Macroeconomic and interest rate volatility under alternative monetary operating procedures

Sixth Annual NBP-SNB Joint Seminar
Zurich, June 15-16 2008

Petra Gerlach-Kristen & Barbara Rudolf
Swiss National Bank

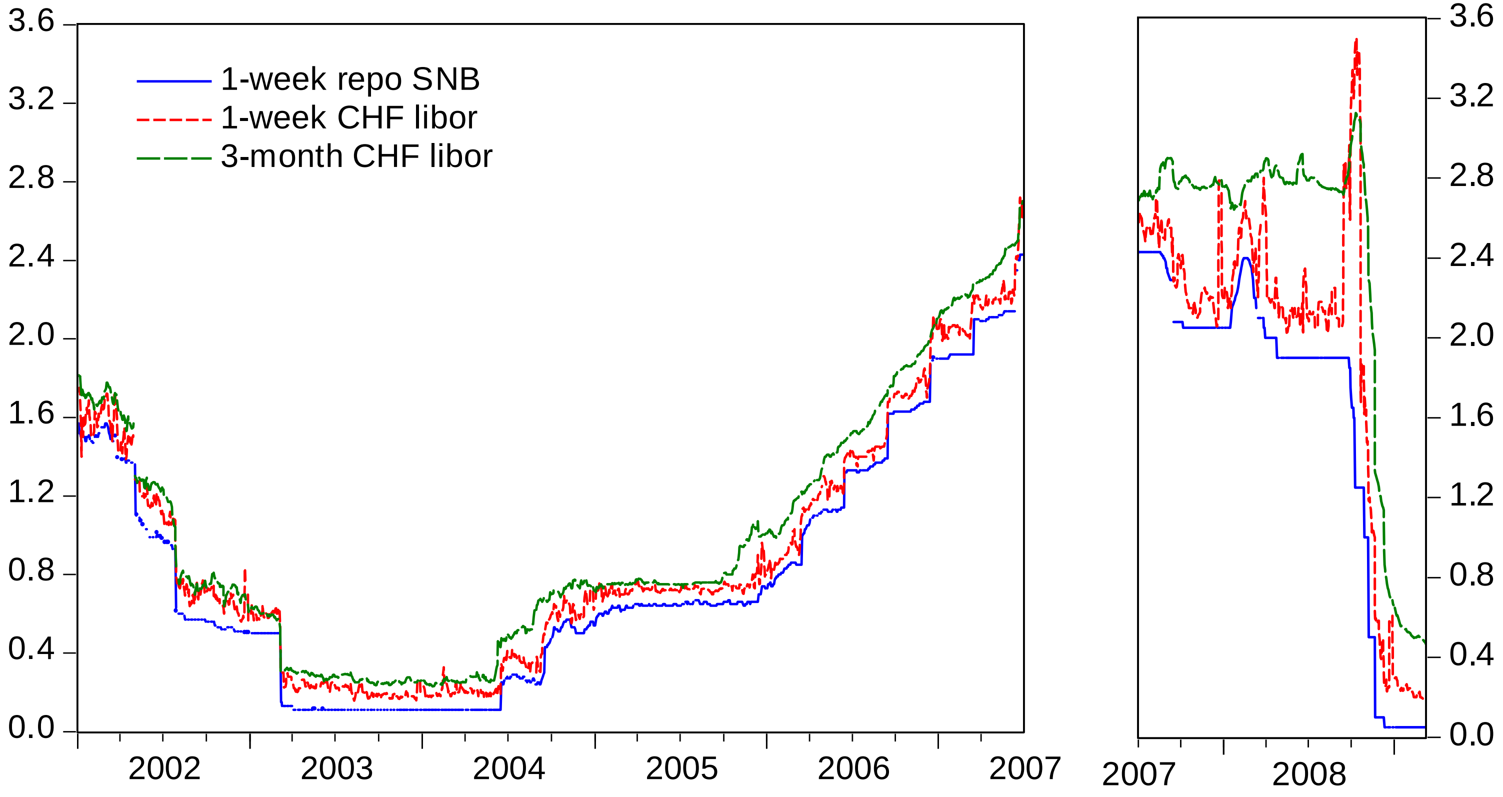
Motivation

- The stance of monetary policy can be set with different interest rates
  - Rate at which the central bank lends money to the financial sector; Bank of England
  - Rate at which commercial banks lend and borrow overnight funds; Federal Reserve
  - Longer-term money market rate; Swiss National Bank
- Two dimensions
  - Riskless vs risky rate
  - Overnight vs longer-term maturity

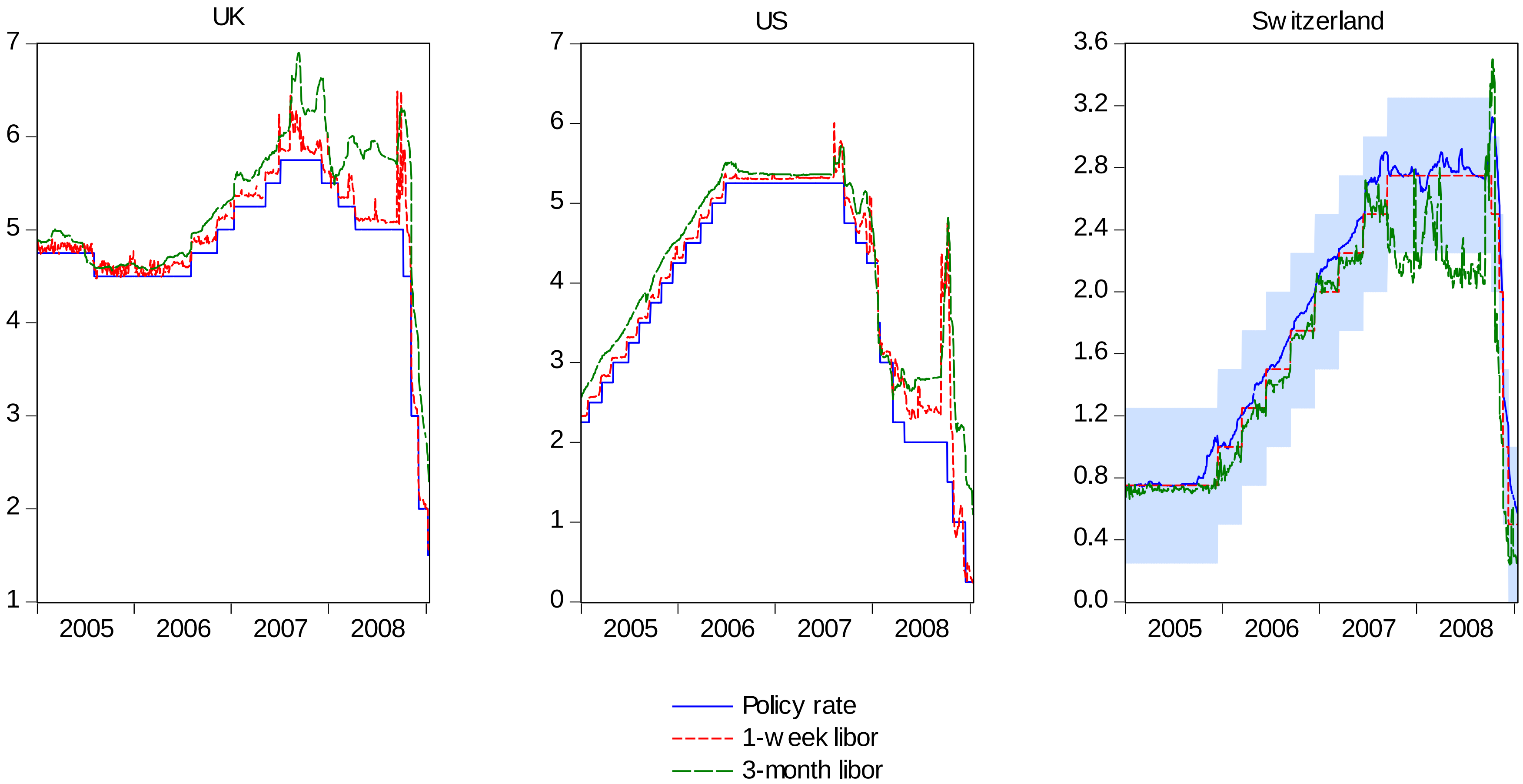
Before the crisis...

