Money Illusion and Housing Frenzies

Markus K. Brunnermeier* and Christian Julliard◊

*Department of Economics
Princeton University

◊Department of Economics
London School of Economics

Harvard University, December, 5th, 2005
Introduction

Housing prices have reached unprecedented heights in recent years. The sharp run-up in housing prices has been so striking that academics and non-academics alike have begun referring to it as housing bubble. Figure 1 illustrates different real house price indexes and shows that this phenomenon has been observed in several OECD countries.

What explains these sharp movements?

Focus: Role of inflation

Brunnermeier and Julliard (2005)
Decision: Monthly rent versus monthly mortgage payments

⇒ Example of money/inflation illusion
  decline in inflation ⇒ decline in nominal interest rate $i$
  ⇒ monthly payments decline
  ⇒ larger mortgage ⇒ higher house prices

BUT

⇒ future mortgage payments are larger in real terms
  (mortgage is not inflated away.)
Decision: Monthly rent versus monthly mortgage payments

⇒ Example of money/inflation illusion

- decline in inflation ⇒ decline in nominal interest rate $i$
- ⇒ monthly payments decline
- ⇒ larger mortgage ⇒ higher house prices

BUT

⇒ future mortgage payments are
⇒ larger in real terms
⇒ (mortgage is not inflated away.)
Decision: Monthly rent versus monthly mortgage payments

⇒ Example of money/inflation illusion
  
  decline in inflation ⇒ decline in nominal interest rate $i$
  ⇒ monthly payments decline
  ⇒ larger mortgage ⇒ higher house prices

BUT

⇒ future mortgage payments are larger in real terms
  (mortgage is not inflated away.)
Decision: Monthly rent *versus* monthly mortgage payments

⇒ *Example* of money/inflation illusion

- decline in inflation
  ⇒ decline in nominal interest rate $i$
  ⇒ monthly payments decline
  ⇒ larger mortgage ⇒ higher house prices

BUT

⇒ future mortgage payments are larger in real terms
  (mortgage is not inflated away.)
Decomposing price movements

Stage 1: Focus on price-rent ratio \( (P_t/L_t) \)
- abstracts from movements of fundamentals that affect prices and rents symmetrically (demographics, land cost etc.)
- not perfect substitutes: pride of ownership, ...

Stage 2: Decompose price-rent ratio in
- expected return (incl. risk premium)
- expected rent growth rate
- “mispricing”

Inflation effect on each part
Decomposing price movements

Stage 1: Focus on price-rent ratio ($P_t/L_t$)
- abstracts from movements of fundamentals that affect prices and rents symmetrically (demographics, land cost etc.)
- not perfect substitutes: pride of ownership, ...

Stage 2: Decompose price-rent ratio in
- expected return (incl. risk premium)
- expected rent growth rate
- “mispricing”

Inflation effect on each part

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
Outline

1 Money illusion - Related literature

2 U.K. evidence
   - Real versus nominal - A first-cut
   - Decomposing inflation effects
   - Financial frictions

3 Cross-country evidence
   - U.S. evidence

4 Conclusion
Outline

1 Money illusion - Related literature

2 U.K. evidence
   - Real versus nominal - A first-cut
   - Decomposing inflation effects
   - Financial frictions

3 Cross-country evidence
   - U.S. evidence

4 Conclusion

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
Outline

1. Money illusion - Related literature

2. U.K. evidence
   - Real versus nominal - A first-cut
   - Decomposing inflation effects
   - Financial frictions

3. Cross-country evidence
   - U.S. evidence

4. Conclusion
Outline

1. Money illusion - Related literature

2. U.K. evidence
   - Real versus nominal - A first-cut
   - Decomposing inflation effects
   - Financial frictions

3. Cross-country evidence
   - U.S. evidence

4. Conclusion
“An economic theorist can, of course, commit no greater crime than to assume money illusion.” Tobin (1972)

- **Money Illusion:**
  Patinkin (1965), Leontief (1936), Fisher (1928)
  “That shirt I sold you will cost me just as much to replace as I am charging you [...] But I have made a profit on that shirt because I bought it for less.”

- **Recent survey evidence:**
  Shiller (1997a), (1997b)

- **Related Psychological Biases:**
  Shafir, Diamond, Tversky (1997), ...

- **Stock market:**
“An economic theorist can, of course, commit no greater crime than to assume money illusion.” Tobin (1972)

- **Money Illusion:**
  Patinkin (1965), Leontief (1936), Fisher (1928)

  “That shirt I sold you will cost me just as much to replace as I am charging you [...] But I have made a profit on that shirt because I bought it for less.”

- **Recent survey evidence:**
  Shiller (1997a), (1997b)

- **Related Psychological Biases:**
  Shafir, Diamond, Tversky (1997), ...

- **Stock market:**
Money illusion - Related literature

“An economic theorist can, of course, commit no greater crime than to assume money illusion.” Tobin (1972)

- **Money Illusion:**
  Patinkin (1965), Leontief (1936), Fisher (1928)
  “That shirt I sold you will cost me just as much to replace as I am charging you [...] But I have made a profit on that shirt because I bought it for less.”

- **Recent survey evidence:**
  Shiller (1997a), (1997b)

- **Related Psychological Biases:**
  Shafir, Diamond, Tversky (1997), ...

- **Stock market:**
“An economic theorist can, of course, commit no greater crime than to assume money illusion.” Tobin (1972)

- **Money Illusion:**
  Patinkin (1965), Leontief (1936), Fisher (1928)
  
  “That shirt I sold you will cost me just as much to replace as I am charging you […] But I have made a profit on that shirt because I bought it for less.”

- **Recent survey evidence:**
  Shiller (1997a), (1997b)

- **Related Psychological Biases:**
  Shafir, Diamond, Tversky (1997), ...

- **Stock market:**
“An economic theorist can, of course, commit no greater crime than to assume money illusion.” Tobin (1972)

- **Money Illusion:**
  Patinkin (1965), Leontief (1936), Fisher (1928)
  “That shirt I sold you will cost me just as much to replace as I am charging you [...] But I have made a profit on that shirt because I bought it for less.”

- **Recent survey evidence:**
  Shiller (1997a), (1997b)

- **Related Psychological Biases:**
  Shafir, Diamond, Tversky (1997), ...

