REQUIRED RESERVES AS A CREDIT POLICY TOOL

(*joint with Enes Sunel and Temel Taşkın*)

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April 26, 2013

2^{nd} NBRM Conference on Policy Nexus and the Global Environment: A New Consensus Emerging from the Crisis?

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INTRODUCTION

Macroprudential Policies and Financial Stability

- Required reserves ratios (RRR) have been used as a macroprudential policy tool in a number of emerging economies (e.g. Brazil, China, Colombia, Peru, and Turkey).
- In particular, they use reserve requirements to curb excessive credit growth in boom episodes and to ease financial constraints in bad times.
- The main aim is to reduce the procyclicality of financial sector.

Motivating Questions

- How do time-varying macroprudential RRR policies affect
  - Real and financial cycles of an economy in response to adverse macroeconomic and financial shocks.
- Impact of alternative RRR policies on volatilities and cyclicality of financial system.
- Optimal intensity of alternative RRR policies.
- Effectiveness of RRR policies in different economic structures (ex. highly leveraged financial system).

Building Blocks

- Quantitative monetary DSGE model with banks
  - Households face cash-in-advance (CIA) constraints.
  - Agency problem between households and banks as in G&K (2011).
  - Banks are subject to time-varying RRR that countercyclically responds to expected credit growth.
  - Simulate the economy in the face of productivity and financial shocks under two different RRR policy regimes: time-varying and fixed.
  - Investigate the effectiveness of alternative time-varying RRR policies that respond to expected asset price growth and output growth.
  - Conduct welfare analysis of alternative time-varying RRR policies compared to fixed RRR policy through loss function approach.

Main Results

- Time-varying RRR rule countervails the negative effects of F.A. mechanism triggered by adverse macroeconomic and financial shocks.
- Counter-cyclical RRR rule reduces volatilities of key real and financial variables in response to macro shocks.
- Time-varying RRR policy reduces the intertemporal distortions created by the credit spread at the expense of higher inflation volatility.
- The effect of time-varying RRR policy is bigger in high risk economy where loan-deposit spread is higher and the leverage of the banking sector is lower.

Related Literature

- Banking $\longmapsto$ Gertler and Karadi (2011), Mimir (2011).
- Required reserves $\longmapsto$ Glocker and Towbin (2011), Montoro (2011).
- Countercyclical time-varying macro-prudential policy $\longmapsto$ Angeloni and Faia (2009), Christensen et al. (2011).
- Contribution
  - Explore the role of RRR policy in response to financial shocks.
  - Focus on the composition of the assets side of the balance sheet rather than size of the balance sheet.
  - Impact of alternative types of RRR rules on volatilities and cyclicality of financial sector.

THE MODEL

Framework

- Households — Household's Problem
  - Workers supply labor, h_t and return their wage incomes, $w_t h_t$ to H.H.
  - Households face cash-in-advance (CIA) constraints.
  - Each banker manages an intermediary and transfers earnings back.
  - H.H. owns intermediaries that its bankers manage.

- Financial Intermediaries — Bank's Problem
  - Collect deposits, b_{t+1} from households, combine it with their own net worth, n_t and purchase firms' shares, $q_t s_t$.
  - They are subject to financial shocks, ω_t (shocks to bank net worth).
  - Agency problem between households and banks, leading to endogenous capital constraints for banks in obtaining funds from households.
  - Banks are subject to time-varying RRR, rr_t, that counter-cyclically responds to expected credit growth.

- Non-financial Firms — Firm's Problem
  - finance capital acquisition, K_{t+1} each period via issuing equities, s_t and selling them to banks at the price of capital, q_t.

