Monetary Policy and Endogenous Financial Crises

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Motivation

- What should the role of financial stability considerations in the design of monetary policy?

  - conventional view: focus on macro stability

  - alternative view: also pre-empt financial crises (and limit their damage ex-post)

- Standard model of monetary policy analysis ignores financial factors
- Extensions with financial frictions: crises triggered by exogenous financial shocks and/or just amplification of nonfinancial shocks

  $\Rightarrow$ no room for monetary policy to pre-empt financial crises

- Need for a model with *endogenous* financial crises

This Paper

- New Keynesian model with financial frictions ⇒ *endogenous* financial crises

⇒ monetary policy can influence the probability of a crisis
⇒ tradeoff between (short run) macro stability and (medium run) financial stability

- Main findings

⇒ proximate cause of a financial crisis: too low returns on investment due to a capital overhang after a protracted boom ⇒ raises borrowers' incentive to channel financial resources to nonproductive activities and default ⇒ collapse of loan markets
⇒ deviations from price stability may be desirable: need to tame booms that may bring about "excessive" capital accumulation
⇒ rule-based policy stressing output stability can help avert crises
⇒ ex-post discretionary interventions may enhance instability

Key Ingredients

- Nominal rigidities $\Rightarrow$ non-neutrality of monetary policy
- Endogenous capital accumulation
- Idiosyncratic productivity shocks $\Rightarrow$ capital reallocation through financial markets
- Financial frictions: asymmetric information and imperfect enforcement

  $\Rightarrow$ possibility of an (endogenous) collapse of financial markets

Related Literature

- Monetary policy and financial frictions
- Reduced form models of endogenous financial crises

Woodford (2012), Svensson (2017), Gourio-Kashyap-Sim (2018), Ajello-Laubach-López Salido-Nakata (2019)

- Micro-founded models of endogenous financial crises

Boissay-Collard-Smets (2016), Gertler-Kiyotaki-Prestipino (2019), Fornaro (2015), Paul (2020),...

- Evidence on financial crises and misallocation:

Foster-Grim-Haltiwanger (2016), Argente-Lee-Moreira (2018), Campello-Graham-Harvey (2010),....

Households

- Infinitely lived representative consumer

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \vartheta \frac{N_t^{1+\nu}}{1+\nu} \right]$$

subject to

$$\int_0^1 P_t(i) C_t(i) di + B_t + \int_0^1 P_t Q_t(j) S_t(j) dj = W_t N_t + (1+i_{t-1}) B_{t-1} + \int_0^1 P_t D_t(j) S_{t-1}(j) dj + X_t$$

where $C_t \equiv \left[\int_0^1 C_t(i)^{1-\frac{1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}}$

- Optimality conditions:

$$C_t(i) = (P_t(i)/P_t)^{-\epsilon} C_t$$

$$\beta(1+i_t)\mathbb{E}_t \left\{ (C_{t+1}/C_t)^{-\sigma} (P_t/P_{t+1}) \right\} = Z_t$$

$$\beta \mathbb{E}_t \left\{ (C_{t+1}/C_t)^{-\sigma} (1 + r_{t+1}^k(j)) \right\} = 1$$

$$W_t/P_t = \vartheta N_t^{\nu} C_t^{\sigma}$$

where $1 + r_{t+1}^k(j) \equiv D_{t+1}(j)/Q_t(j)$

Firms: Final Goods

- Infinitely-lived monopolistic competitors, indexed by $i \in [0,1]$
- Transform intermediate good into a differentiated final good
- Price setting subject to quadratic adjustment costs.

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[\frac{P_t(i)}{P_t} Y_t(i) - \frac{(1-\tau)p_t}{P_t} Y_t(i) - \frac{\varsigma}{2} \left(\frac{P_t(i)}{P_{t-1}(i)} - 1 \right)^2 Y_t \right]$$

subject to $Y_t(i) = (P_t(i)/P_t)^{-\epsilon} Y_t$

- Optimality condition + symmetric equilibrium

$$\Pi_t(\Pi_t - 1) = \mathbb{E}_t \left\{ \Lambda_{t,t+1} (Y_{t+1}/Y_t) \Pi_{t+1} (\Pi_{t+1} - 1) \right\} - \frac{\epsilon - 1}{\varsigma} \left(1 - \frac{\mathcal{M}}{\mathcal{M}_t} \right)$$

where

$$\mathcal{M} \equiv \frac{\epsilon}{\epsilon - 1}$$

$$\mathcal{M}_t = \frac{P_t}{(1-\tau)p_t}$$

Firms: Intermediate Goods

- Perfectly competitive. Live for one period. Unit measure. Ex-ante identical. Subject to idiosyncratic and aggregate productivity shocks.
- Technology for firm with idiosyncratic shock q

$$y_t(q) = A_t[qK_t(q)]^{\alpha} N_t(q)^{1-\alpha}$$

- Assumption:

$$q \in \{0, 1\}$$

with $q = 0$ for a mass μ of firms

- At the end of $t-1$, issue equity. Each firm gets Q_{t-1}
- Shocks observed at the beginning of period t. Firms determine $K_t(q)$ and $N_t(q)$. The gap $K_t(q) - Q_{t-1}$ funded through the loan market, at a (real) interest rate r_t^l.
- End of t, they produce and sell intermediate good at price p_t, and sell $(1-\delta)K_t(q)$ at price P_t

Firms: Intermediate Goods

- Equity return for a firm with productivity q

$$
\begin{aligned}
1 + r_t^k(q) &= \frac{D_t(q)}{Q_{t-1}} \\
&= \frac{1}{Q_{t-1}}\left[\frac{p_t}{P_t} y_t(q) - \frac{W_t}{P_t} N_t(q) - (1 + r_t^l)[K_t(q) - Q_{t-1}] + (1-\delta)K_t(q)\right]
\end{aligned}
$$

- In equilibrium, $Q_{t-1} = K_t$ implying:

$$
r_t^k(q) = \frac{1}{(1-\tau)\mathcal{M}_t}\frac{y_t(q)}{K_t} - \frac{W_t}{P_t}\frac{N_t(q)}{K_t} - (r_t^l + \delta)\frac{K_t(q) - K_t}{K_t} - \delta
$$

Monetary Policy

$$1 + i_t = \frac{1}{\beta} \Pi_t^{\phi_\pi} \left(\frac{Y_t}{Y} \right)^{\phi_y}$$

Loan Market: The Frictionless Benchmark

- All potential lenders observe q, contracts fully enforceable
- Equity return for unproductive firms ($q = 0$)

$$r_t^k(0) = -(r_t^l + \delta)\frac{K_t(0) - K_t}{K_t} - \delta$$

If $r_t^l > -\delta \Rightarrow K_t(0) = 0$ (lends all its capital)
If $r_t^l = -\delta \Rightarrow K_t(0) \in [0, K_t]$ (indifferent between lending or keeping it idle)
If $r_t^l < -\delta \Rightarrow K_t(0) = +\infty$ (borrows and keeps idle)