- ... the difference between these rates used to be small and stable
  - Changes in the implementation rate had a predictable effect on money market rates
- Question which rate matters for the economy was not important
  - Theory view: Shortest interest rate
  - SNB view: Longer-term, risky rate
- Macro models typically assumed only one interest rate i

Development of interest rates in Switzerland: January 2005 to January 2009



Comparison of interest rates development: January 2005 to January 2009



Main characteristics of the model

- Standard IS and Phillips curve setup with forward-looking agents
- Standard loss function with interest rate smoothing
  - Smoothing refers to that interest rate that is used to define the stance of policy
  - This rate may differ from the repo rate that is used to implement monetary policy
- Optimal reaction function for repo rate, since this is the only rate the central bank controls
- Caveat: This analysis assumes the existence of longer-term money markets

The model

- New Keynesian Phillips curve

$$\pi_t = a_\pi E_t \pi_{t+1} + (1 - a_\pi)\pi_{t-1} + a_y y_t + u_{\pi,t}$$

$$u_{\pi,t} = \rho_\pi u_{\pi,t-1} + \sigma_\pi e_{\pi,t}$$

- IS curve

$$y_t = b_y E_t y_{t+1} + (1 - b_y) y_{t-1} - b_r (i_{1,t} - E_t \pi_{t+1}) + u_{y,t}$$

$$u_{y,t} = \rho_y u_{y,t-1} + \sigma_y e_{y,t}$$

- One-period market rate

$$i_{1,t} = i_t + \theta_{1,t}$$

- Risk premium $\theta_{1,t} = \theta_1 + \rho_1 \theta_{1,t-1} + \varepsilon_{1,t}$
- Longer-term market rates

$$i_{j,t} = \frac{1}{j} E_t \sum_{k=0}^{j-1} i_{t+k} + \tau_j + \theta_{j,t}$$

$$\theta_{j,t} = \theta_j + \rho_j \theta_{j,t-1} + \varepsilon_{j,t}$$

  - For the AR coefficients and the covariance matrix of the innovations to the risk premia we use estimated values in the simulation
  - All other parameter values in the simulation are assumed and taken from the literature

Estimates for term and risk premia

	Pre-crisis				Crisis			
j	τ_j	θ_j	ρ_j	$\sigma_j \times 10^{-2}$	τ_j	θ_j	ρ_j	σ_j
1	-	0.05***	0.20	1.52	-	0.43*	0.37	0.53
2	0.05	0.03***	0.54***	1.15	-0.03	0.41*	0.55**	0.49
3	0.10	0.03**	0.67***	0.86	-0.06	0.44*	0.59**	0.49
4	0.14	0.03**	0.66***	0.96	-0.08	0.39*	0.65***	0.45
5	0.18	0.02**	0.72***	0.91	-0.09	0.36*	0.70***	0.42
6	0.21	0.02**	0.73***	0.82	-0.10	0.33*	0.75***	0.38
7	0.24	0.03**	0.67***	0.79	-0.10	0.31*	0.77***	0.37
8	0.26	0.03**	0.71***	0.81	-0.10	0.29*	0.78***	0.36
9	0.27	0.03**	0.72***	0.81	-0.10	0.27*	0.80***	0.35
10	0.29	0.02**	0.73***	0.89	-0.09	0.26	0.81***	0.34
11	0.30	0.03**	0.71***	0.93	-0.08	0.25	0.82***	0.33

Note: Average term premium τ_j and regression output for equation (8). Term premium defined as difference between j-month and one-month OIS rate, risk premium as difference between j-month libor and j-month OIS rate. Pre-crisis data span January 2005 to July 2007, and crisis data August 2007 to January 2009. */**/*** denotes significance at the one/five/ten percent level.

Correlations of risk premium innovations

	Pre-crisis sample										
j	1	2	3	4	5	6	7	8	9	10	11
1	1										
2	0.31	1									
3	0.36	0.69	1								
4	0.21	0.71	0.85	1							
5	0.11	0.62	0.68	0.88	1						
6	0.13	0.71	0.67	0.78	0.86	1					
7	0.17	0.60	0.68	0.73	0.78	0.90	1				
8	0.10	0.60	0.58	0.66	0.74	0.86	0.95	1			
9	0.01	0.56	0.51	0.58	0.69	0.82	0.88	0.97	1		
10	0.01	0.51	0.45	0.51	0.64	0.80	0.86	0.96	0.98	1	
11	-0.05	0.46	0.36	0.43	0.63	0.75	0.82	0.93	0.95	0.97	1
	Crisis sample										
j	1	2	3	4	5	6	7	8	9	10	11
1	1										
2	0.99	1									
3	0.98	1.00	1								
4	0.99	0.99	1.00	1							
5	0.98	0.99	0.99	1.00	1						
6	0.98	0.99	0.99	0.99	1.00	1					
7	0.98	0.99	0.98	0.99	1.00	1.00	1				
8	0.98	0.99	0.98	0.99	1.00	1.00	1.00	1			
9	0.98	0.98	0.98	0.99	1.00	1.00	1.00	1.00	1		
10	0.97	0.98	0.98	0.99	0.99	1.00	1.00	1.00	1.00	1	
11	0.97	0.98	0.98	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1

Optimal monetary policy

- Central bank minimises intertemporal loss function

$$\pounds_{p,0} = E_0 \sum_{t=0}^{\infty} (1-\delta)\delta^t L_{p,t}$$

- with the period loss function

$$L_{p,t} = \frac{1}{2} Y_t' \Lambda_p Y_t,$$

Optimal monetary policy (contd.)

