The Role of Housing Collateral in an Estimated Two-Sector Model of the U.S. Economy

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(Bank of Italy)

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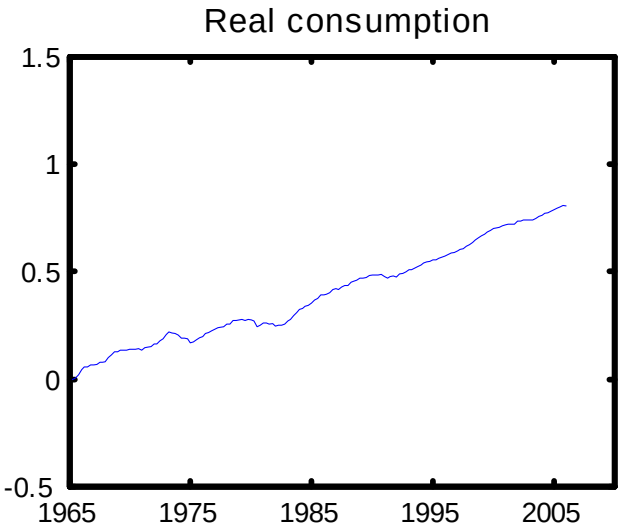
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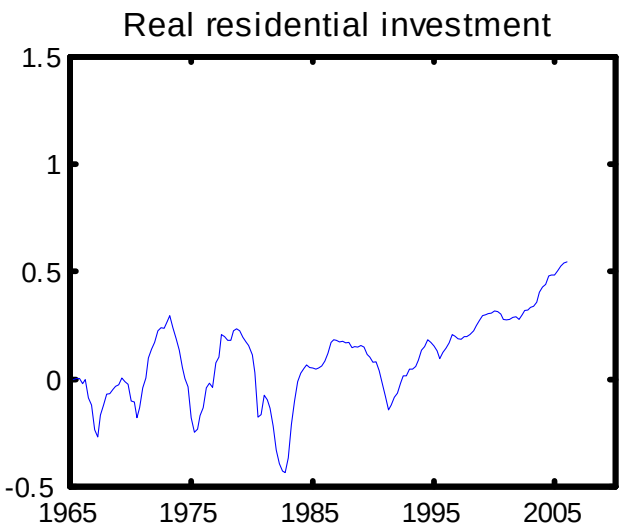
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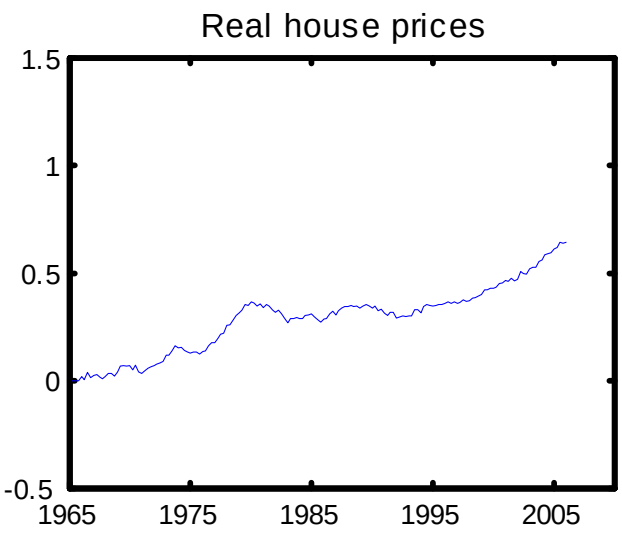
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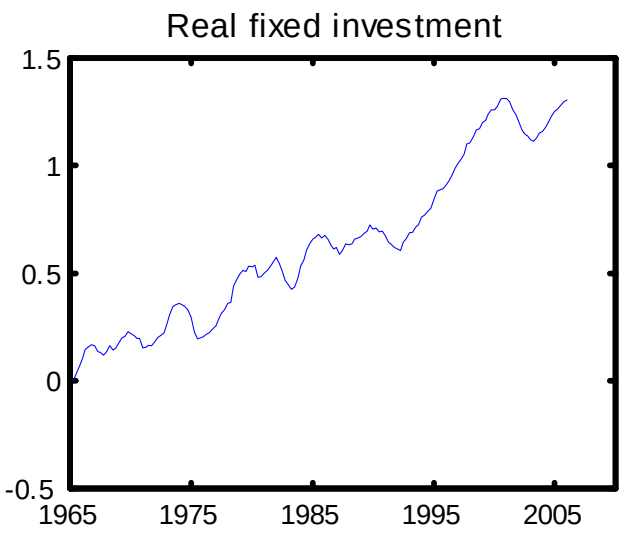
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MOTIVATION

- "... the U.S. economic expansion appears to be solidly on track. Nevertheless, the outlook for real activity faces a number of significant risks, including the possibility that house prices and construction could retrench sharply..." (Fed Vice Chairman Roger W. Ferguson, Jr., March 3, 2006)
- "[I]t is difficult to dismiss the conclusion that a significant amount of consumption is driven by capital gains on some combination of both stocks and residences, with the latter being financed predominantly by home equity extraction" (Alan Greenspan, 2005)

OUR GOAL

Build and estimate a quantitative, small-scale model of the housing market and the macroeconomy with financing frictions on the household side.
Two sectors: consumption sector (sticky prices), housing sector (flexible prices)
Features that we want to capture:

- Role of housing as collateral for loans, and potential wealth effects on consumption

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- Contribution of the recent housing boom to consumption and investment growth
- Contribution of monetary policy to house price dynamics

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2. Most of house price fluctuations can only be accounted by preference shifts
3. Spillovers from housing market to the rest of the economy are not large, but not negligible either
4. If the Fed had tried to deflate the housing boom, there would have been strong negative macroeconomic consequences

RELATED PAPERS

- Four main elements in our paper:
  (1) multi-sector structure with housing;
  (2) nominal rigidities and monetary policy;
  (3) financing frictions;
  (4) lots of shocks;
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- Many papers look for single-bullet explanations of housing booms, outside DSGE framework (Martin 2006, Brunenrmaier Parker 2006, Piazzesi Schneider 2006)

OUTLINE

1. Model
2. Data and estimation strategy
3. Estimation results
4. Model experiments: the recent housing boom, consumption and monetary policy
5. Extensions
6. Conclusions

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Main modeling choices

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  - 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, for small shocks, the constraint is always binding)

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- Real rigidities: habits in consumption, imperfect labor mobility across sectors, capital adjustment costs
- Private debt contracts are in nominal terms
- Different types of shocks

FIRMS

- Maximize profits:

$$\max Y_t / X_t + q_t IH_t - \left(\sum w_{it} n_{it} + R_{ct} k_{ct-1} + R_{ht} k_{ht-1} + R_{lt} l_{t-1}\right)$$

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- where

$$Y_t = \left(A_{ct} \left(n_{ct}^{\alpha} n_{ct}'^{1-\alpha}\right)\right)^{1-\mu_c} k_{ct-1}^{\mu_c}$$

$$IH_t = \left(A_{ct} A_{ht} \left(n_{ht}^{\alpha} n_{ht}'^{1-\alpha}\right)\right)^{1-\mu_h-\mu_l} k_{ht-1}^{\mu_h} l_{t-1}^{\mu_l}$$

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- Two types of households/workers (more on this below)
  α : wage share accruing to unconstrained households
  $1-\alpha$: wage share accruing to constrained households

FIRMS (continued)

Y_t : intermediate good, price of $1/X_t$ relative to the final good
Final good produced by "retailers", each producing a differentiated good
The retailer pricing decision (subject to Calvo constraint and indexation constraint) implies:

$$\begin{aligned} \log \pi_t - \iota_\pi \log \pi_{t-1} &= \beta g_C \left(E_t \log \pi_{t+1} - \iota_\pi \log \pi_t \right) \\ &\quad - \varepsilon_{\pi X} \log \left(\frac{X_t}{X} \right) + \log u_t \end{aligned}$$

$$\varepsilon_{\pi X} = f\left(\iota_\pi, \theta_\pi, \beta g_C\right)$$

UNCONSTRAINED / PATIENT HOUSEHOLDS

- Maximize utility

$$E_0 \sum_{t=0}^{\infty} (\beta g_C)^t z_t \begin{pmatrix} \log\left(c_t - \varepsilon g_C c_{t-1}\right) + j_t \log h_t \\ -\tau_t \left(n_{ct}^{1-\nu} + n_{ht}^{1-\nu}\right)^{\frac{1+\eta}{1-\nu}} \end{pmatrix}$$

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- subject to budget constraint:

$$\begin{aligned} & c_t + \frac{k_{ct}}{A_{kt}} + k_{ht} + q_t \left(h_t - (1-\delta_h) h_{t-1}\right) + \phi_t + p_{lt} \left(l_t - l_{t-1}\right) \\ = \; & w_{ct} n_{ct} + w_{ht} n_{ht} + \left(R_{ct} + (1-\delta_k)/A_{kt}\right) k_{ct-1} \\ & + \left(R_{ht} + 1 - \delta_k\right) k_{ht-1} + f_t + b_t - R_{t-1} b_{t-1}/\pi_t + R_{lt} l_{t-1} \end{aligned}$$

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- ϕ_t : quadratic adjustment costs for the two types of capital
  f_t : profits from monopolistic competition
  l_t : stock of land rented to firms (fixed)

CONSTRAINED / IMPATIENT HOUSEHOLDS

- Maximize utility, discount future more heavily ($\beta' < \beta$)

$$E_0 \sum_{t=0}^{\infty} \left(\beta' g_C\right)^t z_t \left(\begin{array}{c} \log\left(c'_t - \varepsilon' g_C c'_{t-1}\right) + \\ j_t \log h'_t - \tau_t \left(n'^{1-\nu'}_{ct} + n^{1-\nu'}_{ht}\right)^{\frac{1+\eta'}{1-\nu'}} \end{array} \right)$$

