Portfolio Choice with House Value Misperception*

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Abstract

We use data on self-reported and market house values to present empirical evidence of house value misperception at the household level. We build an optimal portfolio choice model that features misperception, as observed in the data. In the model, households make consumption and portfolio decisions on housing and non-housing assets with transaction costs in the housing adjustments. Households use subjective housing valuations, which may differ from market values, and decide each period whether to pay for observing the market value or not. Our model delivers several empirical implications that we test using household-level data: more misperception results, on average, in a lower share of risky stock holdings, lower non-housing consumption, lower household leverage, and higher housing wealth over total wealth.

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1 Introduction

Academics have long recognized that households' estimates of their house values often are not aligned with market values. This misalignment is often explained as misperception or rational inattention and can have an important effect in the portfolio choices of households. In this paper, we study the portfolio allocation and housing choice implications of such divergence between market and subjective house values. To do so, we setup and solve a portfolio choice model that accounts for house value misperception and we empirically test its main implications using household-level data.

We first present empirical evidence of house value misperception at the household level by comparing data on self-reported housing values from the Panel Study of Income Dynamics (PSID) to market housing values constructed using zipcode level data from CoreLogic. We find evidence indicating that homeowners misestimate their house values. We show that overvaluation is negatively correlated with the age and the tenure of the household and we find that the opposite is true for undervaluation. We also find that house value misestimation is time-varying and it moves countercyclically. Finally, our results indicate that misperception varies substantially with the socioeconomic status and the geographical location of the household.

We introduce the empirical evidence of house value misperception in a partial equilibrium model with an agent who makes consumption and portfolio choices of housing and non-housing goods and assets. In the model, the agent does not observe the market value of her house. Instead, she makes portfolio and consumption decisions using her own subjective house value, which may differ from its current unobservable market value. The agent has the option to pay a cost to observe the market value of her home. Therefore, she is not willing to continuously update her information about the market value of her house. As a result, her own subjective house value is different than the current market value. We abstract from modeling the root causes of this divergence. Moreover, the agent incurs a transaction cost when selling the house that she currently owns to buy a new one. The existence of transaction costs makes housing consumption lumpy. This modeling approach results in two inaction regions and, consequently, in two sets of action boundaries. One inaction region determines the states in which the agent does not update her information about the market value of her house. The other inaction region determines the states in which the agent decides not to sell her house and buy a new one that is more adequate to her wealth.

Our model delivers qualitative and quantitative implications for the optimal consumption and portfolio decisions subject to house value misperception and transaction costs. We define misperception as the difference between the subjective value and the market value of the house. First, we study the implications of house value misperception on the portfolio holdings of risky stocks. We find that the share of wealth invested in risky assets is lower the higher the uncertainty about the market value of the house. In addition, if households overvalue their houses, then their share of wealth invested in risky assets tends to be lower. Households who tend to undervalue their house values, also invest a lower share of their wealth in risky assets. Their underestimation is particularly risky near the point of buying a larger house because the actual value of the house may put the agents outside the inaction region (i.e., the house becomes too small for the wealth they hold). In other words, risk aversion is higher near the boundary and as a result, the share of wealth invested in risky assets is substantially lower.

Second, we reveal the implications of house value misperception for the consumption of non-housing goods. We find that consumption is lower the higher the misperception about the market value of the house. Moreover, we document that if households tend to overvalue their houses, then their consumption is lower. We also find that the ratio consumption of nonhousing goods to total wealth is directly proportional to the wealth-to-housing ratio and that the change in this ratio of consumption to total wealth is higher (lower) for households that overestimate (underestimate) their house value.

Third, we study the effects of house value misperception on the portfolio holdings of risk-free assets and leverage. We find that the net debt of households is, on average, positive, that is, households are levered. We find that the leverage of households decreases with house value misperception. Moreover, we document that overvaluation (undervaluation) decreases (increases) household leverage.

Fourth, we study the implications of house value misperception on the portfolio holdings of housing assets and housing adjustments. As in the portfolio choice model with transaction costs in Grossman and Laroque (1990) (GL henceforth), an agent only moves to a more valuable house when her wealth-to-housing ratio reaches an optimal upper boundary. Similarly, an agent only moves to a less valuable house when her total wealth-to-housing ratio reaches an optimal lower boundary.

However, in our analysis, the agent decides whether to acquire information or not and, once she has acquired the information, whether to move to a new home or stay put. These boundaries determine the timing of acquiring information. When the agent pays the cost and observes the market value of her home, she must decide whether the market-based wealth-to-housing ratio is such that it is worth paying the housing transaction cost and move to a different house. We find that households that overvalue their home present a lower wealth-to-housing ratio (i.e., their share of housing wealth over total wealth is higher) with respect to the benchmark model without house value misperception. Those households whose subjective valuation is relatively high, tend to have larger houses than the rest of the households, everything else equal.

We test all these model implications using household-level data on wealth, self-reported housing values, consumption, and asset holdings available from the Panel Study of Income Dynamics (PSID). We construct a measure of house value misperception based on self-reported house values from the PSID surveys and house market data. In the empirical tests, we employ this measure to determine whether house value misperception affects housing and nonhousing portfolio holdings across households.

Although there is a stream of literature that studies the effects of stock value misperception and rational inattention on investor's decisions, very little effort has been made in studying the effects of house value misperception. Misperception and "rational inattention" have been extensely studied for the stock markets, but not in the household finance literature. For example, Duffie and Sun (1990), Gabaix et al. (2006), Reis (2006), and Abel, Eberly, and Panageas (2007) study models of portfolio choices with rational inattention. Alvarez, Guiso, and Lippi (2012) develop a portfolio choice model with rational inattention, durable consumption, and transaction costs. Our paper also builds upon the literature on portfolio choice models with fixed adjustment costs. We use the portfolio choice model in Grossman and Laroque (1990) as a benchmark model for our study. The GL model accounts for transaction costs but it does not account for price misperception. Our model is part of the literature that focuses on particular implications of portfolio choice in the presence of housing (see Flavin and Yamashita (2002), Damgaard, Fuglsbjerg, and Munk (2003), Cocco (2005), Yao and Zhang (2005), Flavin and Nakagawa (2008), Van Hemert (2008), Stokey (2009), Fischer and Stamos (2013), and Corradin, Fillat, and Vergara-Alert (2014).) This literature assumes that households accurately observe house prices and the models studied in these papers do not account for house value misperception. Our paper contributes to fill this gap.

We also contribute to a new literature that studies how house value misperception affects households' decisions. Piazzesi and Schneider (2009) and Ehrlich (2013) analyze how house value misperception affect house prices in search and matching models. Davis and Quintin (2016) focus on how the misperception of house prices affects homeowners' decisions on mortgage defaults.

2 Analysis of House Value Misperception

There are some studies that focus on the empirical analysis of misperception in house values. Although, there is consensus on the existence of house value misperception, there is no agreement on its sign and magnitude. Kish and Lansing (1954) and Agarwal (2007) find that homeowners overestimate their house value by 3% to 4%. Benítez-Silva et al. (2008) obtain overestimation values on the range of 5% to 10%. Contrarily, the empirical analyses in Follain and Malpezzi (1981) and Goodman Jr and Ittner (1992) find that homeowners underestimate the value of their house by about 2%.

In this paper, we study a measure of house value misperception at the household level and we apply it to the analysis of household finance. We use self-reported house values from the Panel Study of Income Dynamics (PSID) as a measure of subjective house value. We also use the CoreLogic Home Price Index (HPI) at the Metropolitan Statistical Area (MSA) and zip code level. The CoreLogic index is a repeat sales index. It matches house price changes on the same properties in the public record files from First American and then computes separate indexes by zip codes, counties, metropolitan statistical area, state, and nationally. Since the data are from public records, the HPI is representative of all loans in the market, not simply the conforming loan market of the GSEs like the Federal Housing Finance Agency (FHFA) index. The HPI is a monthly series beginning in 1975. With the appropriate HPI we construct the market value of the properties by inflating the purchase price of the house. We define house value misperception as the difference between the subjective and the market house price. A positive value of this difference indicates overvaluation, while a negative value indicates undervaluation.

To build this measure, we assume that house value misperception is zero when there is a housing transaction and we estimate deviations of the subjective house value from the market house value in

Table 1: **House value misestimation and tenure of households.** Tenure is measured in years since the purchase of the current home, and it is represented in the columns. The misperception value is computed as described in the text: the value of purchased is indexed with zip code level HPI and compared with the self-reported value of the house each year. The median of this variable is 0.98. Bold indicates that the coefficient is above the median. All the coefficients are in % terms.

