External Shocks, Banks and Monetary Policy in an Open Economy

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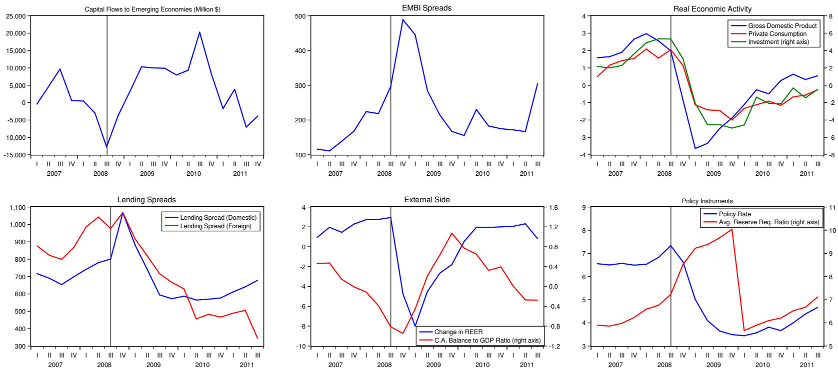
The ideas in this talk are solely authors' and do not reflect the official views or the policies of the Central Bank of the Republic of Turkey.

Macroeconomic dynamics in EMEs around 2007-09 crisis



- Cross-country means of 20 EMEs.
- Sources: BIS, Bloomberg, EPFR, IFS, country central banks.

Research Questions

- What are the macroeconomic and financial effects (transmission channels) of external shocks on EMEs?
- We consider four types of external shocks observed:
  - Country risk premium $\Rightarrow$ Lehman Brothers (September 2008), Taper tantrum (May 2013)
  - US interest rate $\Rightarrow$ FED's policy normalization (expected late(?) 2015)
  - Policy uncertainty $\Rightarrow$ Magnitude of FED's interest rate hike
  - Export demand $\Rightarrow$ Exogenous disturbance in the income of the rest of the world
- Should monetary policy respond to financial variables over and above their effect on inflation in an open economy?

Theoretical Framework

- A New Keynesian small open economy with banking.
- Workers consume, supply labor and save in domestic currency deposits.
- Bankers collect domestic and foreign funds, and lend to production firms.
  - Financial frictions *à la* Gertler and Kiyotaki (2011) between bankers and depositors $\Rightarrow$ countercyclical lending spreads.
  - Frictions are asymmetrically more intense on foreign investors $\Rightarrow$ differentiation in domestic/foreign lending spreads.
- Costly price adjustment framework *à la* Rotemberg (1982).
  - Imperfect exchange rate pass through due to sticky import prices.

Methodology

- Quantitatively investigate how alternative Taylor type monetary policy rules might perform in terms of
  - Macroeconomic stability $\Rightarrow$ inflation and output
  - Domestic financial stability $\Rightarrow$ inflation and credit growth
  - External financial stability $\Rightarrow$ inflation and RER depreciation.
- Construct optimized monetary policy rules based on alternative policy mandates using loss function approach.
- Impulse-response experiments that intend to reflect on the impact of "Taper tantrum" and "(uncertain) policy normalization" shocks.

Main Findings

Literature Review

- Risk premium shocks have more explanatory power than TFP, world interest, and export demand shocks for most macro aggregates.
- Negative external shocks trigger an adverse feedback loop of real depreciation, capital flow reversal, tightening in credit conditions and reduced real economic activity, alongside inflation.
- The credit-augmented IT rule outperforms classical and RER augmented IT rules in minimizing losses that depend on price, output and/or credit growth (or real exchange rate) stability.
    - monetary policy can lean against the wind to reduce the procyclicality in the financial system.
- Augmenting a strict IT rule with a RER stabilization objective does not contribute to macroeconomic stabilization.

Bankers

- Banker j borrows from worker $i \neq j$ and foreigners to finance loans.

$$Q_t l_{jt} = (1 - rr_t)B_{jt+1} + (1 - rr_t)S_t B^*_{jt+1} + N_{jt},$$

- For $\hat{R}_{t+1} = \frac{R_{t+1} - rr_t}{1 - rr_t}$; net worth evolution

$$n_{jt+1} = \left[R_{kt+1} - \hat{R}_{t+1}\right] q_t l_{jt} + \left[R_{t+1} - R^*_{t+1}\right] b^*_{jt+1} + \hat{R}_{t+1} n_{jt}$$

- For $\Psi_t = F(\frac{b^*_{t+1}}{y_t})\psi_t,\ F'(.) > 0$;

$$R_t = E_t \left\{(1 + r_{nt})\frac{P_t}{P_{t+1}}\right\} \qquad R^*_t = E_t \left\{\Psi_t(1 + r^*_{nt})\frac{S_{t+1}}{S_t}\frac{P_t}{P_{t+1}}\right\}$$

- External shocks are assumed to follow AR(1) processes:

Country risk premium: $\ln(\psi_{t+1}) = \rho^{\psi} \ln(\psi_t) + \epsilon^{\psi}_{t+1}$

U.S. interest rate: $\ln(R^*_{t+1}) = \rho^{R^*} \ln(R^*_t) + \sigma^{R^*}_t \epsilon^{R^*}_{t+1}$

