Housing Market Spillovers: Evidence from an Estimated DSGE Model

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What we do

- Two questions:

1. What is the nature of the shocks hitting the housing market?
2. How big are spillovers from the housing market to the wider economy?
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- To answer them we build and estimate a quantitative model with:
  - nominal rigidities and monetary policy;
  - multi-sector structure with housing;
  - financing frictions on the household side.
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  - **Patient Households** work, consume, buy homes, rent capital and land to firms and lend to impatient households
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  - $IH$—sector produces new homes (using $K$, $N$, land and interm. goods)

- **Two Types of Households**
  - **Patient Households** work, consume, buy homes, rent capital and land to firms and lend to impatient households
  - **Impatient/Credit Constrained Households** work, consume, buy homes and borrow against the value of their home
  (We set up preferences in a way that the borrowing constraint is binding)
THE MODEL

- Different trend technological progress across sectors ($C, IK, IH$)
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- Central bank runs monetary policy
- Real rigidities: habits in $C$, imperfect labor mobility, $K$ adjustment costs, variable $K$ utilization
FIRMS

• Firms maximize profits:

\[
\frac{Y_t}{X_t} + q_t IH_t - \left( \sum w_{it} n_{it} + R_{ct} z_{ct} k_{ct-1} + R_{ht} z_{ht} k_{ht-1} + p_{bt} k_{bt} + R_{lt} l_{t-1} \right)
\]

\[
Y_t = \left( A_{ct} \left( n_{ct}^{\alpha} n_{ct}^{1-\alpha} \right) \right)^{1-\mu_c} \left( z_{ct} k_{ct-1} \right)^{\mu_c}
\]

\[
IH_t = \left( A_{ht} \left( n_{ht}^{\alpha} n_{ht}^{1-\alpha} \right) \right)^{1-\mu_h-\mu_b-\mu_l} \left( z_{ht} k_{ht-1} \right)^{\mu_h} k_{bt}^{\mu_b} l_{t-1}^{\mu_l}.
\]

\(X_t\): markup of final good relative to wholesale consumption good
\(q_t\): price of new housing relative to consumption
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- \(X_t\): markup of final good relative to wholesale consumption good
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- Two types of households/workers of measure 1
  - \(\alpha\): wage share of unconstrained households (lenders)
  - \(1 - \alpha\): wage share of constrained households (borrowers)
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- \(Y_t\): sticky price sector, \(IH_t\) flex price sector
UNCONSTRAINED HOUSEHOLDS (Lenders)

\[
\max E_0 \sum_{t=0}^{\infty} (\beta G_C)^t z_t \left( \log (c_t - \varepsilon g_C c_{t-1}) + j_t \log h_t \right)
\]

\[
- \frac{\tau_t}{1+\eta} \left( n_{ct}^{1+\xi} + n_{ht}^{1+\xi} \right)^{1+\eta \over 1+\xi}
\]

- subject to budget constraint:

\[
c_t + k_{ct} + k_{ht} + q_t (h_t - (1 - \delta_h) h_{t-1}) + b_t'
\]

\[
= \tilde{R}_{ct} k_{ct-1} + \tilde{R}_{ht} k_{ht-1} + R_l t l_{t-1} + Div_t + \frac{w_{ct}}{X_{wct}} n_{ct} + \frac{w_{ht}}{X_{wht}} n_{ht} + \frac{R_{t-1} b'_{t-1}}{\pi_t}
\]
CONSTRANGED HOUSEHOLDS (Borrowers)

- Discount future more heavily ($\beta' < \beta$)

$$\max E_0 \sum_{t=0}^{\infty} (\beta' G_C)^t z_t \left( \log (c_t' - \varepsilon' g C c_{t-1}') + j_t \log h_t' 
- \frac{\tau_t}{1 + \eta'} \left( n'_{ct}^{1+\xi'} + n'_{ht}^{1+\xi'} \right)^{\frac{1+\eta'}{1+\xi'}} \right)$$
CONSTRANDED HOUSEHOLDS (Borrowers)