Period loss function differs across operating procedures:

- Repo rate (RR) procedure
  - Policy is formulated and implemented with it
  - $L_{RR,t} = \lambda_\pi \pi_t^2 + \lambda_y y_t^2 + \lambda_i (\Delta i_t)^2$
- Short-term money market rate (SMR) procedure
  - Policy formulated with i1,t and implemented with it
  - $L_{SMR,t} = \lambda_\pi \pi_t^2 + \lambda_y y_t^2 + \lambda_i (\Delta i_{1,t})^2$
- Long-term money market rate (LMR) procedure
  - Policy formulated with i3,t and implemented with it
  - $L_{LMR,t} = \lambda_\pi \pi_t^2 + \lambda_y y_t^2 + \lambda_i (\Delta i_{3,t})^2$

Optimal monetary policy (contd.)

- Minimise loss function with respect to the repo rate
  - Commitment in a timeless perspective
  - Technical problem with LMR procedure: i3,t depends through expectations hypothesis on the expected path of it and on Lagrange multipliers
  - Dual saddle-point problem

$$\max_{\{\gamma_t\}_{t\geq 0}} \min_{\{\pi_t, y_t, i_t\}_{t\geq 0}} E_0 \sum_{t=0}^{\infty} (1-\delta)\delta^t \widetilde{\widetilde{L}}_{p,t}$$

  - with $\gamma_t = [\ \gamma_t^{PC} \quad \gamma_t^{IS}\ ]'$ Lagrange multipliers
  - Assume optimal reaction function and iterate until convergence

Calibration of the model

- Phillips and IS curves

$$a_\pi = b_y = 0.8 \qquad a_y = 0.2 \qquad b_r = 0.5$$

$$\rho_\pi = \rho_y = 0.8 \qquad \sigma_\pi = \sigma_y = 0.5$$

- Central bank preferences

$$\lambda_\pi = \lambda_y = \lambda_i = 1 \qquad \delta = 0.99$$

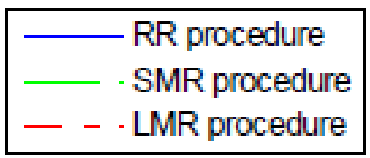
- Term and risk premia as estimated

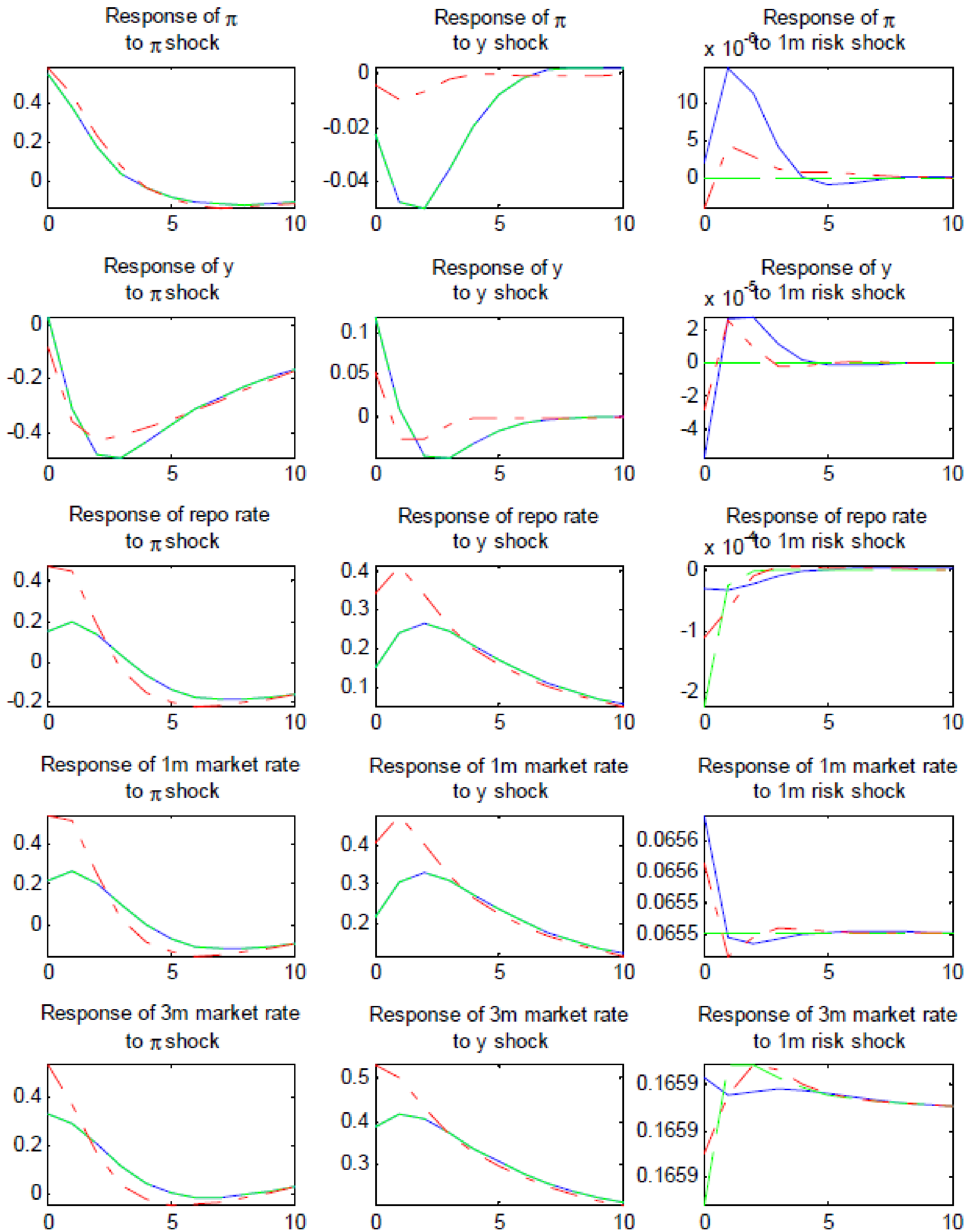
Optimal reaction functions under commitment

