Estimating the Time-varying Effects of Monetary Policy Shocks in Korea

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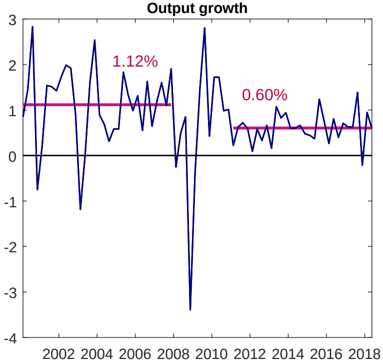
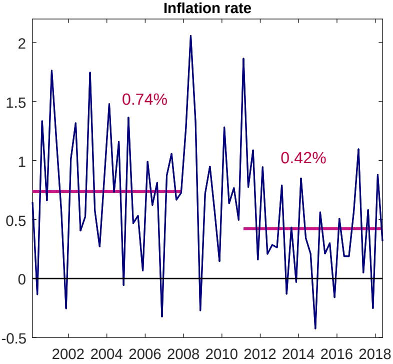
Recent Macro Dynamics of Korea





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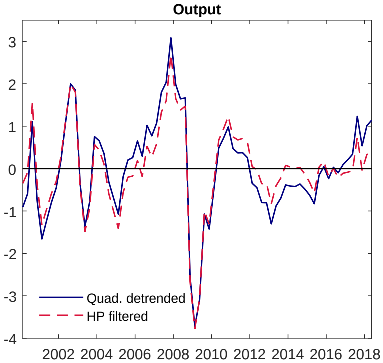
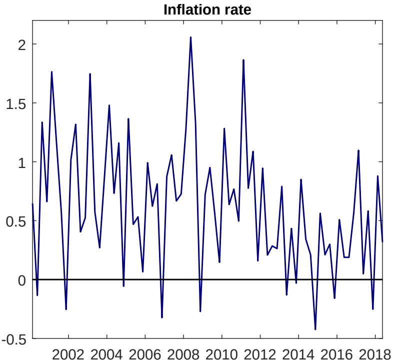




St.Dev.		Whole sample	2000:Q1-2007:Q4	2011:Q1-2018:Q2
Output	Quadratic detrended	1.16	1.14	0.62
	HP filtered	1.06	1.04	0.39
Inflation rate		0.54	0.53	0.47

Motivation

- Two notable changes in the macro dynamics after the global financial crisis (GFC) of 2008-09
  1. both output growth and inflation are lower in level
  2. reduced volatility of output and inflation
- On the point 1, expansionary monetary policy (MP) is an option to counteract this phenomenon
  - e.g., "In the face of slowing growth (. . .) the Bank of Korea should have a clearly accommodative MP stance" from *IMF Staff 2019 Article IV Mission to Korea*
  - a prerequisite for this to be a viable policy option, however, is the efficacy of MP in boosting the economy

Motivation

- Regarding 2, there is a plethora of US literature on the "Great Moderation"
  - the crux of debates is about the source of the reduced macro volatility from the mid-80s to the onset of the GFC
  - "good luck": Sims and Zha (2006, AER)
  - "good policy": Clarida et al. (2000, QJE); Lubik and Schorfheide (2004, AER)
- In spite of significance of the issue, this line of research for Korea is still in its infancy

What We Do

- Estimate a time-varying coefficient vector autoregressive (TVC-VAR) model
  - as in Primiceri (2005, RES) and Galí and Gambetti (2015, AEJ-Macro)
  - with Korean data since the 2000s
- Attempt to seek econometric evidence on:
  - how does the effect of monetary policy shocks on output (and its components) change over time?
  - what are the primary determinants of the change in the macroeconomic dynamics? Any role of monetary policy?

What We Find (Preliminary)

1. A time-varying pattern of the efficacy of MP shocks?
   - the effect of MP shocks on output has decreased gradually during the 2000s
   - the decreasing pattern, however, vanishes and turns out to be more stable in the 2010s
   - diminished responses of both consumption and investment account for this finding

2. The sources of the reduced volatility?
   - the size of shocks is its dominant determinant
   - the contribution of MP is somewhat limited

Econometric Specification

Reduced-form VAR Specification

- A quarterly VAR with time-varying coefficients:

$$z_t = \mu_{0,t} + \mu_1 t + \mu_2 t^2 + D x_t + B_{1,t} z_{t-1} + \ldots + B_{\ell,t} z_{t-\ell} + u_t,$$

  - $\mu_{0,t}$ is a constant, t & t^2 are linear and quadratic time trends
  - x_t: vector of exogenous variables
  - D: coefficients associated with the exogenous variables
  - z_t: vector of endogenous variables
  - $B_{i,t}$'s: matrices of time-varying coefficients
  - u_t: heteroskedastic reduced-form errors with $E(u_t u_t') = \Sigma_{u,t}$

