Monetary Policy and Housing Prices in an Estimated DSGE Model for the US and the Euro Area

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\(^1\)European Central Bank
\(^2\)Banca d’Italia

Monetary policy transmission mechanism in the euro area in its first 10 years
European Central Bank, 28-29 September 2009
Role of **housing** markets and credit **frictions** for business cycle analysis and monetary policy conduct in **open** economy

- Recent growing literature on housing and credit frictions in monetary economies
- Empirical evidence on monetary policy and housing (Jarocinski and Smets (2008)): accounting for house prices may sharpen inference on monetary policy conduct over time
- Open economy: quantify degree of international spillovers and explore implications for optimal monetary policy cooperation
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- Merge two (separate) strands of literature:

  1. Credit frictions and housing DSGE: mainly closed economy (Aoki (2004), Iacoviello (2005), Iacoviello and Neri (2008), Calza et al. (2009), Monacelli (2009)), very few open economy (Christensen et al. (2008), soe for Canada)

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- Build and estimate two-country model with housing sector

- Analyze monetary policy response to housing-related disturbances

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  2. *Normative*: some degree of reaction consistent with optimal response to housing-related shocks
Road map

- Model snapshot
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- Estimation results: parameters, moments, role of housing shocks
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- Conclusions
Model

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Model: closed economy

Equations
Model: open-economy (I)

NON-RESIDENTIAL GOODS SECTOR

DISTRIBUT. (F)

FINAL CONSUMPTION GOOD (F)

IMPORTED GOOD $Y_H^* (j)$

DOMESTIC GOOD $Y_F^* (j)$

INTERMEDIATE CONSUMPTION GOODS (F)

INTERMEDIATE CONSUMPTION GOODS

H-exports

F-exports

K

N

K*

N*
Model: open-economy (II)

RESIDENTIAL GOODS SECTOR (NO TRADE)

FINALE GOODS

Y_D

Y_D (j)

INTERMEDIATE RESIDENTIAL GOODS

FINAL GOODS

Y_D

Y_D (j)

INTERMEDIATE RESIDENTIAL GOODS

FINALE GOODS

Y_D

Y_D (j)

INTERMEDIATE RESIDENTIAL GOODS

Capital
Labor
Land
Capital*
Labor*
Land*
Econometric strategy

Econometric strategy

- Method: Bayesian estimation of the DSGE model: calibration and prior choice
- Symmetric specification of behavioural equations for US and Euro Area

Data: 1985q1 : 2005q4
- macro variables for each area: GDP, cons, invest, employment, CPI, GDP deflator, real wages, 3-month interest rate
- housing variables: real house prices, residential investment, household debt

Open-economy: US current account, euro/dollar exchange rate

Exogenous shocks:
- inefficient shocks and monetary policy shocks are i.i.d.
- all other shocks: AR(1)
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Estimation results: posterior distributions

- Closed economy: results broadly in line with literature (Smets and Wouters (2005)), except for:
  - Risk aversion: $\sigma_X = 0.64$, $\sigma_X = 1.06$.
  - Habit: $h = 0.58$, $h = 0.83$, $h_B = 0.31$, $h_B = 0.28$.

- Open economy: in line with literature (Adjemian et al. (2008)).
  - High home bias (0.98).
  - Low pricing-to-market ($\eta = 0.98$, $\eta = 0.86$).

- Housing-related parameters:
  - Share of borrowers ($\omega$, $\omega$) posterior modes: 0.24, 0.19, lower than prior mean (0.35).
  - Low nominal rigidity in housing sector.
  - High persistence of housing shocks.
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### Matching moments

> Cross-country correlations

<table>
<thead>
<tr>
<th></th>
<th>data</th>
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<th>high</th>
<th>borr</th>
<th>augm.TR</th>
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<tr>
<td>$Z_t, C_t$</td>
<td>0.80</td>
<td>0.68</td>
<td>0.70</td>
<td>0.70</td>
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<tr>
<td>$Z_t, I_t$</td>
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<td>0.72</td>
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<td>0.31</td>
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<tr>
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<td>$T_{Dt}, T^*_{Dt}$</td>
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<td>$\Delta s_t, C_{At}$</td>
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<td>-0.21</td>
<td>-0.34</td>
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</table>
## Housing shocks and economic fluctuations

