,544	49,335	39,394	41,385
	S.D.	36,694	37,299	62,357	62,057	81,911	53,830	58,205
	Obs.	259	412	370	298	317	264	1,920

Table 3.3: Portion of Cashed-out Home Equity in Assets, Income, and Consumption

Year		Wealth inc. Home Equity	Wealth excl. Home Equity	Financial Asset	House	Household Income	Non-durable Consumption
2001	Mean	0.442	1.270	2.666	0.205	0.436	1.955
	S.D.	0.971	5.494	20.423	0.211	0.539	2.358
	Median	0.153	0.250	0.135	0.128	0.248	1.159
2003	Mean	0.354	1.107	1.731	0.170	0.442	2.020
	S.D.	0.952	4.148	14.516	0.171	0.556	2.354
	Median	0.135	0.238	0.217	0.117	0.252	1.200
2005	Mean	0.349	1.252	1.980	0.163	0.494	2.035
	S.D.	0.915	5.073	14.725	0.170	0.631	2.309
	Median	0.135	0.271	0.237	0.108	0.267	1.217
2007	Mean	0.353	1.461	2.390	0.170	0.517	2.292
	S.D.	0.929	5.955	18.865	0.174	0.615	2.689
	Median	0.151	0.318	0.200	0.111	0.304	1.316
2009	Mean	0.273	1.285	3.103	0.154	0.450	2.047
	S.D.	0.980	5.054	18.418	0.173	0.614	2.681
	Median	0.108	0.213	0.171	0.087	0.215	1.097
2011	Mean	0.190	0.867	2.481	0.132	0.369	2.468
	S.D.	0.972	4.246	16.210	0.150	0.537	2.861
	Median	0.073	0.156	0.100	0.080	0.183	1.346
Total	Mean	0.331	1.213	2.355	0.167	0.455	2.126
	S.D.	0.954	5.027	17.180	0.177	0.587	2.541
	Median	0.125	0.240	0.181	0.104	0.242	1.221

Table 3.4: Determinants of Cash-out Refinancing

	(1)	(2)	(3)	(4)	(5)
	All	Fin. Wealth	Fin. Wealth	Fin. Wealth	Fin. Wealth
	All	≤ 10,000	¿ 10,000	≤ 10,000	¿ 10,000
ΔHouseValue(%)	0.830***	0.861***	0.841***	1.145***	1.276***
	[0.053]	[0.066]	[0.091]	[0.195]	[0.248]
Previous LTV	-1.162***	-1.383***	-0.912***	-2.276***	-1.659***
	[0.061]	[0.077]	[0.104]	[0.212]	[0.267]
Remaining Mortgage Period	0.047***	0.049***	0.045***	0.059***	0.045***
	[0.002]	[0.002]	[0.003]	[0.006]	[0.007]
Difference between Original Rate and Current Rate (First Mortgage)	0.053***	0.043***	0.070***	-0.028	0.027
	[0.007]	[0.008]	[0.013]	[0.032]	[0.048]
Previous Home Equity Share	0.155***	0.105***	0.265***	0.063	0.202
	[0.028]	[0.032]	[0.070]	[0.077]	[0.153]
Whether 2nd Mortgage	0.797***	0.764***	0.857***		
	[0.032]	[0.040]	[0.053]		
Whether Other Debt	0.116***	0.035	0.206***	0.028	0.308***
	[0.024]	[0.032]	[0.040]	[0.083]	[0.101]
Difference between Original Rate and Current Rate (2nd Mortgage)				-0.007	-0.010
				[0.014]	[0.025]
ΔIncome(%)	0.014	0.022	-0.015	0.141	0.219*
	[0.030]	[0.038]	[0.049]	[0.111]	[0.128]
Total Income (in $10,000)	-0.011***	-0.011***	-0.007*	-0.023***	-0.010
	[0.003]	[0.004]	[0.004]	[0.009]	[0.009]
Total Wealth (in $10,000)	-0.002***	-0.002*	-0.000	-0.005*	0.001
	[0.001]	[0.001]	[0.001]	[0.003]	[0.002]
Age	0.021***	0.025***	0.007	0.014	0.017
	[0.007]	[0.009]	[0.012]	[0.027]	[0.035]
Age Squared	-0.000***	-0.000***	-0.000	-0.000	-0.000
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Constant	-1.168***	-1.050***	-1.162***	0.677	-0.006
	[0.182]	[0.224]	[0.328]	[0.661]	[0.948]
Observations	12,726	7,716	5,010	1,275	717
Chi-squared	2144.91	1258.97	886.09	231.70	105.47
Pseudo Rsquared	0.13	0.12	0.14	0.14	0.11