	Average	1 − 2	3	4	5	6	7	8	9	10
1984	3.37	**−3.06**	**−3.29**	**0.22**	7.41	11.93	6.44	15.33	2.30	1.49
1985	−0.25	**−4.18**	**−5.16**	**−7.43**	**−4.29**	5.05	6.58	2.94	8.23	**−4.47**
1986	−2.27	**−9.49**	**−5.09**	**−7.20**	**−9.76**	**−3.88**	1.72	7.41	2.12	11.69
1987	−2.73	**−7.53**	**−4.11**	**−9.40**	**−5.55**	**−10.97**	**−1.58**	1.09	4.47	4.37
1988	−1.78	**−1.36**	**−5.68**	**−3.35**	**−7.04**	**−6.19**	**−12.89**	**−0.39**	4.94	**−1.64**
1989	0.36	2.94	**0.88**	3.17	**−1.36**	**−7.85**	**−1.76**	**−10.69**	**−9.09**	7.39
1990	2.47	1.11	6.45	2.58	**−1.07**	**0.40**	**0.97**	**−1.53**	**−6.61**	**−6.13**
1991	3.45	1.67	5.60	9.40	3.77	2.26	2.05	2.02	5.45	**−4.01**
1992	2.29	**−1.85**	2.72	2.45	11.36	2.81	**−0.26**	2.90	**−3.15**	3.21
1993	1.69	1.68	**−3.35**	0.98	3.28	4.88	3.05	**−2.86**	2.84	4.96
1994	1.86	**−0.17**	**−2.46**	**−3.98**	1.49	5.21	6.08	3.36	2.29	5.17
1995	0.62	**−1.17**	**−1.76**	**−3.43**	**−6.14**	1.06	4.79	8.58	5.15	1.62
1996	0.05	**−0.64**	**−3.96**	**−2.04**	**0.29**	**−7.63**	**0.03**	2.80	10.24	2.27
1997	−0.88	**−1.04**	**−0.56**	**−6.54**	**−3.74**	**−1.35**	**−8.77**	**−3.93**	10.42	7.70
1999	−2.82	**−6.56**	**−4.86**	**−3.86**	**−7.60**	**−3.59**	**−4.71**	**−9.21**	**−2.91**	7.28
2001	−2.13	2.86	**−8.34**	**0.96**	**−4.84**	**−8.85**	**−0.70**	**−3.00**	**−8.02**	**−12.78**
2003	−1.57	**0.14**	**0.96**	**−10.41**	**−0.17**	**−3.73**	**−2.97**	3.28	9.06	**−11.04**
2005	−1.52	1.19	**−0.54**	**−0.20**	**−13.84**	**−5.17**	**−1.41**	**−2.20**	2.51	18.83
2007	8.26	14.82	11.42	9.09	17.61	**−4.18**	17.10	10.04	15.26	19.51
2009	11.32	8.03	25.42	17.33	12.65	16.69	**−3.12**	18.34	19.68	4.99
2011	11.83	1.63	7.50	26.77	17.18	12.87	21.33	8.61	7.92	23.50
2013	2.18	**−6.14**	**−3.66**	**−0.70**	13.09	5.99	1.25	4.66	2.57	3.19
Average		0.07	0.57	1.41	2.19	1.10	1.76	2.57	3.88	3.96

the years after the sale. Although this assumption reduces the sample size to households that had moved during the period of study, it increases the accuracy of our measure and is consistent with previous studies. For example, Kuzmenko and Timmins (2011) show that the bias in self-reported housing prices is positively correlated with tenure. They document that long-standing homeowners do not the incentive to acquire information on current house prices and, consequently, they report biased housing values. We also find this correlation, conditional on a cohort effect at purchase time. On average, households who bought the house in the trough of a housing bust tend to over estimate the value of their house over time, while those who bought in periods of substantially positive growth tend to underestimate the value of their house over the years. This effect cohort effect tends to dissipate after 6-7 years of tenure. The recent debacle in house prices starting in 2006 seems to cut across all cohorts and, for any tenure, households grossly overestimate their house values. Table 1 summarizes the misestimation by cohort and tenure.

Table 2: **Wealth to housing ratio and tenure of households.** Rows represent the year of the purchase of the house, T. Columns represent years after the purchase of the house, t. Every coefficient represents the average ratio of total wealth to housing wealth in year t for all the households that moved in year T. The median of this ratio is 1.727. Bold indicates that the coefficient is above the median.

	1985	1990	1995	2000	2002	2004	2006	2008
1984	1.376	1.414	**1.913**					
1989		1.420	1.545	1.595	1.690			
1994			**2.009**	**1.989**	**1.881**	**2.856**	**2.310**	**2.201**
1999				1.452	1.621	1.460	1.820	1.990
2001					**1.998**	**1.733**	**1.932**	1.596
2003						1.563	1.610	**1.782**
2005							1.460	1.606
2007								1.568

We also look at the evolution of two magnitudes that are relevant in the model: the total wealth to housing ratio and the share of wealth invested in risky stocks. In particular, we observe that there are also important cohort effects, as with the misestimation. In order to follow a cohort of households buying a new house at a given year, we have to follow the diagonals of the table, as a 1990 homebuyer will have 3 years of tenure in 1993. Table 2 shows the wealth to housing ratio as a function of tenure. Rows indicate the year in which a new house was purchased, and columns indicate the years after that purchase. Table 3 is similar, showing the evolution of risky stock holdings over time, by cohort. Tables 2 and 3 ought to be read horizontally, as we have structured the cohorts in rows.

Misperceptioin, risky holdings, and wealth to housing ratio present a cohort effect. We have highlighted the values above the median to emphasize this cohort effect. Those households who buy a new house during a period of negative house price growth, like in the beginning of the 90s, present a persistent tendency to overvaluate. This pattern can be observed in table 1. Those households buying a house between 1989 and 1991 keep overvaluing after every year until they have spent 10 years in the house. The same pattern can be observed in tables 2 and 3, where the rows have been arranged to keep track of the same cohort over time. Those cohorts starting in a new house with a wealth to housing ratio or share of risky stock holdings higher than the median, they stay higher than the median over time.

We take this as indicative evidence of the different portfolio allocation behavior as a function of the misperception. The model developed in the next section justifies different choices based on

Table 3: **Risky stock holdings and tenure of households.** Rows represent the year of the purchase of the house, T. Columns represent years after the purchase of the house, t. Every coefficient represents the average ratio of risky stock holdings to total wealth in year t for all the households that moved in year T. The median of this ratio is 0.037. Bold indicates that the coefficient is above the median.

	1985	1990	1995	2000	2002	2004	2006	2008
1984	0.015	0.029	**0.078**					
1989		0.027	**0.057**	0.023	0.028			
1994			**0.038**	**0.050**	**0.044**	**0.054**	**0.068**	**0.086**
1999				0.024	**0.041**	**0.047**	**0.041**	0.033
2001					**0.043**	0.026	0.034	**0.040**
2003						0.023	0.033	0.029
2005							0.024	0.025
2007								0.021

different levels of misperception and uncertainty around market values of housing and generates testable implications.

3 The Model

We study the consumption and portfolio choices of an agent in an economy with a risk-free asset and two types of consumption goods: non-housing and housing goods, with uncertain price evolution. Transactions in the housing market are costly. The infinitely lived agent has non-separable Cobb-Douglas preferences over housing and non-housing goods. She derives utility over a trivial flow of services generated by the house.[1] The utility function can be expressed as:

$$u(C,H) = \frac{1}{1-\gamma}(C^{\beta}H^{1-\beta})^{1-\gamma}, \tag{1}$$

where H is the service flow from the house (in square footage) and C denotes non-housing consumption. $1-\beta$ measures the preference for housing relative to non-housing consumption goods, and γ is the curvature of the utility function.

The housing stock depreciates at a physical depreciation rate δ. If the agent does not buy or sell any housing assets, the dynamics of the housing stock follows the process:

$$dH = -\delta H dt, \tag{2}$$

[1]This specification can be generalized as long as preferences are homothetic. Davis and Ortalo-Magne (2011) show that expenditure shares on housing are constant over time.

for a given initial endowment of housing assets H_0. The agent does not observe the price of her house continuously. Instead, the agent pays an observation cost ϕ_o to observe the market value of the house at any given time. As long as the agent does not pay the cost, he receives no signal about the market value. After observing the market value of the house, the household decides whether to change the size of the house or not. We assume that the subjective value of the house, P, follows a geometric Brownian motion for a given initial price P_0:

$$dP = P\mu dt + P\sigma dZ, \tag{3}$$

where μ and σ are constant parameters.

We assume that the misperception of the household takes the form of a constant percentage difference between the market value and the subjective value, m^i. For simplicity, misperception takes two values: $m^l < 0 < m^h$ denote constant parameters that define the overvaluation and undervaluation in house prices with probability $1-\pi$ and π respectively. We assume that the agent knows about the existence of house value misperception, the value of the parameters m^l and m^h and the probability π.

The value of the riskless bond simply follows the process

$$dB = rBdt. \tag{4}$$

Let W denote the value of the agent's wealth in units of non-housing consumption. Wealth is composed of investments in financial assets and the subjective value of the current housing stock:

$$W = B + \Theta + HP, \tag{5}$$

where B is the wealth held in the riskless asset and Θ is the amount invested in the risky asset.

