Risky Mortgages in a DSGE Model

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Motivation

- The global financial crisis started with an increase in U.S. mortgage delinquencies ▸ Graph
- Banks wrote down several hundred billion dollars in bad loans
- Liquidity crisis brought several financial institutions into or on the brink of bankruptcy
- Credit crunch and the Great Recession

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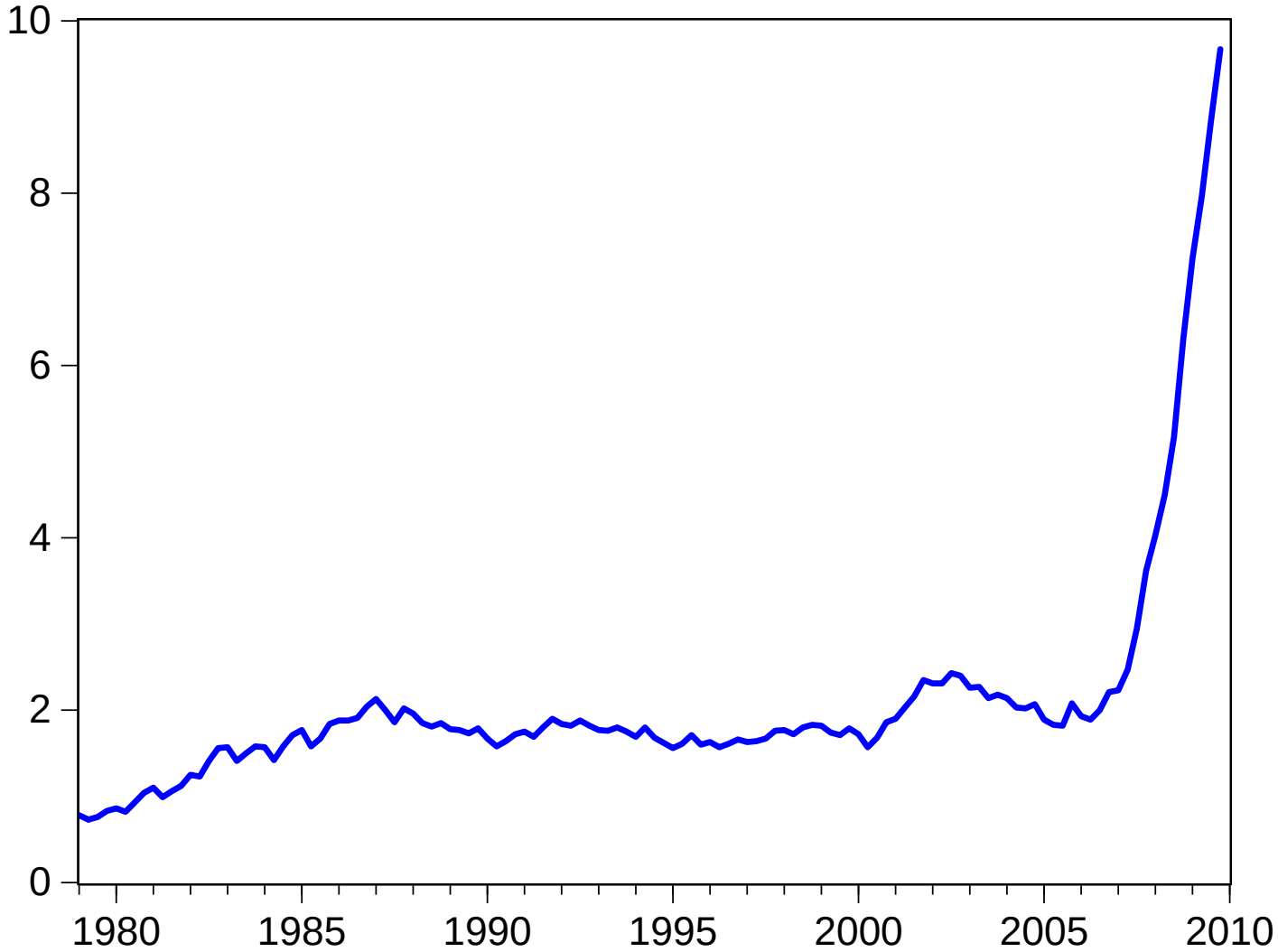
U.S. Seriously Delinquent Mortgages



Percentage of total loans; Not seasonally adjusted

Source: Mortgage Bankers Association, National Delinquency Survey

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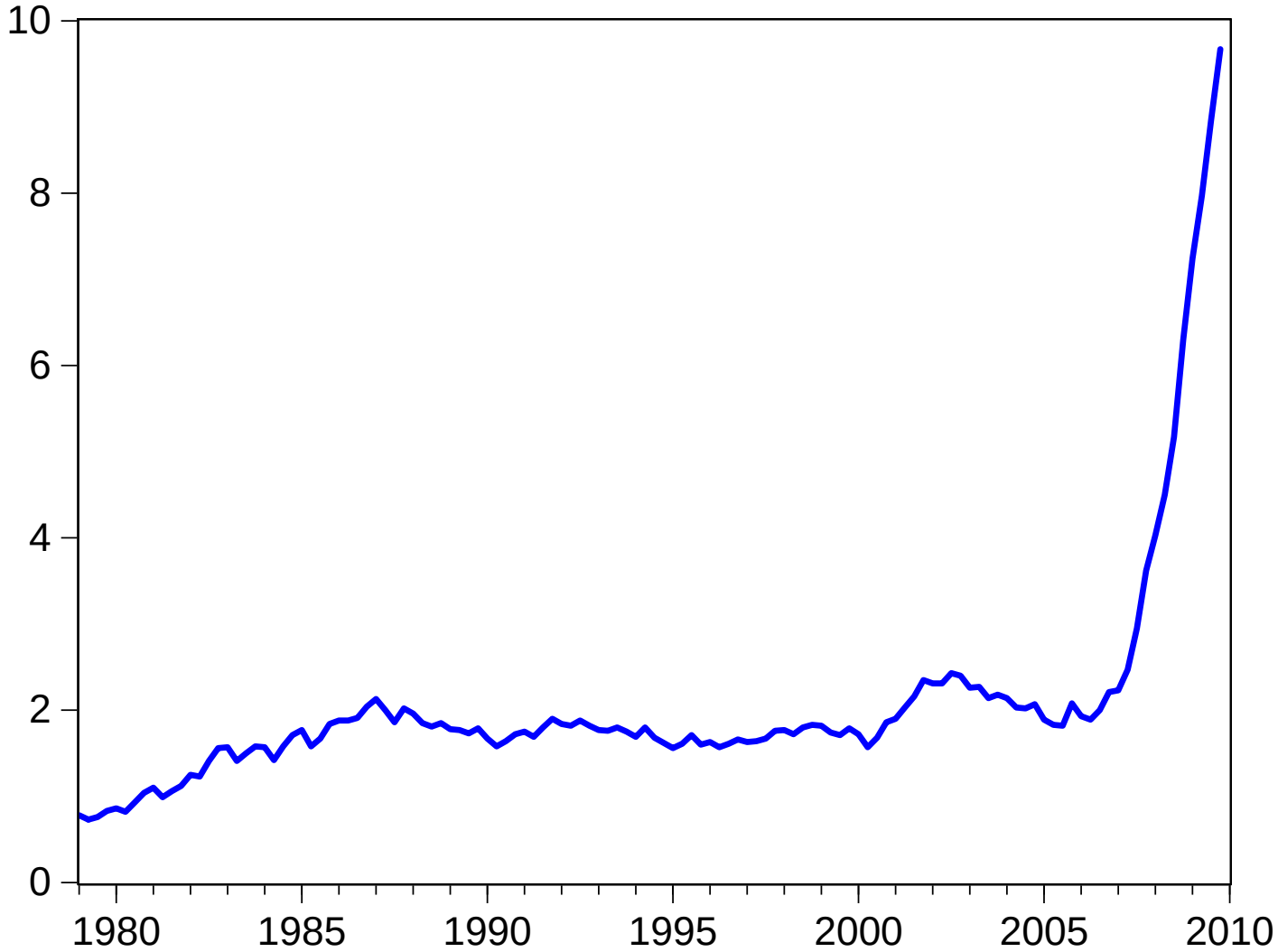

