Local Housing Returns and the Optimal Portfolios of Consumption Constrained Households

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Abstract

Stockholding puzzle refers to the phenomena that household portfolio featured with little stock holding contrasts with prediction of standard portfolio theory. This paper shows this contradiction appears if only studying the portfolio of the unconstrained households while ignoring the mortgage leverage effect for constrained households. This paper proves that for constrained households, it's optimal to hold lower share of stocks but higher share of housing if financial asset is well-diversified market portfolio (S&P 500); however, in order to hedge the extremely levered risk, they should turn to choose individual equities (or equity combinations) with high idiosyncratic risks.

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Key Words: Consumption Constrained Household, Portfolio, Leverage, Local Housing Return

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1 Introduction

U.S. homeowners have a low participation rate in stock markets; and conditional on participation, the share of risk assets, other than housing, is remarkably low. From the Survey of Consumer Finances (2010)[1], the share of U.S. households holding stocks has been around 50% since 1998. This phenomenon, called the stockholding puzzle or "household portfolio composition puzzle" (Guiso and Jappelli (2002)), has been noted by many authors such as Mankiw and Zeldes (1991), who found a very low household participation rate in financial markets in the U.S. (27.6% in 1984 PSID). This phenomenon also exists in Italy: rates of participation in equity markets in Italy are merely 26.43% in 1985, 38.19% in 1995 and 48.24% in 1998 while the shares of financial to total wealth are respectively 11.7% in 1991 and 14.59% in 1998 (shares of housing wealth are respectively 68.91% in 1991 and 65.81% in 1998). Table 1 lists the participation rates for risky asset markets in the U.S., UK, Netherlands, Germany and Italy. For most countries during 1980s and 1990s, less than half of total households invest in risky assets. Fratantoni (1998) finds that, among homeowners under age 50 (likely consumption constrained), rates of stock ownership are very low. Table 2 shows that, even conditional on participation in financial markets, direct stock holding is low, and the sum of direct and indirect stockholding is moderate[2].

This statistical evidence contradicts standard portfolio theory, which predicts that holding significant shares of risky assets helps diversity risk. Recent theoretical and empirical research has attempted to explain this discrepancy. However, measuring the home equity returns is one significant problem with past approaches to the stockholding puzzle. First, returns to housing are local and vary by housing market (Case and Shiller (1989)); only using national housing return failed to consider the locality of housing market. Second, total return to housing is mainly rental return as opposed to appreciation return and rental returns have been ignored or simply based on problematic BLS price indexes. Third, little attention is paid to leverage effect of mortage held by the consumption constrained households, who are featured with exposure to extremely highly levered housing risk. The share of constrained households in the U.S. homeowners is 70% in 2010.

To reduce the portfolio risk for the consumption constrained households, whose house values are several times their net wealth, the relevant alternative to housing is certainly not the market portfolio because the households have insufficient wealth to ever be well

[1] Federal Reserve Board, 2010 SCF Chartbook, http://www.federalreserve.gov/econresdata/scf.

[2] "Direct stockholding" means stocks shares held directly; "Direct and indirect stockholding" includes mutual funds, investment accounts, retirement accounts held directly.

diversified. Thus it is not appropriate to get a conclusion that because a household achieves no diversification benefit from the S&P500, it would not benefit from holding some subset of equities from among those comprising the S&P 500. This paper will show that a well-diversified finanial market portfolio is not a good choice for homeowners because given the high risk of housing, one under-diversified financial portfolio could bring higher diversification gains than a lower-risk market portfolio does.

This paper shows that stockholding puzzle arises if the literatures try to explain the portfolios of households major of whom are constrained through the unconstrained model: unconstrained households act exactly as the standard portfolio theory predicts to hold significant share of stocks; however, it turns out optimal for constrained households to hold low share of stocks and higher share of home equity and there are two reasons: one is that leverage effect of mortgage loan reverses the return-risk position between stock and housing returns; the other is that S&P 500 is not an attractive asset.

Holding one single levered housing asset greatly increases the portfolio risk exposed to constrained households. This paper considers how "extremely constrained" households allocate their portfolio optimally in the specific case where their net wealth is 20% of housing value[3]. They choose the shares of home equity and risky financial assets to be mean-variance efficient. To some extent, the results reconcile the divergence between positive and normative household finance as stated by Campbell (2006) who called for financial research to consider the household's specific problems.

This model part also takes great pains to estimate local housing returns compared to previous research. It allows local variation of the capitalization rate (i.e. in the rental return) and appreciation rate. Estimation results of housing return demonstrate that the differences in the trade-off between housing returns and risk varies across cities. California cities have higher returns and higher risk; Sun Belt cities have lower returns and lower risk; Rust Belt cities have lower returns and higher risk.

The findings confirm expectations that the S&P500 performs poorly in diversifying risk of local house markets. Selected portfolios of individual stocks, vary across cities, are much more likely to prove mean-variance efficient. Estimation results show that portfolio optimization vary greatly with the locations of households for both constrained and unconstrained households. The share of housing equity in the optimal portfolio also varies by location. Note there is no claim that households currently act on this information because it is unknown to them and to financial advisors. Indeed, the optimal portfolios in various cities have been computed for the first time as a result of this research. Therefore

[3]This paper does not explore the conditions for renters or housing sale.

this is purely an exercise in normative economics.

2 Literature Review

Mankiw and Zeldes (1991) first find evidence against theoretical predictions of standard portfolio theory applied to household behavior. They use 1984 PSID data and find that about 75% of the households hold no stocks; and 13% of the poor (with liquid assets lower than $1,000) hold stocks; only 47.7% of the rich (with liquid assets more than $100,000) hold stocks. Haliassos and Bertaut (1995) use 1983 SCF data and find that 19% of the 70th income percentile of households hold some stocks and the average value held is lower than $800; those between 90th and 99th income percentile have well-diversified portfolios, but only 44%-55% of total households hold stocks. Fratantoni (1998) finds that the median share of equities in the portfolios of homeowners under the age of 55 is zero. Fratantoni (2001) further uses the 1989 SCF and reports that the median share of risky assets for homeowners is just 3.32%. Guiso and Jappelli (2005) find that conditional shares of risky assets (mutual fund, stocks and investment accounts) in household portfolios are only 10.2% and 20.1% in 1995 and 1998 SHIW data.

Campbell (2006) summaries the difference between "positive" and "normative" household finance, and discusses how the "discrepancies or investment mistakes" between them have different effects on heterogeneous households. Recent theoretical models have contributed to an explanation of this difference.

Brueckner (1997) demonstrates that "the investment constraint" proposed by Henderson and Ioannides (1983) leads to mean-variance inefficiency. Fratantoni (2001), Chetty and Szeidl (2012) further argue that committed mortgage expenditure risk of owning a house can help explain the small equity proportion in household portfolio. Cocco (2005) explains the limited financial assets in portfolios of younger and poorer households in terms of a combination of fixed cost of equity market participation and the correlation of housing price with labor income and stock returns. The rental return is ignored. Risky labor income is also widely used to explain the puzzle analysis (Bertaut and Haliassos (1997), Heaton and Lucas (1997), and Cocco, Gomes and Maenhout (2005)); Davidoff (2006) illustrates that households whose incomes covary relatively strongly with housing prices should own relatively little housing in a static environment.

Overall the positive literature suggests that, as homeowners become less consumption constrained, they eventually include equities in their portfolios but prepayment of the mortgage balance has an initial priority for recent home buyers. Thus previous literature

has explained the stockholding puzzle using correlations between local housing asset prices and income or an aggregate market return index (usually the S&P 500).

Normative analysis of optimal household portfolio has analyzed using a standard CAP-M approach in which there are two risk assets, housing and the market portfolio (S&P 500). Diversification benefit of household portfolios deeply depend on the corrleation between the two assets. Flavin and Yamashita (2002, 2011), Yamashita and Nakagawa (2008) find that from 1968 to 1992, homeowners get little diversification benefit from holding the S&P 500 with annual data; Jin (2011) finds a positive correlation between housing appreciation and the S&P 500 from 2000 to 2007 with annual data. Quan and Titman (1999) detect positive correlation between U.S. real estate and stock returns over longer holding periods from 1984 to 1996 with annual data. Englund, Quigley and Hwang (2002) find housing returns in Stockholm are positively correlated with REITs and stocks while negatively correlated with T-bills and bonds from 1981 to 1993 with quarterly data. Jud et al. (2006) find significant negative correlation between U.S. housing appreciation and returns to small CAP stocks but positive correlation with the S&P500 from 1978 to 2001 with quarterly data; Ibbotson and Siegel (1984) found a negative correlation between U.S. real estate index and S&P 500 returns from 1947 to 1982 with annual data. Eichholtz and Hartzell (1996) documens a negative correlation for Canada, the U.K. and the U.S. between property and stock indexes from 1985, 1977 and 1977 to 1993 with quarterly data. The common problem with these studies is that, for the consumption-constrained household holding risky housing in a particular location, there is no virtue in holding the market portfolio. Therefore testing for diversification using the S&P 500, or a similar market index, to represent the alternative risk asset is artificially restrictive and likely to miss attractive opportunities for diversification presented by alternative portfolios of risk assets. The finding that such households fail to hold risk assets and pay down their mortgages instead does not imply that they are behaving optimally. Rather it suggests that they lack information on the opportunity to diversify the unique risk associated with homeownership in particular cities.

Further, consumption constrained households solve quite different portfolio problems from unconstrained households; local housing returns requires local household portfolios. Mian and Sufi (2010, 2011) shows that home equity-based borrowing is stronger for younger households featured with lower credit scores or high initial credit card utilization rates, indicating importance of the efficient portfolios for such constrained households. Besides the commonly proposed housing price index futures (Case, Shiller and Weiss (1993), Shiller (2008), McDuff (2012)), correlation between housing and financial asset

returns is often used as instrument for diversifying portfolio risk. Englund, Quigley and Hwang (2002) provide the simulated optimal portfolios for constrained households under different horizons with mean-variance method; Yao and Zhang (2005), and Flavin and Yamashita (2002, 2011) provides the life-cycle simulation results for households with different constraints[4]. Pelizzon and Weber (2008) demonstrate that in mean-variance model, negative correlation between housing and equity returns helps hedge portfolio risk.

3 Model

In the model, the representative household in city i decides the allocation of net wealth Ω to risky financial assets $\mathbb{R}$ and housing equity $\mathbb{N}$. There are separate models of unconstrained and constrained households. The unconstrained model solves the portfolio problem of households whose total wealth is large compared to their desired housing consumption. The constrained model solves the portfolio problem of "extremely constrained" households whose total wealth is only 20% of the asset price of their housing consumption; this assumption makes sense considering that most FHA loans borrowers have an average LTV value of about 95% (Nichols, Pennington-Cross and Yezer (2005), Caplin, Tracy and Cororaton (2012)).

3.1 Unconstrained Model

The unconstrained model is a typical standard portfolio problem. Unconstrained households choose their optimal portfolios by maximizing utility:

$$MAX\ U = S^T E(R) - \frac{A}{2} S^T V S \tag{1}$$

$$s.t.\ S^T I = 1 \tag{2}$$

$$s_i \geq 0, s_i\ is\ ith\ element\ of\ vector\ S \tag{3}$$

where S is $n * 1$ vector of asset shares; and s_i is ith element of vector S, representing share of asset i in household portfolio, $i = 1, 2, 3...n$; specially, $s_n = s_h$, the share of home

[4]Flavin and Yamashita (2002) propose the maximium share of stock in life-cycle is 11.3%; Englund, Hwang and Quigley (2002) proposes as much as 500% of stock shares by allowing borrowing T-bills; Yao and Zhang (2005) proposes around 70%-90%; Cocco (2005) proposes 6% for age group 35-50 and 23.5% for age group 50-65.

equity; R is the return matrix of financial assets (with mean vector($\overline{\mu}$)) and housing equity; A is the parameter of risk aversion; V is the variance-covariance matrix for all asset returns; I is a $n * 1$ vector with element equal to 1. No-borrowing constraints are applied to all risky financial assets, and the mortgage cannot exceed housing value[5].

The optimal solution for wealth allocation without considering constraints is,

$$S^* = V^{-1}\frac{\overline{\mu}}{A} \tag{4}$$

The optimal solution for wealth allocation without considering non-negativity constraints is,

$$S^* = \frac{V^{-1}}{A}(\mu - \frac{I^T V^{-1}\overline{\mu}}{I^T V^{-1} I} I) \tag{5}$$

A full understanding of the model needs considering the KKT conditions because of the concern solutions. From equation (4), the optimal portfolios are only determined by asset performance and risk preference of households: given the degree of risk aversion and the investment horizon, households can fully diversify idiosyncratic risk, as predicted by standard portfolio theory.

The var-covariance matrix of asset returns and mean return vector $\overline{\mu}$ are different across cites; thus households hold different portfolios if their residential location changes.

3.2 Constrained Model

This section shows the optimization technique for a household portfolio in a static mean-variance model. The model is based on derivation for a housing-constrained model in Pelizzon and Weber (2008).