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

Table 3.5: Probit Regression Estimating the Probability of Investing in Assets

Probit Reg. Dependent Var.	**ΔCons>10%**	**ΔCons>20%**	**Stck Inv.>0**	**IRA Inv.>0**	**Real Est Inv.>0**	**Home Repair > 0**
1(Cash-out)	-0.033	0.008	-0.145**	-0.158***	0.099*	0.341***
	[0.033]	[0.034]	[0.063]	[0.034]	[0.051]	[0.035]
ΔIncome (%)	0.205***	0.207***	-0.157***	-0.095***	-0.046	-0.115***
	[0.025]	[0.026]	[0.047]	[0.027]	[0.042]	[0.030]
Total Income (in $100,000)	-0.001	-0.002	0.046***	0.031***	0.025***	0.038***
	[0.002]	[0.003]	[0.004]	[0.002]	[0.004]	[0.003]
Total Wealth (in $100,000)	0	0	0.005***	0.005***	0.004***	0.003***
	[0.000]	[0.000]	[0.001]	[0.000]	[0.001]	[0.000]
Age	-0.007***	-0.012**	-0.012***	0.073***	0.014	0.047***
	[0.001]	[0.005]	[0.002]	[0.006]	[0.009]	[0.006]
Age Squared	0.000**	0	0.000***	-0.001***	-0.000**	-0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.271***	0.179	-1.609***	-2.426***	-2.246***	-2.733***
	[0.061]	[0.128]	[0.109]	[0.148]	[0.227]	[0.168]
Obs.	11044	11044	12316	12316	12316	12300
Chi-squared	1083.94	894.91	417	1187.11	229.02	706.61
Pseudo Rsquared	0.07	0.07	0.11	0.09	0.05	0.07

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

Table 3.6: Regression of Net Investments on Mortgage Balance Change

Dependent Var.	(1)	(2)	(3)	(4)
Net Investment In	Stock	IRA	Real Estate	Home Repair
Amount of Cashed-out Home Equity	-0.274*	0.013	0.452***	0.028**
	[0.152]	[0.016]	[0.145]	[0.012]
ΔIncome (%)	-7,913	104	-25,295	-386
	[14,930]	[1,934]	[20,078]	[1,293]
Total Income (in $100,000)	672.97	346.20**	1,178.94	98.86
	[1,171.34]	[161.70]	[1,748.47]	[111.73]
Total Wealth (in $100,000)	-208.13	27.52	703.88***	14.26
	[218.14]	[23.92]	[246.72]	[18.09]
Age	-695	1,341***	6,028	-194
	[3,690]	[456]	[5,189]	[324]
Age Squared	8.079	-15.291***	-67.582	0.858
	[35.594]	[4.291]	[50.815]	[3.088]
Year F.E.	Yes	Yes	Yes	Yes
Constant	42,173	-24,286**	-193,375	25,411***
	[98,175]	[11,861]	[130,475]	[8,315]
Obs.	94	544	160	368
Rsquared	0.08	0.1	0.23	0.04
Adj Rsquared	-0.05	0.08	0.18	0.01

