Do Central Banks Respond to House Price Movements?

A Bayesian DSGE Approach

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Outline

Section 1

Introduction

Background

- Housing impacts both wealth and collateral capacity (Mishkin, 2007)
- House prices influence business cycles (Iacoviello and Neri, 2010)
- Whether monetary policy should react to house price movements (Iacoviello, 2005)
- Empirically examining **whether the central bank directly responded to house prices**

Past Literature

Response to Housing (Bjørnland and Jacobsen, 2010; Aastveit et.al, 2023)

- Interest rates respond to house prices in IRFs, intermediary role of inflation
- Housing coefficient positive in certain years

Bayesian DSGE Approach (Lubik and Schorfheide, 2007; Kitney, 2015)

- Bayesian DSGE study response to exchange rates, changes in credit spreads

Research Purpose

Contribution to literature

- Empirically examine central banks' response to house prices in chosen years, regions
- Analyze and compare IRFs, isolate interest rates' response to housing and inflation

Methodology

- Estimate a New Keynesian DSGE model with housing, using the Bayesian technique

Section 2

A New Keynesian Model with Housing

Households

- Patient households utility and budget constraint:

$$\max_{c'_t, h'_t, L'_t, B'_t} E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln c'_t + j_t \ln h'_t - \frac{(L'_t)^\eta}{\eta} \right\}$$

$$c'_t + q_t h'_t + \frac{R_{t-1} b'_{t-1}}{\pi_t} = b'_t + w'_t L'_t + q_t h'_{t-1} + F_t + T'_t \tag{1}$$

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- Impatient households utility and budget constraint:

$$\max_{c''_t, h''_t, L''_t, B''_t} E_0 \sum_{t=0}^{\infty} \beta''^t \left\{ \ln c''_t + j_t \ln h''_t - \frac{(L''_t)^\eta}{\eta} \right\}$$

$$c''_t + q_t h''_t + \frac{R_{t-1} b''_{t-1}}{\pi_t} = b''_t + w''_t L''_t + q_t h''_{t-1} + T''_t \tag{2}$$

- Impatient households borrowing constraint:

$$b''_t \leq m'' E_t \left(\frac{q_{t+1} h''_t \pi_{t+1}}{R_t} \right) \tag{3}$$

Entrepreneur

- Intermediate goods production function :

$$Y_{w,t} = A_t K_{t-1}^{\mu} h_{t-1}^{\nu} (L_t')^{\alpha(1-\mu-\nu)} (L_t'')^{(1-\alpha)(1-\mu-\nu)} \tag{4}$$

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- Entrepreneurs utility function and budget constraint:

$$\max_{c_t} E_0 \sum_{t=0}^{\infty} \gamma^t \ln c_t$$

$$\frac{Y_{w,t}}{X_t} + b_t + q_t h_{t-1} - w_t' L_t' - w_t'' L_t'' = c_t + q_t h_t + \frac{R_{t-1} b_{t-1}}{\pi_t} + I_t + \xi_{k,t} \tag{5}$$

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- Entrepreneur borrowing constraint:

$$b_t \leq m E_t \left(\frac{q_{t+1} h_t \pi_{t+1}}{R_t} \right) \tag{6}$$

- I_t is investment:

$$K_t = I_t + (1-\delta) K_{t-1} \tag{7}$$

Final Goods & Retailer

- Final output produced by firms:

$$Y_t = \left(\int_0^1 Y_t(z)^{\frac{\epsilon-1}{\epsilon}} dz \right)^{\frac{\epsilon}{\epsilon-1}} \tag{8}$$

- The retailer faces an individual demand :

$$Y_t(z) = \left(\frac{P_t(z)}{P_t} \right)^{-\epsilon} Y_t \tag{9}$$

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- New Keynesian Phillips Curve:

$$\widehat{\pi}_t = -\frac{(1-\theta)(1-\theta\beta)}{\theta} \widehat{X}_t + \beta E_t \widehat{\pi}_{t+1} + \widehat{u}_t \tag{10}$$

Central Bank

- Taylor rule without housing:

$$\widehat{R}_t = r_R \widehat{R}_{t-1} + (1 - r_R)\Big[(1 + r_\pi)\widehat{\pi}_{t-1} + r_Y \widehat{Y}_{t-1}\Big] + \widehat{e}_{R,t} \tag{11}$$