The price of the risky asset, S, follows a geometric Brownian motion:

$$dS = S\ \alpha_S dt + S\ \sigma_S dZ_1. \tag{6}$$

The agent decides how long to remain without acquiring information, τ. Once the agent pays the cost to acquire the information, $\phi_o PH$, the true market value is revealed and she has to change the size of the house or to stay in the same house for another period τ until the next acquisition of information depending on the realization of m. If the household moves to a new house, she incurs a transaction cost that is proportional to the value of the house that she is selling, $\phi_a PH$. The agent also makes her consumption and portfolio decisions using her subjective valuation while she has no other information on the market value of the house. The evolution of wealth is

$$\begin{aligned} dW &= [r(W - HP) + \Theta(\alpha_S - r) + (\mu_P - \delta)HP - C]dt \\ &\quad + (\Theta\sigma_S + HP\rho_{PS}\sigma_P)dZ_1 + HP\sigma_P\sqrt{1-\rho_{PS}^2}dZ_2. \end{aligned} \tag{7}$$

The value function of the problem for acquiring information is:

$$\begin{aligned} V(W,H,P) = \max_{C,\Theta,H',\tau} E\Bigg[&\int_0^\tau u(C, He^{-\delta t})dt \\ &+ \mathbb{I}_{H'>H} e^{-\rho\tau}\pi V\left(W(\tau), He^{-\delta\tau}, P(\tau)\right) + (1-\pi)\widetilde{V}\left(W(\tau), H(\tau), P(\tau)\right) \\ &+ \mathbb{I}_{H'<H} e^{-\rho\tau}(1-\pi) V\left(W(\tau), He^{-\delta\tau}, P(\tau)\right) + \pi\widetilde{V}\left(W(\tau), H(\tau), P(\tau)\right)\Bigg], \end{aligned} \tag{8}$$

where $W(\tau) = W(\tau^-) - \phi_o P(\tau^-)H(\tau^-) + m^i P(\tau^-)H(\tau^-)$, $P(\tau) = P(\tau^-)(1+m^i)$, $H(\tau) = H'$ and $H(\tau^-) = He^{-\delta\tau}$ when the agent acquires information. Conversely, when the agent adjusts housing, H', $W(\tau) = W(\tau^-) - \phi_a P(\tau^-)H(\tau^-) - \phi_o P(\tau^-)H(\tau^-) + m^i P(\tau^-)H(\tau^-)$ and $\widetilde{V}$ is the indirect utility of adjusting housing.

4 Equilibrium of the Model

The value function of this problem, $V(W(t), H(t), P(t))$, satisfies the following Hamilton-Jacobi-Bellman (HJB) partial differential equation

$$\sup_{C,\Theta,H',\tau} E\left(dV\left(W,H,P\right) + u\left(C,H\right)dt\right) = 0. \tag{9}$$

Equilibrium is defined as a set of allocations $H(t), B(t), \Theta(t)$, and $C(t)$, a policy function that describes the optimal timing of acquisition of information τ, such that the household maximizes her lifetime utility and the period-by-period budget constraint is satisfied.

We can use the homogeneity properties of the value function to formulate the problem in terms of the financial wealth-to-housing ratio, $z = \widetilde{W}/(PH) = (\Theta + B)/(PH)$, as follows:

$$V(W,H,P) = \bar{V}(\widetilde{W},H,P) = H^{1-\gamma}P^{\beta(1-\gamma)}\ \bar{V}\left(\frac{\widetilde{W}}{PH},1,1\right) = H^{1-\gamma}P^{\beta(1-\gamma)}v\,(z)\,. \tag{10}$$

This formulation simplifies this problem to solving for $v(z)$. The homogeneity properties are shared by V, which allows us to use 10 in the solution of the problem at the boundary where the agent decides to acquire information and potentially to adjust housing. Furthermore, let c denote the scaled control $c = C/(PH)$ and θ the scaled control $\theta = \Theta/(PH)$.

The financial wealth-to-housing ratio, z, is the only state variable of this problem. The optimal timing for re-balancing wealth composition and the size of housing and non-housing adjustments are determined by this state variable. A solution for the equilibrium of the model consists of a value function $v(z)$ defined on the state space, where bounds $\underline{z}_o$ and $\overline{z}_o$ define an inaction region for the information acquisition problem, while $\underline{z}_a$ and $\overline{z}_a$ are the bounds for adjusting housing and z_H^* is the optimal return point. Finally, the consumption and portfolio policy c^* and θ^* are defined on $(\underline{z}_o,\, \overline{z}_o)$. The function $v(z)$ satisfies the Hamilton-Jacobi-Bellman equation on the inaction region. Value matching and smooth pasting conditions hold at the two sets of upper and lower bounds, and an optimality condition holds at the return point.

Proposition 1 *The solution of the optimal portfolio choice problem defined above presents the following properties:*

1. $v(z)$ satisfies

$$\widetilde{\rho}v(z) = \sup_{c,\theta}\left\{u(c) + \mathcal{D}v(z)\right\}, \quad z \in (\underline{z}_o, \overline{z}_o), \tag{11}$$

where

$$\begin{aligned}\mathcal{D}v(z) =&(z(r+\delta-\mu_P+\sigma_P^2(1+\beta(\gamma-1)))\\ &+\theta(\alpha_S - r - (1+\beta(\gamma-1))\rho_{PS}\ \sigma_S\sigma_P) - c)v_z(z)\\ &+\frac{1}{2}(z^2\sigma_P^2 - 2z\hat{\theta}\ \rho_{PS}\ \sigma_P\sigma_S + \theta^2\sigma_S^2)v_{zz}(z),\end{aligned} \tag{12}$$

$$v(z) = M\frac{(z+1-\phi_a-\phi_0)^{(1-\gamma)}}{1-\gamma}, \quad z \notin (\underline{z}_a, \overline{z}_a) \tag{13}$$

and M is defined as

$$M = (1-\gamma)\sup_{z\geq\epsilon}(z+1)^{\gamma-1}v(z), \tag{14}$$

2. *The return point z_a^* attains the maximum in*

$$v(z^*) = M\frac{(z_a^*+1)^{(1-\gamma)}}{1-\gamma}. \tag{15}$$

3. *Value matching and smooth pasting conditions hold at the two thresholds $(\underline{z}_o, \overline{z}_o)$*

$$v(z) = \pi v\left(\frac{\overline{z}_o}{1+m^h}+1-\phi_o\right) + (1-\pi)M\frac{(\overline{z}_a+1-\phi_a-\phi_o)^{(1-\gamma)}}{1-\gamma}, \tag{16}$$

$$v(z) = (1-\pi)v\left(\frac{\underline{z}_o}{1+m^l}+1-\phi_o\right) + \pi M\frac{(\underline{z}_a+1-\phi_a-\phi_o)^{(1-\gamma)}}{1-\gamma} \quad if \quad z>0,$$

$$v(z) = \pi v\left(\frac{\underline{z}_o}{1+m^h}+1-\phi_o\right) + (1-\pi)M\frac{(\underline{z}_a+1-\phi_a-\phi_o)^{(1-\gamma)}}{1-\gamma} \quad if \quad z\leq 0, \tag{17}$$

where $\overline{z}_a = \overline{z}_o/(1+m^l)$, $\underline{z}_a = \underline{z}_o/(1+m^h)$ if $z>0$ and $\underline{z}_a = \underline{z}_o/(1+m^l)$ if $z \leq 0$.

4. *Given a financial wealth-to-housing ratio z in the area $(\underline{z}_o, \overline{z}_o)$, the agent chooses a optimal consumption $c^*(z)$ and portfolio $\theta^*(z)$ and $b^*(z)$*

$$c^*(z) = \left(\frac{v_z(z)}{\beta}\right)^{1/(\beta(1-\gamma)-1)}, \tag{18}$$

$$\theta^*(z) = -\omega\frac{v_z(z)}{v_{zz}(z)} + \frac{\rho_{PS}\sigma_P}{\sigma_S}z, \tag{19}$$

$$b^*(z) = z - \theta^*(z), \tag{20}$$

for the constant ω defined as $\omega = \left[\alpha_S - r + (1-\beta(1-\gamma))\rho_{PS}\sigma_P\right]/\sigma_S^2$.

Figure 1 uses a simple setup to provide intuition on the equilibrium of the model. Consider that an agent has a total wealth-to-housing ratio between 2.5 and 3.0 at the initial time $t=0$ (i.e., point 0 in Figure 1). Assume that $t=0$ belongs to a time interval in which the agent overvalues her house. The agent must pay a transaction cost every time she adjusts her housing consumption and also an observation cost every time she decides to appraise her house and see the market value. Therefore, she does not continuously update the house and she does not pay for an appraisal until she has accumulated a sufficient amount of wealth to compensate for the observation costs and, in case she decides to move, for the transaction cost. When the subjective wealth-to-housing ratio, $\tilde{W}/(\tilde{P}H)$ in the figure, reaches the upper bound of the inaction region for information acquisition (point 1), the agent pays the observation cost, observes the market and decides whether to sell the house and purchase another house. Because the agent is overvaluing the value of her house when she reaches this upper boundary at time τ_1, she observes that her current wealth-to-housing ratio is actually higher than what she anticipated (point 1') and she decides to move to a bigger house. Th

