Financial System Reforms and China's Monetary Policy Framework: A DSGE-Based Assessment of Initiatives and Proposals

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Monetary Policy in Mainland China

Particularities

1. Banks operate with tight limits (PBoC imposes a floor on loan rates and there are caps on deposit rates).
2. The PBoC uses non-market tools such as loan quotas (window guidance), which essentially involves telling banks how to do their jobs.
3. The required reserve ratio has over the last decade become an important tool for the short-run fine-tuning of monetary policy.

Financial System Reform

Several Recent Initiatives

(i) Creation of over-the-counter (OTC) equity market to provide new financing for SME firms.

(ii) Creation of a high-yield SME bond market.

(iii) Creation of jointly issued notes as a pooled debt instrument.

(iv) Widening of the interest rate benchmark band in July 2012 (lending rates 20 % below and 10 % above the official benchmark).

(v) Credit-backed securization programme allowing to turn loans into securities.

(vi) Renminbi exchange rate band widening.

(vii) Creation of so-called wealth management products that can substitute traditional bank deposits.

(viii) Wenzhou Financial Liberalisation.

Implications of Financial Liberalisation

Important Questions

- ⇒ What are possible benefits of interest rate liberalisation?
- ⇒ What role can a bond market play in the interest rate liberalization process?
- ⇒ Whether and to what extent will the effectiveness of window guidance be affected by financial market liberalisation?
- ⇒ What do these developments imply for the conduct of monetary policy in China?

A Snapshot of Financial Reform

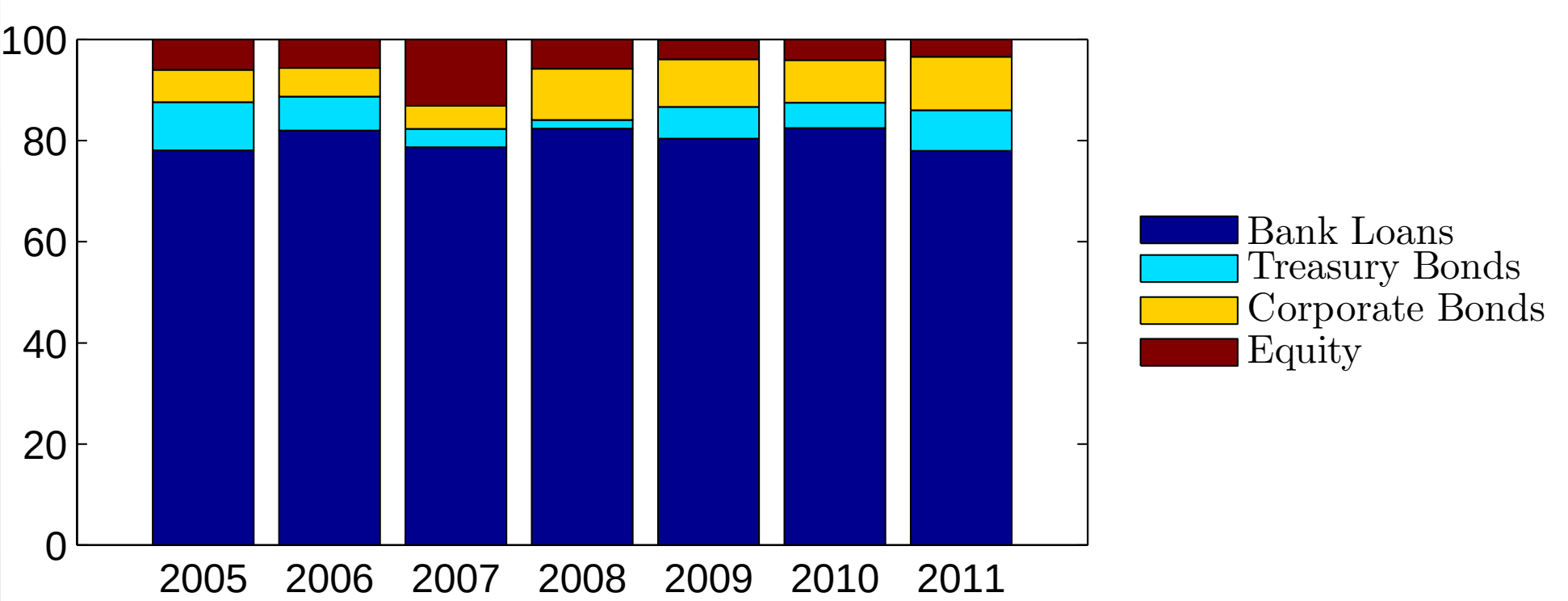
China in the Midst of Transformation

- Liberalisation of administrative guidelines in terms of lending rate floors and deposit rate ceilings.
- Development of deeper bond markets, including treasury bonds, commercial bank paper and corporate bonds.

$\Rightarrow$ The key issue is: Will a more market-oriented financial system foster stable and inclusive economic growth, facilitate internal rebalancing, and safeguard financial stability?

A Snapshot of Financial Reform

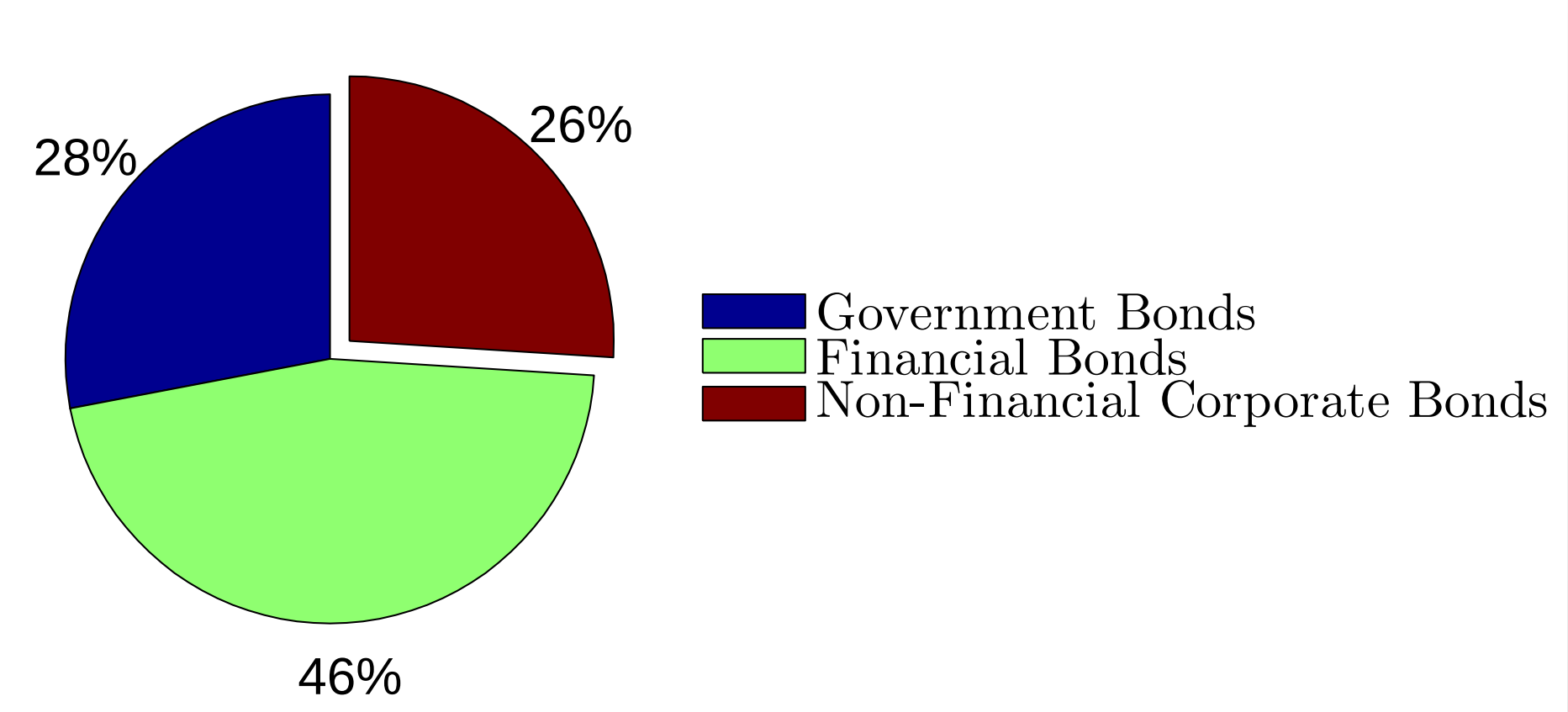
China's Financing Structure, 2005 - 2011 in Percent



