Portfolio Choice in the Presence of Housing

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Abstract

I show that investment in housing plays a crucial role in explaining the patterns of cross sectional variation in the composition of wealth and the level of stockholdings observed in portfolio composition data. Due to investment in housing, younger and poorer investors have limited financial wealth to invest in stocks, which reduces the benefits of equity market participation. House price risk crowds out stockholdings, but this crowding out effect is larger for low financial net-worth. Transaction costs of changing houses reduce the frequency of house trades and also lead investors to reduce their exposure to stocks. In the model as in the data leverage is positively correlated with stockholdings.

JEL classification: G11.

1 Introduction

This paper studies portfolio choice in the presence of housing, which is important because owner-occupied housing is the single most important asset in many investors' portfolios. I try to answer to the following questions: How does investment in housing affect the composition of an investor's portfolio? In particular, do house price risk and the illiquid nature of the housing investment lead investors to reduce their exposure to stocks? What determines household leverage, and how does it relate to stock holdings?[2] And finally, how are answers to these questions affected by labor income risk?[3]

To answer these questions I solve a model of the optimal portfolio and consumption decisions of a typical investor, who receives a stream of risky labor income. The investor needs to decide the size of the house to buy, how much to consume of goods other than housing, how much to borrow using the house as collateral, and portfolio composition among stocks and Treasury bills. I assume that there is a transaction cost for selling the house, so that there is a dimension of irreversibility in the housing investment. Following the literature on limited stock market participation (Basak and Cuoco, 1998, Luttmer, 1999), I assume that there is a fixed cost of equity market participation, and ask how the housing investment decision affects investors' willingness to pay the fixed cost.[4]

I use house price and labor income data from the Panel Study of Income Dynamics (PSID),

[2]Heaton and Lucas (2000) find, for stocks relative to financial assets, that "a higher mortgage leads to higher stock holdings, suggesting that some stocks are indirectly financed via mortgage debt."

[3]Of course, if markets were complete so that future labor income could be capitalized and its risk insured, then human capital could simply be added to current wealth, and would play no particular role. But market incompleteness seems to be an important feature to consider when studying portfolio choice. Moral hazard issues prevent investors from borrowing against future labor income, and insurance markets for labor income risk are not well developed.

[4]One well-documented feature of the data on portfolio composition is that many households, particularly poorer and younger ones, do not own stocks at all. This is inconsistent with simple frictionless models of portfolio choice, but may be explained if there is a fixed cost of equity market participation.

for the years 1970 through 1992, to parameterize the model. During this period house prices grew an average of 1.6 percent per year. The correlation between income shocks, house prices, and stock returns is of particular interest for my model. I find that aggregate income shocks are strongly positively correlated with house price shocks, but that these are uncorrelated with stock returns.

The results from the model show that investment in housing plays a crucial role in explaining the patterns of cross sectional variation in the composition of wealth and the level of stockholdings observed in PSID data. For investors who hold a leveraged portfolio the equity premium is the expected return on stocks less the rate of interest on debt, which is larger than the rate of interest on Treasury bills. This implies a lower equity premium, making stocks less attractive as an asset. Furthermore, due to investment in housing, younger and poorer investors have limited financial wealth to invest in stocks, which reduces the benefits of equity market participation. Therefore, in the presence of housing, a lower fixed cost of equity market participation is needed to generate the empirically observed levels of participation.

I also find that house price risk crowds out stock holdings, both for high and low financial net-worth investors, but this crowding out effect is larger at low levels of financial net-worth. Transaction costs of changing houses reduce the frequency of house trades and, as house price risk, lead investors to reduce their exposure to stocks. The crowding out effect of both house price risk and transaction costs is important for explaining the level of stockholdings observed in the data.

Finally, the model addresses the issue of why in cross-sectional data, leverage and investment in stocks tend to be positively correlated. Due to the consumption dimension of housing, investors who have more future labor income acquire more expensive houses, and borrow more. At the same time labor income, although risky, resembles more closely Treasury bills, inducing a tilt in the financial portfolio towards stocks.

There is a vast literature on portfolio selection.[5] Yet most of this literature ignores housing. Two exceptions are Grossman and Laroque (1991) and Flavin and Yamashita (1998). Grossman and Laroque develop a model with a single illiquid durable consumption good from which an infinitely lived investor derives utility. Absent from their analysis are house price risk and nontradable income which play a crucial role in my paper. More recently Flavin and Yamashita studied the impact of the portfolio constraint imposed by the consumption demand for housing, which they call the "housing constraint," on investors' optimal holdings of financial assets. At each age the ratio of housing to net worth is taken to be equal to the value in PSID data, and static mean-variance analysis is used to characterize optimal portfolios. Instead, my model is dynamic, and investors choose the size of their house together with their financial portfolio.[6]

The paper is organized as follows. In Section 2, I present the set-up of the model. In section 3, I use PSID data to parameterize the model. Section 4 presents the results. Section 5 compares these results to PSID data on portfolio composition. This comparison is important since it provides evidence of the strengths and limitations of the model. Section 6 discusses the model and results. The final section concludes.

[5]Merton, 1971, and Samuelson, 1969, are classical references.

[6]The model in my paper builds on the literature on buffer-stock saving (Carroll, 1997, Deaton, 1991), and the recent literature on portfolio choice with uninsurable labor income risk (Heaton and Lucas, 1997, Viceira, 2000).

2 The Model

2.1 Preferences

I model the asset and consumption choices of an investor who lives for T periods.[7] In each period t, the investor needs to choose the size of house to own, H_t, and other non-durable goods consumption, C_t. The date t price per unit of housing is denoted by P_t, such that a house of size $\overline{H}$ has price $P_t\overline{H}$ at date t. The size of the house should be interpreted broadly as reflecting not only the physical size but also its quality. The price of other goods consumption (the numeraire) is fixed and normalized to one. The investor derives utility from both housing and non-durable goods, and after date T from bequeathing terminal wealth, W_{T+1}. Preferences are described by:

$$U_1 = E_1 \sum_{t=1}^{T} \beta^{t-1} \frac{(C_t^{1-\theta} H_t^{\theta})^{1-\gamma}}{1-\gamma} + \beta^T \frac{W_{T+1}^{1-\gamma}}{1-\gamma} \tag{1}$$

where β is the time discount factor, γ is the coefficient of relative risk aversion, and θ measures preference for housing relative to non-durable consumption goods.

2.2 Labor Income Risk

The investor works for the first K periods of his life ($K < T$) in which labor is supplied inelastically.[8] At each date $t < K$ the investor receives a stochastic labor income stream $\widetilde{Y}_t$, against which he cannot borrow. Let lower case letters denote the log of the variable, i.e., $y_t \equiv \ln(Y_t)$. Investor i's age t labor income is exogenously given by:

[7] It is possible to extend the model to allow for uncertain life span in the manner of Hubbard, Skinner and Zeldes (1994). Uncertain life span probably is one of the reasons why old households reduce their consumption of housing services only late in life, often precipitated by widowhood. Uncertain life span does not however explain why reverse annuity mortgages are not more widely used.

[8] Bodie, Merton and Samuelson (1991) have studied the effects of labor suplly flexibility on portfolio choice.

$$\widetilde{y}_{it} = \begin{cases} f(t, Z_{it}) + \widetilde{u}_{it}, \text{ for } t \leq K \\ P, \text{ for } t > K \end{cases} \tag{2}$$

where $f(t, Z_{it})$ is a deterministic function of age, t, and other individual characteristics, Z_{it}, and $\widetilde{u}_{it}$ can be decomposed into an aggregate (η_t) and idiosyncratic components (ω_{it}) such that:

$$\widetilde{u}_{it} = \widetilde{\eta}_t + \widetilde{\omega}_{it}. \tag{3}$$

I assume that idiosyncratic labor income risk is transitory so that $\widetilde{\omega}_{it}$ is an i.i.d. normally distributed random variable with mean zero and variance σ^2_ω. The aggregate shock, $\widetilde{\eta}_t$, follows a first-order autoregressive ($AR(1)$) process:

$$\widetilde{\eta}_t = \phi \eta_{t-1} + \widetilde{\epsilon}_t. \tag{4}$$

where ϵ_t is an i.i.d. normally distributed random variable with mean zero and variance σ^2_ϵ. Thus prior to retirement log income is the sum of a deterministic component, that can be calibrated to capture the hump-shape of earnings over the life-cycle, and two random components, one transitory and one persistent. Log income in retirement is modeled as a fixed pension (P) reflecting the fact that at this stage of life most of the uncertainty related to future labor income has been resolved.