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$$c'_t + q_t \left(h'_t - (1-\delta_h) h'_{t-1}\right) = w'_{ct} n'_{ct} + w'_{ht} n'_{ht} + b'_t - \frac{R_{t-1}}{\pi_t} b'_{t-1}$$

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- and to borrowing constraint

$$b'_t \leq m E_t \left(q_{t+1} h'_t \pi_{t+1} / R_t\right)$$

MONETARY POLICY

$$R_t = (R_{t-1})^{r_R} \left(\pi_t^{r_\pi} \left(\frac{GDP_t}{g_C GDP_{t-1}} \right)^{r_Y} \overline{rr} \right)^{1-r_R} e_{Rt}$$

SHOCKS

- Stationary AR(1)
  z_t : preference (discount factor) shock
  j_t : housing demand shock
  τ_t : labor supply shock
  e_{Rt} : monetary shock (iid)
  u_t : markup/inflation shock (iid)
- Trend-stationary shocks

$$\begin{aligned}
\ln A_{ct} &= t \ln(1+\gamma_{AC}) + \ln A_{ct}, \quad \ln A_{ct} = \rho_{AC} \ln Z_{ct-1} + \varepsilon_{ct} \\
\ln A_{ht} &= t \ln(1+\gamma_{AH}) + \ln A_{ht}, \quad \ln A_{ht} = \rho_{AH} \ln Z_{ht-1} + \varepsilon_{ht} \\
\ln A_{kt} &= t \ln(1+\gamma_{AK}) + \ln A_{kt}, \quad \ln A_{kt} = \rho_{AK} \ln Z_{kt-1} + \varepsilon_{kt}
\end{aligned}$$

MARKET CLEARING

$$C_t + IK_{ct}/\mathrm{A}_{kt} + IK_{ht} = Y_t - \phi_t$$
$$h_t + h'_t - (1-\delta_h)\left(h_{t-1} + h'_{t-1}\right) = IH_t.$$

By Walras' law, $b_t + b'_t = 0$.

HOW DOES THE MODEL WORK?

1. At a basic level, it works like an RBC model with sticky prices in the $Y-$sector, like an RBC with flex prices in the $IH-$sector
2. Sector specific shocks or preference shocks can shift resources from one sector to the other
3. Role of housing, debt and borrowing constraints

   Housing as collateral generates wealth effects on consumption from fluctuations in house prices Debt in nominal terms creates the potential for debt deflation effects

ROLE OF TRENDS

1. Log preferences and Cobb-Douglas yield balanced growth
2. C and qI_h grow at the same rate over time.
3. Real fixed investment can grow faster than C, if there is investment-specific technological progress
4. Real housing investment can grow slower than C, if land is a limiting factor and technological progress A_h is "slow"
5. Long-run growth rates (in gross terms)

$$
\begin{aligned}
g_C &= g_{IK_h} = g_{q \times IH} = 1 + \gamma_{AC} + \frac{\mu_c}{1-\mu_c}\gamma_{AK} \\
g_{IK_c} &= 1 + \gamma_{AC} + \frac{1}{1-\mu_c}\gamma_{AK} \\
g_{IH} &= 1 + (1-\mu_l)\,\gamma_{AC} + \frac{\mu_c \mu_h}{1-\mu_c}\gamma_{AK} + (1-\mu_h-\mu_l)\,\gamma_{AH} \\
g_q &= 1 + \mu_l \gamma_{AC} + \frac{\mu_c\,(1-\mu_h)}{1-\mu_c}\gamma_{AK} - (1-\mu_h-\mu_l)\,\gamma_{AH}.
\end{aligned}
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4. Some parameters (input shares, discount factors) calibrated prior to estimation to match the usual ratios
   $\beta = 0.9925$, $\beta' = 0.97$, $Y = N_c^{0.65} k_c^{0.35}$, $IH = N_h^{0.75} k_h^{0.15} I^{0.10}$
   Target $(K + qH) / GDP = 3$, $(qH) / GDP = 1.3$,
   $(\delta_h qH) / GDP = 0.06$

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5. Other parameters estimated by Bayesian techniques

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- 2 for financing frictions α, m

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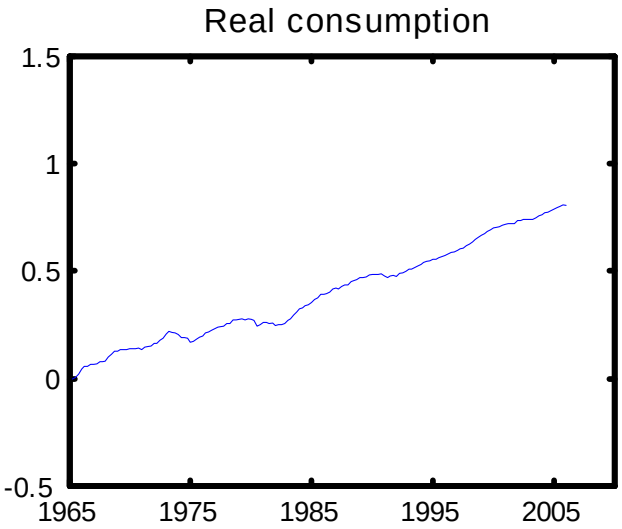
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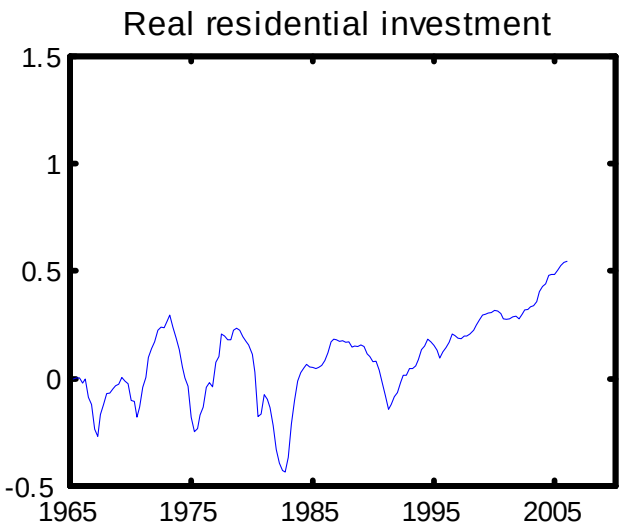
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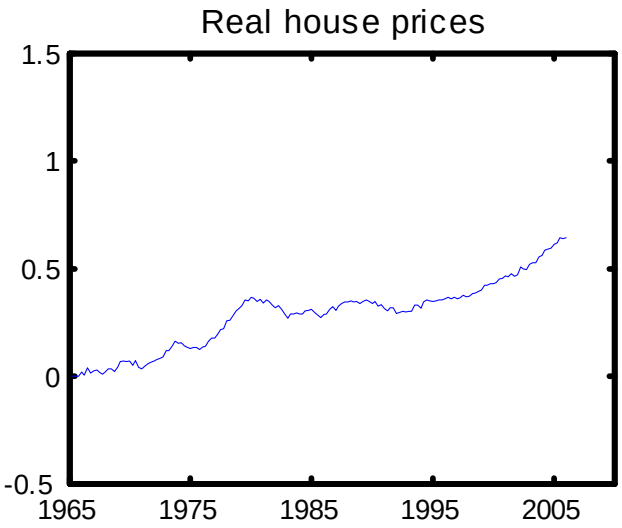
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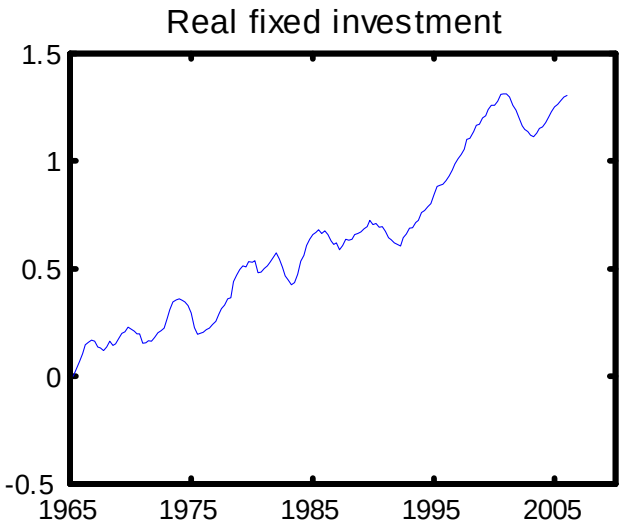
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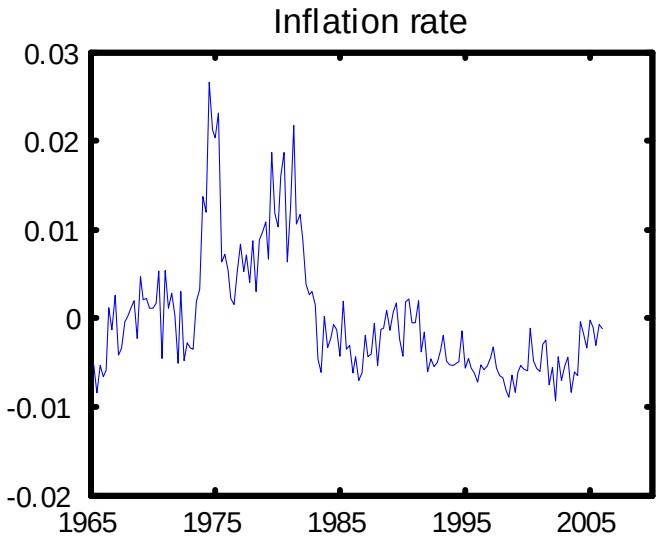
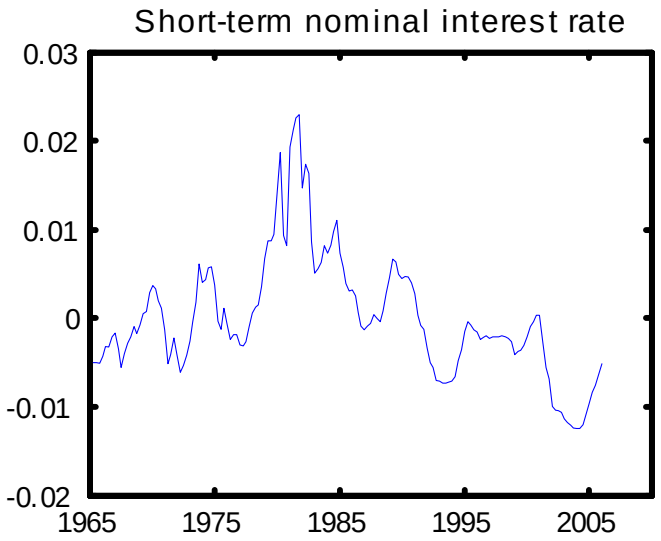
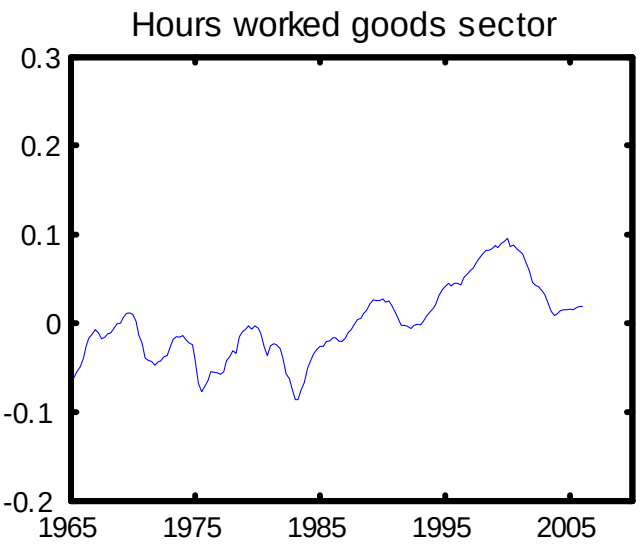
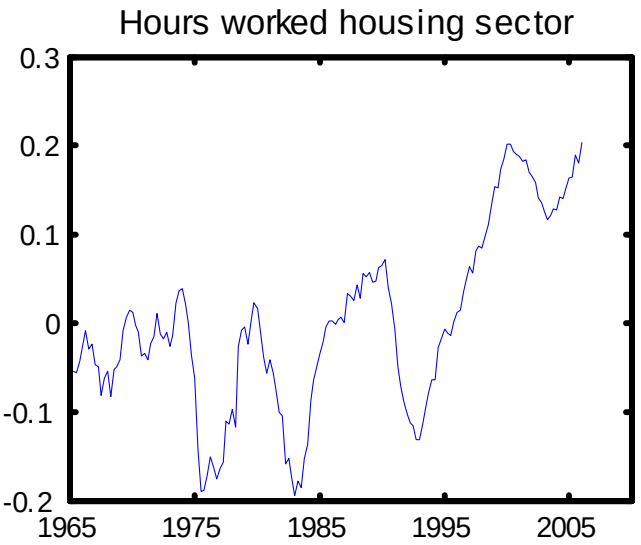
1965
1975
1985
1995
2005

