Monetary Policy and Endogenous Financial Crises

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Motivation

- Conventional view on monetary policy: focus on macro stability (inflation, output gap)
- Should monetary policy also promote financial stability?
- 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 $\Rightarrow$ *endogenous* financial crises

$\Rightarrow$ monetary policy can influence the probability of a crisis
$\Rightarrow$ tradeoff between (short run) price stability and (medium run) financial stability

- Key ingredients

(i) Nominal rigidities $\Rightarrow$ non-neutrality of monetary policy
(ii) Endogenous capital accumulation $\Rightarrow$ protracted investment booms
(iii) Idiosyncratic productivity shocks $\Rightarrow$ capital reallocation through credit markets
(iv) Private information and limited enforcement $\Rightarrow$ "financial fragility"
(v) Global solution method $\Rightarrow$ non-linearities

- Focus on monetary policy, other policies ignored (e.g. macroprudential)
- Focus on a novel mechanism underlying a financial crisis: "capital overhang" leading to a collapse of credit markets and misallocation of capital.

Main Findings

- Proximate cause of a financial crisis: low returns on investment (r_t^k) after a protracted investment boom

  ⇒ downward pressure on loan rates r_t^c
  ⇒ higher incentive for unproductive firms to borrow (and default)
  ⇒ endogenous tightening of credit
  ⇒ (eventual) collapse of credit markets

- Monetary policy affects the incidence of financial crises through its influence on r_t^k

  - short run: through changes in output and markups
  - medium run: through influence on capital accumulation

- Deviations from price stability may be desirable: need to tame booms that may bring about "excessive" capital accumulation
- A properly designed rule including a "financial fragility" indicator can reduce the incidence of crises and may improve welfare
- Discretionary monetary policy interventions may enhance financial instability (e.g. unwarranted loose monetary policies followed by sharp corrections)

Related Literature

- Monetary policy and financial frictions
- Monetary policy with heterogenous agents
- 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

Gertler-Kiyotaki (2015), 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), Muller-Verner (2023),...

- Evidence on the role of monetary policy as a source of financial crises

Grimm-Jorda-Schularick-Taylor (2023), Jimenez-Kuvshinov-Peydro-Richter (2023),...

Households

- Infinitely-lived representative consumer

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma} - 1}{1-\sigma} - \chi \frac{N_t^{1+\varphi}}{1+\varphi} \right)$$

subject to

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

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

- Optimality conditions:

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

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

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

$$W_t/P_t = \chi C_t^{\sigma} N_t^{\varphi}$$

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

- Assumption: $1 + i_t^b = (1 + i_t) \exp\{z_t\}$, where $z_t = \rho_z z_{t-1} + \varepsilon_t^z$ is a "bond premium" shock (e.g. Smets and Wouters 2007)

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

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

subject to $Y_t(i) = C_t(i) + I_t(i) + \Upsilon_t(i) = (P_t(i)/P_t)^{-\epsilon}(C_t + I_t + \frac{\varrho}{2} Y_t \pi_t^2)$

- Optimality condition + symmetric equilibrium

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

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, indexed by $j \in [0,1]$. Ex-ante identical. Subject to idiosyncratic and aggregate productivity shocks.
- Technology

$$X_t(j) = A_t[\omega_t(j)K_t(j)]^{\alpha} N_t(j)^{1-\alpha}$$

where $\log A_t = \rho_a \log A_{t-1} + \varepsilon_t^a$

- Assumption:

$$\omega_t(j) \in \{0,1\}$$

with $\omega_t(j) = 0$ for a fraction μ of firms ("unproductive")

- At the end of $t-1$, each firm gets an equity injection $Q_{t-1}(j)$ which is used to buy initial capital (at price P_{t-1}). By symmetry: $Q_{t-1}(j) = Q_{t-1} = K_t = (1-\delta)K_{t-1} + I_{t-1}$, where $I_{t-1} = \left(\int_0^1 I_{t-1}(i)^{1-\frac{1}{\epsilon}} di\right)^{\frac{\epsilon}{\epsilon-1}}$
- Shocks $\omega_t(j)$ observed at the beginning of period t. Firms determine $K_t(j)$ and $N_t(j)$. The gap $K_t(j) - K_t \lesseqgtr 0$ funded/channeled through a credit market, with (real) interest rate r_t^c.

