Reserve Requirements and Optimal Chinese Stabilization Policy[1]

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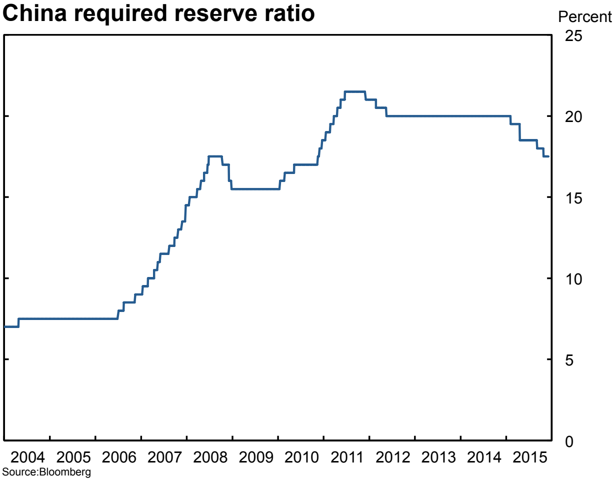
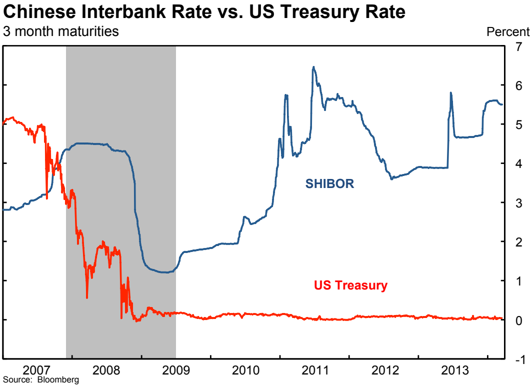
[1]The views expressed herein are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of San Francisco or the Federal Reserve System.

The PBOC frequently adjusts reserve requirements (RR)



- Since 2005, adjusted RR over 40 times
- Between 2006 and 2011, RR rose from 8.5% to 21.5%

Active RR adjustments when global interest rates declined



- Under capital controls, declines in US yields raised cost of sterilization for PBOC (e.g., Chang, Liu, and Speigel (2015))
- Raising RR a cheaper alternative to sterilization

RR increases encouraged shadow banking activity

- Shadow bank lending increased over 30% per year between 2009 and 2013
  - Shadow banking facilitates financial intermediation but increases financial risks [Gorton and Metrick (2010)]
- Tightened regulations on formal banking contributed to shadow bank expansion (Elliott, et al (2015); Hachem and Song (2016); Chen, Ren, and Zha (2016))
  - binding loan/deposit caps (small/medium banks)
  - Interest rate controls
  - Increases in RR
- Large-scale fiscal stimulus in 2008-09 fueled demand for shadow bank financing

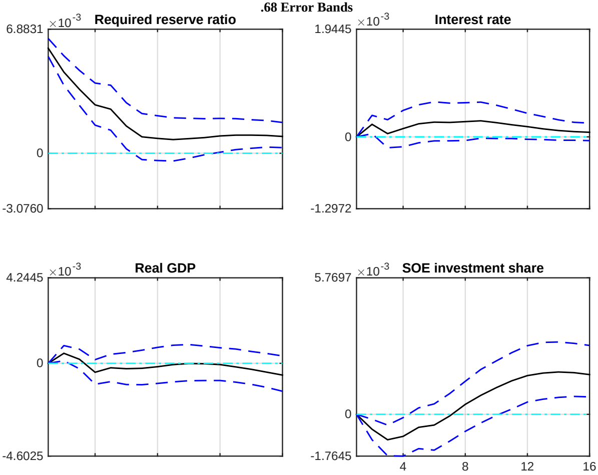
Impact of RR on financing costs affects resource allocations

- RR act as a tax on commercial banks
- Disproportionately affects state-owned enterprises (SOEs)
  - SOEs enjoy implicit government guarantees on loans
  - SOEs have superior access to bank loans despite low productivity
- Shadow banking not subject to RRs
  - Main source of financing for privately-owned enterprises (POEs) (Lu, et al. (2015))
- $\uparrow$ RRs reallocates resources from SOEs to POEs
  - Reduces SOE activity relative to POE
  - POEs have higher average productivity (Hsieh-Klenow, 2009)
  - Thus, raising RR increases aggregate TFP