2.3 The Housing Investment

As for owner-occupied housing I assume a correspondence between the size of the house the investor owns and the consumption benefits that he derives from it.[9] Frequently, the price of

[9]Thus, as Grossman and Laroque (1991), I ignore rental markets. Rental markets allow investors to separate the consumption and investment dimensions of housing. In this paper I assume that there are market frictions which make buying a strictly preferred alternative. Possible market frictions include taxes, transaction costs, and moral hazard.

housing in a given region is affected by labor income shocks in the same region. I capture this by assuming that cyclical fluctuations in house prices are positively correlated with cyclical fluctuations in aggregate income. Let p_t denote the date t log price of one unit of housing, and $p_t^{'} \equiv p_t - bt$ the detrended log price of housing. I assume that:[10]

$$\widetilde{p}_t^{'} = \beta \eta_t. \tag{5}$$

To capture the illiquid nature of the housing investment I assume that a house sale is associated with a monetary cost equal to a proportion λ of the house value. Annual maintenance costs are equal to a proportion δ of the house value.

2.4 Financial Assets and Credit Markets

There are two financial assets. A riskless asset, called *Treasury bills,* with gross real return $\overline{R}_F$ and a risky asset, called *stocks,* with gross real return $\widetilde{R}_t$. The log return on the risky asset $\widetilde{R}_t$ is assumed to be:

$$\log\left(\widetilde{R}_t\right) = \mu + \widetilde{\iota}_t \tag{6}$$

where $\mu > 0$ is the expected log return and $\widetilde{\iota}_t$, the innovation to log returns, is assumed to be distributed as $N(0, \sigma_\iota^2)$. I allow innovations in log returns to be correlated with innovations to aggregate income shocks (and house prices), and denote the corresponding coefficient of correlation by $\rho_{\epsilon,\iota}$. The dollar amount the investor has in bills and stocks at date t are denoted B_t and S_t, respectively. I assume that the investor cannot short-sell either of these assets such that:

[10]The assumption of correlation equal to one greatly simplifies the solution of the problem since it avoids the introduction of one additional state variable. In the parameterization section I use PSID data to estimate the correlation between $p_t^{'}$ and η_t. This allows us to assess how reasonable the assumption of perfect correlation is.

$$S_t \geq 0,\ B_t \geq 0 \text{ for } \forall t. \tag{7}$$

These restrictions may be motivated by the costs associated with short positions. I allow for fixed costs of equity market participation: to have access to equity markets the investor has to pay a one-time monetary fixed cost equal to F.

A third financial asset, which I call a *mortgage*, allows the investor to borrow against the value of the house, at a gross real fixed rate of $\overline{R}_D$. The dollar amount the investor owes in mortgages at date t is denoted D_t. I assume that the investor may borrow up to the value of the house minus a down payment, which is assumed to be a proportion (d) of the value of the house, such that:

$$D_t \leq (1-d)P_t H_t \text{ for } \forall t. \tag{8}$$

I assume that the investor is allowed in every period to costlessly renegotiate the desired level of debt, as it is the case for a home line of credit.[11]

2.5 The Investor's Optimization Problem

The investor starts period $t > 1$ with liquid wealth (LW_t) given by:

$$LW_t = \widetilde{R}_t S_{t-1} + \overline{R}_f B_{t-1} - \overline{R}_D D_{t-1}. \tag{9}$$

Following Deaton (1991), I denote the sum of date t liquid wealth plus date t labor income by *cash-on-hand*. Period t cash-on-hand is equal to $X_t = LW_t + Y_t$ (in period 1 there is no initial level of housing and $LW_1 = 0$). At each date $t \leq T$ the investor needs to decide on the level of housing, consumption of other goods, whether to pay the fixed cost of equity market

[11]The possibility of in every period costlessly renegotiating the level of outstanding debt, up to constraint (8), greatly simplifies the numerical solution of the problem since it avoids having the level of outstanding debt as a state variable.

participation (if he has not done so before), and portfolio composition among liquid assets. I denote by α_t the proportion of liquid assets invested in stocks over stocks plus bills, which by assumption is constrained to lie in the unit interval. The date t budget constraint is given by:

$$S_t + B_t = \begin{cases} X_t - C_t - \delta P_t H_{t-1} + D_t, \ \forall t \ s.t. \ H_t = H_{t-1} \\ X_t - C_t - \delta P_t H_{t-1} + D_t + (1-\lambda) P_t H_{t-1} - P_t H_t, \ \forall t \ s.t. \ H_t \neq H_{t-1} \end{cases} \tag{10}$$

Wealth at date $T+1$ is given by:

$$W_{T+1} = X_{T+1} - \delta H_T P_{T+1} + (1-\lambda) H_T P_{T+1}. \tag{11}$$

The investor maximizes (1) subject to (2) through (11), plus the constraints that consumption must be non-negative at all dates. The control variables for this problem are $\{C_t, H_t, D_t, \alpha_t, FC_t\}_{t=1}^{T}$, and the state variables are $\{t, H_{t-1}, X_t, \eta_t, IFC_t\}_{t=1}^{T}$. FC_t takes the value of one if the investor chooses to pay the fixed cost of equity market participation in period t, and zero otherwise. IFC_t takes the value of one if the investor is an equity market participant, and zero otherwise.

The Bellman equation for this problem is:

$$V_t(X_t, H_{t-1}, \eta_t, IFC_t) = \underset{C_t, H_t, D_t, FC_t, \alpha_t}{Max} \left[\frac{(C_t^{1-\theta} H_t^{\theta})^{1-\gamma}}{1-\gamma} + \beta E_t V_{t+1}(\widetilde{X}_{t+1}, H_t, \widetilde{\eta}_{t+1}, IFC_{t+1}) \right] \ \forall t \leq T$$

where given my assumptions the level of housing at the beginning of date t is equal to the chosen level of housing at date $t-1$.

2.6 Solution Technique

The problem cannot be solved analytically. I use standard numerical techniques for solving it (Judd, 1998). Given the finite nature of the problem a solution exists and can be obtained by backward induction. I start by approximating the state-space and the variables over which the choices are made with equally spaced grids. The density functions for the

random variables (namely, the innovations to the risky asset returns, house prices, and labor income process) were approximated using Gaussian quadrature methods to perform numerical integration (Tauchen and Hussey, 1991). I use a five-state transition probability matrix to approximate the aggregate labor income process.

In period $T+1$, and for each admissible combination of the state variables, I obtain the utility associated with each level of terminal wealth. Since this is the terminal period the utility function coincides with the value function. In every period t prior to $T+1$, I obtain the utility associated with the different choices of housing, other consumption, debt and portfolio choice among liquid assets. The date t value function is equal to current utility plus the expected discounted continuation value associated with the choices made, and given the value of the state variables. To compute this continuation value for points which do not lie on the grid I use cubic spline interpolation. The combinations of the choice variables ruled out by the constraints of the problem were attributed a very large (negative) utility so that they will never be optimal. I optimize over the different choices using grid search. I then iterate backwards. Whenever in the solution to the problem the upper limit for the grids turned out to be binding, I increased it and solved the problem again.

3 Parameterization

3.1 Time Parameters

Each period in the model is calibrated to correspond to five real life years.[12] I assume that the investor is born at age 25, retires at age 65 and dies at age 75. All parameters and labor income process were adjusted to take into account the five year nature of each period.