THE DATA (2)


Inflation rate
0.03
0.02
0.01
0
-0.01
-0.02
1965
1975
1985
1995
2005


Short-term nominal interest rate
0.03
0.02
0.01
0
-0.01
-0.02
1965
1975
1985
1995
2005


Hours worked goods sector
0.3
0.2
0.1
0
-0.1
-0.2
1965
1975
1985
1995
2005


Hours worked housing sector
0.3
0.2
0.1
0
-0.1
-0.2
1965
1975
1985
1995
2005

THE BAYESIAN ESTIMATION

- We combine priors on the parameters of the model with the likelihood function for the data
- The posterior density of the parameters does not belong to any standard family
- Need to rely on Monte Carlo methods to draw parameters from the posterior distribution (MCMH)

3. RESULTS

Prior and Posterior Parameters: comments

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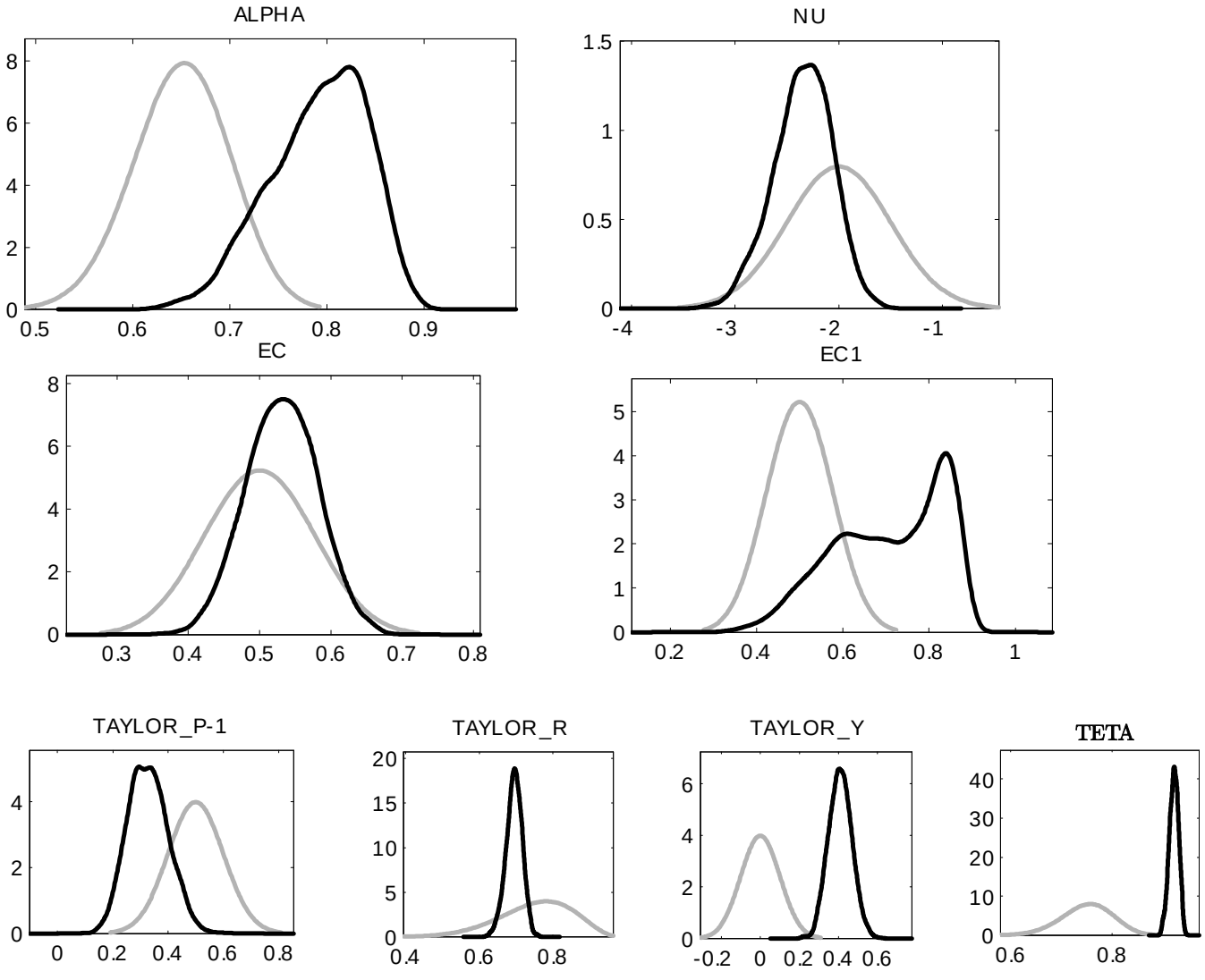
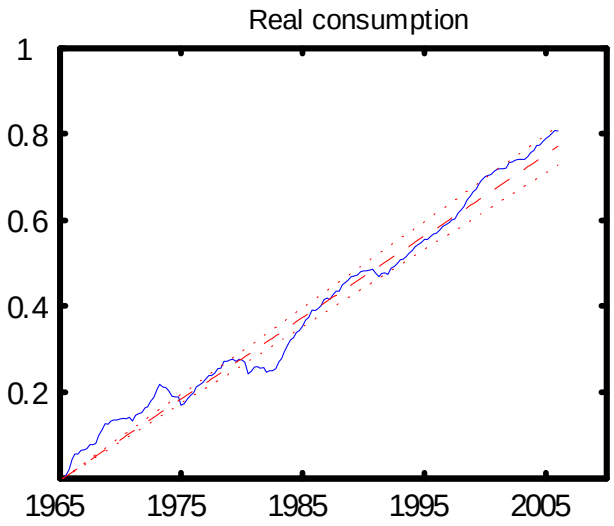
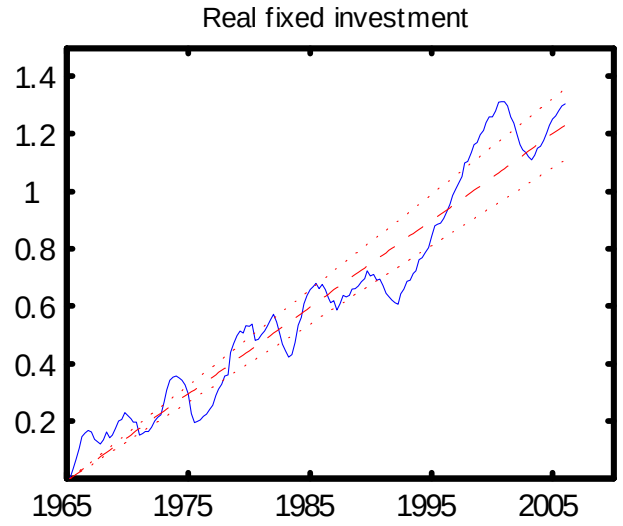
5. Low degree of labor mobility across sectors