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Government

- Money supply is assumed to grow at a constant rate $\overline{\mu}$

$$M_{0t+1} = exp(\overline{\mu}) M_{0t}$$

- Required reserves ratio follows a time-varying rule in response to deviations of expected future credit growth.

$$rr_t = \bar{rr} + \phi E_t \Big[\log(q_{t+1} s_{t+1}) - \log(q_t s_t) \Big]$$

where $\phi > 0 \Rightarrow$ relax financial markets when credit is shrinking

- The money market equilibrium necessitates

$$M_{0t+1} = M_{t+1} + P_t rr_t b_{t+1}$$

- Increases in the monetary base are rebated to households through lump-sum transfers

$$T_t = M_{0t+1} - M_{0t}$$

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Shock Processes

- Productivity shocks

$$z_{t+1} = \rho_z z_t + \epsilon^z_{t+1} \qquad \epsilon^z_{t+1} \sim N(0, \sigma_z)$$

- Financial shocks

$$\omega_{t+1} = \rho_\omega \omega_t + \epsilon^\omega_{t+1} \qquad \epsilon^\omega_{t+1} \sim N(0, \sigma_\omega)$$

QUANTITATIVE ANALYSIS

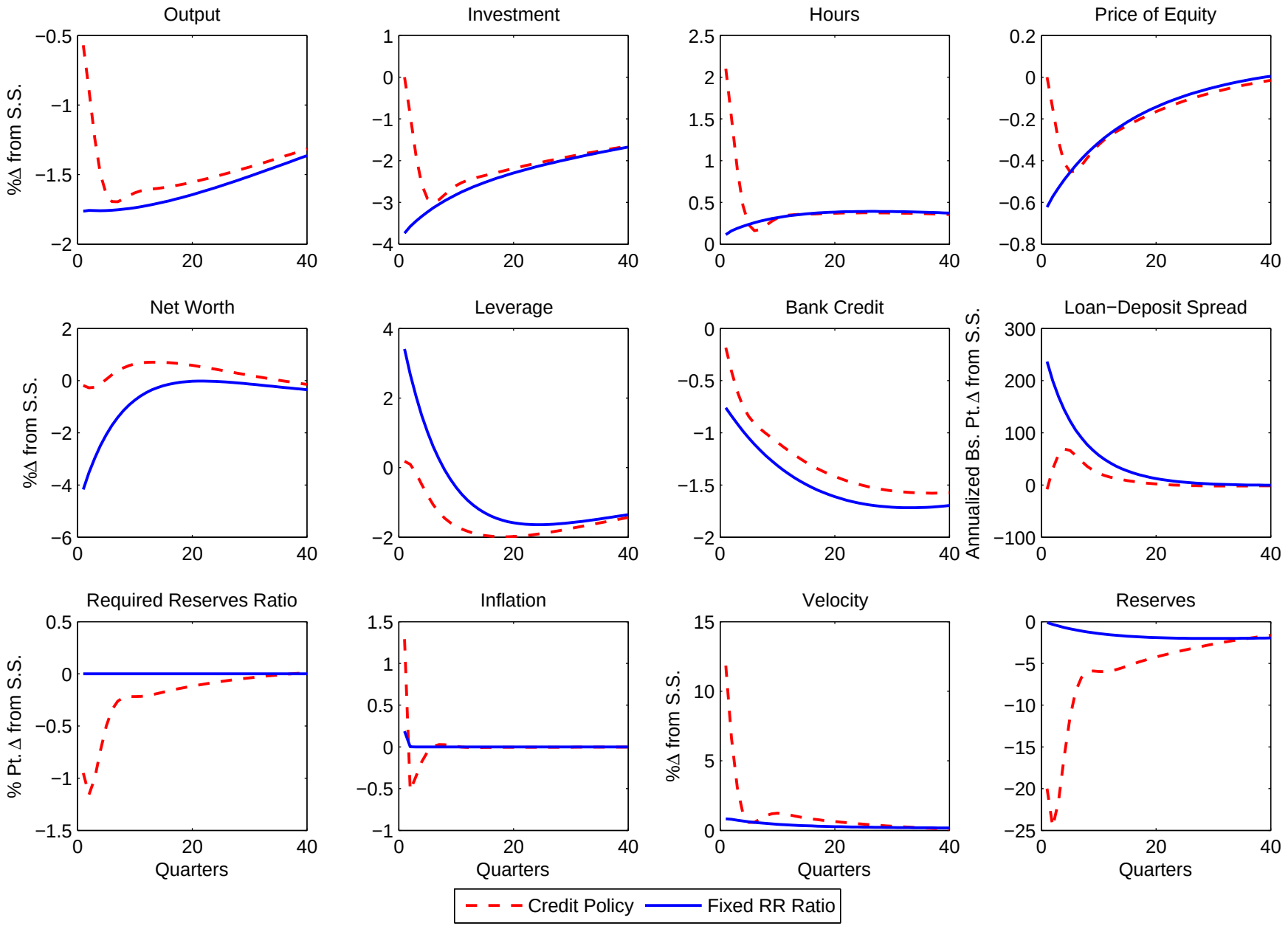
Model Parameterization and Calibration

Description	Value	Target
Preferences		
Quarterly discount factor (β)	0.9885	Annualized real deposit rate (4.73%)
Relative risk aversion (γ)	2	Angeloni and Faia (2009)
Inverse of the Frisch elasticity (ν)	3	Glocker and Towbin (2012)
