Contemporary monetary policy in China: A move towards price-based policy?

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Outline

- Motivation
- Policy rules & previous literature
- Data
- Policy rule estimation for China
  - OLS
  - VAR estimations
  - Rolling estimations
- Conclusions

Motivation

- Along with economic reforms, also the monetary policy conduction is going through a transition in China
  - Traditionally policy has relied on quantity based instruments & unconventional policy tools
  - In recent years the, People's Bank of China (PBC) has conducted several market-based reforms and claims to be aiming to more market-based policy implementation
- Responsiveness of monetary instruments? Is there any change?
- Monetary policy rules utilized to specify the possible forms of reaction functions

Chinese monetary policy characteristics

- Objectives: price stability & economic growth
  - Broad money (M2) used as main intermediate target
- Central planning in funding allocations abandoned in 1998

  → Move to more market-based policy conduction
  - CB interest rate
  - Money supply via open market operations, relending and issuance of CB bills
  - Reserve requirement ratio (RRR) frequently used policy tool
  - The role of window guidance policy and other administrative measures
- Exchange rate policy
  - Dual-track exchange rate until 1994
  - After that a strict dollar peg until July 2005
  - Summer 2008 – May 2010 another peg to USD
  - Foreign exchange interventions need to be sterilized
    - RRR and CB bills the most important instrument

Estimated policy rules

- McCallum

$$\Delta b_t = \alpha_0 \Delta b_t^* - \alpha_x \Delta \widehat{x}_{t-1} + \alpha_e \widehat{e}_{t-1}^{neer} + \alpha_b \Delta b_{t-1}$$

- Hybrid McCallum-Hall-Mankiw

$$\Delta b_t = \beta_0 \Delta b_t^* - \beta_\pi \widehat{\pi}_t - \beta_y \Delta \widehat{y}_t + \beta_e \widehat{e}_t^{reer} + \beta_b \Delta b_{t-1}$$

- Taylor

$$i_t = \gamma_0 + \gamma_\pi \widehat{\pi}_t + \gamma_y \Delta \widehat{y}_t + \gamma_e \widehat{e}_t^{reer} + \gamma_i i_{t-1}$$

- Hybrid McCallum-Taylor

$$i_t = \delta_0 + \delta_x \Delta \widehat{x}_{t-1} + \delta_e \widehat{e}_{t-1}^{neer} + \delta_i i_{t-1}$$

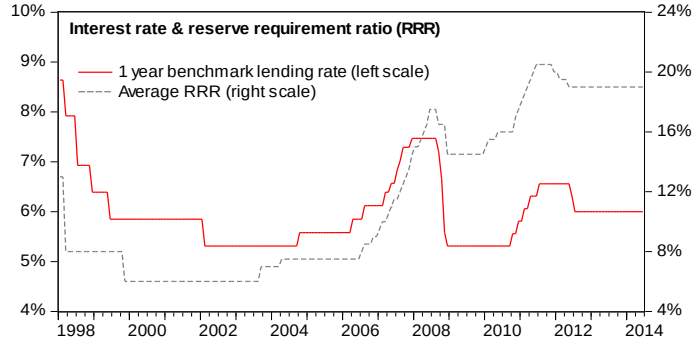
Previous literature for China

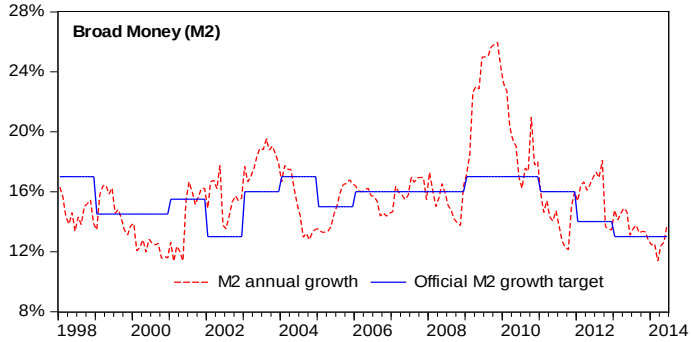
- Mehrotra & Sánchez-Fung (2010)
  - Estimate McCallum-type reaction function using VAR for 1994 - 2008
    - Base money supply reacting to inflation gap, output gap and exchange rate gap
    - Monetary policy procyclical in terms of inflation, but stabilizing via the output gap
    - Policy not very responsive to changes in exchange rate
  - Test also Taylor rule, but find it unsuitable for describing monetary policy in China
- Fan, Yu, & Zhang (2011)
  - Estimate Taylor rule and Hybrid McCallum rule in 1992 - 2009
    - Policy response to inflation rate, real output gap and exchange rate
    - Taylor rule: Positive reaction to inflation (coefficient <1), no significant reaction to output gap or exchange rate
    - McCallum rule: negative reactions to both output gap and inflation, reactions to exchange rate small and insignificant
      - During 2000 – 2009 money supply more sensitive to inflation rate and insensitive to output gap

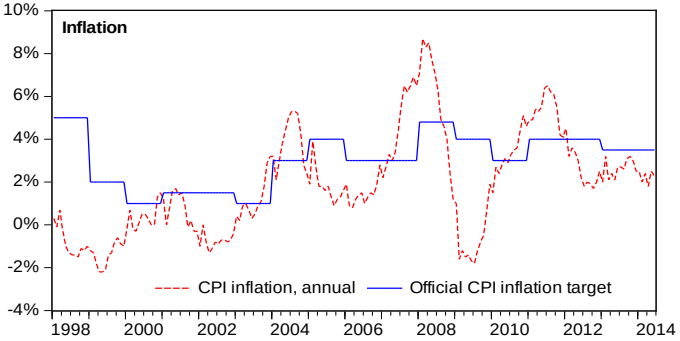
Data

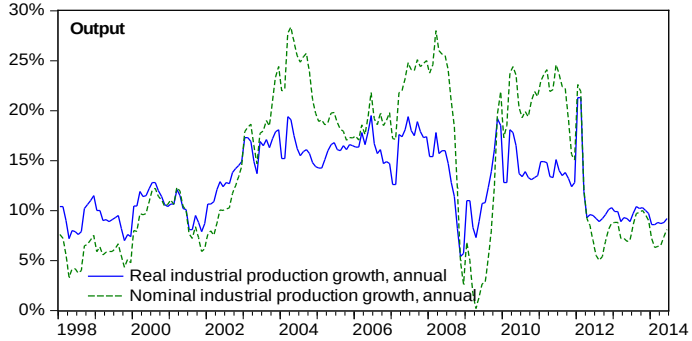
- Monthly data starting from 1998
  - Estimation period 1998M1 – 2014M06 (198 obs.)
- Policy instruments:
  - Interest rate: PBC 1-year benchmark loan rate
  - Money supply: M2 y-o-y growth
- Policy target variables
  - Inflation deviation
    - HP-filtered CPI inflation gap
  - Real & nominal output growth deviation
    - HP-filtered gap in Industrial production y-o-y growth
  - Exchange rate deviation
    - HP-filtered REER/NEER index gaps
  - In money supply rules, also the official target M2 growth rate is employed

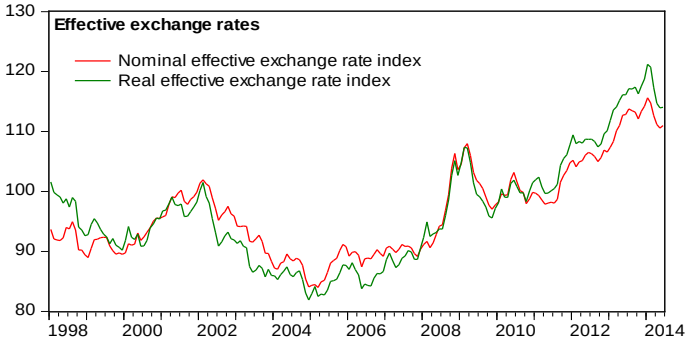
Data


Interest rate & reserve requirement ratio (RRR)
1 year benchmark lending rate (left scale)
Average RRR (right scale)
10%
9%
8%
7%
6%
5%
4%
24%
20%
16%
12%
8%
4%
1998
2000
2002
2004
2006
2008
2010
2012
2014