[12]This is done for computational reasons, to keep the dimensionality of the problem low.

3.2 Labor Income

To parameterize the labor income process I use data from the PSID for the years 1970 through 1992. The families that were part of the Survey of Economic Opportunities subsample were dropped to obtain a random sample of the US population. The estimation was restricted to households with a male head.

In order to implicitly allow for (potentially) endogenous ways of self insurance against pure labor income risk I use a broad definition of labor income. In particular labor income in each year is defined as total reported labor income plus unemployment compensation, workers compensation, social security, supplemental social security, other welfare, child support and total transfers (mainly help from relatives), all this for both head of household and if present his spouse. Labor income defined in this way was then deflated using the Consumer Price Index, with 1992 as baseyear. Five-year labor income is for each household equal to the sum of discounted labor income over the relevant age group.[13] All age groups for which five observations were not available were dropped from the sample.

To estimate equation (2) the function $f(t, Z_t)$ was assumed to be additively separable in t and Z_t, where the vector Z_t included age dummies, a family fixed effect, marital status and household composition. Figure 1 shows the estimated age dummies. This is the age profile passed on to the simulation exercise.

The residuals obtained from the fixed-effects regressions of (log) labor income on $f(t, Z_{it})$ can be used to estimate σ_η^2 and σ_ω^2. Define Y_t^* as:

$$\log(Y_{it}^*) \equiv \log(Y_{it}) - \widehat{f}(t, Z_{it}). \tag{12}$$

Using (3) to substitute out gives:

[13]The rate used to discount labor income is five percent. This is the same rate that Heaton and Lucas (2000) use.

$$\log(Y_{it}^*) = \widetilde{\eta}_t + \widetilde{\omega}_{it}. \tag{13}$$

Averaging across individuals gives:

$$\overline{\log(Y_{it}^*)} = \widetilde{\eta}_t. \tag{14}$$

The variance of $\widetilde{\eta}_t$ is obtained immediately as the variance of $\overline{\log(Y_t^*)}$. Subtracting this variance from the variance of $\widetilde{u}_{it}$ gives the variance of $\widetilde{\omega}_{it}$. The estimated standard deviations are shown in table 1. This table also reports the estimated autoregressive coefficient in (4).

Labor income at retirement is set equal to the average of the labor income variable for the retirees in PSID data.

3.3 House Prices

Homeowners in the PSID are asked to assess the current (at the date of the interview) market value of their house. Therefore the market value of the house does not correspond to a real transaction. A major concern with self-assessed values is that households, when asked about the current market value of their house, do not try to rationally assess this value. However, Skinner (1994) compared the self assessed house values in the PSID to the objective measures of the Commerce Department, and found that the two series are quite close in mapping housing price changes in the 1970's and 1980's.

The self assessed value of the house was deflated using the Consumer Price Index, with 1992 as the base year, to obtain real house prices. Define $p_{it} \equiv \log(P_{it})$ where P_{it} is the real price of house i at time t. Averaging across houses I obtain for each year t an index of house prices:

$$p_t = \frac{\sum_{i=1}^{N_t} p_{it}}{N_t} \ , \ t = 1970, ..., 1992. \tag{15}$$

where N_t is the number of observations at time t. Using (15) I estimate equation (5). Table 1 presents the results. During this period log real house prices increased an average 1.59% per year. Part of this increase is probably due to an improvement in the quality of housing, which cannot be accounted for using PSID data. Therefore, in the simulations I decided to use a lower value for the average annual increase in house prices, of one percent. Aggregate labor income is strongly positively correlated with cyclical fluctuations in house prices: the coefficient of correlation is as high as 0.597 and significantly different from zero.

3.4 Financial Assets and Credit Markets

The riskfree rate used is 2 percent per year. To parameterize the mortgage rate premium I subtract the three month Treasury bill rate to the 30 year fixed FHA nominal mortgage rate. The average annual premium for the period 1964 to 1997 is 3.01 percent. Part of this premium is the acquisition of an option on future inflation, a feature absent from the model. Accordingly, I decided to use a lower annual mortgage rate premium, of 2 percent, or an annual mortgage rate of 4 percent.

I use an annual mean return on risky assets of 10 percent and a standard deviation of the log stock return equal to 0.1674 (Campbell, Lo and MacKinlay, 1997). The one-time monetary fixed cost of equity market participation is set to $\$1,000$, but I will consider other values for this parameter. The correlation between innovations to aggregate labor income and innovations to stock returns is slightly positive in the data, and equal to 0.047, although not statistically different from zero. Therefore in the baseline case I set it equal to zero.

3.5 Other Parameters

In the baseline case γ is equal to 5, below the upper bound of 10 considered plausible by Mehra and Prescott (1985). The parameter θ measures how much the investor values housing consumption relative to other goods consumption. Other preference parameters include the

discount factor β. I parameterize these to at least roughly match the mean levels of housing and mortgage relative to financial assets observed in the data. Accordingly, the parameters chosen in the baseline case were β equal to 0.96 on an annual basis and θ equal to 0.10. I will do comparative statics with respect to these parameters. It may be reasonable to assume that θ varies over life, depending on the number and age of the children in the household. Introducing a time varying θ would be easy, but I abstract from these additional effects.

With respect to the transaction costs of changing houses, Smith, Rosen, and Fallis (1988) estimate for home ownership, the monetary component of these costs to be approximately $8-10$ percent of the unit being exchanged. This estimate comprises transactions costs associated with search, legal costs, costs of readjusting home furnishings to a new house, and a psychic cost from disruption. The latter type of cost may vary significantly over life. As with θ, it would be fairly easy to consider age varying λ, but I abstract from this. I set λ equal to 8 percent. Reasonable values for the down payment are between 10 and 20 percent of the value of house. I use d equal to 15 percent. Leigh (1980) estimates the annual depreciation rate of housing units in the US to be between 0.0036 and 0.0136. I use δ equal to 0.01 on an annual basis. Table 2 summarizes the parameters used in the baseline case.

3.5.1 Preference Parameter Heterogeneity

In the baseline case all investors have the same preference parameters. However, it is important to recognize that in practice there is preference parameter heterogeneity which may introduce correlations between the variables in the model. As motivation suppose that the population is composed of investors who differ in the coefficient of relative risk aversion. If less risk averse investors invest a higher fraction of their savings in stocks and take on more debt, then risky asset holdings will be positively correlated with mortgage levels. I study these effects by allowing for parameter heterogeneity. In particular I consider the effects on portfolio composition of heterogeneity in the discount factor, preference for housing and risk aversion.

4 Results

To study the determinants of portfolio composition in the presence of housing I simulate the behavior of investors who differ in labor income realizations, and examine the cross-sectional variation in the portfolio composition by net worth and age. Following Heaton and Lucas (2000) I consider several definitions of net worth: (a) "liquid net worth" is the sum of stocks and bills minus debt, (b) "financial net worth" which is liquid net worth plus house value, and (c) "total net worth" which is financial net worth plus capitalized labor and pension income. The terms "liquid assets," "financial assets," and "total assets" refer to the same classifications but without the subtraction of debt.

4.1 Portfolio Composition by Net Worth

One well documented feature of the data on portfolio composition is that many households, particularly poorer ones, do not own stocks (Mankiw and Zeldes, 1991). How does the investment in housing affect households' willingness to participate in equity markets and the patterns of portfolio composition?

The first two columns of Table 3 show the mean share of stocks and bills in liquid assets, by financial net worth, predicted by the model. I consider two financial net worth groups: less than and greater or equal than one hundred thousand US dollars. In the model, as in the data, low financial net worth households do not participate in equity markets. Poorer households are liquidity constrained and, given their limited liquid wealth, prefer not to pay the fixed cost of equity market participation. This results in a portfolio heavily tilted towards real estate: the mean real estate share is roughly eighty-nine percent of financial assets for low financial net worth households, which is much larger than the fifty-one percent for the high financial net worth group. Poorer investors also tend to hold a highly leveraged portfolio, with a mean ratio of debt to financial assets as high as thirty-seven percent.