Relative utility weight of leisure (ψ)	46.16	Hours worked (0.33)
Production Technology		
Share of capital in output (α)	0.4	Labor share of output (0.64)
Capital adjustment cost parameter (φ)	6.76	Elasticity of price of capital w.r.t. investment-capital ratio of 0.25
Depreciation rate of capital (δ)	0.037	Average annual ratio of investment to capital (14.8%)
Government		
Steady-state value of RRR ($\bar{rr}$)	0.05	Pre-macroprudential policy period
Adjustment parameter in the RRR rule (ϕ)	3.28	Standard deviation of RRR for 2010:Q4-2012:Q2 (2.33%)
Growth rate of monetary base (μ)	0.0446	Time series average for 2006:Q1-2011:Q4
Financial Intermediaries		
Fraction of diverted loans (λ)	0.514	Annual commercial & industrial loan spread (1.96%)
Prop. transfer to the entering bankers (ϵ)	0.0005	1.33% of aggregate net worth
Survival probability of the bankers (θ)	0.9625	Capital adequacy ratio of 16% for commercial banks
Shock Processes		
Persistence of TFP process (ρ_z)	0.9821	Estimated persistence from detrended log $TFP_t = \rho_z \log TFP_{t-1} + \epsilon_{zt}$
Std. deviation of productivity shocks (σ_z)	0.0183	Estimated standard deviation from detrended log $TFP_t = \rho_z \log TFP_{t-1} + \epsilon_{zt}$
Std. deviation of financial shocks (σ_ω)	0.0531	Relative volatility of bank capital w.r.t. output for 2003:Q1-2011:Q4 (1.24)