- **Variance decomposition**

<table>
<thead>
<tr>
<th></th>
<th>Domestic Housing</th>
<th>Other Domestic</th>
<th>Non Domestic</th>
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<tbody>
<tr>
<td></td>
<td>$\epsilon_t^{AD}$</td>
<td>$\epsilon_t^{LTV}$</td>
<td>$\epsilon_t^D$</td>
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<tr>
<td><strong>US</strong></td>
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<tr>
<td>$Z_t$</td>
<td>0.34</td>
<td>0.39</td>
<td>2.45</td>
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<tr>
<td>$C_t$</td>
<td>1.32</td>
<td>1.30</td>
<td>2.99</td>
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<tr>
<td>$Z_{Dt}$</td>
<td>57.65</td>
<td>0.04</td>
<td>31.93</td>
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<tr>
<td>$T_{Dt}$</td>
<td>7.87</td>
<td>0.08</td>
<td>80.11</td>
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<tr>
<td>$\Pi_t$</td>
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<td>0.01</td>
<td>0.02</td>
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<tr>
<td>$R_t$</td>
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<td>0.48</td>
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<tr>
<td>$B_t$</td>
<td>2.94</td>
<td>36.16</td>
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<td><strong>Euro Area</strong></td>
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<tr>
<td>$Z_{t}^*$</td>
<td>0.09</td>
<td>0.25</td>
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<tr>
<td>$C_{t}^*$</td>
<td>0.68</td>
<td>0.92</td>
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<tr>
<td>$Z_{Dt}^*$</td>
<td>59.51</td>
<td>0.04</td>
<td>34.36</td>
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<tr>
<td>$T_{Dt}^*$</td>
<td>5.62</td>
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<td>$\Pi_t^*$</td>
<td>0.03</td>
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<td>$R_{t}^*$</td>
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<td>$B_{t}^*$</td>
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<td>$\Delta S_t$</td>
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<td>0.00</td>
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<tr>
<td>$CA_t$</td>
<td>0.00</td>
<td>0.01</td>
<td>0.84</td>
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</table>

- **Sensitivity to $\omega$**
The propagation of EA monetary policy shocks

- Benchmark (plain and shaded area), high $\omega$ (dotted, blue), $\omega = 0$ (cross, red)
The propagation of EA housing demand shocks

- **Housing preference** Def: Benchmark (plain and shaded area), high $\omega$ (dotted, blue), $\omega = 0$ (cross, red)
Summary of results on internal propagation mechanism

- Housing-specific shocks generate sizeable effects on non-residential consumption (*collateral channel*)
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- Open economy: *small* international spillovers (housing sector is flex-price, nontraded)
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- However, housing shocks help capturing observed cross-correlations in residential investment and housing prices
Summary of results on internal propagation mechanism

- Housing-specific shocks generate sizeable effects on non-residential consumption (*collateral channel*)
- Open economy: *small* international spillovers (housing sector is flex-price, nontraded)
- However, housing shocks help capturing observed cross-correlations in residential investment and housing prices
- Credit frictions alter the relative responses of aggregate consumption and output to exogenous shocks (e.g. G shocks)
Monetary policy and housing prices

- Monetary policy implications of housing-related disturbances
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- *Positive* perspective: estimate model under *augmented* Taylor rules (allow for *systematic* response to house price fluctuations)
Monetary policy and housing prices

- Monetary policy implications of housing-related disturbances
- *Positive* perspective: estimate model under *augmented* Taylor rules (allow for *systematic* response to house price fluctuations)
- *Normative* perspective: compare response to housing demand shock under (i) estimated rules and (ii) optimal monetary policy cooperation
Positive perspective: estimate model under augmented Taylor rules

\[ r_t = \rho r_{t-1} + r_{\Delta \pi} (\pi_t - \pi_{t-1}) + (1 - \rho) (r_{\pi \pi} \pi_{t-1} + r_y y_{t-1}) + r_{\Delta y} \Delta y_t + r_{\Delta T_D} \Delta t_{D,t} + \log(\varepsilon^R_t) \]
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Prior distributions for \( r_{\Delta T_D}, r_{\Delta T_D}^* : N(0,0.5) \)
Historical conduct of monetary policy (I)