Firms: Intermediate Goods

- Profits for a productive firm conditional on optimal labor choice

$$\begin{aligned} D_t^p &= \frac{p_t}{P_t} X_t^p - \frac{W_t}{P_t} N_t^p - (1 + r_t^c)\left[K_t^p - K_t\right] + (1-\delta) K_t^p \\ &= \frac{\Phi_t}{(1-\tau)\mathcal{M}_t} K_t^p - (1 + r_t^c)\left[K_t^p - K_t\right] + (1-\delta) K_t^p \\ &= (r_t^k - r_t^c) K_t^p + (1 + r_t^c) K_t \end{aligned}$$

where

$$r_t^k \equiv \frac{\Phi_t}{(1-\tau)\mathcal{M}_t} - \delta$$

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

Monetary Policy

- Taylor-type rule (baseline)

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

- Strict inflation targeting (SIT)

$$\pi_t = 0$$

Financial Market Equilibrium: The Frictionless Benchmark

- Idiosyncratic shocks $\{\omega_t(j)\}$ observable, contracts fully enforceable
- Unproductive firms sell their capital and lend the proceeds to productive firms, which use it to finance additional investment

$$(1-\mu)[K_t^p - K_t] = \mu K_t$$

$$\Rightarrow (1-\mu)K_t^p = K_t$$

$$r_t^c = r_t^k = r_t^q$$

- Labor market clearing

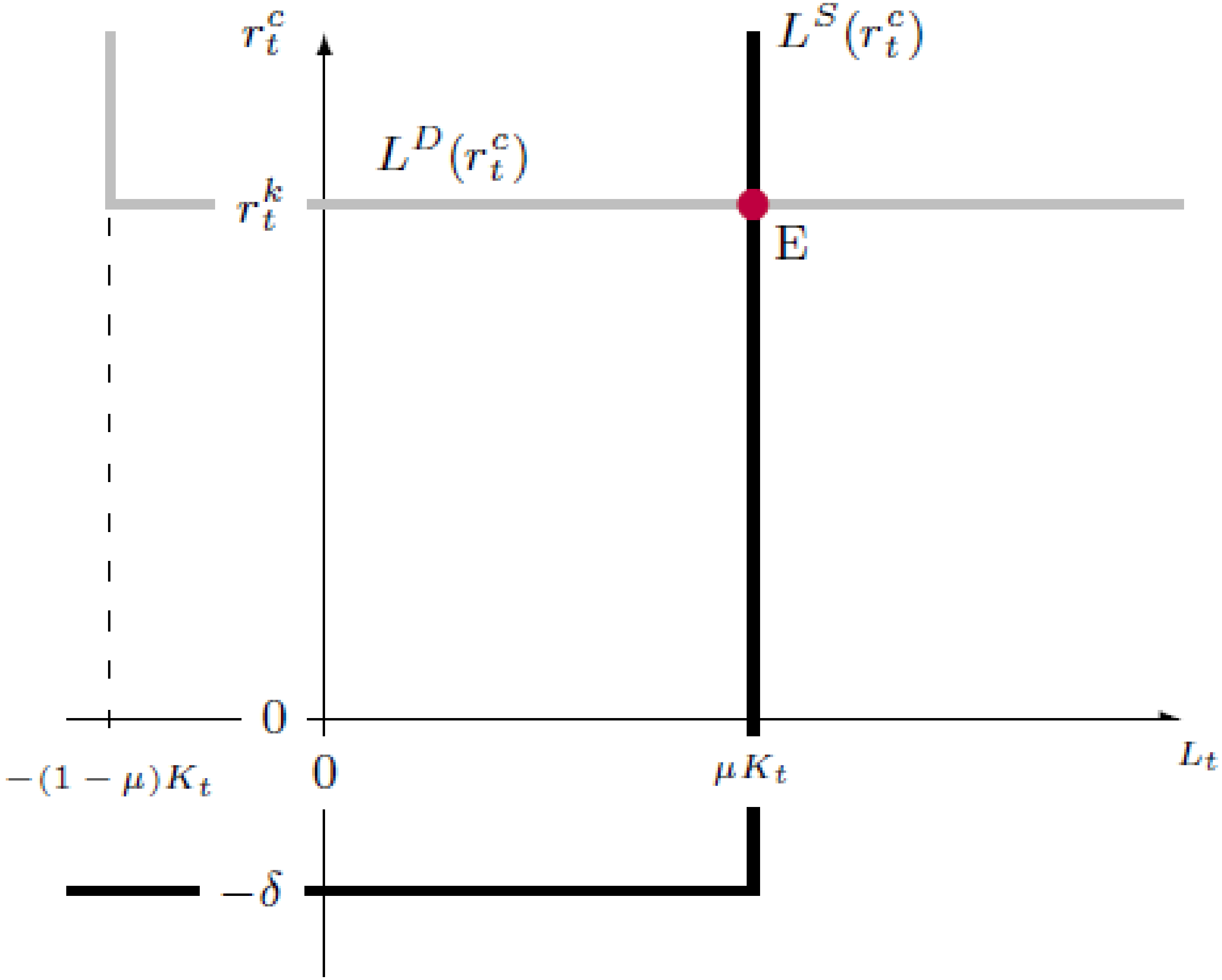
$$(1-\mu)N_t^p = N_t$$