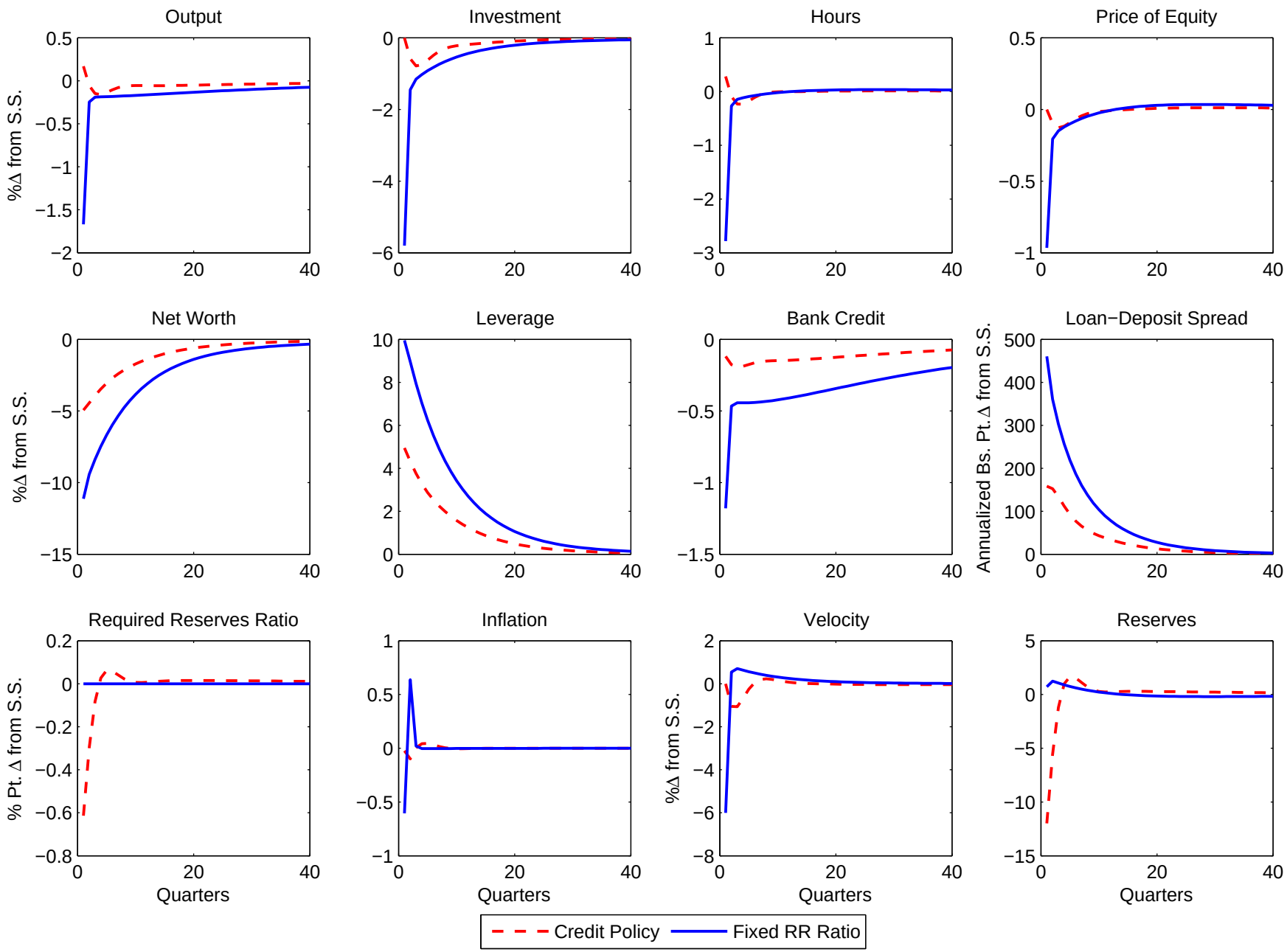
Contribution of Financial Shocks to Business Cycles

Variable	TFP Shocks	Financial Shocks
Real Variables		
Output	78.32	21.68
Consumption	94.38	5.62
Investment	53.13	46.87
Hours	1.11	98.89
Financial Variables		
Credit	56.20	43.80
Deposits	22.80	77.20
Net worth	18.19	81.81
Leverage	15.89	84.11
Credit spread	32.47	67.53
Asset prices	52.84	47.16
Monetary Variables		
Inflation	3.92	96.08