- **Stock market:**
Money illusion - Related literature

2 U.K. evidence
   - Real versus nominal - A first-cut
   - Decomposing inflation effects
   - Financial frictions

3 Cross-country evidence
   - U.S. evidence

4 Conclusion

Brunnermeier and Julliard (2005) 
Money Illusion and Housing Frenzies
A first cut

PV of permanent service flow  \( = L + \frac{L}{1+r} + \frac{L}{(1+r)^2} + \ldots \)

\[
\frac{P_t}{L_t} = E_t \left[ \sum_{\tau=t+1}^{\infty} \frac{1}{(1 + r_\tau)^{\tau-t-1}} \right] \approx \frac{1}{r}
\]

with money illusion

\[
\frac{P_t}{L_t} = \tilde{E}_t \left[ \sum_{\tau=t+1}^{\infty} \frac{1}{(1 + r_\tau)^{\tau-t-1}} \right] \approx E_t \left[ \sum_{\tau=t+1}^{\infty} \frac{1}{(1 + i_\tau)^{\tau-t-1}} \right] \approx \frac{1}{i}
\]

- Regress \( P_t/L_t \) separately on \( 1/r_t, 1/i_t, \) and \( \pi_t \).
A first cut

PV of permanent service flow  

\[ \frac{P_t}{L_t} = E_t \left[ \sum_{\tau=t+1}^{\infty} \frac{1}{(1 + r_{\tau})^{\tau-t-1}} \right] \approx \frac{1}{r} \]

with money illusion

\[ \frac{P_t}{L_t} = \tilde{E}_t \left[ \sum_{\tau=t+1}^{\infty} \frac{1}{(1 + r_{\tau})^{\tau-t-1}} \right] \approx \frac{1}{i} \]

- Regress \( P_t/L_t \) separately on \( 1/r_t \), \( 1/i_t \), and \( \pi_t \).
Forecasting regressions

- Regress $P_t/L_t$ separately on $1/r_t$, $1/i_t$, and $\pi_t$.
- Persistence of $P_t/L_t$ and regressors might lead to spurious results.
- Regress forecasts error on $1/r$, $1/i$, and $\pi$.

$$\hat{\delta}_{t+1,t+1-s} = \begin{cases} 
  P_{t+1}/L_{t+1} & \text{for } s = 0 \\
  P_{t+1}/L_{t+1} - \hat{E}_{t-s}[P_{t+1}/L_{t+1}] & \text{for } s > 0
\end{cases}$$

where $\hat{E}_{t-s}[P_t/L_t]$ reduced form VAR for $P_t/L_t$, log gross return, $r_{h,t}$, the rent growth rate $\Delta l_t$ and the log real interest rate, $r_t$. 
Forecasting regressions

- Regress $P_t/L_t$ separately on $1/r_t$, $1/i_t$, and $\pi_t$.
- Persistence of $P_t/L_t$ and regressors might lead to spurious results.
- Regress forecasts error on $1/r$, $1/i$, and $\pi$.

\[
\hat{\delta}_{t+1,t+1-s} = \begin{cases} 
P_{t+1}/L_{t+1} & \text{for } s = 0 \\
P_{t+1}/L_{t+1} - \hat{E}_{t-s}[P_{t+1}/L_{t+1}] & \text{for } s > 0
\end{cases}
\]

where $\hat{E}_{t-s}[P_t/L_t]$ reduced form VAR for $P_t/L_t$, log gross return, $r_{h,t}$, the rent growth rate $\Delta l_t$ and the log real interest rate, $r_t$. 

Brunnermeier and Julliard (2005) 
Money Illusion and Housing Frenzies
Forecasting regressions

- Regress $P_t/L_t$ separately on $1/r_t$, $1/i_t$, and $\pi_t$.
- Persistence of $P_t/L_t$ and regressors might lead to spurious results.
- Regress forecasts error on $1/r$, $1/i$, and $\pi$.

$$\delta_{t+1,t+1-s} = \begin{cases} P_{t+1}/L_{t+1} & \text{for } s = 0 \\ P_{t+1}/L_{t+1} - \hat{E}_{t-s}[P_{t+1}/L_{t+1}] & \text{for } s > 0 \end{cases}$$

where $\hat{E}_{t-s}[P_t/L_t]$ reduced form VAR for $P_t/L_t$, log gross return, $r_{h,t}$, the rent growth rate $\Delta l_t$ and the log real interest rate, $r_t$. 

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
Figure 3: \( t \)-statistics and \( R^2 \) of univariate regressions of the forecast error \( \hat{\delta}_{t+1, t+1−τ} \) on interest rates and interest rate reciprocals (both nominal and real) as well as inflation.

\( \text{Panel A: } t \)-statistics

\( \text{Panel B: } R^2 \)}
Price-rent ratio and TIPS implied real interest rates

(standardized series)

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
1 Money illusion - Related literature

2 U.K. evidence
   - Real versus nominal - A first-cut
   - Decomposing inflation effects
   - Financial frictions

3 Cross-country evidence
   - U.S. evidence

4 Conclusion

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
Decomposing inflation effects

\[ R_{h,t+1} = \frac{P_{t+1} + L_{t+1}}{P_t} \]

- Log-linearize around steady state and iterate

\[
R_t = \lim_{T \to \infty} \left[ \sum_{\tau=1}^{T-1} \rho^{T-\tau} \left( \Delta l_{t+\tau} - r_{h,t+\tau} \right) + \rho^T \left( p_{t+T} - l_{t+T} \right) \right].
\]

- Note if \( p_t \) is distorted, then so are all realized \( r_{h,t+\tau} \)
- Subtract \( r^f \) to obtain excess \( \Delta l^e \) and excess returns \( r^e \)
- Take expectations: \( E \) (objective), \( \tilde{E} \) (subjective)
Construction of $\psi$-Mispricing

- Taking expectations and assuming that TVCs hold

$$p_t - l_t = \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t \left[ \Delta l_{t+\tau}^e \right] - \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t \left[ r_{h,t+\tau}^e \right]$$

rational traders

$$= \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}_t \left[ \Delta l_{t+\tau}^e \right] - \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}_t \left[ r_{h,t+\tau}^e \right]$$

irrational traders

- Hence,

$$p_t - l_t = \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t \left[ \Delta l_{t+\tau}^e \right] - \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}_t \left[ r_{h,t+\tau}^e \right] +$$

$$+ \left( \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}_t \left[ \Delta l_{t+\tau}^e \right] - \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t \left[ \Delta l_{t+\tau}^e \right] \right)$$

$\psi_t$-Mispricing measure

$$\psi_t := \sum_{\tau=1}^{\infty} \rho^{\tau-1} \left( \tilde{E}_t - E_t \right) \left[ \Delta l_{t+\tau}^e \right]$$
Construction of $\psi$-Mispricing

- Taking expectations and assuming that TVCs hold

\[
p_t - l_t = \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [\Delta l^e_{t+\tau}] - \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [r^e_{h,t+\tau}] + \left( \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}_t [\Delta l^e_{t+\tau}] - \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [\Delta l^e_{t+\tau}] \right)
\]

- Hence,

\[
p_t - l_t = \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [\Delta l^e_{t+\tau}] - \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}_t [r^e_{h,t+\tau}] + \left( \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}_t [\Delta l^e_{t+\tau}] - \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [\Delta l^e_{t+\tau}] \right)
\]

$\psi^*_t$-Mispricing measure

\[
\psi_t := \sum_{\tau=1}^{\infty} \rho^{\tau-1} \left( \tilde{E}_t - E_t \right) [\Delta l^e_{t+\tau}]
\]
Construction of $\psi$-Mispricing

- Taking expectations and assuming that TVCs hold

$$p_t - l_t = \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t \left[ \Delta l_{t+\tau}^e \right] - \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t \left[ r_{h,t+\tau}^e \right]$$

$$= \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}_t \left[ \Delta l_{t+\tau}^e \right] - \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}_t \left[ r_{h,t+\tau}^e \right]$$