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- Taylor rule with housing:

$$\widehat{R}_t = r_R \widehat{R}_{t-1} + (1 - r_R)\Big[r_q \widehat{q}_t + (1 + r_\pi)\widehat{\pi}_{t-1} + r_Y \widehat{Y}_{t-1}\Big] + \widehat{e}_{R,t} \tag{12}$$

Exogenous Process

- Housing preference shock $e_{j,t} \sim \mathrm{N}(0, \sigma_j^2)$:

$$j_t = \rho_j j_{t-1} + e_{j,t} \tag{13}$$

- Productivity shock $e_{A,t} \sim \mathrm{N}(0, \sigma_A^2)$:

$$A_t = \rho_A A_{t-1} + e_{A,t} \tag{14}$$

- Inflation shock $e_{u,t} \sim \mathrm{N}(0, \sigma_u^2)$:

$$u_t = \rho_u u_{t-1} + e_{u,t} \tag{15}$$

Section 3

Econometric Methodology

Data

Baseline sample period: *1990:Q1-2008:Q2*, 4 US quarterly time series:

- R_t: quarterly federal funds rate
- π_t: annualized quarterly growth rate of the GDP deflator (seasonally adjusted)
- g_{Y_t}: per capita real GDP growth rate
- Δq_t: demeaned real house price growth rate

Bayesian Technique

- The log-linearized DSGE model can be expressed as:

$$\Gamma_0 s_t = \Gamma_1 s_{t-1} + \Psi \epsilon_t + \Pi \eta_t \tag{16}$$

- The solution is a VAR in s_t:

$$s_t = \Phi_1(\theta_{\mathcal{M}}) s_{t-1} + \Phi_\epsilon(\theta_{\mathcal{M}}) \epsilon_t \tag{17}$$

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- Observation equation

$$\mathcal{Y}_t = M + H s_t, \tag{18}$$

- Match data to the observation equation:

$$\begin{bmatrix} R_t \\ \pi_t \\ g_{Y_t} \\ \Delta q_t \end{bmatrix} = \begin{bmatrix} r^* + \pi^* \\ \pi^* \\ g^* \\ - \end{bmatrix} + \begin{bmatrix} 400\hat{R}_t \\ 400\hat{\pi}_t \\ 100(\hat{Y}_t - \hat{Y}_{t-1}) \\ 100(\hat{q}_t - \hat{q}_{t-1}) \end{bmatrix} \tag{19}$$

Bayesian Technique

- Priors :

$$p(\theta_{\mathcal{M}}|\mathcal{M}) \tag{20}$$

- The likelihood function :

$$\mathcal{L}(\theta_{\mathcal{M}}|Y_T, \mathcal{M}) = p(Y_T|\theta_{\mathcal{M}}, \mathcal{M}) = \prod_{t=1}^{T} p(\mathcal{Y}_t|Y_{t-1}, \theta_{\mathcal{M}}, \mathcal{M}) \tag{21}$$

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- Bayes' rule:

$$p(\theta_{\mathcal{M}}|Y_T,\mathcal{M}) = \frac{p(Y_T|\theta_{\mathcal{M}},\mathcal{M})p(\theta_{\mathcal{M}}|\mathcal{M})}{p(Y_T|\mathcal{M})}. \tag{22}$$

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- Posterior kernel:

$$p(\theta_{\mathcal{M}}|Y_T,\mathcal{M}) \propto p(Y_T|\theta_{\mathcal{M}},\mathcal{M})p(\theta_{\mathcal{M}}|\mathcal{M}) \equiv \mathcal{K}(\theta_{\mathcal{M}}|Y_T,\mathcal{M}) \tag{23}$$

Calibration

Table 1: Calibrated Parameters

Description	Parameter	Value
Entrepreneurs' discount factor	γ	0.98
Patient households' discount factor	β	0.99
Impatient households' discount factor	β''	0.95
Labor disutility	η	1.01
Housing services weight	j	0.10
Housing share	ν	0.03
Capital share	μ	0.30
Capital depreciation rate	δ	0.03
Markup	X	1.05
Wage share	α	0.64
Entrepreneurs' loan-to-value	m	0.89
Households' loan-to-value	m''	0.55
Probability unchanged price	θ	0.75