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This Paper

- Focuses on an increase in mortgage delinquencies and its transmission to the rest of the economy
- Introduces endogenous default on mortgages in a DSGE model with housing
- Analyzes an unanticipated increase in mortgage risk
- Compares economies with different leverage ratios
- Compares different degrees of interest rate inertia in monetary policy

Results

1. An increase in mortgage risk
   - raises mortgage default and the mortgage premium
   - produces a credit crunch that generates a recession
2. Economies with lower mortgage risk have higher leverage ratios
3. High leverage ratios amplify the effects of a mortgage risk shock
4. Inertial monetary policies amplify the effects of a mortgage risk shock (zero lower bound scenario)

Literature

- **Housing Sector**: Iacoviello (2005), Iacoviello and Neri (2009), Calza, Monacelli and Stracca (2009), Aoki, Proudman and Vlieghe (2004)
- **Durable Consumption Goods**: Barsky, House and Kimball (2007), Erceg and Levin (2006), Carlstrom and Fuerst (2006), Monacelli (2009)
- **Financial Accelerator**: Bernanke and Gertler (1989), Carlstrom and Fuerst (1997), Bernanke, Gertler and Gilchrist (1999)
- **Risk, Default and Repayment Shocks**: Christiano, Motto and Rostagno (2009), Cohen-Cole and Martinez-Garcia (2008), Iacoviello (2010), Dellas, Diba and Loisel (2010)

The Model
Households

Fraction ψ of impatient (Borrowers) and $1 - \psi$ of patient (Savers) households

- Consume a non-durable good, C_t
- Consume services from and accumulate houses, H_{t+1}
- Supply two types of labor, $N_{C,t}$ and $N_{H,t}$
- Savers make loans to Borrowers, L_{t+1}

Borrowers

$$\max_{C_t, H_{t+1}, N_{C,t}, N_{H,t}, L_{t+1}, \bar{\omega}_{t+1}} \sum_{t=0}^{\infty} \beta^t E_0 \left\{ U\left(X_t, N_{C,t}, N_{H,t}\right) \right\}, \quad 0 < \beta < 1$$

where

$$X_t \equiv \left[(1-\alpha)^{\frac{1}{\eta}} C_t^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} H_{t+1}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \quad \eta \geq 0,$$

subject to three constraints:

Budget constraint (nominal terms)

$$P_{C,t} C_t + P_{H,t} H_{t+1} + [1 - F(\bar{\omega}_t)](1 + R_{Z,t}) L_t = L_{t+1} + W_{C,t} N_{C,t} +$$

$$W_{H,t} N_{H,t} + (1-\delta) [1 - G(\bar{\omega}_t)] P_{H,t} H_t,$$

Participation constraint

Incentive-compatibility constraint

Mortgage Risk

- Each household consists of many members
- The household decides total housing investment H_{t+1}
- The i-th member receives H^i_{t+1} and finalizes the mortgage contract according to household instructions
- Idiosyncratic shock ω^i_{t+1} (observable by the member only) such that the ex-post housing stock is $\omega^i_{t+1} H^i_{t+1}$ (or ex-post housing value is $\omega^i_{t+1} p_{H,t+1} H^i_{t+1}$)
- $E_t(\omega^i_{t+1} H^i_{t+1}) = H_{t+1}$, i.e. there is *no* aggregate mortgage risk
- For $\omega^i_{t+1} \in [0, \bar{\omega}_{t+1})$ loans are defaulted; for $\omega^i_{t+1} \in [\bar{\omega}_{t+1}, \infty]$ loans are repaid
- Lenders pay the cost μ to monitor defaulting borrowers and seize the collateral
- Perfect insurance among household members

The Mortgage Contract

Participation constraint of lenders

$$(1+R_{L,t})L_{t+1} = \int_0^{\bar{\omega}_{t+1}} \omega_{t+1}(1-\mu)(1-\delta)P_{H,t+1}H_{t+1}f(\omega)d\omega + \int_{\bar{\omega}_{t+1}}^{\infty} (1+R_{Z,t+1})L_{t+1}f(\omega)d\omega$$

Incentive-compatibility constraint

$$\bar{\omega}_{t+1}(1-\delta)P_{H,t+1}H_{t+1} = (1+R_{Z,t+1})L_{t+1}$$

$R_{L,t}$ is the pre-determined and non-state-contingent rate of return on total loans

$R_{Z,t+1}$ is the adjustable and state-contingent mortgage rate

$\bar{\omega}_{t+1}$ is the threshold value of the idiosyncratic shock

Savers

$$\max_{\widetilde{C}_t,\widetilde{H}_{t+1},\widetilde{N}_{C,t},\widetilde{N}_{H,t}\widetilde{L}_{t+1}} \sum_{t=0}^{\infty} \gamma^t E_0 \left\{ U(\widetilde{X}_t, \widetilde{N}_{C,t}, \widetilde{N}_{H,t}) \right\}, \qquad 0 < \beta < \gamma < 1$$

subject to

$$P_{C,t}\widetilde{C}_t + P_{H,t}\widetilde{H}_{t+1} + \widetilde{L}_{t+1} = (1 + R_{L,t-1})\widetilde{L}_t + W_{C,t}\widetilde{N}_{C,t} + W_{H,t}\widetilde{N}_{H,t}$$

$$+\widetilde{\Delta}_t + (1 - \delta)P_{H,t}\widetilde{H}_t$$

where $\widetilde{\Delta}_t$ are profits from firms

Intermediate Goods Producers

- Each sector has monopolistically competitive intermediate goods producers
- Continuum of differentiated goods $i \in [0,1]$
- Firm i produces according to

$$Y_{j,t}(i) = A_{j,t}\left[\zeta^{\frac{1}{\varsigma}} N_{j,t}(i)^{\frac{\varsigma-1}{\varsigma}} + (1-\zeta)^{\frac{1}{\varsigma}} \widetilde{N}_{j,t}(i)^{\frac{\varsigma-1}{\varsigma}}\right]^{\frac{\varsigma}{\varsigma-1}}, \quad 0 < \zeta < 1, \varsigma > 0$$

- Calvo price setting

Final Goods Producers

- Each sector has perfectly competitive final goods producers
- Flexible prices and CRS technology

$$Y_{j,t} = \left(\int_0^1 Y_{j,t}(i)^{\frac{\varepsilon_j - 1}{\varepsilon_j}} di \right)^{\frac{\varepsilon_j}{\varepsilon_j - 1}}, \quad \varepsilon_j > 1, \quad j = C, H$$

Monetary Policy

Monetary policy rule:

$$\frac{1+R_{L,t}}{1+R_L} = A_{M,t}\left[\pi_{C,t}^{\phi_\pi}\right]^{1-\phi_r}\left[\frac{1+R_{L,t-1}}{1+R_L}\right]^{\phi_r}, \quad \phi_\pi > 1,\ \phi_r < 1$$

- Interest rate smoothing
- Monetary policy targets inflation in the non-durable sector

Functional Forms

Utility function:

$$U(X_t, N_{C,t}, N_{H,t}) \equiv \ln X_t - \frac{\nu}{1+\varphi}\left[N_{C,t}^{1+\xi} + N_{H,t}^{1+\xi}\right]^{\frac{1+\varphi}{1+\xi}}, \qquad \varphi, \xi \geq 0$$