Source: IMF (2012) and WIND.

A Snapshot of Financial Reform

Outstanding Bonds, December 2011



Source: IMF (2012) and WIND.

The Conceptual DSGE Framework

A Sketch

- Two-Household closed Economy framework based on Iacoviello (2005) enriched with a private banking sector (without housing) as in Chen et al. (2012).
- Following Kiyotaki and Moore (1997) households are divided into two groups: Impatient entrepreneurs and patient households.
- Entrepreneurs are further divided into two subgroups:
  - Large scale corporates use bond issuing to finance the production of intermediate goods.
  - Small scale enterprises take loans from banks to finance the production of intermediate goods.
- Banks borrow deposits from the patient households and give loans to small scale enterprises.
- Intermediate goods are sold in the retail sector.
- The monetary authority uses the policy rate (which influences the interbanking market), window guidance, and administered retail lending and deposit rates.

Patient Households

Optimization Problem

$$\max_{\{C_t^P, N_t, D_t\}} \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta_p^t \mathcal{V}_t \left[\frac{1}{1-\sigma_P} \left(C_t^P\right)^{1-\sigma_p} - \frac{1}{1+\varphi} N_t^{1+\varphi} \right] \right\},$$

$$\text{s.t. } C_t^P + D_t = \frac{R_{t-1}^D D_{t-1}}{\Pi_t} + \frac{W_t}{P_t} N_t + F_t^R + F_t^B,$$

- $C_t^P, N_t, D_t, W_t, P_t, F_t^R$ and F_t^B represent consumption, labour supply, real deposits, the nominal wage rate, the CPI, and real lump-sum profits received from the retail and the banking sector.
- $R_t^D = \left(1 + r_t^d\right)$ is the gross interest rate on deposits.
- $\Pi_t \equiv \frac{P_t}{P_{t-1}}$ is the consumer price inflation.
- $\mathcal{V}_t \equiv \exp\left(\nu_t\right)$ represents an intertemporal preference shock, reflecting shifts in the marginal utility of consumption.

Patient Households

Optimality Conditions

$$\frac{1}{1+r_t^D} = \beta_p \mathbb{E}_t \left[\left(\frac{C_{t+1}^P}{C_t^P} \right)^{-\sigma_p} \frac{P_t}{P_{t+1}} \frac{\mathcal{V}_{t+1}}{\mathcal{V}_t} \right],$$

$$\frac{W_t}{P_t} = \left(C_t^P \right)^{\sigma_p} N_t^{\varphi}.$$

Conventional results:

- The marginal rate of substitution between present and future consumption equals the price (opportunity costs) of domestic consumption, measured by the real gross yield on saving, adjusted for the time preference.
- The marginal rate of substitution between leisure and consumption is equal to the price (the opportunity costs) of leisure, the real wage.

Large Scale Corporates

Optimization Problem

$$\max_{\left\{C_t^L, K_t^L, B_t, N_t^L, I_t^L\right\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \mathcal{V}_t \frac{1}{1-\sigma_e} \left(C_t^L\right)^{1-\sigma_e},$$

$$\text{s.t } C_t^L + \frac{W_t}{P_t} N_t^L + \frac{R_{t-1}^B}{\Pi_t} B_{t-1} + I_t^L + \mathcal{A}_t^L = \frac{Y_t^L}{X_t} + B_t,$$

$$K_t^L = (1-\delta) K_{t-1}^L + I_t^L,$$

$$Y_t^L = A_t \left(K_{t-1}^L\right)^{\alpha} \left(N_t^L\right)^{1-\alpha},$$

- C_t^L, K_t^L, B_t and I_t^L are consumption, capital, bonds, and investments; Y_t^L and X_t represent real output and the markup of final over intermediate goods (as in Bernanke et al. (1999)).
- $R_t^B \equiv \left(1 + r_t^b\right)$ represents the gross interest rate on bonds.
- $A_t \equiv \exp\left(a_t\right)$ represents labour-augmenting productivity.
- Convex adjustment costs: $\mathcal{A}_t^L \equiv \psi \left(\frac{I_t^L}{K_{t-1}^L \mathcal{U}_t} - \delta\right)^2 \frac{K_{t-1}^L}{2\delta}$, where $\mathcal{U}_t \equiv \exp\left(u_t\right)$ represents a cost decreasing investment shock.

Large Scale Corporates

Optimal Consumption and Labour Demand

$$\frac{1}{1+r_t^b} = \beta_e \mathbb{E}_t \left[\left(\frac{C_{t+1}^L}{C_t^L} \right)^{-\sigma_e} \frac{P_t}{P_{t+1}} \frac{\mathcal{V}_{t+1}}{\mathcal{V}_t} \right],$$

$$\frac{W_t}{P_t} = (1-\alpha) \frac{Y_t^L}{X_t N_t^L}$$

- The entrepreneur's consumption dynamics follow a similar Euler equation as consumption of patient households does.
- The second optimality condition is a conventional labour demand curve.

Large Scale Corporates

Optimal Investments

$$v_t = \left(C_t^L\right)^{-\sigma_e}\left(\frac{\psi}{\delta}\left(\frac{I_t^L}{K_{t-1}^L\mathcal{U}_t}-\delta\right)\frac{I_t^L}{K_{t-1}^L\mathcal{U}_t}-\frac{\psi}{2\delta}\left(\frac{I_t^L}{K_{t-1}^L\mathcal{U}_t}-\delta\right)^2\right)$$
$$+\beta_e\mathbb{E}_t\left(\left(C_{t+1}^L\right)^{-\sigma_e}\frac{\alpha Y_{t+1}^L}{K_t^L X_{t+1}}+(1-\delta)\,v_{t+1}\right),$$

v_t represents the shadow price of capital:

$$v_t \equiv \left(C_t^L\right)^{-\sigma_e}\mathcal{V}_t\left[\left(1+\frac{\psi}{\delta}\left[\frac{I_t^L}{K_{t-1}^L\mathcal{U}_t}-\delta\right]\right)\right].$$

$\Rightarrow$ The shadow price of capital equals the sum of

(i) the capital contribution to lower installation costs,
(ii) the capital's marginal product next period,
(iii) the shadow value of capital next period.