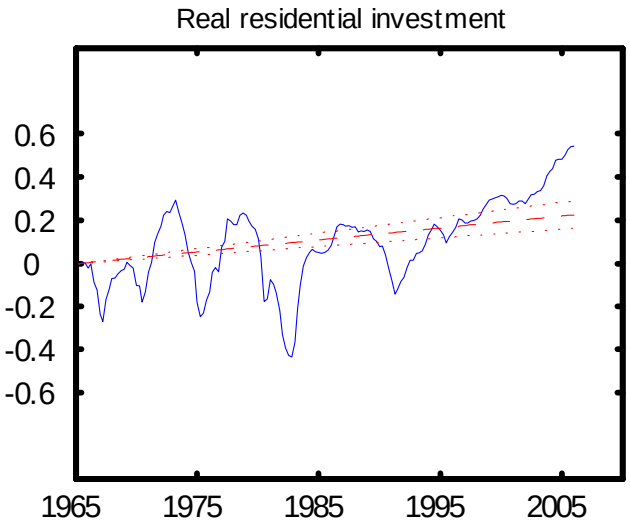
Selected priors (grey) and posteriors (black)

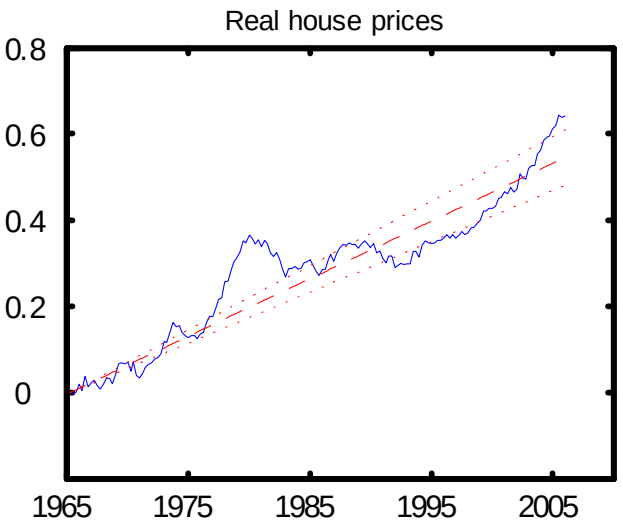


Variables and estimated trends

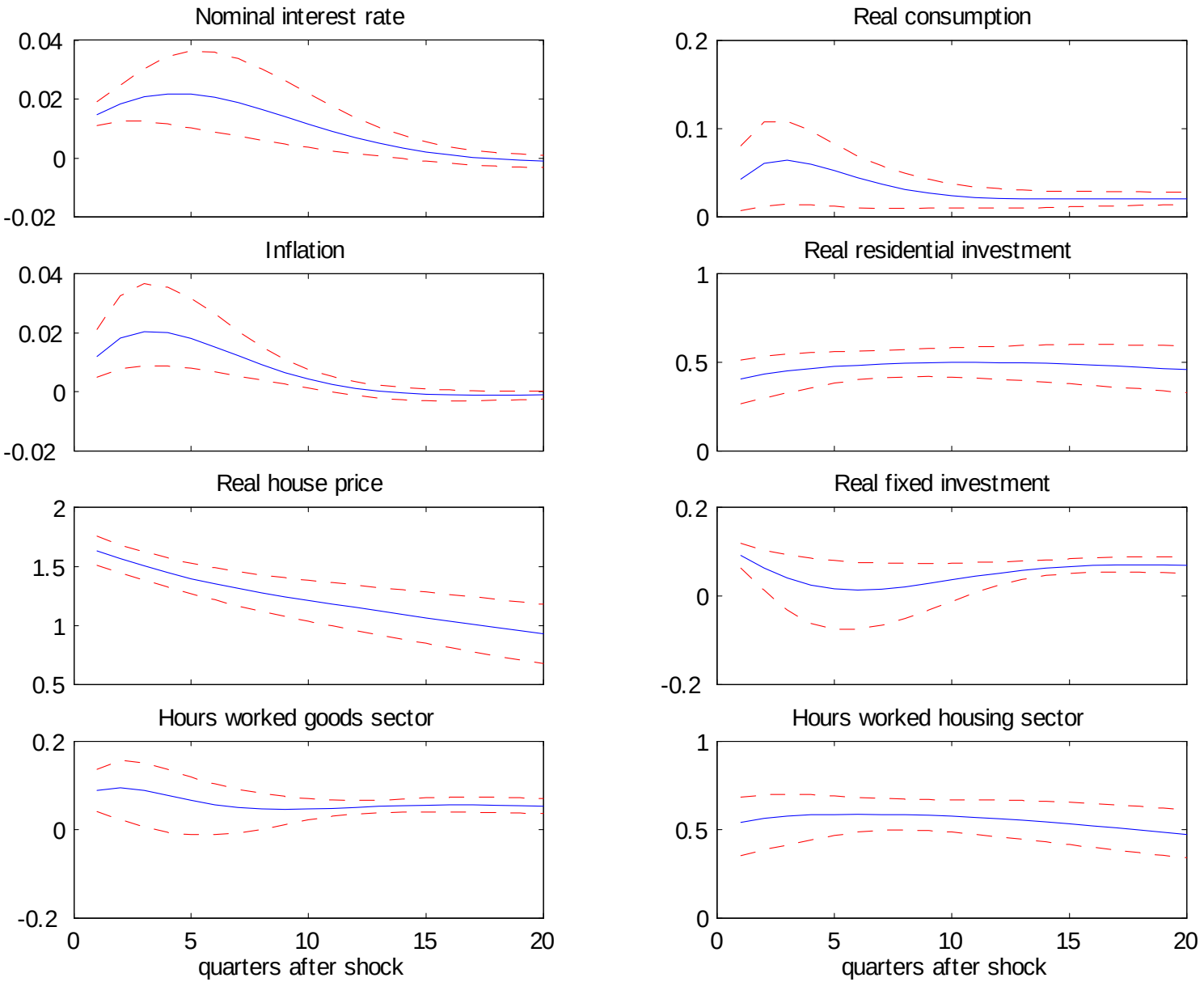




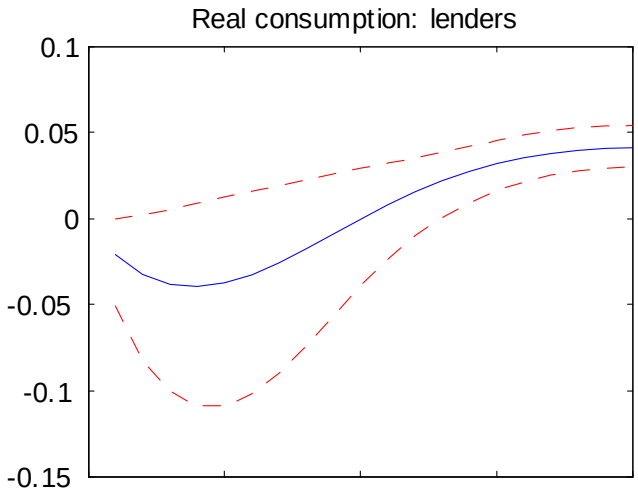


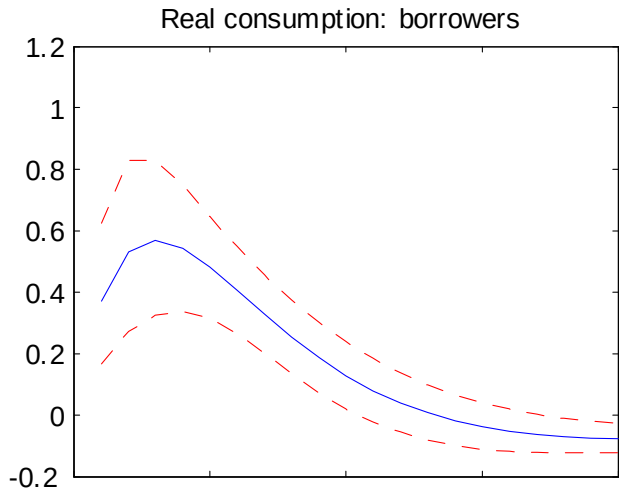


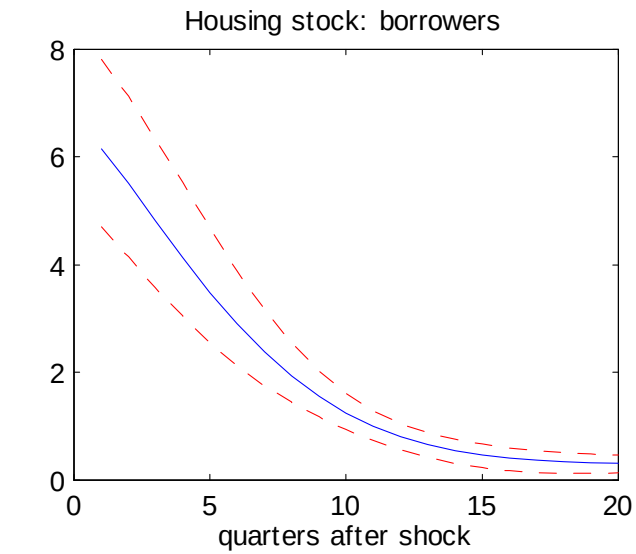
Impulse Responses: Housing Demand Shocks