Leverage Ratio:

$$\frac{I}{I + w_C N_c + w_H N_H}$$

Total output:

$$Y_t = Y_{C,t} + p_{h,t} Y_{H,t}$$

Exogenous Shocks

$$\ln A_{C,t} = \rho_C \ln A_{C,t-1} + \epsilon_{C,t}$$

$$\ln A_{H,t} = \rho_H \ln A_{H,t-1} + \epsilon_{H,t}$$

$$\ln A_{M,t} = \rho_M \ln A_{M,t-1} + \epsilon_{M,t}$$

Idiosyncratic risk in the housing sector:

$$\ln \omega_t \sim N(-\frac{\sigma^2_{\omega,t}}{2}, \sigma^2_{\omega,t})$$

Mortgage risk shock:

$$\ln \frac{\sigma_{\omega,t}}{\sigma_\omega} = \rho_\sigma \ln \frac{\sigma_{\omega,t-1}}{\sigma_\omega} + \epsilon_{\sigma_\omega,t}$$

Benchmark Calibration

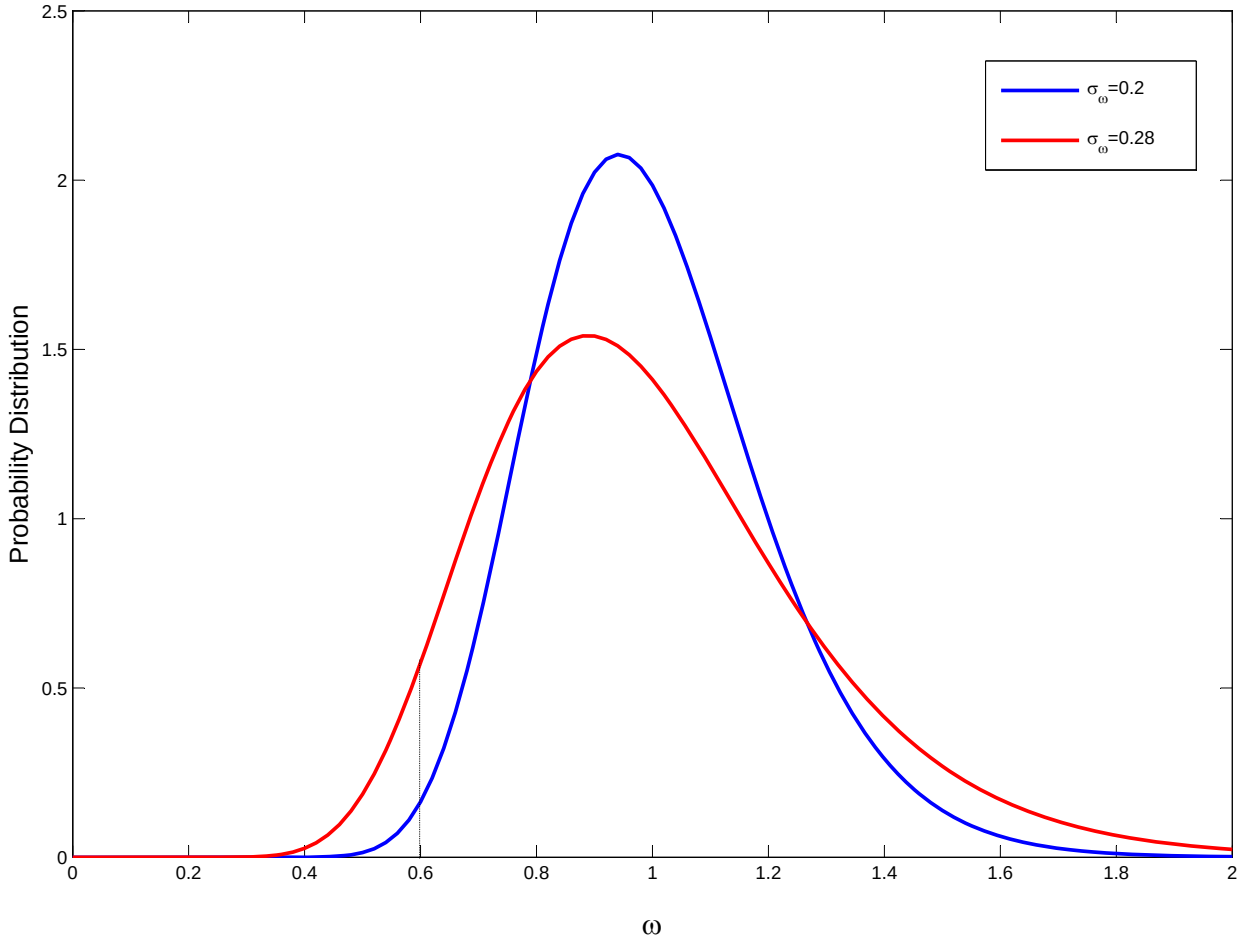
Parameter	Value	Description
γ	0.99	Discount factor of Savers
β	0.98	Discount factor of Borrowers
ψ	0.5	Relative size of Borrower group
δ	0.01	Rate of depreciation for housing
ε_C	7.5	Elasticity of substitution for C goods
ε_H	7.5	Elasticity of substitution for H goods
ς	3	Elasticity of substitution across labor inputs
ζ	0.5	Share of Borrower labor in the production function
ξ	0.871	Elasticity of substitution across labor types
α	0.16	Share of housing in consumption bundle
ν	2.5	Disutility from work
η	1	Elasticity of substitution between C and H goods
φ	1	Inverse of elasticity of labor supply
θ_C	0.67	Calvo probability in C
θ_H	0	Calvo probability in H
ϕ_π	1.5	Taylor-rule coefficient on inflation
ϕ_r	0.9	Taylor-rule coefficient on past nominal interest rate
ρ_C	0.9	Serial correlation of productivity shocks in C
ρ_H	0.9	Serial correlation of productivity shocks in H
ρ_M	0	Serial correlation of monetary policy shocks
σ_ω	0.20	Standard deviation of idiosyncratic shocks
μ	0.12	Monitoring cost

Low-Leverage Calibration: $\sigma_\omega = 0.6$

Steady State Values			
Variable	Benchmark	Low Leverage	% Difference
Output *C*	0.5407	0.5399	0.15
Output *H*	0.1465	0.1419	3.24
Consumption, Borrowers	0.4789	0.4887	-2.01
Consumption, Savers	0.6026	0.5912	1.93
Housing Demand, Borrowers	11.5421	10.5337	9.57
Housing Demand, Savers	17.7524	17.8431	-0.51
Hours Worked, Borrowers in *C* Sector	0.5879	0.5789	1.55
Hours Worked, Borrowers in *H* Sector	0.1617	0.1549	4.41
Hours Worked, Savers in *C* Sector	0.4948	0.5019	-1.41
Hours Worked, Savers in *H* Sector	0.1361	0.1343	1.37
Loans	2.1747	0.7980	**172.54**
Loan-to-Value Ratio*	59.17	24.37	**142.80**
Leverage Ratio*	80.12	60.01	**33.51**
Default Rate on Mortgages†	2.36	8.21	**-71.22**
External Finance Premium†	0.41	2.44	-83.20
Mortgage Interest Rate†	4.51	6.54	-31.04