- **Positive** perspective: estimate model under *augmented* Taylor rules

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    + r_{\Delta y} \Delta y_t + r_{\Delta T_D} \Delta t_{D,t} + \log(\varepsilon_t^R)
\]

- Prior distributions for $r_{\Delta T_D}, r^{*}_{\Delta T_D}: N(0,0.5)$
- Estimated posterior modes: $r_{\Delta T_D} = 0.10$, $r^{*}_{\Delta T_D} = 0.17$ (other parameters robust)
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- Estimated posterior modes: \( r_{\Delta T_D} = 0.10, \ r^*_T = 0.17 \) (other parameters robust)

- Large improvement in fit: log marginal density = -2450.12 (benchmark: -2485.19)
Historical conduct of monetary policy (II)

- Analyze historical role of housing preference shocks (not reported)

Housing pref. shocks capture larger share of volatility, smaller of residential investment and house prices

Intuition: "housing demand (t)" "cost of borrowing" counteract initial "housing demand"

Thus: larger fluctuations in r, smaller response of housing quantities and prices
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Optimal monetary policy cooperation

- Optimal policy cooperation (Ramsey): max conditional expected welfare

\[
\mathcal{W}_{\text{world},0} = \mathcal{W}_{\text{H},0} + \mathcal{W}_{\text{F},0}
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Definitions
Optimal monetary policy cooperation

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**Definitions:**

\[ \mathcal{W}_{H,t} \equiv \omega \mathcal{W}^B_{H,t} + (1 - \omega) \mathcal{W}^S_{H,t} + \lambda_R \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j (R_{t+j} - R^*)^2 \]

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- Restrict attention to optimal response to housing demand shocks (not large fluctuations in housing prices)
- Do not provide systematic analysis of all factors that affect optimal cooperation (future research)
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Optimal response to housing preference shock

- Optimal response (plain) with benchmark (dotted) and augmented estimated Taylor rule (cross, blue)

- Optimal and augmented Taylor rule quite similar in US (less so in EA)
Optimal response to housing preference shock

- No borrowing ($\omega = 0$)

- Still optimal to control for housing price fluctuations
Optimal simple rules

- Additional exercise: compute optimal (welfare-max) simple rules: $r_{\Delta T_{D,t}} = 0.04$, $r_{\Delta T_{D,t}}^* = 0.02$
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- Results are \textbf{conditional} on type of structural disturbances considered
Conclusions

- Explore role of housing markets and credit frictions for monetary policy conduct in open economy.
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  1. Better characterization of credit frictions to account for cross-country transmission of shocks
  2. Deeper analysis of optimal monetary policy cooperation
THE END
Housing sector data

- US: Census index (quality-adjusted, price of new one-family houses sold including value of lot); alternatives: OFHEO (Conventional Mortgage House Price Index): repeat sales, upward biased; Case-Shiller-Weiss: repeat sales, shorter period

- Euro Area: interpolate original (annual) data to obtain quarterly series
Housing preference shock

\[
\tilde{X}_t^b \equiv \left[ \left( 1 - \epsilon_t^D \omega_D \right)^{\frac{1}{\eta_D}} \left( \tilde{C}_t^b - h_b \tilde{C}_{t-1}^b \right)^{\frac{\eta_D-1}{\eta_D}} + \left( \epsilon_t^D \omega_D \right)^{\frac{1}{\eta_D}} \left( \tilde{D}_t^b \right)^{\frac{\eta_D-1}{\eta_D}} \right]^{\eta_D \over \eta_D-1}
\]