- Hence,

$$p_t - l_t = \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t \left[ \Delta l_{t+\tau}^e \right] - \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}_t \left[ r_{h,t+\tau}^e \right] +$$

$$+ \left( \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}_t \left[ \Delta l_{t+\tau}^e \right] - \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t \left[ \Delta l_{t+\tau}^e \right] \right)$$

$\psi_t$-Mispricing measure

$$\psi_t := \sum_{\tau=1}^{\infty} \rho^{\tau-1} \left( \tilde{E}_t - E_t \right) \left[ \Delta l_{t+\tau}^e \right]$$
Example Money Illusion: \( \tilde{E}_t [\Delta l_{t+\tau}] = E_t [\Delta l_{t+\tau} - (\pi_{t+\tau} - \bar{\pi})] \)

\[
\psi_t = -\sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [\pi_{t+\tau} - \bar{\pi}]
\]

- Problem: How to construct a proxy for \( \tilde{E}_t [r^e_{h,t+\tau}] \)
  - \( \Rightarrow \) use linear subjective risk factor \( \lambda_t \)
  - GARCH-estimate of cond. volatility of long housing short \( r^f \)
  - Model \( \tilde{E}_t [r^e_{h,t+\tau}] \) as (and run OLS):

\[
\sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [r^e_{h,t+\tau}] = \alpha + \beta \lambda_t + \xi_t + \psi_t
\]

- Empirical strategy:
  1. Obtain \( \hat{E} [\Delta l^e_{t+\tau}] \) from VAR and \( \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [r^e_{h,t+\tau}] \)
  2. Add controls to remove \( \xi_t \) [from OLS-residual \( (\xi_t + \psi_t) \)]
Example  Money Illusion: \( \tilde{E}_t [\Delta l_{t+\tau}] = E_t [\Delta l_{t+\tau} - (\pi_{t+\tau} - \bar{\pi})] \)

\[ \psi_t = - \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [\pi_{t+\tau} - \bar{\pi}] \]

- Problem: How to construct a proxy for \( \tilde{E}_t [r_{h,t+\tau}] \)
  - ⇒ use linear subjective risk factor \( \lambda_t \)
  - GARCH-estimate of cond. volatility of long housing short \( r^f \)
  - Model \( \tilde{E}_t [r_{h,t+\tau}] \) as (and run OLS):

\[ \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [r_{h,t+\tau}] = \alpha + \beta \lambda_t + \xi_t + \psi_t \]

\[ = \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}_t [r_{h,t+\tau}] \]

- Empirical strategy:
  1. Obtain \( \hat{E} [\Delta l_{t+\tau}] \) from VAR and \( \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [r_{h,t+\tau}] \)
  2. Add controls to remove \( \xi_t \) [from OLS-residual (\( \xi_t + \psi_t \))]

Brunnermeier and Julliard (2005)  Money Illusion and Housing Frenzies
Example   Money Illusion:  \[ \tilde{E}_t [\Delta l_{t+\tau}] = E_t [\Delta l_{t+\tau} - (\pi_{t+\tau} - \bar{\pi})] \]

\[ \psi_t = - \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [\pi_{t+\tau} - \bar{\pi}] \]

Problem: How to construct a proxy for \( \tilde{E}_t \left[ r^e_{h,t+\tau} \right] \)

⇒ use linear subjective risk factor \( \lambda_t \)

GARCH-estimate of cond. volatility of long housing short \( r^f \)

Model \( \tilde{E}_t \left[ r^e_{h,t+\tau} \right] \) as (and run OLS):

\[ \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t \left[ r^e_{h,t+\tau} \right] = \alpha + \beta \lambda_t + \xi_t + \psi_t \]

Empirical strategy:

1. Obtain \( \hat{E} \left[ \Delta l^e_{t+\tau} \right] \) from VAR and \( \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t \left[ r^e_{h,t+\tau} \right] \)

2. Add controls to remove \( \xi_t \) [from OLS-residual \( (\xi_t + \psi_t) \)]
Construction of $\psi$-Mispricing

**Example** Money Illusion: $\tilde{E}_t [\Delta l_{t+\tau}] = E_t [\Delta l_{t+\tau} - (\pi_{t+\tau} - \bar{\pi})]$  

$$\psi_t = - \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [\pi_{t+\tau} - \bar{\pi}]$$

- **Problem:** How to construct a proxy for $\tilde{E}_t \left[ r^e_{h,t+\tau} \right]$
  - ⇒ use linear subjective risk factor $\lambda_t$
    GARCH-estimate of cond. volatility of long housing short $r^f$
  - Model $\tilde{E}_t \left[ r^e_{h,t+\tau} \right]$ as (and run OLS):
    $$\sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t \left[ r^e_{h,t+\tau} \right] = \alpha + \beta \lambda_t + \xi_t + \psi_t =: \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}_t \left[ r^e_{h,t+\tau} \right]$$

- **Empirical strategy:**
  1. Obtain $\hat{E} \left[ \Delta l^e_{t+\tau} \right]$ from VAR and $\sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t \left[ r^e_{h,t+\tau} \right]$
  2. Add controls to remove $\xi_t$ [from OLS-residual ($\xi_t + \psi_t$)]
Construction of $\psi$-Mispricing

Example  Money Illusion:  
\[ \tilde{E}_t [\Delta l_{t+\tau}] = E_t [\Delta l_{t+\tau} - (\pi_{t+\tau} - \bar{\pi})] \]

\[ \psi_t = - \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [\pi_{t+\tau} - \bar{\pi}] \]

- Problem: How to construct a proxy for $\tilde{E}_t [r_{h,t+\tau}]$
  - \( \Rightarrow \) use linear subjective risk factor \( \lambda_t \)
  - GARCH-estimate of cond. volatility of long housing short \( r^f \)
  - Model $\tilde{E}_t [r_{h,t+\tau}]$ as (and run OLS):

\[ \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [r_{h,t+\tau}] = \alpha + \beta \lambda_t + \xi_t + \psi_t \]

\[ =: \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}_t [r_{h,t+\tau}] \]

- Empirical strategy:
  1. Obtain $\hat{E} [\Delta l_{t+\tau}]$ from VAR and $\sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t [r_{h,t+\tau}]$
  2. Add controls to remove $\xi_t$ [from OLS-residual ($\xi_t + \psi_t$)]

Brunnermeier and Julliard (2005)  
Money Illusion and Housing Frenzies
The different measures of mispricing

- $\psi$-mispricing measure depends on added controls for $\xi$.
  1. $\psi$ with controls (quarterly dummies, VAR(1)-forecast)
  2. $\psi'$ without controls

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
$\varepsilon_t$-Mispricing measure (very conservative)

$$
\varepsilon_t := \sum_{\tau=1}^{\infty} \rho^{\tau-1} \left( \tilde{E}_t - E_t \right) \left[ \Delta l^e_{t+\tau} - r_{h,t+\tau}^e \right] \\
+ \tilde{E}_t \left[ \lim_{T \to \infty} \rho^T \left( p_{t+T} - l_{t+T} \right) \right]
$$

$$
p_t - l_t = \sum_{\tau=1}^{\infty} \rho^{\tau-1} E_t \left[ \Delta l^e_{t+\tau} - r_{h,t+\tau}^e \right] + E_t \left[ \lim_{T \to \infty} \rho^T \left( p_{t+T} - l_{t+T} \right) \right] =: \varepsilon_t
$$