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$$\max E_0 \sum_{t=0}^{\infty} (\beta' G_C)^t z_t \begin{pmatrix} \log (c_t' - \varepsilon' g_C c_{t-1}') + j_t \log h_t' \\ - \frac{\tau_t}{1+\eta'} \left( n_{ct}'^{1+\xi'} + n_{ht}'^{1+\xi'} \right) \end{pmatrix}$$

- subject to budget constraint

$$c_t' + q_t (h_t' - (1 - \delta_h) h_{t-1}') = \frac{w_{ct}'}{X'_{wct}} n_{ct}' + \frac{w_{ht}'}{X'_{wht}} n_{ht}' + b_t' - \frac{R_{t-1}}{\pi_t} b_{t-1}'$$
CONSTRUANDED HOUSEHOLDS (Borrowers)

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$$- \frac{\tau_t}{1+\eta'} \left( n_{ct}' \frac{1+\xi'}{1+\zeta'} + n_{ht}' \frac{1+\xi'}{1+\zeta'} \right)$$

- subject to budget constraint

$$c_t' + q_t \left( h_t' - (1 - \delta_h) h_{t-1}' \right) = \frac{w_{ct}'}{\chi_{wct}'} n_{ct}' + \frac{w_{ht}'}{\chi_{wht}'} n_{ht}' + b_t' - \frac{R_{t-1}}{\pi_t} b_{t-1}'$$

- and to borrowing constraint

$$b_t' \leq mE_t \left( q_{t+1} h_t' \pi_{t+1} / R_t \right)$$

$m : $ loan-to-value ratio
MONETARY POLICY

\[ R_t = (R_{t-1})^{r_R} \left( \pi_t^{r_\pi} \left( \frac{GDP_t}{G_C \cdot GDP_{t-1}} \right)^{r_Y} \frac{1}{r_\pi} \right)^{1-r_R} u_{Rt} \]

- \( u_{Rt} \): iid monetary policy shock
- \( s_t \): highly persistent inflation objective shock
SHOCKS

- Stationary AR(1)
  - $z_t$: preference (discount factor) shock
  - $j_t$: housing demand shock (or household technology shock)
  - $\tau_t$: labor supply shock
  - $u_{Rt}$: monetary shock (iid)
  - $s_t$: inflation objective shock
  - $u_{pt}$: markup/inflation shock (iid)

- Trend-stationary shocks

\[
\begin{align*}
\ln A_{ct} &= t \ln (1 + \gamma_{AC}) + \ln Z_{ct}, & \ln Z_{ct} &= \rho_{AC} \ln Z_{ct-1} + u_{Ct} \\
\ln A_{ht} &= t \ln (1 + \gamma_{AH}) + \ln Z_{ht}, & \ln Z_{ht} &= \rho_{AH} \ln Z_{ht-1} + u_{Ht} \\
\ln A_{kt} &= t \ln (1 + \gamma_{AK}) + \ln Z_{kt}, & \ln Z_{kt} &= \rho_{AK} \ln Z_{kt-1} + u_{Kt}
\end{align*}
\]
HOW DOES THE MODEL WORK?

1. At a basic level, it works like an RBC model with sticky prices/wages in the $Y$—sector, like an RBC with flex prices/sticky wages in the $IH$—sector (added twist: $IH$ sector produces durables)