Small Scale Enterprises

Optimization Problem

$$\max_{\left\{C_t^S, K_t^S, L_t, N_t^S, I_t^S\right\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \mathcal{V}_t \frac{1}{1-\sigma_e} \left(C_t^S\right)^{1-\sigma_e},$$

$$\text{s.t } C_t^S + \frac{W_t}{P_t} N_t^S + \frac{R_{t-1}^l}{\Pi_t} L_{t-1} + I_t^S + \mathcal{A}_t = \frac{Y_t^S}{X_t} + L_t,$$

$$K_t^S = (1-\delta) K_{t-1}^S + I_t^S,$$

$$Y_t^S = A_t \left(K_{t-1}^S\right)^{\alpha} \left(N_t^S\right)^{1-\alpha},$$

- C_t^S, K_t^S, L_t and I_t^S are consumption, capital, loans, and investments.
- $R_t^L \equiv \left(1 + r_t^l\right)$ represents the gross retail lending rate.
- $A_t \equiv \exp\left(a_t\right)$ represents labour-augmenting productivity.
- Y_t^S and X_t represent real output and the mark-up of final over intermediate goods (as in Bernanke et al. (1999)).
- Convex adjustment costs, $\mathcal{A}_t$, are the same as for large firms.

Small Scale Enterprises

Optimal Consumption

All FOCs are similar to those of the large corporates except the Euler equation:

$$\frac{1}{1+r_t^l} = \beta_e \mathbb{E}_t \left[\left(\frac{C_{t+1}^S}{C_t^S} \right)^{-\sigma_e} \frac{P_t}{P_{t+1}} \frac{\mathcal{V}_{t+1}}{\mathcal{V}_t} \right],$$

$\Rightarrow$ Since small scale enterprises need bank loans to finance production, the relevant interest rate for the intertemporal consumption path is the bank lending rate.

Retailers

Calvo Pricing

$$
\begin{aligned}
(1+\mu_t)\, G_{1,t} &= G_{2,t}, \\
G_{1,t} &= \frac{Y_t}{X_t}\left(C_t^P\right)^{-\sigma_p}\mathcal{V}_t + \theta\beta_p\mathbb{E}_t\left(\Pi_{t+1}^{\left(\frac{1+\mu_t}{\mu_t}\right)} G_{1,t+1}\right), \\
G_{2,t} &= \Pi_t^*\left[Y_t\left(C_t^P\right)^{-\sigma_p}\mathcal{V}_t + \theta\beta_p\mathbb{E}_t\left(\frac{\Pi_{t+1}^{(1/\mu_t)}}{\Pi_{t+1}^*} G_{2,t+1}\right)\right], \\
1 &= \theta\Pi^{(1/\mu_t)} + (1-\theta)\left(\Pi^*\right)^{-(1/\mu_t)}, \\
\Delta_t &= \theta\Pi_t^{\left(\frac{1+\mu_t}{\mu_t}\right)}\Delta_{t-1} + (1-\theta)\left(\Pi_t^*\right)^{-\left(\frac{1+\mu_t}{\mu_t}\right)},
\end{aligned}
$$

- Only $(1-\theta)$ adjust prices ($\Pi_t^* \equiv P_t^*/P_t$: relative price).
- Δ_t represents price dispersions, μ_t a time-varying markup.

$\Rightarrow$ Final goods production: $Y_t = \frac{A_t}{\Delta_t}K_t^{\alpha}N_t^{1-\alpha}$.

- Profits, $F_t = (1-1/X_t)\,Y_t$, are rebated to patient households.

Aggregation and Market Clearing

$$
\begin{aligned}
K_t &\equiv \gamma K_t^L + (1-\gamma) K_t^S = (1-\delta) K_{t-1} + I_t, \\
Y_t^E &\equiv \gamma Y_t^L + (1-\gamma) Y_t^S = A_t K_{t-1}^{\alpha} N_t^{1-\alpha} = \Delta_t Y_t, \\
I_t &\equiv \gamma I_t^L + (1-\gamma) I_t^S, \\
N_t &\equiv \gamma N_t^L + (1-\gamma) N_t^S = (1-\alpha) \frac{Y_t^E}{X_t W_t}, \\
C_t^E &\equiv \gamma C_t^L + (1-\gamma) C_t^S, \\
Y_t &= C_t^P + C_t^E + I_t,
\end{aligned}
$$

where γ represents the fraction of large scale corporates.

Modelling the Chinese Banking Sector

A Chinese Banking Sector

- Incorporating the partial-equilibrium modelling work of He and Wang (2012) and Chen et al. (2011) into the DSGE framework.
- The banking sector determines the demand function for deposits and excess reserves, and the supply function for loans, taking all interest rates as given.
- The deposit and lending rates are market-determined as long as the guidelines of the central bank are not binding.
- We also incorporate money creation by private banks.

Money Creation

Private Banks' Balance Sheet

Assets	Liabilities
Deposits from patient households represent a fraction of the created deposits and are used as required reserves, D_t	Newly created deposits (money creation), D_t / η_t
Funds provided to entrepreneurs, $\gamma B_t + (1-\gamma) L_t$	Net position in interbank market, IB_t

Note: The DSGE framework does not include bank capital and so bank capital is not included in the bank's net worth on the liability side.

- η_t represents the required reserve ratio.

$\Rightarrow$ $IB_t + D_t / \eta = (1-\gamma) L_t + \gamma B_t + D_t$.

Private Banks

Intertemporal Optimization: Maximizing the Discounted Sum of Cash Flows

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_b^t \left\{ \begin{array}{c} (1-\gamma)\left(R_t^L L_t - L_{t+1}\right) + R_t^R D_t - D_{t+1} + \gamma\left(R_t^B B_t - B_{t+1}\right) \\ -\left(\frac{R_t^D D_t}{\eta} - \frac{D_{t+1}}{\eta}\right) - \left(R_t^{IB} IB_t - IB_{t+1}\right) - \frac{\kappa}{2}\left(L_t - L_t^{cb}\right)^2 - \mathcal{C}_t \end{array} \right\}$$

$$\text{s.t. } IB_t + D_t/\eta = (1-\gamma) L_t + \gamma B_t + D_t,$$

- β_b represents the banks' discount factor.
- R_t^{ib} and R_t^r represent the interbank interest rate and the interest rate on required reserves.
- Deviations of actual credits from the CB target (L_t^{cb}) induce costs, given by $\frac{\kappa}{2}\left(L_t - L_t^{cb}\right)^2$.
- Quadratic management costs for loans, deposits, and excess reserves: $\mathcal{C}_t \equiv \frac{1}{2Y}\left\{c_d\left[\frac{D_t^2 - D^2}{\eta^2}\right] + (1-\gamma)\, c_l\left[L_t^2 - L^2\right] + \gamma c_b\left[B_t^2 - B^2\right]\right\}$.

Private Banks

Profits

By substitution of the bank's budget constraint, the problem can be reduced to a period-by-period maximization of profits,

$$(1-\gamma)\left(R_t^L L_t - L_{t+1}\right) + R_t^R D_t - D_{t+1} + \gamma\left(R_t^B B_t - B_{t+1}\right)$$
$$-\left(\frac{R_t^D D_t}{\eta} - \frac{D_{t+1}}{\eta}\right) - \left(R_t^{IB} IB_t - IB_{t+1}\right) - \frac{\kappa}{2}\left(L_t - L_t^{cb}\right)^2 - \mathcal{C}_t$$

which are rebated to patient households.