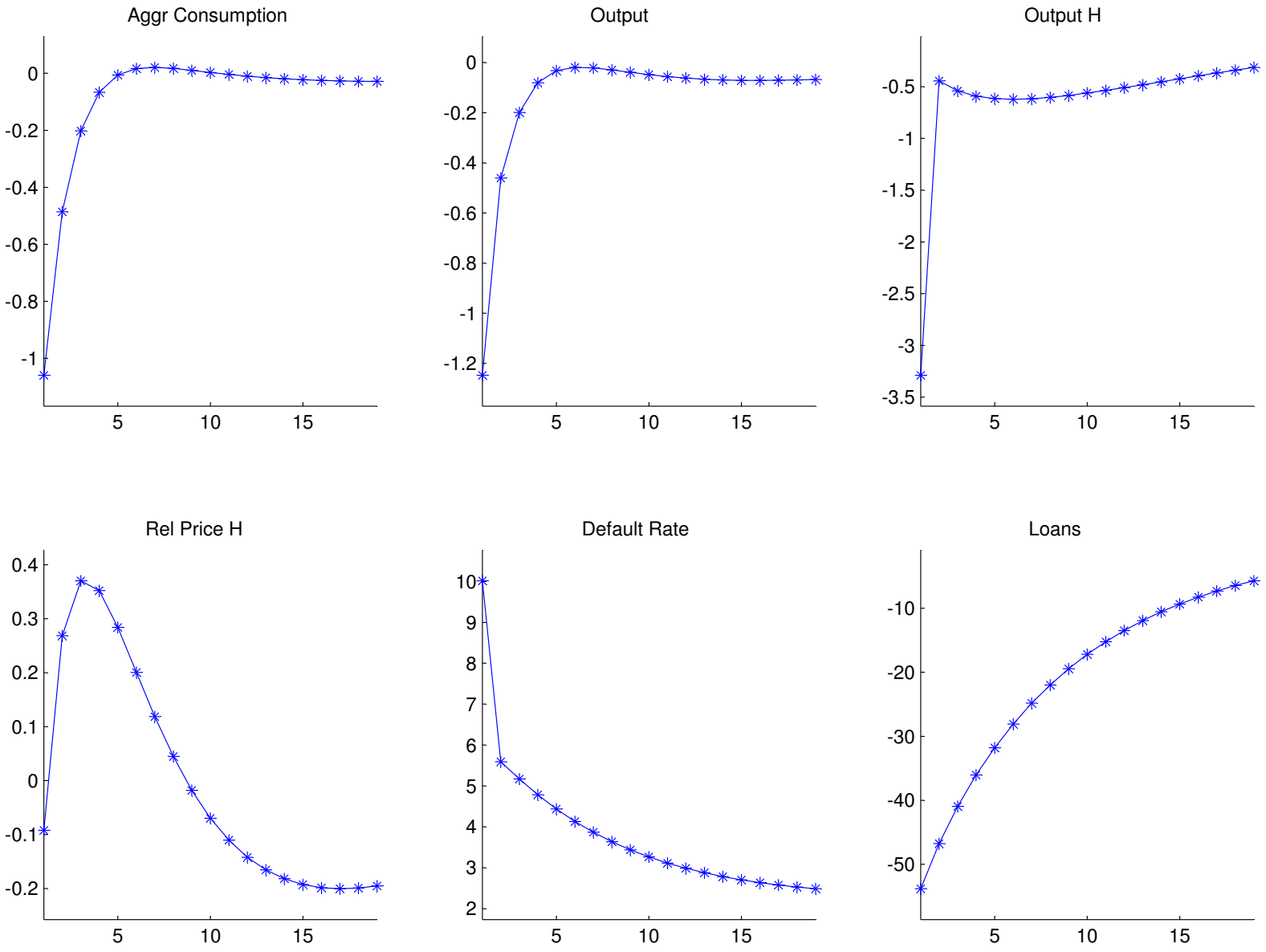
* Percentage points.
†Annual, percentage points.

Credit Crunch



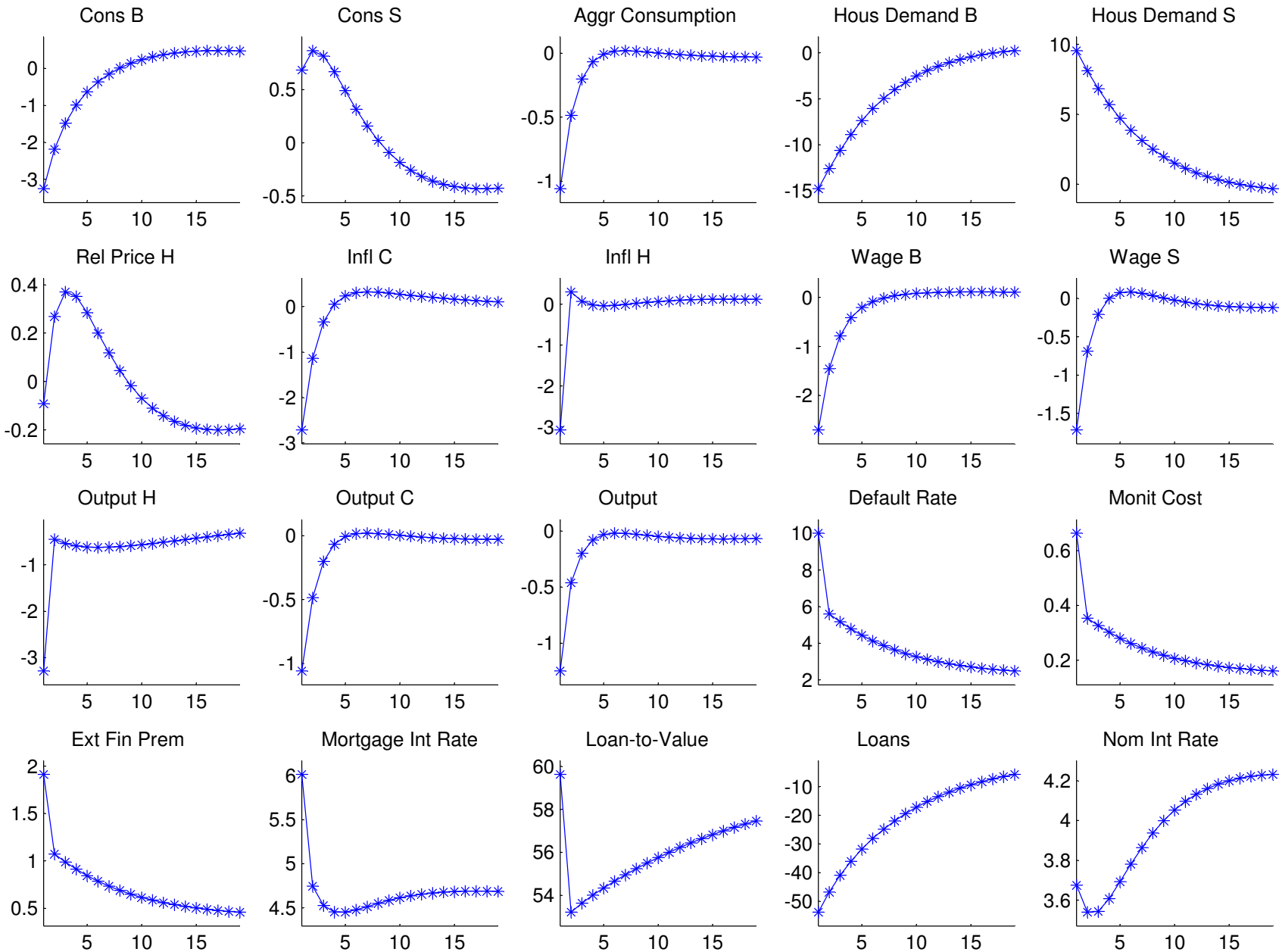
Mortgage Risk shock: increase in $\sigma_{\omega,t}$, the standard deviation of the distribution of idiosyncratic housing investment risk