2. Sector specific shocks or preference shocks can shift resources from one sector to the other

3. Housing collateral generates wealth effects on consumption from fluctuations in housing values
ROLE OF TRENDS

1. Log preferences and Cobb-Douglas yield balanced growth
2. $C$ and $qIH$ grow at the same rate over time.
3. $IK$ can grow faster than $C$, thanks to $A_K$ progress
4. $IH$ can grow slower than $C$, if land is a limiting factor and $A_H$ is slow
5. Long-run growth rates

\[
\begin{align*}
\frac{\Delta C}{C} &= \gamma_{AC} + \frac{\mu_c}{1 - \mu_c} \gamma_{AK} \\
\frac{\Delta IK}{IK} &= \gamma_{AC} + \frac{1}{1 - \mu_c} \gamma_{AK} \\
\frac{\Delta IH}{IH} &= (\mu_h + \mu_b) \gamma_{AC} + \frac{\mu_c (\mu_h + \mu_b)}{1 - \mu_c} \gamma_{AK} + (1 - \mu_h - \mu_l - \mu_b) \gamma_{AH} \\
\frac{\Delta q}{q} &= (1 - \mu_h - \mu_b) \gamma_{AC} + \frac{\mu_c (1 - \mu_h - \mu_b)}{1 - \mu_c} \gamma_{AK} \\
&\quad - (1 - \mu_h - \mu_l - \mu_b) \gamma_{AH}
\end{align*}
\]
2. ESTIMATION

1. Use 10 time-series (1965Q1-2006Q4) for US logged raw series for $C, IH, IK, q, R, \pi$, sectoral hours $N_c$ and $N_h$, sectoral wages $\Delta w_c$ and $\Delta w_h$.
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2. Some parameters calibrated to match steady state ratios
   $\beta = 0.9925$, $\beta' = 0.97$, $m = 0.85$
   $Y = N_c^{0.65} k_c^{0.35}$, $IH = N_h^{0.70} k_h^{0.10} k_b^{0.10} / 0.10$
   Targets: $(K + qH) / GDP = 3.2$, $(qH) / GDP = 1.35$, $(\delta_h qH) / GDP = 0.06$
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3. Other parameters (including degree of financing frictions) estimated by Bayesian techniques
3. RESULTS

Prior and Posterior Parameters

1. Slow rate of technological progress in housing construction
   \( \gamma_{AC} = 0.32\%, \quad \gamma_{AH} = 0.08\% \)
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3. RESULTS

Prior and Posterior Parameters

1. Slow rate of technological progress in housing construction
   \((\gamma_{AC} = 0.32\%, \ \gamma_{AH} = 0.08\%)\)

2. Wage share of credit constrained households \(1 - \alpha = 21\%\)

3. High price rigidity \((\theta_{\pi} = 0.83)\) and indexation \((\iota_{\pi} = 0.71)\)
   High wage rigidity \((\theta_{wc} = 0.81, \theta_{wh} = 0.91)\), low wage indexation
   \((\iota_{wc} = 0.07, \iota_{wh} = 0.42)\)
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   \( \iota_{wc} = 0.07, \iota_{wh} = 0.42 \)

4. Taylor rule: 
   \[ R_t = 0.61R_{t-1} + 0.39 \left[ 1.38\pi_t + 0.51 \left( gdp_t - gdp_{t-1} \right) \right] \]
Variables and estimated trends

![Real Consumption](image1)

![Real Residential Investment](image2)

![Real Business Investment](image3)

![Real House Prices](image4)
Variance Decomposition

Housing demand shocks and housing technology shocks account for one quarter each of the cyclical volatility of residential investment and house prices. Monetary shocks account for between 15 and 20 percent
Impulse Responses, Housing Preference Shocks

- Real Consumption
- Real Business Investment
- Real Residential Investment
- Real House Prices
- Real GDP
- Nominal Interest Rate

- Flexible Price
- Flexible Wage
- No Collateral Effects
- Baseline
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Role of Monetary Shocks

1. Sensitivity of residential investment to monetary shocks larger than that of business investment, in line with VAR evidence
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2. Key reason: wage stickiness
   If IH sector were flex wage, flex price, it would not contract after contractionary policy (BHK 2007)
Role of Monetary Shocks

1. Sensitivity of residential investment to monetary shocks larger than that of business investment, in line with VAR evidence

2. Key reason: wage stickiness
   If IH sector were flex wage, flex price, it would not contract after contractionary policy (BHK 2007)

3. Model elasticity of house prices to a monetary shocks of similar magnitude to what is found in VAR studies
Our two original questions, revisited.