Private Banks

Optimality Conditions

$$
\begin{aligned}
R_t^L &= R_t^{IB} + \kappa \left(L_t - L_t^{CB} \right) + (c_l / Y) L_t, \\
R_t^B &= R_t^{IB} + (c_b / Y) B_t, \\
R_t^D &= R_t^{IB} + \eta \left(\left(R_t^R - R_t^{IB} \right) - (c_d / Y) \left(D_t / \eta^2 \right) \right).
\end{aligned}
$$

- Opportunity costs for loans and bonds are given by the sum of the interbank rate, management costs and costs for deviating from the central bank loan target.
- Opportunity costs for deposits depend on a weighted average of the yield on reserves (due to the required reserve ratio), the interbank rate, and the management costs for deposits.
- We close the banking side of our model, by assuming that banks have unlimited access to a lending facility at the central bank, and arbitrage ensures $r_t^{ib} = r_t$ (as in Gerali et al. (2010)).

The People's Bank of China

PBoC interest rate corridor

Loan and deposit rates are restricted by the guidelines of the central bank:

$$R_t^L \geq R_t^{L,CB}, R_t^D \leq R_t^{D,CB}.$$

$$\Rightarrow R_t^L = \max\left(R_t^{L,CB}, R_t^{L,PB}\right), R_t^D = \min\left(R_t^{D,CB}, R_t^{D,PB}\right),$$

where $R_t^{L,PB}$ and $R_t^{D,PB}$ represent the market rates, and $R_t^{L,CB}$ and $R_t^{D,CB}$ the restrictions of the central bank.

- $\Rightarrow$ These one-sided constraints induce asymmetric business cycle effects that are not fully captured by conventional linear approximation methods.
- $\Rightarrow$ Standard analytical DSGE approaches appear unfit for the analysis of Chinese monetary policy.

The People's Bank of China

Monetary Policy

- Taylor rule: $R_t = R_{t-1}^{\phi_r} \left(R \left(\frac{\Pi_t}{\overline{\Pi}} \right)^{\phi_\pi} \left(\frac{Y_t}{Y} \right)^{\phi_y} \right)^{(1-\phi_r)}$.
- Benchmark deposit and lending rates:

$$R_t^{D,CB} = \left(R_{t-1}^D \right)^{\phi_r^d} \left(R_t \frac{R^D}{R} \right)^{(1-\phi_r^d)},$$

$$R_t^{L,CB} = \left(R_{t-1}^L \right)^{\phi_r^l} \left(R_t \frac{R^L}{R} \right)^{(1-\phi_r^l)}.$$

- Window guidance:

$$L_t^{CB} = \left(L_{t-1}^{CB} \right)^{\phi_l^{cb}} \left(L \left[\frac{L_t}{L} \right]^{\phi_l^l} \left[\left(\frac{\Pi_t}{\overline{\Pi}} \right)^{\phi_\pi^l} \left(\frac{Y_t}{Y} \right)^{\phi_y^l} \right]^{(1-\phi_l^l)} \right)^{(1-\phi_l^{cb})}.$$

- Interest rate on required reserves: $R_t^r = R_t$.

Simulations

One-Sided Constraints

To deal with the inequality constraints, induced by the PBoCs interest rate corridor, we introduce auxiliary variables:

$$\begin{aligned} R_t^{L,aux} &\equiv \left(R_t^{L,PB}/R_t^{L,CB}\right) \geq 1, \\ R_t^{D,aux} &\equiv \left(R_t^{D,CB}/R_t^{D,PB}\right) \geq 1. \end{aligned}$$

$\Rightarrow$ $R_t^{L,aux} = 1$ ($R_t^{D,aux} = 1$), if $R_t^{L,PB} < R_t^{L,CB}$ ($R_t^{D,PB} > R_t^{D,CB}$).

$\Rightarrow$ Lending and deposit rates are then determined by

$$R_t^L = R_t^{L,aux} R_t^{L,CB}$$

and

$$R_t^D = R^{D,CB}/R_t^{D,aux}.$$

To solve for R_t^L and R_t^D we use the method explained in Holden and Paetz (2012).

The PBoCs Interest Rate Constraints

Efficient Simulation of DSGE Models with Inequality Constraints

The Algorithm

- Holden and Paetz (2012) describe a very simple method to deal with inequality constraints in DSGE models.
- The algorithm can be used for IRFs and complete simulations and is much faster than, for example, the extended path methods proposed by Adjemian and Juillard (2011) (steady state IRFs and simulations need a few seconds).
- The idea is based on the introduction of *shadow price* shocks that hit the bounded variable whenever it violates the constraint:

$$\sum_{s=0}^{T-1} \epsilon_{s,t-s}^{SP},$$

where $\epsilon_{s,t}^{SP} \overset{i.i.d.}{\sim} \mathcal{N}(0,1)$, if $t = 0$ and zero otherwise.

$\Rightarrow$ Shocks hit the equation in consecutive periods (if $s = t$).

The PBoCs Interest Rate Constraints

Efficient Simulation of DSGE Models with Inequality Constraints

The Algorithm

1. Multiply the equation, determining the bounded variable with $\exp \sum_{s=0}^{T-1} \epsilon_{s,t-s}^{SP}$, where T represents the number of periods you believe the constraint to hold.
2. Generate IRFs of the model with shadow price shocks. Save the IRFs with respect to the shadow price shocks consecutively as column vectors in a matrix M.
3. Solve the following optimisation problem:

$$\alpha^* = \arg\min \left[\alpha' \left(v + m + M^* \alpha\right)\right]$$
$$\text{s.t. } \alpha \geq 0 \text{ and } v + m + M^* \alpha \geq 0,$$

   where M^* is the $T \times T$ upper square Matrix of M, and v and m represent the IRFs and the steady state of the constrained variable.
4. The IRFs of the constrained variable are now given by $v + m + M\alpha^*$. And the results for all other variables are derived in the same fashion by multiplying the corresponding shadow price IRF matrix by α^*.

The PBoCs Interest Rate Constraints

Efficient Simulation of DSGE Models with Inequality Constraints

Intuition

α determines the linear combination of shadow price shocks, needed to keep the variable bounded:

$$\alpha^* = \arg\min \left[\alpha' \left(v + m + M^* \alpha\right)\right]$$
$$\text{s.t. } \alpha \geq 0 \text{ and } v + m + M^* \alpha \geq 0,$$

- $\Rightarrow$ If the IRF in a particular period is greater than zero, the optimal α entry would be zero and the shadow price shock has no impact.
- $\Rightarrow$ If the constraint in a particular period is violated, the optimal α entry is exactly of the size, that implies $v + m + M^* \alpha = 0$, and the constraint binds.
- $\Rightarrow$ Since the shocks hit in the future, but are known today, the method is consistent with a rational expectations solution of the model.

The PBoCs Interest Rate Constraints

Efficient Simulation of DSGE Models with Inequality Constraints

Extension for 2 Constraints

Define v_1, v_2, m_1 and m_2 for each constrained variable separately and let $M^*_{i,j}$ be the matrix of the responses of bounded variable i to the shadow price shock of variable j. Now solve

$$\alpha^* \equiv \begin{bmatrix}\alpha_1^{*\prime} & \alpha_2^{*\prime}\end{bmatrix} = \arg\min \begin{bmatrix}\alpha_1' & \alpha_2'\end{bmatrix} \left[\begin{bmatrix} m_1 + v_1 \\ m_2 + v_2 \end{bmatrix} + \begin{bmatrix} M^*_{1,1} & M^*_{1,2} \\ M^*_{2,1} & M^*_{2,2} \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} \right].$$

$\Rightarrow$ The reaction of the bounded variables are

$$v_1 + m_1 + M_{1,1}\alpha_1^* + M_{1,2}\alpha_2^*$$

and

$$v_2 + m_2 + M_{2,1}\alpha_1^* + M_{2,2}\alpha_2^*.$$

$\Rightarrow$ The impulse responses for a variable k can be derived by

$$v_k + m_k + M_{k,1}\alpha_1^* + M_{k,2}\alpha_2^*,$$

where $M_{k,j}$ represents shadow price shock IRF of k with respect to j, and v_k is the conventional IRF of k.