Loan Market: The Frictionless Benchmark

- Equity return for productive firms ($q = 1$) (conditional on optimal labor choice)

$$r_t^k(1) = \frac{\alpha \Phi_t}{(1-\tau)\mathcal{M}_t} \frac{K_t(1)}{K_t} - (r_t^l + \delta) \frac{K_t(1) - K_t}{K_t} - r_t^l$$

where $\Phi_t \equiv \frac{y_t(1)}{K_t(1)} = A_t^{\frac{1}{\alpha}} \left(\frac{1-\alpha}{(1-\tau)\mathcal{M}_t(W_t/P_t)} \right)^{\frac{1-\alpha}{\alpha}}$

If $r_t^l < \frac{\alpha \Phi_t}{(1-\tau)\mathcal{M}_t} - \delta \Rightarrow K_t(1) = +\infty$
If $r_t^l = \frac{\alpha \Phi_t}{(1-\tau)\mathcal{M}_t} - \delta \Rightarrow$ indifferent about scale
If $r_t^l > \frac{\alpha \Phi_t}{(1-\tau)\mathcal{M}_t} - \delta \Rightarrow K_t(1) = 0$ (lend all its capital).

Figure 2: Loan Supply

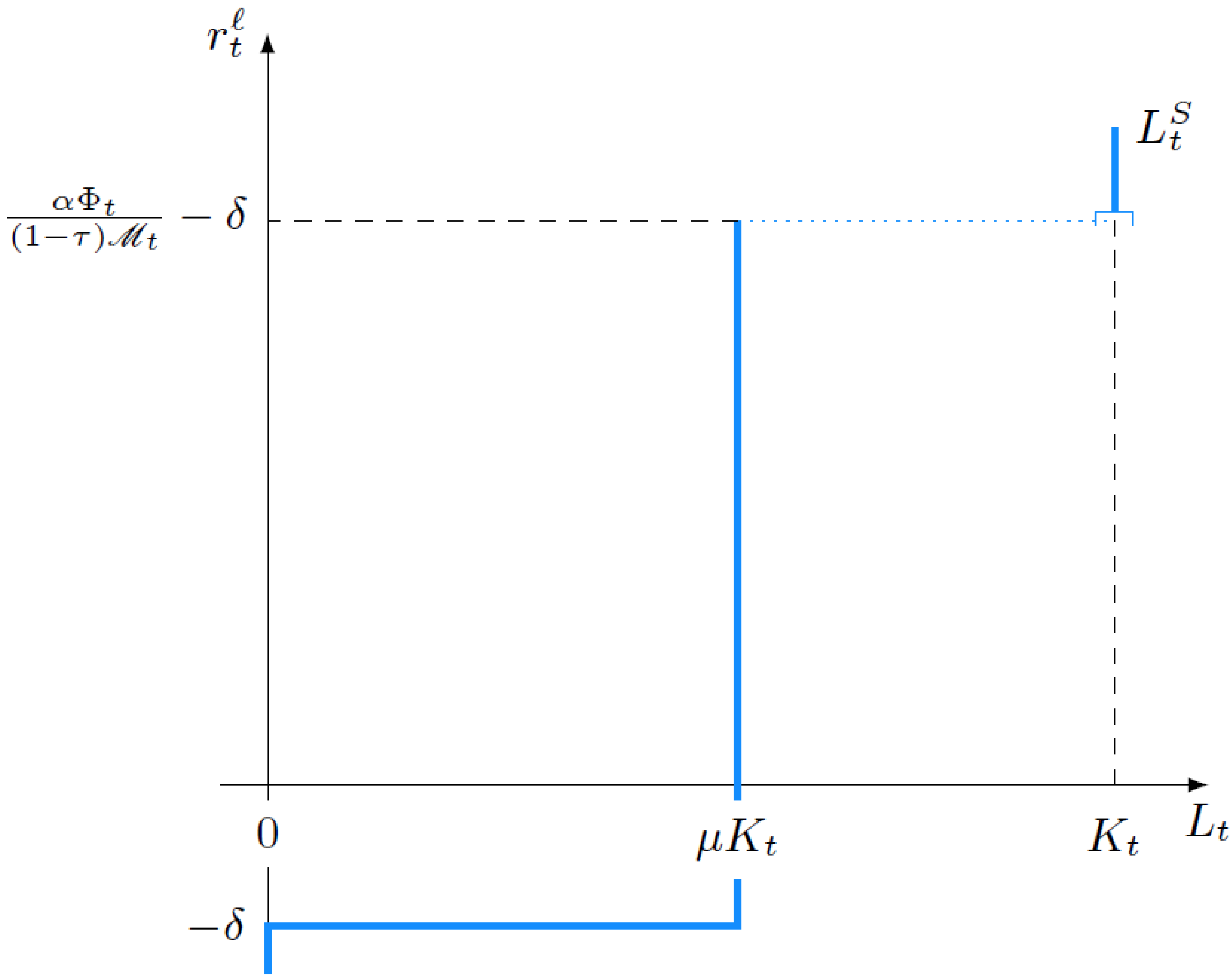


Figure 3: Loan Demand (frictionless)