Illustrative macro evidence of RR's reallocation effects

- Simple BVAR with RR, 3-mo deposit rate, log real GDP, SOE investment share
- Data 1995:Q1 to 2013:Q4; 4-qtr lags with Sims-Zha priors
- Ordering implies RR responds to all shocks in impact period
- Impulse responses: positive shock to RR reduces SOE investment share
- Results robust to RR being ordered last

BVAR: ↑ RR reallocates investment away from SOEs



Corroborating micro evidence of RR's reallocation effects

- Do RR increases reduce SOE stock returns relative to POE?
- Consider regression model:

$$\sum_{h=-H}^{H} R^{e}_{j,t+h} = a_0 + a_1 \Delta RR_{t-1} + a_2 SOE_{jt} \times \Delta RR_{t-1} + a_3 SOE_{jt} + bZ_{jt} + \varepsilon_{jt}$$

where $R^{e}_{j,t+h} = R_{j,t+h} - \hat{\beta}_j R_{m,t+h}$ denotes risk-adjusted excess return, ΔRR_{t-1} denotes changes in RR, and Z_{jt} is a vector of controls (size, book-to-market, industry fixed effects, year fixed effects)
- Focus on *relative* effects on SOEs ($a_2 < 0$?)
- Daily data for non-financial firms listed on Shanghai/Shenzhen stock exchanges, 2005-2015
- Identification: event study of RR announcement effects

RR announcements effects on stock returns

Event window	1-day (H=0)	3-day (H=1)	5-day (H=2)
RR_{t-1}	0.00206	0.00479	0.01057
	(7.20)	(9.21)	(15.74)
$\mathbf{SOE_{jt} \times RR_{t-1}}$	-0.0012	-0.00225	-0.00442
	(-3.21)	(-3.32)	(-5.05)
SOE_{jt}	-0.00007	-0.00026	-0.00041
	(-2.60)	(-5.29)	(-6.47)
$Size_{jt}$	-0.00034	-0.00099	-0.00155
	(-27)	(-43)	(-53)
BM_{jt}	0.00009	0.00024	0.00047
	(2.22)	(3.29)	(4.96)
Sample size	4,119,971	4,079,847	4,0003,53
R^2	0.00071	0.00182	0.00288

The RR announcements effects observed mainly after 2009, with rise of shadow banking following fiscal stimulus

	Pre-stimulus (2005-2008)		Post-stimulus (2009-2015)	
Event window	1-day (H=0)	3-day (H=1)	1-day (H=0)	3-day (H=1)
RR_{t-1}	0.0010	0.0003	0.0029	0.0081
	(2.00)	(0.31)	(8.08)	(12.57)
$\mathbf{SOE_{jt} \times RR_{t-1}}$	0.0001	0.0012	-0.0024	-0.0046
	(0.11)	(1.03)	(-4.78)	-5.03
SOE_{jt}	0.00002	0.0005	-0.0002	-0.0005
	(2.90)	(4.09)	(-4.85)	(-8.86)
$Size_{jt}$	-0.0003	-0.0008	-0.0004	-0.0011
	(-9)	(-14)	(-26)	(-41)
BM_{jt}	0.0000	0.0001	0.0001	0.0004
	(-0.25)	(-0.56)	(2.91)	(4.50)
Sample size	1,018,628	1,003,518	3,101,343	3,076,329
R^2	0.0005	0.0011	0.0008	0.0022

What we do

- Build a two-sector DSGE model with financial frictions and Chinese characteristics to study:

  1. implications of RR policy for allocation efficiency, aggregate productivity, and social welfare
  2. role of RR policy in stabilizing business cycle fluctuations
  3. optimal RR under simple policy rules and interactions with interest-rate policy

Main findings

- Raising RR improves aggregate productivity
  - Acts as tax on banking and SOE activity
  - Diverts resources to more productive POEs
- But raising RR also increases bailout costs
  - SOE funding costs rise
  - More incidence of SOE bankruptcies
- Tradeoff between efficiency and bailout costs → interior optimal RR
- RR rule and interest-rate rule complementary for stabilization
  - Interest-rate rule effective for stabilizing inflation and output
  - RR rule more effective for reallocating resources