Reduced-form VAR Specification

- A quarterly VAR with time-varying coefficients:

$$z_t = \mu_{0,t} + \mu_1 t + \mu_2 t^2 + D x_t + B_{1,t} z_{t-1} + \ldots + B_{\ell,t} z_{t-\ell} + u_t,$$

  - x_t contains four variables having potential impacts on monetary policy decision-making
    - the growth rate of oil price, federal funds rate, and real exchange rate (e.g., Kim (2000)) as well as US output
  - z_t consists of three variables
    - the benchmark specification has output (Y), inflation rate (π), and overnight call rate (R)
    - extended 4-variable models are also considered comprising $\{Y, C, \pi, R\}$, and consumption (C) is replaced with investment (I), and C and I sub-components in order to calculate the responses of these variables to MP shocks
  - set $\ell = 3 \Leftarrow$ based on the information criteria (AIC and BIC)

Corresponding Structural VAR

- The structural VAR model:

$$
\begin{aligned}
A_t z_t = & A_t \left(\mu_{0,t} + \mu_1 t + \mu_2 t^2 + D x_t \right) \\
& + A_t B_{1,t} z_{t-1} + A_t B_{2,t} z_{t-2} + A_t B_{3,t} z_{t-3} + e_t,
\end{aligned}
$$

  - A_t: lower-triangular Cholesky decomposition of $\Sigma_{u,t}$
    - posit that the policy rate has no contemporaneous effect on macroeconomic variables, such as production and prices
    - e.g., Christiano, Eichenbaum, and Evans (1999, HoM)
  - e_t: structural innovations with $E(e_t e_t') = \Sigma_{e,t}$ where all the off-diagonal elements of $\Sigma_{e,t}$ are zero
    - $A_t u_t = e_t$ and $A_t \Sigma_{u,t} A_t' = \Sigma_{e,t} \Sigma_{e,t}'$

Data and Estimation

- Sample: 1990:Q1–2018:Q2
  - the 10-year sample 1990:Q1–1999:Q4 is used to initiate the prior distributions
  - the empirical results are for the period 2000:Q1–2018:Q2
- Bayesian inference as in Galí and Gambetti (2015)
  - Gibbs sampling for 22,000 posterior draws
  - with the first 20,000 used as a burn-in period and every 2nd thinned, leaving a sample size of 1,000
- For comparison, the fixed-coefficient (FC) VAR results are also provided

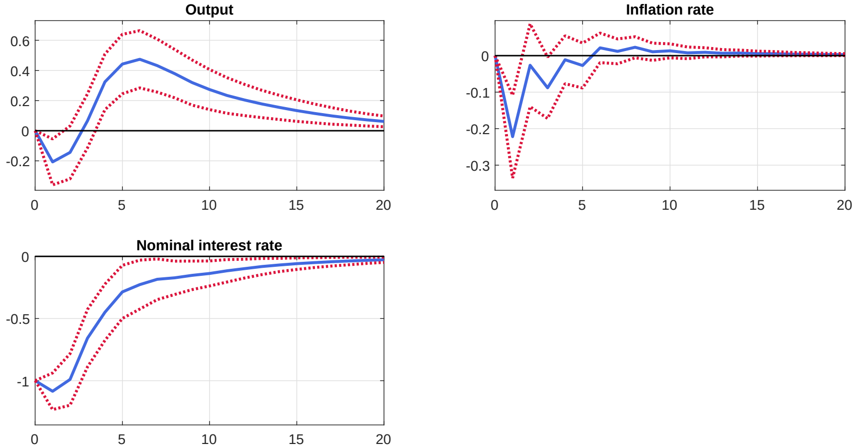
Data and Estimation

Definitions of the output components

- "Consumption" (C): private consumption
  - "durable consumption" (C^d) $=$ durable $+$ semi-durable
  - "nondurable consumption" (C^{nd}) $=$ nondurable $+$ service
  - $C \approx C^d + C^{nd}$
- "Investment" (I) $=$ "residential" (I^r) $+$ "nonresidential" (I^{nr})