Broad Money (M2)
M2 annual growth
Official M2 growth target
28%
24%
20%
16%
12%
8%
1998
2000
2002
2004
2006
2008
2010
2012
2014

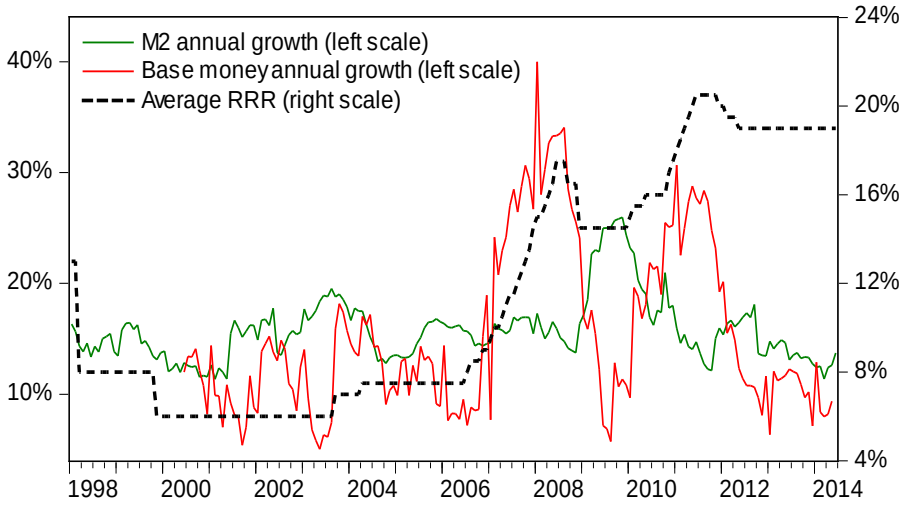

Inflation
CPI inflation, annual
Official CPI inflation target
10%
8%
6%
4%
2%
0%
-2%
-4%
1998
2000
2002
2004
2006
2008
2010
2012
2014


Output
Real industrial production growth, annual
Nominal industrial production growth, annual
30%
25%
20%
15%
10%
5%
0%
1998
2000
2002
2004
2006
2008
2010
2012
2014


Effective exchange rates
Nominal effective exchange rate index
Real effective exchange rate index
130
120
110
100
90
80
1998
2000
2002
2004
2006
2008
2010
2012
2014

Money supply measure

- Estimation results using only broad money aggregate (M2)
  - Base money aggregate affected by the frequent increases in the reserve requirement ratio
    - Increases in RRR during times of policy tightening cause the base money to accumulate, opposite to its role as a stabilizing policy instrument



Money supply rules

	McCallum rules				Hybrid McCallum-Hall-Mankiw rules			
Time period	Whole sample Δb_t	1998m1 –2007m12 Δb_t	2008m1 –2014m06 Δb_t	Whole sample Δb_t	Whole sample Δb_t	1998m1 –2007m12 Δb_t	2008m1 –2014m06 Δb_t	Whole sample Δb_t
Δb_t^*	0.146^{***} [4.65]	0.122^{***} [2.85]	0.209^{***} [3.814]	0.144^{***} [4.55]	0.152^{***} [4.37]	0.126^{***} [2.77]	0.276^{***} [4.09]	0.151^{***} [4.33]
$-\widehat{x}_{t-1}$	0.086^{***} [5.01]	0.070^{**} [2.33]	0.099^{***} [4.24]	0.079^{***} [3.72]				
$-\widehat{\pi}_t$					0.218^{***} [3.96]	0.135^{*} [1.86]	0.369^{***} [3.98]	0.214^{***} [3.84]
$-\widehat{y}_t$					0.008 [0.21]	-0.024 [-0.46]	-0.026 [-0.46]	0.002 [0.06]
$\widehat{e}_{t-1}^{neer}$				0.019 [0.55]				
$\widehat{e}_t^{reer}$								0.012 [0.41]
Δb_{t-1}^i	0.856^{***} [28.26]	0.875^{***} [20.25]	0.807^{***} [16.28]	0.858^{***} [28.12]	0.850^{***} [25.35]	0.870^{***} [18.85]	0.747^{***} [12.27]	0.851^{***} [25.27]
$\overline{R}^2$	0.874	0.763	0.907	0.875	0.872	0.757	0.908	0.871
SIC.	2.955	2.757	3.283	2.980	3.003	2.813	3.309	3.029
LM (12) -test	2.27^{**} (0.01)	1.89^{**} (0.04)	0.81 (0.64)	2.33^{**} (0.01)	2.49^{***} (0.00)	2.15^{**} (0.02)	0.79 (0.66)	2.47^{**} (0.01)

OLS estimates. [*t*-values in square brackets], ***1 %, ** 5 % and * 0 % level of significance.
Breusch-Godfrey Lagrange multiplier (LM) test for no serial correlation in residuals up to order twelve (p-value in parenthesis).

Money supply rules

- McCallum rule
  - Stabilizing policy response to nominal output gap
    - Long run coefficients around *0.50 - 0.60*

- McCallum-Hall-Mankiw rule
  - Countercyclical policy towards inflation
    - Long run coefficients for inflation deviation around *1.00 - 1.40*
    - Stronger reactions compared to Fan et al. (2011)
  - Reactions to output gap statistically insignificant

➢ Stronger policy reactions in the sub-period 2008→

- Money supply in general not responsive to exchange rate

Interest rate rules

	Taylor rules						Hybrid McCallum-Taylor rules					
Time period	Whole sample	1998m1 –2007m12	2008m1 –2014m06	Whole sample	1998m1 –2007m12	2008m1 –2014m06	Whole sample	1998m1 –2007m12	2008m1 –2014m06	Whole sample	1998m1 –2007m12	2008m1 –2014m06
	i_t	i_t	i_t	i_t	i_t	i_t	i_t	i_t	i_t	i_t	i_t	i_t
constant	0.396***	0.325***	0.714***	0.347***	0.293**	0.621***	0.411***	0.336***	0.605***	0.360***	0.281**	0.646***
	[4.35]	[2.99]	[3.50]	[3.72]	[2.56]	[3.02]	[4.51]	[3.08]	[3.46]	[3.95]	[2.45]	[3.95]
$\widehat{\pi}_t$	0.014*	0.013	0.026**	0.010	0.012	0.019						
	[1.96]	[1.17]	[2.28]	[1.45]	[1.09]	[1.59]						
$\widehat{y}_t$	0.020***	0.014*	0.020***	0.016***	0.012	0.016**						
	[4.01]	[1.71]	[3.27]	[3.11]	[1.39]	[2.41]						
$\widehat{x}_{t-1}$							0.008***	0.008*	0.010***	0.003	0.005	0.002
							[3.55]	[1.73]	[3.34]	[1.00]	[0.87]	[0.52]
$\widehat{\epsilon}_t^{reer}$				-0.008**	-0.005	-0.012*						
				[-1.98]	[-0.87]	[-1.97]						
$\widehat{\epsilon}_{t-1}^{neer}$										-0.015***	-0.010	-0.025***
										[-3.04]	[-1.45]	[-3.49]
i_{t-1}	0.932***	0.944***	0.880***	0.940***	0.949***	0.896***	0.929***	0.942***	0.898***	0.938***	0.951***	0.892***
	[62.05]	[52.36]	[26.19]	[60.85]	[49.92]	[26.40]	[61.59]	[51.96]	[31.36]	[62.27]	[49.72]	[33.32]
$\overline{R}^2$	0.958	0.958	0.957	0.959	0.958	0.959	0.955	0.958	0.949	0.957	0.958	0.956
SIC	-0.955	-0.854	-0.969	-0.948	-0.821	-0.965	-0.905	-0.872	-0.830	-0.925	-0.850	-0.926
LM (12)	1.28	2.85***	1.42	1.18	3.14***	1.44	1.61*	3.04***	2.02**	1.31	3.04***	1.74*
-test	(0.23)	(0.00)	(0.18)	(0.30)	(0.00)	(0.17)	(0.09)	(0.00)	(0.04)	(0.22)	(0.00)	(0.08)

OLS estimates. [*t*-values in square brackets], ***1 %, ** 5 % and * 0 % level of significance.
Breusch-Godfrey Lagrange multiplier (LM) test for no serial correlation in residuals up to order twelve (p-value in parenthesis).