Adverse TFP Shocks



Adverse Financial Shocks



Impact of Credit Policy on Volatilities and Procyclicality

Variable	Fixed Reserves $\phi = 0$ $\sigma_{rr} = 0$	Moderate $\phi = 1.45$ $\sigma_{rr} = 1.17\%$	Benchmark $\phi = 3.28$ $\sigma_{rr} = 2.33\%$	Aggressive $\phi = 4.79$ $\sigma_{rr} = 3.50\%$
Volatilities				
Real Variables				
Output	2.51	1.92	1.70	1.60
Consumption	1.38	1.36	1.27	1.23
Investment	6.15	3.83	3.36	3.14
Hours	2.13	2.23	2.32	2.38
Financial Variables				
Credit	1.81	1.15	1.03	0.97
Deposits	1.88	1.36	1.65	1.94
Net worth	17.19	6.91	6.96	6.98
Leverage	15.71	6.56	6.67	6.73
Credit spread	0.58	0.29	0.27	0.26
Asset prices	1.56	0.97	0.85	0.79
Monetary Variables				
Inflation	0.20	0.24	0.30	0.35
Cyclicality of Financial System				
$\rho(\Delta_{spread}, \Delta_{GDP})^c$	-0.86	-0.08	-0.02	0.04
$\rho(\Delta_{credit}, \Delta_{GDP})^c$	0.96	0.67	0.79	0.80

Impact of Alternative Policy Rules on Volatilities and Procyclicality

Variable	No Reserves $\bar{rr} = 0$ $\phi = 0$	Fixed Reserves $\bar{rr} = 0.05$ $\phi = 0$	Credit Policy $\bar{rr} = 0.05$ $\phi = 3.28$	Output Policy $\bar{rr} = 0.05$ $\phi = 1.84$	Asset Prices Policy $\bar{rr} = 0.05$ $\phi = 4.98$
Volatilities					
Real Variables					
Output	2.65	2.51	1.70	1.93	1.64
Consumption	1.39	1.38	1.27	1.28	1.22
Investment	6.66	6.15	3.36	4.63	3.28
Hours	2.58	2.13	2.32	3.42	2.42
Financial Variables					
Credit	1.95	1.81	1.03	1.36	1.02
Deposits	1.99	1.88	1.65	1.93	1.70
Net worth	18.39	17.19	6.96	8.26	7.03
Leverage	16.78	15.71	6.67	7.71	6.75
Credit spread	0.68	0.58	0.27	0.33	0.27
Asset prices	1.69	1.56	0.85	1.17	0.83
Monetary Variables					
Inflation	0.23	0.20	0.30	0.39	0.32
Cyclicality of Financial System					
$\rho(\Delta_{spread}, \Delta_{GDP})$	-0.85	-0.86	-0.02	-0.39	0.03
$\rho(\Delta_{credit}, \Delta_{GDP})$	0.97	0.96	0.79	0.83	0.70