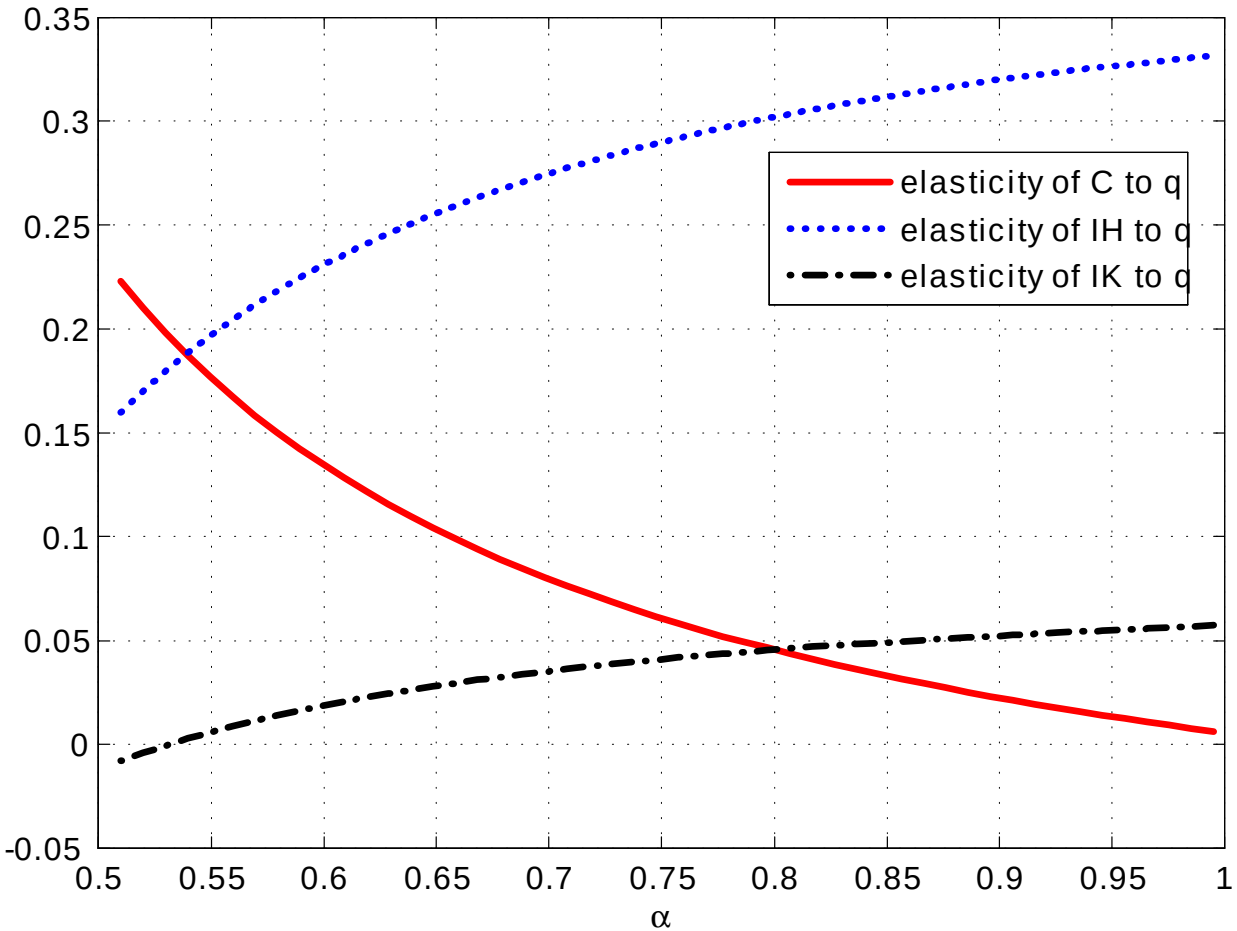
Housing Demand Shocks across agents



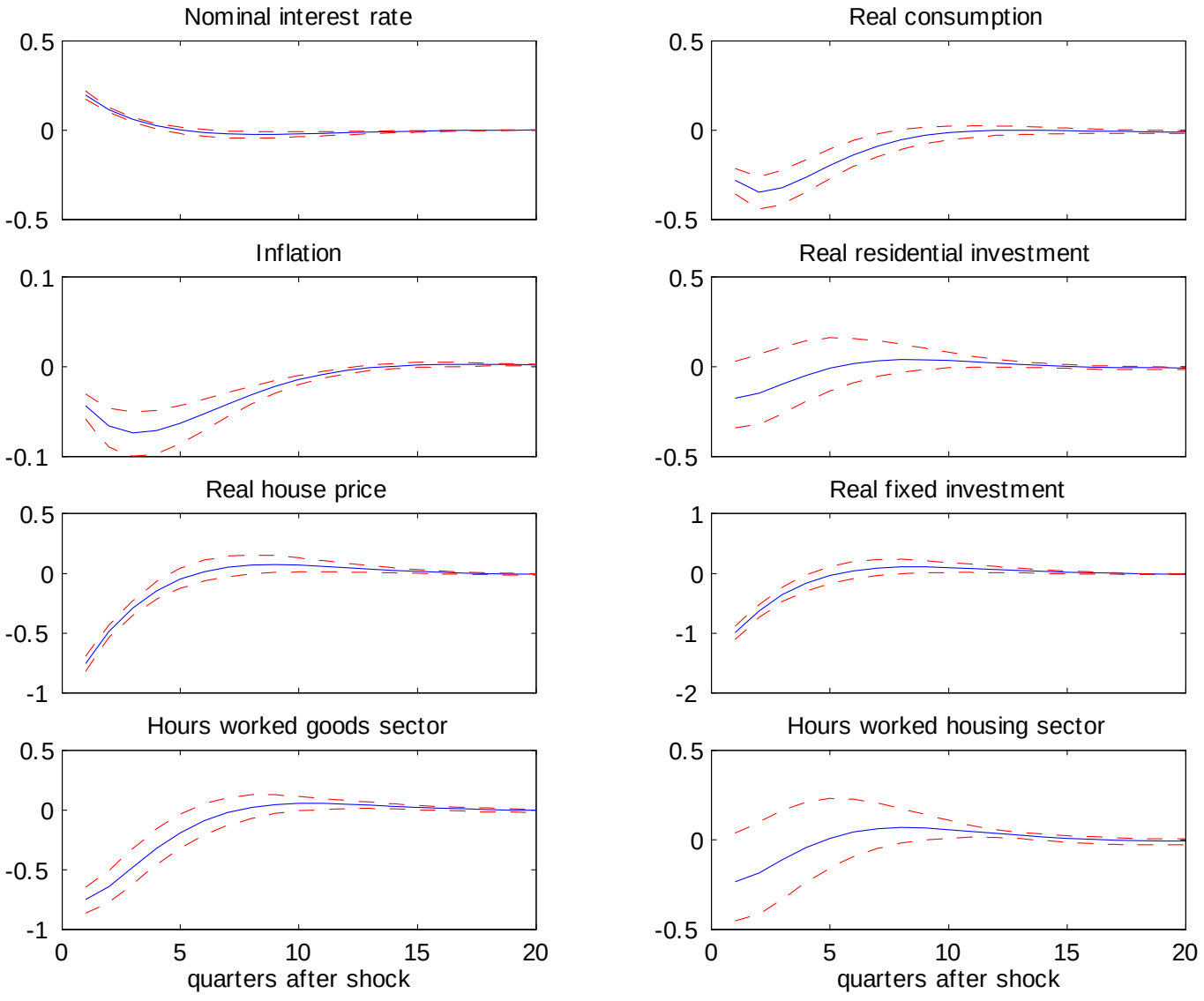




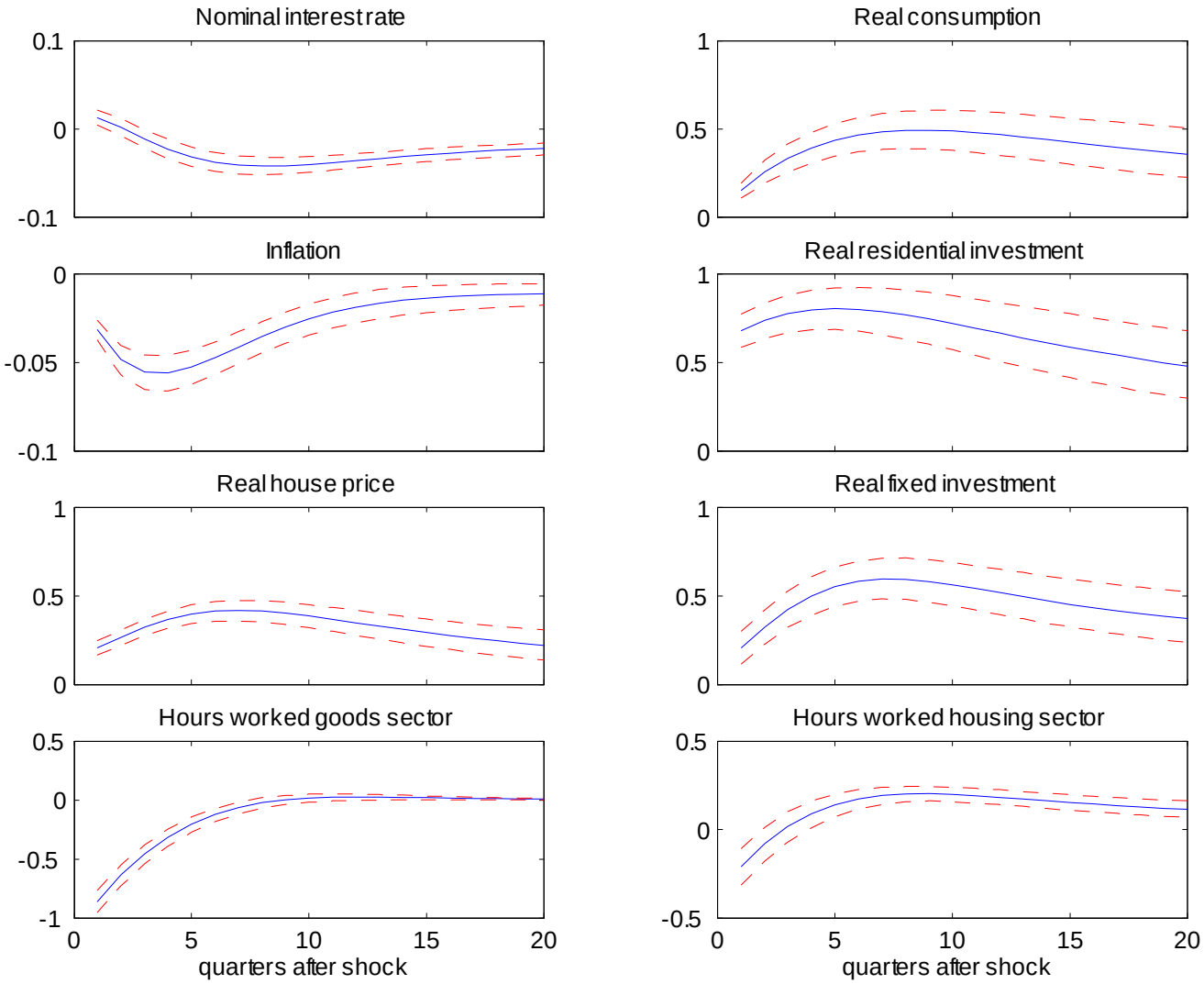
Housing Demand Shocks and the Fraction of Unconstrained Agents