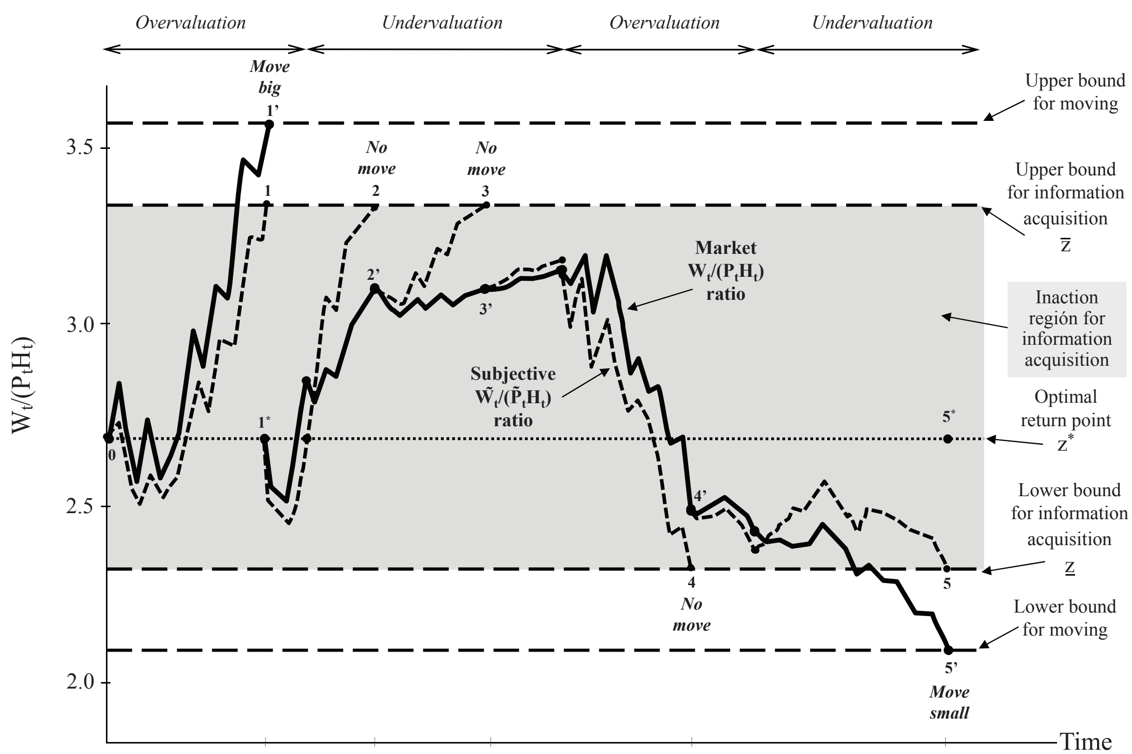

Figure 1: **Mechanism of the model.** The figure plots a hypothetical path of the subjective wealth-to-housing ratio and its corresponding market wealth-to-housing ratio. It shows the four scenarios that the agent can face: reaching the upper boundary of the inaction region when she overvalues her house; reaching the upper boundary of the inaction region when she undervalues her house; reaching the lower boundary of the inaction region when she overvalues her house; and reaching the lower boundary of the inaction region when she undervalues her house. When the subjective wealth-to-housing ratio reaches the upper bound, the agent checks whether the benefits of resizing the house overweight the transaction costs.

Assume that the agent starts undervaluying her house (she does not know it) at some time after $t = \tau_1$. The wealth-to-housing ratio evolves over time until it reaches the upper bound again (point

2) at time $t = \tau_2$. The agent then pays the observation cost, learn the market value of her house and, therefore the market value of her wealth-to-housing ratio, which lays in the inaction region (point 2'). She decides not to move and the wealth-to-housing ratio evolves over time until it reaches the upper bound again (point 3) at time $t = \tau_3$. Because she learns that she is undervaluying her house, her market wealth-to-housing ratio is still in the inaction region (point 3'), thus she does not move and updates her wealth-to-housing ratio. The scenario of undervaluation and increasing wealth-to-housing ratio (points 2, 2', 3, and 3') is a symmetrical situation to the one in which the agent overvalues her house and reaches the lower boundary of the inaction region (points 4 and 4'). Finally, assume that at some time after $t = \tau_4$ the agent starts undervaluying her house again but now her wealth-to-housing ratio decreases. When her subjective wealth-to-housing ratio reaches the lower bound at time $t = \tau_5$, she acquires the information about her house value. In this case, it is optimal for her to move and purchase a less valuable house, which takes her wealth-to-housing ratio up to its optimal level (point 5').

5 Numerical Results and Testable Implications of the Model

The problem described and analyzed in Sections 3 and 4 cannot be solved in closed-form. Therefore, we implement a numerical approach to derive the solution of this optimal control problem. We use the numerical results of the model to provide the main testable implications of the model.

Table 4 reports the parameters that we use for the benchmark calibration of the model. Regarding the parameters of the utility function, we assume a curvature of the utility function γ of 2, a rate of time preference ρ equal to 2.5%, and a degree of house flow services $1 - \beta$ equal to 40%. We set the annual risk-free rate to 1.5% and the drift and standard deviation of the risky asset to 7.7% and 16.55%, respectively. These figures are consistent with the long-term return and standard deviation of U.S. aggregate stock indices. We assume that the transaction cost of adjusting housing ϕ_a is 6% of the total value of the house, while the information cost ϕ_o is 1%. We set the physical depreciation rate of the house at 2%.

We also assume that the standard deviation of the house price growth is equal to 12.5%. We also parameterize the housing value misperception as a constant proportion of the value of the house, up 5% and down 5% for households that undervalue and overvalue their home, respectively.

Table 4: **Parameters used for benchmark calibration.**

Variable	Symbol	Value
Curvature of the utility function	γ	2
House flow services	$1-\beta$	0.4
Time preference	ρ	0.025
Risk free rate	r	0.015
Housing stock depreciation	δ	0.02
Transaction cost	ϕ_a	0.06
Information cost	ϕ_o	0.01
Risky asset drift	α_S	0.077
Standard deviation risky asset	σ_S	0.165
Correlation house price - risky asset	ρ_{PS}	0.25
Standard deviation house price	σ_P	0.125
House price drift	μ_P	0.03
Overvaluation	m_H	5%
Undervaluation	m_L	-5%
Probability	π	0.5

The parameter σ is calibrated such that the unconditional standard deviation of our house price growth process is equal to 12.5%. Thus, σ is set to 0.124. With this, we argue that our results are not driven by an inherently riskier process, but by risk aversion. Finally, Table 4 reports the conditional probability of overvaluation for the benchmark case at 50%. Therefore, the conditional probability of undervaluation is also 50%.

In the remainder of this section, we introduce the main predictions of the model on risky stock holdings (Subsection 5.1), consumption (Subsection 5.2), risk-free holdings and leverage (Subsection 5.3), as well as housing holdings and housing adjustments (Subsection 5.4).

5.1 Risky stock holdings: Model predictions

What are the effects of misperception on the risky stock holdings? To answer this question, we first compare the portfolio holdings of risky stock in a Grossman-Laroque framework to the ones in our model with misperception. The top panel of Figure 2 shows that the risky holdings in a model with costly acquisition of information are lower than in a Grossman-Laroque for any level of wealth to housing ratio. The figure also illustrates the fact that the inaction region is narrower, as the edges of both the solid and the dashed lines determine the information boundaries.

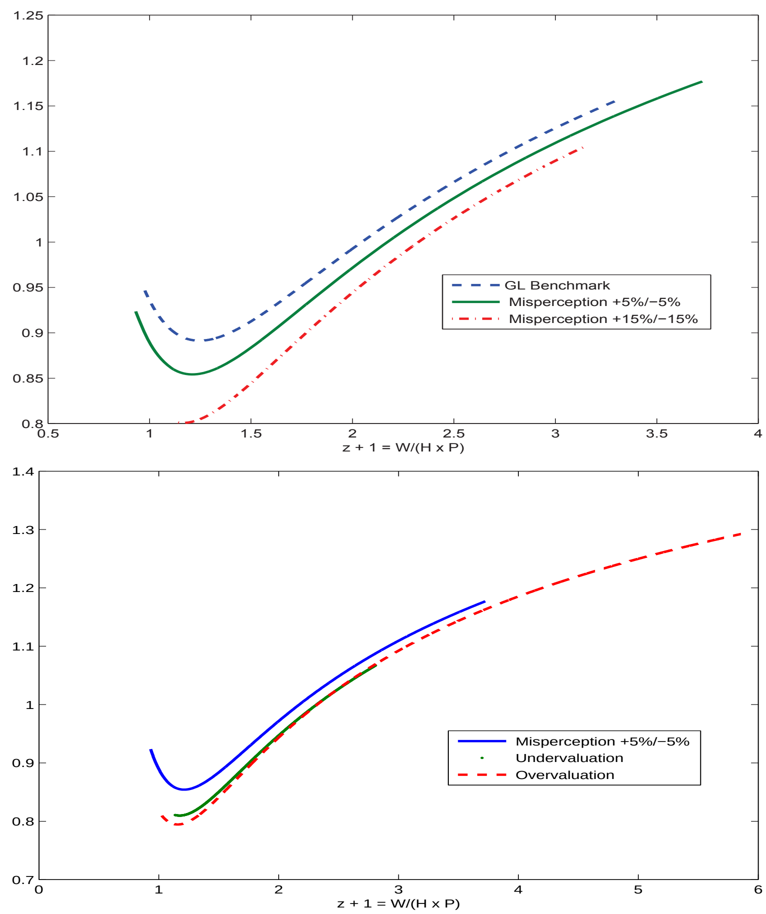

Figure 2: **Risky stock holdings and misperception.** Share of wealth invested in risky holdings, $\theta(z_t)/(z_t + 1)$ as a function of the wealth to housing ratio, $z_t + 1$. In the top panel, the solid line represents our benchmark model with misperception +5%/-5%, the dashed and dotted line represents the same model with misperception +10%/-10%, and the dashed line represents a model with costless information (no misvaluation) equivalent to the Grossman-Laroque (GL) benchmark model. In the bottom panel, the benchmark model with misperception +5%/-5% is represented in solid line, the dashed line corresponds to a household that is more likely to overvalue (lower π), and the dotted line corresponds to a household that is more likely to undervalue (higher π).

Moreover, the top panel of Figure 2 describes the optimal risky stock portfolio choices when households are subject to a more disperse distribution of misperception. In this particular case, we show the policy function for the share of risky stock holdings when misperception can be up to 5% versus the case in which misperception can be up to 15%. The model predicts that the higher the misperception dispersion, the lower the risky asset holdings. This result is a direct implication of a higher risk aversion that the households experience when misperception is more volatile. In addition, the inaction region also becomes narrower. This result implies that households acquire information more often as misperception becomes wider.