More Severe Financial Frictions

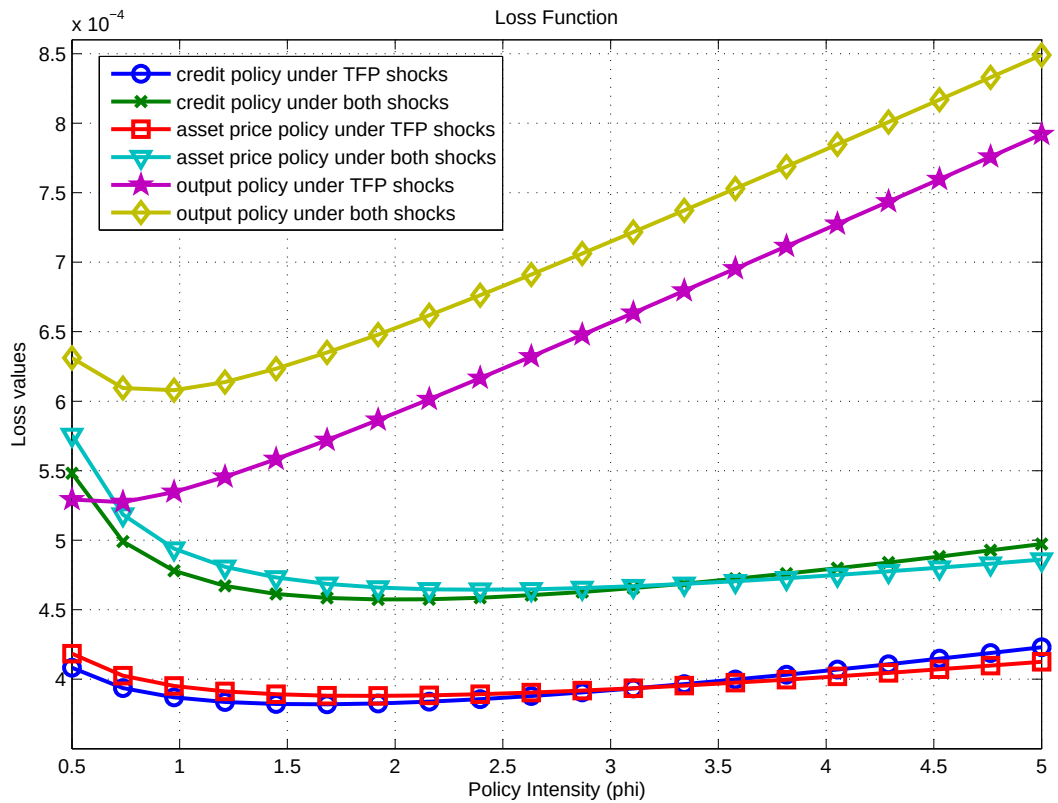
Variable	Fixed Reserves $\lambda = 0.25$ ($\bar{\kappa} = 12.85$) ($\overline{R_k - R} = 27$ bs. pt.)	Credit Policy $\lambda = 0.25$ $\phi = 3.73$	Fixed Reserves $\lambda = 0.75$ ($\bar{\kappa} = 4.28$) ($\overline{R_k - R} = 67$ bs. pt.)	Credit Policy $\lambda = 0.75$ $\phi = 2.82$
Volatilities				
Real Variables				
Output	2.25	1.61	2.79	1.81
Consumption	1.37	1.29	1.43	1.28
Investment	4.78	2.87	7.39	3.86
Hours	1.11	2.28	2.96	2.37
Financial Variables				
Credit	1.42	0.88	2.15	1.17
Deposits	1.04	1.50	2.90	1.97
Net worth	20.91	6.49	15.90	7.19
Leverage	19.78	6.46	14.18	6.73
Credit spread	1.06	0.36	0.42	0.23
Asset prices	1.21	0.72	1.87	0.97
Monetary Variables				
Inflation	0.11	0.32	0.28	0.29
Cyclicality of Financial System				
$\rho(\Delta_{spread}, \Delta_{GDP})$	-0.88	-0.02	-0.86	-0.01
$\rho(\Delta_{credit}, \Delta_{GDP})$	0.96	0.86	0.97	0.68

More Volatile Asset Prices

Variable	Fixed Reserves $\varphi = 0.5$ ($\bar{\kappa} = 6.25$) ($\overline{R_k - R} = 48$ bs. pt.)	Credit Policy $\varphi = 0.5$ $\phi = 4.13$	Fixed Reserves $\varphi = 13.75$ ($\bar{\kappa} = 6.25$) ($\overline{R_k - R} = 48$ bs. pt.)	Credit Policy $\varphi = 13.75$ $\phi = 2.7$
Volatilities				
Real Variables				
Output	2.64	2.08	2.42	1.60
Consumption	1.16	1.12	1.58	1.40
Investment	7.43	5.36	5.20	2.52
Hours	2.28	2.19	2.03	2.35
Financial Variables				
Credit	0.84	0.69	2.79	1.36
Deposits	1.37	1.29	2.25	1.86
Net worth	8.34	6.63	24.16	7.13
Leverage	7.94	6.54	21.72	6.68
Credit spread	0.31	0.30	0.78	0.27
Asset prices	0.14	0.10	2.63	1.27
Monetary Variables				
Inflation	0.22	0.25	0.19	0.31
Cyclicality of Financial System				
$\rho(\Delta_{spread}, \Delta_{GDP})$	-0.85	0.03	-0.87	0.03
$\rho(\Delta_{credit}, \Delta_{GDP})$	0.61	0.46	0.97	0.81