U.S. policy uncertainty: $\sigma^{R^*}_{t+1} = (1 - \rho^{\sigma^{R^*}})\sigma^{R^*} + \rho^{\sigma^{R^*}} \sigma^{R^*}_t + \epsilon^{\sigma^{R^*}}_{t+1}$

Workers

Bankers' profit maximization

Optimization Problem

$$V_{jt} = \max_{l_{jt+i}, b^*_{jt+1+i}} E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \Lambda_{t,t+1+i} \; n_{jt+1+i} \tag{1}$$

- Bankers survive with a likelihood of $0 < \theta < 1$ and are subject to

$$V_{jt} \geq \lambda\Big(q_t l_{jt} - \omega_l b_{jt+1}\Big) \tag{2}$$

- Financial frictions, $\lambda > 0$ and $\omega_l = 0$ reduce the magnitude of intermediated funds
  - Loan-deposit spreads emerge due to limited external finance.
  - Domestic and foreign debt are perfect substitutes.
- In the data, $\frac{b^*}{b+b^*} = 40\%$ in Turkey between 2002-2010.
- If domestic depositors have a comparative advantage in monitoring banks, i.e. $0 < \omega_l < 1$ a fraction of domestic debt becomes non-divertable

Asymmetry in financial frictions

Spreads

- $\lambda > 0$ and $\omega_l = 0$ reduce the magnitude of intermediated funds $\Rightarrow$

$$E_t \left\{ \Lambda_{t,t+i+1} R_{kt+i+1} \right\} > E_t \left\{ \Lambda_{t,t+i+1} \hat{R}_{t+i+1} \right\} = E_t \left\{ \Lambda_{t,t+i+1} R^*_{t+i+1} \right\}$$

- If domestic lenders monitor better, i.e. $0 < \omega_l < 1$, part of domestic debt is non-divertable $\Rightarrow$

$$E_t \left\{ \Lambda_{t,t+i+1} R_{kt+i+1} \right\} > E_t \left\{ \Lambda_{t,t+i+1} \hat{R}_{t+i+1} \right\} > E_t \left\{ \Lambda_{t,t+i+1} R^*_{t+i+1} \right\}$$

- Competition for funds in the domestic deposit market bids up real deposit rates.

- The credit spread over real deposit rates becomes smaller.

- Can pick $0 < \omega_l < 1$ to hit $\frac{b^*}{b+b^*}$ in the data.

Symmetric equilibrium

▸ Capital Producers ▸ Final-Goods Producers ▸ Intermediate-Goods Producers

$$q_t l_{jt} - \omega_l b_{jt+1} = \frac{\nu_t - \nu_t^*}{\lambda - \zeta_t} n_{jt} = \kappa_{jt} n_{jt} \tag{3}$$

where $\zeta_t = \nu_t^l + \nu_t^*$.

- Divertable assets cannot exceed an endogenous multiple of bank capital, i.e.,

$$q_t l_t - \omega_l b_{t+1} = \kappa_t n_t \tag{4}$$

- Substitute (4) into (7), we get

$$n_{et+1} = \theta \left\{ \left[R_{kt+1} - R_{t+1}^* \right] \kappa_t + R_{t+1}^* \right\} n_t \tag{5}$$

- New entrants are endowed with $\frac{\epsilon}{1-\theta}$ fraction of exiting bankers' assets

$$n_{nt+1} = (1-\theta) \frac{\epsilon}{1-\theta} q_t l_t = \epsilon q_t l_t \tag{6}$$

$$n_{t+1} = n_{et+1} + n_{nt+1}. \tag{7}$$

Monetary authority

- Central bank conducts monetary policy using three types of Taylor rule configurations and discretionary changes in reserve requirements.

$$\log\left(\frac{1+r_{nt}}{1+\overline{r_n}}\right) = \rho_{r_n}\log\left(\frac{1+r_{nt-1}}{1+\overline{r_n}}\right) + (1-\rho_{r_n})\left[\varphi_\pi E_t \log\left(\frac{1+\pi_{t+1}}{1+\overline{\pi}}\right) + \varphi_y \log\left(\frac{y_t^H}{\overline{y}}\right)\right]$$

$$\log\left(\frac{1+r_{nt}}{1+\overline{r_n}}\right) = \rho_{r_n}\log\left(\frac{1+r_{nt-1}}{1+\overline{r_n}}\right) + (1-\rho_{r_n})\left[\varphi_\pi E_t \log\left(\frac{1+\pi_{t+1}}{1+\overline{\pi}}\right) + \varphi_l \log\left(\frac{q_t l_t}{q_{t-1} l_{t-1}}\right)\right]$$

$$\log\left(\frac{1+r_{nt}}{1+\overline{r_n}}\right) = \rho_{r_n}\log\left(\frac{1+r_{nt-1}}{1+\overline{r_n}}\right) + (1-\rho_{r_n})\left[\varphi_\pi E_t \log\left(\frac{1+\pi_{t+1}}{1+\overline{\pi}}\right) + \varphi_s \log\left(\frac{s_t}{s_{t-1}}\right)\right]$$

$$\log(1+rr_t) = (1-\rho_{rr})\log(1+\overline{rr}) + \rho_{rr}\log(1+rr_{t-1}) + \epsilon^{rr}$$