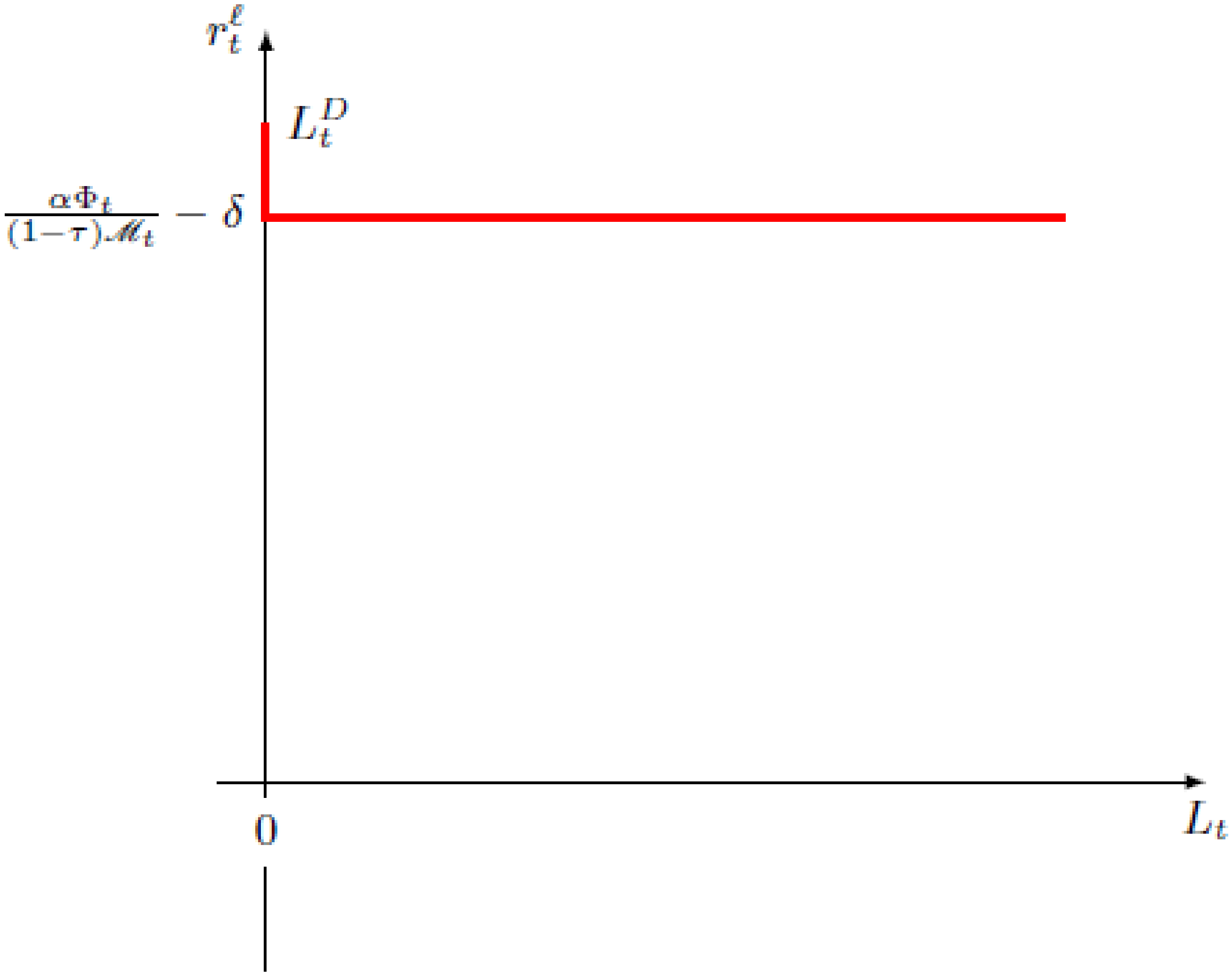
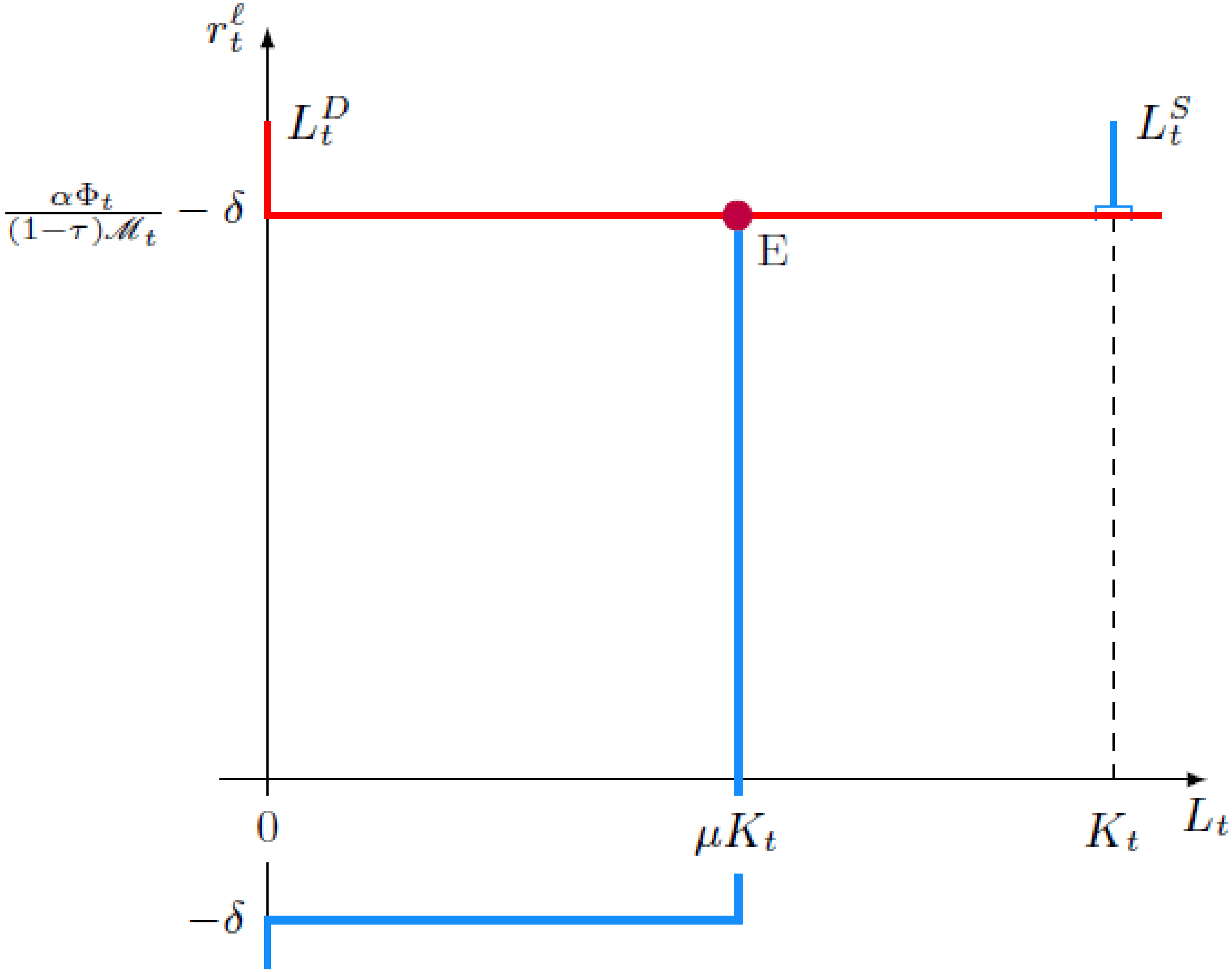


Figure 4: Loan Supply and Demand (frictionless)



Loan Market: The Frictionless Benchmark

- Loan market equilibrium

$$r_t^l = r_t^k(0) = r_t^k(1) = \frac{\alpha \Phi_t}{(1-\tau)\mathcal{M}_t} - \delta$$

- Unproductive firms lend all their capital to productive ones:

$$\begin{aligned} K_t &= (1-\mu) K_t(1) \\ N_t &= (1-\mu) N_t(1) \\ Y_t &= (1-\mu) y_t(1) = A_t K_t^{\alpha} N_t^{1-\alpha} \end{aligned}$$

$\Rightarrow$ equilibrium equivalent to standard NK model with a representative firm.