Prior Distribution

Table 2: Prior Distribution

Parameter	Distribution	Mean	S.D
ψ	Gamma	2.0	1.0
ρ_j	Beta	0.5	0.2
ρ_A	Beta	0.5	0.2
ρ_u	Beta	0.5	0.2
r_R	Beta	0.75	0.1
r_π	Normal	1.5	0.1
r_Y	Normal	0.1	0.05
r_q	Normal	0.1	0.05
r^*	Gamma	2.0	0.5
π^*	Gamma	2.3	2.0
g^*	Normal	0.4	0.2
σ_R	Ive.gamma	0.5	0.1
σ_A	Ive.gamma	0.5	0.1
σ_j	Ive.gamma	0.5	0.1
σ_u	Ive.gamma	0.5	0.1

Posterior Distribution

Table 3: Posterior Distribution

Parameter	$r_q \neq 0$ Mean	$r_q \neq 0$ 90% HPD interval	$r_q = 0$ Mean	$r_q = 0$ 90% HPD interval
ψ	4.40	[2.52,6.25]	4.66	[2.67,6.62]
ρ_j	0.93	[0.89,0.96]	0.91	[0.89,0.94]
ρ_A	0.44	[0.33,0.55]	0.31	[0.22,0.41]
ρ_u	0.04	[0.01,0.08]	0.05	[0.01,0.09]
r_R	0.49	[0.36,0.62]	0.50	[0.38,0.63]
r_π	1.53	[1.37,1.69]	1.51	[1.35,1.68]
r_Y	0.18	[0.11,0.25]	0.20	[0.14,0.27]
r_q	0.11	[0.06,0.16]	—	—
r^*	1.95	[1.17,2.71]	1.99	[1.21,2.72]
π^*	2.10	[0.02,4.14]	1.98	[0.09,3.80]
g^*	0.51	[0.41,0.6]	0.49	[0.28,0.59]
σ_R	0.07	[0.06,0.07]	0.07	[0.06,0.07]
σ_A	0.10	[0.08,0.10]	0.10	[0.09,0.12]
σ_j	0.20	[0.13,0.27]	0.17	[0.12,0.23]
σ_u	0.07	[0.06,0.07]	0.07	[0.06,0.07]

Section 4

Quantatitive Analysis

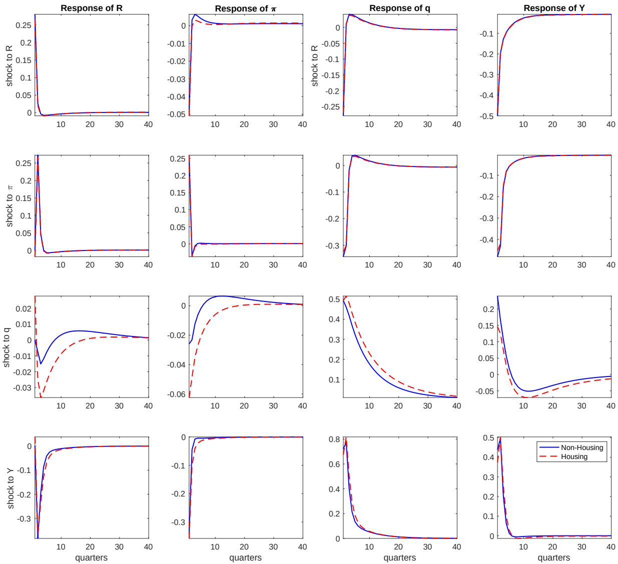
Model Comparison

K-R Ratio

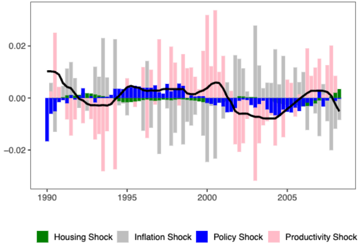
2(log data density H1 - log dara density H0)= $2(\ln p(Y_T|\theta_H) - \ln p(Y_T|\theta_O))$

	Log data density
$r_q = 0 : \ln p(Y_T\|\theta_O)$	-917.72
$r_q \neq 0 : \ln p(Y_T\|\theta_H)$	-914.16
K-R ratio	7.12

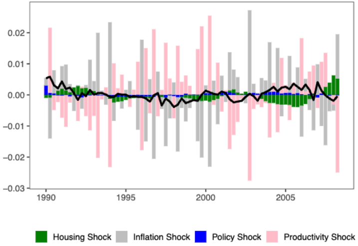
Impulse Responses



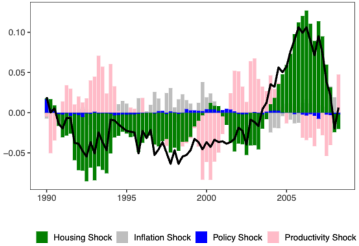
Historical Shock Decomposition $r_q = 0$