The bottom panel of of Figure 2 displays the effects of overvaluation or undervaluation on risky stock holdings. It compares the share of wealth invested in risky stocks in the benchmark model to the share in risky stocks in models with equal probability of over and under valuation. The dotted line represents a household with a probability of undervaluing of 75% ($\pi = 75\%$, while the dashed line represents a household with a probability of overvaluing their house of 75% ($\pi = 25\%$).

Let's focus on the lower boundary. That is the region of financial wealth-to-housing ratio z where the household is close to acquire information to evaluate whether to downsize the house or not. Given our set of parameters, the lower adjustment and information bound is located in a positive region, $z > 0$. If the risk of overvaluing is higher (dashed line), there is a higher risk that after the information is revealed, the agent does not downsize the house. That increases risk aversion relative to a situation where the risk of overvaluing is lower, conditional on wealth. Therefore, we observe less risky stock holdings for overvaluing households around the lower boundary. On the other hand, because the inaction region is larger in the overvaluation case, the agent is holding more risky stocks for high levels of financial wealth relative to the housing holdings.

5.2 Consumption: Model predictions

The equilibrium of the model provides the consumption of non-housing goods or numeraire consumption. Therefore, we can analyze the effect of misperception in house prices on the consumption. Figure 3 shows the numeraire consumption as a function of the wealth-to-housing ratio. The top panel shows that if the acquisition of information is costly, then the agent consumes less goods than in a Grossman-Laroque world with no information costs. This means that house value misperception results in a lower numeraire consumption.

The bottom panel of Figure 3 shows that higher overvaluation (equivalently, lower undervaluation) leads to lower consumption. This effect is stronger for low values of the wealth-to-housing ratio, that is, closer to the lower boundary of the inaction region and it is weaker for high values of the wealth-to-housing ratio, that is, closer to the upper boundary. Note that the higher the overvaluation, the higher the upper boundary of the inaction region. Therefore, the highest values of numeraire consumption occur in cases in which the agent overvalues her house and presents a high value of wealth-to-housing ratio.

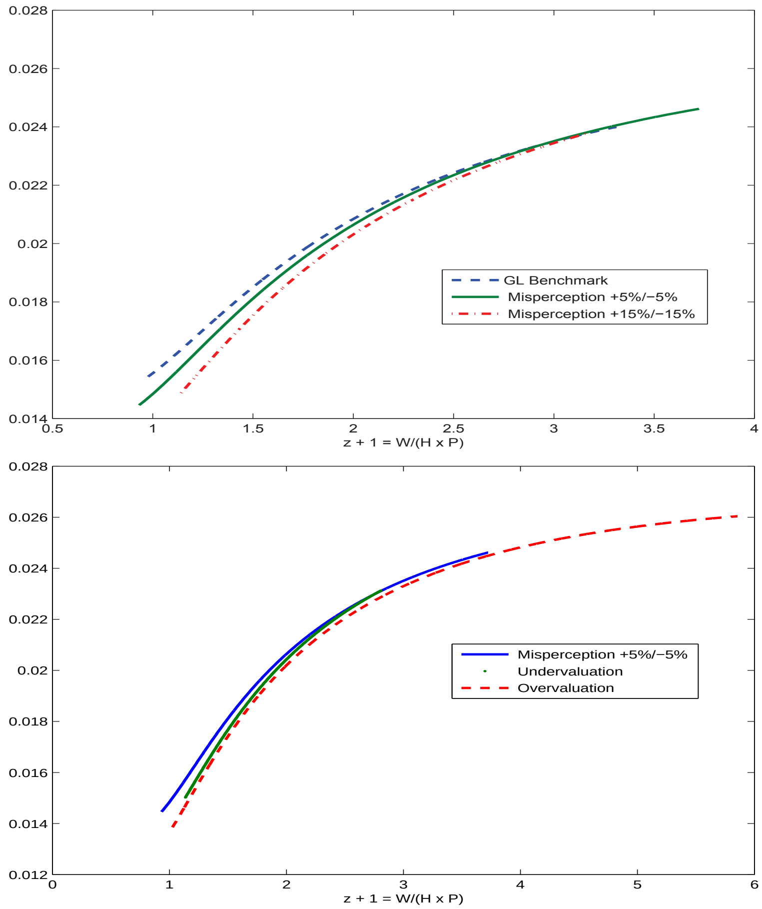

Figure 3: **Consumption and mispeception.** Numeraire consumption, $c(z_t)/(z_t+1)$, as a function of wealth to housing ratio, z_t+1.In the top panel, the solid line represents our benchmark model with misperception +5%/-5%, the dashed and dotted line represents the same model with misperception +10%/-10%, and the dashed line represents a model with costless information (no misvaluation) equivalent to the Grossman-Laroque (GL) benchmark model. In the bottom panel, the benchmark model with misperception +5%/-5% is represented in solid line, the dashed line corresponds to a household that is more likely to overvalue (lower π), and the dotted line corresponds to a household that is more likely to undervalue (higher π).

5.3 Risk-free holdings and leverage: Model predictions

The equilibrium of the model provides the risk-free holdings and the leverage position of the agent. Figure 4 exhibits the effects of house value misperception in the risk-free holdings and the leverage of the agent. In the model, negative risk-free holdings is equivalent to a leverage position, that is, for simplicity we assume that the agent can borrow at the risk-free rate. The top panel of Figure 4 shows that if the acquisition of information is costly, then the agent has less leverage than in a Grossman-Laroque world with no information costs. Therefore, the mode predicts that higher misperception leads to lower leverage. Note also that the share of wealth invested in the risk-free holdings is always negative. This means that the agent is borrowing in all the models.

The bottom panel of Figure 4 shows that higher overvaluation leads to lower leverage. It also shows that the higher undervaluation leads to lower leverage. Note also that the higher values of leverage (that is, the lowest risk-free holdings) are obtained in situations of lowest values of the wealth-to-housing ratio and lowest misperception. This means that the agents are willing to leverage up to avoid moving to a smaller house. Moreover, they are willing to get more leverage in the models with the lower house value misperception.

5.4 Housing holdings and housing adjustments: Model predictions

The solution of the model, as described in Section 4, consists of a policy function that takes the shape of action boundaries to: (1) acquire costly information about the market value of the house, and (2) engage in a costly housing adjustment. Figure 5 summarizes the numerical solution of the model. The solid line in the figure shows the difference between the indirect utility function of not acquiring information and not making a housing adjustment (i.e., not moving), versus acquiring information and updating the house value and making a housing adjustment or not, depending on the sign of the misperception. When this difference goes to zero, it is optimal for the agent to pay the cost of acquiring information, which brings her to, either the housing adjustment boundary, or back into the inaction region. If the housing adjustment boundary is hit, the agent moves to a new house and the wealth to housing ratio returns to the optimal point on the dotted line.

The relevant magnitudes of the solution to this calibration of the model are summarized in Table 5. This table presents five sets of results, all in terms of values of wealth to housing ratios. The first one displays the Grossman-Laroque boundaries for transaction, with no costly acquisition of information (and the same parameterization as in our benchmark case). The second row displays our benchmark results. What we observe is that the inaction region in the presence of costly acquisition of information is wider than in the case with perfect information. Agents move to a bigger (smaller) house when their wealth to housing ratio is higher (lower) than with perfect information. Agent acquire information later than they would transact a house with perfect information and have a 50/50% chance of actually moving to a new home. If they plan on moving to a bigger house and realize that they are under-valuating their house (m^h realizes), they do not engage in a transaction.

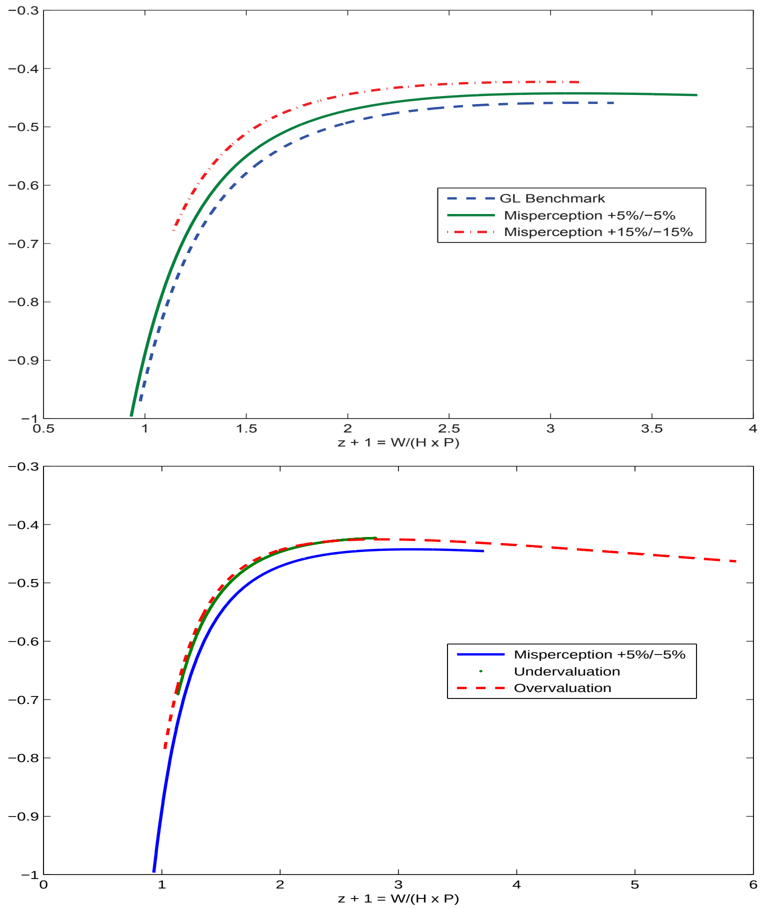

Figure 4: **Risk-free holdings, leverage and misperception.** Share of wealth invested in the risk-free holdings, $(z_t - \theta(z_t))/(z_t + 1)$, as a function of wealth to housing ratio, $z_t + 1$. Negative risk-free holdings means that the household is leveraged. In the top panel, the solid line represents our benchmark model with misperception +5%/-5%, the dashed and dotted line represents the same model with misperception +10%/-10%, and the dashed line represents a model with costless information (no misvaluation) equivalent to the Grossman-Laroque (GL) benchmark model. In the bottom panel, the benchmark model with misperception +5%/-5% is represented in solid line, the dashed line corresponds to a household that is more likely to overvalue (lower π), and the dotted line corresponds to a household that is more likely to undervalue (higher π).

