House Prices, Expectations, and Time-Varying Fundamentals

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January 31, 2012

Abstract

We investigate the behavior of the equilibrium price-rent ratio for housing in a simple Lucas-type asset pricing model with external habit formation preferences that give rise to time-varying risk aversion. We also allow for time-varying persistence and volatility in the stochastic process for rent growth, consistent with U.S. data on rent growth for the period 1960 to 2011. Under fully-rational expectations, the model significantly underpredicts the volatility of the U.S. price-rent ratio for reasonable levels of risk aversion. We demonstrate that the model can approximately match the volatility of the U.S. price-rent ratio if agents continually update their estimates for the mean, persistence and volatility of fundamental rent growth using only recent data (i.e., over the most recent 5 years), or if agents employ a simple adaptive forecast rule that places a large weight on current data relative to past data. These two versions of the model can be distinguished by their predictions for the correlation between expected future returns on housing and the price-rent ratio. The adaptive forecast model predicts a positive correlation such that agents expect higher future returns when house prices are high relative to fundamentals—a feature that appears consistent with survey evidence on the expectations of real-world housing investors.

Keywords: Asset Pricing, Excess Volatility, Credit Cycles, Bubbles.

JEL Classification: E32, E44, G12, O40.

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Basic question: What drives the volatility of asset prices?

- Asset prices appear to exhibit “excess volatility” when compared to the discounted stream of ex post realized dividends or cash flows. (starting w/ Shiller, 1981 and LeRoy and Porter, 1981)

- Fundamental explanations of volatility require agents’ discount rates to be extremely volatile (e.g., habit formation). Ok, but then agents should expect low future returns after a sustained price run-up, i.e., when price-dividend ratios are high.

- Survey evidence reveals the opposite: Investors appear to expect high future returns after a sustained price run-up.

- This Paper: A standard asset pricing model with adaptive expectations can match various housing market volatility statistics and predicts a positive correlation between the price-rent ratio and expected future returns.
Periods of stagnant real prices interspersed with booms and busts.
Periods of stagnant real prices interspersed with booms and busts.
Related literature (partial list)

- Deviations from full-info/RE in house price models
  - Adam, Kuang and Marcet (2011)
  - Boz and Mendoza (2010)
  - Granziera and Kozicki (2011)

- Deviations from full-info/RE in stock price models
  - Chow (1989)
  - Barsky and Delong (1993),
  - Timmerman (1996),
  - Lansing (2006, 2010),
  - Branch and Evans (2010)
  - Adam and Marcet (2010).
Bubbles versus rationally low risk premia
Are the two situations observationally equivalent?

John Cochrane (2009): “... Crying bubble is empty unless you have an operational procedure for distinguishing them from rationally low risk premiums...”

\[ p_t = d_t + E_t \left( \frac{1}{1+r} \right) p_{t+1}, \quad r = \frac{r^f + \text{risk premium}}{1} \]

Discount rate = Expected Return

\[
= d_t + E_t \left[ \frac{d_{t+1}}{1+r} + \frac{d_{t+2}}{(1+r)^2} + \frac{d_{t+3}}{(1+r)^3} + \ldots , \quad d_{t+1}/d_t = 1 + g \right]
\]

\[ \frac{p_t}{d_t} = \frac{1}{r - g}, \quad \text{provided } r > g. \]

A high p-d ratio can be justified by fundamentals if expected return \((r)\) is low because risk premium is low.

Problem with this story: Survey evidence reveals that expected returns are high when p-d ratios (or price-rent ratios) are high.
Rational explanations of U.S. house price boom
Was the boom really accompanied by a decline in expected returns?

Favilukis, Ludvigson, and Van Nieuwerburgh (2011)

“...There was a widespread relaxation of underwriting standards in the U.S. mortgage market during the period leading up to the credit crisis of 2007...By the end of 2006, households routinely bought homes with 100% financing using a piggyback second mortgage or home equity loan...Loans for 125% of the home value were even available…”

“...A financial market liberalization drives price-rent ratios up because it drives risk premia down…”

“...Procyclical increases in equilibrium price-rent ratios reflect rational expectations of lower future returns…”
Did housing investors expect low future returns in 2005?
Rational model predicts low expected returns at market peaks.
“..These data suggest that levels of bubble expectations for institutional investors may be driven by lagged price changes over this time interval.”