The PBoCs Interest Rate Constraints

Efficient Simulation of DSGE Models with Inequality Constraints

Simulation

1. Sample from the shock distribution to generate the period t exogenous shock.
2. Simulate the model for T periods to attain the path by which it would return to trend were there no bounds, and no shocks after period t. If the bounds are never hit along this path, then we have a valid simulation of period t.
3. Otherwise, add shadow shocks in the same way as before, except that the simulated return paths of the economy's variables take the role of the IRFs above.
4. The found solution to the quadratic programming problem gives a valid, new value for variables at t, and we repeat steps 1. $-$ 3. for $t+1$.

Calibration

Description	Value
Households:	
Discount factors of different household types	$\beta_p = 0.9985, \beta_e = 0.9925$
Cost parameters in the Banking Sector	$c_l = c_e = c_d = 1\%$
Equilibrium required reserve ratio	$\eta = 0.1$
Intertemporal elasticities of substitution	$\sigma_p = \sigma_e = 1$
Frisch elasticity	$\varphi = 1$
Depreciation rate of capital	$\delta = 0.03$
Adjustment cost parameter	$\psi = 2$
Firms:	
Price Rigidity	$\theta = 0.6$
Output elasticity of capital	$\alpha = 0.5$
Steady state net mark-up	$\mu = 0.1$
Monetary Policy:	
Taylor rule	$\phi_\pi = 1.5, \phi_y = 0.125, \phi_r = 0.5$
Benchmark deposit and lending rates	$\phi_r^l = \phi_r^d = 0.7$
Window Guidance	$\phi_l^{cb} = 0.5, \phi_l^l = 0.3,$
	$\phi_l^\pi = 50, \phi_l^y = 5, \kappa = 1$
Annual inflation target	$\overline{\Pi} = 2.45\%$

Varying degrees of Interest Rate Liberalisation

Modelling Approach

$$
\begin{aligned}
R_t^{D,CB} &= (1-\mathcal{W})\left[\left(R_{t-1}^{D}\right)^{\phi_r^d}\left(R_t\frac{R^D}{R}\right)^{(1-\phi_r^d)}\right] \\
&\quad +\mathcal{W}\left[R_t-(c_d/Y)\left(D_t/\eta_t^2\right)\right], \\
R_t^{L,CB} &= (1-\mathcal{W})\left[\left(R_{t-1}^{L}\right)^{\phi_r^l}\left(R_t\frac{R^L}{R}\right)^{(1-\phi_r^l)}\right] \\
&\quad +\mathcal{W}\left[R_t+\kappa\left(L_t-L_t^{CB}\right)+(c_l/Y)\,L_t\right].
\end{aligned}
$$

- $\Rightarrow$ $\mathcal{W}=0\%$: No liberalisation, constraints bind fully.
- $\Rightarrow$ $\mathcal{W}=100\%$: Full liberalisation, constraints are ignored.
- $\Rightarrow$ This allows us to study impulse response functions for different degrees of interest rate liberalisation simply by changing the weight parameter $\mathcal{W}$.

Impulse Response Functions

Shocks

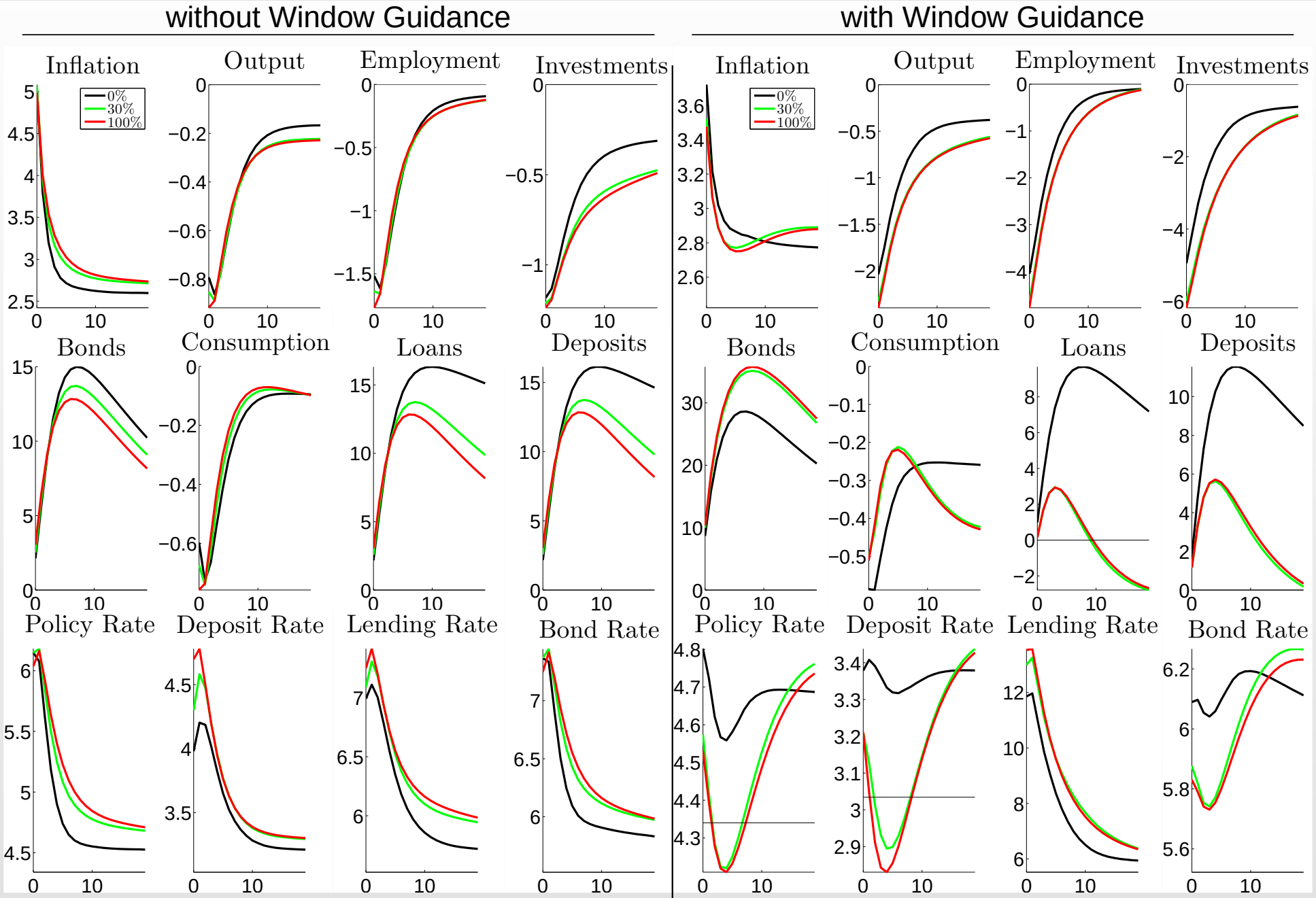
All shocks follow AR(1) processes

$$x_t = \rho^x_{t-1} x_{t-1} + \varepsilon^x_t,$$

where all innovations $\varepsilon^j_t \overset{i.i.d}{\sim} \mathcal{N}\left(0, \sigma^2_j\right)$.