Interest rate rules

- Taylor rule
  - Estimated reactions to output gap positive and statistically significant
    - Contrary to previous literature with earlier data
    - Long run coefficients *0.20 - 0.30*
  - Reactions to inflation stabilizing and significant for the latter sub-period
    - Long run coefficients still far from the 'Taylor principle' (~ *0.20*)
- McCallum-Taylor rule
  - Stabilizing policy towards nominal output gap
    - Long run coefficients < 0.20
- Policy reacts also to exchange rate according to theoretical assumptions
  - I.e. policy loosening when currency appreciates

➢ Interest rate becomes more responsive in latter sub-period

VAR analysis

- The policy rules are utilized in VAR models. The estimated models are:
  - McCallum

$$\begin{bmatrix} \Delta b^{M2} \\ -\widehat{x} \\ \widehat{e}^{neer} \end{bmatrix}_t = \alpha_1 \begin{bmatrix} \Delta b^{M2} \\ -\widehat{x} \\ \widehat{e}^{neer} \end{bmatrix}_{t-1} + \ldots + \alpha_k \begin{bmatrix} \Delta b^{M2} \\ -\widehat{x} \\ \widehat{e}^{neer} \end{bmatrix}_{t-k} + \alpha_0 + u_t$$

  - Hybrid McCallum-Hall-Mankiw

$$\begin{bmatrix} \Delta b^{M2} \\ -\widehat{\pi}^{cpi} \\ -\widehat{y} \\ \widehat{e}^{reer} \end{bmatrix}_t = \beta_1 \begin{bmatrix} \Delta b^{M2} \\ -\widehat{\pi}^{cpi} \\ -\widehat{y} \\ \widehat{e}^{reer} \end{bmatrix}_{t-1} + \ldots + \beta_k \begin{bmatrix} \Delta b^{M2} \\ -\widehat{\pi}^{cpi} \\ -\widehat{y} \\ \widehat{e}^{reer} \end{bmatrix}_{t-} + \beta_0 + u_t$$

  - Taylor

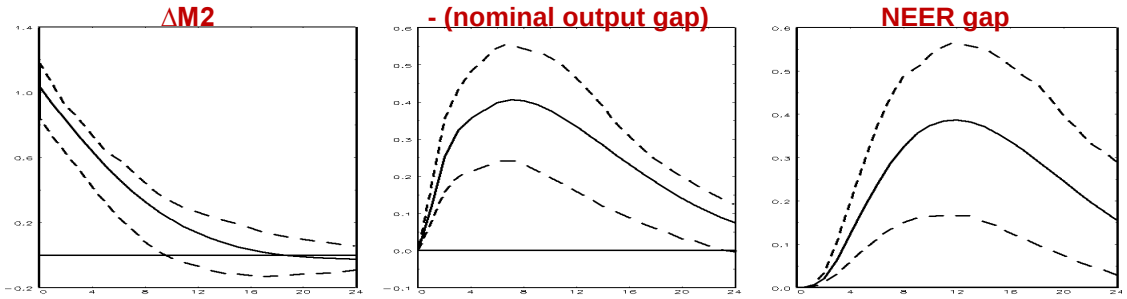
$$\begin{bmatrix} i \\ \widehat{\pi}^{cpi} \\ \widehat{y} \\ \widehat{e}^{reer} \end{bmatrix}_t = \gamma_1 \begin{bmatrix} i \\ \widehat{\pi}^{cpi} \\ \widehat{y} \\ \widehat{e}^{reer} \end{bmatrix}_{t-1} + \ldots + \gamma_k \begin{bmatrix} i \\ \widehat{\pi}^{cpi} \\ \widehat{y} \\ \widehat{e}^{reer} \end{bmatrix}_{t-k} + \gamma_0 + u_t$$

  - Hybrid McCallum-Taylor

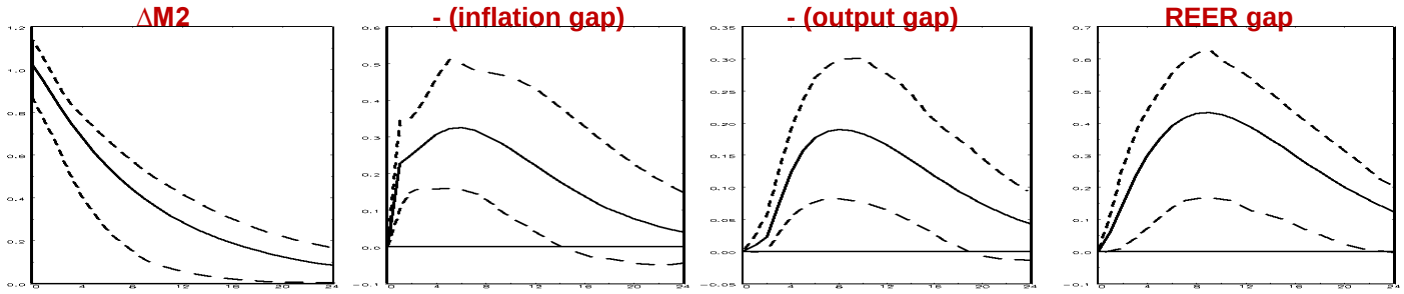
$$\begin{bmatrix} i \\ \widehat{x} \\ \widehat{e}^{neer} \end{bmatrix}_t = \delta_1 \begin{bmatrix} i \\ \widehat{x} \\ \widehat{e}^{neer} \end{bmatrix}_{t-1} + \ldots + \delta_k \begin{bmatrix} i \\ \widehat{x} \\ \widehat{e}^{neer} \end{bmatrix}_{t-k} + \delta_0 + u_t$$

VAR model impulse responses

- Responses in broad money supply to one standard deviation shock in each of the variables one at a time
  - McCallum rule: responses in $\Delta M2$



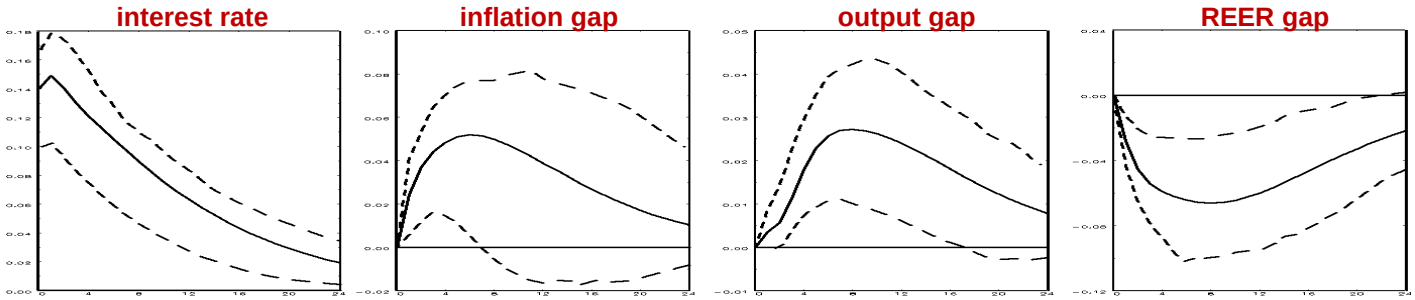
  - McCallum-Hall-Mankiw: responses in $\Delta M2$