For consumption constrained households, their LTV is 80% or more and the schedule of mortgage interest rates is assumed to increase by 2% if LTV increase from 80% to close to 100%[6]; thus mortgage schedule becomes,

$$\frac{d\varphi(l)}{dl} > 0, l \in [0.8, 1) \tag{6}$$

[5]This constraint excludes the possibility of LTV>100% and the maximium ratio of LTV is 99.8% in this paper.

[6]Nichols, Pennington-Cross and Yezer (2005) have a detail discussion about mortgage rate for heterogeneous borrowers. For simplicity, this paper assumes a simple linear mortgage rate schedule for LTV greater or equal 80%. Chomsisengphet and Pennington-Cross (2006) document for premier plus grade, the mortgage rate gap for LTV equal to 80% and 100% falls between 1.7% and 2.4%. In the part of using REIT as proxy of housing, the paper uses 0.5% instead of 2%.

where φ is the mortgage interest rate and l is the LTV ranging from 80% to 100%. Therefore, in order to hold risky assets other than housing, homeowners will have to raise LTV above 80%.

The optimal portfolio problem is numerically solved by following two steps. First, for each given value of LTV, quadratic technique searches the optimal share for risky assets subject to the linear constraint $\sum_{i=1}^{n-1} s_i = 1 - h_i$, where s_i is the share for risky asset i and h_i is the share of housing equity implied by the LTV. The second step pools the local optimal portfolios for each LTV from the first step, finds the global optimal portfolio with maximum utility level.

In the first search stage, housing share is assumed to be fixed at $\widetilde{h}$, thus LTV is $\widetilde{l}$, and housing returns have mean $\widetilde{r}$ and variance $\widetilde{\sigma}^2$, mortgage rate is $\widetilde{\varphi}$. Other non-housing risky asset returns are assumed to have mean vector R_s and variance-covariance matrix Σ; the covariance vector between risky asset and housing return is a $n*1$ vector $\widetilde{\sigma}_{sh}$. Thus for each LTV value, households face a different return and variation-covariance matrix. The total asset variance-covariance matrix, mean return matrix and share vector are,

$$V = \begin{bmatrix} \Sigma & \widetilde{\sigma}_{sh} \\ \widetilde{\sigma}_{sh}^T & \widetilde{\sigma}^2 \end{bmatrix} \tag{7}$$

$$R = \begin{bmatrix} R_s \\ \widetilde{r} \end{bmatrix} \tag{8}$$

$$S = \begin{bmatrix} X \\ \widetilde{h} \end{bmatrix} \tag{9}$$

Then the optimal shares of risky assets question can be expressed as:

$$MAX\ U = S^T E(R) - \frac{A}{2} * S^T V S \tag{10}$$

$$= \begin{bmatrix} X \\ \widetilde{h} \end{bmatrix}^T \begin{bmatrix} R_s \\ \widetilde{r} \end{bmatrix} - \frac{A}{2} \begin{bmatrix} X \\ \widetilde{h} \end{bmatrix}^T \begin{bmatrix} \Sigma & \widetilde{\sigma}_{sh} \\ \widetilde{\sigma}_{sh}^T & \widetilde{\sigma}^2 \end{bmatrix} \begin{bmatrix} X \\ \widetilde{h} \end{bmatrix} \tag{11}$$

which can be written as,

$$MIN\ \mathcal{L} = \frac{A}{2} X^T \Sigma X + (A\widetilde{h}\widetilde{\sigma}_{sh}^T - R_s^T)X + (\frac{A\widetilde{h}^2\widetilde{\sigma}^2}{2} - \widetilde{h}\widetilde{r}) \tag{12}$$

Without considering the constraints, the first order condition is,

$$\frac{\partial \mathcal{L}}{\partial X} = AX^T\Sigma + A\widetilde{h}\widetilde{\sigma}_{sh}^T - R_s^T = 0 \tag{13}$$

The optimal share vector of risky assets is,

$$\widetilde{X}^* = \Sigma^{-1}(\frac{R_s}{A} - \widetilde{h}\widetilde{\sigma}_{sh}) \tag{14}$$

Thus for each LTV value, there will be a local optimal $\widetilde{X}^*$ vector; and, for each city, there will be a globally optimal X^* vector.

The optimal solution for consumption constrained households has the following properties. Let $\widehat{r}$ equal the sum of the housing capitalization rate and appreciation rate (unlevered housing return). Thus for period t, home equity returns can be written as,

$$r_t = \frac{P_t(CAP_t - c) - \widetilde{\varphi}L_t + (P_{t+1} - P_t)}{P_t - L_t} = \frac{\widehat{r} - \widetilde{\varphi}\widetilde{l}}{1 - \widetilde{l}} \tag{15}$$

where P_t is housing value, CAP_t is capitalization rate, L_t is the loan and $\widetilde{l} = L_t/P_t$, c is annual housing cost including tax, maintenance cost and depreciation. The correlation between unleveraged housing and risky asset returns is,

$$\theta = cov(\widehat{r}, r_s) \tag{16}$$

Thus housing return and variance when $LTV = \widetilde{l}$ can be rewritten as,

$$\widetilde{r} = E(\frac{\widehat{r} - \widetilde{\varphi}\widetilde{l}}{1 - \widetilde{l}}) = E(\widehat{r}) + \frac{\widetilde{l}}{1 - \widetilde{l}}[E(\widehat{r}) - E(\widetilde{\varphi})] \tag{17}$$

$$\widetilde{\sigma}^2 = var(\frac{\widehat{r} - \widetilde{\varphi}\widetilde{l}}{1 - \widetilde{l}}) = var(\widehat{r}) + \frac{\widetilde{l}^2 var(\widetilde{\varphi}) - 2\widetilde{l}cov(\widehat{r}, \widetilde{\varphi}) + (2\widetilde{l} - \widetilde{l}^2)var(\widehat{r}))}{\left(1 - \widetilde{l}\right)^2} \tag{18}$$

Thus the correlation between leveraged housing and risky asset return is[7],

$$\widetilde{\sigma}_{sh} = cov\left(\frac{\widehat{r} - \widetilde{\varphi}\widetilde{l}}{1 - \widetilde{l}}, r_s\right) \approx \frac{\theta}{1 - \widetilde{l}} \tag{19}$$

The constrained optimal share of risky assets from equation (14) can be rewritten as,

$$\widetilde{X}^* = \Sigma^{-1}(\frac{R_s}{A} - 5\theta) \tag{20}$$

[7] Covariance between mortgage rate and stock returns are negligible for simplicity.

Risky asset shares are mainly determined by the correlation between local housing and national risky asset returns, 5θ. The parameter 5 appears because the minimum leverage ratio for the consumption constrained household in this case is 5. From equation (17) and (18), levered housing returns would be more higher and volatile, as illustrated in figure 1.

3.3 Proposition

Based on the optimal solutions for both models, this leads naturally to the theoretical prediction that there should be notable variation of optimal portfolio shares among cities. Thus the model implies has,

Proposition 1 *Consumption constrained households in different cities have different optimal portfolio composition.*

Different cities would have different variance-covariance matrix between national financial assets local housing returns, which can explain the different portfolios in different cities: different housing markets have different correlation with risky assets as in equation (16), thus the optimal risky asset share vector will be different as in equation (20). Appendix I gives the specific solution in equation (33), and given the available financial assets, the location of households determines the second term which is the correlation between housing and financial asset returns. This is the key that leads to portfolio variations across cities.

The model has a second proposition,

Proposition 2 *Consumption constrained households prefer to hold individual risky assets than their portfolios (Efund and Vfund); prefer to hold risky assets negatively correlated with local housing returns, rather than the well-diversified market portfolio with little room to covary with local housing returns.*

The proof can be found in Appendix I.

4 Data

The used data are AHS national micro data, housing price appreciation data, stock returns, REIT returns and market portfolio data.

Data used for estimating capitalization rates are from National Micro data of American Housing Survey (AHS) from 1985 to 2009. AHS surveys are conducted every other year.

ICPSR provides data before 1995 while HUD User Database provides the data after 1997. In order to reduce the heterogeneity of house characteristics, only multi-family houses and condominiums are kept to estimate the CAP rate (Follian and Malpezzi (1980), Phillips (1988)). 32 SMSAs (1980 Standard) have enough observations to obtain statistically robust estimates. Because homeowners tend to over-appraise the housing values (Ilhanfeldt and MartinezVazquez (1986), DiPasquale and Somerville (1995), Agarwal (2007)), the CAP rate is likely systematically downwards biased.

Housing price appreciation rates are taken from the weighted repeat sale indexes of the Office of Federal Housing Enterprise Oversight (OFHEO). OFHEO provides the housing price index with method proposed by Calhoun (1996).

Mortgage rate is 30 year fixed mortgage rate (FRM)[8]. Measures of inflation are from the Bureau of Labor Statistics Consumer Price Index. Metropolitan Statistical Areas (MSA) are redefined based on social and economic changes in different geographic areas by the Office of Management and Budget (OMB); and OFHEO uses MSA to define different geographic areas; however, American Housing Survey (AHS) has been using Standard Metropolitan Statistical Areas (SMSA) to define different geographic areas, though it includes MSA information in later surveys. This paper decomposes MSA from OMB and SMSA from Census into cities and counties; then redefines 38 metropolitan areas (cities): some cities are closely adjacent, for example, Washington DC-Bethesda-Rockville and Washington DC-Arlington-Alexandria, Detroit and Farmington Hills, Suffolk and Nassau.

There are two kinds of risky financial assets $\mathbb{R}$: individual stocks and market portfolios. In the specific computations implemented here, households choose stocks, from among 10 representative stocks for 10 sectors; when choosing market portfolios, they can only choose one of the 5 quasi mutual funds: three market portfolios from the Center for Research in Security Prices (or CRSP): market value-weighted portfolio (Vrate), market equal-weighted portfolio (Erate) and S&P500 Index (S&P500)); and two stock quasi mutual funds: 10-stock value-weighted portfolio (Vfund) and 10-stock equal-weighted portfolio (Efund).

One concern with using these 10 stocks (discussed in data part) is their S&P500 status (except for BP and UHS). S&P 500 stocks may have lower returns compared than non-S&P 500 stocks due to locality bias (Ivkovic and Weisbenner (2005)); but these 10 stocks are the "stars" in S&P 500 stock pool. However, the goal here is to explore the diversification effect of holding individual stocks for consumption constrained households;

[8]Campbell and Cocco (2003) discuss the choice of ARM versus FRM, and shows FRM is attractive for risk-averse household with a large mortgage.

the relative risk-return positions matter little given the focus of this research on the potential for diversifying local housing risk.

However, an alternative way of choosing individual stocks considers the locality of stock holding among MSAs. Some recent financial studies explore the local HPI changes and the performance of firm stocks whose headquarters are located in those cities (Anderson and Beracha (2012), Henock and Sun (2012)). Some studies explore the local population density and stock performance (Hong, Kubik and Stein (2009)). These studies match publicly traded stocks and local housing market through the reported firm addresses. In contrast, this research explores the benefit of holding "national" stocks without considering whether the corporate headquarters or major plants are located locally. The 10 stocks are chosen to meet this goal.

Monthly returns for individual stocks are from CRSP via access to Wharton Research Data Services (WRDS); market (equal/value-weight) portfolio returns and S&P500 Index are also from WRDS. The 10 stocks are American Electric Power Co Inc. (AEP), British Petroleum Plc. (BP), DuPont Chemical (DD), General Electric Co (GE), International Business Machines (IBM), Procter & Gamble Co (P&G), Progressive Corp (PROG), Universal Health Services Inc. (UHS), Verizon Communications Inc. (VZ), and Wal-Mart Stores Inc. (WMT). Fama and French (1992, 1993) propose a three-factor-model and Carhart (1997) adds a fourth momentum factor to control common risk factors in returns and risks of the stocks. A comparison between using raw and excess stock returns will be discussed in future robustness part[9].

REIT data is from CRSP via access to WRDS and Yahoo! Finance. 17 REITs are from CRSP and one REIT is from Yahoo! Finance. Table 12 lists the detail information of the 18 REITs: about 8 of them concentrate their investments in one state: BRE properties Inc. focuses on California; Mack-Cali Realty Corp focuses on north New Jersey; Kilroy Realty Corp and Essex Property Trust Inc. focuses on major cities in California and Seattle; First Real Estate Investment Trust focuses on New Jersey; Income Opportunity Realty concentrates in Texas; Roberts Realty Investors Inc. invests in greater Atlanta area; Washington Real Estate Investment Trust invests in greater Washington DC area. Besides, Mid-America Apartment Communities Inc. invests in major Sun Belt states. The other 9 REITs are more diversified but still focus on major cities rather than national investments.