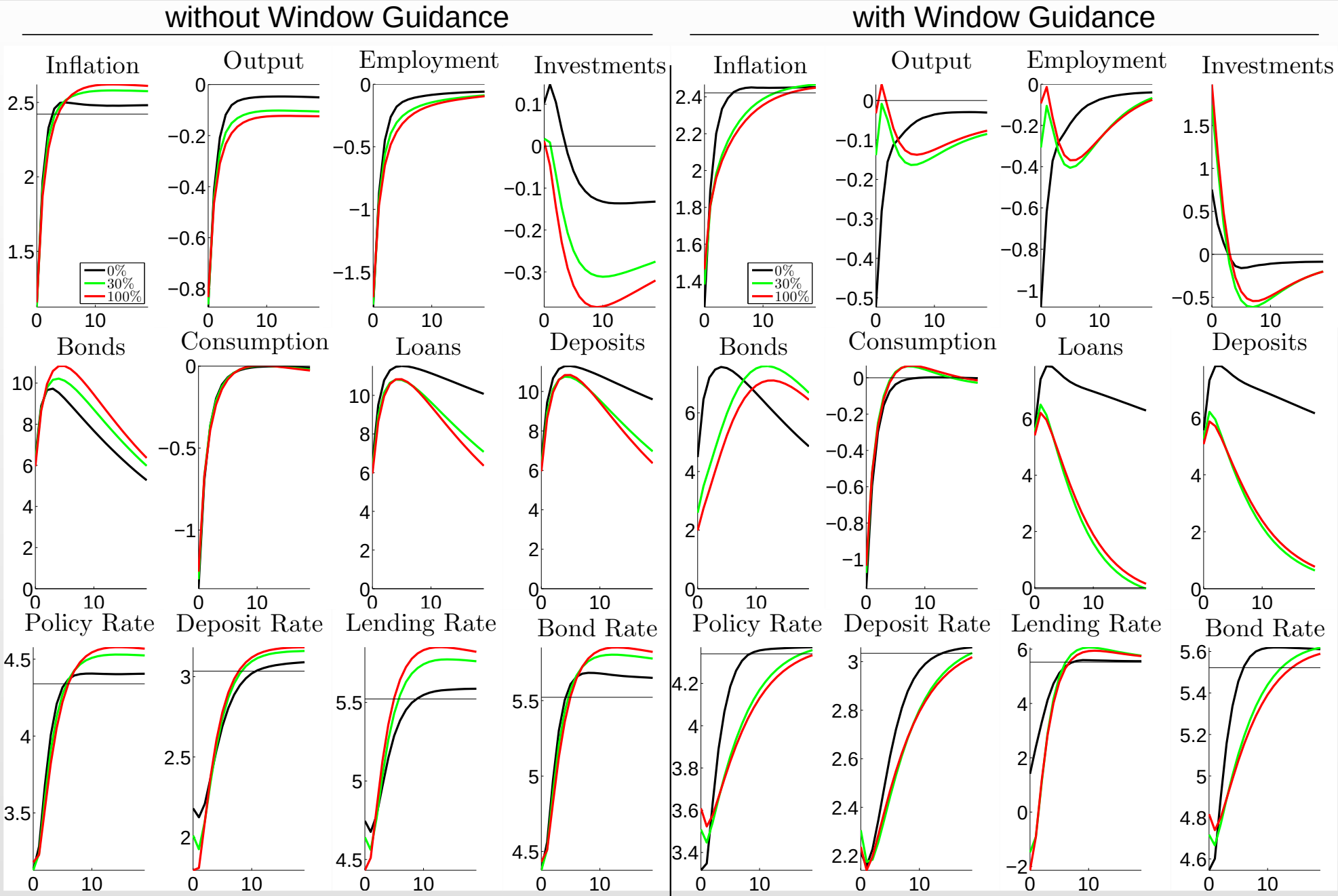
- Productivity shock, cost-push shock, preference shock, and investment shock.
- For the IRFs, we calibrate the standard deviation of these shocks such that they lead to a comparable effect on inflation at impacts of $\sigma_\mu = 0.05, \sigma_a = 0.005, \sigma_\nu = 0.005$ and $\sigma_u = 0.05$.
- The AR(1)-parameters are all set to $\rho_j = 0.7$.
- In the simulation exercise below, we evaluate the performance of (i) a gradual interest rate liberalisation for a fixed share of bond finance (10 %), (ii) a gradual bond market liberalisation, and (iii) a policy mix with a more aggressive Taylor rule and no interest rate regulation.

IRFs, Pos. Cost-P. Shock, Interest Rate Deregulation



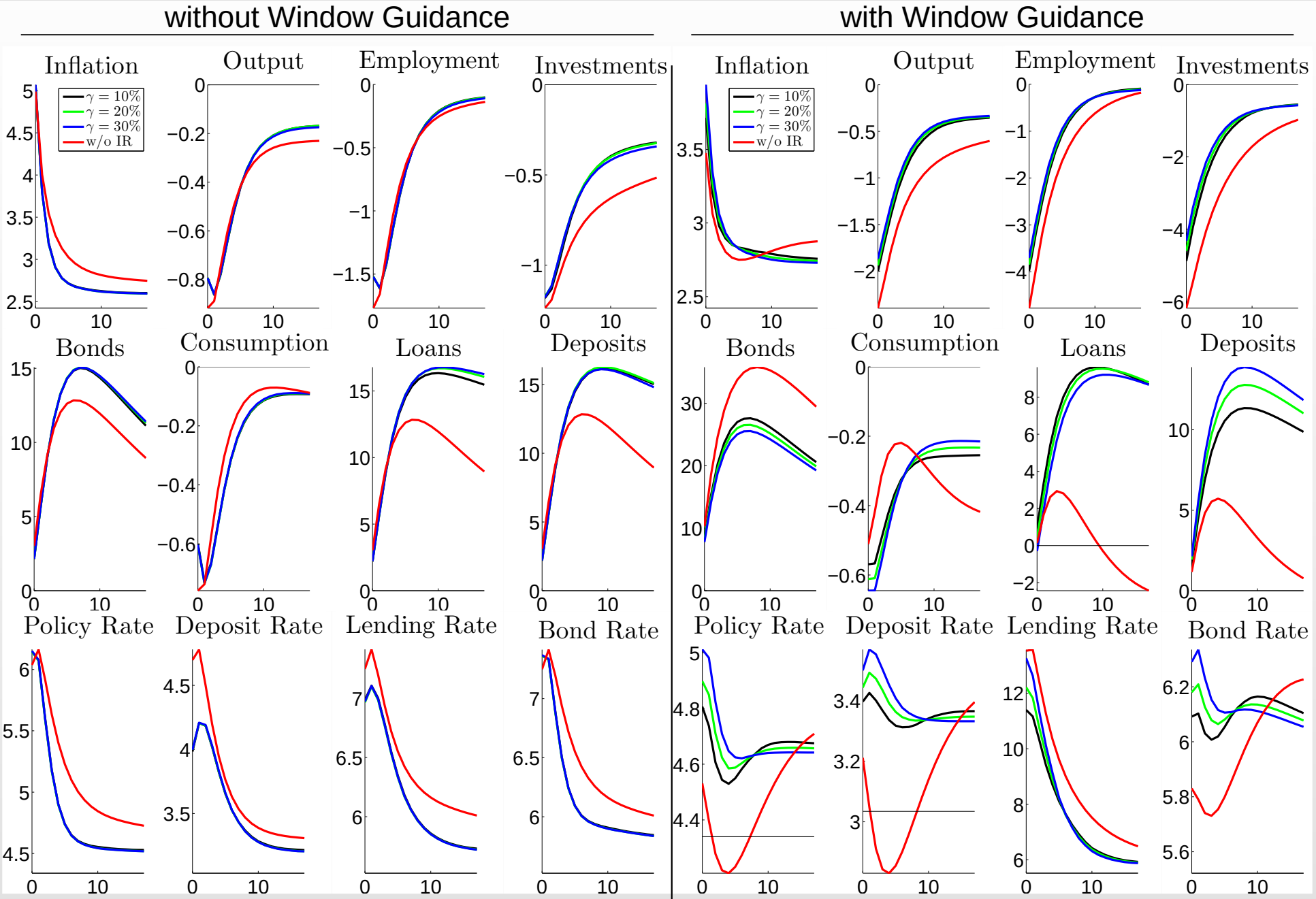
$\mathcal{W} = 100\%$: **interest rate constraints are ignored;** $\mathcal{W} = 0\%$ **fully binding constraints.**