- Aggregate output

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

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

Credit Market Equilibrium: The Frictionless Case



Frictional Financial Markets

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

  (i) Lend K_t. Payoff: $(1+r_t^c)K_t$
  (ii) Keep capital idle. Payoff: $(1-\delta)K_t$
  (iii) Pretend to be productive, borrow $K_t^p - K_t$, and abscond. Implied payoff:

$$(1-\delta)K_t^p - \theta(K_t^p - K_t)$$

  where θ is a default cost.

- Incentive compatibility constraint

$$(1-\delta)K_t^p - \theta(K_t^p - K_t) \leq (1+r_t^c)K_t$$

- Implied *borrowing limit*

$$K_t^p - K_t \leq \frac{r_t^c + \delta}{1-\delta-\theta} \, K_t$$

  with the maximum leverage ratio *increasing* in r_t^c

Frictional Financial Markets: Equilibrium

- Aggregate loan supply (by unproductive firms)

$$L_t^S = \mu(K_t - K_t^u) = \begin{cases} \mu K_t & \text{for } r_t^c > -\delta \\ [0, \mu K_t] & \text{for } r_t^c = -\delta \\ -\infty & \text{for } r_t^c < -\delta \end{cases}$$

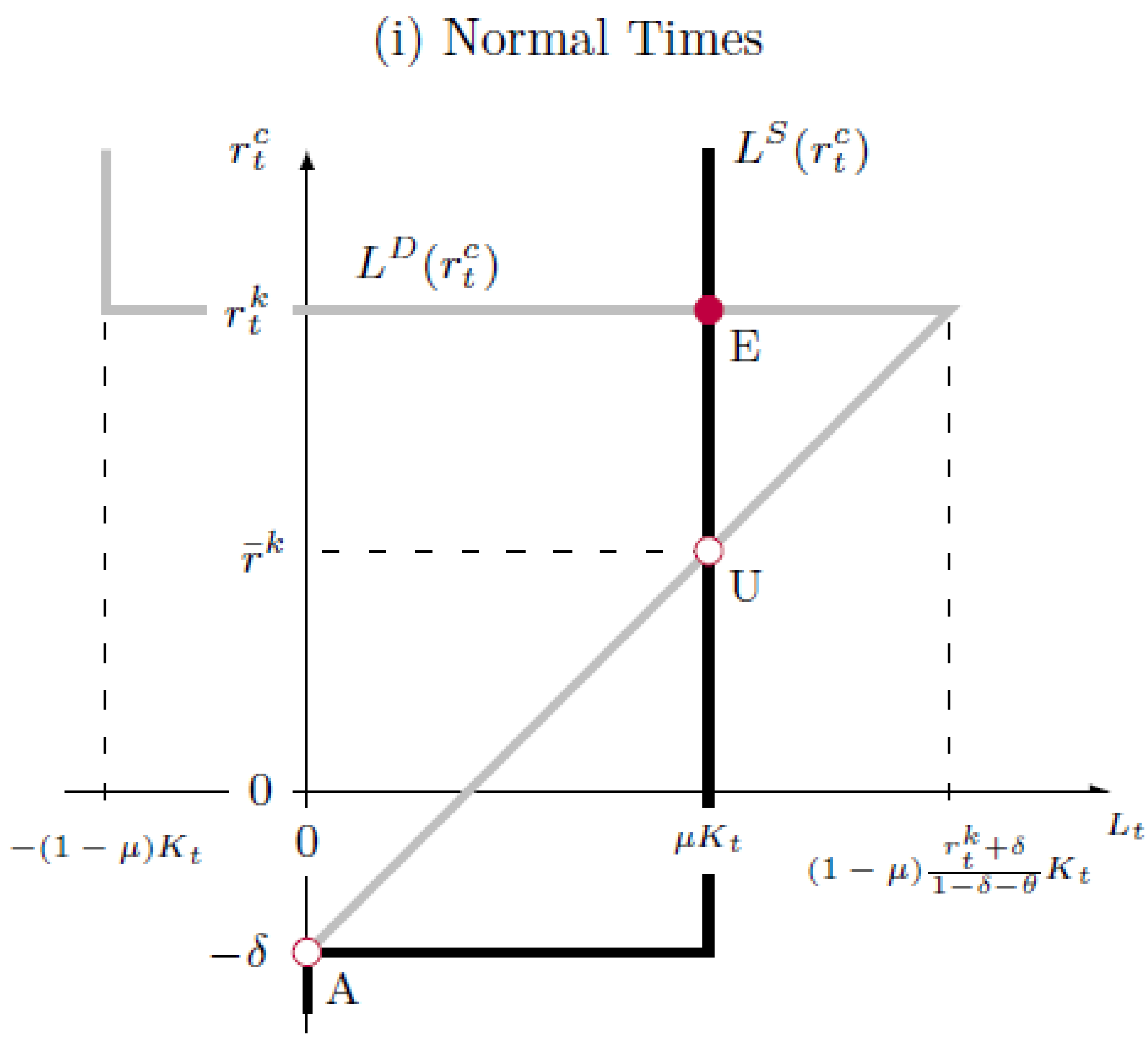
- Aggregate loan demand (by productive firms)