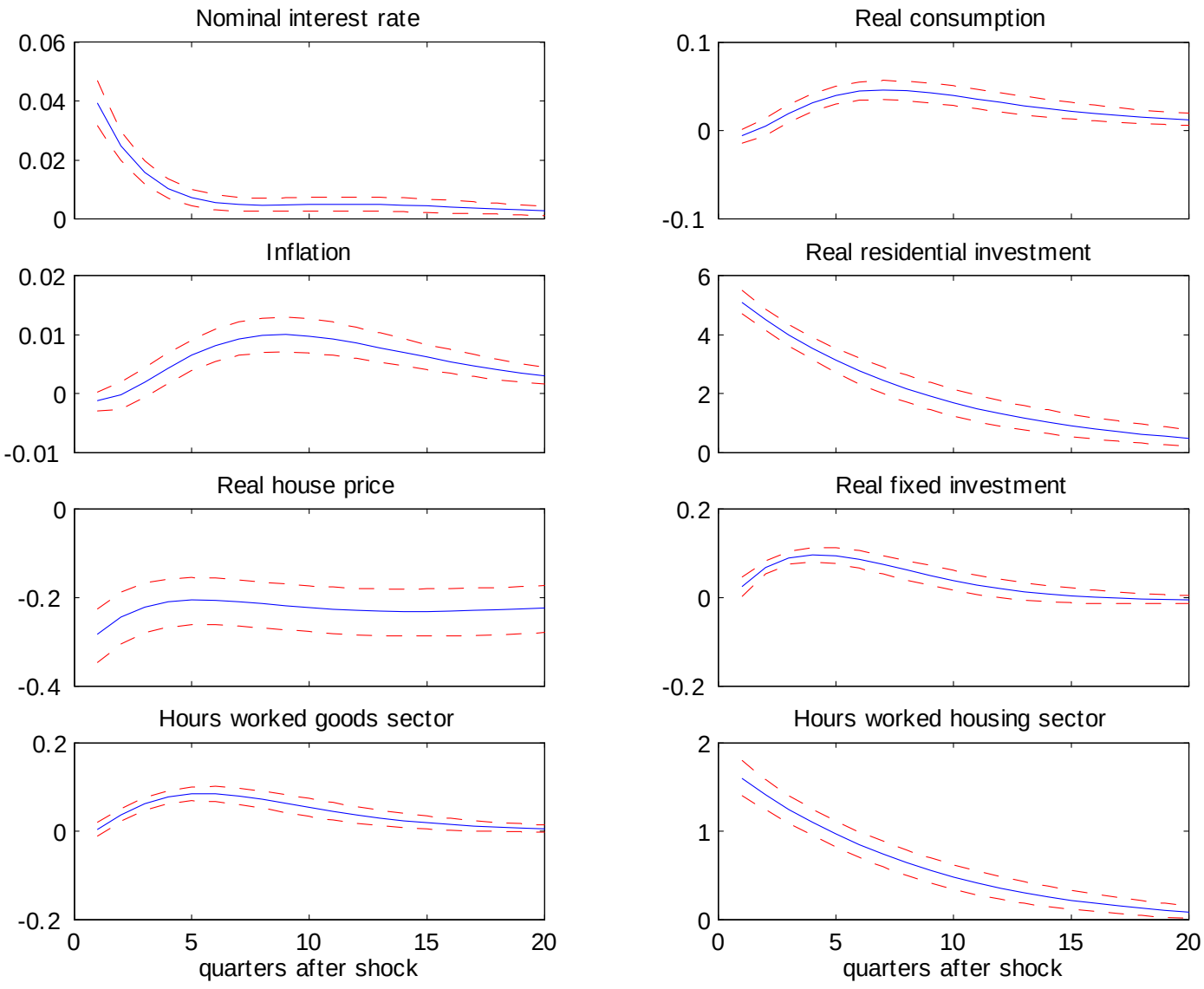
Impulse Responses: Monetary Shocks



Impulse Responses: Goods Technology shock



Impulse Responses: Housing Technology shock



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4. The model can account well for the trends.

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3. Key reason: sticky price sectors bear the large impact of a monetary contraction
   (for more on this, Barsky, House and Kimball 2006, Carlstrom and Fuerst 2006)
4. The model elasticity of house prices to a monetary shocks is of similar magnitude to what is found in VAR studies (Del Negro and Otrok, 2006)

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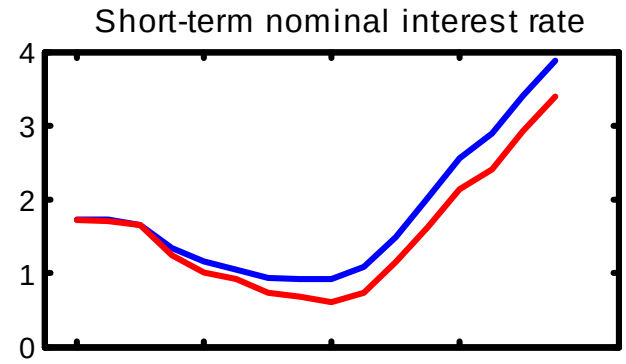
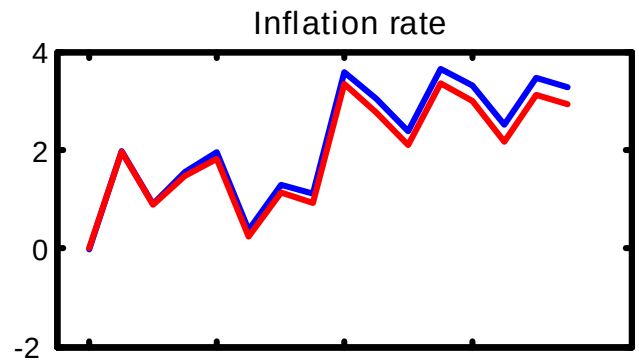
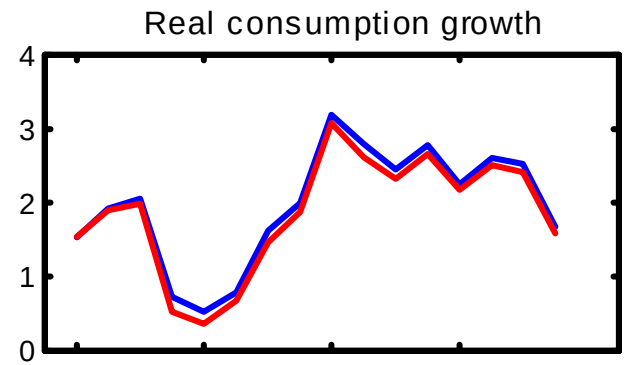
2. Because we can think of this shock as exogenous, we can measure its contribution to consumption and investment growth
3. We do so shutting off preference shocks from 2002Q1

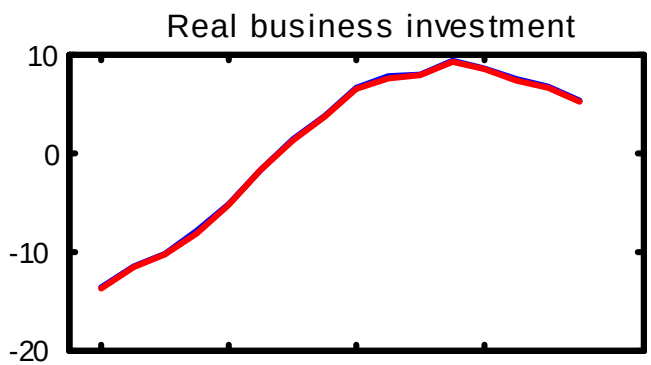
SHUTTING OFF THE HOUSING BOOM

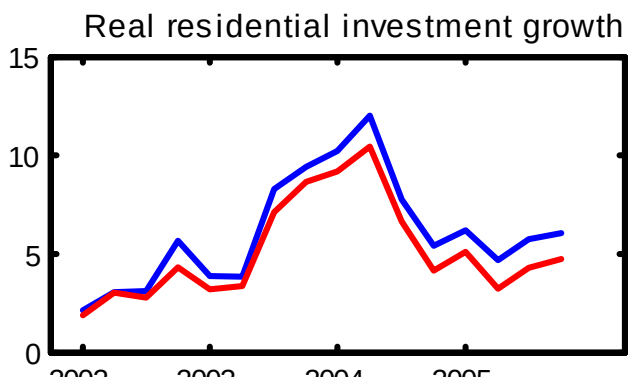
Blue lines: data (YOY growth), Red: no housing demand shock