4.2 Portfolio Composition over the Life-Cycle

The theoretical literature on portfolio composition in presence of nontradable income has found that when labor income shocks are uncorrelated with stock returns labor income resembles more closely Treasury bills than stocks (Heaton and Lucas, 1997, Jagannathan and Kocherlakota, 1996). This has implications for the composition of an investor's portfolio over the life-cycle: as investors age, implicit holdings of Treasury bills under the form of future labor income become less important, and investors make up for this decrease by shifting portfolio allocation towards riskless bills (Viceira, 2000). Thus, the theoretical literature predicts that the portfolio share invested in stocks is decreasing over life. However, the empirical literature has found that the portfolio share invested in stocks is actually *increasing* over life, with some mixed evidence that points to slight decrease late in life. Can the investment in housing be the reason why the model without housing predicts a life-cycle pattern of stockholdings that is the opposite of what we observe in the data?

To address this question the first four columns of Table 4 show the evolution over the life-cycle of the shares of stocks and bills relative to liquid assets, predicted by the model. The model with housing predicts an increasing life-cycle share of stock investments. Early in life, investment in housing keeps liquid assets low, and investors choose not to pay the fixed cost required for participating in the equity market. For investors in the lower age group, liquid assets are only three percent of financial assets. It is only later in life when liquid assets become sufficiently large, that stock market participation becomes more widespread.

Late in life the presence of housing also prevents a decline in the share of stocks in liquid assets. In the model with housing, as investors age, liquid assets are less important relative to other asset holdings (human capital and housing) for future consumption. Old investors are more willing to accept risk in their portfolio of liquid assets since future consumption is less correlated with the return on the liquid assets portfolio.

Table 4 also shows that stock holdings are much less important when measured relative to

financial assets rather than liquid assets. The reason is the importance of real estate, which varies between ninety-seven percent for the youngest investors, and seventy-two percent for investors in the fifty to sixty-five years of age group.

These magnitudes change again considerably when we consider total assets. Considering human capital as an asset provides the most complete view of investors' wealth. Human capital is computed in the simplest way possible: at each age it is equal to the expected value of future labor income discounted at the annual rate of five percent.[14] The last four columns of Table 4 show that human capital is an important component of wealth at all ages, but particularly for young investors: the share of human capital in total assets is as high as 86.9 percent for investors in the less than thirty-five years of age group.

When we consider total assets there are also some striking changes in the life-cycle patterns of asset allocation: when measured relative to financial assets the importance of real estate is roughly decreasing over life, whereas when measured relative to total assets it increases in importance throughout life. These changes in patterns arise naturally in my model due to the declining importance of capitalized labor income as investors age.

4.3 Determinants of Portfolio Composition

To more systematically summarize the correlations between stock holdings and other variables predicted by the model I run the following Tobit regressions, where the dependent variable in the first equation is stocks relative to liquid assets (LA), financial assets (FA), and total assets (TA), and in the second equation is the dollar amount held in stocks:

$$\left(\frac{Stocks}{j}\right)_i = a_1 + a_2 INC_i + a_3 FNW_i + a_4 AGE_i + a_5 REFNW_i + a_6 MORTFNW_i + \delta_i \qquad j = LA, FA, T$$

$$Stocks_i = a_1 + a_2 INC_i + a_3 FNW_i + a_4 AGE_i + a_5 RE_i + a_6 MORT_i + \delta_i.$$

[14] This is the rate that Heaton and Lucas (2000) use to compute the present discounted value of future labor income.

The independent variables are: income (INC), financial net worth (FNW), age, real estate over financial net worth (REFNW), and mortgage debt over financial net worth (MORTFNW). MORT and RE are the corresponding dollar variables. The coefficients a_i are the regression coefficients and δ_i is the residual.[15]

Table 5 shows the correlations predicted by the model. In the model labor income, although risky, resembles more closely bills than stocks. Therefore higher levels of labor income induce a shift in portfolio allocation towards stocks. Hence the positive correlation between income and stock holdings.[16]

To understand the predicted correlation between the share of stocks held in liquid assets and financial net worth, it is helpful to have in mind the shape of the underlying portfolio rule. For investors who have paid the fixed cost of equity market participation, the portfolio rule, conditional on given levels of housing and debt, and at a given age, is decreasing in financial net worth. Investors hold bills under the form of future labor income. As financial net worth increases, these implicit holdings of Treasury bills become less important relative to financial wealth, and investors make up for this decrease by shifting portfolio composition towards bills.

For investors who have not yet paid the fixed cost of equity market participation the portfolio rule is not monotonic. For low levels of financial net worth, investors decide not to participate in equity markets. It is only when financial net worth (and liquid assets) are sufficiently large that they pay the fixed cost, and at this point stock holdings increase with financial net worth. After this level, the decreasing portfolio rule described above obtains. Table 5 shows that for stocks relative to liquid assets the decreasing part of the rule tends to dominate so that the predicted correlation between stockholdings and financial net worth is negative.

[15]These are regressions similar to the ones run by Heaton and Lucas (2000).

[16]It is future and not current labor income which constitutes the implicit holdings of an asset. But the two tend to be positively correlated.

The effects of non-participation in equity markets are picked up by the real estate variable. Investors who have high levels of real estate relative to financial net worth do not participate in equity markets. Hence the negative correlation between these variables. Interestingly, mortgage debt tends to be positively correlated with stock holdings. The reason is that investors who have higher future labor income borrow more, but at the same time labor income resembles more closely bills than stocks, which induces a shift in the portfolio allocation towards stocks.

The coefficient on age is positive which reflects the life-cycle patterns shown in Table 4. Table 5 shows that some of the predicted correlations are sensitive to the measure of stock holdings used. In particular the coefficient on financial net worth flip from negative to positive when we measure stocks relative to total assets.

In the section 5, I will examine the cross-sectional variation in the composition of wealth by age and net worth, and run regressions similar to those in Table 5 on PSID portfolio composition data, to study the extent to which the effects at work in the model are also present in the data. This comparison will provide evidence on the strengths and limitations of the model.

4.4 Fixed Costs of Equity Market Participation

Fixed costs of equity market participation play an important role in my model. Without them every investor in the model would own stocks, which would be at odds with the well documented feature of the data on portfolio composition that many households do not own stocks at all. It is obvious that fixed costs can generate limited stock market participation. The important question is the *magnitude* of the fixed cost needed to generate the empirically observed levels of stock market participation.

To address this issue Table 6 compares the portfolio implications and the levels of stock market participation for four different values of the fixed cost: five hundred, one thousand

(the baseline case), five thousand, and ten thousand US dollars. Table 6 shows that a fixed cost of one thousand US dollars goes a long way towards generating limited stock market participation. The proportion of investors who participate in equity markets drops from 0.86 for a fixed cost of five hundred dollars, to roughly forty-one percent for a fixed cost of one thousand dollars. The reason is the presence of housing. Since in my model liquid assets are kept low by the housing investment, the benefits of equity market participation are smaller, and a lower fixed cost is needed to generate the empirically observed levels of participation.

4.5 The Effects of House Price Risk

The housing investment keeps liquid assets low and poorer investors from participating in equity markets. But what are the effects of *house price risk* on asset allocation? In particular, does house price risk crowd out stockholdings? Table 7 compares the portfolio shares for the baseline case to the case when the variance of house price shocks is set to zero (the no house price risk scenario). One may reasonably expect that house price risk has an impact on asset allocation that depends on financial net-worth. Therefore table 7 reports portfolio shares conditional on financial net-worth.