\[
X_t^s \equiv \left[ \left( 1 - \epsilon_t^D \omega_D \right)^{\frac{1}{\eta_D}} \left( C_t^s - h_s C_{t-1}^s \right)^{\frac{\eta_D-1}{\eta_D}} + \left( \epsilon_t^D \omega_D \right)^{\frac{1}{\eta_D}} \left( D_t^s \right)^{\frac{\eta_D-1}{\eta_D}} \right]^{\eta_D \over \eta_D-1}
\]

\[
\epsilon_t^D = \rho_D \epsilon_{t-1}^D + u_t^D
\]
Loan-to-value ratio shock

\[
\tilde{b}_{H,t} \leq \varepsilon_t^{LTV} (1 - \chi) \mathbb{E}_t \left\{ T_{D,t+1} \tilde{D}_t \frac{\pi_{t+1}}{R_t} \right\}
\]

\[
\varepsilon_t^{LTV} = \rho_{LTV} \varepsilon_{t-1}^{LTV} + u_t^{LTV}
\]
Optimal monetary policy response to housing demand shocks

▶ Euro Area
Housing market and collateral constraints

- Two household types in each country:

  ▶ Different intertemporal discount factor shares: $(1 - \omega)$ patient, $\omega$ impatient.

  Credit frictions: collateral constraint faced by impatient agent $(\epsilon b_H, t) (1 - \chi) E_t T D_t, t + 1 e^{-D_t / \pi_t} + 1 R_t$.

  Residential goods sector: dual role. Housing (durable good) can be consumed and pledged as collateral. Housing good cannot be internationally traded.
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  \]

- Residential goods sector: dual role
  - housing (durable good) can be consumed and pledged as collateral
  - housing good *cannot* be internationally *traded*
Borrower’s problem

\[
\max E_t \left\{ \sum_{j \geq 0} \beta^j \left[ \frac{1}{1-\sigma_X} \left( \tilde{X}^b_{t+j} \right) \frac{1}{1-\sigma_X} - \frac{\varepsilon^L_{t+j} \tilde{L}_C}{1+\sigma_L} \left( L^b_{C,t+j} \right) \frac{1}{1+\sigma_L} \right] \right\}
\]

consumption index:

\[
\tilde{X}^b_t \equiv \left[ (1 - \varepsilon^D_t \omega_D) \right]^{\frac{1}{\eta_D}} \left( \tilde{C}^b_t - h_B \tilde{C}_{t-1} \right)^{\frac{\eta_D-1}{\eta_D}} + \left( \varepsilon^D_t \omega_D \right)^{\frac{1}{\eta_D}} \left( \tilde{D}^b_t \right)^{\frac{\eta_D-1}{\eta_D}}\right]^{\frac{\eta_D}{\eta_D-1}}
\]

s.t.

\[
\tilde{C}^b_t + T_{D,t} \left( \tilde{D}^b_t - (1 - \delta) \tilde{D}^b_{t-1} \right) + \frac{R_{t-1} \tilde{B}^b_{H,t-1}}{\pi_t P_{t-1}}
\]

\[
= \frac{\tilde{B}^b_{H,t}}{P_t} + \frac{\tilde{A}^b_t}{P_t} + \frac{W^b_{C,t} L^b_{C,t} + W^b_{D,t} L^b_{D,t}}{P_t}
\]

and

\[
\tilde{b}_{H,t} \leq \varepsilon^{LTV}_t (1 - \chi) \mathbb{E}_t \left\{ T_{D,t} + \frac{\tilde{D}_t}{R_t} \right\}
\]
Saver’s problem

$$\max \mathbb{E}_t \left\{ \sum_{j \geq 0} \gamma^j \left[ \frac{1}{1-\sigma_X} \left( X^s_{t+j} \right)^{1-\sigma_X} - \frac{\varepsilon^L_{t+j} L^C}{1+\sigma_{LC}} \left( L^s_{C,t+j} \right)^{1+\sigma_{LC}} \right] \right\}$$

consumption index:

$$X^s_t \equiv \left[ \left( 1 - \varepsilon^D_t \omega_D \right)^{\frac{1}{\eta_D}} \left( C^s_t - h C^s_{t-1} \right)^{\frac{\eta_D-1}{\eta_D}} + \varepsilon^D_t \omega^\frac{1}{\eta_D} D^s_t \right]^{\frac{\eta_D}{\eta_D-1}}$$

s.t.