Reaction to	π_{t-1}	y_{t-1}	i_{t-1}	$u_{\pi,t}$	$u_{y,t}$	$\theta_{1,t}$	$\theta_{3,t}$	$\theta_{1,t-1}$	γ_{t-1}^{PC}	γ_{t-1}^{IS}
					Pre-crisis simulation					
RR procedure	0.00	0.06	0.54	0.33	0.74	-0.17	0.00	0.00	-0.01	0.09
SMR procedure	0.00	0.06	0.54	0.33	0.74	-1.00	0.00	0.54	-0.01	0.09
LMR procedure	0.01	0.32	0.00	1.17	1.96	-0.82	-0.07	0.00	-0.01	0.59
					Crisis simulation					
RR procedure	0.00	0.06	0.54	0.33	0.74	-0.22	0.00	0.00	-0.01	0.09
SMR procedure	0.00	0.06	0.54	0.33	0.74	-1.00	0.00	0.54	-0.01	0.09
LMR procedure	0.01	0.32	0.00	1.17	1.96	-0.88	-0.10	0.00	-0.01	0.59

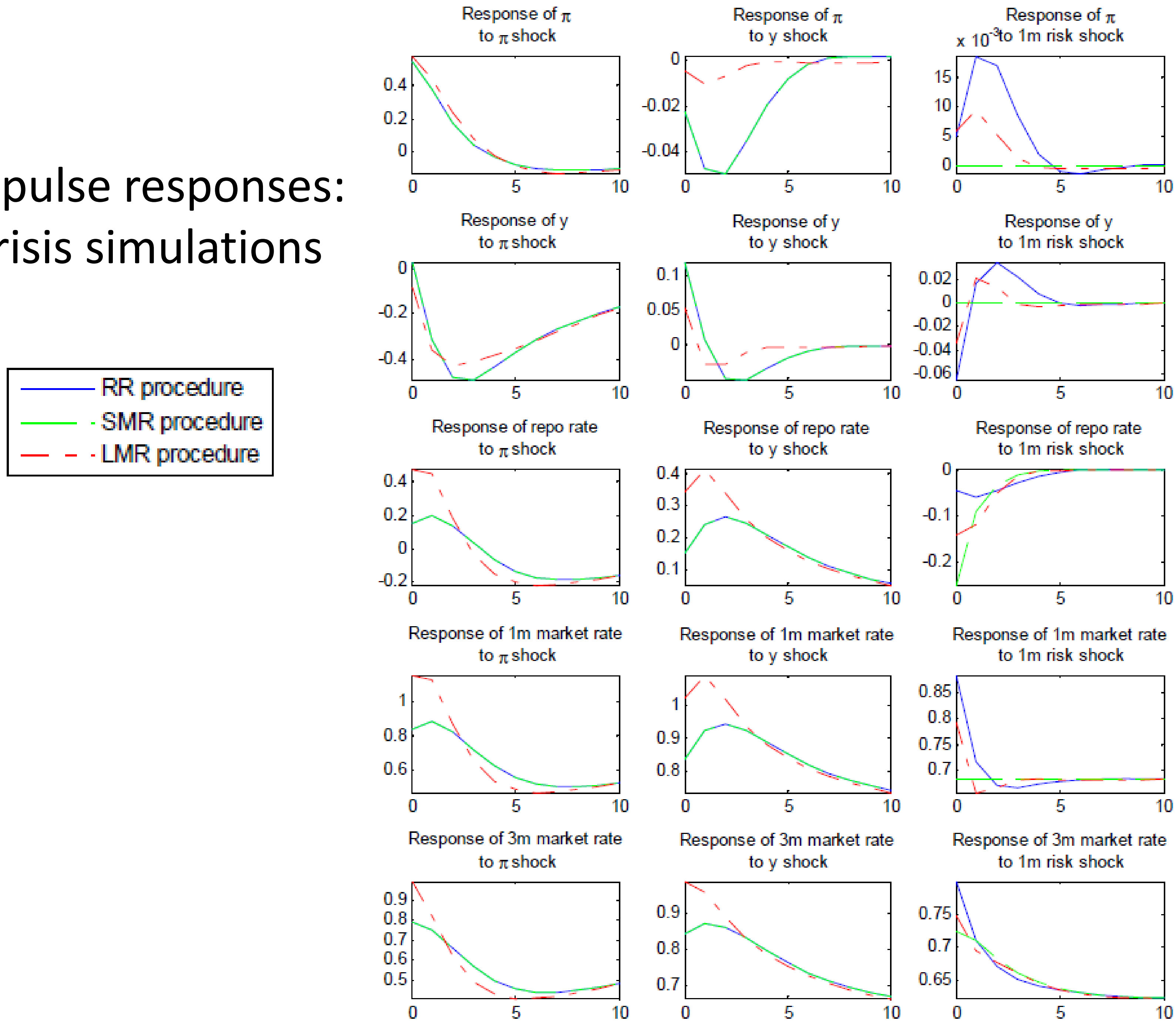
Note: Repo rate reaction function coefficients for different operating procedures. RR/SMR/LMR procedure stands for repo rate/short-term/long-term money market rate procedure.

Impulse responses: pre-crisis simulations





Impulse responses: crisis simulations



Volatility

- Macroeconomic volatility split into inflation and output gap volatility

$$inflation\ volatility_p = \frac{1}{T}\sum_{t=1}^{T}\pi_{p,t}^2$$

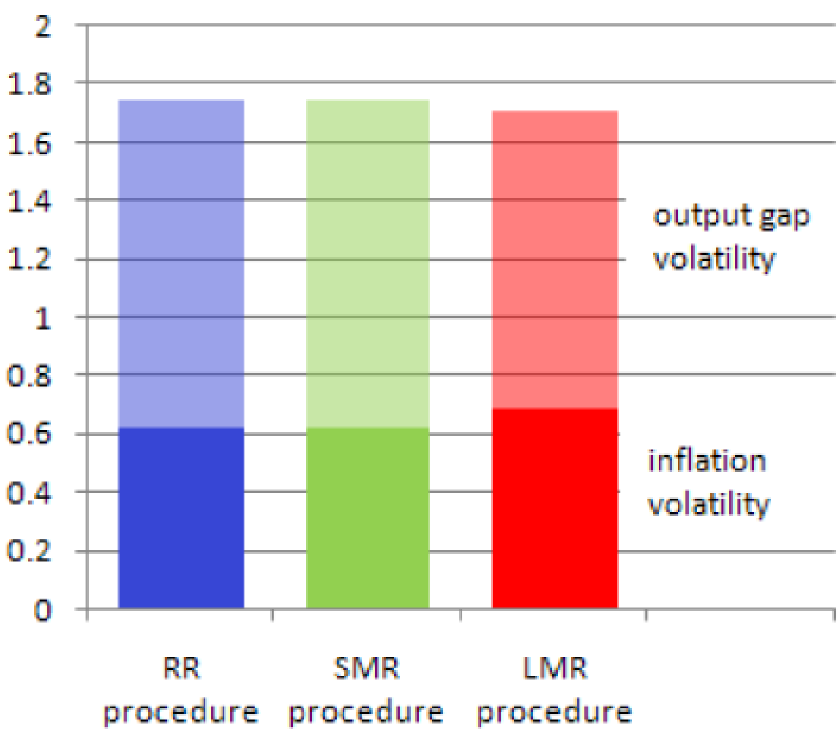
$$output\ gap\ volatility_p = \frac{1}{T}\sum_{t=1}^{T}y_{p,t}^2$$