IRFs, Neg. Pref. Shock, Interest Rate Deregulation



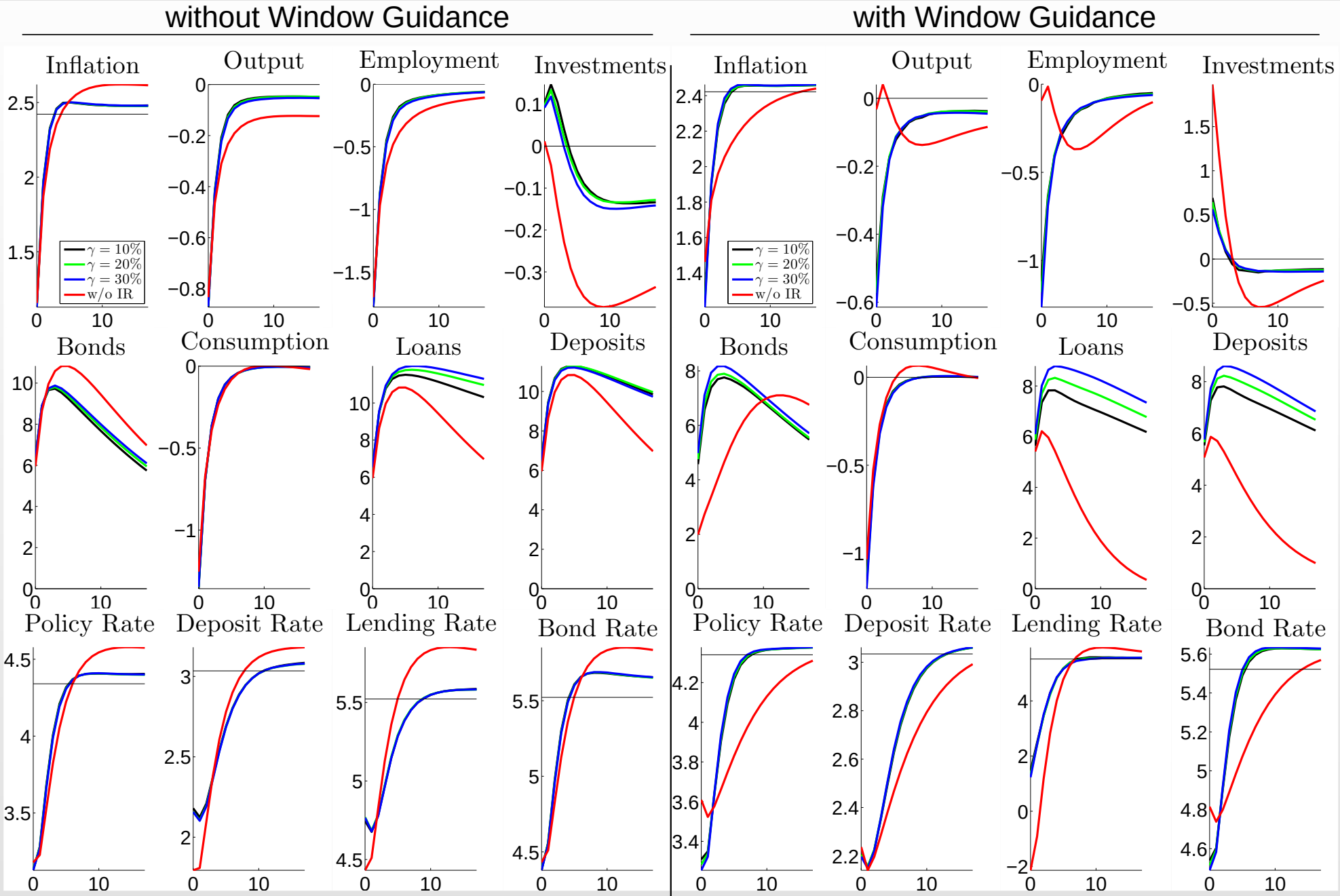
$\mathcal{W} = 100\%$: **interest rate constraints are ignored;** $\mathcal{W} = 0\%$ **fully binding constraints.**

IRFs, Pos. Cost-P. Shock, Bond Market Deregulation



γ: share of bond finance; w/o IR: no interest rate constraints.

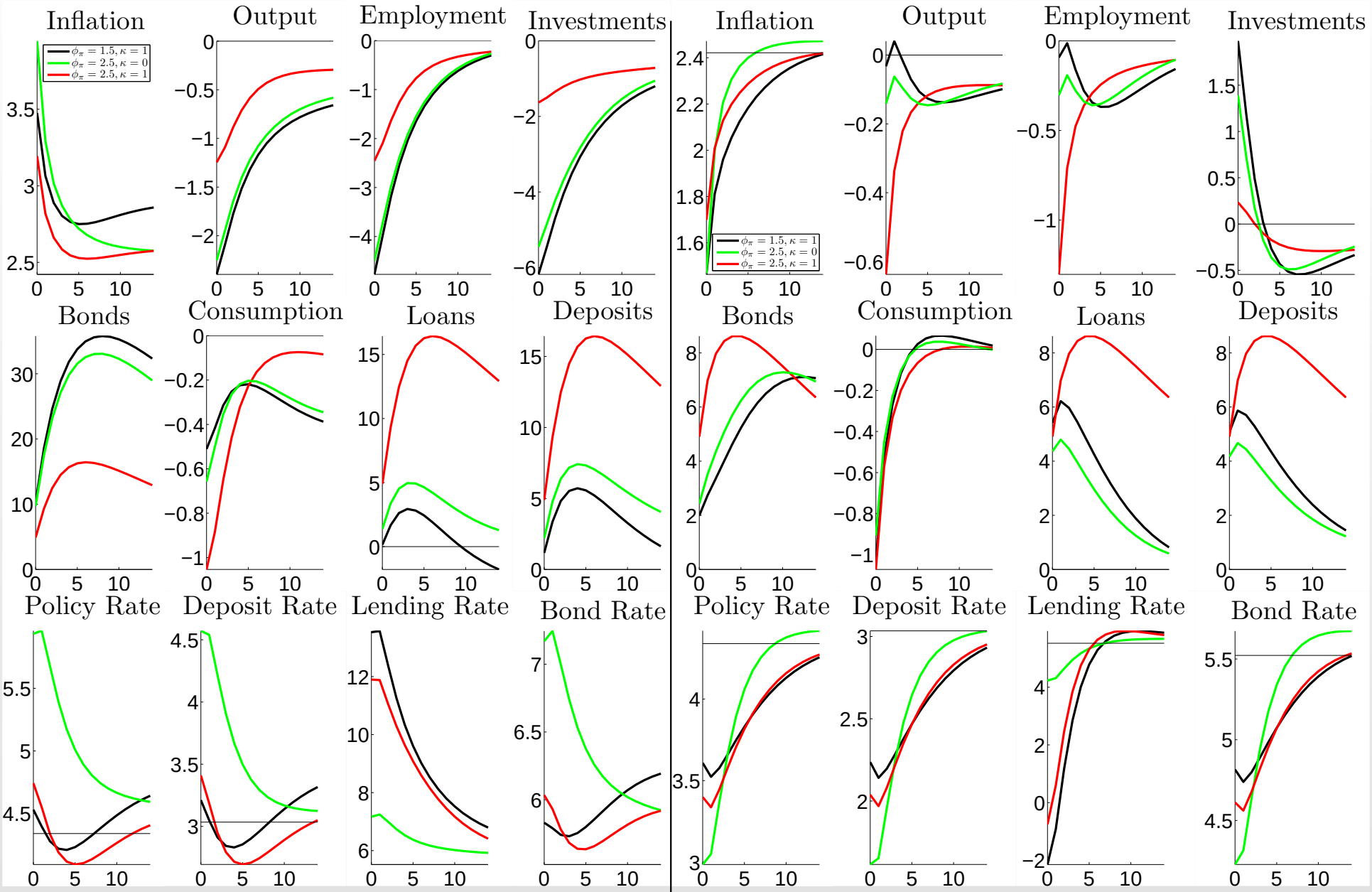
IRFs, Neg. Pref. Shock, Bond Market Deregulation



