Online Appendix to *"Optimal Portfolio Choice with Predictability in House Prices and Transaction Costs"*

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This document presents additional support for the paper "Optimal Portfolio Choice with Predictability in House Prices and Transaction Costs". We divide the document into four sections. The first section provides a robustness exercise for the existence of predictability in house prices. The second section provides the derivation of the model without transaction cost. In the third section we provide additional material on the simulation. The fourth section provides robustness analysis on the empirical results of the paper.

1 Robustness for the Predictability in House Prices

This section is an extended version of Appendix A of the paper. We present robustness results for the predictability in house prices. Following Campbell and Shiller (1988), we exploit the identity that relates log-linearized stock returns with dividend price ratios and dividend growth:

$$p_t - d_t = \alpha + E_t \sum_{j=1}^{\infty} \rho^{j-1} \left(\Delta d_{t+j} - r_{t+j}\right) + E_t \lim_{j \to \infty} \rho^j \left(p_{t+j} - d_{t+j}\right). \tag{1}$$

Price-rent ratios only move if they forecast future returns, if they forecast future rent growth, or if the price-rent ratio grows at a faster rate than the discount rate. Our analysis focuses on how future returns and rent growth rates are explained by current rent-price ratios, in the absence of bubbles.[1] The objective of this section is to motivate the time variation of expected housing returns and, in particular, to show the relation between the Markov switching process presented in the paper

[1]Note that if the price dividend ratio is stationary, or bounded, or it does not explode faster than ρ^{-1}, then the last term disappears and we are back to equation (1). If we impose that there are no bubbles, this last term would be zero.

and the traditional predictability regressions studied in the literature. In addition, we show that the predictability regressions on the rent-price ratio (or dividend-price ratio for stocks) support the hypothesis of a significantly higher degree of predictability of housing returns relative to stock returns. Since the model we present in the paper is a partial equilibrium, we do not model prices and the agent takes them as given. Instead of having a pricing model, we have a reduced model for the price dynamics. The goal of this section is to show that the reduced form predictability imposed in the pricing dynamics is a good representation of the predictability endogenously generated by price-rent ratios. Equation (1) motivates the return predictability regression, which consists of regressing returns on either lagged price-rent ratio, or dividend growth predictability, by regressing rent growth on lagged price-rent ratio

$$r_{t+1} - \bar{r} = \kappa_0 + \kappa_r(p_t - d_t) + \varepsilon^r_{t+1} \Delta d_{t+1} - \bar{d} = \kappa_0 + \kappa_d(p_t - d_t) + \varepsilon^d_{t+1}. \tag{2}$$

The price-rent ratios have been computed as in Campbell et al. (2009) using annualized quarterly data from 1978 to 2007 on house prices from the Federal Housing Finance Agency (FHFA) and rents from the Bureau of Labor Statistics (BLS). We use the annualized 1-month Treasury Bill as a risk-free rate to obtain excess returns. Returns are defined as the change in the house price index plus the rent-price ratio adjusted by the CPI growth ex-shelter. For the comparison with stock market predictability, we use the CRSP returns on the value-weighted market portfolio (NYSE/Amex/Nasdaq/Arca). Dividend growth series are constructed from the returns and the ex-dividend returns series.

Table 1 presents the results of the in sample predictability regressions. We regress future housing returns, at different horizons, on current rent-price ratios. We observe that the rent-price ratio has a strong predictive power on future housing returns. At the aggregate level, a 1% variation in the rent-price ratio implies a 23.02% variation in a three-year horizon return using FHFA data for house prices. For longer horizons, results are even stronger. As we increase the horizon, the coefficient of the rent-price ratios, $(d_t - p_t)$, which forecasts future housing returns, becomes higher and more statistically significant.[2] When forecasting 4$-$ and 5$-$year returns, a 1% increase in rent-price

[2] The explanation for this phenomenon, in the absence of the bubble term, is that the $(d_t - p_t)$ ratios are highly persistent. When estimating an $AR(1)$ to rent-price ratios for the sample, we cannot reject non-stationarity, supporting the idea of bubble-like behavior during the last few years. On the other hand, for the trimmed data set, the autocorrelation coefficient of the rent-price ratios series is 0.93 for annual data. Obviously, this results in a larger R^2

ratios implies an increase of 41% and 47%, respectively, in housing returns at the aggregate level. Similar results appear at the U.S. census macro region level. Panel B shows the results with an alternative data set. We construct rent-prices data using housing services from NIPA as a proxy for rents, and value of residential investment from the Flow of Funds to compute prices. The results in panel B are robust to including most of the last decade, as opposed to Panel A, whose results reverse if we include the periods of dramatic increase in home prices. We present the full sample results in Table 2 below.

We also find that house price changes are more predictable than stock prices at all horizons but one-year, for the FHFA sample. Panel C in Table 1 shows that stock return predictability explained by price-dividend ratios is less than half the predictability that we observe in housing returns. The right-hand side of the table shows that rent growth rates do not predict future returns. This is the case for both housing and stock returns, reinforcing the idea that housing return predictability is due to movements in rent-price or dividend-price ratios, respectively. The evidence presented in Table 1 motivates the assumption of predictability in housing returns and not in stock returns. Modeling stock returns with a predictable component results in an additional state variable. For simplicity, we solely focus on the role of housing return predictability in portfolio choice and housing tenure decisions.

Figure 1 shows the rent-price ratio, with a 4-year lead as the regressions suggest, and the probability of home price growth being in the high-growth regime. The sample size of the rent-price ratio is substantially shorter but for the period in which the two of them overlap, the peaks in the probability of the high-growth regime correspond to peaks in the rent-price ratio time series. The correlation is positive for most of the sample except for the last few observations. This is in line with the inability of the rent-price ratios to explain expected returns that may be explained only by future expected appreciation. Our partial-equilibrium approach does not allow us to address the origin of a bubble-like outcome.