Two sector DSGE model

- Representative household consumes, saves, and supplies labor
- Retail sector: use wholesale goods as inputs; monopolistic competition and sticky prices
- Wholesale goods a CES aggregate of intermediate goods produced by SOEs and POEs
  - POEs have higher average productivity (Hsieh-Klenow, 2009)
  - External financing for working capital subject to costly state verification —financial accelerator (BGG, 1999)
- Banks provide working capital to both firms
  - Loans to SOEs are subject to RR, but debt guaranteed by government (on-balance-sheet)
  - Loans to POEs exempt from RR, but no government guarantees (off-balance-sheet)

Representative household

- Utility function

$$U = \mathrm{E} \sum_{t=0}^{\infty} \beta_t \left[\ln(C_t) - \Psi \frac{H_t^{1+\eta}}{1+\eta} \right],$$

- Budget constraints

$$C_t + I_t + \frac{D_{st} + D_{pt}}{P_t} = w_t H_t + r_t^k K_{t-1} + R_{t-1} \frac{D_{s,t-1} + D_{p,t-1}}{P_t} + T_t$$

- Capital accumulation with adjustment costs (CEE 2005)

$$K_t = (1-\delta) K_{t-1} + \left[1 - \frac{\Omega_k}{2} \left(\frac{I_t}{I_{t-1}} - g_I \right)^2 \right] I_t,$$

Retail sector

- Final good CES composite of differentiated retail products

$$Y^f = \left[\int_0^1 Y_t(z)^{(\epsilon-1)/\epsilon} dz \right]^{\epsilon/(\epsilon-1)}$$

- Demand curve facing each retailer

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

- Monopolistic competition in retail markets, with quadratic price adjustment costs (Rotemberg, 1982)

$$\frac{\Omega_p}{2} \left(\frac{P_t(z)}{\pi P_{t-1}(z)} - 1 \right)^2 C_t$$

- Optimal price: markup over relative price of wholesale goods

Wholesale and intermediate goods

- Wholesale good a CES composite of SOE and POE products

$$M_t = \left(\phi Y_{st}^{\frac{\sigma m - 1}{\sigma m}} + (1-\phi) Y_{pt}^{\frac{\sigma m - 1}{\sigma m}} \right)^{\frac{\sigma m}{\sigma m - 1}}$$

- Intermediate good production function in sector $j \in \{s, p\}$

$$Y_{jt} = A_t \bar{A}_j \omega_{jt} K_{jt}^{1-\alpha} \left[(H_{jt}^e)^{1-\theta} H_{jt}^{\theta} \right]^{\alpha}$$

- where $\omega_{jt} \sim F_{jt}(\cdot)$ denotes idiosyncratic productivity shocks
- $\bar{A}_j =$ is scale of TFP, with $\bar{A}_s < \bar{A}_p$
- Aggregate TFP: $A_t = g^t A_t^m$, where A_t^m follows the process

$$\ln A_t^m = \rho_a \ln A_{t-1}^m + \epsilon_{at},$$

Financial frictions

- Firms finance working capital with net worth $N_{j,t-1}$ and external debt B_{jt} (BGG)
- Working capital constraint satisfies

$$\frac{N_{j,t-1} + B_{jt}}{P_t} = w_t H_{jt} + w^e_{jt} H^e_{jt} + r^k_t K_{jt}$$

  where w^e_{jt} is the real wage rate of managerial labor
- Constant returns implies that revenue linear in net worth

$$p_{jt} Y_{jt} = \tilde{A}_{jt} \omega_{jt} \frac{N_{j,t-1} + B_{jt}}{P_t}$$

  where $\tilde{A}_{jt}$ denotes rate of return on firm investment (in consumption units)

Defaults

- Firms default if realized productivity ω_{jt} sufficiently low:

$$\omega_{jt} < \bar{\omega}_{jt} \equiv \frac{Z_{jt} B_{jt}}{\tilde{A}_{jt}(N_{j,t-1} + B_{jt})}$$

  where $Z_{j,t}$ is contractual rate of interest
- If firm defaults, liquidated by lender with fraction m_{jt} lost output
- Government covers loan losses on SOE loans (but not POE loans) using lump sum taxes

Financial intermediaries

- Banks Take deposits from household at rate R_t
- "On balance sheet" loans to SOEs subject to RR
  - Modeled as simple tax on SOE lending
  - Government guarantees imply risk-free loan rate R_{st} for SOEs

$$(R_{st} - 1)(1 - \tau_t) = (R_t - 1).$$

  - RR drives wedge between loan and deposit rate
- "Off balance sheet" loans to POEs not subject to RR
  - Face funding cost $R_{pt} = R_t$
  - No government guarantees on POE debt $\Rightarrow$ default premium over funding cost (i.e., credit spread) on private loans