Parametrization and calibration

Description	Parameter	Value	Target
Financial Intermediaries			
Fraction of the revenues that can be diverted	λ	0.598	Commercial loan/domestic deposits spread
Fraction of domestic deposits that cannot be diverted	ω_l	0.822	Banks' liability composition (foreign funds)
Survival probability of the bankers	θ^b	0.925	Leverage ratio of 7.5 for commercial banks
Proportional transfer to the entering bankers	ϵ^b	0.0015	1.33% of aggregate net worth
Monetary Authority and Government			
Domestic and foreign currency required reserve ratios	rr	0.06	Required reserve ratio for 2002 - 2013
Reaction parameter to output gap in Taylor rule	φ_y	2.2564	Estimated from the Turkish data
Reaction parameter to credit growth in Taylor rule	φ_l	0.2280	Estimated from the Turkish data
Reaction parameter to change in RER in Taylor rule	φ_s	1.4268	Estimated from the Turkish data
Steady state government expenditure to GDP ratio	g_H	0.1	average share of government spending in GDP
Shock Processes			
Persistence of risk premium process	ρ_Ψ	0.9628	Estimated from the Turkish EMBI data
Standard deviation of risk premium shocks	σ_Ψ	0.0032	Estimated from the Turkish EMBI data
Persistence of U.S interest rate process	$\rho_{R_n^*}$	0.977	Estimated from the US data
Standard deviation of U.S. interest rate shocks	$\sigma_{R_n^*}$	0.00097	Estimated from the US data
Persistence of U.S policy uncertainty process	$\rho^{\sigma^{R^*}}$	0.15	N/A
Standard deviation of U.S. policy uncertainty shocks	$\sigma^{\sigma^{R^*}}$	0.0015	Estimated from the US data

Other

Inefficiencies and external shocks

- Monopolistic competition $\rightarrow$ Higher mark-up $\rightarrow$ Lower employment and output
- Price rigidity $\rightarrow$ Increased import prices due to ER pass through and higher price dispersion $\rightarrow$ Higher inflation $\rightarrow$ Increased menu costs $\rightarrow$ lower output
- Financial friction $(\lambda > 0)$ $\rightarrow$ Insufficient substitution of foreign debt with domestic deposits $\rightarrow$ Less intermediated funds $\rightarrow$ Larger credit spreads $E_t[R_{kt+1} - R_{t+1}],\ E_t[R_{kt+1} - R^*_{t+1}] \uparrow$ $\rightarrow$ Reduced investment and output
- Asymmetry in the financial friction $(\omega > 0)$ $\rightarrow$ Differentiates domestic and foreign funding rate, and partly eliminates the arbitrage between loan-domestic deposit rates i.e., $E_t[R_{kt+1} - R^*_{t+1}] > E_t[R_{kt+1} - R_{t+1}] > 0$.

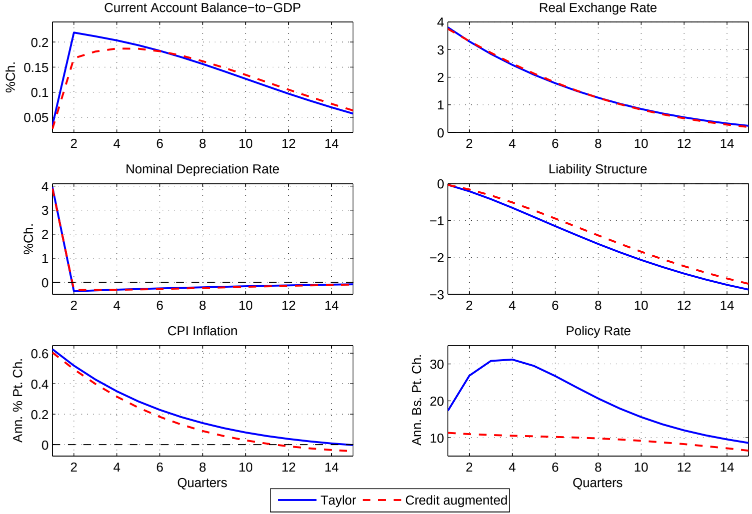
Variance decomposition (%)

	TFP	Country Risk Premium	U.S. Interest Rate	Export Demand
Real Variables				
Output	49.31	28.41	4.92	17.35
Consumption	21.11	65.48	10.99	2.42
Investment	8.14	76.92	12.60	2.33
Financial and External Variables				
Credit	37.38	51.53	7.92	3.17
Liability Composition (Foreign)	30.51	41.30	6.81	21.37
Domestic lending spread	18.28	46.38	7.38	27.97
Foreign Lending spread	17.21	49.46	7.95	25.39
Real Exchange Rate	2.90	82.56	11.78	2.77
C.A. Balance to GDP ratio	9.73	47.00	7.70	35.56
Nominal Variables				
CPI inflation rate	52.08	38.90	6.24	2.78
Policy Rate	52.27	39.71	6.14	1.87