Price-rent ratios seem to follow non-stationary behavior during the recent years, which implies that the last term in equation (1) might not converge to zero fast enough. When current prices are explained by growing expectations of future prices, little power is left for price-dividend ratios or dividend growth to explain future price changes. Campbell, Giglio, and Polk (2010) present a similar

as well.

argument justifying the exclusion of recent years. House prices growth first order autocorrelation is 71.3%. In Table 2 we use the entire sample available. We observe a sign change when we use data from the recent episode of house prices sharp increase and fall. When current price growth is explained by future price growth, predictability power of rent-price ratio disappears.

Table 3 shows evidence of the loss of explanatory power when fluctuations in rents are ignored. We run the same regression as in Table 1, assuming constant rents. The coefficient estimates show a significant decline with respect to those including rents in the predictive regression, which indicates that the main source of predictive power is not the high autocorrelation in price growth, but the joint dynamics of rents and prices.

Table 4 provides results at the MSA level. In general, each region shows results that are consistent with the aggregate results, except some exceptions such as Denver or Miami.

2 Derivation of the Model Without Transaction Costs ($\epsilon = 0$)

The value function is defined by

$$\bar{V}(W(0), P(0), i) = \sup_{C,\Theta,H} E\left[\int_0^\infty e^{-\rho t} u(C,H)dt\right], \quad i = 1, ..., n. \tag{3}$$

The associated Hamilton-Jacobi-Bellman equation is the following in the regime i:

$$\rho\bar{V}(\cdot,i) = \sup_{C,\Theta,H}\left\{U(C,H) + \mathcal{D}\bar{V}(\cdot,i) + \sum_{i\neq j}\lambda_{ij}(\bar{V}(\cdot,j) - \bar{V}(\cdot,i))\right\}, \tag{4}$$

where

$$\begin{aligned}\mathcal{D}\bar{V}(\cdot,i) = {} & [r(W-HP) + \Theta(\alpha_S - r) + (\mu_i - \delta)HP - C]\bar{V}_W(\cdot,i) \\ & + \mu_i P_t \bar{V}_P(\cdot,i) + \frac{1}{2}(\Theta^2\sigma_S^2 + 2HP\Theta\rho_{PS}\sigma_S\sigma_P + H^2P^2\sigma_P^2)\bar{V}_{WW}(\cdot,i) \\ & + \frac{1}{2}P^2\sigma_P^2\bar{V}_{PP}(\cdot,i) + (\Theta P\rho_{PS}\sigma_S\sigma_P + HP^2\sigma_P^2)\bar{V}_{WP}(\cdot,i), \quad i = 1, ..., n.\end{aligned} \tag{5}$$

We can use the homogeneity properties of the value function to reduce the problem with three state variables (W, P, i) to one with two state variables, $x = W/P$ and i, since

$$\bar{V}(W, P, i) = P^{\beta(1-\gamma)}\bar{V}\left(\frac{W}{P}, 1, i\right) = P^{\beta(1-\gamma)}\bar{v}\left(x, i\right), \quad i = 1, ..., n. \tag{6}$$

Let us introduce the scaled controls $\bar{c} = C/P$ and $\bar{\theta} = \Theta/P$. Substituting and simplifying we obtain

$$\bar{\rho}_i \bar{v}(x, i) = \sup_{\bar{c}, \bar{\theta}, H}\left\{U(\bar{c}, H) + \mathcal{D}\bar{v}(x, i) + \sum_{i \neq j}\lambda_{ij}(\bar{v}(x, j) - \bar{v}(x, i))\right\}, \tag{7}$$

where

$$\begin{aligned}\mathcal{D}\bar{v}(x, i) =& ((x - H)(r - \mu_i + \sigma_P^2(1 + \beta(\gamma - 1))) + \bar{\theta}(\alpha_S - r - (1 + \beta(\gamma - 1))\rho_{PS}\sigma_S\sigma_P) - \bar{c})\bar{v}_x(x, i) \\ &+ \frac{1}{2}((x - H)^2\sigma_P^2 - 2(x - H)\bar{\theta}\rho_{PS}\sigma_P\sigma_S + \bar{\theta}^2\sigma_S^2)\bar{v}_{xx}(x, i), \quad i = 1, ..., n.\end{aligned} \tag{8}$$

Let

$$\bar{\rho}_i = 0.5(-2\rho + \beta(-1 + \gamma)(-2\alpha_i + (1 + \beta(\gamma - 1))\sigma_P^2), \quad i = 1, ..., n. \tag{9}$$

We derive explicit expressions for both the value function and the optimal policies. We first guess that the optimal controls are given by

$$\bar{c}^*(x, i) = \alpha_{c,i}x, \quad H^*(x, i) = \alpha_{h,i}x/P, \quad \bar{\theta}^*(x, i) = \alpha_{\theta,i}x \tag{10}$$

and the value function for the no transaction costs problem is given by

$$\bar{v}(x, i) = \alpha_{v,i}\frac{x_t^{1-\gamma}}{1 - \gamma}, \tag{11}$$

where $i = 1, ..., n$. Then, we verify that the value function and the candidate control policies are the optimal policies for the no transaction costs case.