Table 7 shows that house price risk crowds out stock holdings, both for high and low financial net-worth investors. As expected, this crowding out effect is larger for lower financial net-worth investors: in the presence of house price risk the portfolio share of stocks relative to financial assets is twenty-eight percent lower for households with less than one hundred thousand dollars, and only fourteen percent lower for wealthier households. The relative importance of stock holdings in the liquid assets portfolio is also lower in the presence of house price risk, both for high and low financial net worth investors. Finally, Table 7 shows that house price risk also leads to lower stock market participation among low financial net-worth households, although the quantitative effect is very small.

4.6 The Effects of Transaction Costs

Transaction costs of adjusting the level of housing have potentially large effects on portfolio composition: for many investors housing is an important component of wealth, and transaction costs of adjusting the level of housing are substantial. A transaction cost equal to ten percent of the value of the house sold is reasonable (Smith, Rosen, and Fallis, 1988). In addition, investors trade owner-occupied houses for the purpose of consumption smoothing as well as portfolio re-balancing.[17]

Table 8 compares the portfolio allocations for different values of the transaction cost. The values considered are six, eight (the baseline case), and ten percent of the value of the unit being exchanged. Higher transaction costs reduce the frequency of house trades: for a value of ten percent investors on average trade houses once every twenty years, whereas for a transaction cost of six percent the corresponding figure is fifteen years.[18] Higher transaction costs also lead to a lower portfolio share of stocks.

4.7 Preference Parameter Heterogeneity

Preference parameter heterogeneity is a possible explanation for the large cross-sectional variation in portfolio composition identified in empirical studies. In this section I study the extent to which the model is able to generate cross-sectional variation in portfolio composition from preference parameter heterogeneity. In particular I study the portfolio implications of differ-

[17]The effects of transaction costs of portfolio adjustment have been studied by Balduzzi and Lynch (1999), Constantinides (1986), Davis and Norman (1990), Heaton and Lucas (1997), Lynch and Balduzzi (1999), among others. The literature has focused on transaction costs of adjusting stock holdings. Transaction costs tend to have larger effects on portfolio allocations when investors trade for the purpose of consumption smoothing as well as portfolio re-balancing.

[18]The frequency of house trades in my model is lower than in the data, but I do not model changes in family composition or moving for work related reasons, which would lead to an increase in the frequency of house trades.

ent values for the discount factor, the coefficient of relative risk aversion, and preference for housing.

Table 9 shows that preference parameter heterogeneity has large effects on portfolio composition, and stock holdings. The nature of these effects depends on the parameter considered. When the discount factor is lowered to 0.9 from 0.96 investors save less and are therefore less willing to pay the fixed cost of equity market participation. This explains the decreased importance of stock holdings.

I also compare investors who differ in their preference for housing. For θ equal to 0.15 the role of housing as a consumption good is increased. This has the obvious implication that for investors with a higher θ real estate is a more important asset category. Higher levels of housing tend to be associated with higher debt ratios. The effects of risk aversion on asset allocation are also substantial: less risk averse households invest a much higher share in stocks and are more likely to participate in equity markets. Summarizing, Table 9 shows that a higher coefficient of relative risk aversion, higher preference for housing, or a lower discount factor can generate lower stock holdings and introduce significant cross-sectional variation in portfolio composition. The effects of a lower discount factor are particularly large in my model since liquid assets are kept low by the housing investment.

Table 10 shows the determinants of portfolio composition predicted by the model for different values of the preference parameters. This table shows that parameter heterogeneity, and the nature of this heterogeneity, has important implications in terms of the predicted correlations between stock holdings and other variables. Although the predicted coefficients on age, relative real estate and relative mortgage are always positive, negative and positive, respectively, the predicted sign on financial net worth and income depend on the values for the preference parameters. This is important because in empirical studies of portfolio composition investors are heterogeneous along these non-observable dimensions.

5 Comparison of the Model With The Data

To study the extent to which the effects at work in the model are also present in data I compare portfolio composition predicted by the model to that observed in PSID data.[19] I use the 1989 wave, which the most recent wave available, in final release form, containing asset information. Throughout, I restrict the sample to those households who own a house,[20] and do not belong to the Survey of Economic Opportunities. I first describe the variables used, and then present and discuss the results.

5.1 Description of the Data

When considering data on portfolio composition there exist asset categories which are not present in the model. Broadly these include bonds, vehicles, real estate other than the main home, and business assets.[21] This requires that we restate our definitions of net worth: (a) "liquid net worth" is the sum of stocks, bonds and cash[22] minus all forms of debt, (b) "financial net worth" which is liquid net worth plus house value, vehicles, other real estate, and the value of family owned business or farm, and (c) "total net worth" which is financial net worth plus capitalized labor and pension income. As before, the terms "liquid assets," "financial assets," and "total assets" refer to the same classifications but without the subtraction of debt.[23]

[19]Recent empirical studies on portfolio composition include Bertaut and Haliassos, 1997, Guiso, Jappelli, and Terlizzesse, 1996, Heaton and Lucas, 2000, Poterba and Samwick, 1997, or see Heaton and Lucas (1999) for an excellent survey of the literature.

[20]This may introduce biases as households who own a house tend to be older and wealthier. Households older than seventy-five years of age were dropped from the sample.

[21]The PSID data does not contain information on the value of pensions and retirement plans. Retirement wealth was also treated in a stylized way in the model.

[22]I consider cash to include money in checking or savings accounts, money market funds, Treasury bills and certificates of deposit. These assets are riskless in nominal terms whereas the riskless asset in the model is riskless in real terms. I use these definitions as an approximation.

[23]All households who refused to answer or did not know the answer to the amounts invested in these assets and those for whom financial net worth is negative were dropped from the sample.

An important asset for most households is human capital. I compute the value of human capital in the simplest way possible. For those households whose head is younger than sixty-five years of age, broadly defined labor income is assumed to remain constant until age sixty-five, at which age it decreases in the average proportion of the decrease observed in the data. For households aged over sixty-five labor income was assumed to remain constant until age seventy-five. Human capital is equal to the present discounted value of future labor income, discounted at the annual rate of five percent.[24]

5.2 Portfolio Composition by Financial Net Worth and over the Life-Cycle

I first consider the cross-sectional variation in the composition of wealth by financial net worth and age, and compare it to that predicted by the model. Table 11 shows that the shares of liquid assets and financial assets held in stocks increase with financial net worth. The levels in the data are smaller than those predicted by the model (Table 3), both for low and high financial net-worth investors, although for high financial net-worth households the percentage difference is larger. When considering stock holdings over the life-cycle, Table 12 shows that the share of stocks is increasing over life, with a slight decrease after age sixty-five for stocks relative to liquid assets. Comparing Tables 4 and 12, we see that the model with housing is more successful at keeping the levels of stockholdings and equity market participation low among young households than among households older than fifty years of age.

Table 12 also shows that as in the model human capital is an important component of wealth at all ages, but more so for younger households. As in the model the declining importance of human capital over life explains why, when measured relative to total assets, the importance of real estate increases over life, whereas the reverse is true for real estate relative to financial assets. Leverage ratios decrease over life. Summarizing, the model is able

[24]A measure of human capital was computed in a similar manner by Heaton and Lucas (2000).

to explain the cross-sectional patterns of portfolio composition by financial net worth and age. The housing investment plays a crucial role in keeping stockholdings and equity market participation low, mainly among low net-worth and young households.

5.3 Determinants of Portfolio Composition

I run regressions similar to those run using synthetic data, and present the results in Table 13. I include business wealth in these regressions, since Heaton and Lucas (2000) emphasize the importance of entrepreneurial risk for portfolio choice. The estimated coefficients should be compared to those predicted by the model and shown in Table 5. Although the model is able to predict the signs of the estimate coefficients for stocks relative to total assets and total stock holdings, there are differences for stocks relative to liquid and financial assets, namely the sign of the estimated coefficients for financial net worth. These differences are discussed in the next section.

6 Discussion of Model and Results

The model is able to explain the patterns of cross sectional variation in the composition of wealth observed in the data, and the effects of the housing investment on portfolio composition, but it has several limitations that need to be acknowledged and discussed.