- violation of the TVC under the objective measure

Brunnermeier and Julliard (2005) | Money Illusion and Housing Frenzies
Money illusion
U.K. evidence
Decomposing inflation effects
Financial frictions

\(\varepsilon\)-Mispricing

- \(\varepsilon\)-Mispricing measure
  - non-neglectable
  - martingale property cannot be rejected
  - analysis holds in first differences

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure4}
\caption{Price-rent ratio and mispricing measures}
\end{figure}

Next, we analyze the explanatory power of the inflation illusion proxies for the \(\varepsilon\)-mispricing. Panel B of Table 1 shows that \(\varepsilon\), as inflation illusion would imply, covaries negatively (and significantly) with inflation. Similarly, the univariate regressions with nominal interest rate \(i_t\) and \(\log(1/i_t)\) also deliver significant results consistent with money illusion. Overall, the explanatory power of the inflation illusion proxies is reduced for the \(\varepsilon\)-mispricing. This is not surprising, since \(\varepsilon\) seems to overstate the time-variation of the mispricing.

3.2.3 Robustness Analysis

Assessing Uncertainty. To assess the robustness of these results, we next consider the uncertainty due to the fact that we do not directly observe expected future returns on housing and rent growth rates, but instead we use the estimated VAR to construct their proxies. Under a diffuse prior, the posterior distribution of the estimated VAR can be factorized as the product of an inverse Wishart and, conditional on the covariance matrix, conditional on the covariance matrix, conditional on the covariance matrix.

\cite{BrunnermeierJulliard2005} Money Illusion and Housing Frenzies
### Table 1: Univariate Regressions, Newey-West (1987) corrected t-statistics in brackets.

<table>
<thead>
<tr>
<th>Dependent Variables:</th>
<th>Regressors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_t$</td>
<td>$i_t$</td>
</tr>
<tr>
<td>$\log (1/i_t)$</td>
<td></td>
</tr>
</tbody>
</table>

**Panel A**

<table>
<thead>
<tr>
<th>Coeff.</th>
<th>$R^2$</th>
<th>Coeff.</th>
<th>$R^2$</th>
<th>Coeff.</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{\psi}_t$</td>
<td>$-4.09$</td>
<td>.83</td>
<td>$-6.80$</td>
<td>.74</td>
<td>$0.136$</td>
</tr>
<tr>
<td>$\sum_{\tau=1}^\infty \rho^{\tau-1} \hat{E}<em>t \Delta l</em>{t+\tau}^e$</td>
<td>$-2.58$</td>
<td>.12</td>
<td>$-3.96$</td>
<td>.09</td>
<td>$0.093$</td>
</tr>
<tr>
<td>$- \sum_{\tau=1}^\infty \rho^{\tau-1} \hat{E}<em>t r</em>{h,t+\tau}^e$</td>
<td>$1.92$</td>
<td>.03</td>
<td>$3.581$</td>
<td>.03</td>
<td>$-0.050$</td>
</tr>
</tbody>
</table>

**Panel B**

<table>
<thead>
<tr>
<th>Coeff.</th>
<th>$R^2$</th>
<th>Coeff.</th>
<th>$R^2$</th>
<th>Coeff.</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{\psi}_t'$</td>
<td>$-6.15$</td>
<td>.17</td>
<td>$-10.85$</td>
<td>.17</td>
<td>$0.241$</td>
</tr>
<tr>
<td>$\hat{e}_t$</td>
<td>$-3.90$</td>
<td>.65</td>
<td>$-6.3$</td>
<td>.55</td>
<td>$0.129$</td>
</tr>
</tbody>
</table>

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
### Empirical evidence

**Dependent Variables:**

<table>
<thead>
<tr>
<th></th>
<th>( \pi_t )</th>
<th>( R^2 )</th>
<th>( i_t )</th>
<th>( R^2 )</th>
<th>( \log (1/i_t) )</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \hat{\psi}_t )</td>
<td>–4.09</td>
<td>.83</td>
<td>–6.80</td>
<td>.74</td>
<td>.136</td>
<td>.69</td>
</tr>
<tr>
<td></td>
<td>(13.479)</td>
<td></td>
<td>(11.765)</td>
<td></td>
<td>(8.020)</td>
<td></td>
</tr>
<tr>
<td>( \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}<em>t \Delta l^e</em>{t+\tau} )</td>
<td>–2.58</td>
<td>.12</td>
<td>–3.96</td>
<td>.09</td>
<td>.093</td>
<td>.12</td>
</tr>
<tr>
<td></td>
<td>(2.390)</td>
<td></td>
<td>(1.938)</td>
<td></td>
<td>(2.083)</td>
<td></td>
</tr>
<tr>
<td>( -\sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}<em>t r^e</em>{h,t+\tau} )</td>
<td>1.92</td>
<td>.03</td>
<td>3.581</td>
<td>.03</td>
<td>–.050</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td>(1.066)</td>
<td></td>
<td>(1.050)</td>
<td></td>
<td>(.595)</td>
<td></td>
</tr>
<tr>
<td><strong>Panel B</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \hat{\psi}'_t )</td>
<td>–6.15</td>
<td>.17</td>
<td>–10.85</td>
<td>.17</td>
<td>.241</td>
<td>.19</td>
</tr>
<tr>
<td></td>
<td>(2.48)</td>
<td></td>
<td>(2.66)</td>
<td></td>
<td>(2.82)</td>
<td></td>
</tr>
<tr>
<td>( \hat{\epsilon}_t )</td>
<td>–3.90</td>
<td>.65</td>
<td>–6.3</td>
<td>.55</td>
<td>.129</td>
<td>.52</td>
</tr>
<tr>
<td></td>
<td>(7.946)</td>
<td></td>
<td>(6.927)</td>
<td></td>
<td>(5.991)</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Univariate Regressions, Newey-West (1987) corrected \( t \)-statistics in brackets.
### Table 1: Univariate Regressions, Newey-West (1987) corrected \( t \)-statistics in brackets.