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

Table 3.7: Change in Home Equity Share

			Year						
			2001	2003	2005	2007	2009	2011	Total
A. Change in Home Equity Share	Non Cash Out	Mean	-0.026	-0.020	-0.009	-0.037	-0.059	-0.068	-0.037
		S.D.	0.269	0.312	0.250	0.297	0.302	0.327	0.295
	Cash Out	Mean	-0.113	-0.080	-0.098	-0.125	-0.183	-0.168	-0.125
		S.D.	0.409	0.366	0.357	0.371	0.455	0.569	0.421
	Total	Mean	-0.044	-0.036	-0.032	-0.055	-0.086	-0.088	-0.057
		S.D.	0.305	0.328	0.284	0.316	0.345	0.388	0.330
B. Change in Home Equity Share (Passive)	Non Cash Out	Mean	0.024	0.023	0.036	0.025	-0.048	-0.021	0.005
		S.D.	0.143	0.102	0.105	0.088	0.231	0.274	0.177
	Cash Out	Mean	0.052	0.041	0.054	0.053	-0.050	-0.034	0.022
		S.D.	0.203	0.159	0.209	0.161	0.226	0.316	0.217
	Total	Mean	0.029	0.028	0.041	0.030	-0.048	-0.023	0.009
		S.D.	0.156	0.121	0.139	0.107	0.230	0.281	0.187
C. Change in Home Equity Share (Active)	Non Cash Out	Mean	-0.050	-0.023	-0.042	-0.055	-0.002	-0.039	-0.035
		S.D.	0.235	0.222	0.221	0.213	0.329	0.403	0.283
	Cash Out	Mean	-0.158	-0.129	-0.149	-0.168	-0.150	-0.082	-0.140
		S.D.	0.296	0.271	0.248	0.305	0.441	0.638	0.377
	Total	Mean	-0.070	-0.052	-0.069	-0.077	-0.032	-0.047	-0.058
		S.D.	0.250	0.241	0.233	0.238	0.359	0.454	0.309

Table 3.8: Home Equity Share Rebalancing Regression

Dependent Var.	All		Cashed-out		Non Cashed-out	
ΔActive Real Est Share	2001-2007	2009-2011	2001-2007	2009-2011	2001-2007	2009-2011
	(1)	(2)	(3)	(4)	(5)	(6)
ΔPassive Real Est Share	-0.601***	-0.815***	-0.631***	-0.589***	-0.552***	-0.891***
	[0.019]	[0.023]	[0.038]	[0.071]	[0.022]	[0.021]
Previous Home Equity Share (Demeaned)	-0.636***	-0.666***	-0.651***	-0.710***	-0.618***	-0.643***
	[0.009]	[0.018]	[0.022]	[0.060]	[0.010]	[0.016]
Total Income (in $100,000)	0.005***	0.003***	0.006***	0.005*	0.005***	0.003***
	[0.000]	[0.001]	[0.001]	[0.003]	[0.000]	[0.001]
Total Wealth (in $100,000)	-0.003***	-0.002***	-0.003***	-0.003***	-0.003***	-0.002***
	[0.000]	[0.000]	[0.000]	[0.001]	[0.000]	[0.000]
Age	0.003***	0.013***	0.004	0.014	0.002***	0.013***
	[0.000]	[0.002]	[0.003]	[0.010]	[0.000]	[0.002]
Age Squared	-0.000***	-0.000***	-0.000	-0.000	-0.000***	-0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Constant	-0.175***	-0.445***	-0.300***	-0.511*	-0.121***	-0.423***
	[0.013]	[0.068]	[0.086]	[0.265]	[0.013]	[0.062]
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5468	2815	1251	524	4217	2291
R-squared	0.49	0.48	0.43	0.27	0.51	0.59
Adjusted R-square	0.49	0.48	0.43	0.26	0.51	0.59
F-Statistics	582.49	371.20	106.13	27.68	493.94	466.62