In the parameterization section I set $exp(\mu + \sigma_\iota^2/2) > \overline{R}_D > \overline{R}_F$. Since debt levels can be costlessly renegotiated, it follows that no investor holds simultaneously bills and debt. Those investors who do not participate in equity markets prefer to pay their debt rather than hold bills, and stock market participants prefer to pay their debt or invest in stocks rather than hold bills. Since in practice many debt holders (whether stock market participants or not) also hold bills a natural question to ask is what is missing from the model that may explain this counterfactual implication. A natural candidate is the assumption that debt levels can

be costlessly renegotiated.[25] When it is costly to increase the level of outstanding debt, as for example when renegotiating a conventional mortgage contract, investors may wish to simultaneously hold a small amount of bills and debt.

The difficulty that the model has in generating demand for Treasury bills at low levels of financial net worth is also reflected in the different estimated signs for the coefficients on the financial net worth variable for synthetic and PSID data (for stocks relative to liquid and financial assets).

The model showed that the housing investment and house price risk are more likely to affect the stockholdings and equity market participation of low financial net worth and young households. This makes sense, but also raises the issue of what is missing from the model that might bring the predicted levels of stock holdings and equity market participation among older and high financial net worth households closer to those observed in the data. The comparison of Tables 3 and 11, and 4 and 12 provides some answers. From these tables we see that one important asset for these households, not considered in the model, is business wealth. More than ten percent of the financial assets of high net-worth households are under the form of privately held businesses. Business wealth may help reduce the level of stock holdings for two reasons. First, it may keep liquid assets low, and investors from participating in equity markets. Second, since the income from businesses is more volatile and more correlated with stock returns than labor income, it may constitute an important source of background risk, as emphasized by Heaton and Lucas (2000).

A further limitation of the analysis is the assumed stochastic process for house prices. I focused attention on cyclical fluctuations in house prices and the correlation between the latter, income shocks, and stock returns. However, the true stochastic process for house prices is likely to be more complex than the one I have assumed, involving higher-order autoregressive

[25] I made this assumption for tractability, to avoid having the level of outstanding debt as an additional state variable.

or moving average terms (Case and Shiller, 1989, Poterba, 1991).[26]

A final limitation of the analysis is taxes, which I ignored. It is intuitive that the tax benefits associated with mortgage interest payments may have important effects on asset allocation. For example, they may help magnify the effects of nontradable income on debt levels: investors who expect their future labor income to be higher, and be in a higher tax bracket, will borrow more.

7 Conclusion

In this paper I studied portfolio choice in the presence of housing. This is important since owner-occupied housing is the single most important asset in many investors' portfolios. The model provided answers to the questions raised in the introduction, which I now briefly discuss. Investment in housing has important implications for asset accumulation and portfolio choice among stocks and Treasury bills. Early in life, and at low levels of financial net worth, it keeps liquid assets low and reduces the benefits of equity market participation. House price risk and transaction costs of adjusting the level of housing crowd out stockholdings. The model also proposed an explanation as to why in the data leverage and stockholdings tend to be positively correlated. For investors with a more leveraged portfolio capitalized labor income tends to be a more important component of wealth. Higher capitalized labor income induces a shift in portfolio composition towards stocks so that for many of the parameterizations considered leverage and stock holdings tend to be positively correlated.

[26] Of course, the difficulty in considering more general processes for house prices is that they lead to an increase in the number of state variables.

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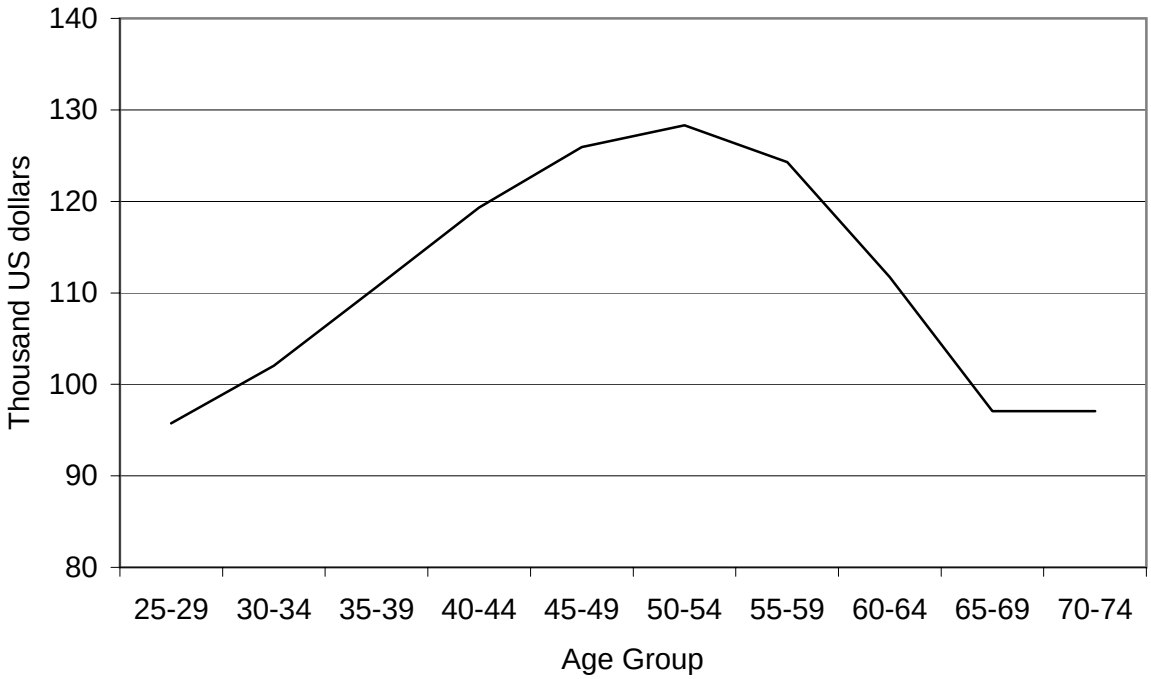


Figure 1: Five-year labor income profile. The data is from the PSID for the years 1970 through 1992. The families that were part of the Survey of Economic Opportunities were dropped from the sample. Labor income in each year is defined as total reported labor income plus unemployment compensation, workers compensation, social security, supplemental social security, other welfare, child support, and total transfers, all this for both head of household and if present his spouse. Labor income was deflated using the Consumer Price Index to obtain real variables.

Table 1: Estimated parameters of the labor income and house price processes. The data is from the the PSID for the years 1970 through 1992. The families that were part of the Survey of Economic Opportunities were dropped from the sample. Labor income in each year is defined as total reported labor income plus unemployment compensation, workers compensation, social security, supplemental social security, other welfare, child support, and total transfers, all this for both head of household and if present his spouse. Labor income and house prices were deflated using the Consumer Price Index to obtain real variables. House prices is an index of house prices for the families in PSID data.

Description	Parameter	Value
Autoregression parameter	ϕ	.6577
Stdev. idiosyncratic inc. shocks	σ_ω	.1392
Stdev. aggregate inc. shocks	σ_η	.0194
Real house price growth	b	.0159
Stdev. house prices	$\sigma_{p'}$	.0620
Corr. house prices and agg. inc. shocks	$\rho_{\eta p'}$	.597*

* significant at the 1 percent level

Table 2: Baseline Parameters (annual). This Table reports the parameters used in the baseline case.

Description	Parameter	Value
Risk Aversion	γ	5
Discount factor	β	.96
Preference for housing	θ	.10
Down payment	d	.15
Depreciation rate	δ	.01
Transaction Cost	λ	.08
Riskless rate	$\overline{R}_F - 1$	.02
Mortgage rate	$\overline{R}_D - 1$	.04
Mean stock return	$exp(\mu + \sigma_\eta^2/2) - 1$	.10
Std of log stock return	σ_η	.1674
Fixed cost	F	\$1,000

Table 3: Portfolio Shares By Financial Net Worth Predicted By The Model. This Table reports mean portfolio shares of various assets relative to liquid assets, financial assets, and total assets. Liquid assets is the sum of stocks and Treasury bills. Financial assets is liquid assets plus house value. Total assets is financial assets plus human capital. Debt is reported relative to financial assets and total assets. Stock Market Participation is the proportion of investors who participate in equity markets. Data are from simulating the model in section 2, with the parameters shown in Table 2. Investors are categorized by financial net worth. Financial net worth is defined as the sum of stocks, bills, and house value less debt.