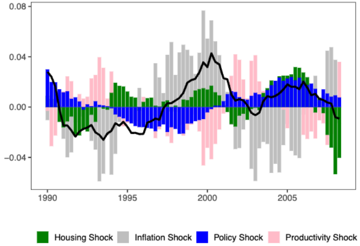
(a) Interest Rates



(b) Inflation

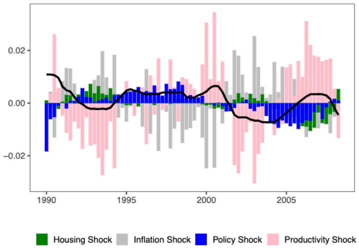


(c) Real House Prices

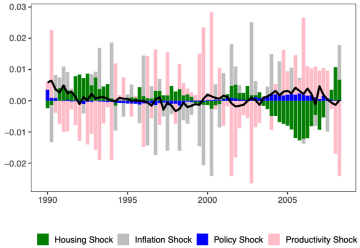


(d) Output

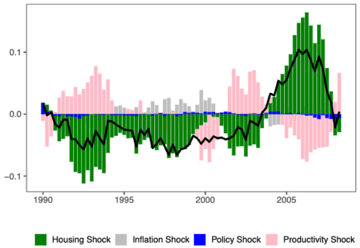
Historical Shock Decomposition $r_q \neq 0$



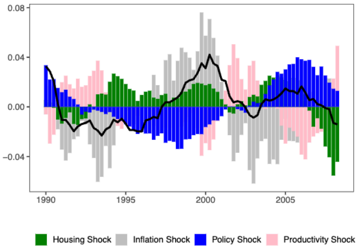
(a) Interest Rates



(b) Inflation



(c) Real House Prices

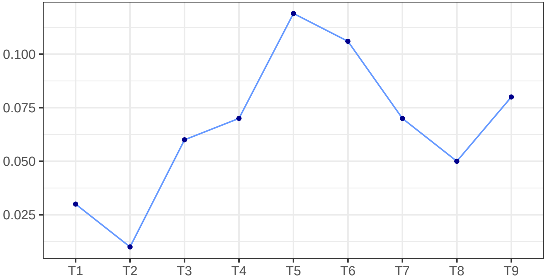


(d) Output

Rolling Window Analysis

	T1 1969 I-1979 I	T2 1974 I-1984 I	T3 1979 I-1989 I	T4 1984 I-1994 I	T5 1989 I-1999 I	T6 1994 I-2004 I	T7 1999 I-2009 I	T8 2004 I-2014 I	T9 2009 I-2019 I
K-R ratio	-3.9	-4.78	-2.32	-0.72	4.82	4.02	-1.68	-2.16	-0.02

- Time-varying housing parameter:



Section 5

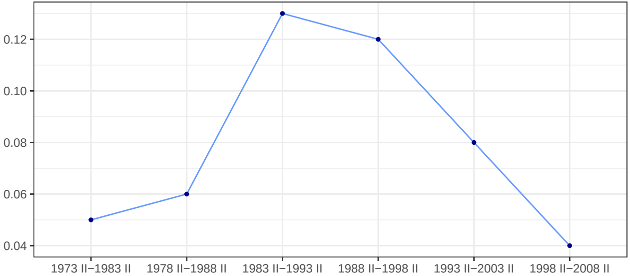
Cross Country Analysis

Cross Country Analysis

- Chosen regions and sample periods:

Country	Years
Australia	1973:Q2-2008:Q2
New Zealand	1990:Q2-2008:Q2
United Kingdom	1987:Q2-2008:Q2
Euro Area	1996:Q2-2008:Q2
Canada	1973:Q2-2008:Q2

- Canada housing coefficient r_q:



Section 6

Robust Checks

Robust Checks

- Alternative FHFA house price index
- Alternative prior
  - Interest rate smoothing
  - Inflation coefficient
  - House price coefficient
- Taylor rule
  - Contemporaneous
  - Forward-looking

Section 7

Conclusion Remarks

Conclusion Remarks

- Federal Reserve episodically responded to house price movements
- No response in Australia, New Zealand, UK, EA. Canada responded
- Significant housing coefficient in the Taylor rule affects the housing shock transmission
- Comparing IRFs, interest rates respond directly and positively to house price increase

Limitation & Future works

- More factors in the DSGE model
- More shocks to better capture observational errors
- Expand the model to an open economy model
- Estimating more parameters instead of calibration

The End

Thank You