- Interest rate volatility for each maturity j

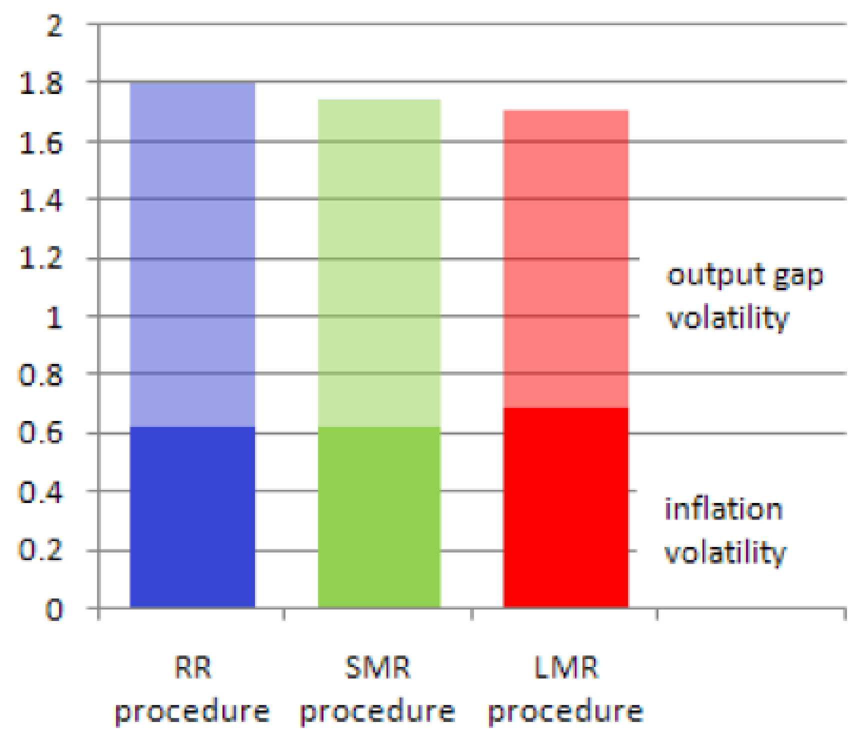
$$interest\ rate\ volatility_{j,p} = \frac{1}{T}\sum_{t=1}^{T}i_{j,p,t}^2$$

Macroeconomic volatility under commitment

Pre-crisis simulation

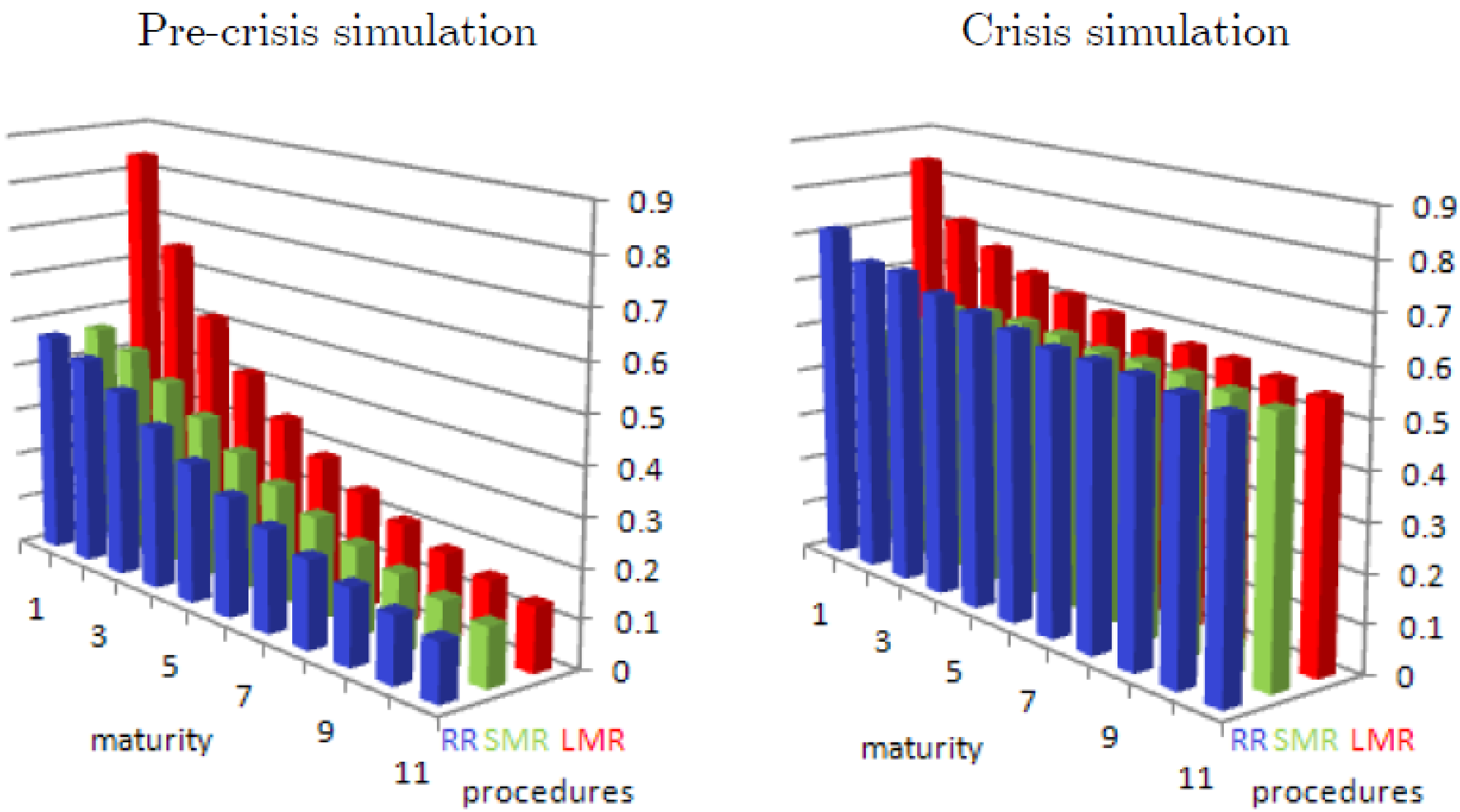


Crisis simulation



Note: Simulations with 10,000 draws. RR/SMR/LMR procedure stands for repo rate/short-term/long-term money market rate procedure.