Empirical Results

Impulse Responses: FC-VAR



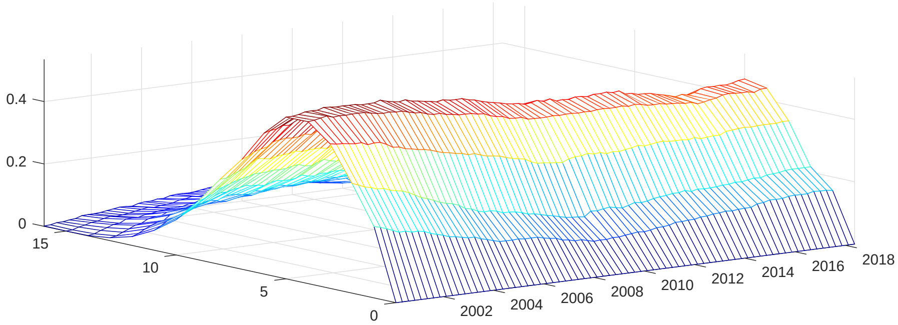
IRF (%) to a 100 bp decrease in R

Solid: Point estimates; Dashed: 68% bands

Comparison to the US Estimates

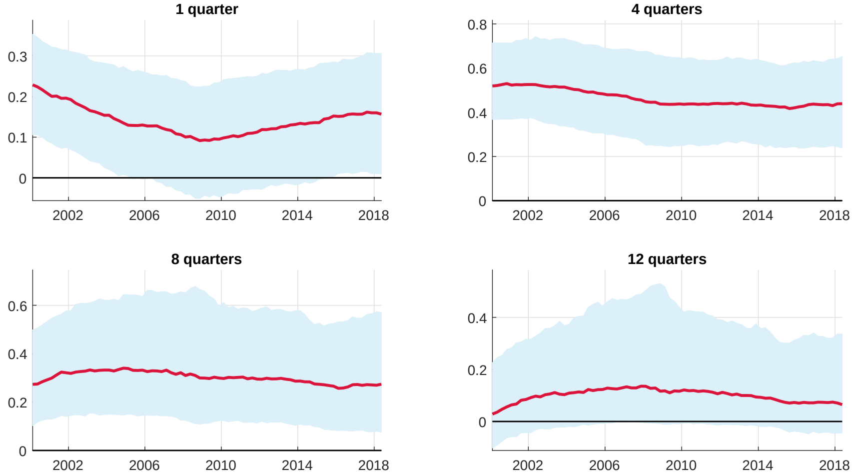
- US VAR evidence: in response to a 100 bp decrease in the FFR, a peak rise in GDP is ranged from 0.3% to 0.8%
  - Leeper-Sims-Zha (1996) $\Rightarrow$ 0.35% (59-96)
  - Bernanke-Gertler-Watson (1997) $\Rightarrow$ 0.4% (65-95)
  - Faust-Swanson-Wright (2004) $\Rightarrow$ 0.6% (Futures markets for the FFR, 91-01)
  - Uhlig (2005) $\Rightarrow$ 0.3% (sign restrictions, 65-96)
  - Gorodnichenko (2006) $\Rightarrow$ 0.8% (factor-based VAR, 65-96)
- Our output response is in line with these estimates
  - a peak effect in output of 0.47%
- However, a price puzzle seems to be present

Impulse Responses of Y



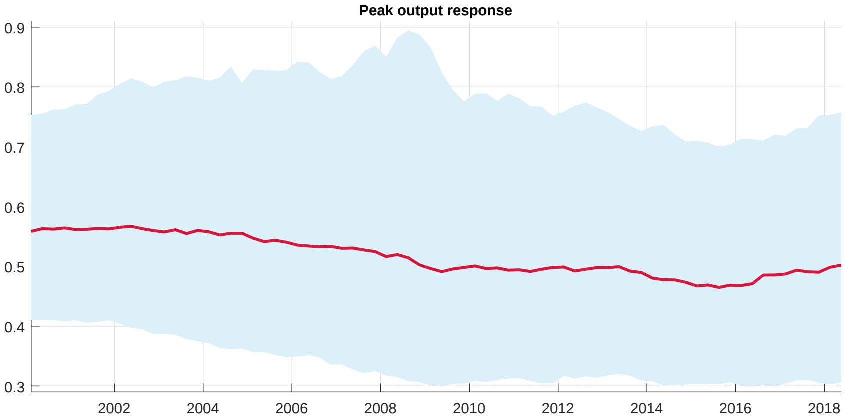
Median output IRF estimates (%) to 100 bp decreases in R

Impulse Responses of Y



Y responses (%), median and 68% band estimates

IMPULSE RESPONSES OF Y



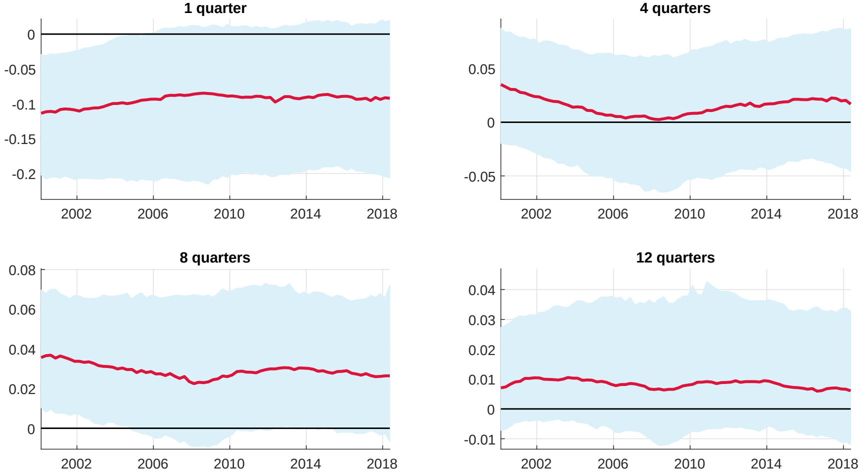
Peak Y responses (%), median and 68% band estimates