Stock returns (including dividends) are used in maximizing household utility to de-

[9]Following 4 factor model, Beracha and Skiba (2013) propose a asset pricing model for housing returns with market-wide, economical, geographical and momentum factor, and find "local risk factors indirectly capture the risk reward relation previously attributed to the market-wide risk factor."

termine the equilibrium share of each stock in portfolio. Figure 1 shows the relative attractiveness of these all the financial assets and two types of housing returns: levered and unlevered. Table 3 lists the statistics description of 10 stocks and 5 market portfolios: DuPont Chemical and British Petroleum have poor trade-off of risk and returns than the other stocks; S&P 500 is featured with medium risk but very lower return than other market portfolios. Table 4 lists the covariance between these 10 stocks. UHS is negatively correlated with 3 stocks, while Progressive, Verizon, DuPont and GE are positively correlated with all other assets; AEP and WMT are correlated with coefficient as low as 0.001, while UHS and AEP are correlated with coefficients as high as 0.066; GE are highly correlated with most stocks and PG are less correlated with most stocks.

5 Empirical Results

Table 5 lists descriptive statistics on the annualized total return to housing investment for 38 cities, indicating significant geographic variation of housing returns; appendix II describes the technique of estimating CAP rate and computing appreciation rate. Cities in the Sun Belt have lower variance in their housing returns: Texas and Florida cities have lower average housing returns and medium risks; California cities have risky housing returns: San Francisco, San Jose, Los Angles, Oakland, San Diego and Santa Ana have higher average housing returns and risks; Northeastern cities have attractive housing returns: Washington DC, Boston, and Greater New York have higher housing returns and lower risk than California cities; Rust Belt cities have less attractive housing returns: lower housing returns and lower risks. These, of course, are measured ex-post returns to investment.

From figure 1, residential real estate in individual cities is generally less risky than stocks. Mean values of annual housing returns are in range of 5%~10% and the standard deviation are in range of 4%~12%; stocks have average returns of 9%~20% and standard deviations of 14%~30%. These are all ex post returns to 100% equity investment. Another finding is positions of market portfolios with lower risks and individual stocks with unhedged idiosyncratic risk: given the choice of market portfolio and housing, households may allocate their wealth to the single asset with higher Sharpe ratio. Though this choice is meean-variance efficient, it may just add the risk because these two assets are negligibly correlated; for unconstrained households, they would like to hold a well-diversified financial portfolio instead of allocating part of their wealth to housing featured with high idiosyncratic risks.

Table 6 and 7 compute the correlations of total housing returns with individual stocks and market portfolios respectively. For the correlation between housing and individual stocks, Detroit, Farmington Hills, Tampa, and Cambridge are negatively correlated with 1 or less stocks; housing in most California cities are negatively correlated with 2 or less stocks while returns in Houston and mid-Atlantic are with more stocks. From theoretical predictions, diversification arising from negative correlation is expected to have a direct effect on the portfolio composition.

Some studies use VAR regression to explore above correlation (Englund, Quigley and Hwang (2002), Rehring (2012)); or observe performance of stock returns after ranking local housing price changes where the headquarters of these stocks are located (Henock and Sun (2012), Anderson and Beracha (2012)). In a mean-variance setup, above techniques may help to explore the potential negative correlation between housing returns and stock returns, but bring complexity in solving the optimal portfolio.

In the subsections presenting results below, the "unconstrained model" is the standard portfolio problem assuming that households can diversify risk without consumption constraints – i.e. households can hold any amount of housing equity that they please. Then the "constrained model" describes how the consumption constrained households, the main concern of this paper, allocate their wealth.

Given the characteristics of returns in various cities shown in Table 5, a few assumptions are required to compute optimal portfolio choices for consumption constrained households in each of the 38 cities. The parameter of risk aversion is 3[10]; and the real annual property tax and other cost is 1.5%; the investment horizon is annual[11].

5.1 Understanding the Stockholding Puzzle

Now consider the case in which households can only choose housing and only one of the 3 market portfolios. In table 8, columns 1-3 list the share of each market portfolio when unconstrained households are free to choose housing and one market portfolio. The S&P500 is not attractive to households (mean share is only 22%), compared with other 2 market portfolios. The reason for this result is clear. The S&P500 has little higher average return than local housing, but has much higher risk and there is a higher

[10] Most papers would use several parameters equal to 1, 2, 4, 8 or 16. See Englund, Quigley and Hwang (2002), Flavin and Yamashita (2002). Due to a long city list, in the estimation part, this paper only considers the case when parameter equal to 3.

[11] Campbell and Viceira (2002) have a detail discussion about investment horizon for different finanial assets and housing. This paper uses annual data is due to the fact that housing CAP rate is estimated on biennual AHS data. Quarterly data would "oversmoothe" the CAP rate.

positive or lower negative correlation between S&P500 and local housing returns in most cities. For the two other market portfolios from CRSP, Erate and Vrate, shares are higher than S&P500. These portfolios have significant higher mean return and higher risk than housing returns. They have lower correlation with housing returns in individual cities. In previous research, the S&P500 is used as the alternative risk asset to housing. The finding is consistent with Flavin and Yamashita (2002) suggests that households are willing to hold very substantial amounts of housing equity when the S&P500 is their alternative choice. However, considering the value of degree of risk aversion is just 3, the significant shares of these market portfolios tend to be "overestimated" for more risk reverse households.

In the constrained model, consumption constrained households have net worth equal to 20% of the house value they prefer to occupy. These households have the option of renting which is not considered here. It is also the fact that many households choose to own with ratios of value to net worth of 10 or more. The ratio 5 is chosen here for illustrative purposes. A small change in the model can find the mean variance efficient portfolio allocation for a variety of value/net worth consumption constrained households.

Compared with the unconstrained model, stock and levered house equity returns reverse their position as shown in figure 1: levered housing equity returns have higher mean value and becomes riskier. Houses with less diversification effect are not preferred by unconstrained households, and it can be predicted that market portfolios with less diversification effect are not preferred by consumption constrained households[12].

The results for portfolio choice by consumption constrained households with the S&P500 and housing as risk assets in column 4-6 of table 8) are easily summarized. The portfolio share of the S&P500 is always zero in most cities. This further confirms the Flavin and Yamashita (2002) result that, given the choice between average house returns for the entire U.S. and the market portfolio, households tend to ignore equities and make the largest down payment possible. By extension, such households would continue to prepay their mortgage rather than buying the S&P500. Though it is optimal for them to hold little finanial asset, their portfolio is levered sharply. Turning to other market portfolios cases, the results are quite similar. The Erate and Vrate indexes are not attractive and the reason is the same as the S&P500. Compared with individual stocks portfolios, housing shares in market portfolios cases are higher in most cities.

[12]Englund, Hwang and Quigley (2002) finds households hold no housing in shorter run; considering housing return featured with lower mean value and lower risk, this paper is consistent with their findings: results not displayed with quarterly data confirms that households will hold no stocks when levered housing return is more risky.

Thus when previous studies use market portfolios to study the portfolio choice for unconstrained households, the results will constrast with those for the consumption constrained households; missing the leverage role of mortgage would lead to the so-called stockholding puzzle. The results suggest why consumption constrained households may not hold the S&P500 or another proxy for the market portfolio because it is not, in fact, effective in diversifying away the unique risk associated with holding housing in individual housing markets. Market portfolios like S&P500, Erate or Vrate have been well diversifying the idiosyncratic risk in the finanicial market, leaving little room to be correlated with risky housing returns; thus, it's not optimal for households to pool one low-risk finanial asset (S&P500) and one high-risk housing asset to be mean-variance efficient; otherwise, they have to allocate majority of their wealth to the individual asset with the highest Sharpe ratio. In contrast, there are individual stocks that have low levels of correlation with housing returns in individual cities as shown below: this allows the households to pool the risky financial assets and risky housing asset to constrcut a well-diversified portfolio.

5.2 Normative Analysis: Risk Reduction for Consumption Constrained Households

Consumption constrained households face extreme risk of portfolio featured with high LTV ratio and lower financial assets. This part shows that instead of holding the S&P 500, they can significantly reduce their portfolio risk by turning to hold the individual equities or their combinations. This part discusses the portfolio problems for unconstrained households first to illustrate that holding individual stocks matter little to them compared with S&P500.

Consider the environment where unconstrained households can choose any portfolio consisting of housing from a single city and flexible proportions of the 10 equities selected to represent alternative stock investments. From figure 1, stocks have higher risk and average return than housing. Optimization results are consistent with predictions of standard portfolio theory and the two propositions above. The results in columns 1-3 of table 9 illustrate differences in the optimal share of housing equity across cities. In most cities, households allocate as little wealth as possible to housing equity; only in Baltimore, Houston, Milwaukee, Fort Lauderdale and Pittsburgh, households allocate significant shares of wealth to housing equity. Turning to $Efund$ and $Vfund$ constructed artificially from the 10 individual stocks: their shares in the unconstrained household

portfolios are also very high. When calculating $Vfund$, higher weights are assigned to GE, IBM and Wal-Mart, which have medium returns yet higher risk. This can explain why $Efund$ is more attractive than $Vfund$. Generally, for unconstrained households, they can hold siginificant share of risky finanical assets to well diverisify the portfolio risk; this is consistent with prediction of standard portfolio theory. And unconstrained households prefer holding portfolios of individual stocks rather than market portfolios, as can be confirmed by figure 3 for households in Cleveland: combing individual stocks (or their comnination, $Efund/Vfund$) and housing produces a more attractive efficient frontier than combing $S\&P500$ and housing.

However, if applying these results to all households, there would be problems: as in Survey of Consumer Finance 2010, 70% of U.S. homeowners hold mortgage loan in their primary residence and are consumption constrained households.

In the flexible stock model where consumption constrained households can choose any portfolio of 10 equities, they behave differently from the single index cases. From columns 4-6 of table 9, households in most areas choose LTV well above 90% (average of 92%) so less than half wealth is in housing equity. This variation can be explained by the degree of correlation between local housing and individual stock returns. Households in Houston could even hold zero home equity to diversify housing risk; though the results is surprising due to high correlation degree with BP, it indicates great potential of diversification gain by holding individual stocks. In Baltimore, Camden, Houston, Suffolk, Nassau, Philadelphia and Pittsburgh, households allocate more than 90% of their wealth to individual stocks.

Table 10 lists the different optimal equity portfolios for consumption constrained households across 38 cities. The representative households would choose different stock compositions, even though they are geographically close: households in northern Washington D.C. (Bethesda and Rockville) hold different shares of stocks from those in southern Washington D.C. (Arlington and Alexandria); households in Boston and Cambridge hold different shares of United Health Service and P&G. Moreover, some stocks are very attractive while some are not: United Health Service are held by households in 33 cites, Wal-Mart in 24 cites, British Petroleum in 26 cities, Progressive in 21 cities, IBM and P&G in 13 cities; Verizon, DuPont, General Electric, and American Electric Power stocks are not held by any household. Due to the negative correlation between housing return in Houston and BP, households there will allocate two thirds of their wealth to this stock though oil refinery industry invests significantly in Houston. Turning to $Efund$ and $Vfund$: Vfund is held in a significant proportion, and Efund is even more widely held

reaching over 50% in a few cities and less than 10% only in 7 cites.

If households were aware of the possibility of using these risky assets, they would include them in a portfolio with housing equity. This can be demonstrated by table 10. In all cities, constrained households allocate diversified portfolios, in contrast to the unconstrained model. Results in this section confirm the two propositions: households choose different optimal portfolio as they reside in different cities; consumption constrained households hold higher housing shares that those in fully diversified model. Finally constrained households prefer holding portfolios of individual stocks rather than market portfolios, as can be confirmed by figure 4 for households in Cleveland: combing individual stocks and housing produces a more attractive efficient frontier than combing $S\&P500$ and housing.

5.3 REIT: Proxy for Housing Returns

This paper considers a proxy measure of local housing return: 18 REITs which highly focus on residential real estate in one specific state. In this case, the paper assumes households choose the shares of REITs and individual stocks and explores the diversification roles other non-REIT financial assets play. The 18 REITs are carefully chosen based the investing types (mainly apartment) and geographic locations.

Table 12 lists geographic information for the 18 REITs from CRSP[13]: Washington Real Estate Investment (WRE), Mack Cali Realty Corp. (CLI), Income Opportunity Realty (IOT), Roberts Realty Investors Inc. (RPI), and First Real Estate Investment Trust of New Jersey (FREVS) are the ones with investment concentrating in one MSA; BRE Properties Inc. (BRE), Essex Property Trust (ESS) and Kilroy Realty Corp (KRC) concentrate in the major MSAs along the west coast; AvalonBay Communities Inc. (AVB), Home Properties Inc. (HME), and Mid-America Apartment Communities Inc. (MAA) focus on a larger region but with similar housing fundamentals; Associated Estates Realty Corp. (AEC), Apartment Investment and Management Co. (AIV), Camden Property Trust (CPT), Equity Residential (EQR), Maxus Realty Trust Inc. (MARTI), Post Properties Inc. (PPS) and UDR Inc. (UDR) tend to be more diversified.