In terms of the model, they are reverted back to the inaction region, instead of pushed to the transaction boundaries. An analogous argument holds for the lower boundary and agents wishing to downsize their house.

In summary, the model has a prediction on the size of the inaction region as we have seen in Table 5, the general effect is that the presence of misperception results in a larger inaction region. The model predicts that, the higher the misperception, the more often agents will acquire

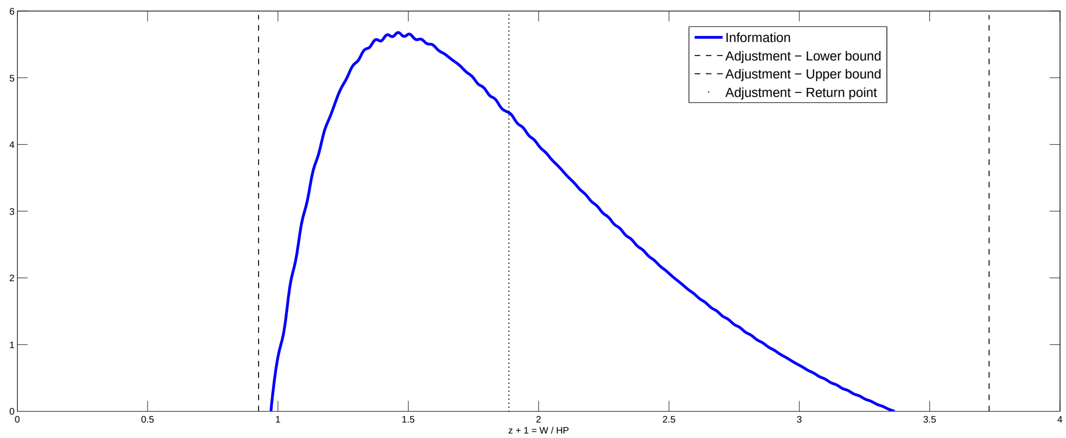

Figure 5: **The inaction regions for information acquisition and housing adjustments.** The solid line represents the values for the difference between the (scaled) value function in the continuation region and the value function of acquiring information and potentially adjusting the housing holdings. The boundaries for acquiring information lie at the points where the solid line crosses zero. The vertical dashed lines represent the boundaries for housing adjustments, that is, for moving houses. The vertical dotted line represents the optimal return point after the household moves to a new house.

Table 5: **Acquisition of information, housing adjustments, and misperception.** Model outcomes for the information acquisition boundaries, the housing adjustment boundaries, and the return points under different parameterizations. GL represents the equiibrium results under the Gossman-Laroque model with no costs of information. Benchmark displays the results of the model with the benchmark parameterization of Table 4, that is, with a house value misperception of +5%/-5%. Increase misperception shows the results of the benchmark model with an increase of house value misperception to +15%/-15%. Overvaluation and undervaluation represent the benchmark model with a probability of 75% of overvaluing and undervaluing, respectively.

	Adjust Lower Bound	Info. Lower Bound	Return Point	Info. Upper Bound	Adjust Upper Bound
GL (no misperception)	-0.025		0.955		2.311
Benchmark (+5%/-5%)	-0.074	-0.070	0.885	2.432	2.867
Increase misperception	0.120	0.138	0.773	2.160	2.542
Overvaluation - $\nabla\pi$	0.022	0.023	0.709	4.855	5.111
Undervaluation - $\Delta\pi$	0.127	0.134	0.948	1.807	1.902

information, and also they will adjust housing more often, everything else equal.

Finally, we perform a sensitivity analysis to the dispersion of misperception and to the probability of overvaluation. The third row shows the relevant boundaries when the market value of the house can be 15% above or below the subjective valuation, as opposed to 5% in the benchmark case. The last two rows show sensitivity to the probability of being over or under evaluating. The model shows that when misperception is higher, the inaction region is overall narrower than in the benchmark case. Therefore, agents will acquire information more often than in the benchmark case. Regarding housing adjustments, households will move to a bigger house sooner, yet they will delay a downsize of the house. Finally, an increase in the probability of overvaluing has an effect of shifting up the inaction region and it does enlarge the inaction band for information acquisition. The return point is lower, which means that after changing the house, the value of the house relative to the household's wealth is higher than in the benchmark case. Differently, an increase in the probability of undervaluing has an effect of shrinking the information acquisition region and the return point is higher than in the benchmark case.

6 Empirical Results

We use household level data to test the testable implications of the model. We utilize the data from the PSID from 1984 to 2013. PSID contains data on asset holdings and housing wealth at the household level. We calculate financial wealth as the sum of an individual's house value, their second house value (net of debt), business value (net of debt), other assets (net of debt), stock holdings (net of debt), checking and savings balances, IRAs and annuities less the mortgage principal on the primary residence. Other assets include bonds and insurance.[2] We divide these variables into two groups: risky assets and safe assets. Risky assets include stock holdings, IRAs and annuity holdings. The safe assets comprise other assets (net of debt), checking balances, and savings balances, less the outstanding mortgage principal on the primary residence. The variables regarding financial wealth are net of debt, with the sole exception of the primary residence value.

Table 6 presents the descriptive statistics for the main variables that we use in the empirical analysis. We present the means and standard deviations of the relevant variables. The most important variable in the model is the wealth-to-housing ratio, z. Stock holdings are approximately 1.1% of financial wealth for the entire subsample. 29.2% of households own stocks and for those, stockholdings represent 4% of their financial wealth in our sample. We report statistics on stock holdings without retirement assets (IRA, 401k). We define the dummy m_{BIG} (m_{SMALL}) to identify

[2] For comparability across different survey waves, we exclusively focus on first mortgages.

Table 6: **Descriptive statistics**. Sample averages and standard deviations (in parenthesis) for the main variables used in our analysis from PSID. The ratio $z = W/(P \cdot H)$ corresponds to the ratio of financial wealth net of debt over housing value without considering human capital as part of the wealth. Financial wealth is the summation of individual's house value, their second house value (net of debt), business value (net of debt), other assets (net of debt), stock holdings (net of debt), checking and savings balances, IRAs and annuities less the mortgage principal on the primary residence. Stock share is the share of equity in stocks and mutual funds including (not including) equity in IRAs, equity in 401k and thrifts (retirement assets) over total financial wealth. Leverage is the ratio of net debt to total wealth net of debt. D_{it} is the absolute value of the deviation of subjective valuation of the house from the market value of the house. $misper_{it}$ is the measure of misperception, i.e., subjective value of the house minus market value of the house. Age corresponds to the age of the household head. m_{BIG} and m_{SMALL} are dummy variables that account for individuals who moved to a house having a higher and lower value, respectively.

	Mean	Std. Dev	Min	Max	Obs.
z (wealth-to-housing ratio)	1.643	0.985	−2.410	4.923	20,299
Stock share (total)	0.011	0.020	−0.051	0.051	20,298
Stockholders	0.292	0.455	0.000	1.000	20,298
Stock share (only stockholders)	0.038	0.018	−0.051	0.051	5,922
Leverage (net debt-to-wealth ratio)	0.072	0.107	−0.356	0.419	11,339
Consumption-to-wealth ratio	0.036	0.036	0.000	0.193	11,631
$disper_{it}$	10.196	15.582	0.000	357.037	42,180
$misper_{it}$	1.843	27.267	−99.399	430.262	42,180
Age	39.739	12.559	16	100	183,055
$move_{\text{BIG}}$	0.002	0.040	0	1	266,154
$move_{\text{SMALL}}$	0.002	0.041	0	1	266,154

households selling the current house to buy a more (less) valuable house in the same U.S. census region. The variables D_{it} and $misper_{it}$ measure misperception. $misper_{it}$ is defined as the difference between the subjective, self-reported value of the house in PSID and the market value constructed as described in Section 2. We observe that, on average, households tend to overestimate the value of their homes, but not by much, about 1.84% in our sample, but the variation across households is considerable.

Finally, we report summary statistics for variables that we use to distinguish between changes in housing that occur for reasons that are exogenous to the model and changes in housing that occur because individuals have a total wealth-to-housing ratio that is close to the boundary. To account for moves that are required for exogenous reasons, we use variables that capture changes in the household around each home purchase. Consequently, we control for changes in family size, marital status, and employment status in our empirical specification.