<table>
<thead>
<tr>
<th>Dependent Variables:</th>
<th>Regressors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \pi_t )</td>
<td>( i_t )</td>
</tr>
<tr>
<td>coeff.</td>
<td>( R^2 )</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Panel A</td>
<td></td>
</tr>
<tr>
<td>( \hat{\psi}_t )</td>
<td>-4.09</td>
</tr>
<tr>
<td>(13.479)</td>
<td></td>
</tr>
<tr>
<td>( \sum_{\tau=1}^{\infty} \rho^{\tau-1} \hat{E}<em>t \Delta l</em>{t+\tau}^e )</td>
<td>-2.58</td>
</tr>
<tr>
<td>(2.390)</td>
<td></td>
</tr>
<tr>
<td>- ( \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}<em>t r</em>{h,t+\tau}^e )</td>
<td>1.92</td>
</tr>
<tr>
<td>(1.066)</td>
<td></td>
</tr>
<tr>
<td>Panel B</td>
<td></td>
</tr>
<tr>
<td>( \hat{\psi}'_t )</td>
<td>-6.15</td>
</tr>
<tr>
<td>(2.48)</td>
<td></td>
</tr>
<tr>
<td>( \hat{\varepsilon}_t )</td>
<td>-3.90</td>
</tr>
<tr>
<td>(7.946)</td>
<td></td>
</tr>
</tbody>
</table>

Brunnermeier and Julliard (2005) | Money Illusion and Housing Frenzies
Robustness analysis - Methodology

Posterior of estimated VAR (under diffuse prior, sample size $n$ and $m$ parameters)

$$\beta \mid \Sigma \sim N \left( \hat{\beta}, \Sigma \otimes (X'X)^{-1} \right)$$

$$\Sigma^{-1} \sim \text{Wishart} \left( \left( n\hat{\Sigma} \right)^{-1}, n - m \right)$$

1. Draw covar-matrices $\hat{\Sigma}$ from inverse Wishart with $\hat{\Sigma}$, $n$ and $m$

2. Cond. on $\hat{\Sigma}$ draw VAR-coefficients $\hat{\beta} \sim N \left( \hat{\beta}, \hat{\Sigma} \otimes (X'X)^{-1} \right)$

3. Use $\hat{\beta}$ to construct $\sum_{\tau} \rho^{\tau-1} \hat{E}_t \Delta l_{t+\tau}^e$, $\sum_{\tau} \rho^{\tau-1} \hat{E}_t r_{h,t+\tau}^e$, and $\hat{\psi}_t$

4. Regress $\hat{\psi}_t$, $\sum_{\tau} \rho^{\tau-1} \hat{E}_t \Delta l_{t+\tau}^e$, $\sum_{\tau} \rho^{\tau-1} \hat{E}_t r_{h,t+\tau}^e$ on $\pi_t$, $i_t$, $1/i_t$

5. Iterate and compute confidence intervals for OLS coefficients and $R^2$ from their percentiles

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
Robustness analysis - Methodology

**Posterior of estimated VAR** (under diffuse prior, sample size $n$ and $m$ parameters)

\[ \beta | \Sigma \sim N \left( \hat{\beta}, \Sigma \otimes (X'X)^{-1} \right) \]

\[ \Sigma^{-1} \sim \text{Wishart} \left( \left( n\hat{\Sigma} \right)^{-1}, n - m \right) \]

1. Draw covar-matrices $\hat{\Sigma}$ from inverse Wishart with $\hat{\Sigma}$, $n$ and $m$
2. Cond. on $\hat{\Sigma}$ draw VAR-coefficients $\hat{\beta} \sim N \left( \hat{\beta}, \hat{\Sigma} \otimes (X'X)^{-1} \right)$
3. Use $\hat{\beta}$ to construct $\sum_\tau^\infty \rho_t^{\tau-1} E_t \Delta l_{t+\tau}^e$, $\sum_\tau^\infty \rho_t^{\tau-1} E_t r_{h,t+\tau}^e$, and $\hat{\psi}_t$
4. Regress $\hat{\psi}_t$, $\sum_\tau^\infty \rho_t^{\tau-1} E_t \Delta l_{t+\tau}^e$, $\sum_\tau^\infty \rho_t^{\tau-1} E_t r_{h,t+\tau}^e$ on $\pi_t$, $i_t$, $1/i_t$
5. Iterate and compute confidence intervals for OLS coefficients and $R^2$ from their percentiles
Robustness analysis - Methodology

Posterior of estimated VAR (under diffuse prior, sample size $n$ and $m$ parameters)

$$
\beta | \Sigma \sim N \left( \hat{\beta}, \Sigma \otimes (X'X)^{-1} \right)
$$

$$
\Sigma^{-1} \sim \text{Wishart} \left( \left( n\hat{\Sigma} \right)^{-1}, n - m \right)
$$

1. Draw covar-matrices $\hat{\Sigma}$ from inverse Wishart with $\hat{\Sigma}$, $n$ and $m$

2. Cond. on $\hat{\Sigma}$ draw VAR-coefficients $\hat{\beta} \sim N \left( \hat{\beta}, \hat{\Sigma} \otimes (X'X)^{-1} \right)$

3. Use $\hat{\beta}$ to construct $\sum_T^{\infty} \rho_T^{T-1} \dot{E}_t \Delta l_{t+T}, \sum_T^{\infty} \rho_T^{T-1} \dot{E}_t r_{h,t+T}^{e}$, and $\dot{\psi}_t$

4. Regress $\dot{\psi}_t, \sum_T^{\infty} \rho_T^{T-1} \dot{E}_t \Delta l_{t+T}, \sum_T^{\infty} \rho_T^{T-1} \dot{E}_t r_{h,t+T}^{e}$ on $\pi_t, i_t, 1/i_t$

5. Iterate and compute confidence intervals for OLS coefficients and $R^2$ from their percentiles

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
Robustness analysis - Methodology

Posterior of estimated VAR (under diffuse prior, sample size $n$ and $m$ parameters)

$$
\beta|\Sigma \sim N\left(\hat{\beta}, \Sigma \otimes (X'X)^{-1}\right) \\
\Sigma^{-1} \sim \text{Wishart} \left(\left(n\hat{\Sigma}\right)^{-1}, n - m\right)
$$

1. Draw covar-matrices $\hat{\Sigma}$ from inverse Wishart with $\hat{\Sigma}$, $n$ and $m$
2. Cond. on $\hat{\Sigma}$ draw VAR-coefficients $\hat{\beta} \sim N\left(\hat{\beta}, \hat{\Sigma} \otimes (X'X)^{-1}\right)$
3. Use $\hat{\beta}$ to construct $\sum_{\tau}^{\infty} \rho^{\tau-1} \hat{E}_t \Delta l_{t+\tau}^e$, $\sum_{\tau}^{\infty} \rho^{\tau-1} \hat{E}_t r_{h,t+\tau}^e$, and $\hat{\psi}_t$
4. Regress $\hat{\psi}_t$, $\sum_{\tau}^{\infty} \rho^{\tau-1} \hat{E}_t \Delta l_{t+\tau}^e$, $\sum_{\tau}^{\infty} \rho^{\tau-1} \hat{E}_t r_{h,t+\tau}^e$ on $\pi_t$, $i_t$, $1/i_t$
5. Iterate and compute confidence intervals for OLS coefficients and $R^2$ from their percentiles

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
Robustness analysis - Methodology

Posterior of estimated VAR (under diffuse prior, sample size \( n \) and \( m \) parameters)

\[
\beta|\Sigma \sim N \left( \hat{\beta}, \Sigma \otimes (X'X)^{-1} \right)
\]

\[
\Sigma^{-1} \sim \text{Wishart} \left( \left( n\hat{\Sigma} \right)^{-1}, n - m \right)
\]