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

Table 3.9: Real Estate Rebalancing Regression

Dependent Var.	All		Cashed-out		Non Cashed-out	
ΔActive Real Est Share	2001-2007	2009-2011	2001-2007	2009-2011	2001-2007	2009-2011
	(1)	(2)	(3)	(4)	(5)	(6)
ΔPassive Real Est Share	-0.440***	-0.393***	-0.430***	-0.297***	-0.440***	-0.420***
	[0.008]	[0.013]	[0.020]	[0.041]	[0.008]	[0.012]
Previous Home Equity Share (Demeaned)	-0.370***	-0.335***	-0.397***	-0.277***	-0.338***	-0.338***
	[0.008]	[0.014]	[0.021]	[0.046]	[0.008]	[0.013]
Total Income (in $100,000)	0.004***	0.001	0.005***	0.002	0.004***	0.001
	[0.000]	[0.001]	[0.001]	[0.002]	[0.000]	[0.001]
Total Wealth (in $100,000)	-0.002***	-0.001***	-0.001***	-0.001*	-0.002***	-0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Age	0.002***	0.007***	0.002	0.015**	0.001***	0.004***
	[0.000]	[0.002]	[0.003]	[0.007]	[0.000]	[0.002]
Age Squared	-0.000***	-0.000***	0.000	-0.000	-0.000***	-0.000**
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Constant	-0.143***	-0.226***	-0.253***	-0.581***	-0.082***	-0.107**
	[0.011]	[0.049]	[0.078]	[0.186]	[0.010]	[0.045]
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4738	2477	1051	458	3687	2019
R-squared	0.45	0.30	0.35	0.14	0.51	0.41
Adjusted R-square	0.45	0.30	0.35	0.12	0.50	0.41
F-Statistics	423.26	149.09	63.32	10.21	418.26	200.40

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

Table 3.10: Aggregate Return on Total Wealth by Cash-out and Real Estate Investment Statuses

			Inv in Real Estate (2001-2007)		
			Yes	No	Total
Aggregate Return on Total Wealth (2001-2007)	Cash Out	Mean	0.714	0.584	0.614
	(2001-2007)	S.D.	0.975	1.024	1.015
	Not Cash Out	Mean	0.620	0.540	0.554
	(2001-2007)	S.D.	0.967	1.020	1.011
	Total	Mean	0.673	0.561	0.584
		S.D.	0.973	1.022	1.013
Aggregate Return on Total Wealth (2007-2011)	Cash Out	Mean	-0.147	-0.117	-0.124
	(2001-2007)	S.D.	0.859	0.910	0.898
	Not Cash Out	Mean	-0.134	-0.068	-0.080
	(2001-2007)	S.D.	0.801	0.871	0.859
	Total	Mean	-0.142	-0.092	-0.102
		S.D.	0.834	0.890	0.879

Note: Aggregate return on total wealth is based on the change in self-reported value of total wealth between 2001 and 2007. Cashed-out households indicate households that cashed out at least once between 2001 and 2007. Investment in real estate indicates households that investment in other real estate at least once between 2001 and 2007.

APPENDICES

APPENDIX A

Solving Maximization Problem

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

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

where

$$V'(W_{t+1}) = \left((1-\theta)^{1-\theta}\theta^{\theta}\right)^{1-\gamma} W_{t+1}^{-\gamma} P_{t+1}^{\theta(\gamma-1)} \tag{A.2}$$

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

$$\begin{aligned} E\left[V'(W_{t+1})(1 + R_{s,t+1})\right] &= E\left[V'(W_{t+1})(1 + R_f)\right] \\ E\left[\exp\left\{\log V'(W_{t+1}) + \log(1 + R_{s,t+1})\right\}\right] &= E\left[\exp\left\{\log V'(W_{t+1}) + \log(1 + R_f)\right\}\right] \\ E\left[\exp\left\{v'(w_{t+1}) + r_{s,t+1}\right\}\right] &= E\left[\exp\left\{v'(w_{t+1}) + r_f\right\}\right] \end{aligned} \tag{A.3}$$

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.