Our model does not explicitly study the portfolio choices of renters. We focus our study on understanding the portfolio decisions of homeowners. In our model, renting would be equivalent to holding zero equity in a house, as in Stokey (2009). We identify the households moving to a different house in the PSID because this survey explicitly reports whether there has been a move since the previous interview. The percentage of owners who move is much lower than the percentage of renters who move. This finding is consistent with the fact that renters face lower transaction costs than homeowners. The percentage of movers to a different U.S. census region or U.S. state is very low among owners. Finally, new homeowners represent 3.79% of the total homeowners in the PSID.

In the reminder of the section, we use the household survey data that we described above to test the main predictions of the model that we developed in Section 5. We first test the hypothesis described in section 5.1 on the effect of misperception on shares of risky stock holdings. We also test the effect of misperception on household consumption that we developed in section 5.2 and on risk-free holdings and leverage in section 5.3. Finally, we test the housing choices that we studied in section 5.4.

6.1 Risky stock holdings: Empirical results

The model predicts that higher misperception results in lower risky stock holdings, as described in the top panel of Figure 2. Two channels are highlighted in the model. The agent becomes more risk averse and the housing price dynamics are perceived to be following riskier process. In addition, Figure 2 shows that the more disperse is the misvaluation, the lower the risky stock holding. Finally, the bottom panel of Figure 2 shows that the slope of the risky stock holdings as a function of the housing-to-wealth ratio is higher for households who overvalue their houses relative to those who undervalue their houses. To test these three predictions, we run the following specification:

$$\frac{\theta_{it}}{z_{it}} = \gamma_0 + \gamma_1 \cdot z_{it} + \gamma_2 \cdot m_{it} + \gamma_3 \cdot z_{it} \cdot m_{it} + \Gamma \cdot X_{it} + u_{it}, \tag{21}$$

where z_{it} is the fraction of housing wealth to total wealth; m_{it} represents the two different measures associated with misperception: (A) *Dispersion*, that is, the absolute value of the distance to the mean of the misperception within the zip code, and (B) *Overvaluation*, that is, the difference between the subjective valuation and the market value of the house measured at the zip code level. We control for ex ante changes in the housing stock for reasons not related to the wealth-to-housing ratio such as changes in employment status, family size and marital status, all included in X_{it}.[3]

Table 7 reports the results of this test. In particular, Panel A shows the results of the test of the implied relationship displayed in the top panel of Figure 2. Panel B shows the results of the test of the implications from the bottom panel of Figure 2. Columns (1)-(3) in both panels use the whole sample in PSID while columns (4)-(6) use the subsample of households who report positive stock holdings. There is a substantial difference in the results across subsamples. The bias imposed by the households who do not participate in the stock market washes out the effects of misperception. Note that we only obtain significant results when we restrict our sample to only stockholders. On the contrary, all the signs are as expected in the specifications limited to stockholders. The sign on misperception, by any of the three measures, is negative, implying that more misperception is associated with lower risky stock holdings. The economic interpretation is not negligible, considering that the average stock holdings (among stockholders) is about 3.8%: an increase in misperception by 10% results in an decrease of risky holdings to 0.69%-1.07% on average, depending on the specification. The specifications contain interaction terms. We obntain that the coefficient on misperception is negative, as expected, and the coefficient on the interaction is positive, consistent to the model predictions displayed in Figure 2.

6.2 Consumption: Empirical results

The model predicts that misperception leads to lower consumption, as shown in the Figure 3, which corresponds to Table 8. To test the model implications described in Section 5.2, we estimate the following empirical relationship:

[3]The goal is to identify those moves that are triggered by the evolution of wealth and house prices and control for those moves that result from an increase or decrease in family size alone, such as births, deaths, divorces, and emancipations. The identification is not perfect, as having children may be correlated with the wealth level, but the results are robust to the inclusion or exclusion of changes in family size. This parameter also includes age and gender of the head of the household.

Table 7: **Risky stock holdings and misperception:** Effects of misperception on the share of risky stock holdings over total wealth. m_{it} represents the measure of misperception. In Panel A, misperception is measured as the absolute value of the distance to the mean of the misperception within the zip code. In Panel B, misperception is the difference between the subjective valuation and the market value of the house measured at the zip code level. Columns 1-3 include all households in the sample while columns 4-6 only include stockholders. Columns 1 and 4 include random effects while columns 2-3, and 5-6 include zip code fixed effects. Columns 3 and 6 include clustered errors at the zip code level.

Panel A: Misperception (dispersion)

	All households			Only stockholders		
	[1]	[2]	[3]	[4]	[5]	[6]
m_{it}	0.000997	−0.000315	−0.000408	−0.006968**	−0.010731***	−0.010729*
	[0.57]	[−0.16]	[−0.20]	[−2.11]	[−2.77]	[−1.88]
z_{it}	0.005560***	0.003693***	0.003670***	0.001718***	0.000773*	0.000775
	[25.32]	[14.05]	[8.92]	[5.10]	[1.79]	[1.15]
$m_{it} * z$	−0.001488*	−0.000805	−0.000761	0.001859	0.002865*	0.002869
	[−1.80]	[−0.91]	[−0.75]	[1.43]	[1.93]	[1.39]
constant	0.364560***	0.248471***	0.241773***	0.04553	−0.077445	−0.076793
	[7.72]	[3.93]	[2.72]	[0.1]	[−0.51]	[−0.33]
R^2	13.32%	54.61%	54.32%	5.83%	57.36%	57.14%

Panel B: Misperception (overvaluation)

	All households			Only stockholders		
	[1]	[2]	[3]	[4]	[5]	[6]
m_{it}	0.000772	−0.000958	−0.000951	−0.005282**	−0.007952***	−0.007951***
	[0.72]	[−0.81]	[−0.65]	[−2.55]	[−3.29]	[−1.99]
z_{it}	0.005354***	0.003619***	0.003601***	0.001893***	0.001120***	0.001122*
	[28.28]	[15.70]	[9.87]	[6.34]	[2.84]	[1.82]
$m_{it} * z$	−0.000236	0.00083	0.000824	0.001076	0.002380**	0.002379
	[−0.44]	[1.44]	[1.03]	[1.28]	[2.45]	[1.62]
constant	0.375420***	0.261828***	0.255353***	0.063773	−0.034879	−0.034326
	[8.04]	[4.20]	[2.91]	[0.72]	[−0.23]	[−0.15]
R^2	13.27%	54.61%	54.32%	6.09%	57.4%	57.18%
FE/RE	RE	FE	FE	RE	FE	FE
Cluster	No	No	Zip	No	No	Zip
Obs.	$13,525$	$13,525$	$13,275$	$4,225$	$4,225$	$4,198$

$$\frac{C_{it}}{z_{it}} = \gamma_0 + \gamma_1 \cdot z_{it} + \gamma_2 \cdot m_{it} + \gamma_3 \cdot z_{it} \cdot m_{it} + \Gamma \cdot X_{it} + u_{it}, \tag{22}$$

where m_{it} represents misperception, measured in the same three ways we used above, z_{it} is the wealth-to-housing ratio, and X_{it} a series of controls.

Table 8: **Consumption and misperception:** Effects of misperception on the ratio of consumption to total wealth. m_{it} represents the measure of misperception. In Panel A, misperception is measured as the absolute value of the distance to the mean of the misperception within the zip code. In Panel B, misperception is the difference between the subjective valuation and the market value of the house measured at the zip code level. The table includes all households in the sample. Column 1 includes random effects while columns 2-3 include fixed effects. Column 3 includes clustered errors at the zip code level.

Panel A: Misperception (dispersion)

	[1]	[2]	[3]
m_{it}	-0.008014^{***}	-0.012556^{***}	-0.01260^{***}
	[−2.99]	[−4.45]	[−3.64]
z_{it}	-0.010316^{***}	-0.010356^{***}	-0.010337^{***}
	[−27.55]	[−25.67]	[−17.73]
$m_{it} * z_{it}$	0.003647^{***}	0.003913^{***}	0.003884^{***}
	[3.12]	[3.25]	[3.20]
constant	1.712719^{***}	1.467278^{***}	1.437393^{***}
	[10.62]	[8.08]	[5.26]
R^2	15.15%	81.85%	81.76%

Panel B: Misperception (overvaluation)

	[1]	[2]	[3]
m_{it}	-0.024522^{***}	-0.024224^{***}	-0.024275^{***}
	[−15.18]	[−14.29]	[−8.73]
z_{it}	-0.009922^{***}	-0.009890^{***}	-0.009876^{***}
	[−31.03]	[−28.49]	[−19.52]
$m_{it} * z_{it}$	0.003667^{***}	0.004058^{***}	0.004065^{***}
	[5.03]	[5.38]	[4.22]
constant	1.318664^{***}	1.213028^{***}	1.183237^{***}
	[8.40]	[6.88]	[4.40]
R^2	17.90%	82.67%	82.58%
FE/RE	RE	FE	FE
Cluster	No	No	Zip
Obs.	8,192	8,192	8,028

The signs on m_{it} are all negative and significant for any of the three definitions of misperception. The economic significance is also relevant. The consumption to wealth ratio decreases to about 1.26% when measuring misperception by the absolute percentage deviation from the mean misperception within zipcode (Panel A), and to about 2.43% when measuring misperception as the percentage difference between subjective home price and market value (Panel B.)