Table 12 shows the performance of assets: due to the limited sample, the previous finding by other scholars that REITs generally have higher return than stocks is not clear. Figure 2, shows the relative risk-return relation between REITs and other financial assets. Please note that REITs use different starting years but stocks are always covering from

[13]Some of the 18 REITs are diversified type; thus when the paper refers to their investment locations, it means the locations of their apartment investment.

1985Q1 to 2009Q4. For comparison, the unlevered housing returns are also displayed.

Table 13 lists the correlation coefficients between REITs and individual stocks. FREVS, IOT and RPI are negatively correlated with 2 stocks; AEC, AVB, CPT, ESS, MAA, MRTI, and PPS are negatively correlated with 1 stock; the rests are positively correlated with all stocks. They are all positively correlated with 5 portfolios.

Results of unconstrained model show that moderate diversification benefit can be derived from holding individual stocks: households would allocate little wealth to REITs; only when REITs are AVB, ESS, FREVS, HME, IOT, MAA and UDR would households hold a non-zero share of REIT. In stock composition,households would hold different stocks in different "housing" markets. Not surprisingly, no household hold General Electric, DuPont Chemical, Verizon and American Electric Power; UHS are held in all 18 cases, BP and P&G in 17 cases, IBM in 14 cases, Wal-Mart in 8 cases and Progressive Inc. in 5 cases. When choosing market portfolios and REITs, unconstrained householed still allocate significant wealth to market portfolios. Again, unconstrained households prefer holding portfolios of individual stocks rather than market portfolios, as can be confirmed by figure 5 for households in Cleveland: combing individual stocks and REIT produces a more attractive efficient frontier than combing $S\&P500$ and REIT.

Table 14 shows choices for consumption constrained households. Portfolios of individual stocks help them to achieve mean-variance efficiency in 13 out of 18 cases; due to the fact that unlevered REIT returns are higher than stock returns in financial market, these results add more support to the diversification role of holding individual stocks. In constrained model, no households allocate any asset to market portfolios[14]. Still, constrained households prefer holding portfolios of individual stocks rather than market portfolios, as can be confirmed by figure 6 for households in Cleveland: combing individual stocks and REIT produces a more attractive efficient frontier than combing $S\&P500$ and REIT. In stock compositions, consumption constrained households only hold positive shares of Wal-Mart, P&G, IBM and Verizon. Surprisingly, UHS and BP are not held in any cases by constrained households while preferred by unconstrained households.

6 Comparative Analysis

This part changes the model setup and asset characteristics to find whether the conclusions are quantitative robust. The comparative analysis focuses on the following aspects: allows

[14]In constrained model using REIT as "housing", this paper allows a less aggressive mortgage schedule: it will increase by 0.5% if LTV increases from 80% to 100%.

risk-free assets, and ignore the CAP rate in total housing return.

By deducting risk free return from housing and financial asset returns, the results do not change in both constrained and unconstrained model[15]. The argument is that as households get extra cash, the payment of the mortgage is their priority (Yao and Zhang (2005), Flavin and Yamashita (2011)); furthermore, risk-free assets does not bring diversification gains; thus it's not optimal for households to hold risk free asset in constrained and unconstrained model either by combing individual stocks or market portfolios.

By ignoring the CAP rate, total housing return will be less attractive (Goetzmann and Spiegel (2000)) and produces different effects on unconstrained and constrained households: as in table 15 for unconstrained households, housing returns are further less attractive because CAP rate is featured with less risk but higher return; unconstrained households further reduce the housing holding in both market portfolio and individual stocks cases; in combination of market portfolio and housing return, S&P 500 gains higher share increase, which is no surprise if recalling that S&P 500 have similar return with housing returns (with CAP rate). As in table 16 for consumption constrained households, the effects are mixed: in figure 7, levered housing returns are becoming lower-return-higher-risk assets; from equation (19), mortgage leverage enlarges the diversification gain/loss, which means that the only motive for consumption constrained households to hold housing is the negative correlation between equity return and housing appreciation rates. For constrained households choosing individual stocks and housing, households in cities where their local housing returns are negatively correlated with stocks would gain higher utility level; the stock composition also changes in most cities; however, the changes of housing shares are mixed because in some cities appreciation rates have opposite correlation with stocks from the cases using total housing returns; the portfolio returns and risks all lowers in all cities. Turn to the combination of market portfolio and housing, S&P500 become less attractive in all cities; Erate and Vrate are less attractively in most cities; share changes of Efund and Ffund are mixed due to individual stock effects. Thus this indicates the ignoring rental return in housing returns would affects the portfolios for the unconstrained households in the same direction; but it would have tremendous mixed effects on the portfolios of the consumption constrained households[16].

[15] This paper uses 90 days T-bill rates as risk free asset return.

[16] This paper also follow others by assuming constant CAP rate as 5% for all cities (Case and Shiller (1989, 1990), Flavin and Yamashita (2002)), and the difference is still very significant.

7 Conclusions

The "stock holding" puzzle reflects the intersection of normative and positive analysis in field of household finance. Normative analysis applying portfolio theory suggests that consumption constrained households will have substantial unique risk and may gain little from holding the market portfolio. However, there should be a portfolio that includes significant amounts of equities, different across urban housing markets that are mean-variance efficient. Positive empirical analysis finds that households tend to hold housing and government guaranteed assets. Over time they pay down mortgage balances and avoid equities.

Some research tries to resolve the paradox by using illiquidity of the housing asset, or the positive correlation between housing returns and the market portfolio to explain household behavior. Other papers have either ignored rental return or used a national index of rents. Few papers consider the geographic variation of housing returns and the specific situation of consumption constrained households.

The paper first estimates the total return to housing over time for the 38 cities. Determining the risk and return characteristics of housing in each city is a difficult task because it requires measuring CAP rates for owner occupied housing and then computes the leveraged housing equity returns by introducing risk based mortgage pricing.

Housing is an attractive asset for the unconstrained household. These households tend to include a substantial portion of housing in their portfolios. It is interesting that, the S&P 500 is not particularly attractive in combination with housing. Of all risk asset portfolios combining housing and other risk assets, that involving housing and the S&P 500 contains the lowest share of equities.

As demonstrated in the theory section, the consumption constrained households have an unusual portfolio choice problem because of the substantial amount of unique risk associated with the highly levered housing investment. It is not surprising that the market portfolio as represented by the S&P500 is ineffective in diversifying away this unique risk. However, it is possible to find individual stocks that are effective at diversifying away unique risk in many cities. In view of this the final empirical results are unsurprising. Consumption constrained households faced with the choice of holding the S&P500 versus housing equity will hold housing equity. However, if these households were aware of the characteristics of all risk assets available, they can find attractive alternatives to housing equity that would help to optimize their portfolios. The risk asset weights in these portfolios vary across cities in a manner that households could not know at present.

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Appendix-I

This part provides the proof for Propostion 1 and 2.

The first part of appendix I demonstrates that the sum of optimal shares of individual stocks is higher than the portfolios which assigns fixed weights to the individual stocks. Assume maximium net wealth of households equal to $\frac{1}{z}$ of housing value, which can be translated into:

$$l = LTV = \frac{z-h}{z} \tag{21}$$

From euqation (21), the housing-stock covariance equation (19), and variance of housing return equation (18), the model has,

$$hr = h\frac{\widehat{r}-\varphi l}{1-l} \tag{22}$$

$$h\sigma_{sh} = h\frac{\theta^T}{1-l} = z\theta^T \tag{23}$$

$$h^2\sigma^2 = h^2\frac{var\left(\widehat{r}-\varphi l\right)}{\left(1-l\right)^2} = z^2 var\left(\widehat{r}-\varphi l\right) \tag{24}$$

Minimium question of constrained households in equation (12) can be rewritten as,

$$MIN\ \mathcal{L} = \frac{A}{2}X^T\Sigma X + \left(zA\theta^T - R_s^T\right)X + \frac{z^2 var\left(\widehat{r}-\varphi l\right)}{2} - z(\widehat{r}-\varphi l) \tag{25}$$

Considering the budget constraint, the model has,

$$1 - X^T E = h \tag{26}$$

where E is column vector with all element euqal to 1. Equation (25) can substitue l and h with their relation with X, substitue $cov(\widehat{r},\varphi)$ with δ,

$$\begin{aligned} MIN\ \mathcal{L} \;=\; & \frac{A}{2}X^T\Sigma X + \left(zA\theta^T - R_s^T\right)X + && (27)\\ & \frac{z^2\left(\sigma^2 + \left(\frac{z-X^TE}{z}\right)^2 var(\varphi) - \frac{2\left(z-X^TE\right)\delta}{z}\right)E^T}{2} && (28)\\ & -z(\widehat{r} - \varphi\frac{z-X^TE}{z}) && (29) \end{aligned}$$

FONC to X is,

$$\frac{\partial \mathcal{L}}{\partial X} = AX^T\Sigma + zA\theta^T - R_s^T - \frac{var(\varphi)\left(z - X^T E\right)}{2}E^T + z\delta E^T + E^T\varphi \tag{30}$$

SOSC to X is,

$$\frac{\partial^2 \mathcal{L}}{\partial X^2} = A\Sigma + var(\varphi)EE^T \tag{31}$$

The matrix of SOSC is positive definite, thus the minimium question will have only one set optimal solution. Portfolio constructed by the individual stocks is weakly less attractive than the individual stock case ($Vfund$ and $Efund$). Assume the optimal stock share vector X_i^* and housing share h_i^* when the households can freely choose individual stocks; if there is any stock share vector $\overline{X_i^*}$ and housing share $\overline{h_i^*}$ so that $U(\overline{X_i^*}, \overline{h_i^*}) > U(X_i^*, h_i^*)$, it violates the maximization conditions. So it's incorrect that $\overline{X_i^*}$ and $\overline{h_i^*}$ can bring higher utility level than X_i^* and h_i^*.

Now turn to the case of choosing housing and market portfolios. Ignoring the risk of mortgage rate, the solution from equation (30) would be,

$$X^* \approx \frac{R_s - 2A\theta + C}{A\Sigma} \tag{32}$$

where $C = \frac{var(\varphi)}{2}z - z\delta - \varphi$, can be seen as constant given the location of households. Above equation can be expressed as,

$$X^* \approx \frac{R_s}{A\Sigma} - \frac{2\theta}{\Sigma} + \frac{C}{A\Sigma} \tag{33}$$

where the first term is Sharpe Ratio of the market portfolio, the second term is the beta value from the single CAPM model using stock portfolios as proxy of market performance, and the last one is inverse ratio of portfolio risk. $S\&P500$ is featured with lower Sharpe ratio and negligible correlation with housing returns, which can explain the phenomena of lower share in empirical results part. From euqation (33), it's not proper to conclude that randomely chosen stocks or their portfolios would bring higher diversification gain than S&P500; however, they could be preferred by the households if they or their portfolios ($Vfund/Efund$) have negative correlations with housing returns even with lower Sharpe ratio.

Appendix-II

This part describes the estimation technique for the total housing returns. A well-estimated housing return should consist of full properties of housing. As stock can provide dividend benefit and price fluctuation risk, house saves home-owner's implicit rent and bring value variation. The implicit benefit could be measured by performance of capitalization rate (CAP rate) while the value variation could be commutated as appreciation rate.

Due to smoothness property of CAP rate, it's inclined to assume a constant national CAP rate. Case and Shiller (1989, 1990) assumes a 5% and 8% CAP rate. Flavin and Yamashita (2002) assumes 5% real CAP rate; Pelizzon and Weber (2008), Hu (2005) follows this value. Yao and Zhang (2005) choose 6% by referring to ratio of national rental cost to value of rental property. Bucciol and Miniaci (2011) use 5% annual CAP rate to do sensitivity analysis. These values are roughly the same magnitude as the findings of Phillips (1988), and Sinai and Souleles (2003). Some of real estate finance literature tend to ignore the CAP rate and just use HPI appreciation rate as housing return (Cocco (2005), Jin (2009)). The reason is because appreciation rate fluctuates more significantly which dominates the volatility of housing return, compared with cap rate. Englund, Hwang and Quigley (2002) argue that this approach fits well in a country with highly correlated regional housing returns but not in United States.

This paper uses AHS data to estimate CAP rate with the pooled Hedonic method proposed by Phillips (1988). Coulson (2008) discusses the choice of log and level values for dependent and independent variables in Hedonic regressions and this paper choose semi-log equation consistent with Phillips (1988). The function of estimating CAP rate is,

$$\ln(price_{ij}) = \beta_0 + \beta_1 * X_{ij} + \beta_2 * D_{ij} + \beta_3 * D_{ij} * X_{ij} + \mu_{ij} \tag{34}$$

where $price_{ij}$ is housing value for owner-occupied type, and net annual rent for rental type for ith propety in MSA j. D_{ij} is 1 for type of owner-occupied and 0 for type of being rented. X is vector of housing characteristics; interacted terms mean quality differences for owner-occupied and rental properties. μ captures noises that influence housing value or rent.