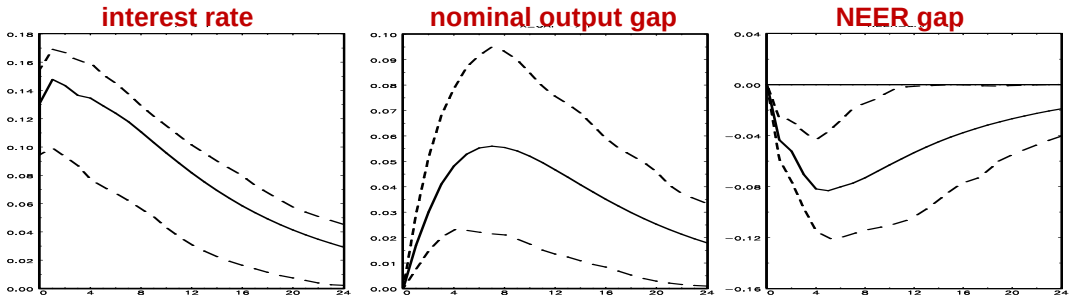
VAR model impulse responses

- Responses in policy interest rate to one standard deviation shock in each of the variables one at a time

  - Taylor rule, responses in *interest rate*

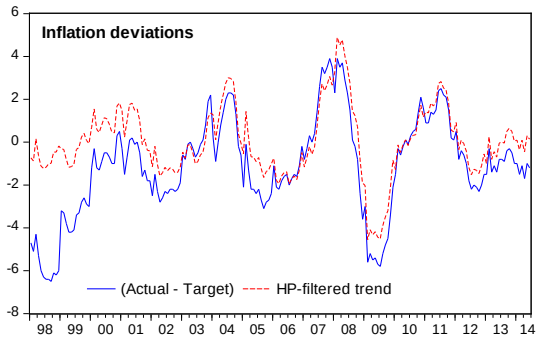


  - Hybrid McCallum-Taylor, responses in *interest rate*



Rolling parameter estimations

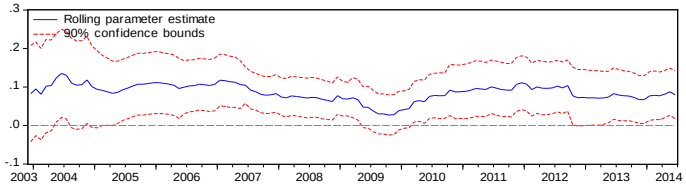
- Focus on the change in the responsiveness of monetary policy instruments over time
  - Monetary policy parameters in the policy rules are estimated in a rolling estimation window
    - 5-year window that is moved one obs. forward at each step
    - HP-filtering for real and nominal output and exchange rate performed at each step, prior to the estimation, using data available only up to that period
    - Inflation gap measured as: Actual – Official target rate



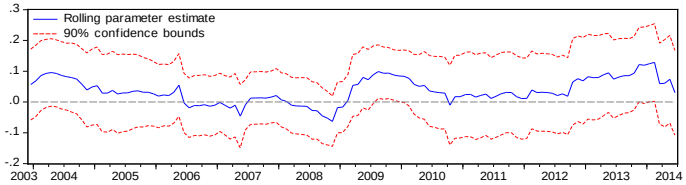
- Next slides show results first for models first with exchange rate term, and then without the exchange rate

McCallum rule

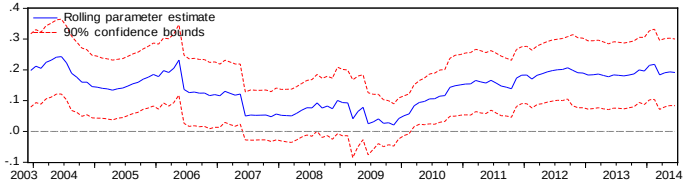
Negative of the nominal output gap (first lag)



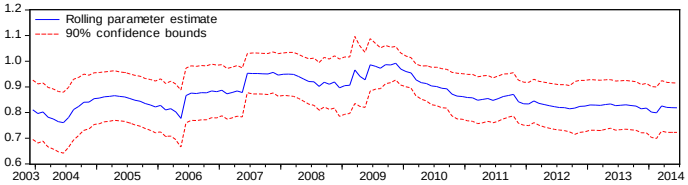
NEER gap (first lag)



Target rate for M2 growth

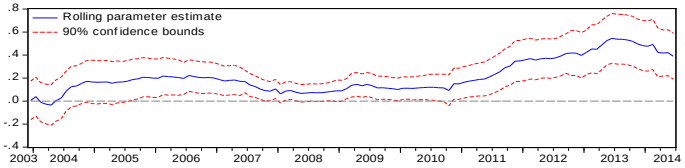


Policy smoothing parameter

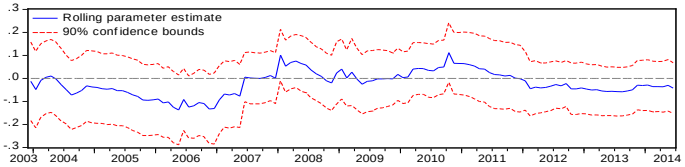


McCallum-Hall-Mankiw rule

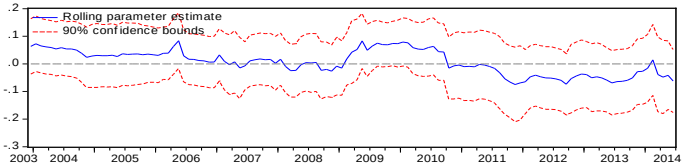
Negative of the inflation gap (Target - Actual)



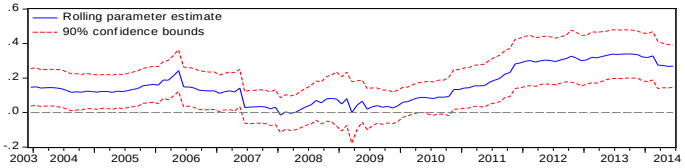
Negative of the output gap



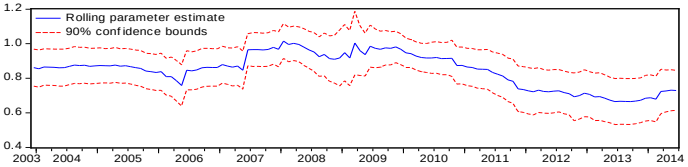
REER gap



Target rate for M2 growth

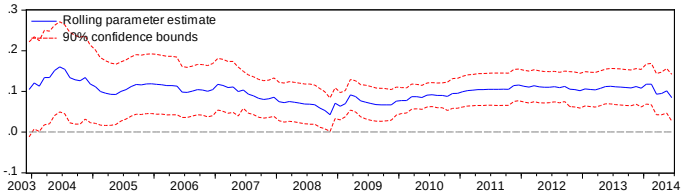


Policy smoothing parameter

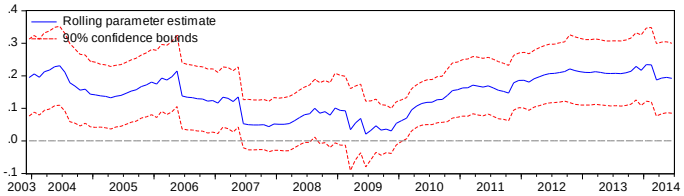


McCallum rule excl. exchange rate

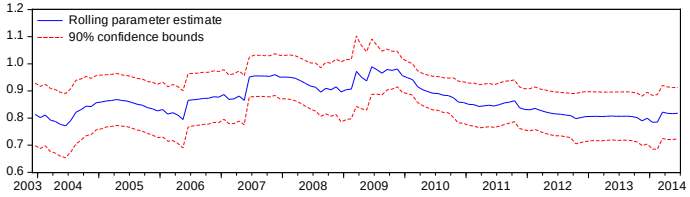
Negative of the nominal output gap (first lag)