γ: share of bond finance; w/o IR: no interest rate constraints.

IRFs, More Aggressive Taylor Rule

positive cost-push shock | negative preference shock



ϕ_π: **taylor rule parameter;** κ: **window guidance.**

Standard Deviations of Different Policy Scenarios

Evaluation

The next slide shows the standard deviations for a simulation of the model over $100,000$ periods.

	y	c	π	n	r	r^l	r^d	r^b	l	d	b	i	w	x
FULL INTEREST RATE REGULATION ($\mathcal{W} = 0$)														
Bond finance	**Without Window Guidance**													
Low share (10%)	5.90	5.79	1.71	5.99	1.68	1.67	1.64	1.70	196.52	183.65	86.49	8.92	7.73	10.25
High share (30%)	5.86	5.75	1.71	6.05	1.68	1.67	1.64	1.70	200.16	161.47	87.96	8.95	7.68	10.27
	With Window Guidance													
Low share (10%)	7.18	6.19	1.63	6.92	1.51	4.85	1.57	1.65	114.39	112.69	131.92	11.72	8.28	10.11
High share (30%)	6.95	6.14	1.66	6.66	1.55	5.31	1.59	1.67	124.84	116.94	125.66	11.02	8.23	10.17
LOWERED INTEREST RATE REGULATION ($\mathcal{W} = 0.3$)														
	Without Window Guidance													
Low share (10%)	6.08	5.86	1.84	6.18	1.88	1.90	1.84	1.93	94.94	93.86	84.60	9.47	7.65	10.11
High share (30%)	5.94	5.75	1.82	6.21	1.87	1.89	1.82	1.92	97.22	93.82	86.30	9.32	7.54	10.14
	With Window Guidance													
Low share (10%)	8.54	6.59	1.66	8.35	1.51	7.06	1.60	1.73	43.49	39.17	176.12	15.70	8.84	10.18
High share (30%)	8.01	6.43	1.72	7.66	1.60	7.96	1.64	1.80	45.61	46.76	151.27	13.97	8.62	10.04
NO INTEREST RATE REGULATION ($\mathcal{W} = 1$)														
	Without Window Guidance													
Low share (10%)	6.12	5.88	1.90	6.23	1.98	2.04	1.96	2.04	83.96	83.96	83.96	9.64	7.56	10.00
High share (30%)	5.97	5.76	1.88	6.24	1.97	2.03	1.94	2.03	84.79	84.79	84.79	9.47	7.45	10.02
	With Window Guidance													
Low share (10%)	8.87	6.77	1.69	8.36	1.52	7.48	1.63	1.77	43.61	38.34	180.13	16.17	9.08	10.05
High share (30%)	8.32	6.60	1.78	7.79	1.66	8.59	1.71	1.89	47.57	45.67	154.42	14.51	8.82	10.03
MORE AGGRESSIVE TAYLOR RULE ($\phi_\pi = 2.5$)														
	Without Window Guidance													
Low share (10%)	4.48	4.36	0.89	5.79	1.47	1.53	1.45	1.53	81.90	81.90	81.90	8.39	6.33	9.21
High share (30%)	4.41	4.31	0.89	5.80	1.47	1.52	1.45	1.52	81.50	81.50	81.50	8.34	6.28	9.21
	With Window Guidance													
Low share (10%)	6.44	4.72	0.71	7.92	1.04	5.60	1.08	1.13	19.54	29.99	160.62	12.89	7.20	9.87
High share (30%)	6.07	4.66	0.76	7.37	1.11	6.16	1.13	1.22	17.63	48.29	139.48	11.63	7.13	9.79

Conclusions

Key Findings

- Interest rate regulation dampens the business cycle.
- Deregulation is only beneficial if PBoC still relies on credit quotas.
- Window Guidance does not contradict monetary policy signals, but smooths interest rate dynamics.
- Effectiveness of window guidance not affected notably by share of bond finance.
- More aggressive monetary policy reduces inflation volatility at lower costs in terms of output and employment volatility, but with greater volatility of loans and deposits (and might be in conflict with exchange rate target).

References I

ADJEMIAN, S. AND M. JUILLARD (2011): "Accuracy of the Extended Path Simulation Method in a New Keynesian Model with a Zero Lower Bound on the Nominal Interest Rate," mimeo.

BERNANKE, B. S., M. GERTLER, AND S. GILCHRIST (1999): "The financial accelerator in a quantitative business cycle framework," in *Handbook of Macroeconomics*, ed. by J. B. Taylor and M. Woodford, Elsevier, vol. 1 of *Handbook of Macroeconomics*, chap. 21, 1341–1393.

CHEN, H., Q. CHEN, AND S. GERLACH (2011): "The Implementation of Monetary Policy in China," Working paper in the second annual international conference on the chinese economy, Hong Kong Institute for Monetary Research, mimeo.

CHEN, Q., M. FUNKE, AND M. PAETZ (2012): "Market and Non-Market Monetary Policy Tools in a Calibrated DSGE Model for Mainland China," BOFIT Discussion Papers 16/2012, Bank of Finland, Institute for Economies in Transition.

References II

GERALI, A., S. NERI, L. SESSA, AND F. M. SIGNORETTI (2010): "Credit and Banking in a DSGE Model of the Euro Area," *Journal of Money, Credit and Banking*, 42, 107–141.

HE, D. AND H. WANG (2012): "Dual-Track Interest Rates and the Conduct of Monetary Policy in China," *China Economic Review*, 23, 928–947.

HOLDEN, T. AND M. PAETZ (2012): "Efficient simulation of DSGE models with inequality constraints," School of Economics Discussion Papers 1612, School of Economics, University of Surrey.

IACOVIELLO, M. (2005): "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle," *American Economic Review*, 95, 739–764.

IMF (2012): "People's Republic of China 2012 Article IV Consultation," IMF Country Report, International Monetary Fund, Washington.

References III

KIYOTAKI, N. AND J. MOORE (1997): "Credit Cycles," *Journal of Political Economy*, 105, 211–48.