6.3 Risk-free holdings and leverage: Empirical results

The model predicts that higher misperception leads to lower leverage. Figure 4 and the analysis in Section 5.3 indicates that leverage decreases as a result of an increase in misperception (i.e., negative risk-free holdings are less negative). We use for this purpose a reduced form approach similar to the one in the previous sections:

$$\frac{B_{it}}{z_{it}} = \gamma_0 + \gamma_1 \cdot z_{it} + \gamma_2 \cdot m_{it} + \gamma_3 \cdot z_{it} \cdot m_{it} + \Gamma \cdot X_{it} + u_{it}, \tag{23}$$

Table 9 exhibits the results of the tests for risk-free holdings and leverage. The results are not significant for all measures of misperception. They are only significant for misperception measured as the percentage deviation from the average misperception within a zip code. And, in this case, the economic significance is substantial. A 10% increase in misperception results in a decrease of leverage by 1.71%, when using the specification of fixed effects, clustered standard errors at the zipcode level and all the controls described above.

6.4 Housing holdings and housing adjustments: Empirical results

The model predicts that the higher the misperception, the lower the housing holdings. Table 5 in Section 5.4 shows that the housing holdings are lower at the return point and also at the boundaries with respect to the benchmark with no misperception. We employ the following reduced form model to test this hypothesis:

$$z_{it} = \gamma_0 + \gamma_1 \cdot m_{it} + \Gamma \cdot X_{it} + u_{it}, \tag{24}$$

Table 10 reports the results of the reduced form estimation introduced in equation (24). We use the two measures of misestimation that have been previously described. Results are in line with the model predictions. As misperception increases, the overall share of housing wealth to total wealth is lower. In particular, it is lower at the information and moving boundaries and at the optimal return point, as seen by the interactions with the "moving" identifiers. The coefficient corresponding to misperception in panels B and C are negative, as expected. The economic magnitude is not as

Table 9: **Leverage and misperception:** Effects of misperception on the ratio of borrowing to total wealth. m_{it} represents the measure of misperception. In Panel A, misperception is measured as the absolute value of the distance to the mean of the misperception within the zip code. In Panel B, misperception is the difference between the subjective valuation and the market value of the house measured at the zip code level. Columns 1-3 include all households in the sample while columns 4-6 only include stockholders. Columns 1 and 4 include random effects while columns 2-3, and 5-6 include zip code fixed effects.

Panel A: Misperception (dispersion)

	[1]	[2]	[3]	[4]	[5]	[6]
m_{it}	-0.073260^{***}	-0.078532^{***}	-0.079416^{***}	-0.139381^{***}	-0.170331^{***}	-0.171242^{***}
	[−5.96]	[−5.46]	[−2.94]	[−7.11]	[−6.92]	[−3.90]
z	-0.028478^{***}	-0.032787^{***}	-0.033081^{***}	-0.039793^{***}	-0.051349^{***}	-0.051589^{***}
	[−17.31]	[−16.46]	[−10.69]	[−14.24]	[−13.98]	[−9.14]
$m_{it} * z$	0.036580^{***}	0.037896^{***}	0.038415^{***}	0.084761^{***}	0.098550^{***}	0.099200^{***}
	[6.27]	[5.89]	[2.98]	[7.91]	[7.70]	[4.03]
constant	-2.860032^{***}	-2.964743^{***}	-3.019332^{***}	1.894726^{***}	1.549514	1.383134
	[−8.48]	[−6.56]	[−4.10]	[2.78]	[1.57]	[0.85]
R^2	5.76%	59.90%	59.69%	6.93%	71.16%	71.01%

Panel B: Misperception (overvaluation)

	All households			Only stockholders		
	[1]	[2]	[3]	[4]	[5]	[6]
m_{it}	-0.020869^{***}	-0.024001^{***}	−0.023897	0.006325	−0.009512	−0.008998
	[−2.75]	[−2.76]	[−1.57]	[0.46]	[−0.54]	[−0.31]
z	-0.024064^{***}	-0.027721^{***}	-0.027931^{***}	-0.030290^{***}	-0.037645^{***}	-0.037771^{***}
	[−16.86]	[−15.91]	[−8.85]	[−12.81]	[−12.14]	[−6.05]
$m_{it} * z$	-0.006731^{*}	−0.003582	−0.003670	-0.038122^{***}	-0.025783^{**}	−0.026115
	[−1.73]	[−0.83]	[−0.48]	[−4.47]	[−2.41]	[−1.44]
constant	-2.823090^{***}	-2.855340^{***}	-2.908469^{***}	1.817843^{***}	1.696728^{*}	1.517266
	[−8.50]	[−6.44]	[−3.97]	[2.70]	[1.71]	[0.90]
R^2	6.08%	59.87%	59.65%	7.52%	70.68%	70.51%
FE/RE	*RE*	*FE*	*FE*	*RE*	*FE*	*FE*
Cluster	*No*	*No*	*Zip*	*No*	*No*	*Zip*
Obs.	8,035	8,035	7,883	3,828	3,828	3,857

relevant as we found for the financial portfolio and consumption variables. The coefficients on $move_{BIG}$ and $move_{SMALL}$ indicate that there exists a wide area of inaction, as the housing to wealth ratio is much higher for those households who move to a bigger house once they hit the boundary than for those who hit the lower boundary and move to a smaller house. This result is expected and not novel, as it is the fundamental result in Grossman and Laroque (1990).

Table 10: **Housing holdings and misperception:** Effects of misperception on the wealth-to-housing ratio, z_{it}. m_{it} represents the measure of misperception. In Panel A, misperception is measured as the absolute value of the distance to the mean of the misperception within the zip code; in Panel B is the difference between the subjective valuation and the market value of the house measured at the zip code level; and in Panel C, a dummy variable that captures the households who are overvaluing.

Panel A: Misperception (dispersion)

	[1]	[2]	[3]	[4]	[5]	[6]
m_{it}	0.124831*	0.114077	0.114442	0.116967*	0.104375	0.105877
	[1.92]	[1.40]	[0.83]	[1.73]	[1.23]	[0.74]
M_{BIG}	0.432496***	0.425157***	0.431673***	0.392655***	0.397729***	0.407339***
	[8.98]	[8.29]	[5.98]	[6.43]	[6.11]	[4.32]
M_{SMALL}	−0.116069***	−0.172867***	−0.173683***	−0.106425**	−0.171225***	−0.172845***
	[−2.58]	[−3.50]	[−3.12]	[−1.98]	[−2.90]	[−2.78]
$m_{it} * M_{BIG}$				0.304983	0.207274	0.178760
				[1.05]	[0.68]	[0.33]
$m_{it} * M_{SMALL}$				−0.086027	−0.014593	−0.008070
				[−0.33]	[−0.05]	[−0.04]
constant	56.632110***	49.079040***	50.081310***	56.343840***	48.833460***	49.848550***
	[7.66]	[5.47]	[3.91]	[7.61]	[5.44]	[3.90]
R^2	12.17%	73.97%	73.66%	12.20%	73.97%	73.66%

Panel B: Misperception (overvaluation)

	[1]	[2]	[3]	[4]	[5]	[6]
m_{it}	−0.122362***	−0.061914	−0.062319	−0.146463***	−0.090914*	−0.091429
	[−3.04]	[−1.23]	[−0.75]	[−3.52]	[−1.74]	[−1.07]
M_{BIG}	0.436575***	0.429429***	0.436161***	0.438253***	0.430087***	0.436813***
	[9.08]	[8.38]	[6.02]	[9.11]	[8.40]	[5.98]
M_{SMALL}	−0.112029**	−0.169643***	−0.170418***	−0.123731***	−0.186964***	−0.187920***
	[−2.49]	[−3.43]	[−3.06]	[−2.73]	[−3.76]	[−3.33]
$m_{it} * M_{BIG}$				0.183322	0.054682	0.056130
				[1.00]	[0.29]	[0.15]
$m_{it} * M_{SMALL}$				0.498756**	0.603182***	0.603977***
				[2.49]	[2.90]	[2.62]
constant	54.774790***	47.402310***	48.397850***	54.938070***	47.686240***	48.680620***
	[7.45]	[5.34]	[3.79]	[7.47]	[5.37]	[3.81]
R^2	12.43%	73.97%	73.66%	12.47%	74.02%	73.70%
FE/RE	RE	FE	FE	RE	FE	FE
Cluster	No	No	Zip	No	No	Zip
Obs.	7,227	7,227	7,055	7,227	7,227	7,055

7 Conclusions

House price misperception affects the optimal behavior of households. When households misestimate the value of their houses because acquiring information on the true market value is costly, they invest less in risky stocks, they tend to move less frequently, they have less leverage, but acquire information more frequently than engage in transactions under free information. When households overvalue their houses, they tend to hold less risky stock as they get closer to a situation where they would like to downsize their house because they become more risk averse. Moreover, when households overvalue their houses, smaller movements in the wealth-to-housing ratio are required to trigger the purchase of a new home.

To reach these conclusions, this paper extends the seminal work in Grossman and Laroque (1990) by considering that households may overestimate or underestimate the value of their houses. We document important differences in the magnitude of house value misperception across U.S. states. In our model, households find costly to acquire information on the market value of their house and thus overestimate or underestimate. This misvaluation affects their consumption and portfolio choice decisions.

Empirical tests using household level data confirm the main implications of the model. Our empirical results illustrate that the over- and underestimation of house values affects the likelihood of buying a new home and the households' investments in housing. We also confirm that housing price misperception has substantial effects on financial portfolios. In sum, our paper demonstrates that the effects of transaction costs and costly acquisition of information are key elements of both housing and non-housing portfolio allocation decisions. We focus on the analysis of these decisions using a partial equilibrium model that takes house price predictability as given. Studying the aggregate general equilibrium implications of house value misperception is an interesting line of future research.

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