FIGURE 4
Percentage Change in Dow Jones Industrial Average Over Six Months (Up to Date of Survey) and the Bubble Expectations Index
“..The average expected one-year stock-market return increased from an average of 11.8 pct in 1998 to 15.8 pct in January 2000, and then declined dramatically to around 6 pct at the end of 2002. Thus, expected returns were high when the market was at its highest...”
Norway: High expected returns after a sustained run-up
Source: Norway FSA Risk Outlook 2011

70 percent of respondents expect house prices to keep rising.
U.S. housing market data: 1960.q1 to 2011.q1
Source: Davis, Lehnert, and Martin (2008), www.lincolninstit.edu

U.S. Real House Prices and Rents
Indexed to 1 in 1960.Q1

U.S. Quarterly Price–Rent Ratio

U.S. Quarterly Real Housing Return

U.S. Quarterly Real Price Growth
U.S. real rent growth: 1960.q2 to 2011.q1
Rent growth exhibits time-varying persistence and volatility.
Lucas-type asset pricing model
Allow for time-varying risk aversion and time-varying stochastic properties of rent growth.

\[
\max_{c_t, h_t} E_0 \sum_{t=0}^{\infty} \beta^t \left( c_t^\theta h_t^{1-\theta} - \kappa C_{t-1}^\theta H_{t-1}^{1-\theta} \right)^{1-\alpha} - 1,
\]

\[
c_t + p_t h_t = y_t + p_t h_{t-1}, \quad (h_t = 1 \text{ and } c_t = y_t \text{ in equilibrium})
\]

FOC: \( p_t = \left( \frac{1-\theta}{\theta} \right) c_t + E_t \beta \frac{\partial U/\partial c_{t+1}}{\partial U/\partial c_t} p_{t+1}, \) Imputed rent

SDF

\[
\bar{x}_{t+1} \equiv \log \frac{y_{t+1}}{y_t} = \bar{x} + (\rho + \psi \varepsilon_t) (x_t - \bar{x}) + \varepsilon_{t+1},
\]

CRRA = \[-\frac{c_t U_{cc}}{U_c} = \frac{\alpha \theta}{1 - \kappa \exp(-\theta x_t)} + 1 - \theta\]
Rational Expectations Solution
Solve transformed FOC given knowledge of stochastic process for rent growth.

Define: \( z_{t+1} = \frac{\exp[\theta (1 - \alpha) x_{t+1}] p_{t+1}/y_{t+1}}{[1 - \kappa \exp(-\theta x_{t+1})]^\alpha} \)

FOC: \( z_t = \beta \exp[\theta (1 - \alpha) x_t] E_t z_{t+1} + \frac{1 - \theta}{\theta} \exp[\theta (1 - \alpha) x_t] [1 - \kappa \exp(-\theta x_t)]^\alpha \)
\( g(x_t) \)

RE \( \Rightarrow \) \( z_t \sim a_0 \exp \{ a_1 [x_t - E (x_t)] + a_2 [v_t - \sigma^2_{\varepsilon}] \} \)

where \( E (x_t) = \bar{x} + \frac{\psi \sigma^2_{\varepsilon}}{1 - \rho}, \) \( v_t \equiv \varepsilon_t (x_t - \bar{x}) \),

Given \( z_t \) \( \Rightarrow \) \( \text{Price/Rent} = \frac{z_t [1 - \kappa \exp(-\theta x_t)]^\alpha}{\exp[\theta (1 - \alpha) x_t]} \)
Boundedly-Rational Expectations
Agent updates parameters of perceived AR1 rent growth process each period.

Perceived rent growth: \[ x_{t+1} = \bar{x}_t + \gamma_t (x_t - \bar{x}_t) + \eta_{t+1} \]
\[ \bar{x}_t = \text{Mean}(x_j), \quad j \in [T_w - 1, t), \]
\[ \gamma_t = \text{Corr}(x_j, x_{j-1}), \]
\[ \sigma^2_{\eta, t} = \text{Var}(x_j) (1 - \gamma^2_t) \]

Perceived RE solution \[ z_t \sim b_{0,t} \exp[b_{1,t} (x_t - \bar{x}_t)] \]

Forecast \[ \hat{E}_t z_{t+1} = b_{0,t} \exp\left[b_{1,t} \gamma_t (x_t - \bar{x}_t) + \frac{1}{2} (b_{1,t})^2 \sigma^2_{\eta, t}\right] \]

Law of motion \[ z_t = \beta \exp[\theta (1 - \alpha) x_t] \hat{E}_t z_{t+1} + g(x_t) \]

where \( b_{0,t} \) and \( b_{1,t} \) depend on \( \bar{x}_t \), \( \gamma_t \), and \( \sigma^2_{\eta, t} \)
Adaptive Expectations
Ease of computation: Agent does not need to know stochastic process for rent growth.