$$\exp\left\{E[x_{t+1}]\right\}\left(1 + \frac{1}{2}Var[x_{t+1}]\right) = \exp\left\{E[y_{t+1}]\right\}\left(1 + \frac{1}{2}Var[y_{t+1}]\right) \tag{A.4}$$

Taking a first-order Taylor expansion around zero

$$E[x_{t+1}] + \frac{1}{2}Var[x_{t+1}] = E[y_{t+1}] + \frac{1}{2}Var[y_{t+1}] \tag{A.5}$$

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

$$\begin{aligned} E[v'(w_{t+1}) + r_{s,t+1}] + \frac{1}{2}Var[v'(w_{t+1}) + r_{s,t+1}] &= E[v'(w_{t+1}) + r_f] + \frac{1}{2}Var[v'(w_{t+1}) + r_f] \\ E[r_{s,t+1} - r_f] + \frac{1}{2}Var[r_{s,t+1}] &= -Cov(v'(w_{t+1}), r_{s,t+1}) \end{aligned} \tag{A.6}$$

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

$$\alpha = \frac{E\left[r_{t+1} - r_f\right] + \frac{1}{2}\sigma_s^2}{\gamma\rho_A\sigma_s^2} - \frac{\gamma\rho_C + \theta(1-\gamma)}{\gamma\rho_A}\frac{\sigma_{ps}}{\sigma_s^2} - \frac{(\rho_B + 1)}{\rho_A}\frac{\sigma_{ys}}{\sigma_s^2} \tag{A.7}$$

where

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

APPENDIX B

Proof for the Proposition 1

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

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

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

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

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.

$$\frac{d\alpha_t}{d\sigma_p^2} = \frac{d\alpha_t}{d\rho_A}\left[\frac{d\rho_A}{dp}\frac{dp}{d\sigma_p^2} + \frac{d\rho_A}{dr_p}\frac{dr_p}{d\alpha_t}\frac{d\alpha_t}{d\sigma_p^2}\right] \tag{B.3}$$

Therefore,

$$\frac{d\alpha_t}{d\sigma_p^2} = \frac{\frac{d\alpha_t}{d\rho_A}\frac{d\rho_A}{dp}\frac{dp}{d\sigma_p^2}}{1 - \frac{d\alpha_t}{d\rho_A}\frac{d\rho_A}{dr_p}\frac{dr_p}{d\alpha_t}} \tag{B.4}$$

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

$$\frac{dr_p}{d\alpha_t} = \left(E\left[r_{t+1} - r_f\right] + \frac{1}{2}\sigma_s^2\right)\left(1 - \frac{1}{\gamma\rho_A}\right) > 0 \tag{B.5}$$

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.

APPENDIX C

Institutional Background about Retirement Benefits

In the United States, various institutions have been developed to support retirees. In this Appendix, we document these institutions in detail. Understanding these institutions is important to our study in the sense that they may affect retirement decisions as well as the financial decisions of retirees. Among various institutions for retirees, Social Security, Medicare, and Individual Retirement Account (IRA) are most influential.

Social Security is a federal insurance program for retirees. Based on the Social Security Act of 1935, Social Security has been developed into an Old Age, Survivors, and Disability Insurance (OASDI) program, which provides benefits to about 88 percent of Americans age 65 or above in 2013. Social Security, which is financed by a payroll tax, requires at least 40 quarters of working periods to be eligible for the retirement benefit. Before the 1983 Social Security Amendment, the full retirement age had been set at 65 for a long time. However, after the Amendment, the full retirement age gradually increased depending on the year of birth ranging from 65 to 67. Additionally, Social Security provides the option to claim the retirement benefit earlier than the full retirement age with a discounted benefit. The earliest age to claim the benefit is 62 and the monthly benefit is discounted up to 30 percent. The option to postpone the benefit after the full eligibility age is also available. In this case, the benefit increases up to 8 percent yearly until age 70. According to the

Social Security Administration's fiscal year 2013 Agency Financial Report, for 53 percent of married couples and 74 percent of unmarried individuals, the Social Security retirement benefit takes 50 percent or more of their income. Since many retirees rely on the benefit of Social Security to finance their retirement, the eligibility age for the retirement benefit can be a key determinant of the retirement decision.