Loan Market: The Case of Frictions

- Asymmetric information and limited enforceability of loan contracts
- Options for an unproductive firm:

(i) borrow to increase its capital, keep it idle, sell it at the end of the period, and abscond. Implied payoff: $(1-\delta)K_t(1)$
(ii) lend out its capital in the loan market. Implied payoff: $(1+r_t^l)K_t$

- Incentive compatibility constraint (maximum leverage ratio)

$$\frac{K_t(q)-K_t}{K_t} \leq \frac{r_t^l+\delta}{1-\delta}$$

Loan Market: The Case of Frictions

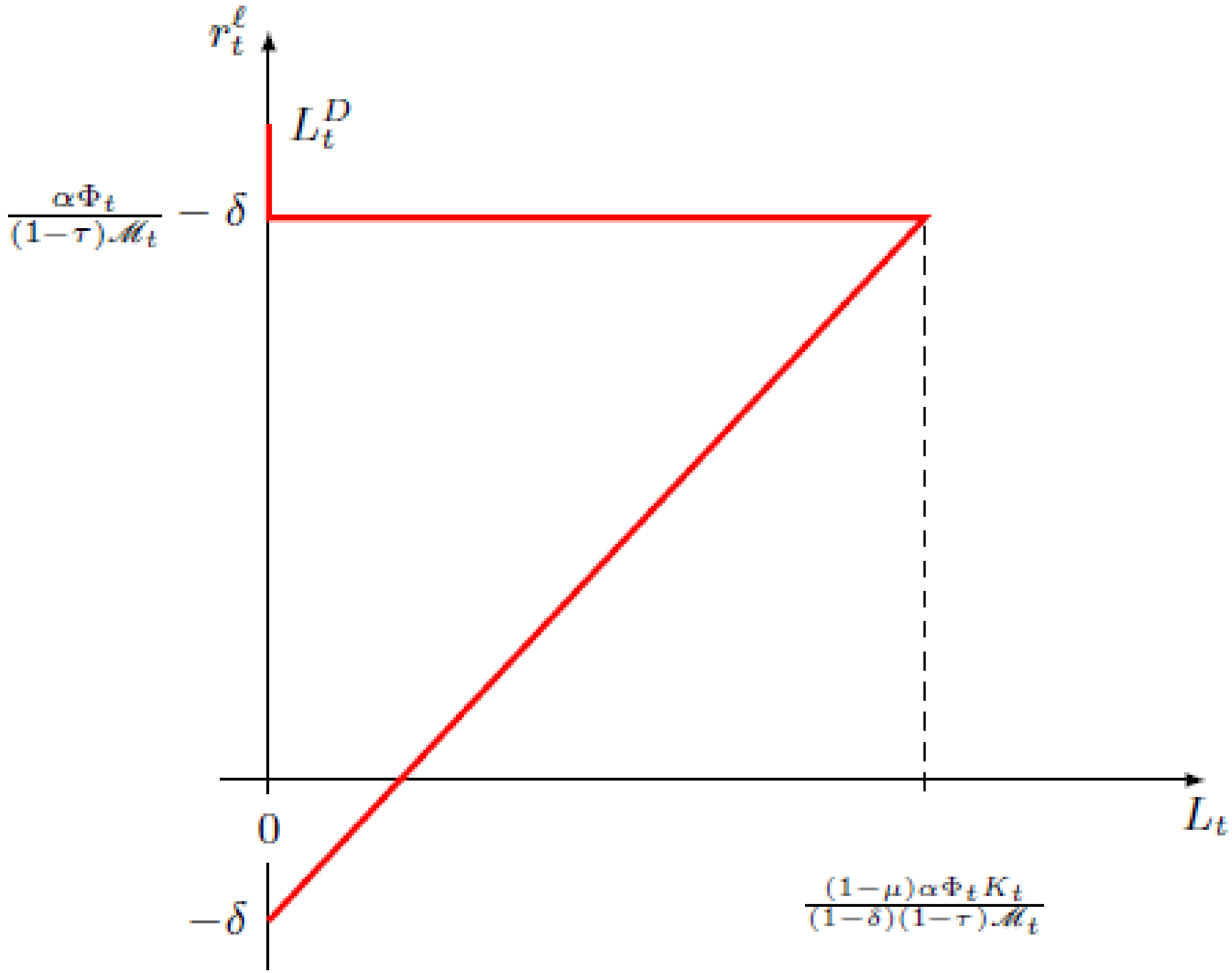
- Aggregate loan supply: same as before

$$L_t^S(r_t^l) = \begin{cases} 0 & \text{for } r_t^l < -\delta \\ [0, \mu K_t] & \text{for } r_t^l = -\delta \\ \mu K_t & \text{for } -\delta < r_t^l \leq \frac{\alpha \Phi_t}{(1-\tau)\mathcal{M}_t} - \delta \\ K_t & \text{for } r_t^l > \frac{\alpha \Phi_t}{(1-\tau)\mathcal{M}_t} - \delta \end{cases}$$

- Aggregate loan demand:

$$L_t^D(r_t^l) = \begin{cases} (1-\mu)\frac{r_t^l+\delta}{1-\delta} K_t & \text{for } r_t^l < \frac{\alpha \Phi_t}{(1-\tau)\mathcal{M}_t} - \delta \\ [0, (1-\mu)\frac{r_t^l+\delta}{1-\delta} K_t] & \text{for } r_t^l = \frac{\alpha \Phi_t}{(1-\tau)\mathcal{M}_t} - \delta \\ 0 & \text{for } r_t^l > \frac{\alpha \Phi_t}{(1-\tau)\mathcal{M}_t} - \delta \end{cases}$$

Figure 4: Loan Demand (frictional)