Responses to a 40% Increase in $\sigma_{\omega,t}$: Benchmark Calibration

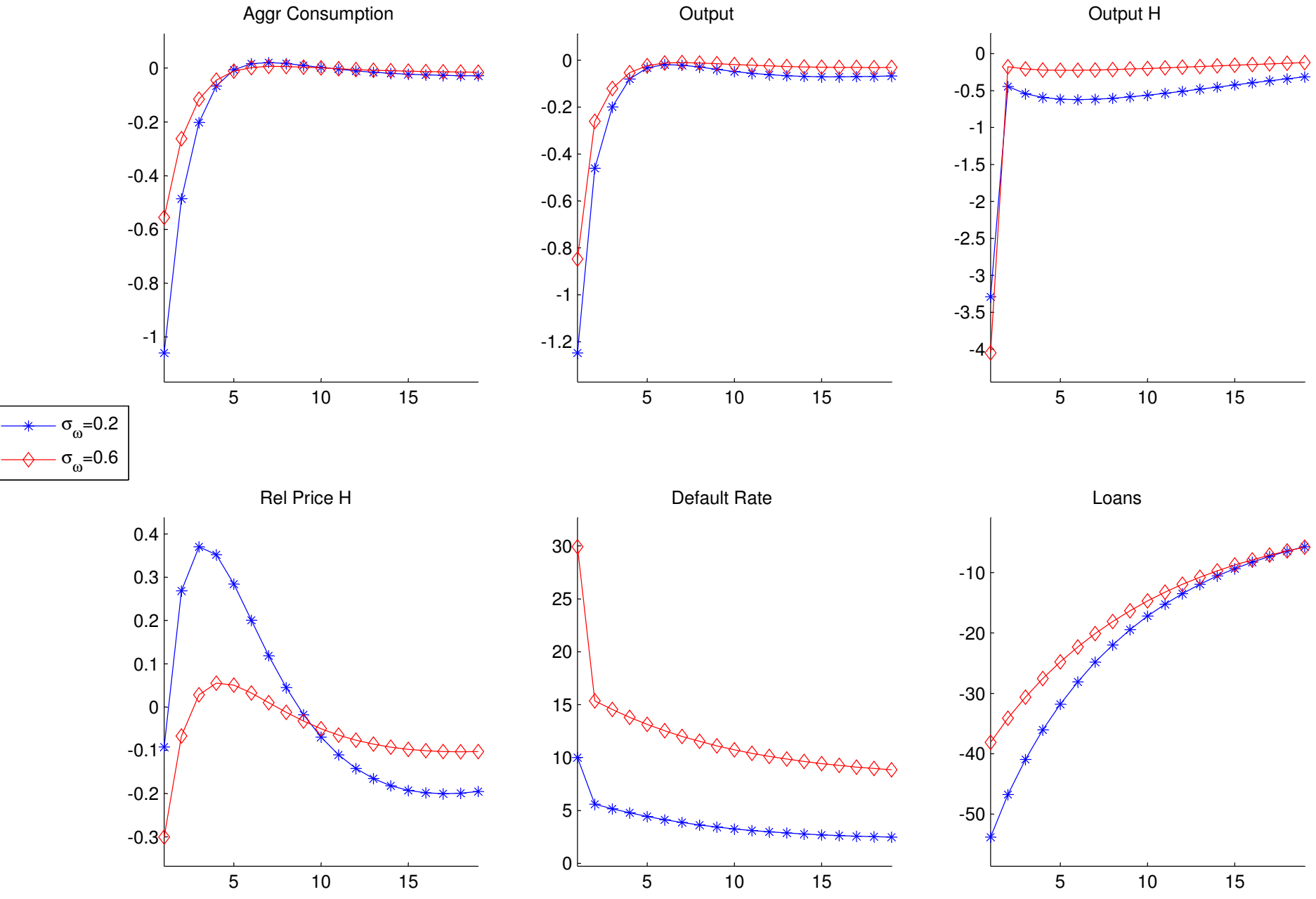


Note: Default rate is annual and in percentage points. Loans are difference from steady state, multiplied by 100.
All other variables are percentage point deviation from steady state