Volatility of market rates under commitment



Note: Simulations with 10,000 draws. RR/SMR/LMR procedure stands for repo rate/short-term/long-term money market rate procedure.

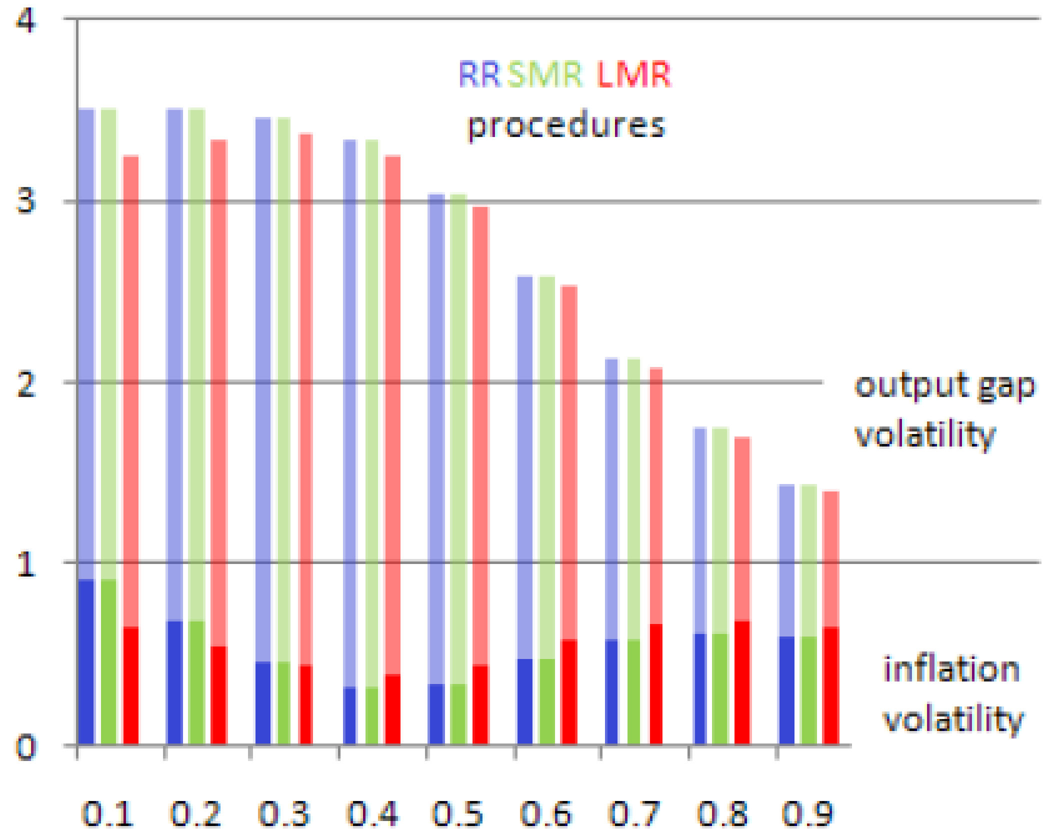
Main findings in baseline model

- Differences in macroeconomic volatility are small, but important
  - LMR procedure performs best
  - SMR better than RR procedure in crisis simulation
- Differences in interest rate volatility large
  - LMR procedure yields most volatile term structure
  - SMR less volatile than RR procedure in crisis; no need to correct for impact of the risk shock
- LMR procedure puts more weight on the future; stabilising effect
- SMR procedure focuses on rate in IS curve

Robustness checks

- How do the results depend on the degree of forward-lookingness?
- What happens if policy is discretionary?
  - Deviation from rules in crisis likely
- What happens if the 3-month rate enters the IS curve?