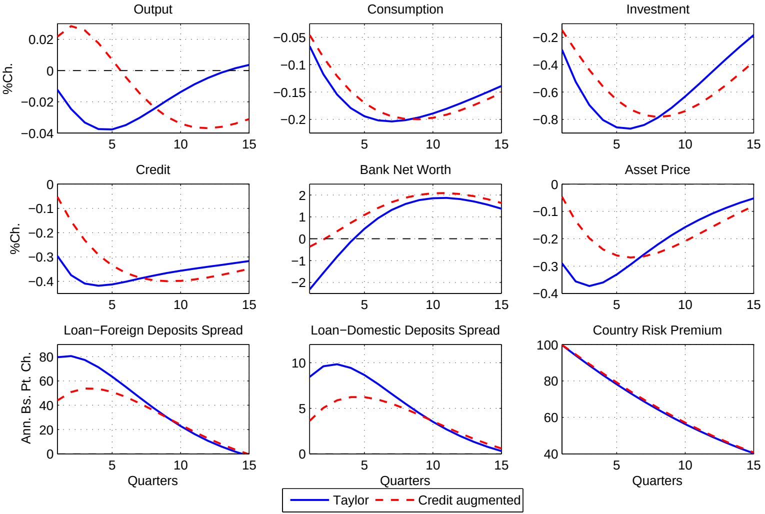
Loss function values for alternative policies and mandates

$\sigma_\pi^2 + \sigma_y^2$	TR1 Loss	φ_π	φ_y	TR2 Loss	φ_π	φ_I	TR3 Loss	φ_π	φ_s
TFP	1.428e-05	1.51	1	9.782e-06	1.76	2	2.7695e-05	1.01	0
Risk prem.	4.551e-06	1.01	2.5	4.695e-06	2.26	2.25	6.4040e-06	1.01	0
US int. rate	5.358e-07	1.01	2.5	5.123e-07	2.01	2	7.262e-07	1.01	0
Export dem.	3.149e-06	1.26	2.5	5.497e-06	1.01	1.75	7.234e-06	1.01	0
All	2.357e-05	2.01	2.5	2.237e-05	2.01	2.25	3.875e-05	1.01	0
$\sigma_\pi^2 + \sigma_y^2 + \sigma_{ql}^2$									
TFP	7.478e-05	4.76	1.5	7.928e-05	3.26	2.5	1.314e-04	2.01	0
Risk prem.	2.735e-05	1.01	2.5	2.275e-05	1.01	1.75	2.783e-05	1.01	0.25
US int. rate	2.791e-06	1.01	2.5	2.596e-06	1.01	1.50	2.965e-06	1.01	0
Export dem.	8.666e-06	1.26	0.25	7.174e-06	1.01	2.00	9.789e-06	1.01	0
All	1.994e-04	4.76	2.25	1.259e-04	2.51	2.5	1.999e-04	1.26	0
$\sigma_\pi^2 + \sigma_y^2 + \sigma_s^2$									
TFP	1.544e-04	1.01	0	1.212e-04	3.51	2.5	1.544e-04	1.01	0
Risk prem.	0.0025	4.76	0	0.0024	4.76	0.75	0.0025	4.76	0
US int.	2.360e-04	4.76	0	2.286e-04	4.76	0.75	2.360e-04	4.76	0
Export dem.	1.284e-04	4.76	0	1.258e-04	4.76	0.50	1.284e-04	4.76	0
All	0.0028	4.26	0.25	0.0026	4.76	1.5	0.0028	3.51	0

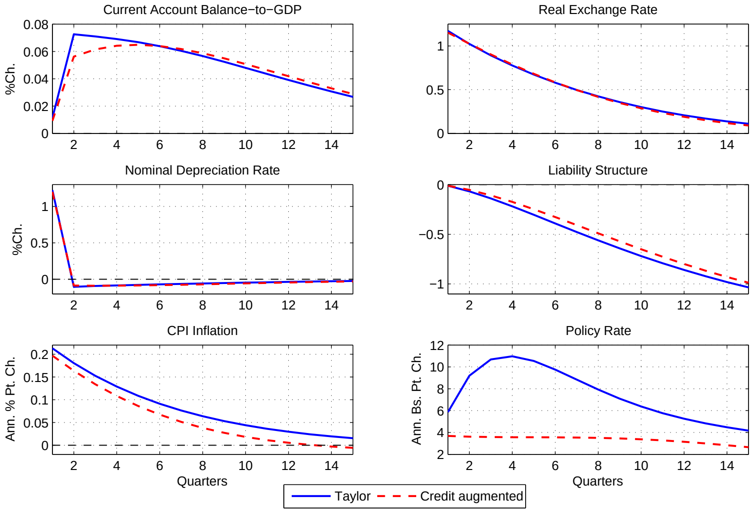
Taper tantrum shock (100 bp increase in risk premium)