3 Heterogeneous Agents Economy Simulation

In Table 5, we report the parameters of the house price process using a three regime Markov switching process. The five U.S. states displayed here are, respectively, California, Florida, New

York, Illinois and Texas. An urban index for the state j is calculated averaging the real FHFA house price indexes of the largest MSAs of the state j creating an urban index and the three regime Markov switching process is estimated on the real returns of the index. Los Angeles and San Francisco FHFA indexes are used for California; Miami and Orlando FHFA indexes for Florida; New York (city) FHFA index for New York; Chicago FHFA index for Illinois; and Dallas and Houston FHFA indexes are used for Texas.

In Table 6, we present the optimal policies based on the house price parameters of Table 5 and the parameters used for the benchmark calibration (see Table 2 of the paper).

4 Robustness on the Empirical Results

In this section, we present the tables addressing two concerns of the editor:

- **Endogeneity** The set of controls as changes in the employment status, changes in family size and changes in marital status are not exogenous. We replicate the tests of Hypothesis 1 and 2 excluding from the sample households that moved to a different house and at the same time changed marital status, employment status and number of children. Results are reported in Table 7 and 8.

- **Housing indicator** According to the second condition of the index definition, the real housing return of the state k has to be higher than the mean real housing return in the high-growth regime of U.S. aggregate for four quarters in a row. Based on the smoothed probabilities for U.S. aggregate, we identify the period $2000 - 2006$ as a high-growth period and we calculate a mean annual real growth rate of 6.37%. Accordingly, we use this as our threshold for condition (ii). We check our results for robustness by lowering the threshold to 5%. We replicate the tests of Hypothesis 1, 2, 3.1 and 3.2 using this housing indicator. Results are reported in Tables 9-12.

Figures and Tables

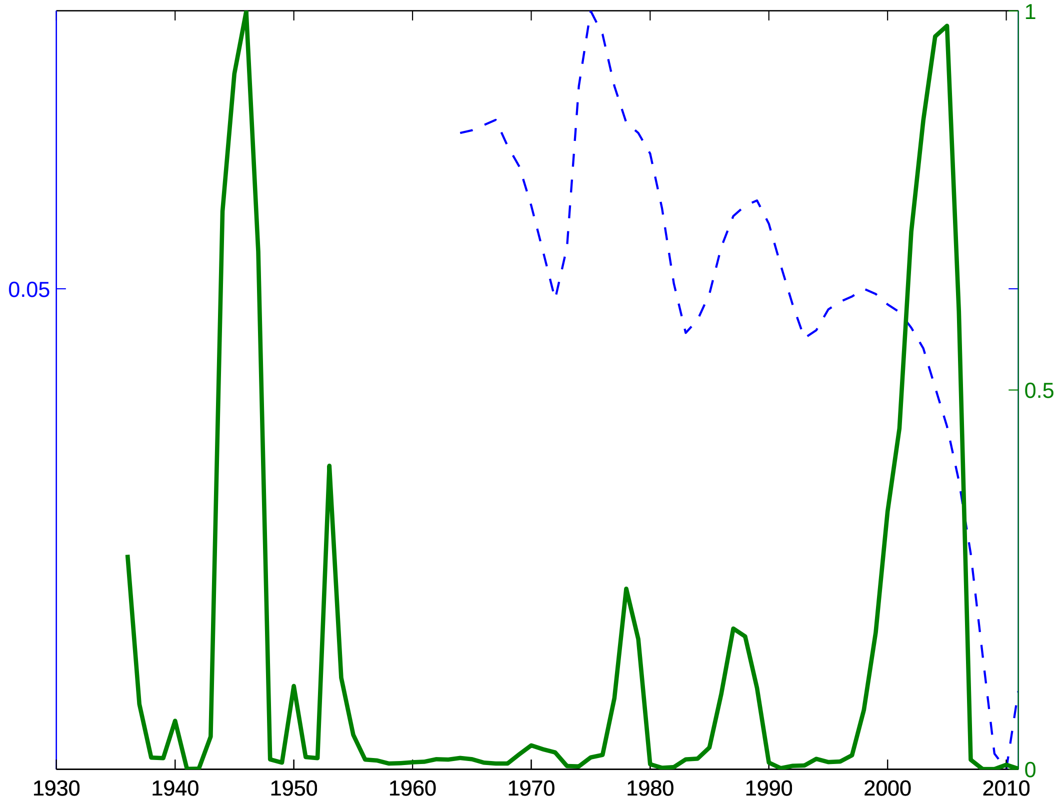

Figure 1: **Probability of being in a high-growth regime of housing returns vs. rent-price ratio.** The bold line represents the smoothed probability of being in a high regime, on the right axis. The dashed line represents the rent-price ratio, on the left axis.

Table 1: **Predictability of excess returns and dividend growth with rent-price ratios**. Predictability of excess returns and dividends growth with rents-to-price ratios, using 4-lags Newey-West corrected standard errors. Data source: Panel A uses annualized price-rent data annualized quarterly data on house prices from the Federal Housing Finance Agency (FHFA) and rents from the Bureau of Labor Statistics (BLS) from 1978 to 2002. Panel B shows the same housing predictability regressions with rent data from NIPA and value data from Flow of Funds from 1960 to 2008. Panel C shows stock return predictability, with stock returns data from CRSP NYSE/Amex/Nasdaq/Arca value-weighted market index from 1926 to 2008.