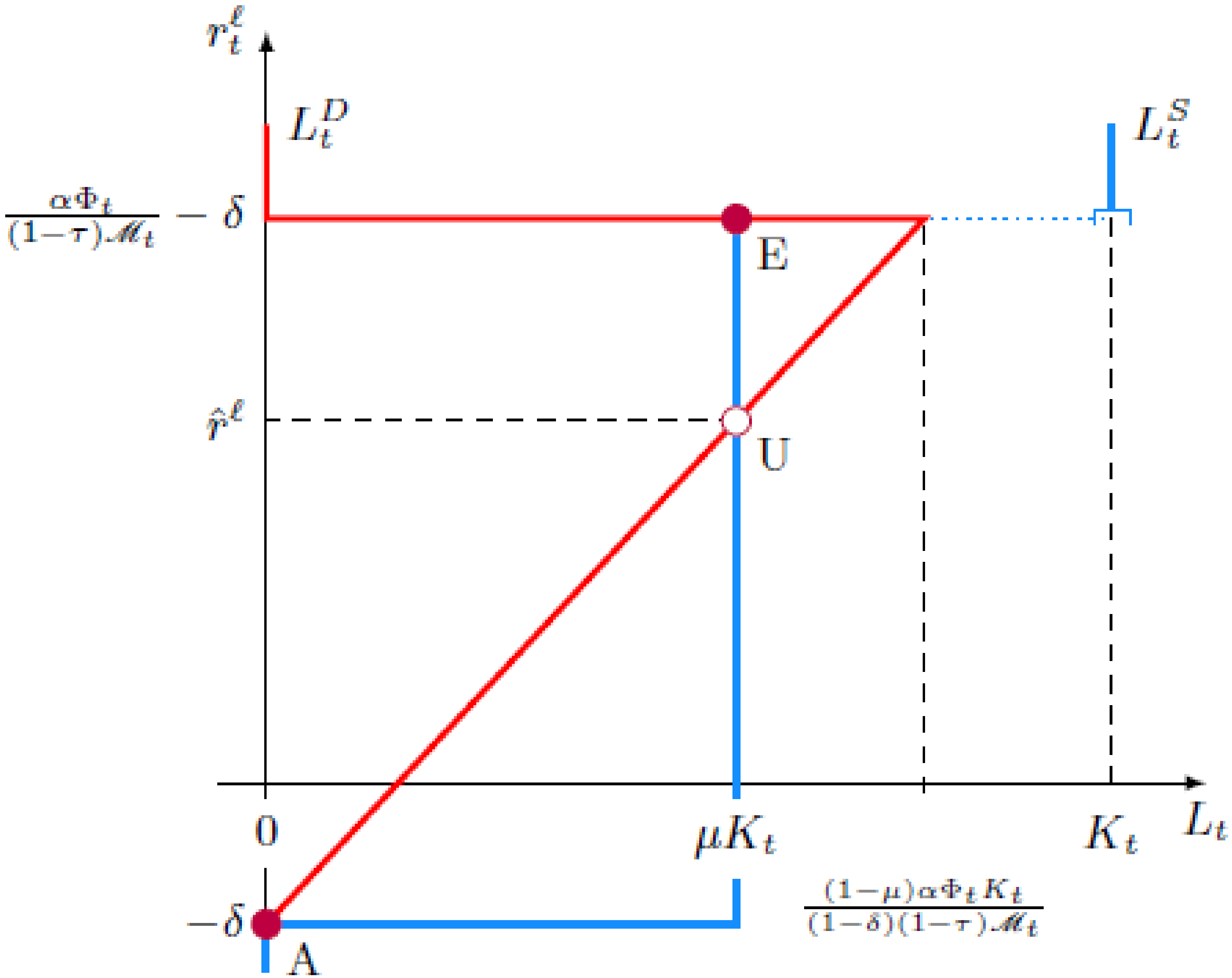
- Case 1 ("high return on investment")

$$\frac{\alpha\Phi_t}{(1-\tau)\mathcal{M}_t} \geq \frac{(1-\delta)\mu}{1-\mu}$$

$\Rightarrow$ equilibrium with trade ("normal times")

$$Y_t = A_t K_t^{\alpha} N_t^{1-\alpha}$$

Figure 5: Loan Demand and Supply



Loan Market: The Case of Frictions

- Case 1 ("high return on investment")

$$\frac{\alpha \Phi_t}{(1-\tau)\mathcal{M}_t} \geq \frac{(1-\delta)\mu}{1-\mu}$$

$\Rightarrow$ equilibrium with trade ("normal times")

$$Y_t = A_t K_t^{\alpha} N_t^{1-\alpha}$$

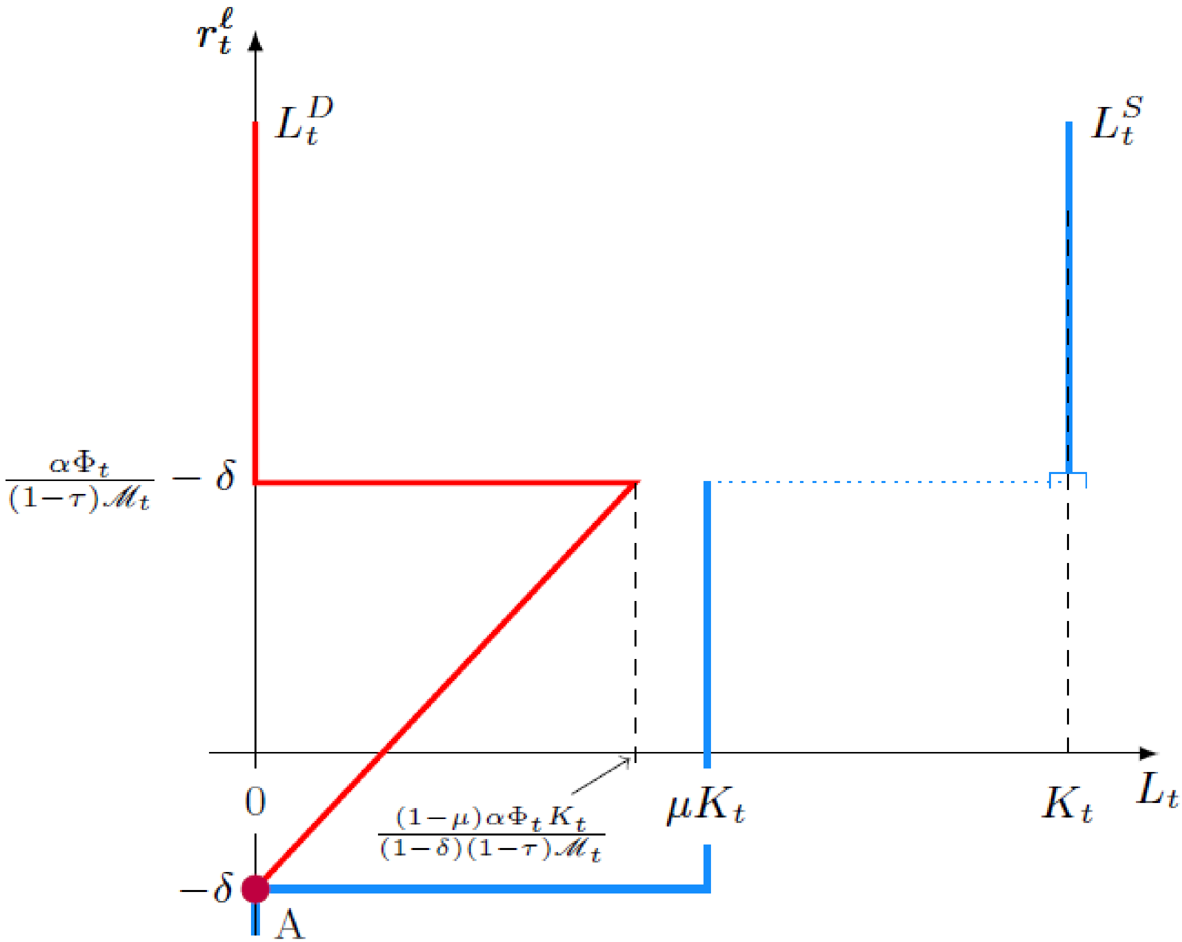
- Case 2 ("low return on investment")