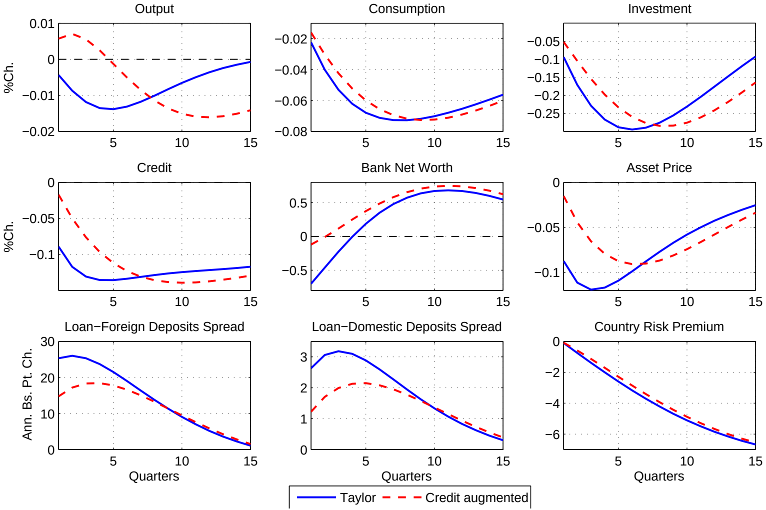
Taper tantrum shock ctd. (100 bp increase in risk premium)



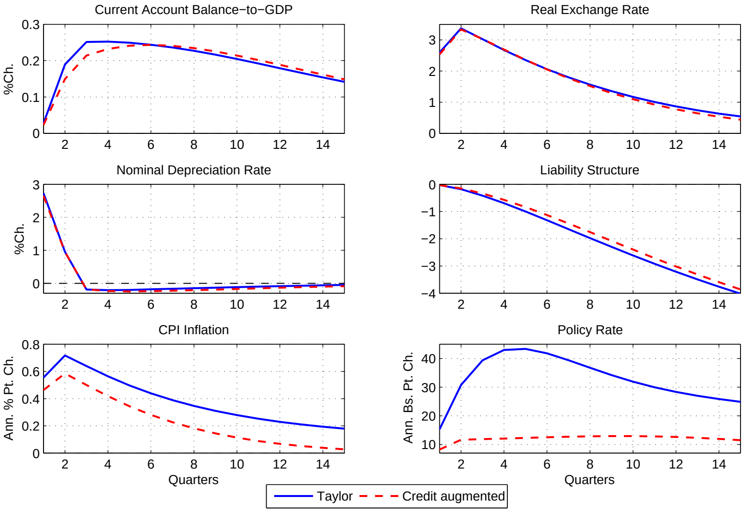
US interest rate shock (25 bp increase)



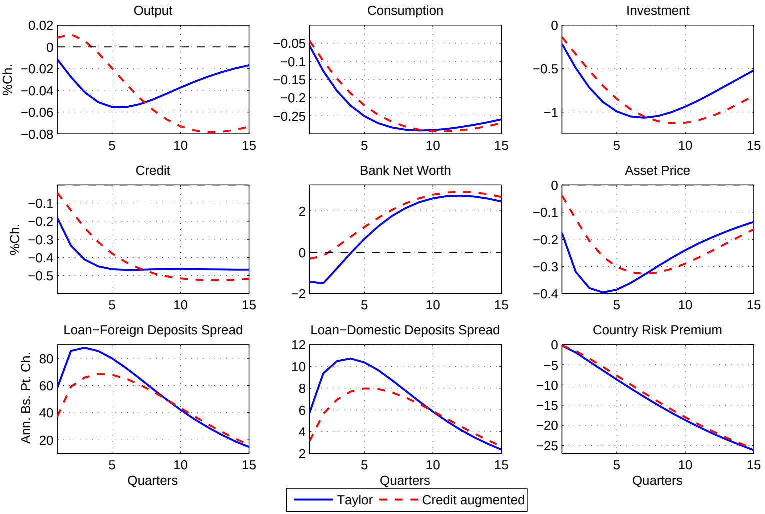
US interest rate shock ctd. (25 bp increase)



Policy uncertainty shock (59 bp variation in FOMC 2015 projections)



Policy uncertainty shock ctd. (59 bp variation in FOMC 2015 projections)