Observations with housing value lower than \$10,000 which are treated as results of non-arm's length transactions are excluded. Annual rent are net of utility (gas, water, fuel and others) as reported by respondents. Both housing values and rent are deflated with the CPI. Thus averaged CAP rate for each MSA in each year can be calculated by,

$$\ln(CAP_{ij}) = \ln(\frac{rent}{value}) = -\widehat{\beta_2} - \widehat{\beta_3} * X_{ij} \tag{35}$$

Housing appreciation rate is always derived from repeated sales price index (Hamilton and Schwab (1985), Hwang and Quigley (2002), Jud et al. (2003, 2006), Cocco (2005)) or panel housing price (Capozza and Seguin (1996), Flavin and Yamashita (2002)). This paper uses quarterly HPI from OFHEO to calculate appreciation rate. Geographic information for CAP rate and appreciation rate can be found from AHS codebook and OMB file, through which the geograhic areas can be matched to produce the 38 cities.

Table 1: Proportion of Households Investing In Risky Assets

Year	U.S.	U.K.	Netherlands	Germany	Italy
Direct Stocking					
1983	19.1%	8.9%	n.a.	9.7%	n.a.
1989	16.8%	22.6%	n.a.	10.3%	4.5%
1995	15.2%	23.4%	11.5%	10.5%	4.0%
1998	19.2%	21.6%	15.4%	n.a.	7.3%
Direct and Indirect Stockholding					
1983	n.a.	n.a.	n.a.	11.2%	n.a.
1989	31.6%	n.a.	n.a.	12.4%	10.5%
1995	40.4%	n.a.	29.4%	15.6%	14.0%
1998	48.9%	31.4%	35.1%	n.a.	18.7%

Notes: Table 1 is from Guiso, Haliassos, and Jappelli (2002). Year of the data: US: 1998; UK: 1997-1998; Netherlands: 1997; Germany: 1993; Italy: 1998. The upper panel report household shares of direct stock holding; the lower panel report household shares of direct and indirect stock holding.

Table 2: Conditional Asset Shares, By Asset Quartiles

	Quartile I	Quartile II	Quartile III	Quartile IV	Top 5%	Average
Direct Stockholding						
U.S.	32.9%	33.0%	25.6%	34.9%	37.9%	34.6%
U.K.	n.a.	73.1%	64.3%	28.8%	23.3%	42.7%
Netherlands	68.3%*	31.5%	34.1%	48.2%	66.6%	47.6%
Germany	23.80%	16.7%	15.8%	29.5%	22.5%	18.6%
Italy	23.3%*	36.8%	21.0%	24.1%	22.1%	23.0%
Direct and Indirect Stockholding						
U.S.	40.7%	45.0%	49.0%	60.4%	64.0%	59.6%
U.K.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Netherlands	40.3%*	32.7%	37.3%	55.2%	66.1%	53.6%
Germany	26.7%	21.9%	20.6%	22.0%	24.5%	21.8%
Italy	53.4%	50.9%	50.2%	50.0%	65.1%	57.3%

Notes: Table 2 is from Guiso, Haliassos, and Jappelli (2002). Year of the data: US: 1998; UK: 1997-1998; Netherlands: 1997; Germany: 1993; Italy: 1998. In table, the panels report asset shares conditional on participation; all statistics use sample weight; values with star (*) indicates the computation is based on fewer than 20 observations; the first three panels report asset shares by gross financial wealth quartiles; the last panel report asset shares by total asset quartiles.

Table 3: Variance-Covariance Matrix of 10 Stocks

Ticker	N	Mean	Std Dev.	Min	Max
AEP	25	7.61%	19.84%	-34.50%	49.81%
BP	25	14.16%	22.19%	-32.56%	49.60%
DD	25	8.64%	21.34%	-40.17%	39.04%
GE	25	11.26%	26.64%	-54.01%	49.53%
IBM	25	10.26%	31.31%	-41.68%	74.66%
PG	25	12.75%	17.53%	-29.39%	59.12%
PROG	25	21.86%	37.00%	-57.85%	94.36%
UHS	25	19.96%	51.41%	-52.25%	200.25%
VZ	25	9.15%	21.63%	-24.68%	54.83%
WMT	25	18.63%	35.69%	-25.33%	104.27%
EFUND	25	13.52%	16.74%	-22.12%	49.01%
VFUND	25	11.90%	18.85%	-21.00%	49.84%
VRATE	25	8.95%	18.37%	-38.27%	32.31%
ERATE	25	11.57%	25.37%	-43.25%	69.41%
SP500	25	6.39%	17.56%	-38.54%	30.79%

Notes: The table uses annual stock returns.

Table 4: Variance-Covariance Matrix of 10 Stocks

■	AEP	BP	DD	GE	IBM	PG	PROG	UHS	VZ	WMT
AEP	0.039	0.008	0.013	0.024	-0.003	0.004	0.038	0.066	0.016	0.000
BP	0.008	0.049	0.031	0.034	0.035	0.019	0.021	-0.014	0.022	0.009
DD	0.013	0.031	0.046	0.039	0.019	0.024	0.021	0.010	0.026	0.022
GE	0.024	0.034	0.039	0.071	0.032	0.031	0.034	0.021	0.037	0.049
IBM	-0.003	0.035	0.019	0.032	0.098	0.013	0.011	0.004	0.014	0.028
PG	0.004	0.019	0.024	0.031	0.013	0.031	0.025	-0.009	0.027	0.025
PROG	0.038	0.021	0.021	0.034	0.011	0.025	0.137	0.062	0.026	0.021
UHS	0.066	-0.014	0.010	0.021	0.004	-0.009	0.062	0.264	0.003	-0.026
VZ	0.016	0.022	0.026	0.037	0.014	0.027	0.026	0.003	0.047	0.032
WMT	0.000	0.009	0.022	0.049	0.028	0.025	0.021	-0.026	0.032	0.127

Notes: The table uses annual stock returns.

Table 5: Statistics Description of Real Annualized Housing Returns

City	Mean	Std Dev.	Min	Max
Atlanta	6.35%	6.42%	-7.98%	17.46%
Baltimore	9.13%	9.59%	-13.73%	30.97%
Washington D.C.-Rockville	8.06%	9.10%	-10.17%	20.46%
Boston	6.47%	10.41%	-13.90%	26.90%
Cambridge	6.11%	9.62%	-13.48%	25.74%
Camden	8.36%	8.27%	-8.47%	20.95%
Chicago	7.23%	6.32%	-10.89%	18.00%
Cincinnati	6.20%	4.23%	-4.27%	13.47%
Cleveland	6.00%	4.35%	-4.62%	14.52%
Dallas	7.61%	7.64%	-6.72%	22.42%
Detroit	8.61%	7.58%	-12.18%	20.99%
Fort Lauderdale	10.44%	12.80%	-20.93%	32.53%
Fort Worth	7.55%	7.12%	-4.80%	21.28%
Houston	10.04%	8.90%	-7.66%	24.10%
L.A.	5.85%	11.53%	-14.64%	23.70%
Miami	7.79%	10.92%	-20.57%	25.90%
Milwaukee	9.95%	4.73%	-0.95%	18.64%
Minneapolis	8.16%	7.41%	-9.20%	22.53%
Suffolk	9.20%	10.40%	-11.19%	26.26%
Nassau	9.20%	10.40%	-11.19%	26.26%
New Orleans	5.74%	7.77%	-7.34%	18.56%
New York	6.28%	9.83%	-12.63%	29.49%
Jersey City	7.05%	11.90%	-12.97%	31.45%
Newark	6.79%	9.66%	-13.11%	29.28%
Oakland	6.27%	11.70%	-16.54%	24.54%
Philadelphia	8.65%	7.73%	-5.87%	23.05%
Phoenix	7.24%	11.91%	-16.54%	40.98%
Pittsburgh	10.35%	7.62%	-2.93%	23.92%
Providence	9.71%	12.24%	-10.64%	37.54%
San Diego	6.55%	10.79%	-15.31%	24.07%
San Francisco	5.64%	10.01%	-12.89%	20.50%
San Jose	7.09%	12.47%	-13.32%	32.87%
Santa Ana	6.86%	11.51%	-15.27%	25.78%
Seattle	8.19%	7.97%	-14.12%	23.05%
St. Louis	6.48%	4.34%	-4.70%	13.88%
Tampa	8.32%	9.85%	-11.74%	25.33%
Farmington Hills	8.51%	7.17%	-12.06%	20.78%
Washington D.C.-Arlington	8.00%	9.59%	-11.15%	23.45%

Notes: Housing returns for each city are deflated with CPI but not net of annual using cost.

Table 6: Variance-Covariance Matrix of Housing and 10 Stocks Returns

	AEP	BP	DD	GE	IBM	PG	PROG	UHS	VZ	WMT
Atlanta	-0.01	-0.02	0.03	0.29	0.11	0.14	0.19	-0.05	0.22	0.40
Baltimore	-0.03	-0.09	-0.19	0.00	-0.18	0.04	0.11	-0.33	0.00	0.06
D.C.-Rockville	0.04	-0.02	-0.06	0.12	-0.18	0.02	0.09	-0.11	0.01	0.09
Boston	0.01	0.20	0.10	0.18	0.10	-0.01	0.29	-0.02	0.16	0.30
Cambridge	0.01	0.19	0.11	0.20	0.15	-0.01	0.28	0.01	0.18	0.32
Camden	-0.01	0.00	-0.11	-0.04	-0.24	-0.08	0.05	-0.27	-0.02	0.03
Chicago	-0.01	0.01	-0.01	0.16	-0.18	0.12	0.13	-0.18	0.08	0.18
Cincinnati	-0.09	-0.10	-0.10	0.07	-0.06	0.02	0.00	-0.21	0.13	0.31
Cleveland	-0.07	0.00	0.06	0.13	-0.07	0.24	0.30	-0.16	0.23	0.36
Dallas	-0.01	-0.17	-0.09	0.26	0.24	-0.03	0.08	0.17	0.10	0.36
Detroit	0.15	0.32	0.33	0.47	0.09	0.27	0.22	0.01	0.22	0.28
Fort Lauderdale	0.10	0.04	0.03	0.21	-0.03	0.07	0.21	0.02	-0.07	-0.03
Fort Worth	-0.01	-0.17	-0.09	0.25	0.24	-0.04	0.05	0.15	0.09	0.32
Houston	-0.28	-0.48	-0.39	-0.08	0.07	-0.06	-0.21	-0.10	-0.07	0.12
L.A.	0.12	0.08	0.05	0.22	-0.09	0.14	0.11	-0.05	0.15	0.14
Miami	0.15	0.07	0.02	0.24	-0.05	0.11	0.16	-0.06	0.00	-0.07
Milwaukee	-0.07	-0.26	-0.17	0.15	-0.09	-0.07	-0.03	0.02	-0.07	0.19
Minneapolis	-0.06	-0.08	-0.05	0.21	0.03	0.05	0.12	0.02	-0.02	0.19
Suffolk	-0.07	0.07	-0.03	0.04	0.02	-0.13	0.14	-0.15	-0.02	0.16
Nassau	-0.07	0.07	-0.03	0.04	0.02	-0.13	0.14	-0.15	-0.02	0.16
New Orleans	-0.02	-0.20	-0.14	0.10	0.06	-0.04	0.05	-0.06	-0.06	0.00
New York	0.08	0.19	0.04	0.19	-0.06	-0.01	0.23	-0.19	0.16	0.24
Jersey City	0.09	0.14	-0.01	0.19	-0.08	-0.14	0.08	-0.02	0.06	0.19
Newark	0.06	0.11	0.00	0.15	-0.08	-0.03	0.24	-0.20	0.13	0.27
Oakland	0.17	0.04	0.01	0.31	-0.02	0.12	0.20	0.17	0.14	0.26
Philadelphia	-0.03	-0.02	-0.11	-0.04	-0.27	-0.10	0.02	-0.30	0.01	0.10
Phoenix	0.17	0.10	0.03	0.32	0.02	0.09	0.18	0.00	-0.04	0.06
Pittsburgh	-0.07	-0.17	-0.21	0.01	-0.07	-0.20	0.04	-0.04	-0.12	0.03
Providence	-0.06	0.03	0.04	-0.06	-0.12	-0.10	0.21	-0.14	-0.03	0.10
San Diego	0.13	0.08	0.06	0.28	-0.03	0.17	0.17	0.01	0.16	0.20
San Francisco	0.15	0.08	0.00	0.30	-0.07	0.07	0.04	0.07	0.20	0.30
San Jose	0.24	-0.01	0.01	0.32	-0.06	0.08	0.09	0.29	0.18	0.24
Santa Ana	0.11	0.06	0.05	0.25	0.01	0.10	0.11	-0.01	0.11	0.19
Seattle	0.01	-0.01	-0.08	0.24	-0.09	0.37	0.11	-0.13	0.25	0.24
St. Louis	-0.11	-0.06	-0.09	0.02	0.00	-0.21	-0.08	-0.09	-0.07	0.08
Tampa	0.10	0.06	0.06	0.25	0.03	0.09	0.25	0.03	0.01	0.09
Farmington Hills	0.14	0.30	0.29	0.41	0.04	0.23	0.22	-0.02	0.17	0.24
D.C.-Arlington	0.10	0.03	-0.05	0.14	-0.13	-0.02	0.11	-0.08	-0.02	0.05

Notes: The matrix is computed with annual returns.