Target rate for M2 growth

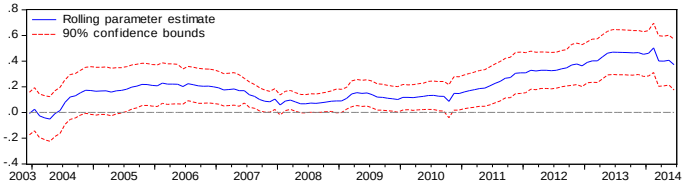


Policy smoothing parameter

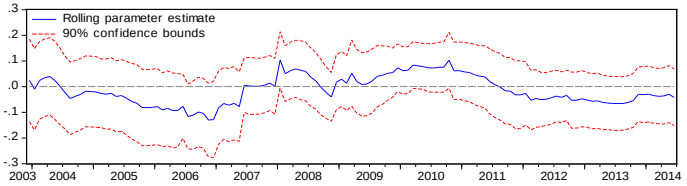


McCallum-Hall-Mankiw rule excl. exchange rate

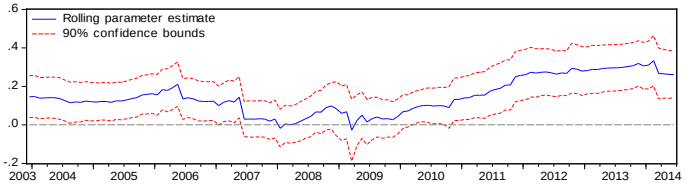
Negative of the inflation gap (Target - Actual)



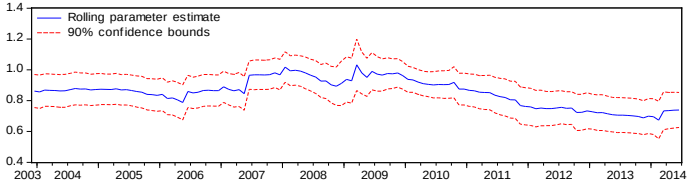
Negative of the output gap



Target rate for M2 growth

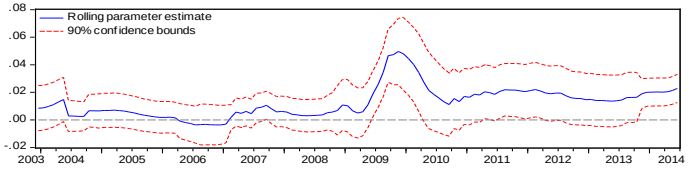


Policy smoothing parameter

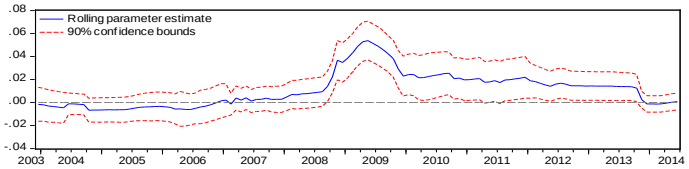


Taylor rule

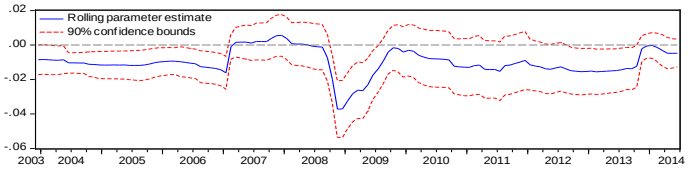
Inflation gap (Actual - Target)



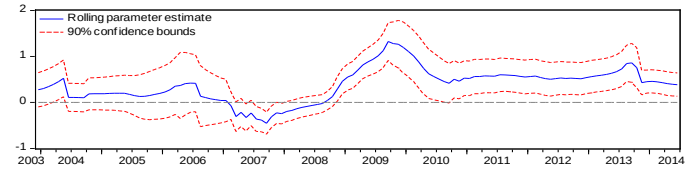
Output gap



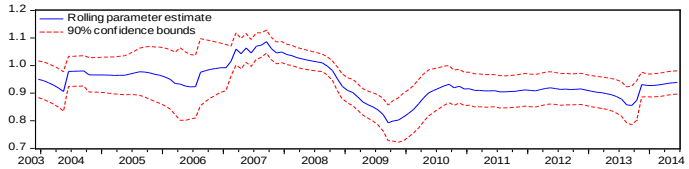
REER gap



Constant term

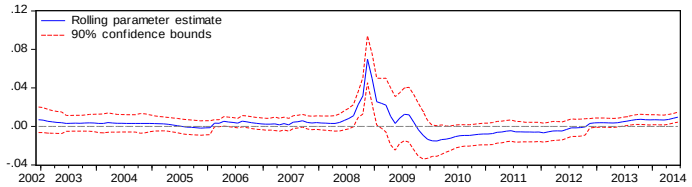


Policy smoothing parameter

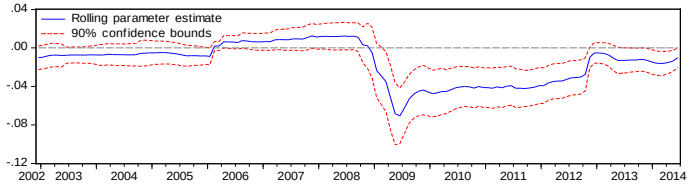


McCallum-Taylor rule

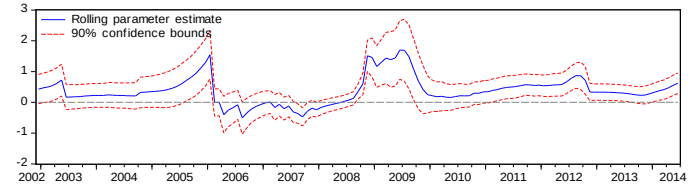
Nominal output gap (first lag)



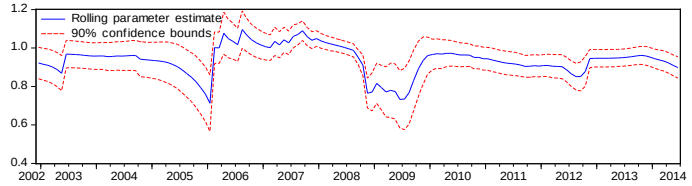
NEER gap (first lag)



Constant term

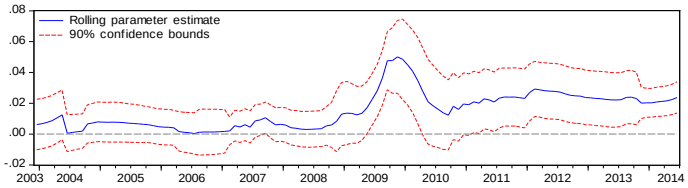


Policy smoothing parameter

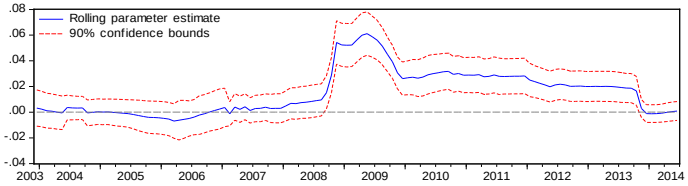


Taylor rule excl. exchange rate

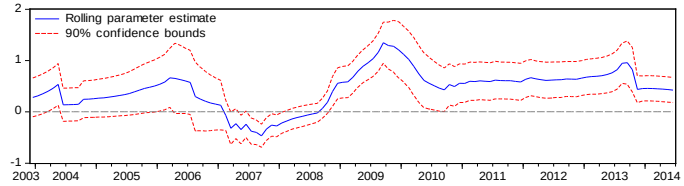
Inflation gap (Actual - Target)