Financial contracts

- Optimal financial contract is a pair $(\bar{\omega}_{jt}, B_{jt})$ that solves

$$\max \tilde{A}_{jt}(N_{j,t-1} + B_{jt}) f(\overline{\omega}_{jt})$$

- subject to the lender's participation constraint

$$\tilde{A}_{jt}(N_{j,t-1} + B_{jt}) g(\overline{\omega}_{jt}) \geq R_{jt} B_{jt}$$

where B_{jt} denotes loan amount and $\bar{\omega}_{jt}$ is cutoff productivity for firm solvency

- Defaults socially costly:

$$f(\overline{\omega}_{jt}) + g(\overline{\omega}_{jt}) = 1 - m_{jt} \int_0^{\overline{\omega}_{jt}} \omega dF(\omega) + l_j \int_0^{\overline{\omega}_{jt}} [\overline{\omega}_{jt} - (1 - m_{jt})\omega] dF(\omega)$$

where $l_s = 1$ and $l_p = 0$ are guarantees on SOE and POE lending respectively

Monetary policy

- Two instruments for monetary policy: deposit rate and RR
- Benchmark policy regime: Taylor rule and constant RR

$$\begin{aligned} \ln\left(\frac{R_t}{R}\right) &= \psi_{rp} \ln\left(\frac{\pi_t}{\bar{\pi}}\right) + \psi_{ry} \ln\left(\frac{G\tilde{D}P_t}{G\tilde{D}P}\right) \\ \tau_t &= \bar{\tau} \end{aligned}$$

- Under Taylor rule, interest rate responds to fluctuations in inflation and output gap

Market clearing and equilibrium

- Final goods marke clearing

$$
\begin{aligned}
Y_t^f &= C_t + I_t + G_t + \frac{\Omega_p}{2}(\frac{\pi_t}{\pi} - 1)^2 C_t \\
&+ \sum_{j \in \{s,p\}} \tilde{A}_{jt} \frac{N_{j,t-1} + B_{jt}}{P_t} m_t \int_0^{\overline{\omega}_{jt}} \omega dF(\omega)
\end{aligned}
$$

- Intermediate goods market clearing

$$
M_t = \left(\phi Y_{st}^{\frac{\sigma_m - 1}{\sigma_m}} + (1 - \phi) Y_{pt}^{\frac{\sigma_m - 1}{\sigma_m}} \right)^{\frac{\sigma_m}{\sigma_m - 1}}
$$

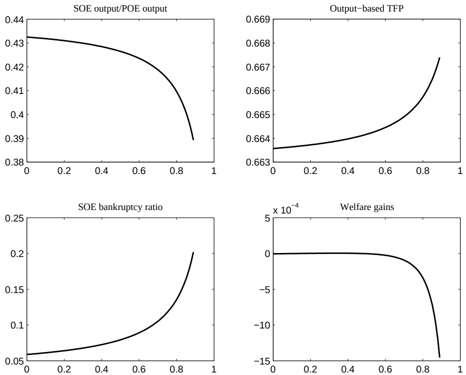
- Capital and labor market clearing

$$
K_{t-1} = K_{st} + K_{pt}, \quad H_t = H_{st} + H_{pt}, \quad H_{pt}^e = H_{st}^e = 1
$$

- Credit market clearing

$$
B_{st} = (1 - \tau_t) D_{st}, \quad B_{pt} = D_{pt}
$$

Steady state impact of RR increase



- Reallocation from SOE to POE improves TFP
- Higher funding costs increase SOE bankruptcies
- Tradeoff $\Rightarrow$ interior optimum $\tau^* = 0.34$ under our calibration

Monetary policy rules for stabilization

- Two instruments for monetary policy: deposit rate and RR
  - Consider two types of simple (Taylor-like) policy rules
  - Interest rate rule

$$\ln\left(\frac{R_t}{R}\right) = \psi_{rp} \ln\left(\frac{\pi_t}{\bar{\pi}}\right) + \psi_{ry} \ln\left(\frac{\tilde{GDP}_t}{\tilde{GDP}}\right)$$

  - Reserve requirement rule

$$\ln\left(\frac{\tau_t}{\tau}\right) = \psi_{\tau p} \ln\left(\frac{\pi_t}{\bar{\pi}}\right) + \psi_{\tau x} \ln\left(\frac{\tilde{GDP}_t}{\tilde{GDP}}\right)$$