Table 7: Variance-Covariance Matrix of Housing and Market Portfolio Returns

	Erate	Vrate	Efund	Vfund	SP500
Atlanta	0.21	0.31	0.05	-0.02	0.12
Baltimore	-0.12	-0.08	-0.08	0.03	-0.07
D.C.-Rockville	-0.02	0.00	0.01	0.06	0.03
Boston	0.22	0.20	0.06	0.05	0.10
Cambridge	0.24	0.24	0.07	0.05	0.11
Camden	-0.14	-0.15	-0.10	-0.03	-0.09
Chicago	0.02	0.04	-0.05	-0.04	-0.01
Cincinnati	-0.02	0.08	-0.16	-0.26	-0.09
Cleveland	0.16	0.12	-0.09	-0.13	-0.03
Dallas	0.18	0.37	0.07	0.07	0.12
Detroit	0.36	0.35	0.27	0.13	0.33
Fort Lauderdale	0.08	0.08	0.10	0.22	0.12
Fort Worth	0.15	0.34	0.05	0.07	0.10
Houston	-0.22	0.06	-0.23	-0.12	-0.20
L.A.	0.12	0.11	0.18	0.13	0.20
Miami	0.07	0.06	0.14	0.20	0.16
Milwaukee	-0.06	0.12	-0.08	0.00	-0.05
Minneapolis	0.07	0.18	-0.04	0.03	0.01
Suffolk	0.00	0.04	-0.02	0.08	0.00
Nassau	0.00	0.04	-0.02	0.08	0.00
New Orleans	-0.05	0.08	-0.03	0.11	-0.01
New York	0.12	0.11	0.06	0.01	0.10
Jersey City	0.05	0.10	0.03	0.01	0.06
Newark	0.09	0.09	0.02	0.00	0.06
Oakland	0.23	0.22	0.13	0.02	0.18
Philadelphia	-0.15	-0.14	-0.12	-0.05	-0.10
Phoenix	0.14	0.19	0.20	0.15	0.22
Pittsburgh	-0.12	-0.03	-0.12	0.16	-0.12
Providence	-0.02	-0.08	-0.08	0.10	-0.07
San Diego	0.18	0.18	0.18	0.11	0.22
San Francisco	0.16	0.20	0.11	-0.09	0.17
San Jose	0.22	0.21	0.12	-0.08	0.18
Santa Ana	0.15	0.17	0.21	0.17	0.23
Seattle	0.11	0.17	0.00	-0.17	0.06
St. Louis	-0.11	0.03	-0.12	0.02	-0.10
Tampa	0.16	0.17	0.15	0.21	0.17
Farmington Hills	0.30	0.28	0.20	0.07	0.26
D.C.-Arlington	0.00	0.01	0.05	0.09	0.07

Notes: The matrix is computed with annual returns.

Table 8: Understanding Stockholding Puzzle: Choose Market Portfolios and Housing

	Unconstrained Model			**Constrained Model**		
City	**SP500**	**Erate**	**Vrate**	**SP500**	**Erate**	**Vrate**
Atlanta	24.53%	38.85%	46.91%	0.00%	22.00%	6.00%
Baltimore	14.69%	29.99%	32.82%	5.00%	13.00%	25.00%
D.C.-Rockville	18.90%	33.83%	38.59%	0.00%	9.00%	7.00%
Boston	36.22%	43.44%	54.37%	0.00%	12.00%	2.00%
Cambridge	36.64%	43.88%	55.51%	0.00%	13.00%	1.00%
Camden	16.31%	31.99%	35.20%	7.00%	22.00%	27.00%
Chicago	18.03%	34.65%	39.44%	0.00%	22.00%	16.00%
Cincinnati	23.88%	38.31%	45.30%	1.00%	36.00%	24.00%
Cleveland	25.36%	38.91%	47.09%	0.00%	28.00%	19.00%
Dallas	15.58%	33.63%	38.15%	0.00%	10.00%	2.00%
Detroit	0.00%	27.84%	25.29%	0.00%	2.00%	0.00%
Fort Lauderdale	12.42%	27.16%	30.90%	0.00%	0.00%	0.00%
Fort Worth	14.83%	33.24%	37.60%	0.00%	11.00%	5.00%
Houston	8.65%	26.72%	26.55%	28.00%	36.00%	51.00%
L.A.	44.57%	47.91%	63.04%	0.00%	0.00%	0.00%
Miami	25.22%	36.85%	44.96%	0.00%	0.00%	0.00%
Milwaukee	0.00%	18.95%	12.35%	0.00%	18.00%	17.00%
Minneapolis	12.52%	30.97%	33.95%	0.00%	15.00%	17.00%
Suffolk	15.57%	30.42%	33.95%	0.00%	6.00%	18.00%
Nassau	15.57%	30.42%	33.95%	0.00%	6.00%	18.00%
New Orleans	35.88%	42.84%	54.55%	0.00%	5.00%	16.00%
New York	35.94%	43.62%	54.58%	0.00%	19.00%	2.00%
Jersey City	37.03%	43.52%	53.34%	0.00%	17.00%	6.00%
Newark	31.39%	41.02%	49.99%	0.00%	20.00%	10.00%
Oakland	41.51%	46.55%	59.41%	0.00%	14.00%	0.00%
Philadelphia	12.20%	29.98%	31.73%	9.00%	24.00%	29.00%
Phoenix	32.91%	41.89%	52.43%	0.00%	0.00%	0.00%
Pittsburgh	0.00%	18.43%	18.36%	11.00%	0.00%	29.00%
Providence	21.51%	31.56%	36.88%	14.00%	0.00%	34.00%
San Diego	34.97%	43.36%	55.11%	0.00%	0.00%	0.00%
San Francisco	41.69%	46.94%	60.54%	0.00%	32.00%	0.00%
San Jose	37.10%	44.73%	54.85%	0.00%	33.00%	0.00%
Santa Ana	34.58%	42.83%	54.58%	0.00%	0.00%	0.00%
Seattle	12.63%	33.54%	34.58%	0.00%	38.00%	6.00%
St. Louis	21.42%	35.90%	42.83%	1.00%	17.00%	20.00%
Tampa	15.49%	31.94%	37.10%	0.00%	0.00%	0.00%
Farmington Hills	0.00%	28.51%	26.65%	0.00%	10.00%	0.00%
D.C.-Arlington	20.48%	34.58%	40.13%	0.00%	3.00%	1.00%

Notes: degree of risk aversion=3; rate of annual using cost =0.015. Each column shows the share of market portfolio when households choose housing and that market portfolio.

Table 9: Results of Unconstrained Model II when Choosing Market Portfolio and Housing

	Unconstrained Model			Constrained Model			
City	**House share**	**Port. Return**	**Port. Risk**	**LTV**	**House share**	**Port. Return**	**Port. Risk**
Atlanta	0.0%	17.5%	2.5%	91.2%	44.0%	29.4%	9.6%
Baltimore	7.6%	17.0%	2.2%	99.8%	1.0%	46.8%	19.8%
D.C.-Rockville	0.0%	17.5%	2.5%	94.4%	28.0%	38.9%	20.7%
Boston	0.0%	17.5%	2.5%	92.2%	39.0%	29.3%	25.0%
Cambridge	0.0%	17.5%	2.5%	91.4%	43.0%	27.2%	21.2%
Camden	0.0%	17.5%	2.5%	98.8%	6.0%	41.5%	15.0%
Chicago	0.0%	17.5%	2.5%	93.8%	31.0%	35.1%	10.0%
Cincinnati	0.0%	17.5%	2.5%	94.6%	27.0%	30.7%	4.5%
Cleveland	0.0%	17.5%	2.5%	92.0%	40.0%	28.1%	4.7%
Dallas	0.0%	17.5%	2.5%	93.2%	34.0%	36.1%	13.6%
Detroit	0.0%	17.5%	2.5%	84.2%	79.0%	39.1%	14.4%
Fort Lauderdale	7.6%	17.1%	2.3%	92.0%	40.0%	51.1%	42.1%
Fort Worth	0.0%	17.5%	2.5%	93.2%	34.0%	36.1%	11.9%
Houston	18.2%	16.3%	1.8%	99.8%	1.0%	50.5%	14.1%
L.A.	0.0%	17.5%	2.5%	88.6%	57.0%	26.1%	34.1%
Miami	0.0%	17.5%	2.5%	93.4%	33.0%	38.9%	30.8%
Milwaukee	11.9%	16.8%	2.1%	95.6%	22.0%	49.4%	5.9%
Minneapolis	0.0%	17.5%	2.5%	92.8%	36.0%	39.0%	13.7%
Suffolk	0.0%	17.5%	2.5%	98.8%	6.0%	44.4%	23.9%
Nassau	0.0%	17.5%	2.5%	98.8%	6.0%	44.4%	23.9%
New Orleans	0.0%	17.5%	2.5%	99.6%	2.0%	28.9%	14.2%
New York	0.0%	17.5%	2.5%	94.6%	27.0%	29.6%	21.5%
Jersey City	0.0%	17.5%	2.5%	98.0%	10.0%	32.6%	32.7%
Newark	0.0%	17.5%	2.5%	95.8%	21.0%	32.3%	20.1%
Oakland	0.0%	17.5%	2.5%	85.0%	75.0%	26.3%	34.3%
Philadelphia	0.5%	17.5%	2.5%	99.0%	5.0%	42.5%	12.3%
Phoenix	0.0%	17.5%	2.5%	88.2%	59.0%	33.8%	36.6%
Pittsburgh	15.5%	16.5%	1.9%	99.2%	4.0%	51.3%	14.0%
Providence	2.3%	17.4%	2.4%	99.6%	2.0%	46.8%	33.7%
San Diego	0.0%	17.5%	2.5%	86.4%	68.0%	28.7%	29.8%
San Francisco	0.0%	17.5%	2.5%	87.8%	61.0%	25.5%	25.5%
San Jose	0.0%	17.5%	2.5%	88.6%	57.0%	32.1%	39.5%
Santa Ana	0.0%	17.5%	2.5%	87.4%	63.0%	31.2%	34.3%
Seattle	0.0%	17.5%	2.5%	91.6%	42.0%	39.1%	17.0%
St. Louis	0.0%	17.5%	2.5%	95.6%	22.0%	32.7%	5.0%
Tampa	0.0%	17.5%	2.5%	89.2%	54.0%	39.1%	25.3%
Farmington Hills	0.0%	17.5%	2.5%	85.8%	71.0%	39.4%	13.1%
D.C.-Arlington	0.0%	17.5%	2.5%	93.8%	31.0%	38.5%	23.4%

Notes: degree of risk aversion=3; rate of annual using cost =0.015..

Table 10: Stock Composition of Constrained Model I

City	PROG	BP	UHS	WMT	PG	IBM
Atlanta	3.13%	36.44%	16.43%	0.00%	0.00%	0.00%
Baltimore	0.00%	36.57%	42.82%	19.60%	0.00%	0.00%
D.C.-Rockville	2.41%	20.40%	21.88%	14.08%	0.00%	13.23%
Boston	0.00%	0.00%	16.24%	0.00%	44.76%	0.00%
Cambridge	0.00%	0.00%	13.34%	0.00%	43.66%	0.00%
Camden	0.00%	4.26%	33.82%	20.28%	18.24%	17.39%
Chicago	3.14%	24.11%	23.95%	12.97%	0.00%	4.83%
Cincinnati	17.30%	31.01%	17.67%	7.02%	0.00%	0.00%
Cleveland	0.00%	31.87%	20.52%	7.61%	0.00%	0.00%
Dallas	15.71%	50.29%	0.00%	0.00%	0.00%	0.00%
Detroit	6.54%	0.00%	11.57%	2.89%	0.00%	0.00%
Fort Lauderdale	0.00%	12.73%	12.71%	34.56%	0.00%	0.00%
Fort Worth	19.69%	46.31%	0.00%	0.00%	0.00%	0.00%
Houston	24.94%	65.70%	8.35%	0.00%	0.00%	0.00%
L.A.	6.01%	0.00%	16.66%	4.07%	0.00%	16.27%
Miami	0.00%	4.83%	21.56%	40.60%	0.00%	0.00%
Milwaukee	20.87%	41.33%	7.60%	8.20%	0.00%	0.00%
Minneapolis	8.12%	39.58%	10.74%	5.56%	0.00%	0.00%
Suffolk	0.00%	0.00%	28.00%	0.00%	66.00%	0.00%
Nassau	0.00%	0.00%	28.00%	0.00%	66.00%	0.00%
New Orleans	2.85%	52.82%	18.34%	23.99%	0.00%	0.00%
New York	0.00%	0.00%	31.24%	0.00%	38.11%	3.64%
Jersey City	0.00%	0.00%	15.09%	0.00%	70.94%	3.97%
Newark	0.00%	0.00%	31.59%	0.00%	42.07%	5.34%
Oakland	0.00%	25.00%	0.00%	0.00%	0.00%	0.00%
Philadelphia	3.23%	4.55%	33.11%	10.99%	22.33%	20.80%
Phoenix	0.00%	3.77%	14.44%	22.79%	0.00%	0.00%
Pittsburgh	4.82%	38.04%	15.54%	16.97%	20.63%	0.00%
Providence	0.00%	0.00%	28.94%	1.16%	55.89%	12.00%
San Diego	1.01%	14.23%	12.52%	0.00%	0.00%	4.24%
San Francisco	26.81%	0.00%	0.00%	0.00%	0.00%	12.19%
San Jose	13.44%	23.92%	0.00%	0.00%	0.00%	5.64%
Santa Ana	8.28%	16.61%	12.12%	0.00%	0.00%	0.00%
Seattle	3.77%	31.34%	21.96%	0.93%	0.00%	0.00%
St. Louis	23.02%	16.24%	11.98%	17.02%	9.75%	0.00%
Tampa	0.00%	16.89%	11.49%	17.62%	0.00%	0.00%
Farmington Hills	5.41%	0.00%	14.48%	9.11%	0.00%	0.00%
D.C.-Arlington	0.00%	10.31%	20.90%	19.22%	10.32%	8.24%

Notes: degree of risk aversion=3; rate of annual using cost =0.015.