$$L_t^D = (1-\mu)(K_t^p - K_t) = \begin{cases} -(1-\mu)K_t & \text{for } r_t^c > r_t^k \\ \left[-(1-\mu)K_t, (1-\mu)\frac{r_t^c+\delta}{1-\delta-\theta}K_t\right] & \text{for } r_t^c = r_t^k \\ (1-\mu)\frac{r_t^c+\delta}{1-\delta-\theta}K_t & \text{for } r_t^c < r_t^k \end{cases}$$

- Market clearing

$$\mu(K_t - K_t^u) = (1-\mu)(K_t^p - K_t)$$

Credit Market Equilibrium: The Case with Frictions



Frictional Financial Markets: Equilibrium

- Case 1 ("high return on investment"):

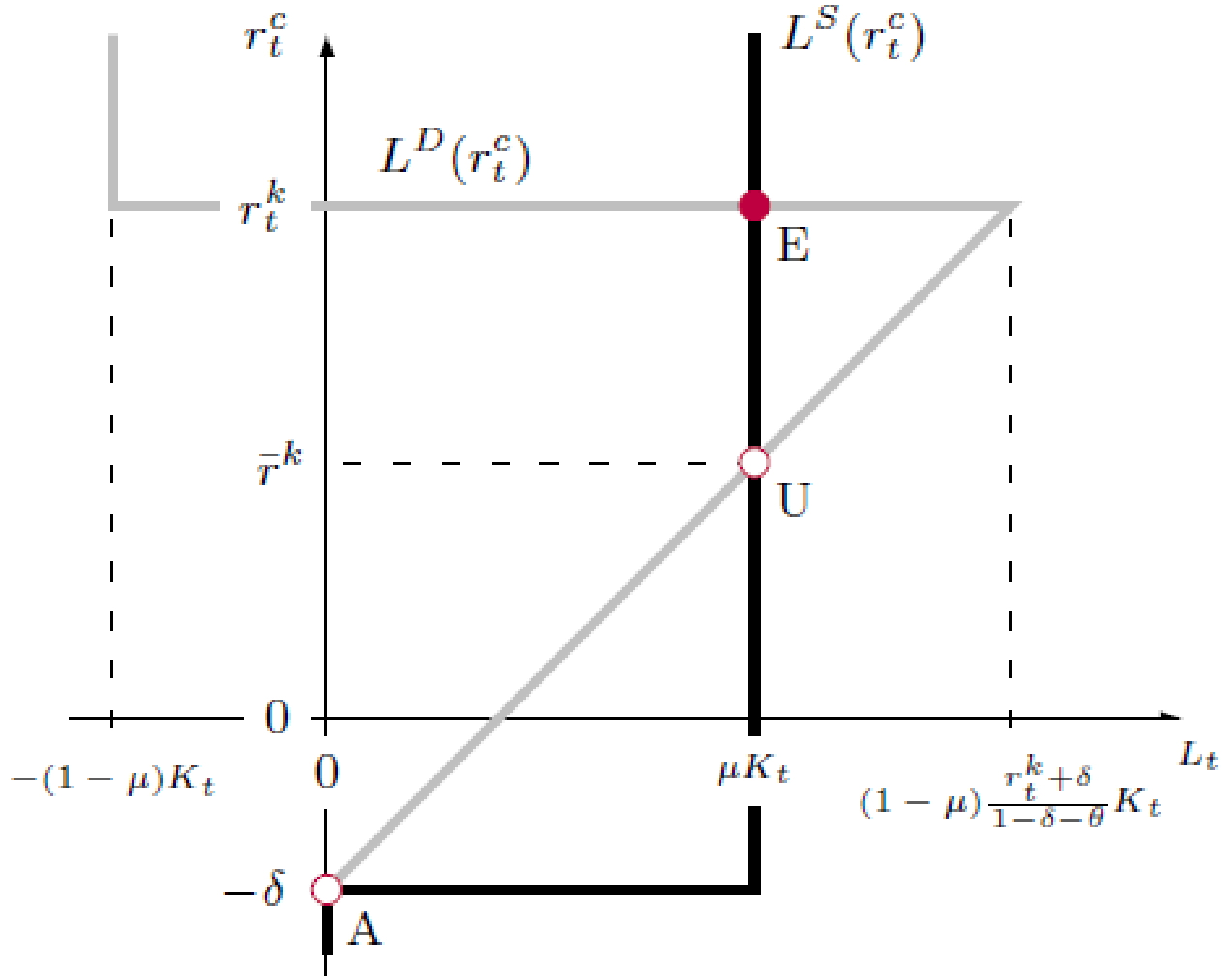
$$r_t^k \geq \frac{(1-\theta)\mu - \delta}{1-\mu} \equiv \bar{r}^k$$