$$\frac{\alpha \Phi_t}{(1-\tau)\mathcal{M}_t} < \frac{(1-\delta)\mu}{1-\mu}$$

$\Rightarrow$ autarkic equilibrium ("financial crisis")

$$Y_t = A_t((1-\mu)K_t)^{\alpha} N_t^{1-\alpha}$$

Figure 9: Emergence of a crisis



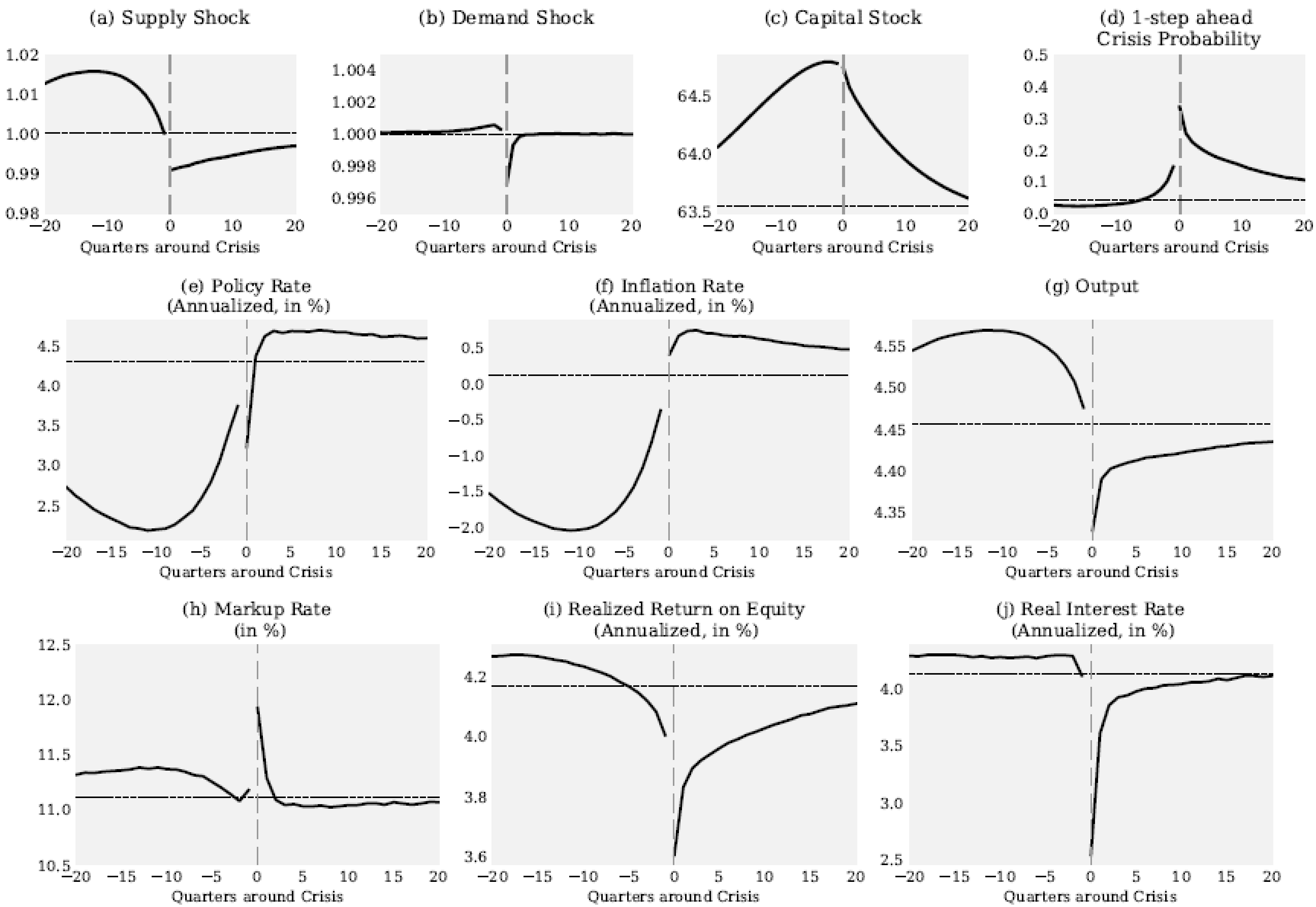
Monetary Policy and Financial Stability

- Crisis condition
$$\frac{\alpha(Y_t/K_t)}{(1-\tau)\mathcal{M}_t} < \frac{(1-\delta)\mu}{1-\mu}$$
- Given K_t, a crisis can be induced by a lower Y_t and/or higher $\mathcal{M}_t$. Monetary policy should seek to stabilize both in the short run.
- The larger K_t, the smaller the shock that may trigger the crisis. Monetary policy should seek to prevent "excessive" capital accumulation in the medium run.
- Feedback effects: anticipation of a possible crisis raises precautionary savings, increasing the probability of a future crisis.

Anatomy of a Financial Crisis

- *Calibration*. Non-standard parameter: fraction of unproductive firms $\mu = 0.024$, which implies a crisis incidence of 8%. Rest of calibration standard (with Taylor rule as baseline)
- *Simulation* of the (nonlinear) calibrated model over 1 million periods, using a global solution method. Identification of crises starting dates, values of different shocks and variables around them. Report average values ("typical crisis").

Figure 2: Typical path to crisis



Monetary Policy Options

- Optimal policy in the absence of financial frictions: strict inflation targeting. But generally not optimal with financial frictions since the flexible price equilibrium allocation is not necessarily efficient (it may involve too many inefficient crises).
- Source of inefficiency: individual agents do not internalize the consequences of their decisions on financial fragility.
- Strict inflation targeting (SIT): fully neutralizes demand-driven crises, but it amplifies output and capital fluctuations driven by technology shocks.
- Output-stability oriented policies ($\uparrow \phi_y$)

Table 3: Economic performance under alternative monetary policy rules

Rule paramaters		Frictionless loan market	Frictional loan market							
ϕ_π	ϕ_y	PCE (%)	PCE (%)	Crisis time (%)	Length (quarters)	Output loss (%)	Y–, M–, and CA–channels			
							$\sigma(Y_t)$	$\sigma(\mathscr{M}_t)$	$\sigma(K_t)$	$\rho(Y_t, \mathscr{M}_t)$
$+\infty$	0.000	–	–	5.03	4.59	-5.60	3.92	0.00	3.70	0.00
1.500	0.125	-0.0062	-0.0408	[8.00]	1.78	-3.20	3.62	1.09	3.16	0.14
1.500	0.212	-0.0059	-0.0116	[5.03]	1.78	-2.83	3.26	1.06	2.77	0.50
1.500	0.309	-0.0075	0.0117	[2.50]	1.68	-2.54	2.93	1.16	2.42	0.72
1.500	0.415	-0.0101	0.0239	[1.00]	1.54	-2.26	2.67	1.32	2.11	0.84
1.500	0.491	-0.0124	0.0267	[0.50]	1.47	-2.12	2.50	1.43	1.92	0.88