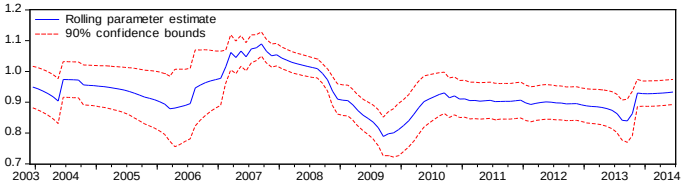
Output gap



Constant term

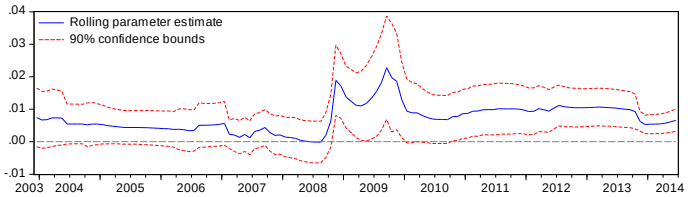


Policy smoothing parameter

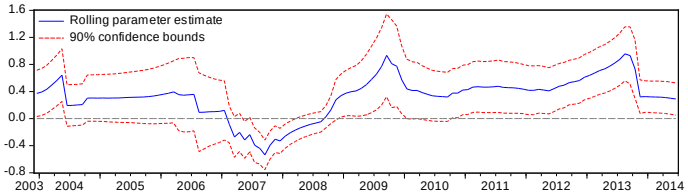


McCallum-Taylor rule excl. exchange rate

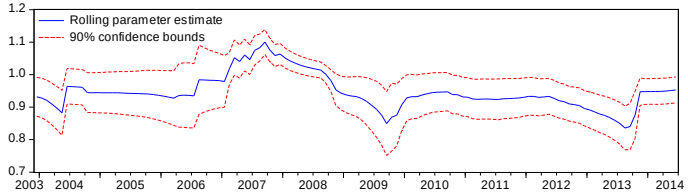
Nominal output gap (first lag)



Constant term



Policy smoothing parameter



Rolling parameter estimates – Summary

- Money supply instrument reacts only to inflation gap
  - Exchange rate not significant for money supply
  - ➢ These results are in line with Fan, Yu, & Zhang (2011) for 2000–2009
- Interest rate instrument reactions statistically significant after early-2008
  - In 2008-2013 interest rate reacts to output gap
  - In deflation period 2009 and again in 2014 reactions also to inflation gap
- In light of these findings the nominal rules not optimal in modeling the policy setting in China

Rolling parameter estimates – RRR-instrument

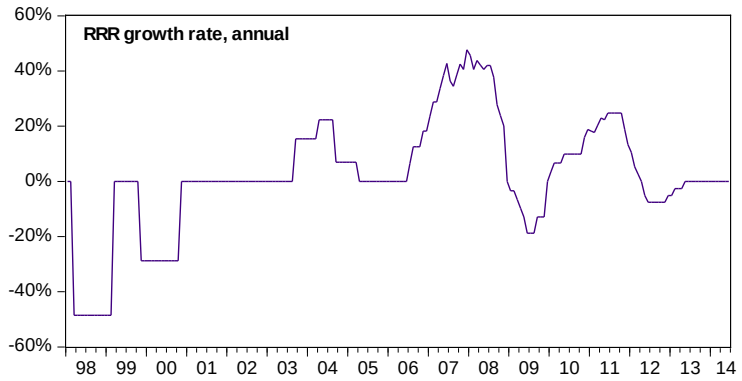
- Rolling parameter estimations also using RRR as the policy instrument:
  - 'Real RRR rule'

$$\Delta rrr_t = \eta_0 + \eta_\pi \widehat{\pi}_t + \eta_y \Delta \widehat{y}_t - \eta_e \widehat{e}_t^{reer} + \eta_r \Delta rrr_{t-1}$$

  - 'Nominal RRR rule'

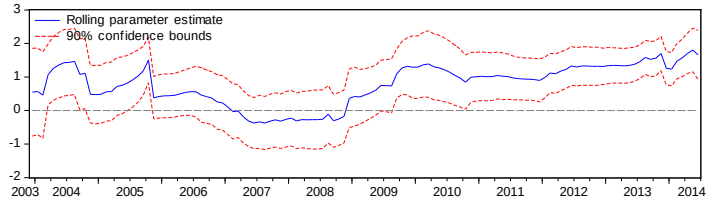
$$\Delta rrr_t = \theta_0 + \theta_x \Delta \widehat{x}_{t-1} - \theta_e \widehat{e}_{t-1}^{neer} + \theta_r \Delta rrr_{t-1}$$

  - Y-o-y change in RRR selected as the dependent variable

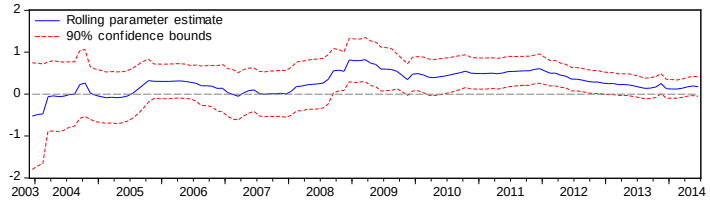


‘Real RRR-rule’

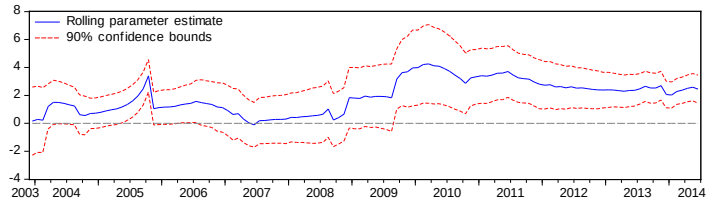
Inflation gap (Actual - Target)



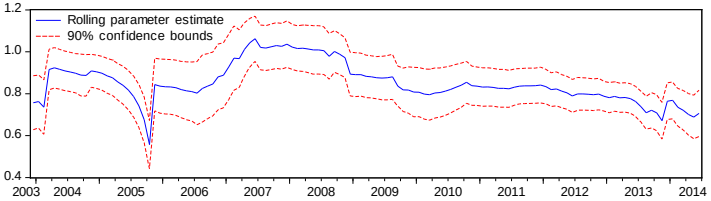
Output gap



Constant term



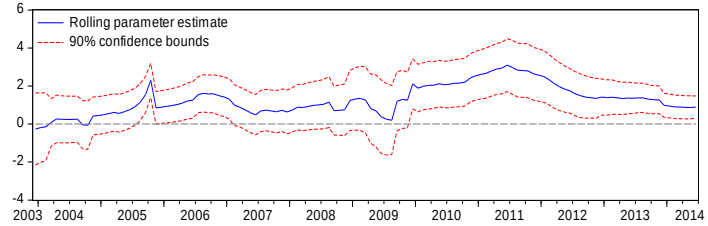
Policy smoothing parameter



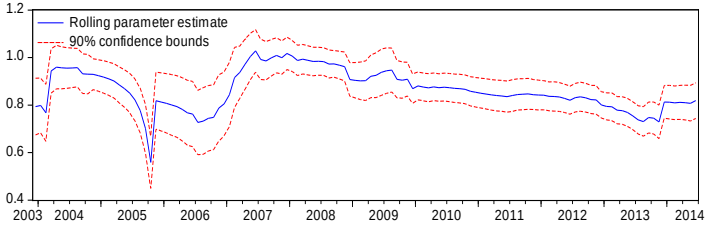
‘Nominal RRR-rule’

Nominal output gap (first lag)