Panel A - Housing Predictability FHFA

	Excess Returns			Dividend growth		
Horizon	β	t-stat	R^2	β	t-stat	R^2
k=1	-1.43	-0.31	0.01	2.15	0.62	0.05
k=3	23.02	2.04	0.26	8.96	1.83	0.14
k=5	47.71	5.69	0.57	5.60	1.53	0.03

Panel B - Housing Predictability NIPA

	Excess Returns			Dividend growth		
Horizon	β	t-stat	R^2	β	t-stat	R^2
k=1	1.70	3.51	0.30	0.10	0.86	0.01
k=3	8.58	6.69	0.53	-0.07	-0.25	0.00
k=5	22.01	8.00	0.62	-0.84	-1.63	0.08

Panel C - Stock Return Predictability

	Excess Returns			Dividend growth		
Horizon	β	t-stat	R^2	β	t-stat	R^2
k=1	3.63	3.18	0.07	-3.45	-2.19	0.05
k=3	10.95	3.58	0.18	-2.17	-0.97	0.01
k=5	18.85	3.76	0.24	-2.69	-1.16	0.01

Table 2: **Predictability of excess returns and dividend growth with rent-price ratios. Full Sample**. Predictability of excess returns and dividend growth with rent-price ratios, 4-lag Newey-West corrected standard errors. Data source: price-rent data using annualized quarterly data from 1978 to 2007 on house prices from the Federal Housing Finance Agency (FHFA) and rents from the Bureau of Labor Statistics (BLS).

		Excess Returns			Dividend growth		
	Horizon	β	t-stat	R^2	β	t-stat	R^2
USA	k=1	-3.31	-2.06	0.15	0.40	0.53	0.01
	k=3	-13.65	-1.83	0.16	2.14	0.85	0.03
	k=5	-21.03	-0.77	0.08	1.29	0.37	0.00
Midwest	k=1	-1.69	-1.44	0.05	0.89	1.59	0.07
	k=3	-3.60	-0.58	0.02	3.01	1.53	0.13
	k=5	-1.75	-0.11	0.00	3.28	1.06	0.08
Northeast	k=1	-1.36	-1.00	0.02	-0.84	-1.29	0.08
	k=3	0.55	0.07	0.00	-0.05	-0.03	0.00
	k=5	18.70	1.24	0.14	4.21	1.28	0.14
South	k=1	-3.54	-2.10	0.16	-0.36	-0.51	0.01
	k=3	-8.46	-0.61	0.05	-0.59	-0.27	0.00
	k=5	7.41	0.27	0.01	-3.32	-0.80	0.04
West	k=1	-4.47	-2.66	0.27	0.13	0.20	0.00
	k=3	-18.04	-1.76	0.26	-0.79	-0.34	0.00
	k=5	-20.93	-0.76	0.09	-8.23	-2.51	0.16
Stocks	k=1	3.63	3.18	0.07	-3.45	-2.19	0.05
	k=3	10.95	3.58	0.18	-2.17	-0.97	0.01
	k=5	18.85	3.76	0.24	-2.69	-1.16	0.01

Table 3: **Predictability of excess returns and dividend growth with inverse price ratios**. Predictability of excess returns and dividend growth with inverse-price ratios in order to test for the predictive power of ignoring rent fluctuations. 4-lag Newey-West corrected standard errors. Data source: price data on annualized house prices from the Federal Housing Finance Agency (FHFA), for the two subsamples.

		Excess Returns			Dividend growth		
	Horizon	β	t-stat	R^2	β	t-stat	R^2
1978-2002	k=1	-6.39	-1.50	0.18	-2.41	-1.21	0.08
	k=2	-16.22	-2.65	0.34	-4.12	-1.01	0.08
	k=3	-26.43	-3.81	0.46	-3.13	-0.55	0.03
	k=4	-35.49	-4.46	0.53	-0.71	-0.10	0.00
	k=5	-42.64	-4.61	0.56	1.58	0.21	0.00
1978-2007	k=1	-7.43	-1.99	0.25	-1.69	-0.95	0.05
	k=2	-19.99	-3.43	0.45	-2.27	-0.62	0.03
	k=3	-34.55	-4.54	0.58	-1.91	-0.39	0.01
	k=4	-48.48	-4.91	0.63	-0.78	-0.14	0.00
	k=5	-60.67	-4.79	0.65	0.21	0.04	0.00

Table 4: **Predictability of excess returns and dividend growth with rent-price ratios. Metropolitan-level analysis.** 4-lag Newey-West corrected standard errors. Data source: quarterly price-rent data from 1978 to 2001 on house prices from the Federal Housing Finance Agency (FHFA) and the Bureau of Labor Statistics (BLS) from 1978 to 2002.