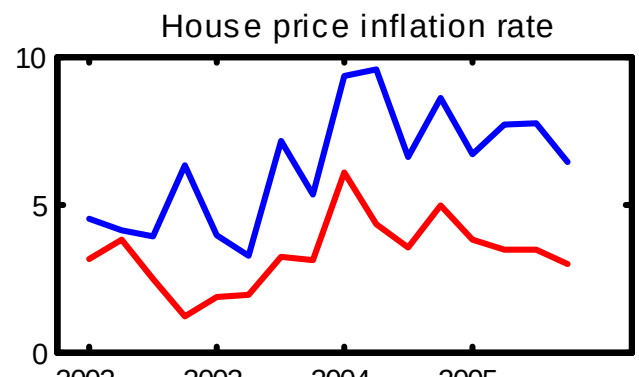












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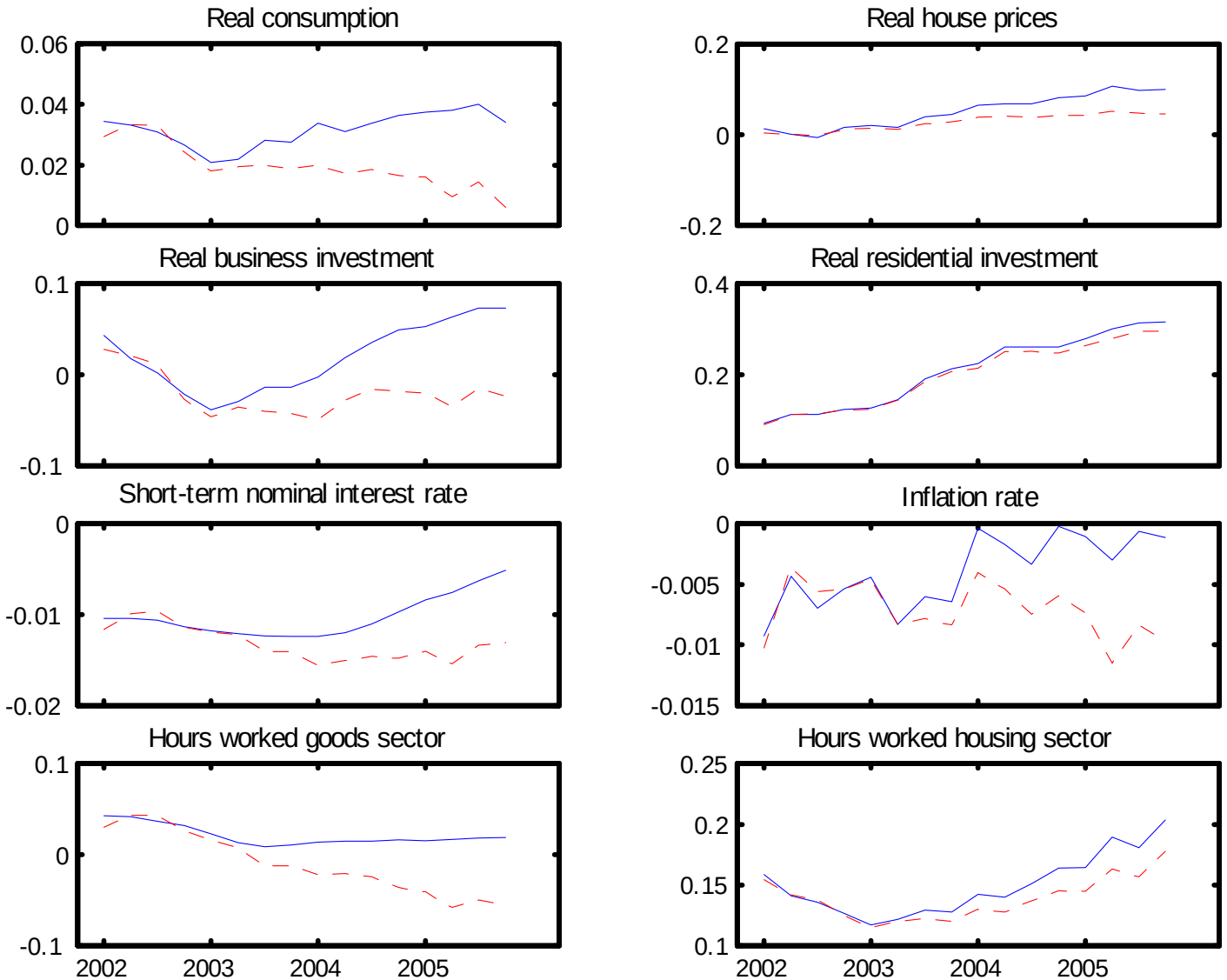
3. To prevent house prices from rising, monetary policy has to tighten so much that the economy falls into recession

FED RESPONDS TO HOUSE PRICES

Blue lines: data (from trend), Red: monetary policy responds to house prices



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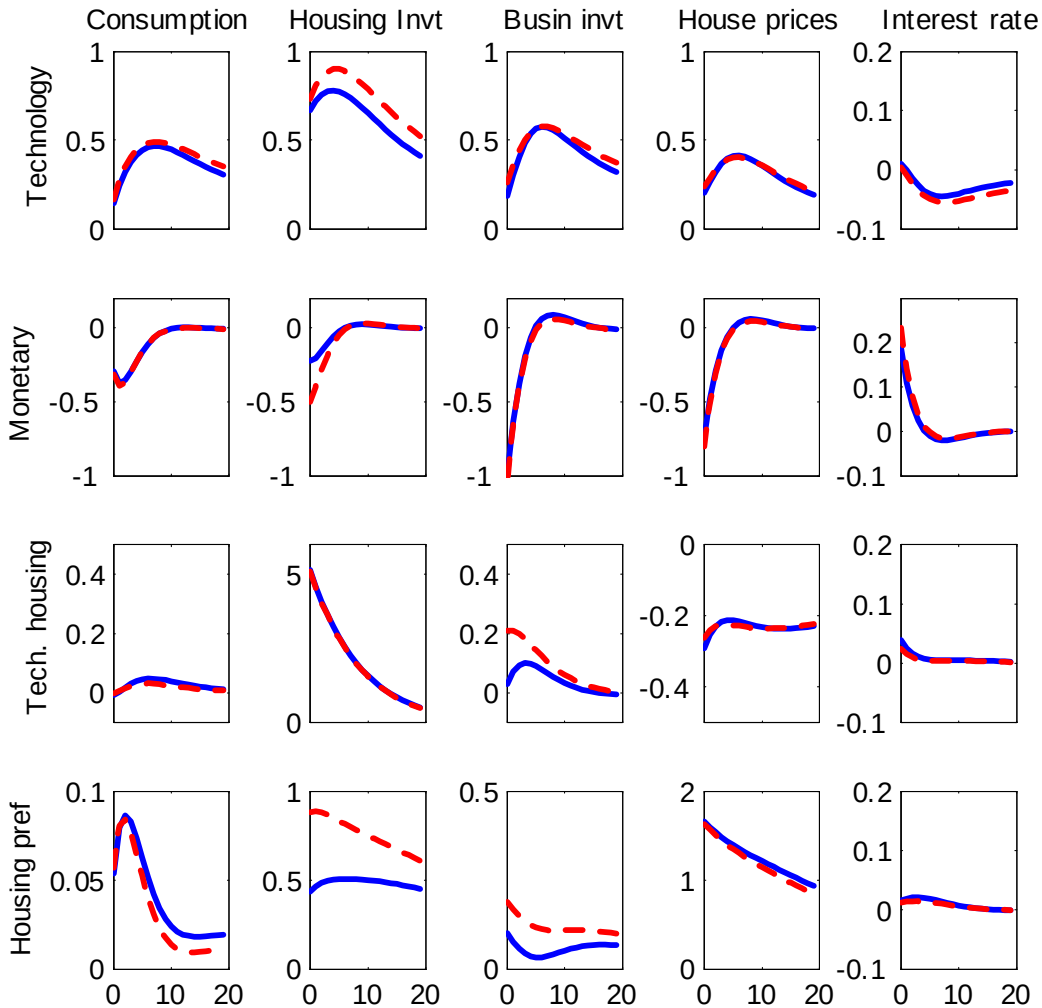
- Intermediate inputs work very similarly to sticky wages (we get similar results when we add sticky wages to the model)

BENCHMARK (blue) VS INTERMEDIATE INPUTS (red)



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- We find it surprising and enlightening that the slow rate of improvement in housing technology can account for the trends in housing investment and housing prices so well
- We are somehow disappointed that big shifts in the MRS between housing and consumption are needed to explain house prices....
- ...but we have a good sense of how big the feedback effects from housing shocks are for the rest of the economy (they line up with intuition, but are based on a microfounded model)