Constant term



Policy smoothing parameter

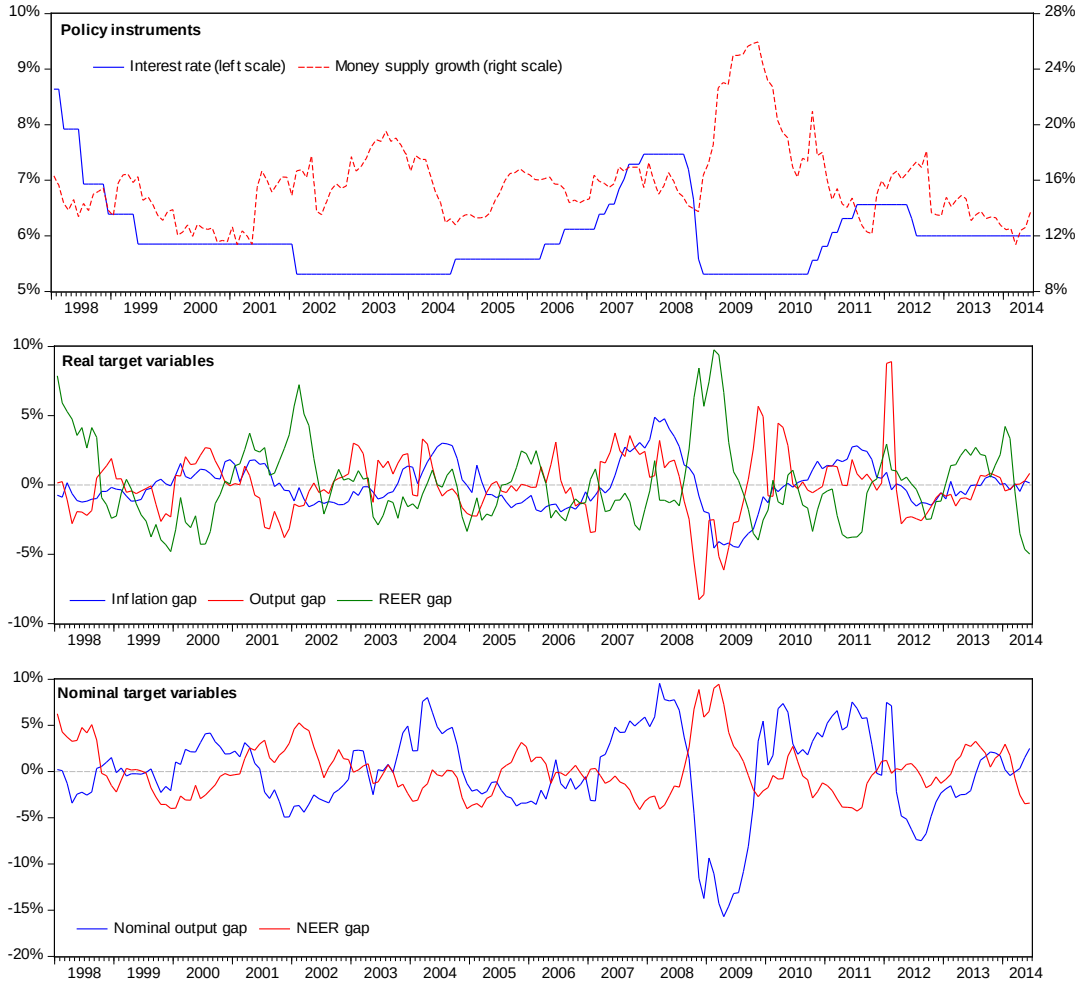


Conclusions

- We study the responsiveness of Chinese monetary policy;
  - In what way the macroeconomic variables have affected the policy setting?
- Generally, the estimated standard policy rules are able to describe Chinese monetary policy surprisingly well
  - Overall, the policy instrument seem to have become more responsive to macroeconomic variables
- The results suggests that the PBC has not sifted exclusively to price based instruments, and at the moment the policy uses the price based as well as quantity-based instruments simultaneously
- The interest rate (and RRR) instrument have become responsive to macroeconomic variables in recent years
  - After 2008, when a rapid policy loosening was carried out to mitigate the effects of the financial crisis

Thank you.

Data


Policy instruments
Interest rate (left scale)
Money supply growth (right scale)
10%
9%
8%
7%
6%
5%
28%
24%
20%
16%
12%
8%
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
Real target variables
Inflation gap
Output gap
REER gap
10%
5%
0%
-5%
-10%
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
Nominal target variables
Nominal output gap
NEER gap
10%
5%
0%
-5%
-10%
-15%
-20%
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014

Robustness checks

- **With an older data… up till 2012m10.**
- Estimation results are robust to:
  - Deriving the inflation and output gaps relative to the official targets (vs. HP-filtering)
  - Using different inflation measures (consumer vs. producer prices)
  - Estimating the response functions with longer lag structures

- Base money (M0) estimation results
  - Procyclical reactions to nominal output gap and inflation, no reaction to real output gap
    - Similar results in terms of inflation to Mehrotra & Sánchez-Fung (2010)

Correlations

	Inflation	Interest rate	Money supply growth	NEER gap	REER gap	RRR change	Nominal output gap	Real output gap
Inflation	1,00							
Interest rate	0,55	1,00						
Money supply growth	-0,46	-0,29	1,00					
NEER gap	-0,50	-0,28	0,18	1,00				
REER gap	-0,25	-0,14	0,07	0,91	1,00			
RRR change	0,54	0,51	0,00	-0,15	0,00	1,00		
Nominal output gap	0,80	0,37	-0,29	-0,61	-0,46	0,46	1,00	
Real output gap	0,33	0,16	0,03	-0,46	-0,41	0,15	0,75	1,00

	RRR_YOY
Mean	2.299937
Median	0.000000
Maximum	47.69241
Minimum	-48.55078
Std. Dev.	20.70489
Skewness	-0.438562
Kurtosis	3.769736
Jarque-Bera	11.23517
Probability	0.003633
Sum	455.3875
Sum Sq. Dev.	84452.39
Observations	198

Null Hypothesis: RRR_YOY has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.227674	0.0253
Test critical values:	1% level	-2.576753	
	5% level	-1.942448	
	10% level	-1.615628	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: RRR_YOY is stationary
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.63032...
Asymptotic critical values*:	1% level	0.73900...
	5% level	0.46300...
	10% level	0.34700...

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

	CPI_DEV
Mean	-1.117677
Median	-1.000000
Maximum	3.900000
Minimum	-6.500000
Std. Dev.	2.303989
Skewness	-0.221116
Kurtosis	2.985292
Jarque-Bera	1.615226
Probability	0.445921
Sum	-221.3000
Sum Sq. Dev.	1045.748
Observations	198

Null Hypothesis: CPI_DEV has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.381722	0.0170
Test critical values:	1% level	-2.576753	
	5% level	-1.942448	
	10% level	-1.615628	

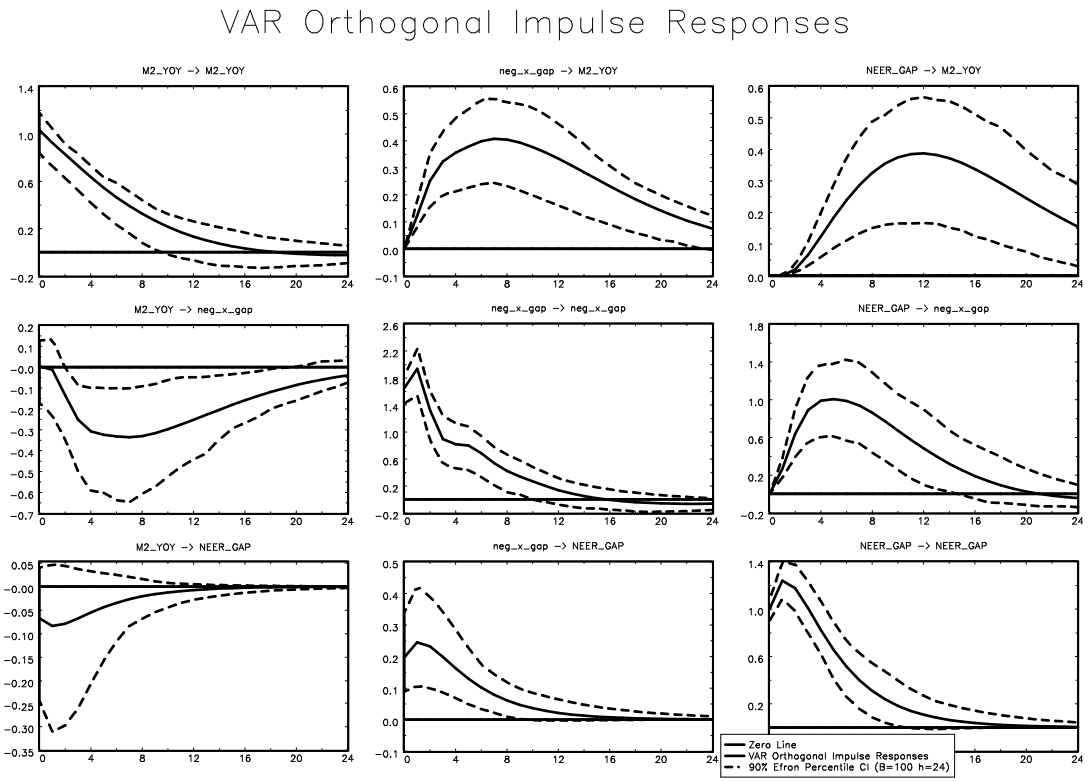
*MacKinnon (1996) one-sided p-values.