1. What drives the housing market? Focus on recent period.
2. How big are the spillovers? Focus on pre and post 1980’s
WHAT DRIVES THE HOUSING MARKET?

Focus on 2000-2006:

<table>
<thead>
<tr>
<th>Period</th>
<th>% q</th>
<th>Technology</th>
<th>Monetary Pol.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998:I</td>
<td>14.1</td>
<td>5.9</td>
<td>2.1</td>
</tr>
<tr>
<td>2005:I</td>
<td>-0.3</td>
<td>-0.2</td>
<td>-2.7</td>
</tr>
<tr>
<td>2005:II</td>
<td>-15.5</td>
<td>-4.3</td>
<td>-11.4</td>
</tr>
<tr>
<td>2006:IV</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparison with 1976-1985 period: monetary policy has played a larger role here.
The figure shows the real house prices and real residential investment over the years from 1965 to 2005. The smooth black line represents the actual data, while the dotted lines with different colors represent various shocks and preferences. The x-axis represents the years, and the y-axis represents the real house prices and real residential investment, with a scale ranging from -0.4 to 0.2.
HOW BIG ARE THE SPILLOVERS?

- Most of the spillovers are through the effect on consumption. For given LTV \( m \), they are a function of \( \alpha \).

Regression based on artificial data generated by the model

\[
\Delta \log C_t = 0.0041 + 0.123 \Delta \log HW_{t-1} \quad \text{if} \quad \alpha = 0.79 \\
\Delta \log C_t = 0.0041 + 0.099 \Delta \log HW_{t-1} \quad \text{if} \quad \alpha = 1
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- To better measure spillovers in sample, we re-estimate the model across subsamples (1965-1982, 1989-2006).
  
  First period: fix $m = 0.775$, $1 - \hat{\alpha} = 0.33$
  Second period: fix $m = 0.925$, $1 - \hat{\alpha} = 0.21$
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  First period: fix $m = 0.775, 1 - \hat{\alpha} = 0.33$
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- Two implications
  Monetary policy is more “powerful” in the second period
  Housing shocks have larger spillover effects on consumption in the second period
Variance of yoy $\Delta C$ explained by collateral effects in
1965-1982: 4 percent  
1989-2006: 12 percent
Doomsday scenario: what if the drop in house prices continues?  
Based on estimates up to 2008Q2  
(Assuming a further decline in house prices over the next two years)
CONCLUSIONS

- Housing demand shocks and housing technology shocks account for roughly one quarter each of the cyclical volatility of residential investment and house prices. Monetary shocks account for between 15 and 20 percent.
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- Spillovers from the housing market to the broader economy are non-negligible and concentrated on consumption rather than business investment.
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• Housing demand shocks and housing technology shocks account for roughly one quarter each of the cyclical volatility of residential investment and house prices. Monetary shocks account for between 15 and 20 percent.

• Spillovers from the housing market to the broader economy are non-negligible and concentrated on consumption rather than business investment.

• These spillovers might have become more important over time, to the extent that financial innovation has increased the marginal availability of funds for credit-constrained agents.
Autocorrelations

Sample Autocorrelation Function (ACF), inflation

Sample Autocorrelation Function (ACF), house price inflation
Alternative model versions

- Real Consumption
- Real Residential Investment
- Real Business Investment
- Real House Prices
- Inflazione
- Nominal Interest Rate

Graphs illustrate the behavior of different economic indicators over time, with lines representing baseline and adjusted cost scenarios, and points indicating unit root scenarios.
Inflation and housing

![House prices](image1)

![Housing investment](image2)

![Inflation (annualized)](image3)

![Inflation objective](image4)