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

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

Credit Market Equilibrium: The Case with Frictions

(i) Normal Times



The Frictional Loan Market: Equilibrium

- Case 1: ("high return on investment")

$$r_t^k \geq \frac{(1-\theta)\mu - \delta}{1-\mu} \equiv \bar{r}^k$$

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

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

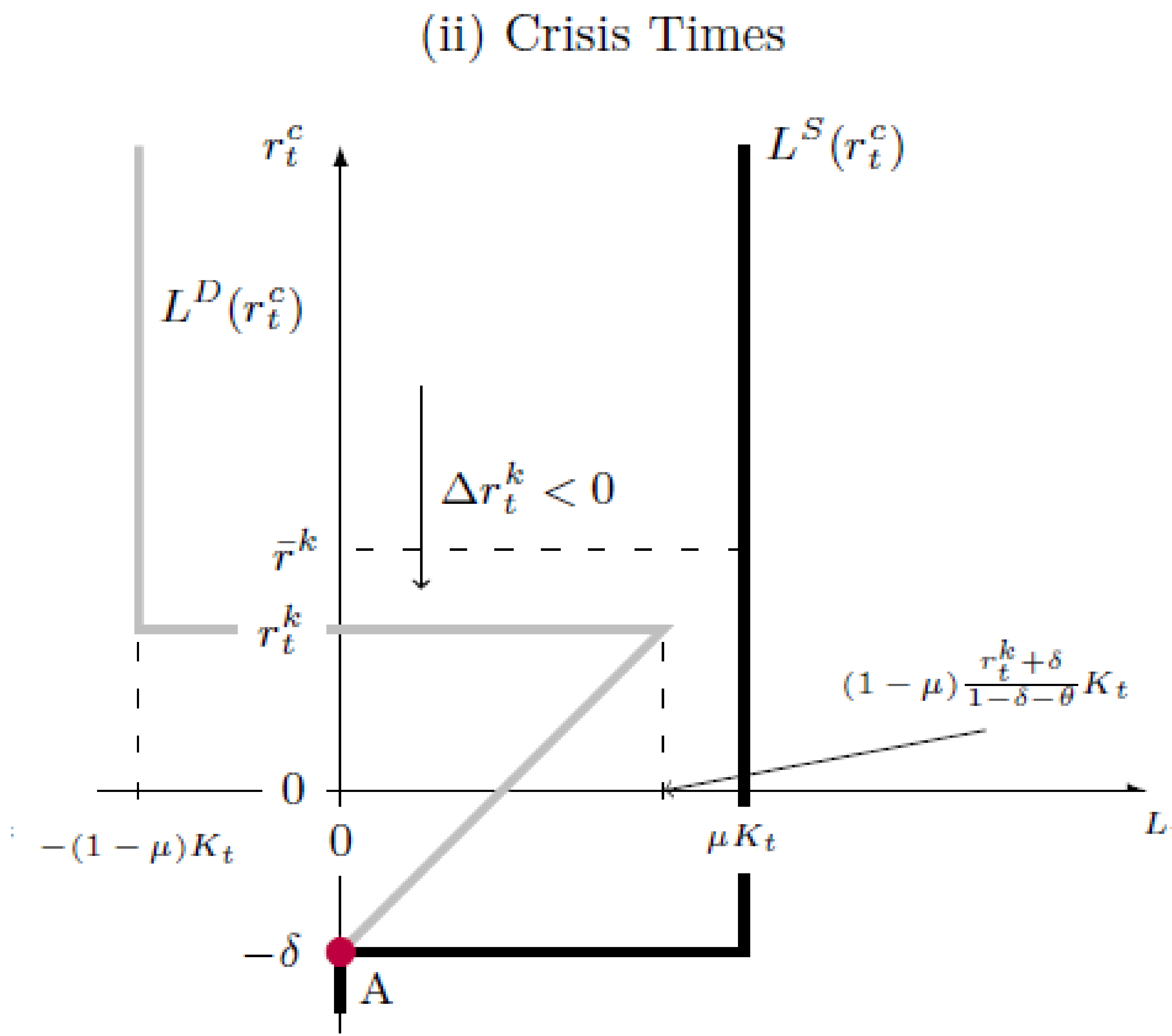
- Case 2: ("low return on investment")