$$C^s_t + T_{D,t} \left( D^s_t - (1 - \delta) D^s_{t-1} \right) + I^s_t + \frac{B^s_{H,t}}{P_t} + \frac{S_t B^s_{F,t}}{P_t} = \frac{R_{t-1} B^s_{H,t-1}}{\pi_t P_{t-1}} + \frac{S_t R^*_t B^s_{F,t-1}}{\pi_t P_{t-1}} + \sum_{j=C,D} \left[ R^k_{t-1} u^j_t K^j_t - \Phi \left( u^j_t \right) K^j_t \right]$$

$$+ \frac{(W^s_{C,t} L^s_{C,t} + W^s_{D,t} L^s_{D,t})}{P_t} + A^s_t + \Pi^s_t$$
Structural shocks

- efficient: technology ($\varepsilon^A_t, \varepsilon^A_{t*}, \varepsilon^A_{tD}, \varepsilon^A_{tD*}$), investment ($\varepsilon^I_t, \varepsilon^I_{t*}$), labor supply ($\varepsilon^L_t, \varepsilon^L_{t*}$), public expenditure ($\varepsilon^G_t, \varepsilon^G_{t*}$), taste ($\varepsilon^B_t, \varepsilon^B_{t*}$), housing preference ($\varepsilon^D_t, \varepsilon^D_{t*}$), loan-to-value ratio ($\varepsilon^{LTV}_t, \varepsilon^{LTV*}_t$), relative home bias ($\varepsilon^{\Delta n}_t$)
Structural shocks

- efficient: technology ($\varepsilon^A_t$, $\varepsilon^A_t^*$, $\varepsilon^D_t$, $\varepsilon^D_t^*$), investment ($\varepsilon^I_t$, $\varepsilon^I_t^*$), labor supply ($\varepsilon^L_t$, $\varepsilon^L_t^*$), public expenditure ($\varepsilon^G_t$, $\varepsilon^G_t^*$), taste ($\varepsilon^B_t$, $\varepsilon^B_t^*$), housing preference ($\varepsilon^D_t$, $\varepsilon^D_t^*$), loan-to-value ratio ($\varepsilon^{LTV}_t$, $\varepsilon^{LTV}_t^*$), relative home bias ($\varepsilon^{\Delta n}_t$)

- inefficient: PPI markups ($\varepsilon^P_t$, $\varepsilon^P_t^*$), CPI markups ($\varepsilon^{CPI}_t$, $\varepsilon^{CPI}_t^*$), external finance risk premium ($\varepsilon^Q_t$, $\varepsilon^Q_t^*$), UIP ($\varepsilon^{\Delta S}_t$)
Structural shocks

- efficient: technology ($\varepsilon_t^A, \varepsilon_t^{A*}, \varepsilon_t^{AD}, \varepsilon_t^{AD*}$), investment ($\varepsilon_t^I, \varepsilon_t^{I*}$), labor supply ($\varepsilon_t^L, \varepsilon_t^{L*}$), public expenditure ($\varepsilon_t^G, \varepsilon_t^{G*}$), taste ($\varepsilon_t^B, \varepsilon_t^{B*}$), housing preference ($\varepsilon_t^D, \varepsilon_t^{D*}$), loan-to-value ratio ($\varepsilon_t^{LTV}, \varepsilon_t^{LTV*}$), relative home bias ($\varepsilon_t^{\Delta n}$)
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- monetary policy ($\varepsilon_t^R, \varepsilon_t^{R*}$)
Structural shocks

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- monetary policy ($\varepsilon^R_t, \varepsilon^R_t^*$)