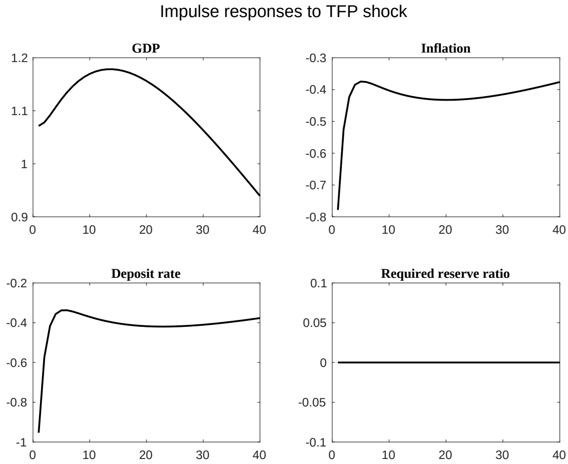
Compare macro stability and welfare under 4 policy rules

- Benchmark policy: Taylor rule with $\psi_{rp} = 1.5$ and $\psi_{ry} = 0.2$ and constant $\tau = 0.15$
- Optimal interest-rate rule: ψ_{rp} and ψ_{ry} set optimally to max welfare, and τ kept constant
- Optimal reserve-requirement rule: $\psi_{\tau p}$ and $\psi_{\tau y}$ set optimally, Taylor rule coefficients kept at benchmark values
- Jointly optimal rule: Coefficients for both interest rates and reserve requirements set optimally

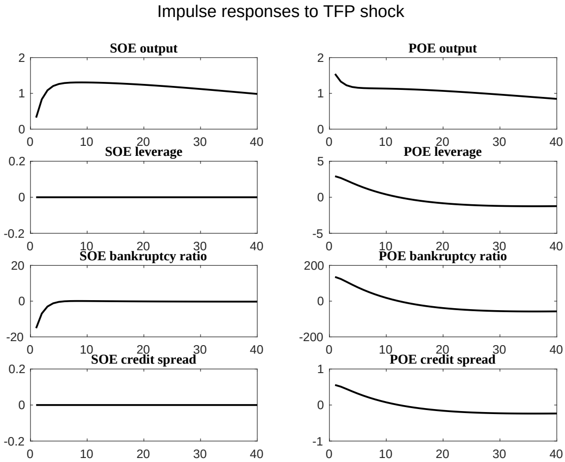
The financial accelerator mechanism

- Financial accelerator: recession → default prob rises → monitoring cost and credit spread increase → firm funding costs rise → more default and even higher credit spread ...
- Financial accelerator muted for SOEs but operative for POEs
  - SOE debt guaranteed by gov't ⇒ no default premium
  - POE debt not guaranteed ⇒ financial accelerator operative ⇒ POE firms more sensitive to macro shocks
- Default premium always countercyclical, but credit spread can be pro- or countercyclical, depending on strength of credit demand (Carstrom-Fuerst, 1997; Faia-Monacelli, 2007)
- Overall macro stability can be enhanced by using RR and interest-rate instruments

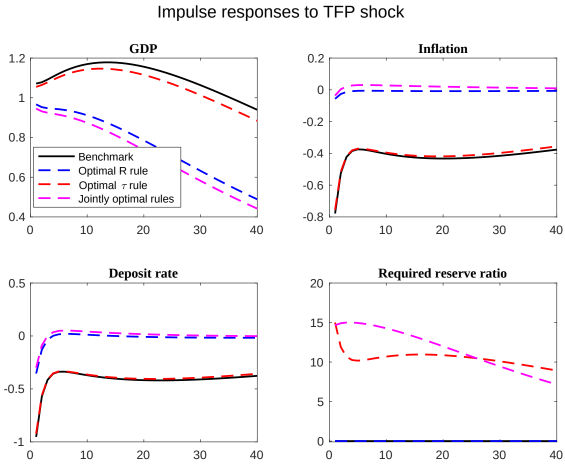
Aggregate Responses to TFP Shock: Benchmark