Impulse Responses of Y

	2000:Q2	2004:Q2	2008:Q2	2012:Q2	2016:Q2	2018:Q2
1 quarter	0.22	0.15	0.10	0.12	0.15	0.16
4 quarters	0.52	0.50	0.45	0.44	0.43	0.44
8 quarters	0.27	0.33	0.32	0.30	0.26	0.27
12 quarters	0.04	0.11	0.13	0.11	0.07	0.06
Y Peak (QTR)	0.52 (4)	0.53 (5)	0.48 (5)	0.47 (5)	0.43 (5)	0.45 (5)

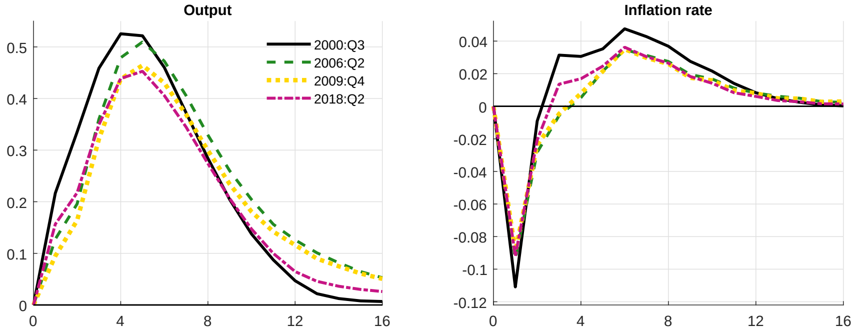
Summary of the Y responses to a 100 basis point decrease in R (%), median estimates