1. Draw covar-matrices \( \hat{\Sigma} \) from inverse Wishart with \( \hat{\Sigma}, n \) and \( m \)
2. Cond. on \( \hat{\Sigma} \) draw VAR-coefficients \( \hat{\beta} \sim N \left( \hat{\beta}, \hat{\Sigma} \otimes (X'X)^{-1} \right) \)
3. Use \( \hat{\beta} \) to construct \( \sum_{\tau} \rho_{\tau}^{-1} \hat{E}_t \Delta l_{t+\tau}^e \), \( \sum_{\tau} \rho_{\tau}^{-1} \hat{E}_t r_{h,t+\tau}^e \), and \( \hat{\psi}_t \)
4. Regress \( \hat{\psi}_t, \sum_{\tau} \rho_{\tau}^{-1} \hat{E}_t \Delta l_{t+\tau}^e \), \( \sum_{\tau} \rho_{\tau}^{-1} \hat{E}_t r_{h,t+\tau}^e \) on \( \pi_t, i_t, 1/i_t \)
5. Iterate and compute confidence intervals for OLS coefficients and \( R^2 \) from their percentiles

Brunnermeier and Julliard (2005) - Money Illusion and Housing Frenzies
Robustness analysis - Methodology

Posterior of estimated VAR (under diffuse prior, sample size $n$ and $m$ parameters)

$$
\beta | \Sigma \sim N \left( \hat{\beta}, \Sigma \otimes (X'X)^{-1} \right)
$$

$$
\Sigma^{-1} \sim \text{Wishart} \left( \left( n\hat{\Sigma} \right)^{-1}, n - m \right)
$$

1. Draw covar-matrices $\hat{\Sigma}$ from inverse Wishart with $\hat{\Sigma}$, $n$ and $m$
2. Cond. on $\hat{\Sigma}$ draw VAR-coefficients $\hat{\beta} \sim N \left( \hat{\beta}, \hat{\Sigma} \otimes (X'X)^{-1} \right)$
3. Use $\hat{\beta}$ to construct $\sum_{\tau}^\infty \rho^{\tau-1} \hat{E}_t \Delta l_{t+\tau}^e$, $\sum_{\tau}^\infty \rho^{\tau-1} \hat{E}_t r_{h,t+\tau}^e$, and $\hat{\psi}_t$
4. Regress $\hat{\psi}_t$, $\sum_{\tau}^\infty \rho^{\tau-1} \hat{E}_t \Delta l_{t+\tau}^e$, $\sum_{\tau}^\infty \rho^{\tau-1} \hat{E}_t r_{h,t+\tau}^e$ on $\pi_t$, $i_t$, $1/i_t$
5. Iterate and compute confidence intervals for OLS coefficients and $R^2$ from their percentiles
Robustness analysis - Results

<table>
<thead>
<tr>
<th>DepVar:</th>
<th>Regressors:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\pi_t$</td>
</tr>
<tr>
<td></td>
<td>coeff.</td>
</tr>
<tr>
<td>Panel A</td>
<td></td>
</tr>
<tr>
<td>$\hat{\psi}_t$</td>
<td>$-3.10$</td>
</tr>
<tr>
<td></td>
<td>$[-7.79, -0.19]$</td>
</tr>
<tr>
<td>$\Delta l$-terms</td>
<td>$-2.6$</td>
</tr>
<tr>
<td></td>
<td>$[-11.8, 9.08]$</td>
</tr>
<tr>
<td>$-r$-terms</td>
<td>$1.81$</td>
</tr>
<tr>
<td></td>
<td>$[-10.41, 9.61]$</td>
</tr>
<tr>
<td>Panel B</td>
<td></td>
</tr>
<tr>
<td>$\hat{\epsilon}_t$</td>
<td>$-3.9$</td>
</tr>
<tr>
<td></td>
<td>$[-11.1, -0.19]$</td>
</tr>
</tbody>
</table>

Table 2: Median and 95 percent confidence intervals for slope coefficients and $R^2$. 

Brunnermeier and Julliard (2005)

Money Illusion and Housing Frenzies
Robustness analysis - Results

<table>
<thead>
<tr>
<th>DepVar:</th>
<th>Regressors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_t$</td>
<td>$i_t$</td>
</tr>
<tr>
<td>coeff.</td>
<td>$R^2$</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td><strong>Panel A</strong></td>
<td></td>
</tr>
<tr>
<td>$\hat{\psi}_t$</td>
<td>$-3.10$</td>
</tr>
<tr>
<td></td>
<td>$[-7.79, -0.19]$</td>
</tr>
<tr>
<td>$\Delta l$-terms</td>
<td>$-2.6$</td>
</tr>
<tr>
<td></td>
<td>$[-11.8, 9.08]$</td>
</tr>
<tr>
<td>$-r$-terms</td>
<td>$1.81$</td>
</tr>
<tr>
<td></td>
<td>$[-10.41, 9.61]$</td>
</tr>
<tr>
<td><strong>Panel B</strong></td>
<td></td>
</tr>
<tr>
<td>$\hat{\epsilon}_t$</td>
<td>$-3.9$</td>
</tr>
<tr>
<td></td>
<td>$[-11.1, -0.19]$</td>
</tr>
</tbody>
</table>

Table 2: Median and 95 percent confidence intervals for slope coefficients and $R^2$. 
1 Money illusion - Related literature

2 U.K. evidence
   • Real versus nominal - A first-cut
   • Decomposing inflation effects
   • Financial frictions

3 Cross-country evidence
   • U.S. evidence

4 Conclusion
Tilt effect of inflation

- inflation *tilts* real mortgage repayment scheme

- can’t afford initial mortgage payments
  - BUT more flexible mortgage schemes
    - Price level adjusted mortgage (PLAM)
    - Graduate payment mortgage (GPM)
    - Interest only mortgages

  are available since 1970’s in UK and mortgages became more flexible over the years

PREDICTION OF TILT EFFECT:
- inflation effect less negative over time

Greene-Modigliani + Tucker (1975)
Figure 6: Point estimates and 95 percent Newey and West (1987) corrected confidence bounds of slope coefficients as sample size increases.

- tilt effect is unlikely to explain inflation effect.
Lock-in effect

- locked in low fixed nominal rate on existing mortgage
  ⇒ reluctant to buy better house if mortgage is not portable

**PREDICTION OF LOCK-IN EFFECT**

- for the full sample estimates

\[ \psi_t = \hat{a} + \hat{b}_1 d_t i_t + \hat{b}_2 (1 - d_t) i_t + \hat{e}_t \Rightarrow \hat{b}_1 \neq \hat{b}_2 \]

where \( d_t \) is an indicator function of upward movements in \( i_t \)

- for rolling samples estimates:
  - \( \text{Corr}[R^2, d_t] > 0 \)
  - \( \text{Corr}[R^2, i_t] < 0 \)

- Can be rejected!

- Surprising? No, since most mortgages in the UK are portable (and flexible interest rate mortgages)
Lock-in effect

- locked in low fixed nominal rate on existing mortgage
  \[ \Rightarrow \text{reluctant to buy better house if mortgage is not portable} \]

PREDICTION OF LOCK-IN EFFECT

- for the full sample estimates
  \[ \psi_t = \hat{\alpha} + \hat{b}_1 d_t i_t + \hat{b}_2 (1 - d_t) i_t + \hat{\epsilon}_t \Rightarrow \hat{b}_1 \neq \hat{b}_2 \]

  where \( d_t \) is an indicator function of upward movements in \( i_t \)

- for rolling samples estimates:
  - \( \text{Corr}[R^2, d_t] > 0 \)
  - \( \text{Corr}[R^2, i_t] < 0 \)

- Can be rejected!