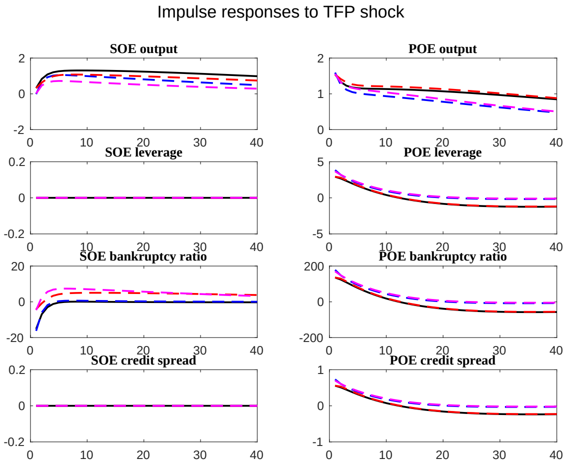
Sectoral responses to TFP shock: Benchmark



Aggregate Responses to TFP Shock: Benchmark vs alternative policies



Sectoral responses to TFP shock: Benchmark vs alternative policies



Macro stability and welfare under alternative rules

Variables	Benchmark	Optimal τ rule	Optimal R rule	Jointly optimal rule
		Policy rule coefficients		
ψ_{rp}	1.50	1.50	7.42	5.18
ψ_{ry}	0.20	0.20	0.07	-0.12
$\psi_{\tau p}$	0.00	-13.14	0.00	11.67
$\psi_{\tau y}$	0.00	4.81	0.00	15.96
		Volatility		
GDP	8.618%	8.155%	5.279%	4.952%
π	3.409%	3.231%	0.084%	0.136%
C	6.118%	5.950%	4.388%	4.306%
H	2.103%	1.835%	0.599%	0.416%
R	3.412%	3.236%	0.398%	0.349%
Y_s	9.091%	6.999%	5.362%	3.415%
Y_p	8.132%	8.455%	5.552%	5.982%
		Welfare		
Welfare gains	—	0.2423%	1.1799%	1.1801%

Jointly optimal rule allows for complementary use of policy tools

- Adjust R-rule to stabilize inflation and GDP
- Adjust τ-rule to achieve desired reallocation of resources across sectors
- Leads to higher welfare gains than each individually optimal rule $\Rightarrow$ the two policy instruments are complementary

Conclusion

- Examine RR policy in DSGE model with BGG financial accelerator and Chinese characteristics
- Changes in RR incur tradeoff between allocation efficiency and SOE bailout costs
- RR and interest rates are complementary policy instruments
  - Interest rate effective for macro stabilization
  - RR more useful for improving allocation efficiency and welfare
- Caveats:
  - Results are "second-best"
  - Open-economy features not in model: RR policy may stem from sterilized intervention in FX market

Parameter calibration I

Variable	Description	Value
	A. Households	
β	Subjective discount factor	0.995
η	Inverse Frisch elasticity of labor supply	2
Ψ	Weight of disutility of working	18
δ	Capital depreciation rate	0.035
Ω_k	Capital adjustment cost	1
	B. Retailers	
ϵ	Elasticity of substitution between retail products	10
Ω_p	Price adjustment cost parameter	22
	C. Firms	
g	Steady state growth rate	1.0125
k	Shape parameter in Pareto distribution of idiosyncratic shocks	1.587
ω_m	Scale parameter in Pareto distribution of idiosyncratic shocks	0.37
A_s	SOE TFP scale (normalized)	1
A_p	POE TFP scale	1.42
α	Capital income share	0.5
θ	Share of household labor	0.94
ψ	Share parameter for SOE output in intermediate good	0.45
σ_m	Elasticity of substitution between SOE and POE products	3
	C. Financial intermediaries	
m_s	SOE monitoring cost	0.15
m_p	POE monitoring cost	0.15
ξ_s	SOE manager's survival rate	0.97
ξ_p	POE manager's survival rate	0.69

Parameter calibration II

Variable	Description	Value
	C. Financial intermediaries	
m_s	SOE monitoring cost	0.15
m_p	POE monitoring cost	0.15
ξ_s	SOE manager's survival rate	0.97
ξ_p	POE manager's survival rate	0.69
	D. Government policy	
π	Steady state inflation rate	1.005
τ	Required reserve ratio	0.15
ψ_{rp}	Taylor rule coefficient for inflation	1.5
ψ_{ry}	Taylor rule coefficient for output	0.2
$\frac{G}{GDP}$	Share of government spending in GDP	0.14
l_s	Fraction of SOE debt guaranteed by the government	1
l_p	Fraction of SOE debt guaranteed by the government	0
	E. Shock process	
ρ_a	Persistence of TFP shock	0.95
σ_a	Standard deviation of TFP shock	0.01