Impulse Responses of π



π responses (%), median and 68% band estimates

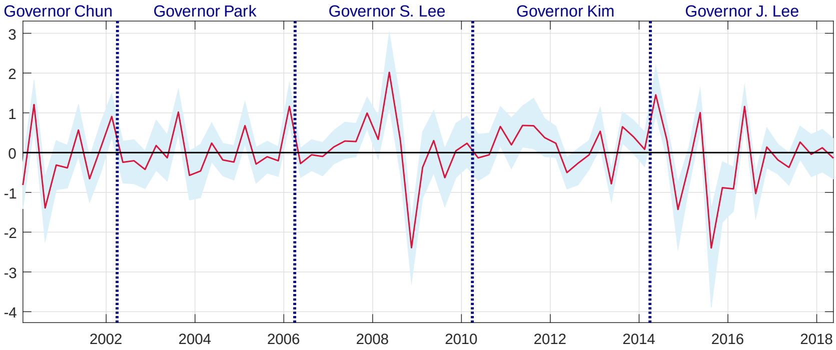
Impulse Responses of Y and π



Y and π responses for selected periods, median estimates

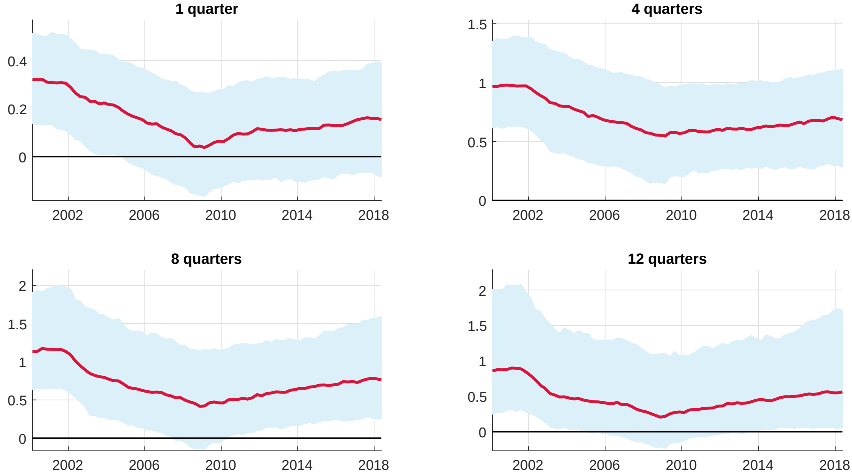
2000:Q3; 2006:Q2; 2009:Q4; 2018:Q2

Estimated MP Shock Sequence



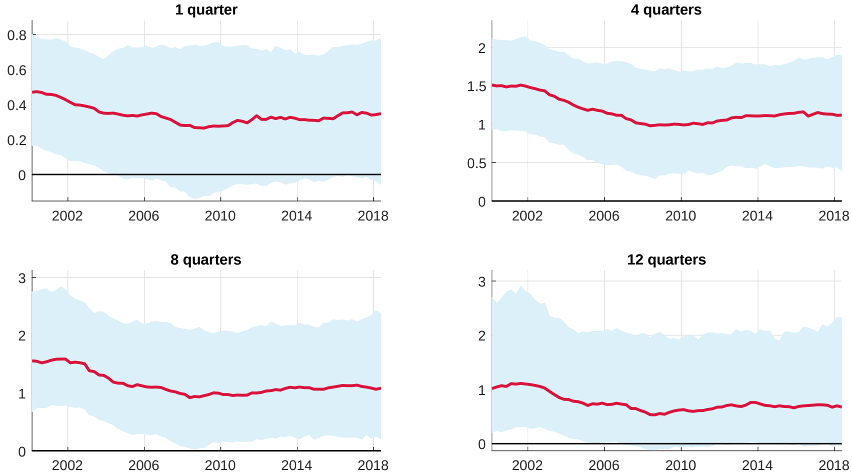
Estimated sequence of monetary policy shocks ($e_{R,t}$), median and 68% band estimates

Impulse Responses of C



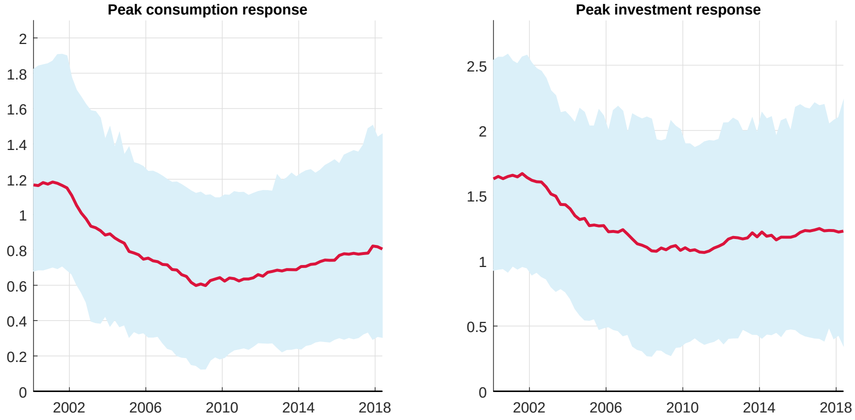
C responses (%), median and 68% band estimates

IMPULSE RESPONSES OF I



I responses (%), median and 68% band estimates

PEAK IMPULSE RESPONSES OF C AND I



Peak C (left) and I (right) responses (%), median and 68% band estimates

Peak Impulse Responses of C and I

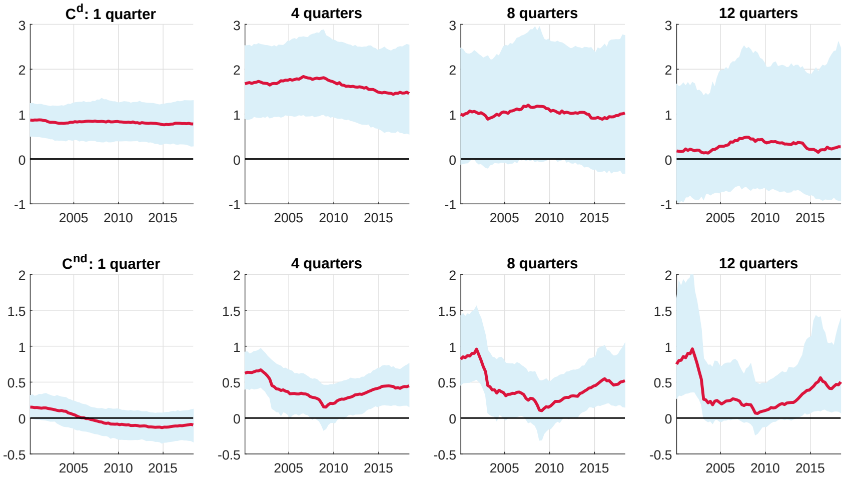
	2000:Q2	2004:Q2	2008:Q2	2012:Q2	2016:Q2	2018:Q2
C peak (QTR)	1.16 (7)	0.87 (5)	0.62 (5)	0.67 (5)	0.78 (6)	0.81 (6)
I peak (QTR)	1.65 (6)	1.35 (5)	1.08 (6)	1.17 (6)	1.23 (6)	1.23 (6)

Summary of the C and I peak responses to a 100 basis point decrease in R (%), median estimates