Forecast is a moving average past values:

\[ \hat{E}_t z_{t+1} = \lambda z_t + (1 - \lambda) \hat{E}_{t-1} z_t, \quad \lambda \in [0, 1], \]
\[ = \hat{E}_{t-1} z_t + \lambda \left[ z_t - \hat{E}_{t-1} z_t \right], \]
\[ = \lambda \left[ z_t + (1 - \lambda) z_{t-1} + (1 - \lambda)^2 z_{t-2} \ldots \right] \]

Resulting law of motion:

\[ z_t = \frac{\beta (1 - \lambda) \exp[\theta (1 - \alpha) x_t]}{1 - \beta \lambda \exp[\theta (1 - \alpha) x_t]} \hat{E}_{t-1} z_t + \frac{g(x_t)}{1 - \beta \lambda \exp[\theta (1 - \alpha) x_t]} \]

Return forecast is also a moving average of past values:

\[ \hat{E}_t \log (R_{t+1 \rightarrow t+4}) = \lambda \log (R_{t-4 \rightarrow t}) + (1 - \lambda) \hat{E}_{t-1} \log (R_{t-4 \rightarrow t}) \]

4-qtr compound return
### Baseline parameter values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\alpha)</td>
<td>Utility curvature parameter</td>
<td>2</td>
</tr>
<tr>
<td>(\kappa)</td>
<td>Utility habit parameter</td>
<td>0.8</td>
</tr>
<tr>
<td>(\theta)</td>
<td>Match mean U.S. price/rent (\sim 82)</td>
<td>0.87</td>
</tr>
<tr>
<td>(\beta)</td>
<td>Match mean U.S. price/income (\sim 12)</td>
<td>0.99</td>
</tr>
<tr>
<td>(\bar{x})</td>
<td>Match mean U.S. rent growth</td>
<td>0.0244%</td>
</tr>
<tr>
<td>(\rho)</td>
<td>Match Corr. Lag 1 U.S. rent growth</td>
<td>0.33</td>
</tr>
<tr>
<td>(\sigma_\varepsilon)</td>
<td>Match Std. Dev. U.S. rent growth</td>
<td>0.423%</td>
</tr>
<tr>
<td>(\psi)</td>
<td>Match Skewness U.S. rent growth</td>
<td>92.1</td>
</tr>
<tr>
<td>(T_w)</td>
<td>Match Std. Dev. U.S. price/rent (\sim 13)</td>
<td>20 qtrs.</td>
</tr>
<tr>
<td>(\lambda)</td>
<td>Match Std. Dev. U.S. price/rent (\sim 13)</td>
<td>0.94</td>
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<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
<th>Value</th>
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<tbody>
<tr>
<td>Mean (x_t)</td>
<td>0.27%</td>
<td>0.27%</td>
</tr>
<tr>
<td>SD (x_t)</td>
<td>0.57%</td>
<td>0.57%</td>
</tr>
<tr>
<td>Corr (x_t, x_{t-1})</td>
<td>0.45</td>
<td>0.45</td>
</tr>
<tr>
<td>Skew (x_t)</td>
<td>0.91</td>
<td>0.92</td>
</tr>
<tr>
<td>Kurt (x_t)</td>
<td>6.6</td>
<td>5.9</td>
</tr>
</tbody>
</table>
Simulated model rent growth
Boundedly-rational agent’s perception of shifting AR1 parameters appears justified.
Simulated price-rent ratios
Non-RE forecast errors exhibit low autocorrelation.
Time-varying risk aversion and expected 4-qtr returns. Under RE, expected return is low when price-rent ratio is high.
### Unconditional Moments