Responses to a 40% Increase in $\sigma_{\omega.t}$: Benchmark Calibration



Responses to a 40% Increase in $\sigma_{\omega,t}$: Low-Leverage Calibration



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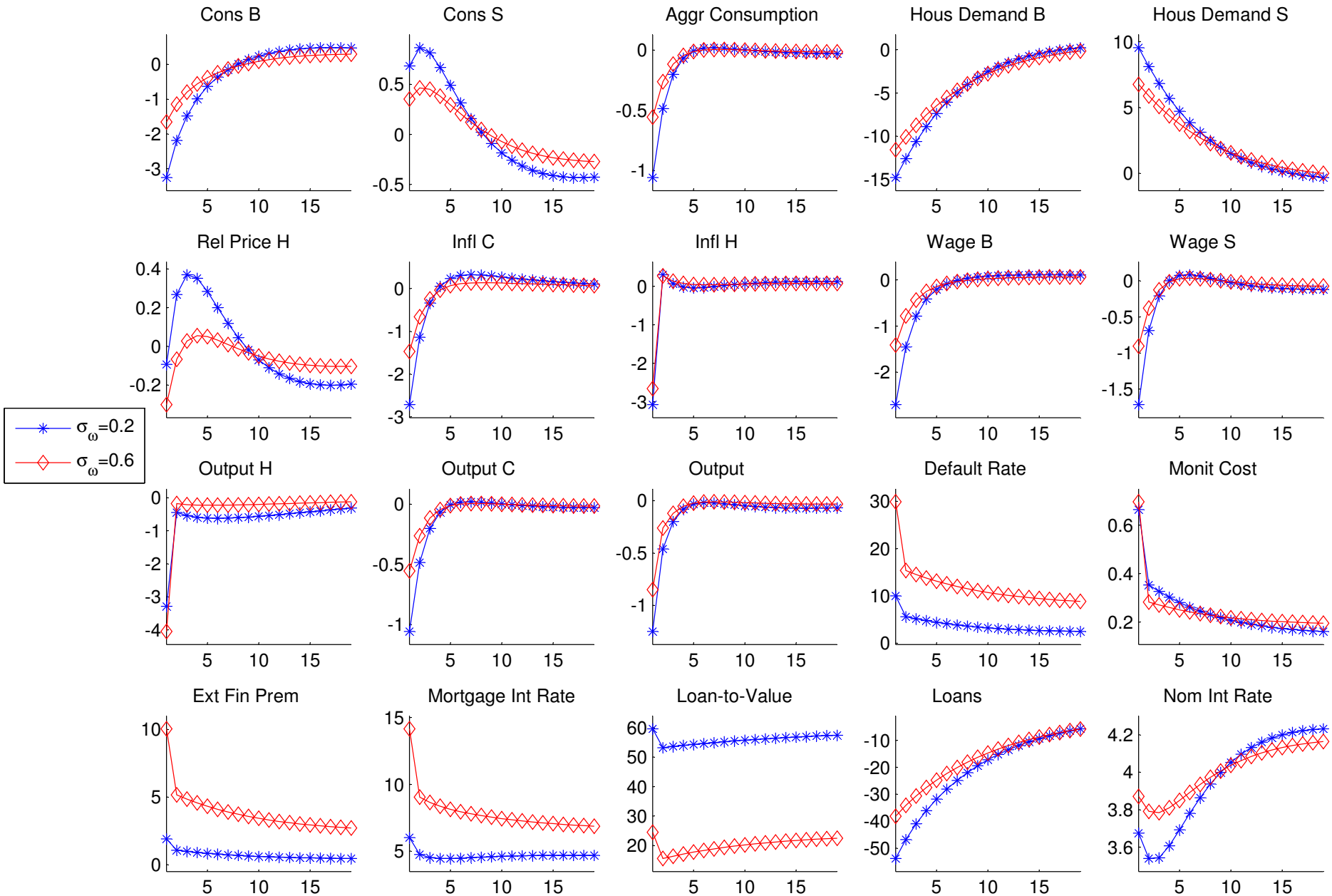
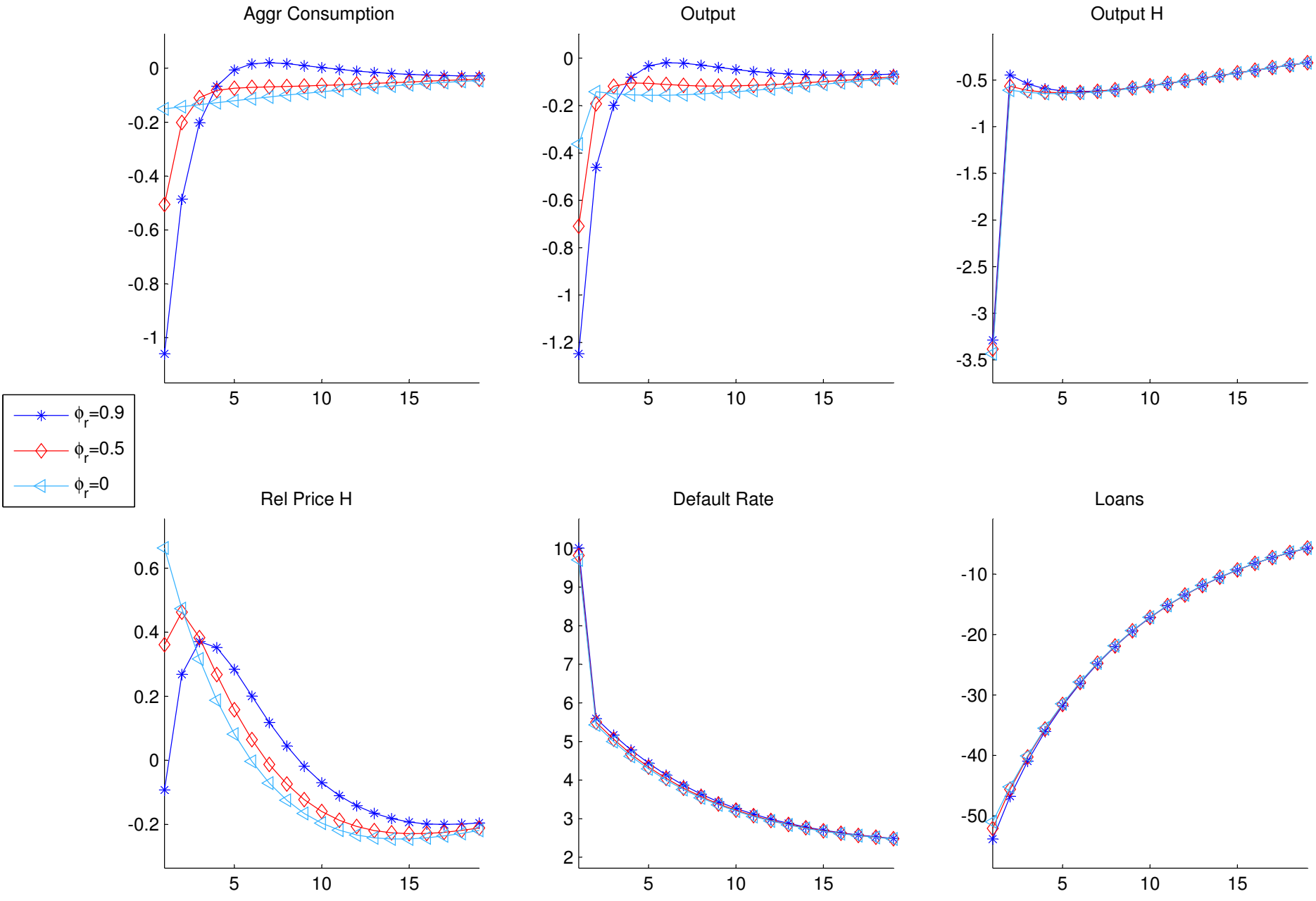


Credit Crunch and Leverage

- Credit crunch is deeper in high-leverage economies
- Stronger adverse effects on Borrowers
- Loans, consumption of non-durable goods, and housing investment fall more
- Deeper fall in total output

Responses to a 40% Increase in $\sigma_{\omega,t}$ with Non-inertial Rule



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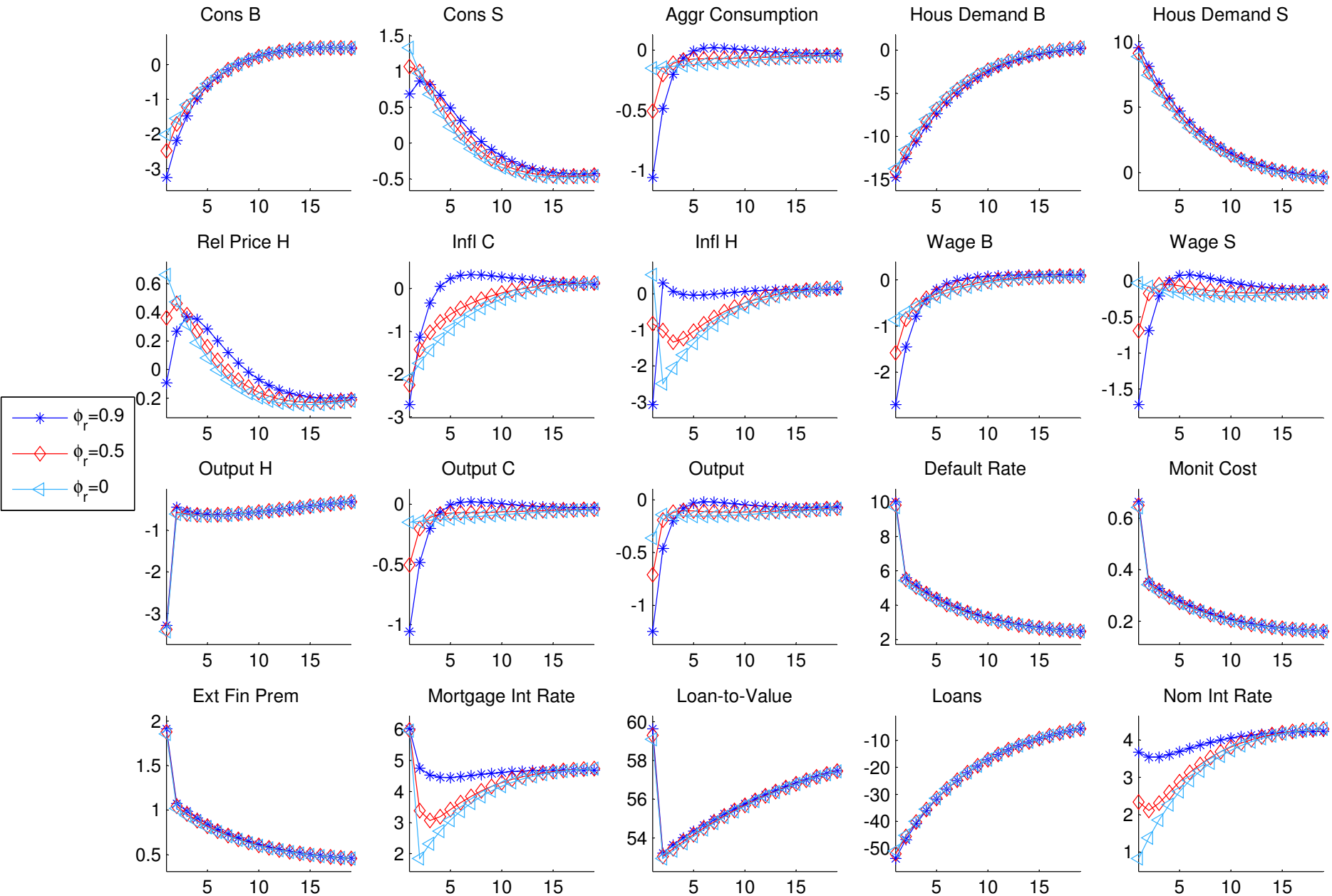
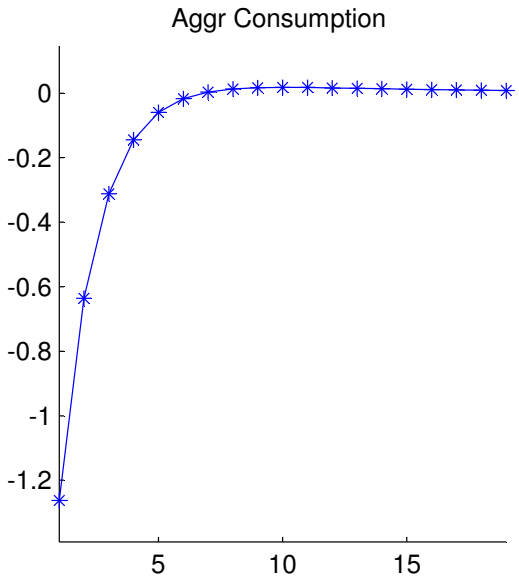
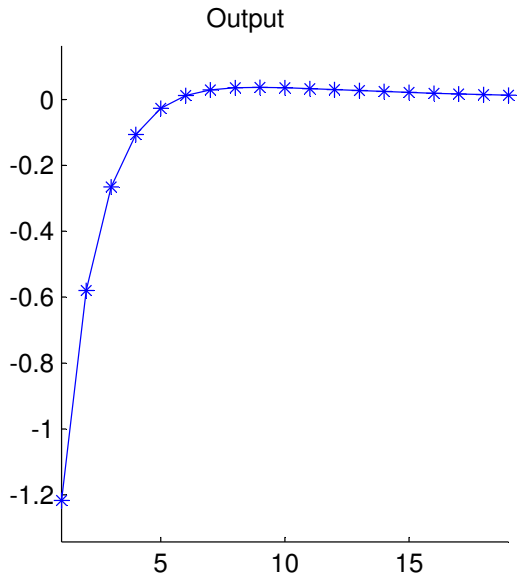