Table 11: Results of Constrained Model II when Choosing Market Portfolio and Housing

	Unconstrained Model		Constrained Model	
City	**Efund**	**Vfund**	**Efund**	**Vfund**
Atlanta	100.00%	74.31%	25.00%	0.00%
Baltimore	74.77%	52.28%	75.00%	47.00%
D.C.-Rockville	86.12%	59.52%	53.00%	32.00%
Boston	100.00%	77.88%	10.00%	0.00%
Cambridge	100.00%	80.94%	8.00%	0.00%
Camden	79.94%	55.22%	74.00%	56.00%
Chicago	94.19%	62.48%	48.00%	27.00%
Cincinnati	100.00%	69.79%	53.00%	26.00%
Cleveland	100.00%	72.15%	37.00%	22.00%
Dallas	96.32%	64.47%	25.00%	0.00%
Detroit	91.14%	53.40%	0.00%	0.00%
Fort Lauderdale	73.08%	50.61%	27.00%	10.00%
Fort Worth	95.38%	63.61%	31.00%	0.00%
Houston	65.30%	43.70%	91.00%	22.00%
L.A.	100.00%	81.89%	20.00%	5.00%
Miami	92.90%	65.40%	32.00%	16.00%
Milwaukee	62.73%	35.55%	56.00%	21.00%
Minneapolis	86.46%	56.84%	41.00%	7.00%
Suffolk	77.70%	53.65%	54.00%	26.00%
Nassau	77.70%	53.65%	54.00%	26.00%
New Orleans	100.00%	77.58%	59.00%	20.00%
New York	100.00%	76.22%	31.00%	15.00%
Jersey City	98.99%	73.25%	41.00%	11.00%
Newark	100.00%	71.38%	38.00%	20.00%
Oakland	100.00%	82.54%	0.00%	0.00%
Philadelphia	76.85%	52.32%	76.00%	54.00%
Phoenix	100.00%	73.91%	15.00%	0.00%
Pittsburgh	61.99%	38.87%	70.00%	36.00%
Providence	75.45%	53.76%	61.00%	55.00%
San Diego	100.00%	77.22%	9.00%	0.00%
San Francisco	100.00%	84.63%	17.00%	0.00%
San Jose	100.00%	76.83%	0.00%	0.00%
Santa Ana	100.00%	75.74%	14.00%	0.00%
Seattle	87.86%	57.54%	29.00%	2.00%
St. Louis	98.84%	66.87%	61.00%	30.00%
Tampa	90.55%	60.34%	17.00%	0.00%
Farmington Hills	89.37%	53.34%	8.00%	0.00%
D.C.-Arlington	87.69%	60.94%	49.00%	29.00%

Notes: degree of risk aversion=3; rate of annual using cost =0.015.column 1-5 lists the share of market portfolios.

Table 12: REITs that Invest in Specified Geographical Areas

REIT	Investment Location	Ticker	Data Period	Mean	Std. Dev.
Asso. Estates Realty	DC,FL,GA,TX,NC	AEC	1993-2009	6.73%	26.10%
	IN,MI,OH,MD,VA	AEC	1993-2009	6.73%	26.10%
Apart. Invest. and Management	CA,WA,SuN Belt	AIV	2004-2010	9.67%	28.72%
AvalonBay Communities	MA,DC,WA,SF,LA,NYC,	AVB	1994-2009	15.76%	28.58%
BRE Properties	CA	BRE	1985-2009	9.52%	21.29%
Mack-Cali Realty	NJ	CLI	1994-2009	12.26%	26.86%
Camden Property Trust	TX, DC, NC, CA	CPT	1993-2009	10.05%	21.46%
	FL, GA, AZ, CO				
Equity Residential	CA,NYC,DC,FL	EQR	1993-2009	10.43%	19.43%
	MA,WA,MD,CO				
Essex Property Trust	CA,WA	ESS	1994-2009	16.31%	26.45%
First REIT of New Jersey	New Jerse North	FREVS	1997-2009	23.68%	34.49%
Home Properties	DC-NYC-Boston	HME	1994-2009	11.85%	18.18%
Income Opportunity Realty Investors	TX	IOT	1987-2009	14.97%	55.15%
Kilroy Realty	CA,WA	KRC	1997-2009	8.47%	27.61%
Mid-America Apart. Communities	Sun Belt	MAA	1994-2009	12.11%	19.40%
Maxus Realty Trust	MO, AR, OK, TX, FL,KS	MRTI	1985-2009	2.85%	27.33%
Post Properties	DC,FL,GA,NC,TX	PPS	1993-2009	4.14%	20.84%
Roberts Realty Investors	Atlanta	RPI	1997-2009	5.74%	44.75%
UDR Inc	MA,TX,VA,WA	UDR	1985-2009	11.09%	21.05%
	CA,DC,MD,FL				
Washington RE Invest. Trust	DC	WRE	1985-2009	10.54%	22.07%

Notes: starting year is the year of being public as reported by CRSP. Most invests in WA and MA are in Seattle and Boston

Table 13: Correlation Coefficient between Returns of REITs and Stocks

Ticker	**AEP**	**BP**	**DD**	**GE**	**IBM**	**PG**	**PROG**	**UHS**	**VZ**	**WMT**
AEC	0.37	0.16	0.34	0.32	0.09	0.10	0.12	0.19	0.15	-0.16
AIV	0.34	0.33	0.52	0.56	0.24	0.31	0.24	0.43	0.09	0.05
AVB	0.47	0.26	0.41	0.52	0.22	0.30	0.26	0.40	0.13	-0.07
BRE	0.39	0.12	0.30	0.45	0.17	0.11	0.27	0.32	0.15	0.03
CLI	0.42	0.36	0.45	0.52	0.20	0.38	0.42	0.43	0.16	0.07
CPT	0.36	0.29	0.48	0.57	0.14	0.28	0.27	0.32	0.17	-0.06
EQR	0.40	0.25	0.48	0.53	0.15	0.37	0.25	0.37	0.14	0.06
ESS	0.39	0.12	0.38	0.43	0.33	0.22	0.16	0.36	0.15	-0.09
FREVS	0.20	0.15	0.48	0.19	0.17	0.08	0.34	0.13	-0.09	-0.11
HME	0.23	0.19	0.38	0.38	0.22	0.17	0.10	0.28	0.14	0.05
IOT	0.12	0.03	0.06	0.13	-0.07	-0.06	0.01	0.19	0.06	0.09
KRC	0.52	0.42	0.45	0.54	0.17	0.30	0.36	0.33	0.19	0.09
MAA	0.27	0.27	0.34	0.37	0.13	0.07	0.15	0.30	0.06	-0.11
MRTI	0.19	0.22	0.28	0.12	0.15	0.07	0.08	0.11	0.04	-0.09
PPS	0.33	0.33	0.39	0.61	0.21	0.15	0.27	0.28	0.16	-0.02
RPI	0.14	0.20	0.38	0.48	0.09	0.20	0.05	0.31	-0.08	-0.03
UDR	0.27	0.14	0.37	0.42	0.08	0.13	0.17	0.23	0.11	0.05
WRE	0.42	0.06	0.28	0.40	0.05	0.37	0.26	0.33	0.18	0.29

Notes: the correlation coefficients are computed based on quarterly data. All data are from CRSP via WRDS.

Table 14: Results of Constrained Model I when Choosing Individual Stocks and REIT

Ticker	LTV	House share	Portfolio Return	Portfolio Risk	utility
AEC	99.20%	4.00%	11.45%	68.68%	-0.916
AIV	80.00%	100.00%	16.08%	86.99%	-1.144
AVB	87.40%	63.00%	18.55%	33.86%	-0.323
BRE	85.00%	75.00%	12.73%	29.59%	-0.317
CLI	80.00%	100.00%	14.20%	28.66%	-0.288
CPT	86.40%	68.00%	13.36%	34.39%	-0.382
EQR	80.00%	100.00%	14.54%	34.68%	-0.375
ESS	89.40%	53.00%	20.67%	37.96%	-0.363
FREVS	96.40%	18.00%	27.66%	45.25%	-0.402
HME	80.00%	100.00%	15.73%	26.48%	-0.240
IOT	99.80%	1.00%	18.52%	183.24%	-2.564
KRC	80.00%	100.00%	11.62%	49.81%	-0.631
MAA	88.80%	56.00%	14.88%	20.37%	-0.157
MRTI	93.60%	32.00%	5.49%	44.47%	-0.612
PPS	82.60%	87.00%	6.32%	38.21%	-0.510
RPI	84.40%	78.00%	3.19%	87.40%	-1.279
UDR	83.20%	84.00%	15.18%	37.54%	-0.411
WRE	81.60%	92.00%	13.82%	31.32%	-0.332

Notes: the table lists the results of choosing REIT and individual stocks. For each REIT, there are 10 stocks to be chosen to form the optimal portfolios. Degree of risk aversion is 4. This table allows the borrowing interest rate increases by 0.005 when LTV increases to 1 from 0.8.

Table 15: Financial Asset Share Change after Ignoring CAP Rate in Unconstrained Model

City	Stocks	SP500	Efund	Vfund	Erate	Vrate
Atlanta	0	+	0	+	+	+
Baltimore	+	+	+	+	+	+
D.C.-Rockville	0	+	+	+	+	+
Boston	0	+	0	+	+	+
Cambridge	0	+	0	+	+	+
Camden	0	+	+	+	+	+
Chicago	0	+	+	+	+	+
Cincinnati	0	+	0	+	+	+
Cleveland	0	+	0	+	+	+
Dallas	0	+	+	+	+	+
Detroit	0	+	+	+	+	+
Fort Lauderdale	+	+	+	+	+	+
Fort Worth	0	+	+	+	+	+
Houston	+	+	+	+	+	+
L.A.	0	+	0	+	+	+
Miami	0	+	+	+	+	+
Milwaukee	+	+	+	+	+	+
Minneapolis	0	+	+	+	+	+
Suffolk	0	+	+	+	+	+
Nassau	0	+	+	+	+	+
New Orleans	0	+	0	+	+	+
New York	0	+	0	+	+	+
Jersey City	0	+	+	+	+	+
Newark	0	+	0	+	+	+
Oakland	0	+	0	+	+	+
Philadelphia	0	+	+	+	+	+
Phoenix	0	+	0	+	+	+
Pittsburgh	+	+	+	+	+	+
Providence	0	+	+	+	+	+
San Diego	0	+	0	+	+	+
San Francisco	0	+	0	+	+	+
San Jose	0	+	0	+	+	+
Santa Ana	0	+	0	+	+	+
Seattle	0	+	+	+	+	+
St. Louis	0	+	+	+	+	+
Tampa	0	+	+	+	+	+
Farmington Hills	0	+	+	+	+	+
D.C.-Arlington	0	+	+	+	+	+

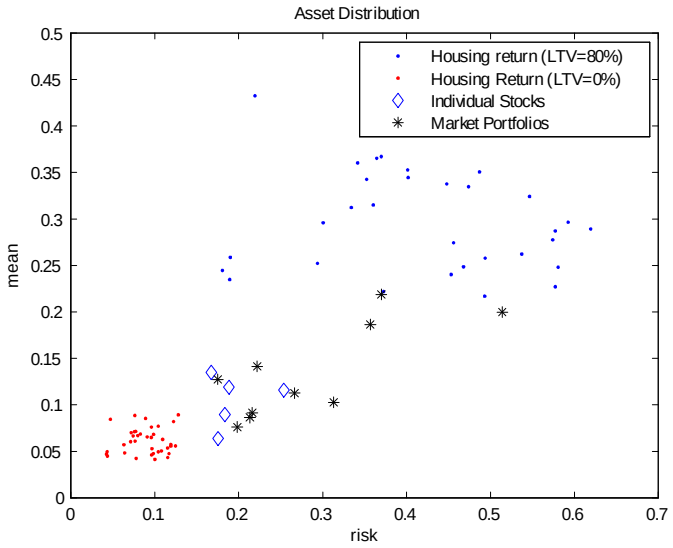
Notes: Column 1 describes change of sum of stock shares in unconstrained model I; columns 2-6 describe the change of unconstrained model II. "+": share of the financial asset increase; "-": share of the finanial asset decrease; "0": share of financial asset doesn't change.