Social Security also provides a health insurance for the elderly who are older than 65 under the name of Medicare. Medicare is the federal health insurance program for people who are older than 65 or who have a disability. As of 2013, the enrollment of Medicare is about 51.9 million, and the elderly takes more than 83 percent of the total enrollment. Even though it is not comprehensive in coverage, Medicare helps retirees pay for various medical services including inpatient care in a hospital, doctors' services, and medications. In 2011, 89.9 percent of the elderly, who are enrolled in Medicare, received some type of benefit from Medicare. Medicare eligibility age remains 65 regardless of the year of individual's birth. However, for Medicare, one must be 65 in order to receive the benefit. (Summarize all age requirement here) Since unexpected medical expenditure is one of the most important concerns in retirement planning, Medicare eligibility age is also important to the retirement decision.

Social Security retirement benefit and Medicare cover the largest part of retirement expenditures. However, they cannot cover all of the expenditure for most retirees. Most retirees usually have other type of income sources such as pensions and savings. Additionally, the government provides tools for encouraging workers to save their earning for retirement. The most well known way to save for retirement is the Individual Retirement Account (IRA) (or 401(k)). This retirement account basically provides benefits of tax-free growth and deferred income tax. As workers save their earnings in this account, their earnings and profits from this investment are exempt from income tax until they withdraw it. However, once workers put their earnings in this retirement account, it is difficult to access this money without penalty until age 59.5 with particular exceptions: medical expense, education expense and first time home purchase. Since the IRA takes non-negligible portion of retirees' total assets, the age requirement for the withdrawal can affect retirement decisions. Additionally, IRA account requires retirees to pull out minimum amount of fund after 70.5, which are called minimum required distributions (MRDs). As retirees pull out money from IRA account, the money should go into one of their asset accounts or consumption. Therefore, this mandatory withdrawal requirement also can affect retirees' financial decisions.

APPENDIX D

Additional Tables

Table D.1: Sample Selection

Selection Criterion	Remaining Observations
Initial Sample	170,928
Excluding Self-Employment	157,516
Keep Household Head Aged from 50 to 80	121,639
Self-Reported Retirement Status is Known	99,087
Risky Share between 0 and 1	87,186