- common: $f^A_t, f^{CPI}_t, f^R_t$
Structural shocks

- efficient: technology ($\varepsilon_A^t$, $\varepsilon_A^t$, $\varepsilon_D^t$, $\varepsilon_D^t$), investment ($\varepsilon_I^t$, $\varepsilon_I^t$), labor supply ($\varepsilon_L^t$, $\varepsilon_L^t$), public expenditure ($\varepsilon_G^t$, $\varepsilon_G^t$), taste ($\varepsilon_B^t$, $\varepsilon_B^t$), housing preference ($\varepsilon_D^t$, $\varepsilon_D^t$), loan-to-value ratio ($\varepsilon_{LTV}^t$, $\varepsilon_{LTV}^t$), relative home bias ($\varepsilon_{\Delta n}^t$)

- inefficient: PPI markups ($\varepsilon_P^t$, $\varepsilon_P^{t*}$), CPI markups ($\varepsilon_{CPI}^t$, $\varepsilon_{CPI}^{t*}$), external finance risk premium ($\varepsilon_Q^t$, $\varepsilon_Q^{t*}$), UIP ($\varepsilon_{\Delta S}^t$)

- monetary policy ($\varepsilon_R^t$, $\varepsilon_R^{t*}$)

- common: $f_A^t$, $f_{CPI}^t$, $f_R^t$

- allow for some covariance between shocks, to capture rest-of-the-world dynamics
Calibrated parameters:

- Preferences: $\beta = 0.96$, $\gamma = 0.99$
- Technology: $\delta_K = 0.1$, $\alpha_C = 0.3$, $\alpha_D = 0.2$, $\alpha_L = 0.1$ (to keep constant share of labor)
- Housing-specific: $\delta = 0.01$, $\omega_D = 0.1$; flexible prices
- Loan-to-value ratio: $\chi = 0.8$. Data not informative, high heterogeneity in EA.

Prior specification: symmetric distributions across countries.
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- Prior specification: symmetric distributions across countries
Housing shocks and economic fluctuations

- variance decomposition: sensitivity to $\omega$

<table>
<thead>
<tr>
<th></th>
<th>No Borrowers</th>
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<td>Non Domestic</td>
<td>Domestic</td>
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<td>9.92</td>
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Euro Area

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<td>$Z_{Dt}^*$</td>
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<tr>
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Welfare criteria: definitions

\[ \mathcal{W}_t^b \equiv E_t \left\{ \sum_{j \geq 0} \beta^j \left[ \frac{1}{1-\sigma_X} \left( \tilde{X}_{t+j}^b \right)^{\frac{1}{1-\sigma_X}} - \frac{\varepsilon_{t+j}^L \tilde{L}_C}{1+\sigma_{LC}} \left( L_{C,t+j}^b \right)^{\frac{1}{1+\sigma_{LC}}} \right] \right\} \]

\[ \mathcal{W}_t^s \equiv E_t \left\{ \sum_{j \geq 0} \gamma^j \left[ \frac{1}{1-\sigma_X} \left( X_{t+j}^s \right)^{\frac{1}{1-\sigma_X}} - \frac{\varepsilon_{t+j}^L \tilde{L}_C}{1+\sigma_{LC}} \left( L_{C,t+j}^s \right)^{\frac{1}{1+\sigma_{LC}}} \right] \right\} \]
Inference on $\omega$

- Sensitivity analysis on $(\omega, \omega^*)$:

<table>
<thead>
<tr>
<th>Prior</th>
<th>B(0.35,0.05)</th>
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| Marginal Loglik. | -2485.19 | -2509.12 | -2478.30 |

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[Back]
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Distributions

- Aggregate observables vs. type-specific model-generated series

Back
Estimation results: Priors and posteriors

- borrowers’ shares: benchmark priors
Estimation results: Priors and posteriors

- borrowers’ shares: benchmark priors

- borrowers’ shares: high priors
Optimal response to a LTV ratio shock

- Optimal response (plain) with benchmark (dotted, red) and augmented estimated Taylor rule (cross, blue)
The propagation of US monetary policy shocks

- Benchmark (plain and shaded area), high $\omega$ (dotted, blue), $\omega = 0$ (cross, black)
The propagation of US housing demand shocks

- Housing preference: Benchmark (plain and shaded area), high $\omega$ (dotted, blue), $\omega = 0$ (cross, black)