Table 16: Financial Asset Share Change after Ignoring CAP Rate in Constrained Model

City	Stocks	Erate	Vrate	SP500	Efund	Vfund
Atlanta	-	-	-	0	+	+
Baltimore	-	-	-	-	-	-
D.C.-Rockville	+	-	-	0	+	+
Boston	-	-	-	0	+	+
Cambridge	-	-	-	0	+	+
Camden	-	-	-	-	-	-
Chicago	-	-	-	0	-	+
Cincinnati	-	-	-	-	-	-
Cleveland	-	-	-	0	-	-
Dallas	+	+	+	0	+	+
Detroit	-	+	0	0	0	0
Fort Lauderdale	+	0	0	0	+	+
Fort Worth	+	+	+	0	+	+
Houston	-	-	-	-	-	0
L.A.	+	0	0	0	+	+
Miami	+	0	0	0	+	+
Milwaukee	-	-	-	0	-	+
Minneapolis	-	-	-	0	0	+
Suffolk	-	+	-	0	-	+
Nassau	-	+	-	0	-	+
New Orleans	-	+	-	0	-	+
New York	+	-	+	0	+	+
Jersey City	-	-	-	0	+	+
Newark	+	-	-	0	+	+
Oakland	+	-	0	0	+	+
Philadelphia	-	-	-	-	-	-
Phoenix	+	0	0	0	+	+
Pittsburgh	-	+	-	-	-	-
Providence	-	+	-	-	-	-
San Diego	+	0	0	0	+	+
San Francisco	+	-	0	0	+	+
San Jose	-	-	0	0	0	0
Santa Ana	+	0	0	0	+	+
Seattle	-	+	-	0	-	+
St. Louis	-	0	-	-	-	-
Tampa	-	0	0	0	+	+
Farmington Hills	-	+	0	0	-	0
D.C.-Arlington	+	-	-	0	+	+

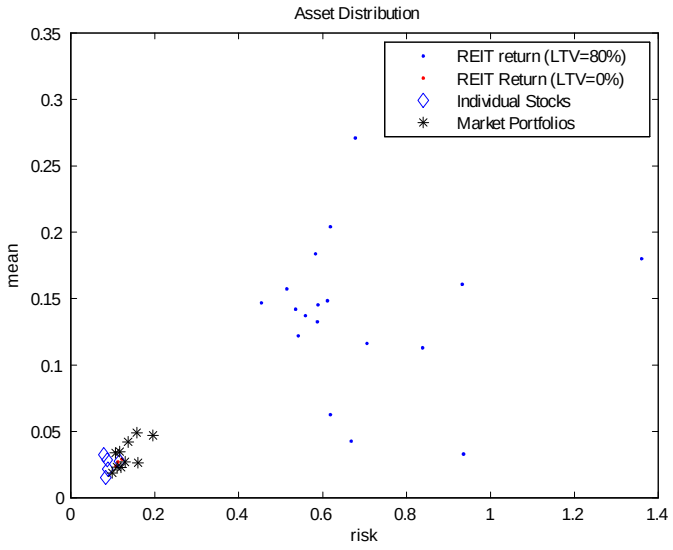
Notes: Column 1 describes change of sum of stock shares in constrained model I; columns 2-6 describe the change of constrained model II. "+": share of the financial asset increase; "-": share of the financial asset decrease; "0": share of financial asset doesn't change.

Figure 1: Distribution of Housing and Financial Asset Returns



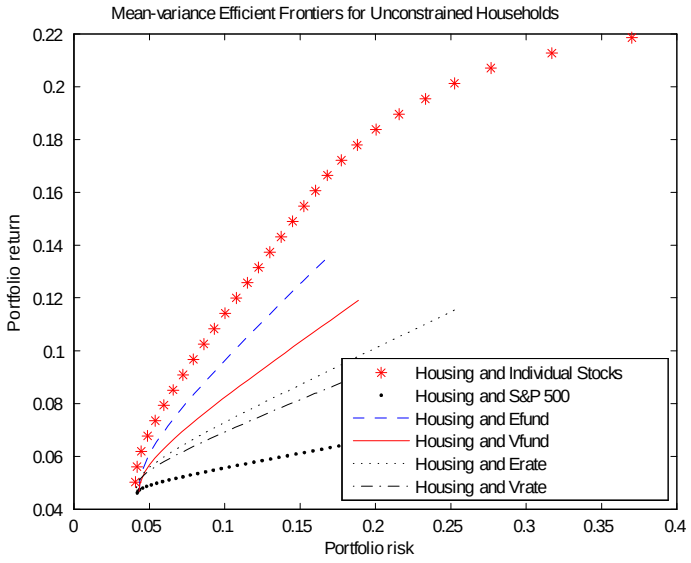
Note: This figure lists the levered and unlevered housing returns for 38 cities; housing returns are net of annual using cost rate (0.015) and deflated with CPI.

Figure 2: Distribution of REIT and Financial Asset Returns



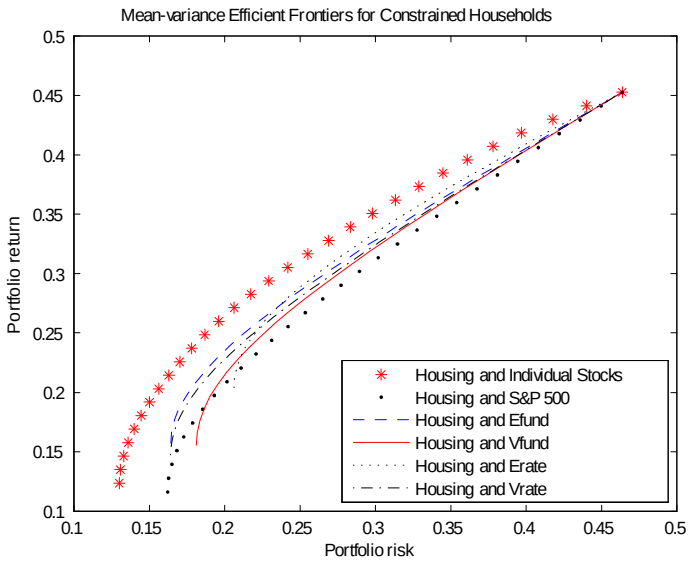
Note: All annualized returns are deflated by CPI. Stock and SP 500 returns are computed all from 1985Q1 to 2009Q4. Housing returns are computed from 1997Q1 to 2009Q4. Housing returns are net of 0.015 annual using cost rate.

Figure 3: Efficient Frontier for the Unconstrained Households



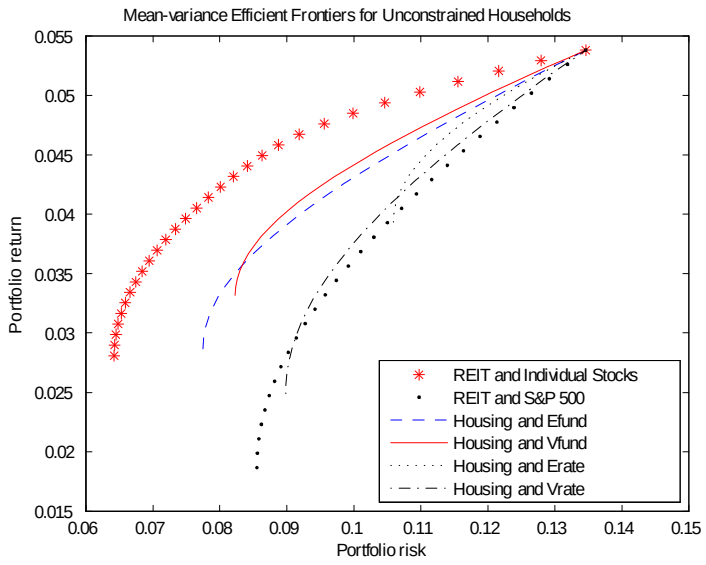
Note: this efficient frontiers are from portfolio consisting of housing return in Cleveland and 10 stocks, SP500, 10-stock-euqal-weight-portfolio (Efund), 10-stock-value-weight-portfolio (Vfund), market-euqal-weight-portfolio (Erate), and market-value-weight-portfolio (Erate) without constraint. Returns of stock, SP500, Erate and Vrate are from CRSP.

Figure 4: Efficient Frontier for the Constrained Households



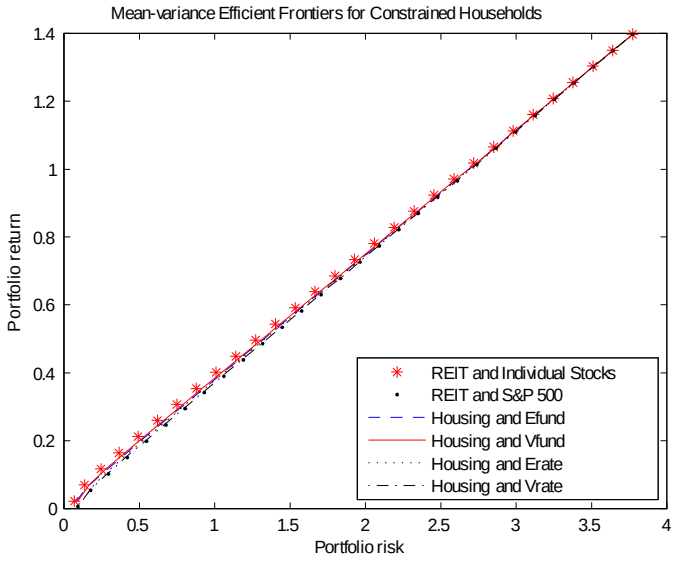
Note: this efficient frontiers are from portfolio consisting of housing return in Cleveland and 10 stocks, SP500, 10-stock-euqal-weight-portfolio (Efund), 10-stock-value-weight-portfolio (Vfund), market-euqal-weight-portfolio (Erate), and market-value-weight-portfolio (Erate) with constraint: net wealth of households equal to 20Returns of stock, SP500, Erate and Vrate are from CRSP.

Figure 5: Efficient Frontier for the Unconstrained Household



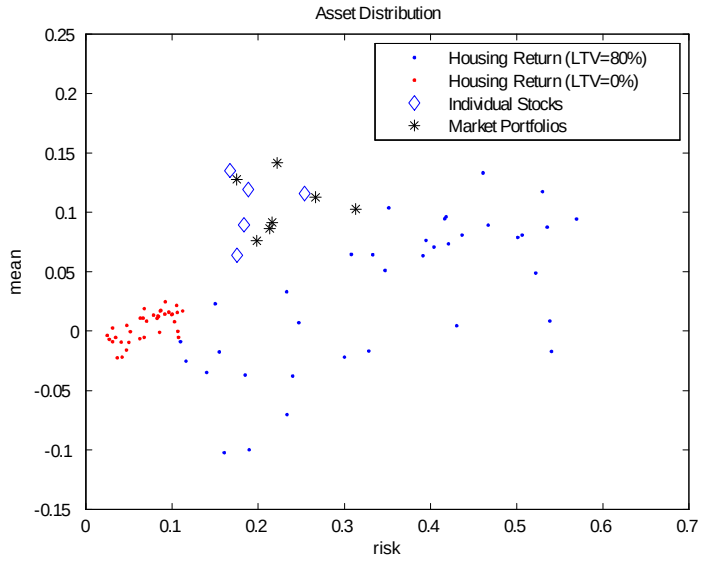
Note: this efficient frontiers are from portfolio consisting of FREVS (NJ) and 10 stocks, SP500, 10-stock-euqal-weight-portfolio (Efund), 10-stock-value-weight-portfolio (Vfund), market-euqal-weight-portfolio (Erate), and market-value-weight-portfolio (Erate) without constraint. Returns of REIT, stock, SP500, Erate and Vrate are from CRSP.

Figure 6: Efficient Frontier for the Constrained Households



Note: this efficient frontiers are from portfolio consisting of FREVS (NJ) and 10 stocks, SP500, 10-stock-euqal-weight-portfolio (Efund), 10-stock-value-weight-portfolio (Vfund), market-euqal-weight-portfolio (Erate), and market-value-weight-portfolio (Erate) with constraint: net wealth of household equal to 20

Figure 7: Distribution of Financial Assets and Housing Returns without CAP Rate



Note:Housing returns are net of CAP rate in this figure. Both Financial assets and housing returns are real values.