Welfare Evaluation: Loss Function Approach

	Fixed Reserves Policy	Credit Policy	Output Policy	Asset Prices Policy
	$\bar{rr} = 0.05$	$\bar{rr} = 0.05$	$\bar{rr} = 0.05$	$\bar{rr} = 0.05$
Loss values	$\phi = 0$	$\phi = 3.28$	$\phi = 1.84$	$\phi = 4.98$
Under only TFP shocks	4.3613e-04	3.9560e-04	5.8147e-04	4.1233e-04
Under both shocks	6.4556e-04	4.6789e-04	4.8579e-04	6.4341e-04



Conclusion

- RRR policies that are meant to stabilize credit growth work as a macro-prudential tool under the existence of TFP and financial shocks.
- However, reduced volatilities of real and financial variables come at the expense of higher inflation volatility.
- For further work, small open economy features and optimal monetary policy considerations shall be introduced in order to reconcile the analysis more with the experience of emerging economies.

THANK YOU

Workers

$$\max_{c_t, l_t, b_{t+1}, M_{t+1}} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t)$$

$$\text{s.t.} \qquad c_t + b_{t+1} + \frac{M_{t+1}}{P_t} = w_t(1 - l_t) + R_t b_t + \frac{M_t}{P_t} + \frac{\Pi_t}{P_t} + \frac{T_t}{P_t}$$

$$\text{and} \qquad c_t \leq \frac{M_t}{P_t} + \frac{T_t}{P_t} + R_t b_t - b_{t+1}$$

$$\Rightarrow \qquad u_c(t) = \beta E_t \Big\{ R_{t+1} u_c(t+1) \Big\}$$

$$\frac{u_l(t)}{P_t w_t} = \beta E_t \left\{ \frac{u_c(t+1)}{P_{t+1}} \right\}$$

Back

Bankers

- Banker j collects deposits from worker $i \neq j$, lend to a large number of identical firms, and hold required "reserves"

$$q_t s_{jt} = (1 - rr_t) b_{jt+1} + n_{jt}$$

-
- Net worth accumulation into the next period,

$$n_{jt+1} = R_{kt+1} q_t s_{jt} - R_{t+1} b_{jt+1} + rr_t b_{jt+1} \quad \Rightarrow$$

$$n_{jt+1} = \underbrace{\left[R_{kt+1} - \left(\frac{R_{t+1} - rr_t}{1 - rr_t} \right) \right]}_{ESP_{t+1}} q_t s_{jt} + \underbrace{\left(\frac{R_{t+1} - rr_t}{1 - rr_t} \right)}_{RR_{t+1}} n_{jt}$$

- Required reserves make net worth financing more preferable

$$\frac{dESP_{t+1}}{drr_t} < 0 \quad \text{and} \quad \frac{dRR_{t+1}}{drr_t} > 0$$

- Banks operate only if $E_t \left\{ \beta^{1+i} \Lambda_{t,t+1+i} ESP_{t+1+i} \right\} \geq 0 \; \forall i$

Back

Bankers cont'd

- Bankers maximize the terminal value of their net worth

$$V_{jt} = \max_{s_{jt}} E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \beta^{1+i} \Lambda_{t,t+1+i} n_{jt+1+i}$$

- s.t. an agency problem: After borrowing from households, bankers can divert λ fraction of their total assets.