$$r_t^k < \frac{(1-\theta)\mu - \delta}{1-\mu}$$

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

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

Credit Market Equilibrium: The Case with Frictions



Monetary Policy and Financial Fragility

- Financial crisis condition:

$$\frac{Y_t}{\mathcal{M}_t K_t} < \left(\frac{1-\tau}{\alpha}\right)\left(\frac{(1-\theta)\mu-\delta}{1-\mu}+\delta\right)$$

- *Given* K_t, a crisis can be triggered by a sufficiently low Y_t and/or sufficiently high $\mathcal{M}_t$ (e.g. by a large adverse demand shock)
- The larger is K_t, the smaller the decline in Y_t and/or increase in $\mathcal{M}_t$ to trigger a financial crisis ("financial fragility")
- Feedback effects: anticipation of a financial crisis raises precautionary savings, increasing K_t and hence financial fragility

$\Rightarrow$ potential gains from preventing "excessive" capital accumulation in the medium run
$\Rightarrow$ what can monetary policy do?

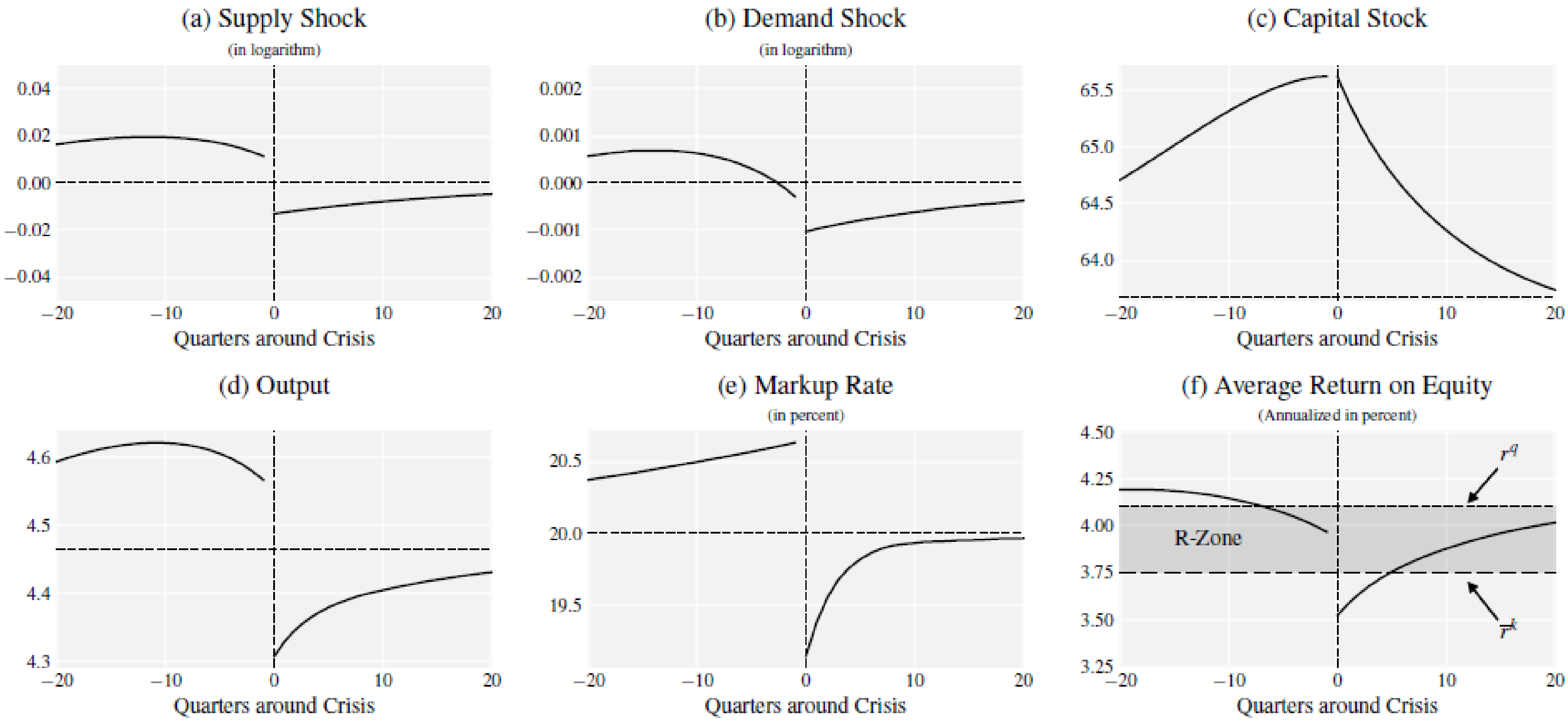
Anatomy of a Financial Crisis

- *Calibration*. Two non-standard parameters:

  $\mu = 0.05$, determines de decline in productivity due to misallocation $[1 - (1-\mu)^{\alpha} = 0.018]$
  $\theta = 0.52$ determines the incidence of crises, given other parameters' settings [10%]
  Rest of calibration standard, with Taylor (1993) 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 3: Average Dynamics Around Crises



Monetary Policy Options

- Optimal policy in the absence of financial frictions: strict inflation targeting (SIT).
- But generally not optimal with financial frictions since the flexible price equilibrium allocation is not necessarily efficient (due to inefficient financial crises).