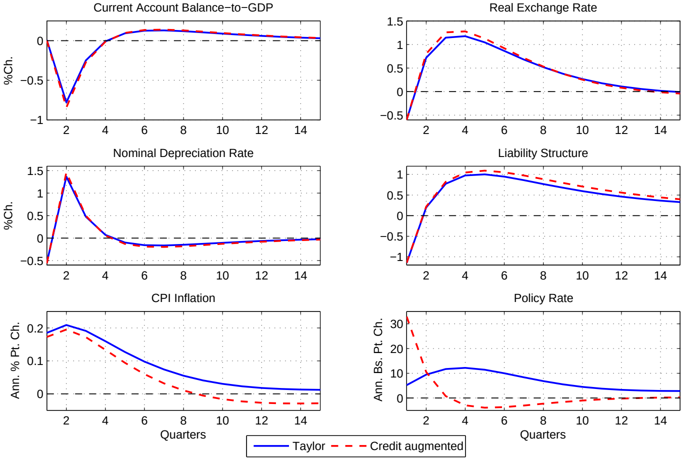


Conclusion

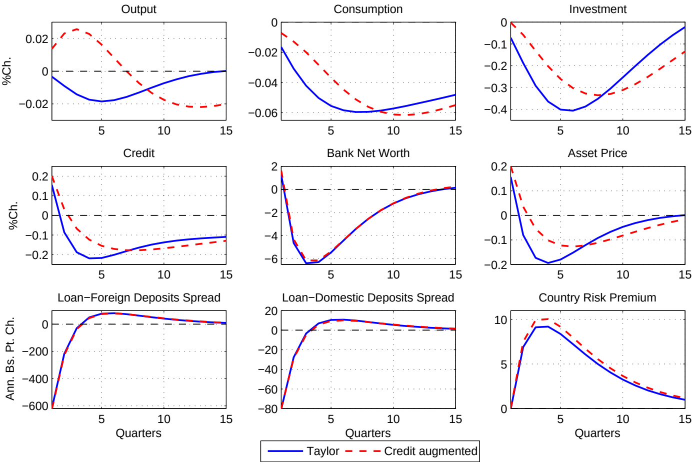
- A New Keynesian small open economy model with financial frictions is able to generate the adverse macroeconomic and financial repercussions of external shocks that EMEs face.
- The credit-augmented IT rule outperforms classical and RER augmented IT rules in minimizing losses that depend on price, output and/or credit growth (or real exchange rate) stability.
  - monetary policy can lean against the wind to reduce the procyclicality in the financial system.
- Augmenting IT rules with external financial stability objective might overwhelm monetary policy.
  - A strict IT rule with a RER stabilization objective does not contribute to macroeconomic stabilization.
- Further research calls for determining (Ramsey) optimal and implementable rules and conducting the normative comparison of policy rules, accordingly.

THANK YOU

Discretionary increase in reserve requirements (1 % point)



Discretionary increase in reserve requirements ctd. (1 % point)



Literature review ▸ Back

- Recent global financial crisis has brought up the issue of macroeconomic and macroprudential policy coordination.
  - Angeloni and Faia (2009), Angelini et al. (2012), Alpanda et al. (2014) and others.
- Additional policy tools are explored in order to target financial stability.
  - Christensen et al. (2011), Glocker and Towbin (2012), Mimir et al. (2013).
- Financial frictions in emerging economies bring additional burden on monetary authorities.
  - Transmission of country borrowing premium shocks to business cycles and domestic deposit and lending rates. Uribe and Yue (2006) and Akinci (2013).
  - Adjusting short term policy rates triggers fear of appreciation/depreciation.

Workers

Back

$$\max_{c_t, h_t, B_{t+1}, m_t} E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(c_t - h_c c_{t-1})^{1-\sigma} - 1}{1-\sigma} - \frac{\chi}{1+\xi} h_t^{1+\xi} + \upsilon \ \log\left(\frac{M_t}{P_t}\right) \right]$$

- Workers save only in domestic currency deposits and hold cash.

$$c_t + \frac{B_{t+1}}{P_t} + \frac{M_t}{P_t} = \frac{W_t}{P_t} h_t + \frac{(1 + r_{nt-1})B_t}{P_t} + \frac{M_{t-1}}{P_t} + \Pi_t - \frac{T_t}{P_t}$$

- c is a CES aggregate of home and foreign goods consumption,

$$c_t = \left[\omega^{\frac{1}{\gamma}} (c_t^H)^{\frac{\gamma-1}{\gamma}} + (1-\omega)^{\frac{1}{\gamma}} (c_t^F)^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}}$$

- Leading to the domestic CPI,

$$P_t = \left[\omega (P_t^H)^{1-\gamma} + (1-\omega)(P_t^F)^{1-\gamma} \right]^{\frac{1}{1-\gamma}}$$

Optimality conditions of workers' problem Back

Lagrange multiplier of the BC:

$$\varphi_t = (c_t - h_c c_{t-1})^{-\sigma} - \beta h_c E_t (c_{t+1} - h_c c_t)^{-\sigma}$$

CS optimality condition:

$$\varphi_t = \beta E_t \left[\varphi_{t+1}(1 + r_{nt}) \frac{P_t}{P_{t+1}} \right]$$

H-F goods optimal consumption demand:

$$\frac{c_t^H}{c_t^F} = \frac{\omega}{1-\omega} \left(\frac{P_t^H}{P_t^F} \right)^{-\gamma}$$

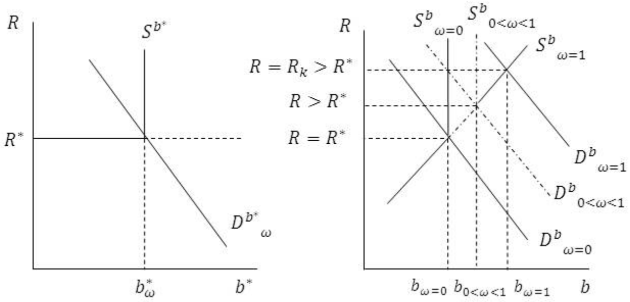
CL optimality condition:

$$\frac{W_t}{P_t} = \frac{\chi h_t^{\xi}}{\varphi_t}$$

CM optimality condition:

$$\frac{\upsilon / m_t}{\varphi_t} = \frac{r_{nt}}{1 + r_{nt}}$$

Financial frictions and spreads ▸ Back



Bankers' profit maximization ▸ Back

- Conjecture $V_{jt} = \nu_t^l q_t l_{jt} + \nu_t^* b_{jt+1}^* + \nu_t n_{jt}$ and solve the Lagrangian with the multiplier μ_t s.t. $V_{jt} \geq \lambda\Big(q_t l_{jt} - \omega_l b_{jt+1}\Big)$ to obtain

$$\nu_t^l = E_t\Big\{\Xi_{t,t+1}\left[R_{kt+1} - \hat{R}_{t+1}\right]\Big\}$$

$$\nu_t = E_t\Big\{\Xi_{t,t+1}\hat{R}_{t+1}\Big\}$$

and

$$\nu_t^* = E_t\Big\{\Xi_{t,t+1}\left[R_{t+1} - R_{t+1}^*\right]\Big\}$$

where $\Xi_{t,t+1} = \Lambda_{t,t+1}[1 - \theta + \theta(\zeta_{t+1}\kappa_{t+1} + \nu_{t+1} - \nu_{t+1}^*)]$

and $\Lambda_{t,t+1+i} = \beta^{i+1}\frac{U_{ct+1+i}}{U_{ct}}$.

- $\lambda, \mu_t, \omega_l > 0 \Rightarrow \nu_t^* > 0$.

Solution to bankers' problem

$$\max_{l_{jt}, b^*_{jt+1}} L = \nu^l_t q_t l_{jt} + \nu^*_t b^*_{jt+1} + \nu_t n_{jt}$$

$$+\mu_t \left[\nu^l_t q_t l_{jt} + \nu^*_t b^*_{jt+1} + \nu_t n_{jt} - \lambda \Big(q_t l_{jt} - \omega_l \left[\frac{q_t l_{jt} - n_{jt}}{1 - rr_t} - b^*_{jt+1} \right] \Big) \right]$$

First Order Conditions:

$$\mathbf{l_{jt}} : \quad \nu^l_t (1 + \mu_t) = \lambda \mu_t \Big(1 - \frac{\omega_l}{1 - rr_t} \Big)$$

$$\mathbf{b^*_{jt+1}} : \quad \nu^*_t (1 + \mu_t) = \lambda \mu_t \omega_l$$

$$\mu_\mathbf{t} : \quad \nu^l_t q_t l_{jt} + \nu^*_t \left[\frac{q_t l_{jt} - n_{jt}}{1 - rr_t} - b_{t+1} \right] + \nu_t n_{jt} - \lambda (q_t l_{jt} - \omega_l b_{jt+1}) \geq 0$$

Capital goods producers

Back

- Buy the deprecited capital at $\frac{P_{I,t}}{P_t}$, repair it, and sell it to the production firms at q_t,

$$\max_{i_t} \sum_{t=0}^{\infty} E_0 \left\{ \beta^t \Lambda_{t,t+1} \left[q_t i_t - \Phi\left(\frac{i_t}{i_{t-1}}\right) q_t i_t - \frac{P_{I,t}}{P_t} i_t \right] \right\}$$

- subject to the evolution of physical capital

$$k_{t+1} = (1-\delta_t)k_t + \left[1 - \Phi\left(\frac{i_t}{i_{t-1}}\right)\right] i_t$$

Q-investment Condition for Capital Goods:

$$\frac{P_{I,t}}{P_t} = q_t \left[1 - \Phi\left(\frac{i_t}{i_{t-1}}\right) - \Phi'\left(\frac{i_t}{i_{t-1}}\right)\frac{i_t}{i_{t-1}}\right] + \beta E_t \left[\Lambda_{t,t+1} q_{t+1} \Phi'\left(\frac{i_{t+1}}{i_t}\right)\frac{i_{t+1}}{i_t}\right]$$

Home - Foreign Goods Optimal Investment Demand:

$$\frac{i_t^H}{i_t^F} = \frac{\omega_i}{1-\omega_i}\left(\frac{P_t^H}{P_t^F}\right)^{-\gamma_i}$$

Final goods producers

Back

- Repackage a continuum of intermediate goods in a competitive market.

$$y_t^j = \left[\int_0^1 y_t^j(i)^{1-\frac{1}{\epsilon}} di\right]^{\frac{1}{1-\frac{1}{\epsilon}}}.$$

where j denotes Home (H) and Foreign (F) intermediate goods.

$$\max_{y_t^j(i)} \quad P_t^j \left[\int_0^1 y_t^j(i)^{1-\frac{1}{\epsilon}} di\right]^{\frac{1}{1-\frac{1}{\epsilon}}} - \left[\int_0^1 P_t^j(i) y_t^j(i) di\right]$$

Iso-elastic demand for each good i of type j:

$$y_t^j(i) = \left(\frac{P_t^j(i)}{P_t^j}\right)^{-\epsilon} y_t^j,$$

Price of each good i of type j:

$$P_t^j = \left[\int_0^1 P_t^j(i)^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}}.$$

Intermediate goods producers (Home)

▸ Foreign ▸ Back

- They use capital and labor in the production of intermediate goods and they can vary capital utilization.