- Incentive compatibility:

$$V_{jt} \geq \lambda q_t s_{jt}$$

Bankers cont'd

-

Bankers cont'd

V_{jt} can be written as follows:

$$V_{jt} = \nu_t q_t s_{jt} + \eta_t n_{jt}$$

where

$$\nu_t = E_t\Big\{(1-\theta)\beta\Lambda_{t,t+1}ESP_{t+1} + \beta\Lambda_{t,t+1}\theta xx_{t,t+1}\nu_{t+1}\Big\}$$

$$\eta_t = E_t\Big\{(1-\theta)\beta\Lambda_{t,t+1}RR_{t+1} + \beta\Lambda_{t,t+1}\theta zz_{t,t+1}\eta_{t+1}\Big\}$$

with $xx_{t,t+1} = q_{t+1}s_{jt+1}/q_t s_{jt}$ and $zz_{t,t+1} = n_{jt+1}/n_{jt} \quad \forall j$

Bankers cont'd

- V_{jt} can be written as follows:

$$V_{jt} = \nu_t q_t s_{jt} + \eta_t n_{jt} \geq \lambda q_t s_{jt}$$

- When it binds:

$$q_t s_{jt} = \frac{\eta_t}{\lambda - \nu_t} n_{jt} = \kappa_t n_{jt}$$

- Financial intermediaries may fund non-financial firms only up to an "endogenous multiple" of their net worth

- We aggregate over j and get: $q_t s_t = \kappa_t n_t$

Net Worth Evolution

- $n_{t+1} = n_{et+1} + n_{nt+1}$
- $\theta \rightarrow$ survival probability of bankers.

$$n_{et+1} = \theta \Big[ESP_{t+1} \kappa_t + RR_{t+1} \Big] n_t$$

- $\frac{\epsilon}{(1-\theta)} \rightarrow$ fraction of exiting bankers' net worth that is transferred to new entrants as start-up funds
- $\Rightarrow n_{nt+1} = (1-\theta) \frac{\epsilon}{(1-\theta)} n_t = \epsilon n_t$
- Law of Motion for Aggregate Net Worth

$$n_{t+1} = \Big\{ \theta \Big[ESP_{t+1} \kappa_t + RR_{t+1} \Big] + \epsilon \Big\} n_t$$

Firms

- Finance capital acquisition each period via issuing equity claims which are purchased by financial intermediaries

$$q_t s_t = q_t K_{t+1}$$

- Produce with a CRS technology by using capital and labor

$$exp(z_t)F(K_t, H_t)$$

- Labor demand satisfies

$$w_t = exp(z_t)F_H(K_t, H_t)$$

- Zero profit condition leads to following condition of return on capital:

$$R_{kt} = \frac{exp(z_t)F_K(K_t, H_t) + q_t(1-\delta)}{q_{t-1}}$$

Back

Competitive Equilibrium

- Nominal monetary base and prices grow constantly in this model, which renders the equations listed above non-stationary. Therefore, following Cooley and Hansen (1989), we make the model stationary by applying the following normalizations: $\widehat{P_t} = P_t/M_{0t+1}$ and $\hat{m}_t = M_{t+1}/(\widehat{P_t} M_{0t+1})$ and solve the model locally around a deterministic steady state.

- A competitive equilibrium of this model economy is defined by sequences of allocations $\{c_t, k_{t+1}, i_t, l_t, h_t, s_t, n_t, n_{et}, n_{nt}, b_{t+1}, \Lambda_{t,t+1}, \nu_t, \eta_t, \kappa_t, \rho_{t,t+1}, \chi_{t,t+1}, \hat{m}_{t+1}, \pi_t\}_{t=0}^{\infty}$, prices $\{q_t, R_{kt+1}, R_{t+1}, w_t, \widehat{P_t}\}_{t=0}^{\infty}$, shock processes $\{z_t, \mu_t\}_{t=0}^{\infty}$ and the government policy $\{rr_t\}_{t=0}^{\infty}$ such that

  (i) allocations solve household's, financial intermediary's, firm's, and capital producer's problems at the equilibrium prices.

  (ii) markets for factor inputs clear.

  (iii) aggregate resource constraint is satisfied.

Back