		Excess Returns			Dividend growth		
	Horizon	β	t-stat	R^2	β	t-stat	R^2
Chicago	k=1	-1.38	-0.53	0.01	1.98	1.73	0.12
	k=5	27.39	3.14	0.29	8.76	2.56	0.31
Cincinnati	k=1	-1.51	-0.86	0.02	0.89	0.68	0.04
	k=5	24.26	1.71	0.27	3.67	0.85	0.07
Cleveland	k=1	-0.27	-0.17	0.00	1.05	0.82	0.04
	k=5	17.06	1.46	0.18	0.83	0.19	0.01
Detroit	k=1	-1.15	-1.04	0.04	-0.02	-0.03	0.00
	k=5	4.68	0.59	0.03	0.45	0.16	0.00
Kansas City	k=1	2.06	0.93	0.06	0.50	0.32	0.01
	k=5	24.04	4.50	0.43	-5.81	-1.34	0.11
Milwaukee	k=1	0.54	0.27	0.00	1.49	1.33	0.14
	k=5	23.34	2.17	0.39	1.69	0.83	0.04
Minneapolis	k=1	-3.38	-2.49	0.22	-1.20	-1.42	0.11
	k=5	1.33	0.07	0.00	-11.42	-2.40	0.43
St. Louis	k=1	-2.58	-1.57	0.07	0.09	0.07	0.00
	k=5	16.81	1.11	0.15	0.37	0.06	0.00
Boston	k=1	0.22	0.12	0.00	-1.54	-1.84	0.16
	k=5	33.56	2.65	0.43	5.98	1.69	0.18
New York	k=1	0.54	0.32	0.00	-1.65	-2.80	0.31
	k=5	25.23	2.00	0.33	0.23	0.08	0.00
Philadelphia	k=1	-1.13	-0.53	0.01	0.90	0.56	0.03
	k=5	28.71	2.66	0.39	12.01	3.27	0.48
Pittsburgh	k=1	-1.18	-0.68	0.02	0.94	0.75	0.04
	k=5	13.87	1.54	0.17	0.34	0.09	0.00
Atlanta	k=1	-3.53	-1.49	0.09	0.51	0.23	0.00
	k=5	32.04	2.11	0.19	-17.34	-1.36	0.10
Dallas	k=1	2.34	1.73	0.09	0.40	0.42	0.01
	k=5	24.06	3.43	0.59	5.27	1.01	0.11
Houston	k=1	3.24	2.46	0.19	1.51	2.14	0.09
	k=5	28.39	7.06	0.77	8.40	4.34	0.45
Miami	k=1	-7.61	-6.05	0.52	-2.31	-4.01	0.25
	k=5	-14.11	-0.86	0.06	-8.37	-3.10	0.37
Denver	k=1	-4.16	-3.04	0.26	-2.84	-2.14	0.30
	k=5	-9.63	-0.54	0.03	-19.15	-3.24	0.46
Honolulu	k=1	-0.87	-0.43	0.00	0.35	0.37	0.01
	k=5	17.88	1.18	0.13	7.12	2.27	0.23
Los Angeles	k=1	-1.26	-0.37	0.01	2.04	1.36	0.12
	k=5	54.73	9.95	0.66	14.78	4.25	0.36
Portland	k=1	-0.98	-0.95	0.03	-0.07	-0.21	0.00
	k=5	8.41	1.18	0.06	1.68	1.03	0.05
San Diego	k=1	-2.51	-0.68	0.04	0.99	0.45	0.02
	k=5	38.76	4.87	0.37	3.94	0.56	0.02
San Francisco	k=1	-0.22	-0.09	0.00	1.04	0.72	0.04
	k=5	36.78	4.48	0.37	7.47	1.55	0.12
Seattle	k=1	-1.90	-1.79	0.08	-0.94	-1.74	0.09
	k=5	1.09	0.12	0.00	-2.66	-1.39	0.14

Table 5: **Parameter values for the house price process - Urban indexes.** Estimation of the parameters of the house price process using a three regime Markov switching process. The growth of house prices in each regime i is denoted by μ_i and its standard deviation is denoted by σ_P, where i can be either $i = l$ (low-growth regime), $i = m$ (medium-growth regime) or $i = h$ (high-growth regime). The conditional probability of moving from regime i to regime j is denoted by λ_{ij}. Columns $(1) - (5)$ report the parameters for five U.S. states using FHFA data; the parameters are quarterly. The five U.S. states displayed here are, respectively, California, Florida, New York, Illinois and Texas. An urban index for the state j is calculated averaging the real FHFA house price indexes of the largest MSAs of the state j creating and the 3-regime markov switching model is estimated on the returns of the index. Los Angeles and San Francisco FHFA indexes are used for California; Miami and Orlando FHFA indexes for Florida; New York (city) FHFA index for New York; Chicago FHFA index for Illinois; and Dallas and Houston FHFA indexes are used for Texas. The likelihood test is used to test the null hypothesis that house prices follow a martingale against the alternative of a regime switching mechanism. Data source: Federal Housing Finance Agency (FHFA) $(1983(1Q) - 2012(2Q))$.

	Federal Housing Finance Agency $1983(1Q) - 2012(2Q)$				
	California (1)	Florida (2)	New York (3)	Illinois (4)	Texas (5)
μ_l	-0.0151	-0.0299	-0.0074	-0.0200	-0.0260
	(0.0023)	(0.0067)	(0.0024)	(0.0082)	(0.0057)
μ_m	0.0121	0.0063	0.0097	0.0032	-0.0036
	(0.0036)	(0.0016)	(0.0033)	(0.0053)	(0.0019)
μ_h	0.0337	0.0305	0.0286	0.0139	0.0060
	(0.0021)	(0.0033)	(0.0022)	(0.0053)	(0.0012)
σ_P	0.0137	0.0138	0.0104	0.0089	0.0071
	(0.0009)	(0.0009)	(0.0011)	(0.0023)	(0.0005)
λ_{ll}	0.9728	0.6319	0.9717	1.000	0.5300
	(0.1693)	(0.1919)	(0.3485)	(0.0706)	(0.2023)
λ_{lm}	0.0271	0.3680	0.0282		0.4699
	(0.0326)	(0.2007)	(0.0369)		(0.2757)
λ_{ml}		0.0342	0.0992	0.0175	0.0939
		(0.0206)	(0.1415)	(0.1495)	(0.0559)
λ_{mm}	0.9140	0.9536	0.8428	0.9410	0.8815
	(0.2612)	(0.0236)	(0.1431)	(0.1552)	(0.0643)
λ_{hl}	0.0401				
	(0.0279)				
λ_{hm}		0.0435	0.0452	0.0615	0.0225
		(0.0429)	(0.0972)	(0.3285)	(0.0435)
LR-test χ^2:					
$\mu_l = \mu_m = \mu_h$	108.80	104.35	129.51	89.21	64.88
P-value	0.000**	0.000**	0.000**	0.000**	0.000**
Num. Obs.	118	118	118	118	118