Macroeconomic volatility and forward-lookingness

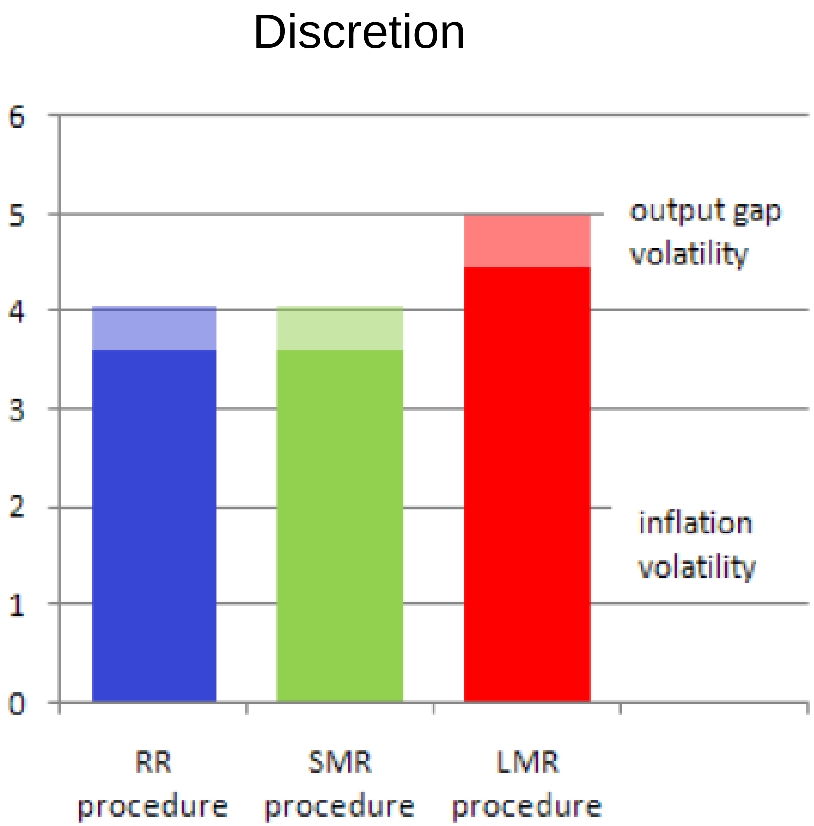


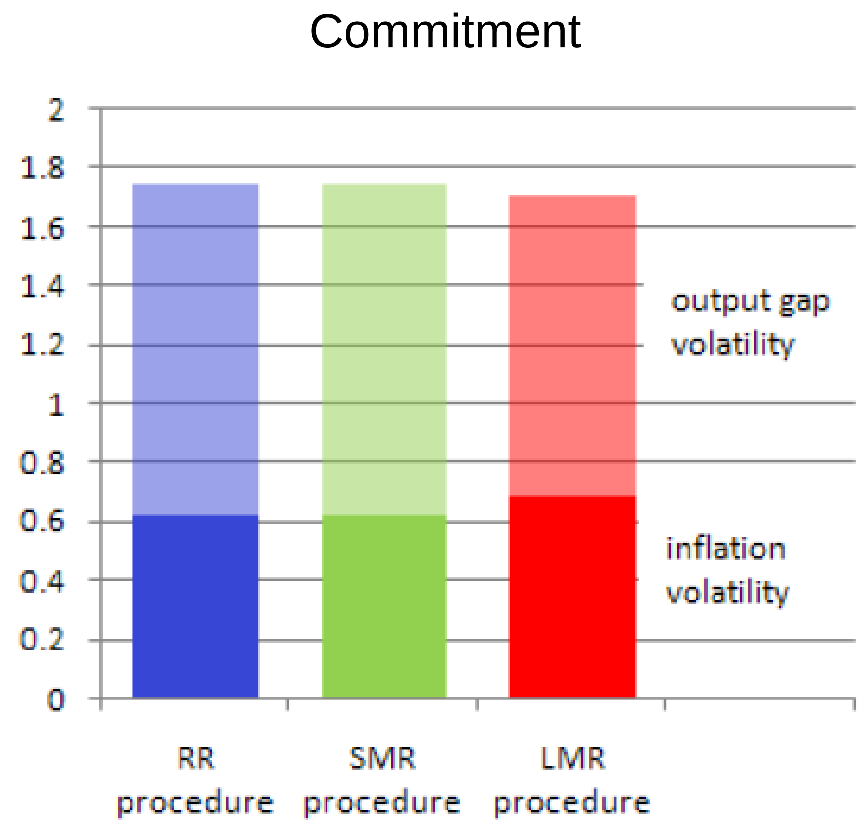
Optimal reaction functions under discretion

Reaction to	π_{t-1}	y_{t-1}	i_{t-1}	$u_{\pi,t}$	$u_{y,t}$	$\theta_{1,t}$	$\theta_{3,t}$	$\theta_{1,t-1}$
Pre-crisis simulation								
RR procedure	0.05	0.10	0.33	2.55	1.16	-0.28	0.00	0.00
SMR procedure	0.05	0.10	0.33	2.55	1.16	-1.00	0.00	0.33
LMR procedure	0.14	0.37	0.00	5.29	2.94	-0.94	0.00	0.00
Crisis simulation								
RR procedure	0.05	0.10	0.32	2.55	1.16	-0.37	0.00	0.00
SMR procedure	0.05	0.10	0.32	2.55	1.16	-1.00	0.00	0.33
LMR procedure	0.14	0.37	0.00	5.29	2.94	-0.97	-0.01	0.00

Note: Repo rate reaction function coefficients for different operating procedures. RR/SMR/ LMR procedure stands for repo rate/short-term/long-term money market rate procedure.

Macroeconomic volatility: discretion vs. commitment

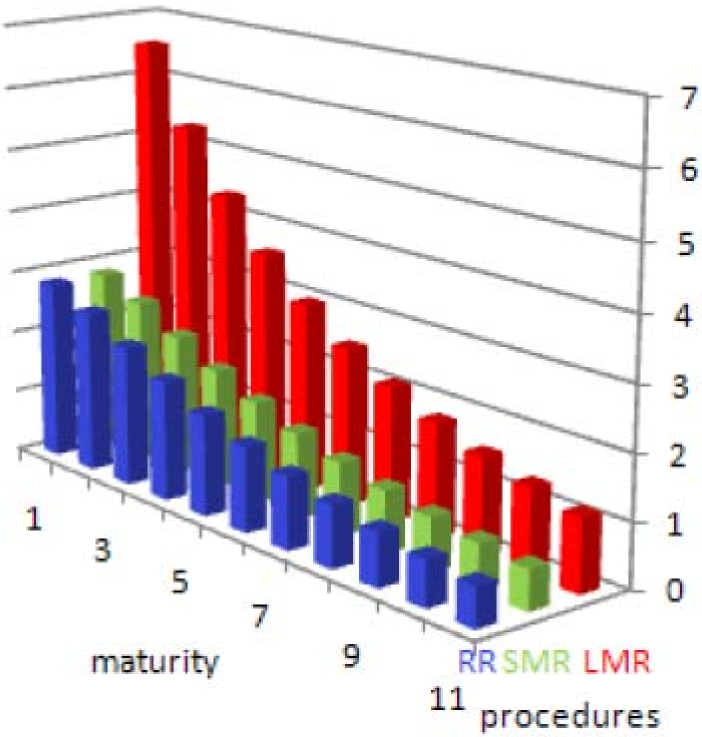




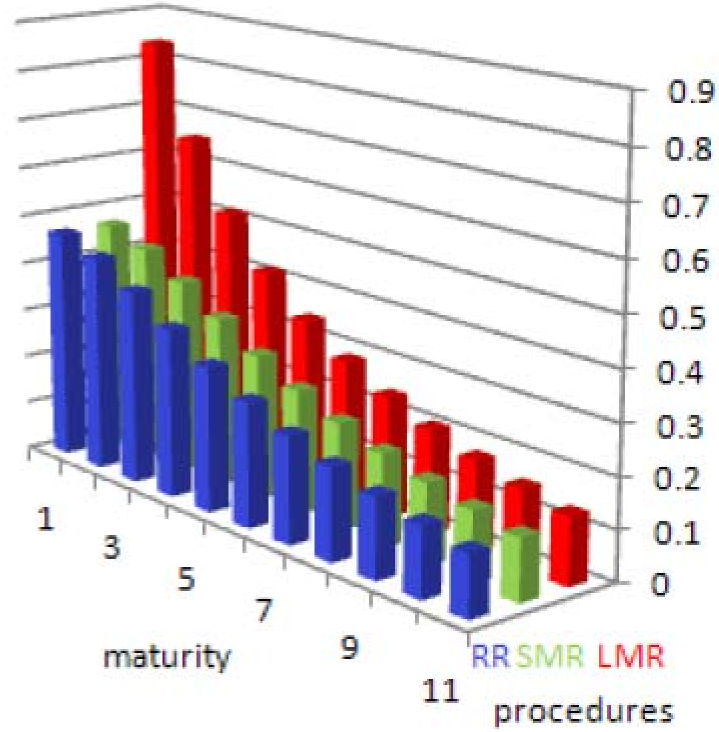
- Stabilisation bias for output gap
- LMR takes expectations for 3 months as given