Table 2: Economic Performance and Welfare Under Alternative Policy Rules

	Rule parameters			Model with Financial Frictions					Frictionless
	ϕ_π	ϕ_y	ϕ_r	Time in Crisis/Stress (in %)	Length (quarters)	Output Loss (in %)	Std(π_t) (in pp)	Welfare Loss (in %)	Welfare Loss (in %)
				Taylor–type Rules					
(1)	1.5	0.125	–	[10]	4.8	6.6	1.2	0.82	0.56
(2)	1.5	0.250	–	7.2	4.0	5.4	1.8	1.48	1.21
(3)	1.5	0.375	–	4.1	3.1	4.4	2.5	3.10	2.07
(4)	2.0	0.125	–	9.7	5.0	7.2	0.6	0.41	0.17
(5)	2.5	0.125	–	9.6	5.1	7.5	0.5	0.31	0.08
				SIT					
(6)	$+\infty$	–	–	9.4	5.1	8.1	–	0.23	0.00
				Augmented Taylor–type Rules					
(7)	1.5	0.125	5.0	5.4	3.9	5.5	1.16	0.65	–
(8)	5.0	0.125	5.0	8.8	5.0	7.4	0.18	0.22	–
(9)	5.0	0.125	25.0	6.9	4.7	6.6	0.19	0.18	–
(10)	10.0	0.125	75.0	6.3	4.6	6.4	0.09	0.16	–
				Backstop Rules					
(11)	1.5	0.125	–	15.5	–	–	1.21	0.56	–
(12)	$+\infty$	–	–	17.1	–	–	0.50	0.10	–

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- Output-stability oriented policies ($\uparrow \phi_y$) limit excessive capital accumulation thus reducing crisis incidence, but more than offset by the costs of inflation.

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- Taylor rule augmented with financial fragility indicator ("yield gap")

$$1 + i_t = \frac{1}{\beta}(1+\pi_t)^{\phi_\pi} \left(\frac{Y_t}{Y}\right)^{\phi_y} \left(\frac{1+r_t^q}{1+r^q}\right)^{\phi_q}$$

where

$$r_t^q = \int_0^1 r_t^q(j)dj = \begin{cases} r_t^k & \textit{for } r_t^k \geq \bar{r}^k \\ -\mu\delta + (1-\mu)r_t^k & \textit{for } r_t^k < \bar{r}^k \end{cases}$$

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- "Backstop" rule: Taylor rule augmented with constraint $r_t^k \geq \bar{r}^k$