Table 6: **Numerical results - Urban Indexes.** Column (1) reports the z ratio that determines the lower bound, the optimal return point (i.e., wealth-to-housing ratio immediately after a housing transaction), and the upper bound, respectively. Column (2) reports the optimal return point for the model in the absence of transaction costs. Columns (3), (4) and (5) report the expected time between two consecutive moves right after a housing transaction, the change in the wealth-to-housing ratio around housing transaction and the drift of the z ratio at the optimal return point, respectively. Column (6) reports the relative risk aversion associated with the indirect utility of total wealth right after a housing transaction, $-(z^* v_{zz}(z^*, i))/v_z(z^*, i)$. Column (7) reports the average fraction of wealth invested in risky assets between two consecutive moves right after a housing transaction. Column (8) reports the fraction of wealth invested in risky assets in the absence of transaction costs. Column (9) reports the change in the risky asset share around housing transaction. Column (10) reports the average fraction of wealth allocated to non housing goods between two consecutive moves right after a housing transaction. Column (11) reports the fraction of wealth allocated to non housing goods in the absence of transaction costs.

	Regime	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	i	$(\underline{z}_i, z_i^*, \overline{z}_i)$	z^{nt}	$E(\tau_i^*)$	Δz	Drift at z^*	$RRA(z^*, i)$	$\frac{E\left(\frac{\hat{\Theta}^*}{\hat{W}^*}\right)}{E(\tau_i^*)}$	$\frac{\Theta^{nt}}{W^{nt}}$	$\Delta\frac{\Theta}{W}$	$\frac{E\left(\frac{C^*}{W^*}\right)}{E(\tau_i^*)}$	$\frac{C^{nt}}{W^{nt}}$
California	H	$(0.251, 1.083, 2.751)$	0.187	5.120	1.668	−0.022	24.406	−0.609	−0.604	0.195	0.015	0.021
	M	$(0.411, 1.284, 2.864)$	0.670	7.376	1.580	−0.016	15.965	0.067	0.077	0.107	0.016	0.025
	L	$(3.430, 6.042, 10.596)$	6.737	6.023	4.554	0.052	10.097	0.242	0.245	0.016	0.030	0.029
Florida	H	$(0.292, 1.527, 2.793)$	0.207	13.398	1.265	−0.044	19.167	−0.452	−0.440	0.145	0.013	0.019
	M	$(0.870, 2.402, 5.149)$	1.412	11.650	2.747	−0.010	14.490	0.159	0.162	0.042	0.015	0.016
	L	$(7.630, 14.176, 28.550)$	8.352	1.440	14.374	0.112	10.130	0.219	0.227	0.007	0.033	0.040
New York	H	$(0.248, 1.266, 2.789)$	0.280	8.461	1.524	−0.026	21.685	−0.22	−0.184	0.132	0.013	0.024
	M	$(0.496, 4.276, 8.215)$	0.822	8.865	3.939	−0.022	10.238	0.222	0.229	0.022	0.021	0.021
	L	$(2.880, 5.241, 9.680)$	5.239	10.875	4.439	0.031	10.104	0.230	0.233	0.013	0.023	0.022
Illinois	H	$(0.412, 1.924, 3.789)$	0.512	15.518	1.865	−0.024	11.889	0.061	0.070	0.052	0.014	0.024
	M	$(1.031, 2.414, 8.340)$	2.047	13.891	5.926	−0.001	10.600	0.181	0.206	0.044	0.016	0.016
	L	$(4.022, 7.343, 14.114)$	7.340	6.769	6.771	0.075	10.057	0.232	0.239	0.013	0.029	0.032
Texas	H	$(1.182, 3.228, 5.432)$	1.298	25.996	2.204	−0.007	10.691	0.209	0.182	0.027	0.016	0.016
	M	$(1.961, 4.145, 10.736)$	4.140	18.550	6.591	0.020	10.207	0.226	0.229	0.022	0.018	0.019
	L	$(2.442, 8.352, 26.107)$	7.923	4.292	17.755	0.098	10.180	0.238	0.247	0.018	0.024	0.036

Table 7: **Test of Hypothesis 1 - Endogeneity.** Coefficients are estimated by using a standard OLS model and ex-ante (i.e., before moving) values of $\tilde{z}_{it}$ as endogenous variable. $m_{BIG_{it}}$ ($m_{SMALL_{it}}$) is a dummy variable equal to one if the family is increasing (decreasing) its housing holdings (i.e., moving to a more (less) valuable house). $\mathbb{1}^{\mu_h}$ is an indicator capturing periods of persistent high appreciation in house prices at U.S. state level. Standard errors, reported in parentheses, are clustered at state level. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level. The regressions include age, year, and state fixed effects. Columns $(2)-(4)$ and $(6)-(8)$ report the coefficients when we do not include the households selling the current house and buying a more or less valuable house and the number of family members, the marital status and the employment status of the household head changes in the same period respectively. Data source: SIPP $(1997-2005)$.