- Surprising? No, since most mortgages in the UK are portable (and flexible interest rate mortgages)

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
Lock-in effect

- locked in low fixed nominal rate on existing mortgage
  ⇒ reluctant to buy better house if mortgage is not portable

PREDICTION OF LOCK-IN EFFECT

- for the full sample estimates

\[ \psi_t = \hat{a} + \hat{b}_1 d_t i_t + \hat{b}_2 (1 - d_t) i_t + \hat{e}_t \Rightarrow \hat{b}_1 \neq \hat{b}_2 \]

where \( d_t \) is an indicator function of upward movements in \( i_t \)

- for rolling samples estimates:
  - \( \text{Corr}[R^2, d_t] > 0 \)
  - \( \text{Corr}[R^2, i_t] < 0 \)

- Can be rejected!

- Surprising? No, since most mortgages in the UK are portable (and flexible interest rate mortgages)
Lock-in effect

- locked in low fixed nominal rate on existing mortgage
  ⇒ reluctant to buy better house if mortgage is not portable

PREDICTION OF LOCK-IN EFFECT

- for the full sample estimates

\[ \psi_t = \hat{a} + \hat{b}_1 d_t i_t + \hat{b}_2 (1 - d_t) i_t + \hat{e}_t \Rightarrow \hat{b}_1 \neq \hat{b}_2 \]

where \( d_t \) is an indicator function of upward movements in \( i_t \)

- for rolling samples estimates:
  - Corr\([R^2, d_t]\) > 0
  - Corr\([R^2, i_t]\) < 0

- Can be rejected!

- Surprising? No, since most mortgages in the UK are portable (and flexible interest rate mortgages)
Lock-in effect

- locked in low fixed nominal rate on existing mortgage
  ⇒ reluctant to buy better house if mortgage is not portable

PREDICTION OF LOCK-IN EFFECT

- for the full sample estimates

$$\psi_t = \hat{a} + \hat{b}_1 d_t i_t + \hat{b}_2 (1 - d_t) i_t + \hat{e}_t \Rightarrow \hat{b}_1 \neq \hat{b}_2$$

where $d_t$ is an indicator function of upward movements in $i_t$

- for rolling samples estimates:
  - $\text{Corr}[R^2, d_t] > 0$
  - $\text{Corr}[R^2, i_t] < 0$

- Can be rejected!

- Surprising? No, since most mortgages in the UK are portable (and flexible interest rate mortgages)
Misprincing measures and the business cycle

- During booms (busts) high quality houses appreciate (de-) more than smaller houses
  - house prices reflect all types of dwellings
  - rent index tends to overweigh lower quality dwellings
- Price-rent ratio might move over business cycle
- Control for business cycle proxy
  - $\hat{c}_t$ Hodrick-Prescott (1997) filter

![Graph](image-url)

Figure 5: U.K. business cycle and inflation measures (i) does not drive out the statistical significance of $t$; $i_t$ and $\log(1/i_t)$, (ii) does not significantly change the point estimates of the elasticities of the mispricing reported in Table 1, (iii) does not increase significantly our ability to explain the time variation in the mispricing, (iv) and that the business cycle alone has very little (in the case of $\hat{c}_t$ and $\hat{c}_t^*$) or no (in the case of $\hat{c}_0^t$) explanatory power for the mispricing measures.

3.3 Tilt Effect

Our empirical results are consistent with money illusion. Nevertheless, we could also be capturing the tilt effect of inflation. Recall from Section 3.1 that the reciprocal of the nominal interest rate, $1/i_t$, is proportional to the amount agents can borrow under a fixed nominal payment mortgage. Such a contract generates a financing constraint that varies with the nominal interest rate and hence with inflation. However, agents could use multiple alternative financing schemes available on the market, that are not affected by the tilt effect. This is for example the case for flexible interest rate mortgages, price level adjusted mortgages (PLAM) or the graduate payment mortgages. — Brunnermeier and Julliard (2005)
## Mispricining measures and the business cycle

<table>
<thead>
<tr>
<th>Row:</th>
<th>DepVar:</th>
<th>( \hat{c}_t )</th>
<th>( \pi_t )</th>
<th>( i_t )</th>
<th>( \log \left( \frac{1}{i} \right) )</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>( \hat{\psi}_t )</td>
<td>0.81 (1.959)</td>
<td></td>
<td></td>
<td></td>
<td>0.07</td>
</tr>
<tr>
<td>(2)</td>
<td></td>
<td>0.32 (2.135)</td>
<td>-4.00 (13.761)</td>
<td></td>
<td></td>
<td>0.85</td>
</tr>
<tr>
<td>(3)</td>
<td></td>
<td>0.378 (2.168)</td>
<td></td>
<td>-6.64 (11.137)</td>
<td></td>
<td>0.76</td>
</tr>
<tr>
<td>(5)</td>
<td>( \hat{\psi}'_t )</td>
<td>1.11 (0.963)</td>
<td></td>
<td></td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>(6)</td>
<td></td>
<td>0.36 (0.349)</td>
<td>-5.98 (2.279)</td>
<td></td>
<td></td>
<td>0.17</td>
</tr>
<tr>
<td>(7)</td>
<td></td>
<td>0.41 (0.369)</td>
<td></td>
<td>-10.5 (2.436)</td>
<td></td>
<td>0.17</td>
</tr>
<tr>
<td>(9)</td>
<td>( \hat{\varepsilon}_t )</td>
<td>0.85 (2.201)</td>
<td></td>
<td></td>
<td></td>
<td>0.07</td>
</tr>
<tr>
<td>(10)</td>
<td></td>
<td>0.41 (2.281)</td>
<td>-3.80 (7.801)</td>
<td></td>
<td></td>
<td>0.67</td>
</tr>
<tr>
<td>(11)</td>
<td></td>
<td>0.49 (2.281)</td>
<td></td>
<td>-6.10 (5.757)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Brunnermeier and Julliard (2005) - Money Illusion and Housing Frenzies
Money illusion - Related literature

U.K. evidence
- Real versus nominal - A first-cut
- Decomposing inflation effects
- Financial frictions

Cross-country evidence
- U.S. evidence

Conclusion
# U.S. Decomposition of inflation effects

<table>
<thead>
<tr>
<th>Dependent Variables:</th>
<th>Regressors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_t$</td>
<td>$i_t$</td>
</tr>
<tr>
<td>coef.</td>
<td>R$^2$</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>Panel A</strong></td>
<td></td>
</tr>
<tr>
<td>$\hat{\psi}_t$</td>
<td>$-6.65$</td>
</tr>
<tr>
<td>($4.525$)</td>
<td>($3.182$)</td>
</tr>
<tr>
<td>$\sum_{\tau=1}^{\infty} \rho^{\tau-1} \hat{E}<em>t \Delta l^e</em>{t+\tau}$</td>
<td>$-2.87$</td>
</tr>
<tr>
<td>($6.572$)</td>
<td>($6.170$)</td>
</tr>
<tr>
<td>$- \sum_{\tau=1}^{\infty} \rho^{\tau-1} \tilde{E}<em>t r^e</em>{h,t+\tau}$</td>
<td>$0.76$</td>
</tr>
<tr>
<td>($0.211$)</td>
<td>($1.130$)</td>
</tr>
<tr>
<td><strong>Panel B</strong></td>
<td></td>
</tr>
<tr>
<td>$\hat{\epsilon}_t$</td>
<td>$-10.2$</td>
</tr>
<tr>
<td>($5.148$)</td>
<td>($2.648$)</td>
</tr>
</tbody>
</table>