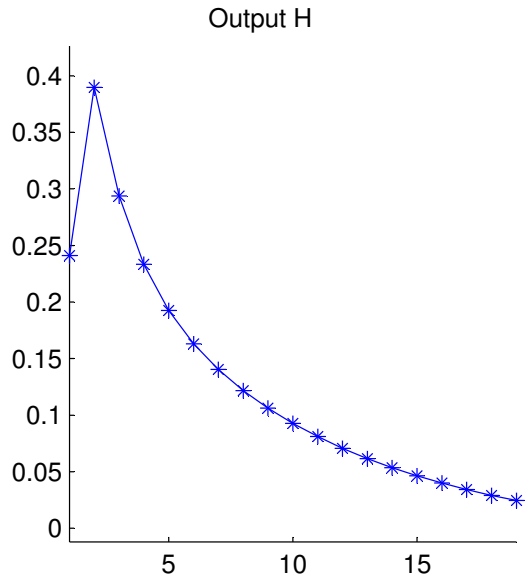
Interest Rate Flexibility

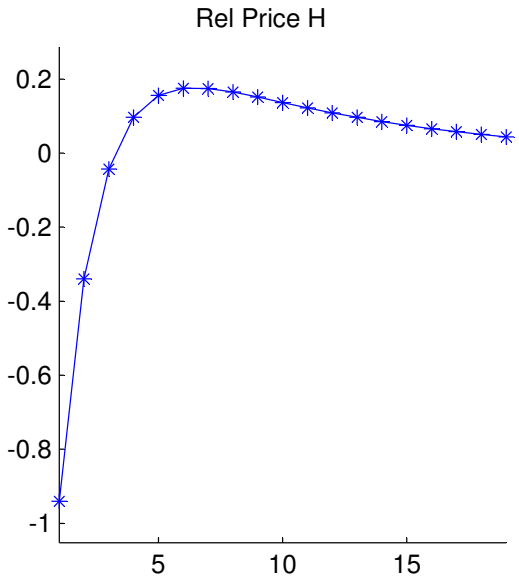
- Interest rate flexibility is important in the response to a mortgage risk shock
- Policy rate is cut more aggressively and non-durable consumption falls less
- Housing prices increase (because Borrowers and Savers increase hours in the housing sector by less)
- Strong inertial rules mimic a zero bound scenario where interest rate cannot be lowered further and the negative effects of a mortgage risk shock are amplified

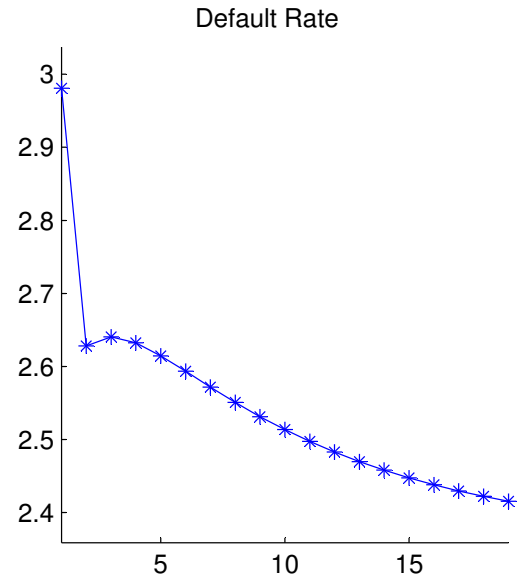
Responses to a 25 basis points Monetary Shock