	(1) Paper	(2) Δ Family & Moving	(3) Δ Marriage & Moving	(4) Δ Employment & Moving	(5) Paper	(6) Δ Family & Moving	(7) Δ Marriage & Moving	(8) Δ Employment & Moving
constant (γ_0)	3.569***	3.601***	3.569***	3.567***	3.559***	3.591***	3.553***	3.557***
	(0.834)	(0.843)	(0.834)	(0.834)	(0.832)	(0.841)	(0.832)	(0.831)
m_{BIG} (γ_1)	1.717***	1.697***	1.711***	1.794***	1.899***	1.855***	1.915***	2.001***
	(0.220)	(0.215)	(0.218)	(0.237)	(0.263)	(0.259)	(0.256)	(0.291)
m_{SMALL} (γ_2)	-1.328***	-1.263***	-1.319***	-1.400***	-1.282***	-1.197***	-1.236***	-1.423***
	(0.216)	(0.221)	(0.221)	(0.225)	(0.238)	(0.244)	(0.243)	(0.237)
$\mathbb{1}^{\mu_h}$ (γ_3)					-0.041	-0.040	-0.039	-0.040
					(0.123)	(0.123)	(0.123)	(0.123)
$m_{BIG} \times \mathbb{1}^{\mu_h}$ (γ_4)					-1.111**	-0.968**	-1.166***	-1.210**
					(0.447)	(0.453)	(0.425)	(0.482)
$m_{SMALL} \times \mathbb{1}^{\mu_h}$ (γ_5)					-0.387	-0.562	-0.417	-0.240
					(0.359)	(0.427)	(0.375)	(0.399)
Δ Family	-0.378***	-0.367***	-0.377***	-0.377***	-0.378***	-0.367***	-0.381***	-0.378***
	(0.069)	(0.068)	(0.069)	(0.069)	(0.069)	(0.068)	(0.069)	(0.069)
Δ Married	-0.162	-0.120	-0.164	-0.162	-0.162	-0.120	-0.124	-0.150
	(0.229)	(0.242)	(0.241)	(0.228)	(0.228)	(0.242)	(0.244)	(0.230)
Δ Employment	-0.667***	-0.659***	-0.667***	-0.657***	-0.665***	-0.658***	-0.665***	-0.659***
	(0.098)	(0.099)	(0.098)	(0.099)	(0.099)	(0.099)	(0.099)	(0.097)
Age	X	X	X	X	X	X	X	X
State	X	X	X	X	X	X	X	X
Year	X	X	X	X	X	X	X	X
R^2	0.170	0.169	0.170	0.170	0.170	0.169	0.170	0.170
Num. Obs.	105813	105244	105777	105632	105813	105244	105749	105524

Table 8: **Test of Hypothesis 2 - Endogeneity**. Probit for the increase of housing holdings and the Heckman selectivity model. Column (1) reports the marginal effect estimates from the probit regressions for increasing the amount of housing holdings. Column (5) reports estimates on the log of the housing adjustment $\ln(\overline{z} - z^*)$ for increasing housing holdings. Columns (2) – (4) and (6) – (8) reports the coefficients of the test when we do not include the households selling the current house and buying a more or less valuable house and the number of family members, the marital status and the employment status of the household head changes in the same period respectively . $\mathbb{1}^{\mu_h}$ is an indicator that captures periods of high expected growth in house prices at the U.S. state level. All the regressions include a constant and age, state and year fixed effects. Standard errors are reported in parentheses. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level. Data source: SIPP (1997 – 2005).

	Probability of housing increase				Size of housing increase			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Paper	Δ Family & Moving	Δ Marriage & Moving	Δ Employment & Moving	Paper	Δ Family & Moving	Δ Marriage & Moving	Δ Employment & Moving
$\tilde{z}$	0.0004***	0.0003***	0.0003***	0.0003***				
	(0.0000)	(0.0000)	(0.0000)	(0.0000)				
$\mathbb{1}^{\mu_h}$	0.0039**	0.0029*	0.0037**	0.0037**	-0.6118***	-0.6119***	-0.6104***	-0.6583***
	(0.0016)	(0.0015)	(0.0016)	(0.0016)	(0.1409)	(0.1395)	(0.1434)	(0.1370)
Δ Family	0.0037***	0.0013**	0.0036***	0.0035***	-0.3867***	-0.1292	-0.3788***	-0.3671***
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.1278)	(0.1103)	(0.1262)	(0.1251)
Δ Married (d)	0.0041	-0.0033	-0.0029	0.0034	-0.1850	0.5458	0.3566	-0.2279
	(0.0042)	(0.0028)	(0.0032)	(0.0041)	(0.2846)	(0.3341)	(0.4011)	(0.2973)
Δ Employment (d)	0.0033**	0.0031**	0.0032**	-0.0038***	-0.2343**	-0.2479*	-0.2325**	0.8294***
	(0.0014)	(0.0014)	(0.0014)	(0.0011)	(0.1153)	(0.1357)	(0.1156)	(0.1318)
Age	X	X	X	X	X	X	X	X
State	X	X	X	X	X	X	X	X
Year	X	X	X	X	X	X	X	X
R^2					0.368	0.386	0.369	0.385
Num. Obs.	105758	105598	105750	105687	1361	1235	1353	1313

Table 9: **Test of Hypothesis 1 - Housing indicator.** PSID, SIPP, and model-simulated data. Coefficients are estimated by using a standard OLS model and ex-ante (i.e., before moving) values of $\tilde{z}_{it}$ as endogenous variable. $m_{BIG_{it}}$ ($m_{SMALL_{it}}$) is a dummy variable equal to one if the family is increasing (decreasing) its housing holdings (i.e., moving to a more (less valuable) house). $\mathbb{1}^{\mu_h}$ is an indicator capturing periods of persistent high appreciation in house prices at U.S. state level. Standard errors, reported in parentheses, are clustered at state level. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level. The regressions include age, year, and state fixed effects. Data source: SIPP ($1997-2005$).