Monetary Policy Options

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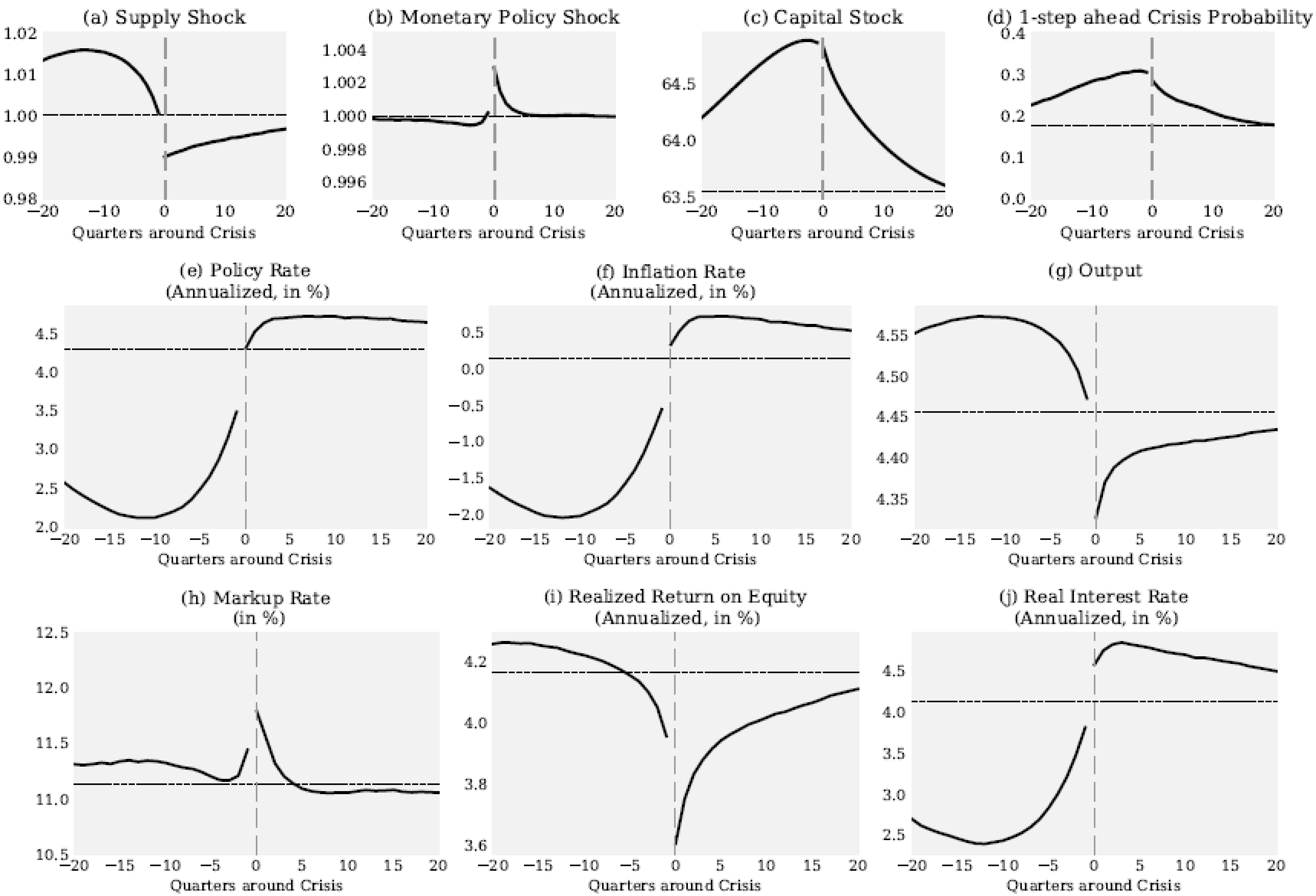
- Source of inefficiency: individual agents do not internalize the consequences of their decisions on financial fragility.
- Strict inflation targeting (SIT): fully neutralizes demand-driven crises, but it amplifies output and capital fluctuations driven by technology shocks.
- Output-stability oriented policies ($\uparrow \phi_y$)
- Rules vs Discretion: the role of monetary policy shocks

- unusually low rates as a source of financial crises
- the "late reaction" dilemma: to tighten or to loosen?

Figure 7: Typical path to crisis with technology and monetary policy shocks



Conclusion

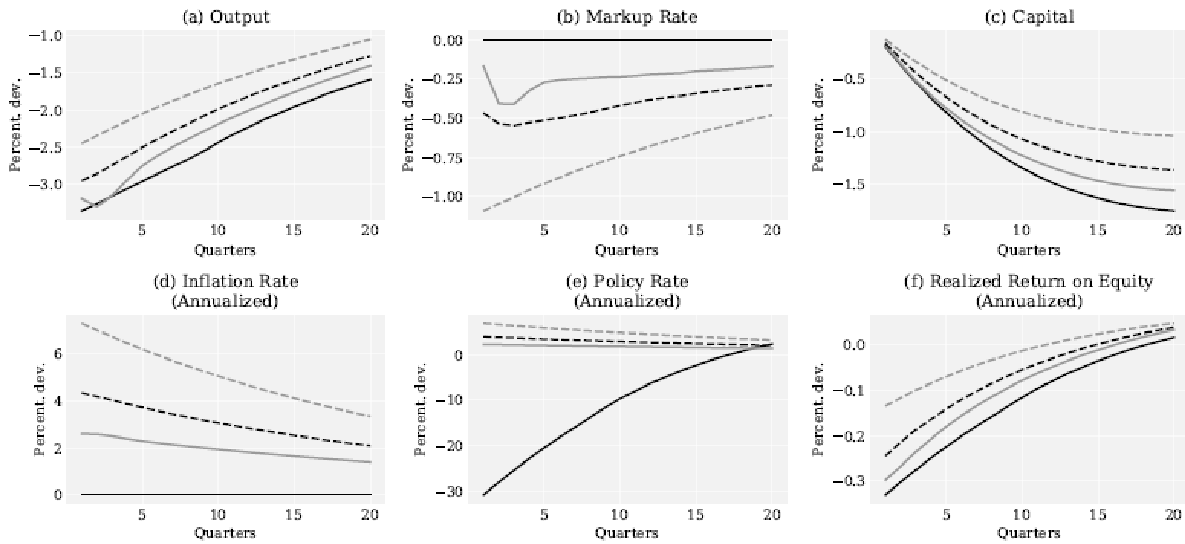
- Simple extension of the basic NK model with financial frictions and endogenous financial crises
- Focus on one dimension of financial crises: misallocation (and loss in productivity) resulting from financial markets not doing their job.
- Lessons for monetary policy: rationale for deviating from price stability as a single focus $\Rightarrow$ need to avert financial fragility