	Liquid Assets		Financial Assets		Total Assets	
Asset	$< 100k$	$\geq 100k$	$< 100k$	$\geq 100k$	$< 100k$	$\geq 100k$
Stocks	0.362	0.964	0.095	0.480	0.032	0.209
Bills	0.638	0.036	0.017	0.014	0.004	0.008
Liquid Assets	1.000	1.000	0.112	0.494	0.036	0.217
Real Estate			0.888	0.506	0.269	0.227
Financial Assets			1.000	1.000	0.305	0.544
Human Capital					0.694	0.556
Total Assets					1.000	1.000
Debt			0.368	0.007	0.091	0.004
Stock Mkt Part.	0.371	1.000				

Table 4: Portfolio Shares By Age Predicted By The Model. This Table reports mean portfolio shares of various assets relative to liquid assets, financial assets, and total assets. Liquid assets is the sum of stocks and Treasury bills. Financial assets is liquid assets plus house value. Total assets is financial assets plus human capital. Debt is reported relative to financial assets and total assets. Stock Market Participation is the proportion of investors who participate in equity markets. Data are from simulating the model in section 2, with the parameters shown in Table 2. Investors are categorized by age.

	Liquid Assets				Financial Assets				Total Assets			
Asset	< 35	$35 - 50$	$50 - 65$	≥ 65	< 35	$35 - 50$	$50 - 65$	≥ 65	< 35	$35 - 50$	$50 - 65$	≥ 65
Stocks	0.008	0.153	0.692	0.713	0.002	0.043	0.276	0.108	0.000	0.008	0.091	0.066
Bills	0.992	0.847	0.308	0.287	0.030	0.018	0.007	0.016	0.004	0.002	0.002	0.010
Liquid Assets	1.000	1.000	1.000	1.000	0.032	0.061	0.283	0.124	0.004	0.010	0.093	0.076
Real Estate					0.968	0.939	0.717	0.876	0.127	0.150	0.207	0.675
Financial Assets					1.000	1.000	1.000	1.000	0.131	0.160	0.300	0.751
Human Capital									0.869	0.840	0.700	0.249
Total Assets									1.000	1.000	1.000	1.000
Debt					0.651	0.461	0.109	0.227	0.085	0.073	0.029	0.192
Stock Mkt Part.	0.008	0.153	0.692	0.766								

Table 5: Determinants of Portfolio Choice Predicted By The Model. Results of cross-sectional Tobit regressions of several measures of stock holdings on several independent variables. The dependent variable is stock holdings relative to several measures of assets, and the dollar amount held in stocks. Data are from simulating the model in section 2, with the parameters shown in Table 2. Total income is current labor income. Financial net worth is defined as the sum of stocks, bills, and house value less debt. Relative real estate is the value of the house relative to financial net worth. Relative Mortgage is the value of debt relative to financial net worth. Real Estate and Mortgage are the corresponding dollar variables. T-statistics are shown in parenthesis.

	Stock Relative To Liquid Assets	Stock Relative To Financial Assets	Stock Relative To Total Assets	Stocks
Intercept	29.322	0.786	0.189	-84833.14
	(16.36)	(190.25)	(62.87)	(-50.46)
Total Income	1.38e-03	9.68e-07	2.30e-07	0.536
	(16.44)	(48.27)	(16.48)	(58.73)
Financial Net Worth	-1.47e-03	-1.98e-07	8.45e-07	
	(-16.42)	(-10.22)	(69.90)	
Age	3.531	1.71e-02	0.016	7883.31
	(23.81)	(83.56)	(96.55)	(79.11)
Relative Real Estate	-66.010	-1.040	-0.353	
	(-24.27)	(-435.83)	(-227.75)	
Relative Mortgage	56.318	0.945	0.330	
	(23.99)	(405.88)	(213.21)	
Real Estate				0.269
				(21.27)
Mortgage				-1.130
				(-87.90)
chi2(5)	49093	109896	93232	44769

Table 6: The Effects of Fixed Costs of Stock Market Participation. This Table reports mean portfolio shares of various assets relative to financial assets. Liquid assets is the sum of stocks and Treasury bills. Financial assets is liquid assets plus house value. Debt is reported relative to financial assets. Stock Market Participation is the proportion of investors who participate in equity markets. Data are from simulating the model in section 2, with the parameters shown in Table 2, with the fixed cost of stock market participation equal to US$ 500, 1,000, 5,000, and 10,000.

Asset	Fixed cost = $500	Fixed cost = $1,000	Fixed cost = $5,000	Fixed cost = $10,000
Stocks	0.141	0.118	0.087	0.049
Bills	0.006	0.017	0.021	0.028
Liquid Assets	0.147	0.135	0.108	0.077
Real Estate	0.853	0.865	0.892	0.923
Financial Assets	1.000	1.000	1.000	1.000
Debt	0.332	0.347	0.373	0.403
Stock Mkt Part.	0.863	0.409	0.299	0.162

Table 7: The Effects of House Price Risk. This Table reports mean portfolio shares of various assets relative to financial assets. Liquid assets is the sum of stocks and Treasury bills. Financial assets is liquid assets plus house value. Debt is reported relative to financial assets. Stock Market Participation is the proportion of investors who participate in equity markets. Data are from simulating the model in section 2, with the parameters shown in Table 2, with the standard deviation of house price shocks set to the baseline case and to zero.

	Baseline		No House Price Risk	
Asset	$< 100k$	$\geq 100k$	$< 100k$	$\geq 100k$
Stocks	0.095	0.480	0.132	0.556
Bills	0.017	0.014	0.013	0.000
Liquid Assets	0.112	0.494	0.145	0.556
Real Estate	0.888	0.506	0.855	0.444
Financial Assets	1.000	1.000	1.000	1.000
Debt	0.368	0.007	0.382	0.000
Stock Mkt Part.	0.371	1.000	0.375	1.000

Table 8: The Effects of Transaction Costs. This Table reports mean portfolio shares of various assets relative to financial assets. Liquid assets is the sum of stocks and Treasury bills. Financial assets is liquid assets plus house value. Debt is reported relative to financial assets. Stock Market Participation is the proportion of investors who participate in equity markets. Frequency of house trades is the average number of years between house trades. Data are from simulating the model in section 2, with the parameters shown in Table 2, with the transaction cost of changing the level of housing equal to 0.06, 0.08 (the baseline case), and 0.10.

Asset	Transaction cost = 0.06	Transaction cost = 0.08	Transaction cost = 0.10
Stocks	0.153	0.118	0.105
Bills	0.018	0.017	0.018
Liquid Assets	0.171	0.135	0.123
Real Estate	0.829	0.865	0.877
Financial Assets	1.000	1.000	1.000
Debt	0.338	0.347	0.350
Stock Mkt Part.	0.439	0.409	0.382
Freq. House Trades	15.4	18.0	20.1

Table 9: Preference Parameter Heterogeneity. This Table reports mean portfolio shares of various assets relative to financial assets. Liquid assets is the sum of stocks and Treasury bills. Financial assets is liquid assets plus house value. Debt is reported relative to financial assets. Stock Market Participation is the proportion of investors who participate in equity markets. Data are from simulating the model in section 2, with the parameters shown in Table 2, with the discount factor equal to 0.90, the preference for housing paremeter equal to 0.15, and the coefficient of risk aversion equal to 2.