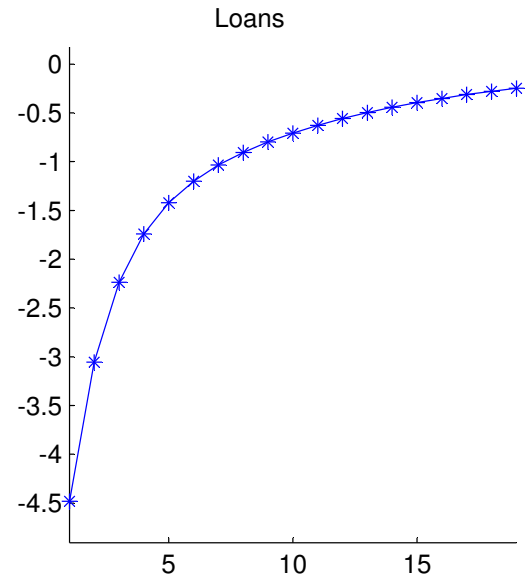












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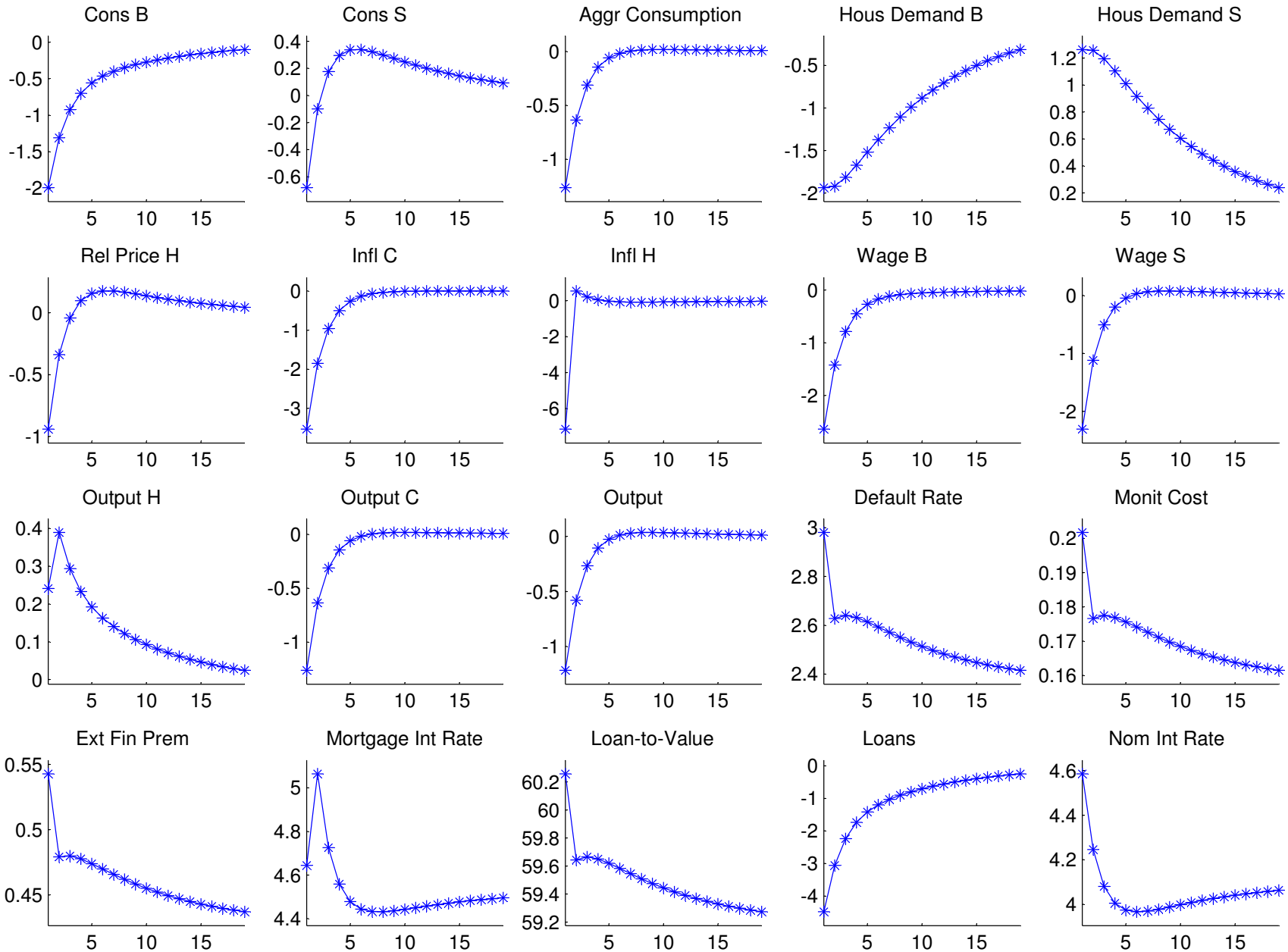


Monetary Policy Shock and Sectoral Co-movement

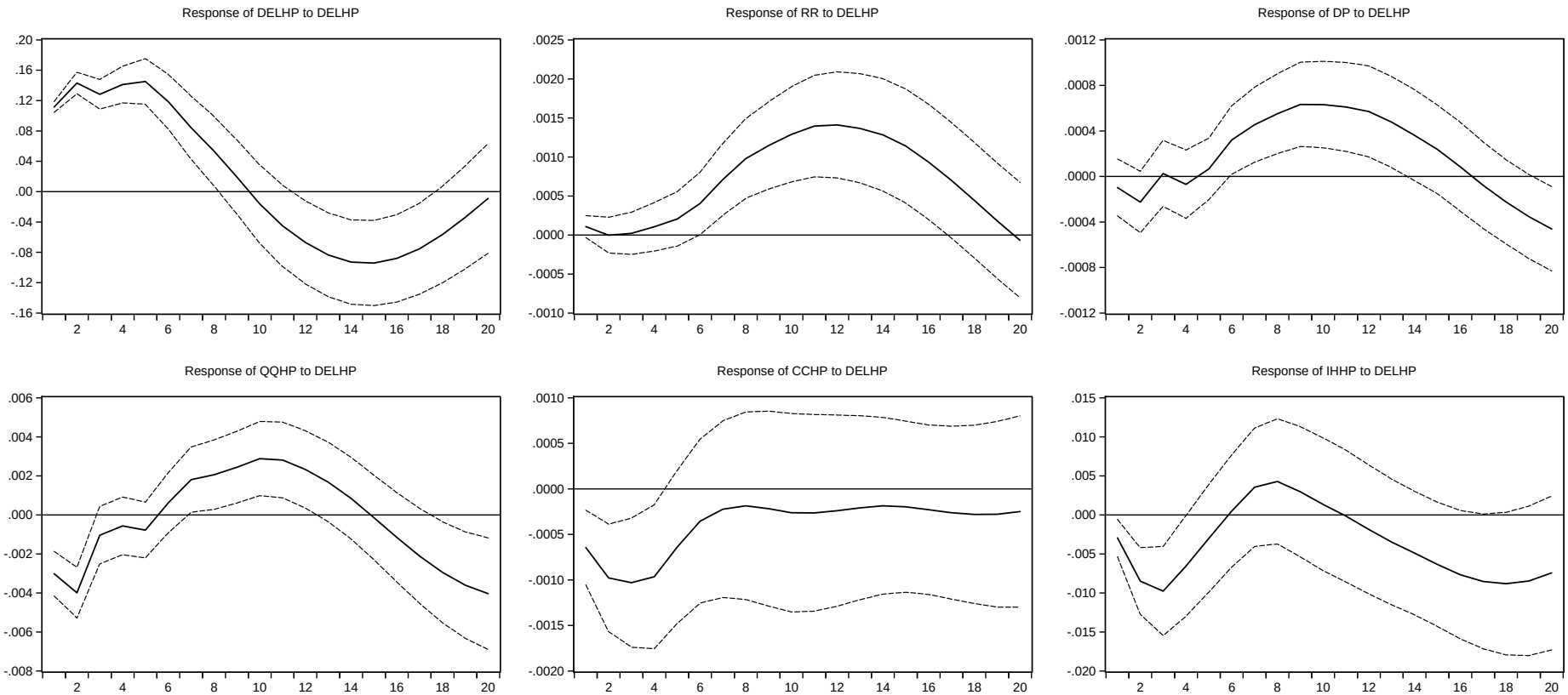
- Representative agent models with sticky non-durable and flexible durable prices display negative co-movement in response to a monetary shock - see Barsky et al. (2007), Carlstrom and Fuerst (2006)
- Empirical evidence supports positive co-movement - see Erceg and Levin (2006)
- Models with credit constraints display positive co-movement only with sticky durable prices - see Monacelli (2009)
- Our model displays positive co-movement with sticky durable prices
- Role of wage stickiness in the housing sector

Conclusions and Extensions

Our model under-predicts the fall in total output and real housing prices seen in the Great Recession

- Perverse effect of monitoring costs. Make the housing sector response: adjustment costs in the housing sector
- Wage stickiness to dampen the output response in the housing sector
- Financial intermediation to provide capital to firms to amplify the effects of mortgage risk shocks
- Consider fixed-rate multi-year contracts and ARM contracts with nonstandard features

VAR Evidence: Innovation to Delinquencies



Notes: VAR estimated from 1980Q1 to 2009Q4. The dashed lines indicate the +/- one standard error bands. The Choleski ordering is DELHP, RR, DP, QQHP, CCHP, IHHP. Vertical axis: percent deviation from baseline.

VAR Evidence: IR of Delinquencies to Innovation to All Variables