Peak Impulse Responses of C and I

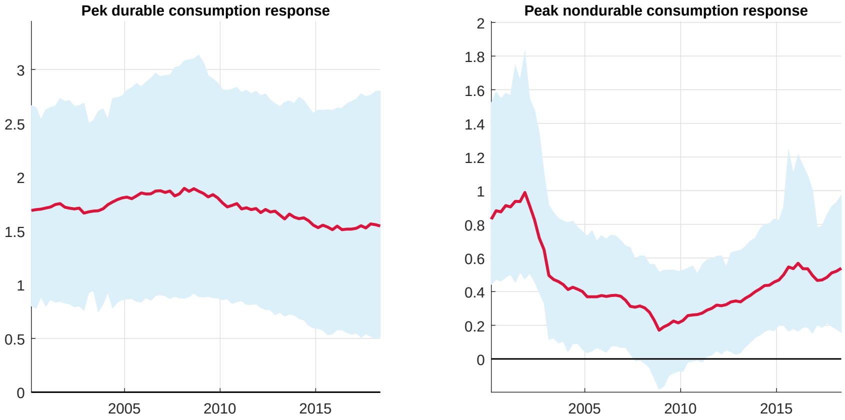
- For shorter horizons, a similar pattern to those of output is observed for the consumption and investment responses
  - the effects of MP shocks to C and I decrease from the early 2000s to the GFC period
  - they bounce back mildly in the subsequent sample
- The diminished effect of MP shocks to C is slightly more pronounced than that to I

IMPULSE RESPONSES OF SUB-C



Durable (above) and nondurable (below) consumption responses (%), median and 68% band estimates

PEAK IMPULSE RESPONSES OF SUB-C

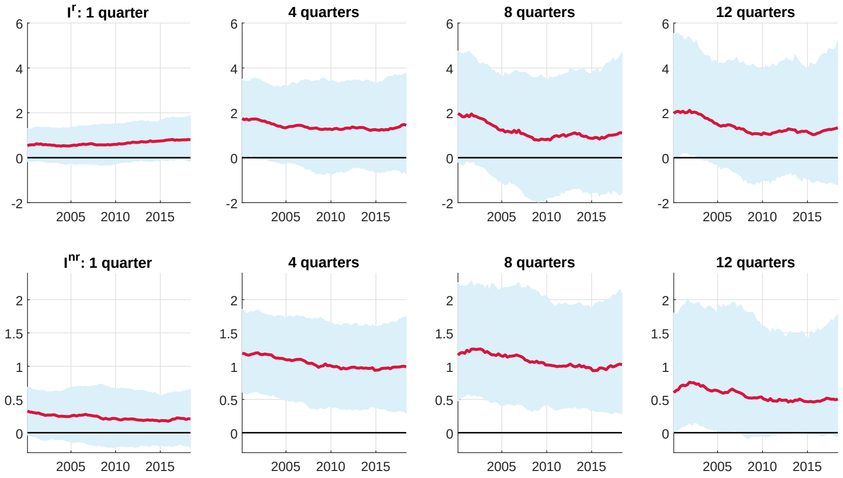


Peak C^d (left) and C^{nd} (right) responses (%), median and 68% band estimates

Peak Impulse Responses of Sub-C

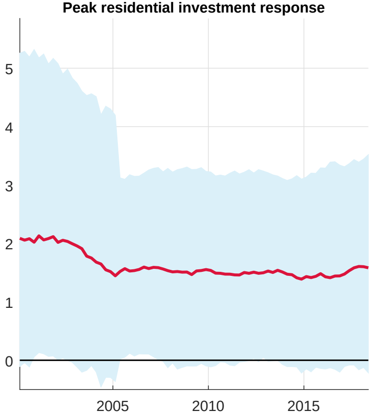
- A stark contrast in results
  - C^d: the effects of MP shocks declines only marginally over time
  - C^{nd}: they are, however, diminished considerably from the early 2000s, and are recovered only partially after the GFC
  - this finding is also observed in the peak responses
- Since the share of C^{nd} is substantially larger than C^d, the time-varying pattern in C is largely affected by that of C^{nd}

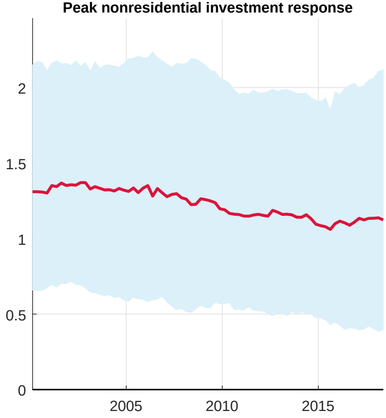
Peak Impulse Responses of Sub-I



Residential (above) and nonresidential (below) investment responses (%), median and 68% band estimates

IMPULSE RESPONSES OF SUB-I





Peak I^r (left) and I^{nr} (right) responses (%), median and 68% band estimates

Impulse Responses of Sub-I

- For I, results also vary widely across its subcomponents
  - I^r: the short- and longer-run effects are different
    - based on the 1-period responses, the expansionary effects of MP shocks are more pronounced over time
    - the pattern, however, becomes more L-shaped as the horizon increases
  - I^{nr}: the expansionary effects of MP shocks decrease constantly over time
- These findings account for the time-varying pattern in the investment responses