	PSID (1)	SIPP (2)	PSID (3)	SIPP (4)
constant (γ_0)	5.812***	3.569***	5.782***	3.568***
	(0.348)	(0.834)	(0.345)	(0.832)
m_{BIG} (γ_1)	2.662***	1.717***	3.253***	2.072***
	(0.494)	(0.220)	(0.555)	(0.279)
m_{SMALL} (γ_2)	0.147	−1.328***	0.538	−1.254***
	(0.375)	(0.216)	(0.480)	(0.258)
$\mathbb{1}^{\mu_h}$ (γ_3)			0.213	−0.014
			(0.189)	(0.108)
$m_{BIG} \times \mathbb{1}^{\mu_h}$ (γ_4)			−2.194***	−1.286***
			(0.648)	(0.423)
$m_{SMALL} \times \mathbb{1}^{\mu_h}$ (γ_5)			−1.032	−0.369
			(0.753)	(0.315)
ΔFamily	−0.283***	−0.378***	−0.285***	−0.377***
	(0.104)	(0.069)	(0.103)	(0.069)
ΔMarried	3.559***	−0.162	3.559***	−0.160
	(0.722)	(0.229)	(0.723)	(0.228)
ΔEmployment	0.614**	−0.667***	0.614**	−0.665***
	(0.282)	(0.098)	(0.283)	(0.099)
Age	X	X	X	X
State	X	X	X	X
Year	X	X	X	X
Num. Obs.	17280	105813	17280	105813

Table 10: **Test of Hypothesis 2 - Housing indicator**. Probit for the increase of housing holdings and the Heckman selectivity model. Column (1) reports the marginal effect estimates from the probit regressions for increasing the amount of housing holdings. Column (2) reports estimates on the log of the housing adjustment $\ln(\overline{z} - z^{*})$ for increasing housing holdings. $\mathbb{1}^{\mu_h}$ is an indicator that captures periods of high expected growth in house prices at the U.S. state level. All the regressions include a constant and age, state and year fixed effects. Standard errors are reported in parentheses. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level. Data source: SIPP (1997 – 2005).

	Probability of housing increase	Size of housing increase
	(1)	(2)
$\tilde{z}$	0.0003***	
	(0.0000)	
$\mathbb{1}^{\mu_h}$	0.0048***	-0.6647***
	(0.0015)	(0.1331)
Δ Family	0.0037***	-0.3817***
	(0.0006)	(0.1279)
Δ Married	0.0040	-0.1392
	(0.0042)	(0.2749)
Δ Employment	0.0033**	-0.2297*
	(0.0014)	(0.1146)
Age	X	X
State	X	X
Year	X	X
Num. Obs.	105758	1361

Table 11: **Test of Hypothesis 3.1 - Housing indicator**. Non-Housing Portfolio holdings. Cross Section Two Step Tobit IV Estimates. The dependent variable is dollars in stocks in Column (1); it is dollars in stocks divided by liquid wealth in Column (2); and it is dollars in stocks divided by financial wealth in Column (3). Specification in Column (4) restricts the sample to individuals with financial wealth above $\$100,000$ and the dependent variable is dollars in stocks divided by financial wealth. Instruments for property value and home equity are the current-year and year of purchase FHFA state price indices. Instruments for the interaction effects using the interactions of the two FHFA state price indices and our indicator $\mathbb{1}_{kt}^{\mu_h}$. All the specifications include state, current year, purchase year, and age fixed effects. They also include a 10-piece linear spline for liquid wealth and the following other controls: income, education and number of children. Standard errors in parenthesis. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level. Data source: SIPP (1997 – 2005).

	Stocks	Stocks share on Liquid Wealth	Stocks share on Financial Wealth	Stocks share on Fin. Wealth (>$100K)
	(1)	(2)	(3)	(4)
House value	-40833**	-28.029**	-5.236	-6.622
	(18437)	(12.111)	(4.806)	(5.589)
Home equity wealth	44118**	26.938**	-2.737	0.611
	(18975)	(12.469)	(5.148)	(5.990)
House value × $\mathbb{1}_{jt}^{\mu_h}$	10715	7.771	0.579	1.340
	(8815)	(5.794)	(2.245)	(2.338)
Home equity × $\mathbb{1}_{jt}^{\mu_h}$	-18745**	-11.739**	-1.913	-4.657*
	(7945)	(5.233)	(2.148)	(2.572)
$\mathbb{1}_{jt}^{\mu_h}$	3455	-0.051	1.036	5.280
	(14807)	(9.733)	(3.826)	(5.334)
Age	X	X	X	X
State	X	X	X	X
Year current	X	X	X	X
Year purchase	X	X	X	X
Other controls	X	X	X	X
Num. Obs.	35624	35624	35624	22754

Table 12: **Test of Hypothesis 3.2 - Housing indicator**. Non-Housing Portfolio Changes around Home Purchases. OLS Estimates. The dependent variable is the change in dollars in stocks in Column (1); it is the change in the stock share of liquid wealth in Column (2); and it is the change in the stock share of financial wealth in Column (3). Instrument for change in the property value is the FHFA state price index in the year of the purchase. All the specifications include state, current year, and age fixed effects. They also include change in financial wealth, change in income, change in number of children, change in marital status, as well as change in unemployment status from the year before to the year after the home purchase. Standard errors, reported in parenthesis, are clustered at state level. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level. Data source: SIPP (1997 – 2005).

	ΔStocks	ΔStocks on Liquid Wealth	ΔStocks on Financial Wealth
	(1)	(2)	(3)
$\mathbb{1}_{jt}^{\mu_h}$	-8548	-0.016	-0.014
	(5413)	(0.011)	(0.013)
ΔProperty value	33601	-0.272	0.001
	(24771)	(0.172)	(0.058)
ΔWealth	19506**	0.110*	0.007
	(8225)	(0.064)	(0.021)
Age	X	X	X
State	X	X	X
Year current	X	X	X
Other controls	X	X	X
Num. Obs.	5961	5961	5961

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