Extras

Table 3. Decomposition of the asymptotic variance of the forecast error

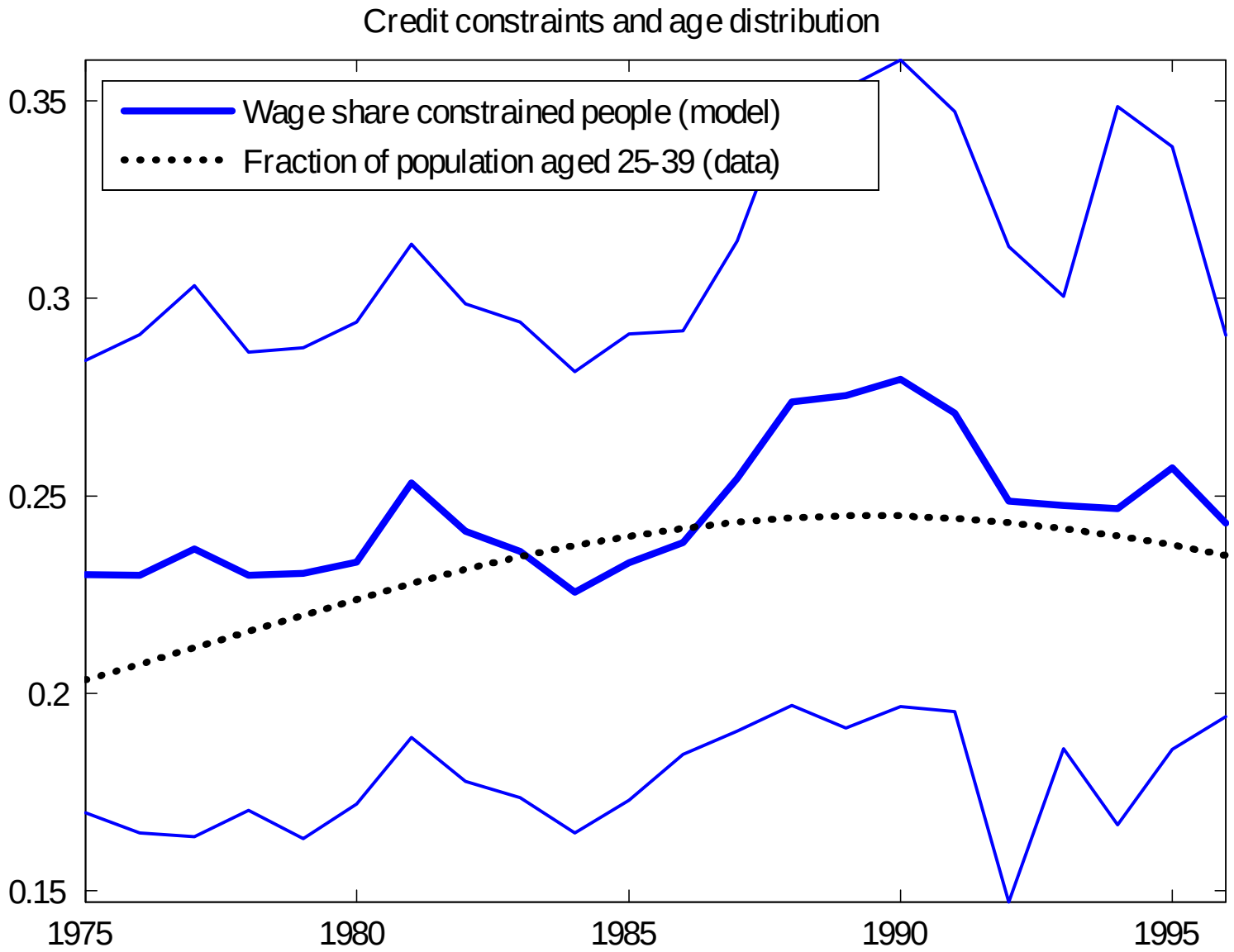
	j	a_c	a_h	ϵ_R	u	a_k	z	τ
C_t	0.19	21.58	0.07	1.76	15.65	18.68	5.48	30.76
	[0.1,0.4]	[10.8,40.6]	[0.0,0.1]	[0.9,3.1]	[9.8,21.9]	[10.4,35.2]	[3.5,8.0]	[19.1,43.3]
π_t	0.28	3.84	0.16	4.20	52.56	1.81	7.15	28.00
	[0.1,1.1]	[2.9,5.3]	[0.1,0.2]	[2.1,8.0]	[45.2,59.1]	[1.1,3.2]	[3.0,15.1]	[20.2,36.1]
IH_t	5.00	6.47	68.29	0.08	0.64	0.1	0.2	17.0
	[2.8,10.8]	[3.7,11.6]	[59.6,75.5]	[0.0,0.2]	[0.1,1.6]	[0.0,0.2]	[0.0,0.6]	[12.2,23.3]
Q_t	66.41	3.93	4.00	1.45	5.15	5.35	0.57	10.00
	[55.4,78.2]	[2.1,6.9]	[2.2,7.1]	[0.9,2.0]	[3.2,7.3]	[2.8,11.8]	[0.1,2.2]	[5.9,15.2]
R_t	0.66	5.75	0.62	12.66	20.77	8.56	11.78	36.60
	[0.2,2.1]	[4.3,7.7]	[0.0,1.0]	[9.8,15.8]	[15.2,26.3]	[6.0,12.2]	[5.0,25.7]	[26.9,45.3]
IK_t	0.14	5.90	0.05	1.51	8.24	69.70	0.50	11.60
	[0.0,0.3]	[2.8,12.4]	[0.0,0.1]	[0.9,2.20]	[5.0,12.0]	[57.7,82.1]	[0.1,2.1]	[6.2,18.5]
$N_{c,t}$	0.42	5.02	0.17	4.55	32.00	0.32	4.19	52.3
	[0.2,0.8]	[3.5,7.2]	[0.1,0.2]	[3.2,6.8]	[25.9,39.4]	[0.1,0.9]	[3.0,6.1]	[41.8,61.7]
$N_{h,t}$	13.15	0.84	15.26	0.36	2.37	0.0	0.58	65.40
	[8.2,23.4]	[0.5,1.5]	[10.6,20.7]	[0.1,0.9]	[0.3,5.4]	[0.0,0.1]	[0.1,2.5]	[55.1,73.3]

	posterior					prior		
parameter	2.5	50	97.5	mean	st. dev.	mean	st. dev.	Type
ϵ	0.423	0.533	0.623	0.530	0.052	0.50	0.075	Beta
ϵ'	0.438	0.732	0.888	0.712	0.132	0.50	0.075	Beta
η	0.381	0.601	0.876	0.607	0.126	0.25	0.10	Gamma
η'	0.299	0.456	0.672	0.464	0.094	0.25	0.10	Gamma
ν	-2.894	-2.296	-1.801	-2.306	0.278	-2.0	0.50	Normal
ν'	-3.003	-2.065	-1.177	-2.071	0.468	-2.0	0.50	Normal
$\phi_{k,c}$	20.307	23.436	26.881	23.467	1.704	10.0	2.50	Gamma
$\phi_{k,h}$	9.575	11.832	13.890	11.804	1.103	10.0	2.50	Gamma
α	0.679	0.790	0.867	0.784	0.051	0.70	0.05	Beta
m	0.734	0.790	0.844	0.789	0.028	0.80	0.025	Beta
r_R	0.643	0.689	0.730	0.688	0.022	0.75	0.10	Beta
r_π	1.186	1.318	1.464	1.319	0.072	1.50	0.10	Normal
r_Y	0.277	0.405	0.532	0.406	0.064	0.0	0.10	Normal
θ_π	0.904	0.922	0.937	0.921	0.009	0.75	0.05	Beta
ι_π	0.705	0.848	0.963	0.784	0.051	0.5	0.20	Beta
γ_{AC}	0.0030	0.0032	0.0034	0.0032	0.0001	0.005	0.01	Normal
γ_{AH}	-0.0029	-0.0023	-0.0017	-0.0023	0.0003	0.005	0.01	Normal
γ_{AK}	0.0021	0.0028	0.0035	0.0028	0.0003	0.005	0.01	Normal
ρ_I	0.949	0.972	0.991	0.972	0.011	0.80	0.10	Beta
ρ_{AC}	0.912	0.949	0.977	0.947	0.017	0.80	0.10	Beta
ρ_{AH}	0.839	0.883	0.919	0.882	0.021	0.80	0.10	Beta
ρ_{AK}	0.899	0.937	0.974	0.937	0.019	0.80	0.10	Beta
ρ_z	0.539	0.717	0.858	0.711	0.083	0.80	0.10	Beta
ρ_τ	0.830	0.876	0.915	0.875	0.021	0.80	0.10	Beta
σ_{AC}	0.010	0.011	0.013	0.011	0.001	0.005	0.10	Gamma
σ_{AH}	0.046	0.052	0.058	0.052	0.003	0.005	0.10	Gamma
σ_{AK}	0.021	0.024	0.028	0.024	0.002	0.005	0.10	Gamma
σ_I	0.029	0.049	0.076	0.050	0.012	0.005	0.10	Gamma
σ_u	0.005	0.006	0.007	0.006	0.001	0.005	0.10	Gamma
σ_R	0.002	0.003	0.003	0.003	0.000	0.005	0.10	Gamma
σ_z	0.013	0.018	0.025	0.018	0.003	0.005	0.10	Gamma
σ_τ	0.038	0.051	0.064	0.051	0.007	0.005	0.10	Gamma

CREDIT CONSTRAINTS OVER TIME

We recursively estimate the model parameters from 1965 to 1984, moving the estimation window ahead one year at the time (last window: 1986-2005).

1. A large fraction of the volatility decline is accounted by decline of volatility of shocks
   (Variance of the housing preference shock is only exception)
2. Monetary policy has become more inertial and more aggressive towards inflation
3. The fraction of credit constrained people exhibits a hump-shaped pattern.


Credit constraints and age distribution
Wage share constrained people (model)
Fraction of population aged 25-39 (data)
0.35
0.3
0.25
0.2
0.15
1975
1980
1985
1990
1995