Table D.2: Summary Statistics

Variable	Mean	S.D.	Med	Min	Max
Retirement Status (Head)					
1:Completely Retired, 0:Partly Retired or Not Retired At All	0.461	0.499	0	0	1
1:Completely Retired or Partly Retired, 0:Not Retired At All	0.575	0.486	1	0	1
Retirement Status (Spouse)					
1:Completely Retired, 0:Partly Retired or Not Retired At All	0.436	0.496	0	0	1
1:Completely Retired or Partly Retired, 0:Not Retired At All	0.559	0.496	1	0	1
Age					
Head	64.6	7.97	64	50	80
Spouse	62.3	8.77	62	24	100
Size of Household	2.33	1.12	2.00	0	19.0
Number of Children	3.14	2.02	3.00	0	20.0
Race (Head)					
White	0.834	0.372	1	0	1
Black	0.128	0.335	0	0	1
Hispanic	0.067	0.250	0	0	1
Other Race	0.037	0.189	0	0	1
Level of Education (Head)					
Year of Schooling	12.9	3.04	12.0	0	17.0
High School	0.419	0.493	0	0	1
Some College	0.211	0.408	0	0	1
College and Above	0.255	0.436	0	0	1
Level of Education (Spouse)					
Year of Schooling	12.5	2.79	12.0	0	17.0
High School	0.414	0.493	0	0	1
Some College	0.232	0.422	0	0	1
College and Above	0.172	0.378	0	0	1
Self-Reported Health Status (Head)					
1: Poor or Fair, 0: Excellent, Vary Good, or Good	0.219	0.414	0	0	1
1: Poor, Fair, or Good, 0: Excellent, Vary Good, or Good	0.538	0.499	1	0	1
Self-Reported Health Status (Spouse)					
1: Poor or Fair, 0: Excellent, Vary Good, or Good	0.224	0.417	0	0	1
1: Poor, Fair, or Good, 0: Excellent, Vary Good, or Good	0.531	0.499	1	0	1
Medical Expenditure ($1,000)					
Head	1.79	2.26	1.07	0	12.0
Spouse	1.99	2.42	1.07	0	12.0
Wealth ($10,000)					
Total Asset	29.6	33.6	17.1	0	166
Total Asset Excluding 2nd Residence	28.3	31.7	16.5	0	155
Total Financial Asset	7.48	12.5	1.65	-0.86	59.9
Total Stock Asset	2.82	6.44	0	0	30.6
Income ($10,000)					
Total Income of Household	5.32	3.96	4.19	0.60	15.5
Total Income of Head	3.07	1.94	2.61	0	6.50
Total Income of Spouse	0.90	1.02	0.559	0	2.97
Risky Share					
Stock Share in Financial Asset	0.179	0.313	0	0	1
Stock Share in Financial and IRA Asset	0.232	0.337	0	0	1
Subjective Measure of Risk Tolerance					
1: Least Risk Averse; 4: Most Risk Averse	3.30	1.06	4	1	4
1: Least Risk Averse; 6: Most Risk Averse	4.66	1.51	5	1	6

Notes: All asset values are winsorized at bottom 5 percent and top 5 percent level and deflated into 2000 Dollars.

Table D.3: Normal Retirement Age in the US

Cohorts: Birth Date	Normal Age of Retirement
Before 1/2/1938	65
1/2/1938-1/1/1939	65 and 2 months
1/2/1939-1/1/1940	65 and 4 months
1/2/1940-1/1/1941	65 and 6 months
1/2/1941-1/1/1942	65 and 8 months
1/2/1942-1/1/1943	65 and 10 months
1/2/1943-1/1/1955	66
1/2/1955-1/1/1956	66 and 2 months
1/2/1956-1/1/1957	66 and 4 months
1/2/1957-1/1/1958	66 and 6 months
1/2/1958-1/1/1959	66 and 8 months
1/2/1959-1/1/1960	66 and 10 months
1/2/1960 and later	67

Table D.4: First Stage Regression

	(1)	(2)	(3)	(4)	(5)	(6)
Head Expected Retirement Status	0.238***	0.244***			0.177***	0.183***
	[0.008]	[0.009]			[0.009]	[0.010]
Partial Retirement Age			0.159***	0.166***	0.134***	0.136***
			[0.006]	[0.006]	[0.008]	[0.009]
Full Retirement Age			0.097***	0.088***	0.069***	0.067***
			[0.006]	[0.007]	[0.009]	[0.010]
Head Age	-0.028***	-0.026***	0.024***	0.027***	-0.053***	-0.054***
	[0.007]	[0.008]	[0.004]	[0.004]	[0.007]	[0.008]
Head Age Square	0.000***	0.000***	-0.000	-0.000	0.001***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Head Self-Reported Health	0.055***	0.068***	0.047***	0.053***	0.057***	0.069***
	[0.007]	[0.008]	[0.004]	[0.005]	[0.007]	[0.006]
Household Size	0.003	-0.000	-0.000	-0.003	0.003	-0.000
	[0.003]	[0.004]	[0.002]	[0.003]	[0.003]	[0.004]
Number of Children	0.004	0.006	-0.000	-0.003	0.004	0.006
	[0.005]	[0.006]	[0.003]	[0.004]	[0.005]	[0.006]
ln(Household Income+1)	-0.160***	-0.165***	-0.140***	-0.144***	-0.160***	-0.164***
	[0.005]	[0.006]	[0.003]	[0.004]	[0.005]	[0.006]
ln (Household Wealth+1)	0.007***	0.008***	0.004***	0.006***	0.007***	0.009***
	[0.001]	[0.002]	[0.001]	[0.001]	[0.001]	[0.002]
Change Marital Status	-0.005	-0.027	-0.003	-0.042	-0.005	-0.030
	[0.016]	[0.056]	[0.010]	[0.035]	[0.016]	[0.056]
Spouse Age Square		-0.000		-0.000		-0.000
		[0.000]		[0.000]		[0.000]
Spouse Self-Reported Health		-0.021***		-0.014***		-0.023***
		[0.008]		[0.005]		[0.007]
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Household Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	35960	28369	84978	64770	35348	27908
R-squared	0.45	0.44	0.32	0.31	0.46	0.45
F-Statistics	1102.70	693.82	762.98	463.24	1007.71	649.44