$$y_t^H(i) = A_t\Big(u_t(i)k_t(i)\Big)^{\alpha} h_t(i)^{1-\alpha} \tag{8}$$

- Total factor productivity follows an AR(1) process:

$$\ln(A_{t+1}) = \rho^A \ln(A_t) + \epsilon_{t+1}^A \tag{9}$$

- They incur convex price adjustment costs as in Rotemberg (1982).

$$P_t \frac{\varphi^H}{2}\left[\frac{P_t^H(i)}{P_{t-1}^H(i)} - 1\right]^2 \tag{10}$$

Intermediate goods producers (Home) ctd.

$$\max_{P_t^H(i)} E_t \sum_{j=0}^{\infty} \Lambda_{t,t+j} \left[\frac{D_{t+j}^H(i)}{P_{t+j}} \right] \tag{11}$$

- They maximize real profits by choosing the sales price:

$$D_{t+j}^H(i) = P_{t+j}^H(i) y_{t+j}^H(i) + S_{t+j} P_{t+j}^{H*} c_{t+j}^{H*}(i) - MC_{t+j} y_{t+j}(i) - P_{t+j} \frac{\varphi^H}{2} \left[\frac{P_{t+j}^H(i)}{P_{t+j-1}^H(i)} - 1 \right]^2 \tag{12}$$

- Optimal sales price is given by

$$p_t^H = \frac{\epsilon}{\epsilon - 1} rmc_t - \frac{\varphi^H}{\epsilon - 1} \frac{\pi_t^H(\pi_t^H - 1)}{y_t^H} + \frac{\varphi^H}{\epsilon - 1} E_t \left\{ \Lambda_{t,t+1} \frac{\pi_{t+1}^H(\pi_{t+1}^H - 1)}{y_t^H} \right\} \tag{13}$$

- $\varphi^H \to 0 \Rightarrow$ home goods prices are flexible and reflect a constant markup of $\frac{\epsilon}{\epsilon-1}$ over the marginal cost.

Intermediate goods producers (Home) ctd.

- Factor demands are determined by their marginal products,

$$p_{I,t}\delta'(u_t)k_t = \alpha\left(\frac{y_t^H}{u_t}\right)rmc_t \tag{14}$$

$$R_{kt} = \frac{\alpha\left(\frac{y_t^H}{k_t}\right)rmc_t - p_{i,t}\delta(u_t) + q_t}{q_{t-1}} \tag{15}$$

$$w_t = (1-\alpha)\left(\frac{y_t^H}{h_t}\right)rmc_t \tag{16}$$

with

$$\delta(u_t) = \delta + \frac{d}{1+\varrho}u_t^{1+\varrho} \tag{17}$$

and $\delta, d, \varrho > 0$.

Intermediate goods producers (Foreign)

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- Importers of foreign goods incur similar rigidities with $MC_t^F = S_t P_t^{F*}$.

$$p_t^F = \frac{\epsilon}{\epsilon - 1} s_t - \frac{\varphi^F}{\epsilon - 1} \frac{\pi_t^F(\pi_t^F - 1)}{y_t^F} + \frac{\varphi^F}{\epsilon - 1} E_t \left\{ \Lambda_{t,t+1} \frac{\pi_{t+1}^F(\pi_{t+1}^F - 1)}{y_t^F} \right\} \tag{18}$$

- Exporters do not have monopoly power, i.e.,

$$c_t^{H*} = \left[\left(\frac{P_t^{H*}}{P_t^*} \right)^{-\Gamma} y_t^* \right]^{\nu^H} (c_{t-1}^{H*})^{1-\nu^H} \tag{19}$$

with $P_t^{H*} = P_t^* = 1$, and y_t^* taken as given.

Parametrization and calibration ctd.

Description	Parameter	Value	Target
Preferences			
Quarterly discount factor	β	0.9821	Average annualized real deposit rate (7.48%)
Relative risk aversion	σ	2	Literature
Habit persistence	h_c	0.7	Literature
Labor supply elasticity	ξ	5	Literature
Relative utility weight of labor	χ	$4x10^3$	steady state hours worked of 0.33
Relative utility weight of money	υ	0.35	M2 to GDP ratio.
Relative weight of domestic goods in consumption basket	ω	0.4	average consumption to GDP ratio
Intra-temporal elasticity of substitution for consumption composite	γ	1	Gertler et al. (2007)
Intra-temporal elasticity of substitution for investment composite	γ_i	1	Gertler et al. (2007)
Firms			
Share of capital in output	α	0.4	Labor share of output (0.6)
Share of domestic goods in the investment composite	ω_i	0.87	average share of investment in GDP (0.15)
Depreciation rate of capital	δ	0.035	Average annual ratio of investment to capital (14.8%)
Steady-state utilization rate	$\overline{u}$	1	Literature
Elasticity of marginal depreciation with respect to the utilization rate	ϱ	1	Gertler et al. (2007)
Elasticity of substitution between varieties	ϵ	11	Steady state mark-up of 1.1
Investment adjustment cost parameter	ψ	4	Elasticity of price of capital w.r.t. investment-capital ratio
Price adjustment cost for domestic intermediate goods producers	φ_H	120	Frequency of price change per quarter
Price adjustment cost for domestic intermediate goods producers	φ_F	120	Frequency of price change per quarter

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