Table 3: Univariate Regressions, Newey-West (1987) corrected $t$-statistics in brackets.
### U.S. Robustness analysis

<table>
<thead>
<tr>
<th>DepVar:</th>
<th>Regressors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_t$</td>
<td>$i_t$</td>
</tr>
<tr>
<td>coeff.</td>
<td>$R^2$</td>
</tr>
<tr>
<td>Panel A</td>
<td></td>
</tr>
<tr>
<td>$\hat{\psi}_t$</td>
<td>$-6.06$</td>
</tr>
<tr>
<td>[−7.32, −2.76]</td>
<td>[.06, .66]</td>
</tr>
<tr>
<td>$\Delta l$-terms</td>
<td>$-2.86$</td>
</tr>
<tr>
<td>[−8.17, 1.53]</td>
<td>[.01, .96]</td>
</tr>
<tr>
<td>$−r$-terms</td>
<td>$0.44$</td>
</tr>
<tr>
<td>[−4.84, 3.21]</td>
<td>[0, .09]</td>
</tr>
<tr>
<td>Panel B</td>
<td></td>
</tr>
<tr>
<td>$\hat{\epsilon}_t$</td>
<td>$-10.2$</td>
</tr>
</tbody>
</table>

Table 4: Median and 95 percent confidence intervals for slope coefficients and $R^2$. 

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
Money Illusion arises if e.g. investors simply compare current rent with current mortgage payment

- Inflation affects house prices
- Rational channels alone do explain inflation effects
  - Low inflation leads to higher expected rent growth
  - Inflation impact on expected housing returns is insignificant
  - Inflation explains substantial part of “mispricing”
- Frictions are unlikely to fully rationalize the empirical findings
  - *Tilt effect* should decline as mortgages became more flexible
  - *Lock-in effect* does not arise since mortgages are portable in UK

⇒ Evidence in favor of money illusion

Money illusion and mortgage markets have important implications for monetary economics
Money Illusion arises if e.g. investors simply compare current rent with current mortgage payment.

Inflation affects house prices.

Rational channels alone do explain inflation effects:
- Low inflation leads to higher expected rent growth.
- Inflation impact on expected housing returns is insignificant.
- Inflation explains substantial part of “mispricing”.

Frictions are unlikely to fully rationalize the empirical findings:
- Tilt effect should decline as mortgages became more flexible.
- Lock-in effect does not arise since mortgages are portable in UK.

⇒ Evidence in favor of money illusion.

Money illusion and mortgage markets have important implications for monetary economics.

Brunnermeier and Julliard (2005)
Money Illusion and Housing Frenzies
Money Illusion arises if e.g. investors simply compare current rent with current mortgage payment.

Inflation affects house prices.

Rational channels alone do explain inflation effects.
- Low inflation leads to higher *expected rent growth*.
- Inflation impact on *expected housing returns* is insignificant.
- Inflation explains substantial part of “mispricing”.

Frictions are unlikely to fully rationalize the empirical findings.
- *Tilt effect* should decline as mortgages became more flexible.
- *Lock-in effect* does not arise since mortgages are portable in the UK.

⇒ Evidence in favor of money illusion.

Money illusion and mortgage markets have important implications for monetary economics.

Brunnermeier and Julliard (2005) - Money Illusion and Housing Frenzies.
Money Illusion arises if e.g. investors simply compare current rent with current mortgage payment.

Inflation affects house prices.

Rational channels alone do explain inflation effects:
- Low inflation leads to higher expected rent growth.
- Inflation impact on expected housing returns is insignificant.
- Inflation explains substantial part of “mispricing”.

Frictions are unlikely to fully rationalize the empirical findings:
- Tilt effect should decline as mortgages became more flexible.
- Lock-in effect does not arise since mortgages are portable in UK.

Evidence in favor of money illusion:

Money illusion and mortgage markets have important implications for monetary economics.

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
First difference estimation

<table>
<thead>
<tr>
<th></th>
<th>Slope coeff.</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.K</td>
<td>−4.022</td>
<td>.31</td>
</tr>
<tr>
<td></td>
<td>(7.459)</td>
<td></td>
</tr>
<tr>
<td>U.S.</td>
<td>−3.629</td>
<td>.35</td>
</tr>
<tr>
<td></td>
<td>(6.588)</td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>−26.21</td>
<td>.85</td>
</tr>
<tr>
<td></td>
<td>(25.82)</td>
<td></td>
</tr>
</tbody>
</table>

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
Price-rent ratio and implied real interest rates

(standardized series)

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies
# Mispricing measures and the business cycle

<table>
<thead>
<tr>
<th>Row</th>
<th>DepVar:</th>
<th>Regressors:</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>$\hat{\psi}_t$</td>
<td>$\hat{c}_t$, $\pi_t$, $i_t$, $\log(1/i)$</td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.81, (1.959)</td>
<td></td>
</tr>
<tr>
<td>(2)</td>
<td></td>
<td>$\pi_t$, $i_t$, $\log(1/i)$</td>
<td>.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.32, (2.135), $-4.00$, (13.761)</td>
<td></td>
</tr>
<tr>
<td>(3)</td>
<td></td>
<td>$i_t$, $\log(1/i)$</td>
<td>.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.378, (2.168), $-6.64$, (11.137)</td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td>$\hat{\psi}'_t$</td>
<td>$\pi_t$, $i_t$, $\log(1/i)$</td>
<td>.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.11, (0.963)</td>
<td></td>
</tr>
<tr>
<td>(6)</td>
<td></td>
<td>$\pi_t$, $i_t$, $\log(1/i)$</td>
<td>.17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.36, (0.349), $-5.98$, (2.279)</td>
<td></td>
</tr>
<tr>
<td>(7)</td>
<td></td>
<td>$i_t$, $\log(1/i)$</td>
<td>.17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.41, (0.369), $-10.5$, (2.436)</td>
<td></td>
</tr>
<tr>
<td>(9)</td>
<td>$\hat{\varepsilon}_t$</td>
<td>$\pi_t$, $i_t$, $\log(1/i)$</td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.85, (2.201)</td>
<td></td>
</tr>
<tr>
<td>(10)</td>
<td></td>
<td>$\pi_t$, $i_t$, $\log(1/i)$</td>
<td>.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.41, (2.281), $-3.80$, (7.801)</td>
<td></td>
</tr>
<tr>
<td>(11)</td>
<td></td>
<td>$\pi_t$, $i_t$, $\log(1/i)$</td>
<td>.57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.49, (2.281), $-6.10$, (7.801)</td>
<td></td>
</tr>
</tbody>
</table>

Brunnermeier and Julliard (2005) Money Illusion and Housing Frenzies