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

Table D.5: Tobit Regression

	Panel (3)	IV1 (4)	IV2 (5)	IV3 (6)
Head Completely Retired	0.054***	0.089	0.065	0.126**
	[0.008]	[0.056]	[0.052]	[0.051]
Head Age	-0.044***	-0.029*	-0.038***	-0.025
	[0.007]	[0.016]	[0.009]	[0.016]
Head Age Square	0.000***	0.000*	0.000***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]
Head Self-Reported Health	-0.048***	-0.038*	-0.077***	0.106***
(1:Poor/Fair, 0:Excellent/VaryGood/Good)	[0.009]	[0.020]	[0.013]	[0.020]
Household Size	-0.033***	-0.028***	-0.016***	-0.009***
	[0.004]	[0.007]	[0.005]	[0.007]
Number of Children	-0.009***	-0.018***	-0.005***	-0.004*
	[0.003]	[0.005]	[0.003]	[0.005]
ln(Household Income+1)	0.135***	0.148***	0.145***	0.154***
	[0.006]	[0.016]	[0.012]	[0.015]
ln (Household Wealth+1)	0.201***	0.274***	0.260***	0.272***
	[0.004]	[0.013]	[0.009]	[0.013]
Change Marital Status	0.026	0.147*	0.044	-0.006
	[0.054]	[0.083]	[0.062]	[0.083]
Spouse Age	0.001	0.001	-0.001	-0.000
	[0.005]	[0.010]	[0.006]	[0.010]
Spouse Age Square	0.000	0.000	0.000	-0.000*
	[0.000]	[0.000]	[0.000]	[0.000]
Spouse Self-Reported Health	-0.065***	-0.112***	-0.031***	-0.042***
(1:Poor/Fair, 0:Excellent/VaryGood/Good)	[0.009]	[0.019]	[0.011]	[0.019]
Year Fixed Effect	Yes	Yes	Yes	Yes
Household Fixed Effect	No	No	No	No
Observations	65750	28369	64770	27908
Chi-square	6675.84	2481.63	5644.98	2464.23
Wald p-value	0.00	0.00	0.00	0.00

Notes: In the Tobit regression, the zero stock share is cut off. Standard errors are in parentheses. 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 D.6: Channel Test - Subject Risk Tolerance Measure with Subsample

	4 Cat.		6 Cat.	
	(1)	(2)	(3)	(4)
Head Completely Retired	-0.265***	-0.075	-0.056	-0.632*
	[0.067]	[0.138]	[0.114]	[0.361]
Household Characteristics	Yes	Yes	Yes	Yes
Head Characteristics	Yes	Yes	Yes	Yes
Spouse Characteristics	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Household Fixed Effect	No	Yes	No	Yes
Observations	8432	8432	2506	2506
R-square		0.06		0.95
Chi-square	146.34		111.43	

Notes: This table shows the result of the ordered logic regression and panel regression of subjective risk measures on the retirement status. The subsample before year 2000 is used. Standard errors are in parentheses. 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.

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