Table 1: Parametrization

Parameter	Target	Value
Preferences		
β	4% annual real interest rate	0.989
σ	Logarithmic utility on consumption	1.000
ν	Inverse Frish elasticity equals 2	0.500
ϑ	Steady state hours equal 1	0.814
Technology and price setting		
α	64% labor share	0.360
δ	6% annual capital depreciation rate	0.015
ϱ	Same slope of the Phillips curve as with Calvo price setting	105.000
ϵ	11% markup rate	10.000
Aggregate shocks		
ρ_a	Persistence of TFP	0.950
σ_a	Standard deviation of TFP innovation (in %)	0.700
ρ_z	Persistence in Smets and Wouters (2007)	0.220
σ_z	Standard deviation of risk–premium innovation in Smets and Wouters (2007) (in %)	0.230
Interest rate rule		
ϕ_π	Standard quarterly Taylor rule (Taylor (1993))	1.500
ϕ_y	Standard quarterly Taylor rule (Taylor (1993))	0.125
Proportion of unproductive firms		
μ	The economy spends 8% of the time in a crisis	0.0239

Figure 4: Impulse response functions around steady state

(a) TFP shock



(b) Demand shock

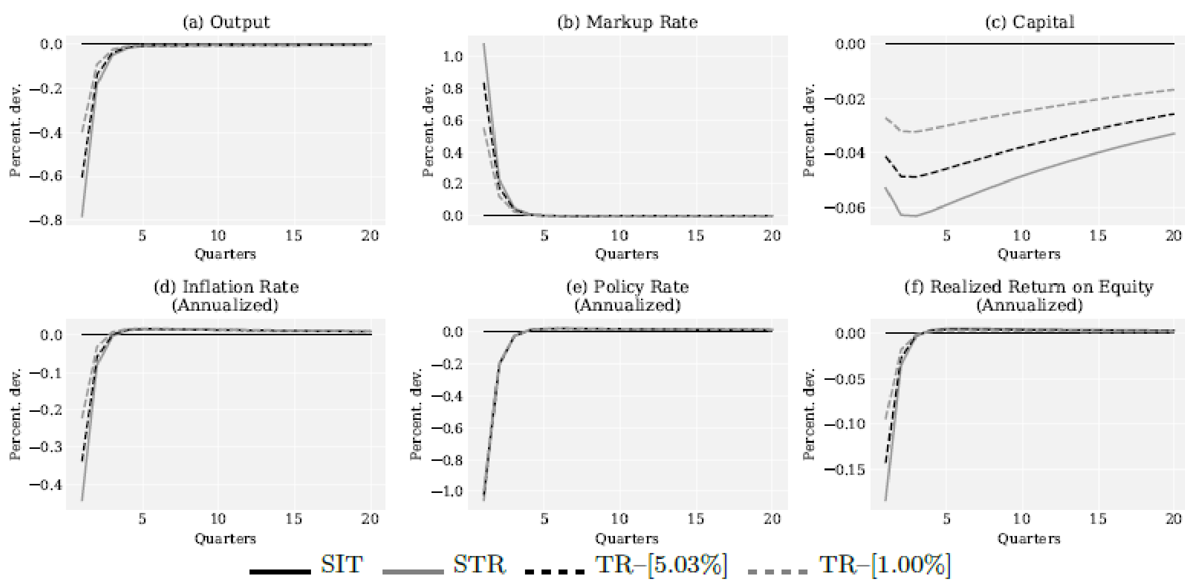
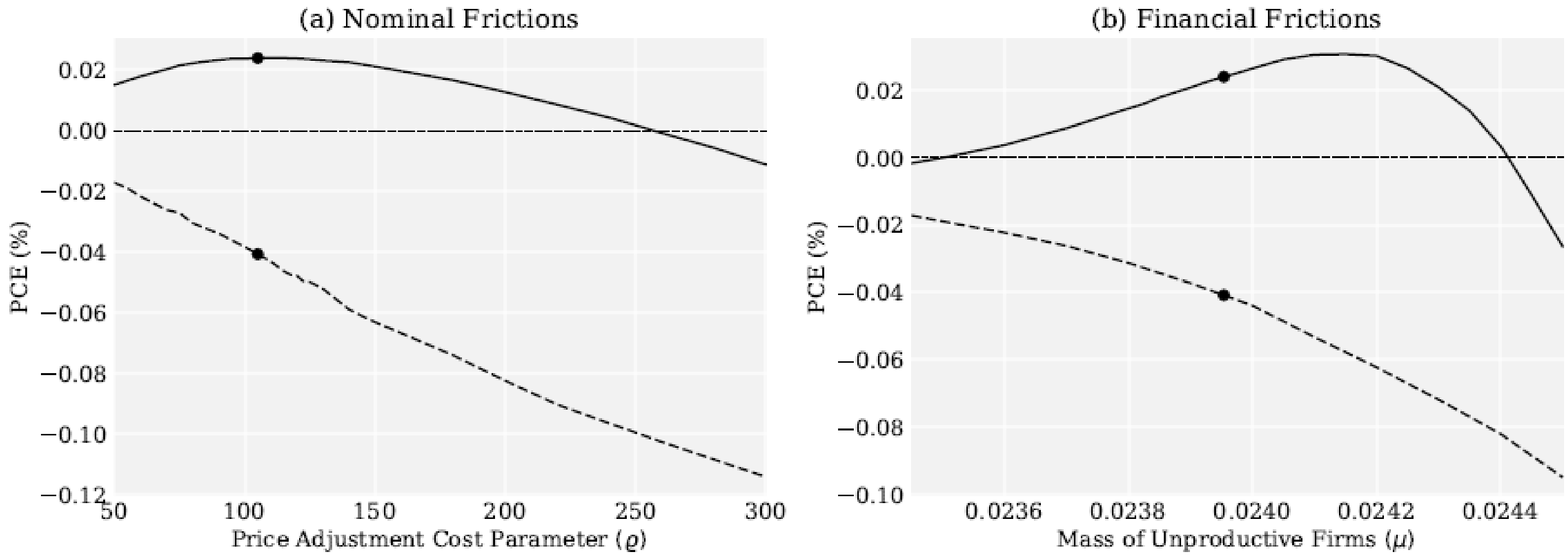


Figure 6: When should a central bank lean?



Notes: Welfare gain (PCE, in %) of the IR–[0.415] or STR rule over SIT (y–axis) as nominal (Panel (a)) or financial (Panel (b)) frictions become more severe —keeping all else equal. A negative PCE means that welfare is higher under SIT than under IR–[0.415] or STR. The dots correspond to our calibrated model, with $\varrho = 105$ and $\mu = 2.39\%$.