Counterfactual Exercise

Counterfactual Exercises

- What are the sources of the reduced volatility in the macro aggregates of Korea?
- Two possible sources conditioning on the VAR model:
  1. monetary policy summarized in the B_t matrices
  2. size of shocks approximated by the standard deviation of u_t (σ_t) estimates
- To assess empirically the contribution of each factor, conduct two counterfactuals
  1. conditional counterfactual: consider alternative scenarios for B_t, while plugging in the actual u_t estimates
  2. unconditional counterfactual: alter the shock size, while maintaining the actual estimates of B_t

CONDITIONAL COUNTERFACTUAL

- The reduced-form VAR can be rewritten as:

$$\begin{bmatrix} Y_t \\ \pi_t \\ R_t \end{bmatrix} = \begin{bmatrix} B_{1,t}^{11} & B_{1,t}^{13} & B_{1,t}^{13} \\ B_{1,t}^{21} & B_{1,t}^{23} & B_{1,t}^{23} \\ B_{1,t}^{31} & B_{1,t}^{33} & B_{1,t}^{33} \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ \pi_{t-1} \\ R_{t-1} \end{bmatrix} + \ldots,$$

- The coefficients in the first two rows (Y and π equations) form the non-policy block, while those in the last row (R equation) can be regarded as the policy block
  - this is because the coefficients in the third row correspond to the Taylor rule coefficients
    - for instance, $B_{1,t}^{31}$, $B_{1,t}^{32}$, and $B_{1,t}^{33}$ are interpreted as the interest rate responses to lagged output and inflation, and interest rate persistence (AR(1)), respectively
  - e.g., Primiceri (2005)

Conditional Counterfactual

- Two dimensions of the conditional counterfactual
  - dimension 1: on the non-policy block vs. on the policy block
  - dimension 2: the coefficients in the B_t matrices at specific periods prevail over the entire sample period
- Regarding the 2nd dimension, we set two periods based on the Bank of Korea's governor term
  - Governor Chun ($-$2002:Q2) / Governor J. Lee (2014:Q2$-$)
  - right after the Asian currency crisis / most recent period
  - early years of the inflation-targeting regime (launched in 1998) / period of a low-inflation environment
- For the possible four cases, calculate standard deviations of output and inflation
  - use the mean of the coefficient estimates over the governor terms

Conditional Counterfactual

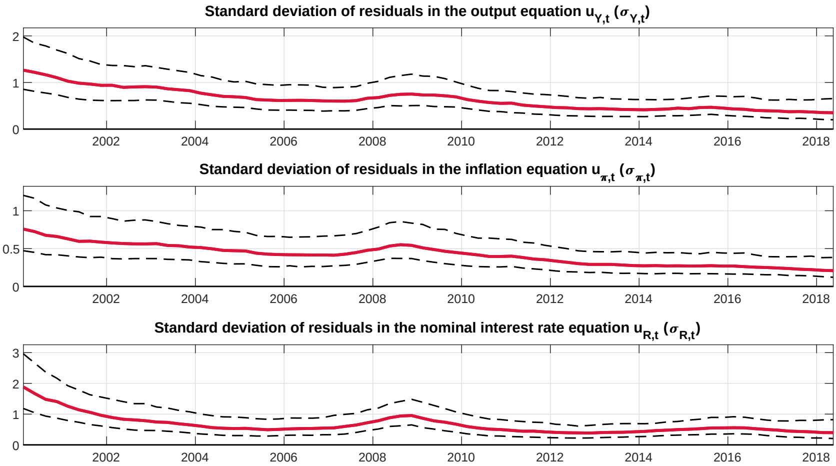
Variable	Sample	Actual	CF 1: Y and π equations		CF 2: R equation	
			Governor Chun	Governor J. Lee	Governor Chun	Governor J. Lee
Output	Whole	1.33	1.41	**1.29**	1.36	1.38
	00-07	1.72	1.76	**1.62**	1.72	**1.70**
	11-18	0.86	1.01	0.88	0.86	0.88
Inflation	Whole	0.55	0.56	0.57	0.55	0.55
	00-07	0.56	0.57	0.59	0.56	0.56
	11-18	0.47	0.48	0.47	0.47	0.47

Median standard deviation estimates

Unconditional Counterfactual

- Change the size of shocks, while keeping the estimates for B_t's at their actual values
- This necessitate proxies for the shock size
  - use the standard deviation estimates of the reduced-form residuals (u_t) as the proxy

Unconditional Counterfactual



Time-varying standard deviations of the reduced-form residuals (u_t)

Solid: median; Dashed: 68% bands

Unconditional Counterfactual

- Conduct Monte Carlo experiments based on the standard deviation estimates of the reduced-form residuals
- Benchmark periods: 2000:Q1 (high volatility) / 2018:Q2 (low volatility)
- Thus unconditional counterfactuals assume that the shock volatility of a specific period, either 2000:Q1 or 2018:Q2, is maintained over the whole sample span