U.S. data 1960.q1 to 2011.q2 versus model simulations.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>U.S. Data</th>
<th>RE</th>
<th>B-RE</th>
<th>AE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>81.8</td>
<td>81.8</td>
<td>83.3</td>
<td>84.6</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>13.2</td>
<td>2.92</td>
<td>11.1</td>
<td>12.6</td>
</tr>
<tr>
<td>$p_t / d_t$ Corr. Lag 1</td>
<td>0.99</td>
<td>0.41</td>
<td>0.96</td>
<td>0.95</td>
</tr>
<tr>
<td>Skew.</td>
<td>1.99</td>
<td>0.72</td>
<td>0.08</td>
<td>−0.21</td>
</tr>
<tr>
<td>Kurt.</td>
<td>6.90</td>
<td>6.35</td>
<td>3.15</td>
<td>3.17</td>
</tr>
<tr>
<td>Mean</td>
<td>1.58%</td>
<td>1.60%</td>
<td>1.58%</td>
<td>1.61%</td>
</tr>
<tr>
<td>Std. Dev</td>
<td>1.76%</td>
<td>4.35%</td>
<td>3.89%</td>
<td>4.75%</td>
</tr>
<tr>
<td>$R_t - 1$ Corr. Lag 1</td>
<td>0.71</td>
<td>−0.26</td>
<td>0.09</td>
<td>0.61</td>
</tr>
<tr>
<td>Skew.</td>
<td>−1.79</td>
<td>0.36</td>
<td>0.42</td>
<td>−0.18</td>
</tr>
<tr>
<td>Kurt.</td>
<td>8.35</td>
<td>5.59</td>
<td>4.11</td>
<td>3.84</td>
</tr>
</tbody>
</table>

Note: Model results computed from 15,000 period simulation.
Sensitivity of results to parameter values.
RE model requires implausibly high risk aversion to match volatility of U.S. price rent ratio.
Forecasting regressions

Campbell-Shiller return identity

\[ R_{t+1} = \frac{p_{t+1}}{p_t - \left( \frac{1-\theta}{\theta} \right) c_t} = \frac{p_{r,t+1}}{p_{r,t} - 1} \exp(x_{t+1}) \]

\[ \log p_{r,t} \approx \text{const.} + \delta_1 \log p_{r,t+1} + \delta_1 x_{t+1} - \delta_1 \log (R_{t+1}) \]

\[ \approx \text{const.} + \sum_{j=1}^{\infty} (\delta_1)^j [x_{t+j} - \log (R_{t+j})] \]

\[ \text{Var} \left( \log p_{r,t} \right) = \text{Cov} \left[ \log (p_{r,t}), \sum_{j=1}^{\infty} (\delta_1)^j x_{t+j} \right] \]

\[ - \text{Cov} \left[ \log (p_{r,t}), \sum_{j=1}^{\infty} (\delta_1)^j \log (R_{t+j}) \right] \]

\[ \Rightarrow \text{Price-rent ratio must predict either future rent-growth or future returns. This motivates the form of forecasting regressions.} \]
Forecasting regressions: Data vs Model

Regression equations

Compound return \( t+1 \rightarrow t+4 = \text{const.} + \hat{b} \log \left( \frac{\text{Price}_t}{\text{Rent}_t} \right) + u_{t+1} \)

Compound rent growth \( t+1 \rightarrow t+4 = \text{const.} + \hat{b} \log \left( \frac{\text{Price}_t}{\text{Rent}_t} \right) + \omega_{t+1} \)

<table>
<thead>
<tr>
<th>Regression</th>
<th>U.S. Data</th>
<th>RE</th>
<th>B-RE</th>
<th>AE</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \log (R_{t+1 \rightarrow t+4}) )</td>
<td>( \hat{b} )</td>
<td>( \hat{b} )</td>
<td>( \hat{b} )</td>
<td>( \hat{b} )</td>
</tr>
<tr>
<td>( \log (R_{t+1 \rightarrow t+4}) )</td>
<td>(-0.181)</td>
<td>(-0.926)</td>
<td>(-0.249)</td>
<td>(-0.465)</td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.011)</td>
<td>(0.004)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>( x_{t+1 \rightarrow t+4} )</td>
<td>(-0.026)</td>
<td>0.090</td>
<td>0.000</td>
<td>(-0.008)</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.004)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
</tbody>
</table>

Standard errors in parenthesis. Model regressions from a 15,000 period simulation.
Typical collateral constraint: \( b_{t+1} \leq m h_t E_t p_{t+1}, \quad m \equiv \max \text{LTV}. \)
Like stock prices, real-world house prices exhibit periods of stagnation interspersed with boom-bust cycles.

A standard rational-expectations model significantly underpredicts the volatility of the U.S. price-rent ratio even when allowing for time-varying risk aversion and time-varying stochastic properties of rent growth.

The model can approximately match the volatility of the U.S. price-rent ratio if boundedly-rational agents continually update their estimates of the properties of fundamental rent growth or if agents employ a simple form of adaptive expectations.

Under adaptive expectations, agents expect higher future returns when house prices are high relative to fundamentals—a feature that appears consistent with survey evidence on the expectations of real-world housing investors.