Asset	$\beta = 0.96, \theta = 0.10, \gamma = 5$	$\beta = 0.90$	$\theta = 0.15$	$\gamma = 2$
Stocks	0.118	0.002	0.024	0.458
Bills	0.017	0.021	0.016	0.004
Liquid Assets	0.135	0.023	0.040	0.462
Real Estate	0.865	0.977	0.960	0.538
Financial Assets	1.000	1.000	1.000	1.000
Debt	0.347	0.661	0.498	0.124
Stock Mkt Part.	0.409	0.014	0.122	0.777

Table 10: Determinants of Portfolio Choice Predicted By The Model - Preference Parameter Heterogeneity. Results of cross-sectional Tobit regressions of stock holdings relative to financial assets on several independent variables. Data are from simulating the model in section 2, with the parameters shown in Table 2, with the discount factor equal to 0.90, the preference for housing paremeter equal to 0.15, and the coefficient of risk aversion equal to 2. Total income is current labor income. Financial net worth is defined as the sum of stocks, bills, and house value less debt. Relative real estate is the value of the house relative to financial net worth. Relative Mortgage is the value of debt relative to financial net worth. T-statistics are shown in parenthesis.

	$\beta = 0.96, \theta = 0.10, \gamma = 5$	$\beta = 0.90$	$\theta = 0.15$	$\gamma = 2$
Intercept	0.786	-0.146	0.711	0.999
	(190.25)	(-2.48)	(66.87)	(4362.11)
Total Income	9.68e-07	-1.06e-07	6.74e-07	1.54e-09
	(48.27)	(-0.52)	(14.30)	(1.26)
Financial Net Worth	-1.98e-07	7.17e-06	6.30e-07	-8.83e-10
	(-10.22)	(22.26)	(16.58)	(-1.31)
Age	1.71e-02	8.17e-02	2.28e-02	5.18e-05
	(83.56)	(17.19)	(36.70)	(4.50)
Relative Real Estate	-1.040	-1.081	-1.094	-1.001
	(-435.83)	(-40.14)	(-191.78)	(-5406.52)
Relative Mortgage	0.945	1.042	1.021	0.826
	(405.88)	(40.48)	(183.36)	(3825.99)

Table 11: Portfolio Shares By Financial Net Worth in PSID Data. This Table reports mean portfolio shares of various assets relative to liquid assets, financial assets, and total assets. Liquid assets is the sum of stocks, cash and bonds. Cash includes money in checking or savings accounts, money market funds, Treasury bills and certificates of deposit. Financial assets is liquid assets plus house value, vehicles, other real estate, and the value of family owned business. Total assets is financial assets plus human capital. Debt includes mortgage debt, and is reported relative to financial assets and total assets. Stock Market Participation is the proportion of investors who participate in equity markets. Data are from the 1989 wave of the PSID. Households are categorized by financial net worth. Financial net worth is equal to financial assets minus debt. The sample is retricted to households who own a house, and do not belong to the Survey of Economic opportunities. All households with negative net worth were dropped from the sample.

	Liquid Assets		Financial Assets		Total Assets	
Asset	$< 100k$	$\geq 100k$	$< 100k$	$\geq 100k$	$< 100k$	$\geq 100k$
Stocks	0.102	0.242	0.015	0.073	0.002	0.030
Cash	0.749	0.599	0.058	0.127	0.011	0.050
Bonds	0.149	0.159	0.022	0.040	0.003	0.015
Liquid Assets	1.000	1.000	0.095	0.240	0.016	0.095
Real Estate			0.762	0.488	0.119	0.169
Vehicles			0.109	0.064	0.014	0.021
Other Real Estate			0.023	0.104	0.005	0.049
Business			0.011	0.104	0.004	0.059
Financial Assets			1.000	1.000	0.158	0.393
Human Capital					0.842	0.607
Total Assets					1.000	1.000
Debt			0.384	0.121	0.052	0.036
Stock Mkt Part.	0.179	0.543				

Table 12: Portfolio Shares By Age in PSID Data. This Table reports mean portfolio shares of various assets relative to liquid assets, financial assets, and total assets. Liquid assets is the sum of stocks, cash and bonds. Cash includes money in checking or savings accounts, money market funds, Treasury bills and certificates of deposit. Financial assets is liquid assets plus house value, vehicles, other real estate, and the value of family owned business. Total assets is financial assets plus human capital. Debt includes mortgage debt and other debt, and is reported relative to financial assets and total assets. Stock Market Participation is the proportion of investors who participate in equity markets. Data are from the 1989 wave of the PSID. Households are categorized by the age of the head of the household. The sample is retricted to households who own a house, and do not belong to the Survey of Economic Opportunities. All households with negative net worth were dropped from the sample.

	Liquid Assets				Financial Assets				Total Assets			
Asset	< 35	$35-50$	$50-65$	≥ 65	< 35	$35-50$	$50-65$	≥ 65	< 35	$35-50$	$50-65$	≥ 65
Stocks	0.120	0.172	0.178	0.147	0.016	0.032	0.047	0.054	0.002	0.007	0.019	0.029
Cash	0.738	0.655	0.685	0.711	0.051	0.061	0.106	0.150	0.007	0.013	0.037	0.063
Bonds	0.142	0.173	0.137	0.143	0.024	0.031	0.031	0.027	0.004	0.007	0.010	0.011
Liquid Assets	1.000	1.000	1.000	1.000	0.091	0.124	0.184	0.231	0.013	0.027	0.066	0.103
Real Estate					0.732	0.686	0.609	0.597	0.092	0.122	0.164	0.199
Vehicles					0.114	0.096	0.082	0.069	0.013	0.015	0.022	0.022
Other Real Estate					0.024	0.046	0.073	0.073	0.004	0.015	0.033	0.038
Business					0.039	0.048	0.051	0.030	0.016	0.023	0.033	0.019
Financial Assets					1.000	1.000	1.000	1.000	0.138	0.202	0.318	0.381
Human Capital									0.862	0.798	0.682	0.618
Total Assets									1.000	1.000	1.000	1.000
Debt					0.503	0.346	0.145	0.060	0.062	0.057	0.032	0.016
Stock Mkt Part.	0.257	0.344	0.324	0.268								

Table 13: Determinants of Portfolio Choice in PSID Data. Results of cross-sectional Tobit regressions of several measures of stock holdings on several independent variables. The dependent variable is stock holdings relative to several measures of assets, and the dollar amount held in stocks. Data are from the 1989 wave of the PSID. Total income is current labor income. Financial net worth is financial assets minus debt. Age is the age of the head of the household. Relative real estate is the value of the house relative to financial net worth. Relative Mortgage is the value of mortgage debt relative to financial net worth. Real estate, mortgage and business are the corresponding dollar variables. The sample is retricted to households who own a house, and do not belong to the Survey of Economic Opportunities. All households with negative net worth were dropped from the sample. T-statistics are shown in parenthesis.

	Stock Relative To Liquid Assets	Stock Relative To Financial Assets	Stock Relative To Total Assets	Stocks
Intercept	-0.257	-0.119	-0.071	-34.818e+4
	(1.81)	(-5.62)	(-7.41)	(-15.36)
Total Income	3.43e-06	1.25e-06	3.44e-07	2.221
	(7.63)	(9.09)	(5.60)	(14.80)
Financial Net Worth	7.39e-08	3.13e-08	2.82e-08	
	(2.21)	(3.09)	(6.34)	
Age	0.002	0.002	0.001	1952.46
	(1.81)	(4.85)	(6.84)	(4.83)
Relative Real Estate	-0.360	-0.190	-0.082	
	(-7.65)	(-13.31)	(-12.76)	
Relative Mortgage	0.355	0.188	0.081	
	(7.47)	(13.02)	(12.55)	
Relative Business	-0.373	-0.196	-0.081	
	(-5.69)	(-9.10)	(-9.12)	
Real Estate				0.400
				(6.32)
Mortgage				-0.066
				(-0.46)
Business				-0.130
				(-5.45)
chi2(6)	180.12	392.29	381.50	422.23