Null Hypothesis: CPI_DEV is stationary
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

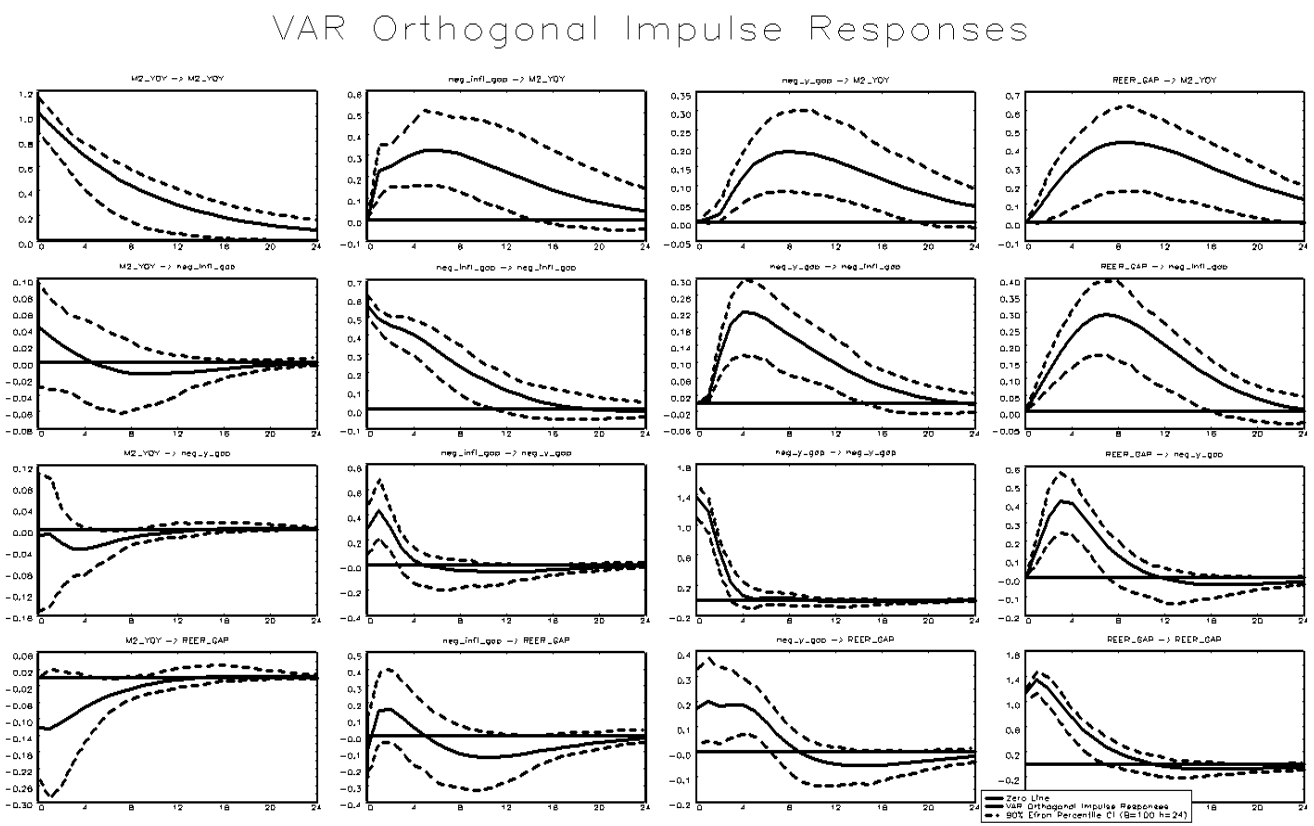
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.33770...
Asymptotic critical values*:	1% level	0.73900...
	5% level	0.46300...
	10% level	0.34700...

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

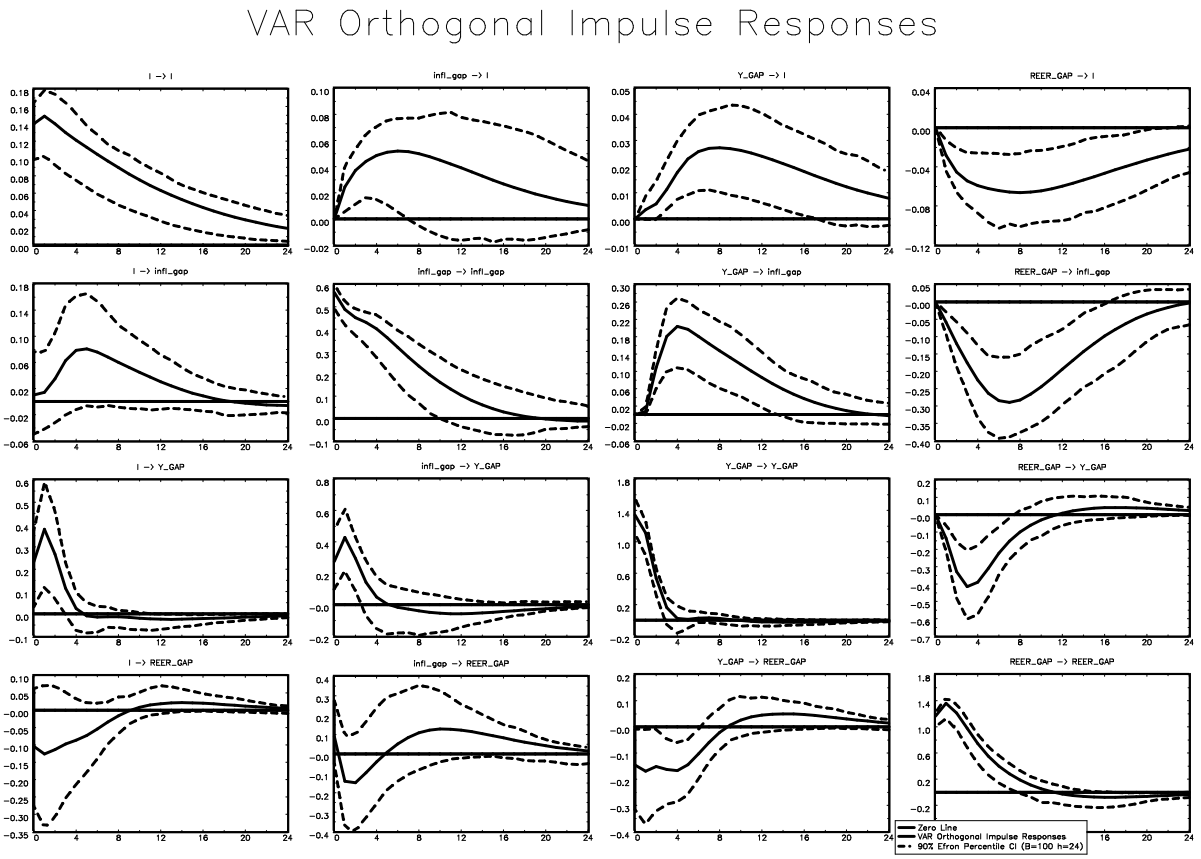
McCallum rule VAR



McCallum-Hall-Mankiw rule VAR



Taylor rule VAR



McCallum-Taylor rule VAR