Volatility of market rates: Discretion vs. Commitment

Discretion



Commitment



3-month rate in IS curve

- Indeterminacy problem for LMR procedure
  - There is an infinite number of combinations of (expected) it over the next three months that yield the same i3,t
- Other procedures do not have this problem
  - Path of i3,t is pinned down by smoothing objective of the respective one-month rate
- Assume small weight on $(\Delta i_t)^2$ for LMR procedure
  - Realistic given path of SNB repo rates

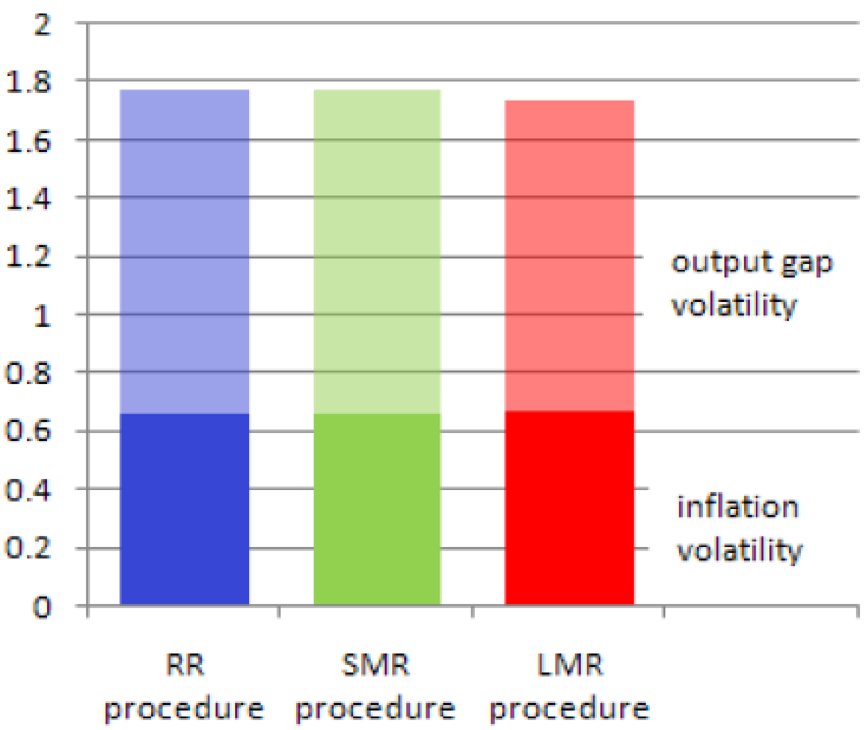
Optimal reaction functions with 3M libor in IS curve

Reaction on	π_{t-1}	y_{t-1}	i_{t-1}	$u_{\pi,t}$	$u_{y,t}$	$\theta_{1,t}$	$\theta_{3,t}$	$\theta_{1,t-1}$	γ_{t-1}^{PC}	γ_{t-1}^{IS}
					Pre-crisis simulation					
RR procedure	0.00	0.05	0.68	0.08	0.82	0.00	-0.33	0.00	0.00	0.07
SMR procedure	0.00	0.05	0.68	0.08	0.82	-0.95	-0.33	0.68	0.00	0.07
LMR procedure	0.00	0.17	0.54	0.23	1.44	0.00	-0.62	0.00	0.00	0.30
					Crisis simulation					
RR procedure	0.00	0.05	0.68	0.08	0.82	0.00	-0.29	0.00	0.00	0.07
SMR procedure	0.00	0.05	0.68	0.08	0.82	-0.92	-0.29	0.68	0.00	0.07
LMR procedure	0.00	0.17	0.54	0.23	1.44	0.00	-0.55	0.00	0.00	0.30

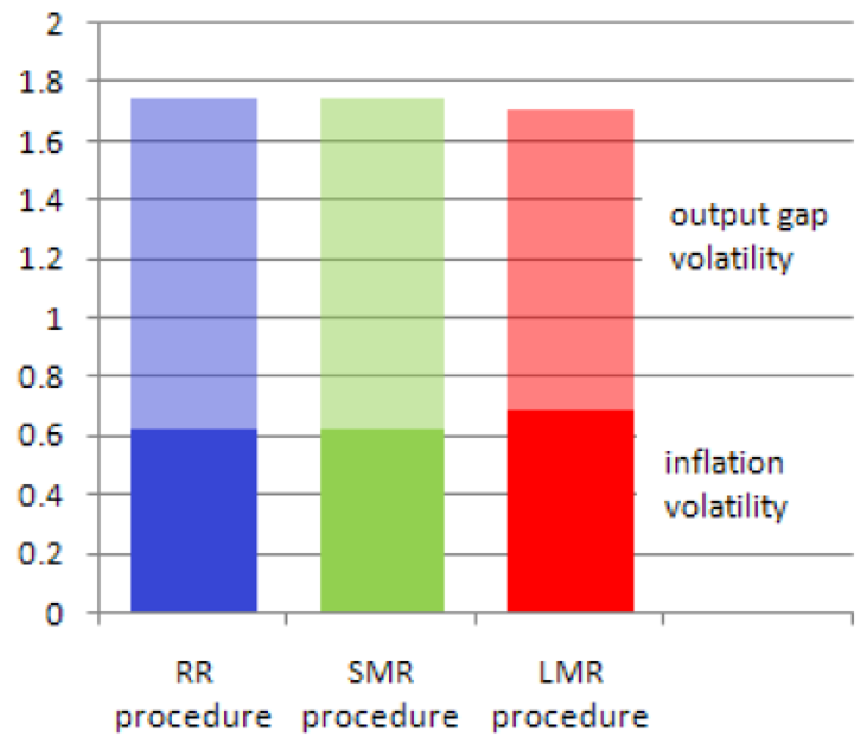
Note: Repo rate reaction function coefficients for different operating procedures. RR/SMR/LMR procedure stands for repo rate/short-term/long-term money market rate procedure.

Macro volatility: 3M vs. 1M market rate in IS curve

3 month LIBOR in IS



1 month LIBOR In IS



Conclusions

- Choice of monetary operating procedure matters
- Macroeconomic volatility
  - Commitment:
    - LMR procedure yields smallest volatility; LMR procedure attaches large weight to future
    - SMR procedure better than RR procedure; SMR procedure uses rate in IS curve
  - Discretion:
    - SMR procedure best, followed by RR procedure
- Interest rate volatility
  - Always highest under LMR procedure
- Caveat: Assumption of existing longer-term markets