Unconditional Counterfactual

Variable	Sample	Actual	CF 1: 2000:Q1	CF 2: 2018:Q2
Output	Whole	1.42	2.82	0.88
	00-07	1.60	2.57	0.89
	11-18	0.83	2.51	0.67
Inflation	Whole	0.53	0.97	0.27
	00-07	0.64	0.93	0.26
	11-18	0.35	0.97	0.26

Median standard deviation estimates

COUNTERFACTUAL: BELLS AND WHISTLES

- Lucas (1976) critique
- Benati and Surico (2009, AER)
  - in the existing literature on the Great Moderation, the conclusion between “good luck” and “good policy” hinges critically upon the empirical methodology
    - VARs tend to ascribe a dominant role in the reduced aggregate volatilities to the size of shocks (“good luck”)
    - whereas the role of good policy stands out more with the DSGE approach (in favor of “good policy”)
- The same argument may be applicable to the results of this paper

Appendix

Appendix 1: Methodology

- Assumptions: states follow random walks

$$B_t = \text{vec}([c_t, B_{1,t}, B_{2,t}, B_{3,t})], \quad B_t = B_{t-1} + \nu_t, \quad \nu_t \sim NID(0, Q)$$

$$\alpha_t = \text{vec}(A_t^{-1}), \quad \alpha_t = \alpha_{t-1} + \zeta_t, \quad \zeta_t \sim NID(0, S)$$

$$\sigma_t = \text{vec}(\text{diag}(\Sigma_{e,t})), \quad \log \sigma_t = \log \sigma_{t-1} + \eta_t, \quad \eta_t \sim NID(0, W)$$

- Informative but diffuse conditional prior distributions
  - calibrated based on 40 initial training samples (90:Q1-99:Q4)
  - OLS estimates parameterize prior means, serve as starting values
- MCMC algorithm to generate sample from unknown joint posterior distribution $p(B^T, \Sigma_u^T, Q, S, W | Z^T)$

Appendix 2: Summary of Gibbs Sampler

1. Initialize A^T, Σ_e^T, hyperparameters Q, S and W
2. Draw coefficients from $p(B^T|Z^T, A^T, Q)$, Carter-Kohn (1994)
3. Draw covariances from $p(A^T|Z^T, \Sigma_e^T, S)$, Carter-Kohn (1994)
4. Draw volatilities from $p(\Sigma_e^T|Z^T, B^T, A^T, W)$, Carter-Kohn (1994)
5. Draw hyperparameters from $p(Q|Z^T, B^T)$, $p(S|Z^T, A^T)$, $p(W|Z^T, \Sigma_e^T)$
6. Go to 2, generate 22k after 20k burn-in iterations

Digression: Issues on Price Puzzle

- Rationale by Sims (1992, EER): Omitted variable problem
  - the missing information is the central bank's concern about future inflation
  - so a policy tightening in anticipation of future inflation would be erroneously interpreted as a policy shock
  - a possible resolution is the inclusion of a commodity price index to supplement information about future inflation
- Hanson (2004, JME):
  - the commodity price is unlikely to capture the central bank's expectations on future inflation
  - evidence of a price puzzle stands out for the pre-Volcker sample, when the Fed did not raise the interest rate sufficiently in response to inflation (passive MP)

Digression: Issues on Price Puzzle

- Castelnuovo and Surico (2010, EJ):
  - use a NK-DSGE model as the data generating process and estimate VARs with artificial data
  - Sims' (1992) argument is valid only when MP is passive
    - only when MP is passive, inflation expectations have explanatory power for inflation dynamics
    - thus they become helpful in mitigating the price puzzle
- Coibion (2012, AEJ-Macro)
  - studies the disparity in results from a standard VAR and the Romer and Romer (2004, AER) narrative approach
  - data from 1970:1 to 1996:12

DIGRESSION: ISSUES ON PRICE PUZZLE

Impulse responses to a MP tightening shock in Coibion (2012)

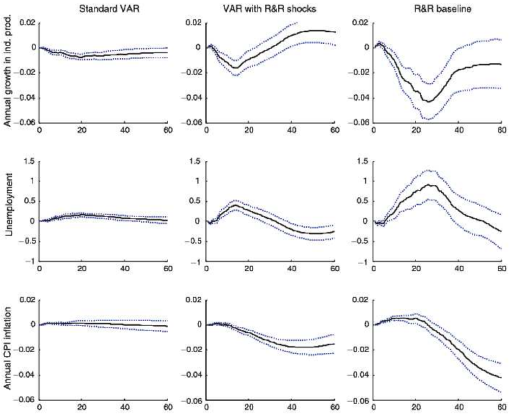


FIGURE 2. IMPULSE RESPONSES OF MACROECONOMIC VARIABLES TO MONETARY POLICY SHOCKS

$\Longrightarrow$ Price puzzle seems to prevail in the R&R framework as well