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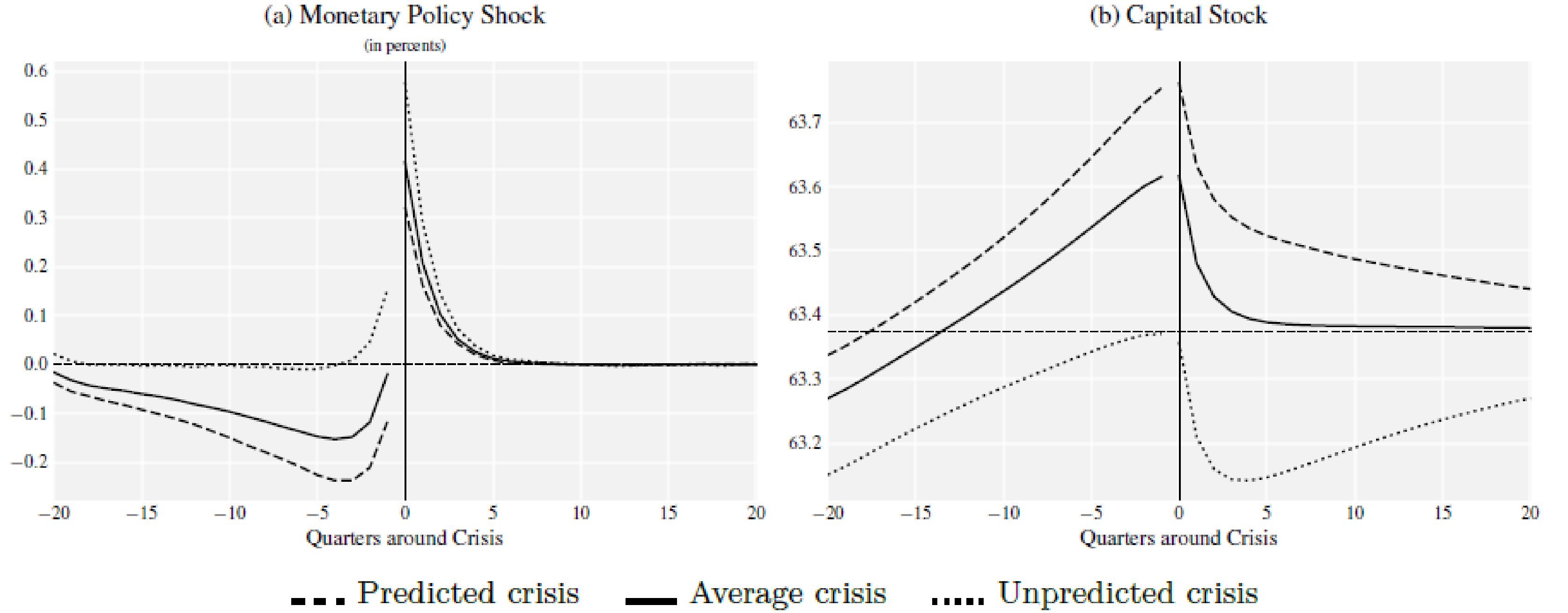
Discretionary Monetary Policy as a Source of Financial Instability

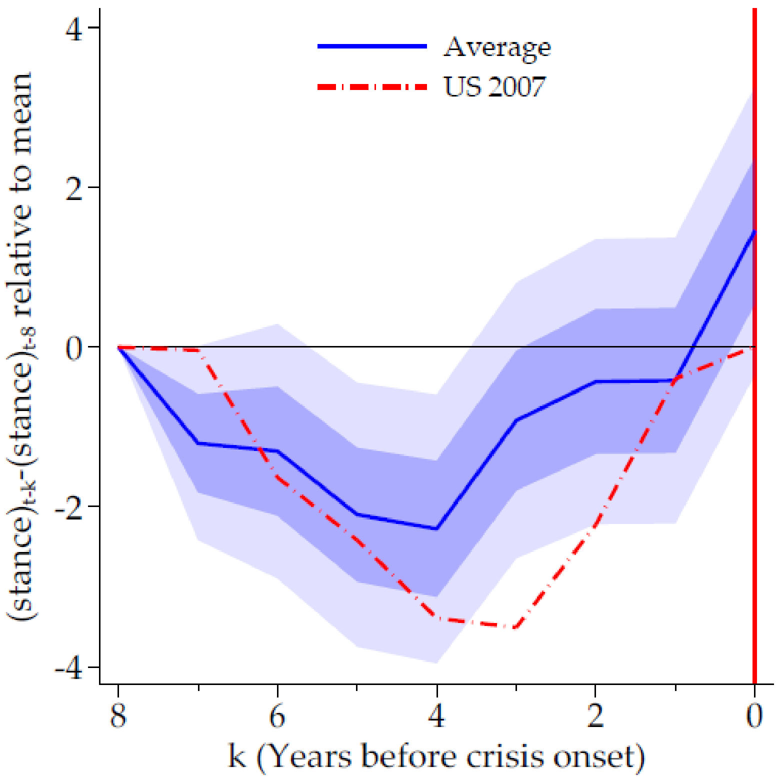
- Simulations with exogenous monetary policy shocks as the only source of fluctuations

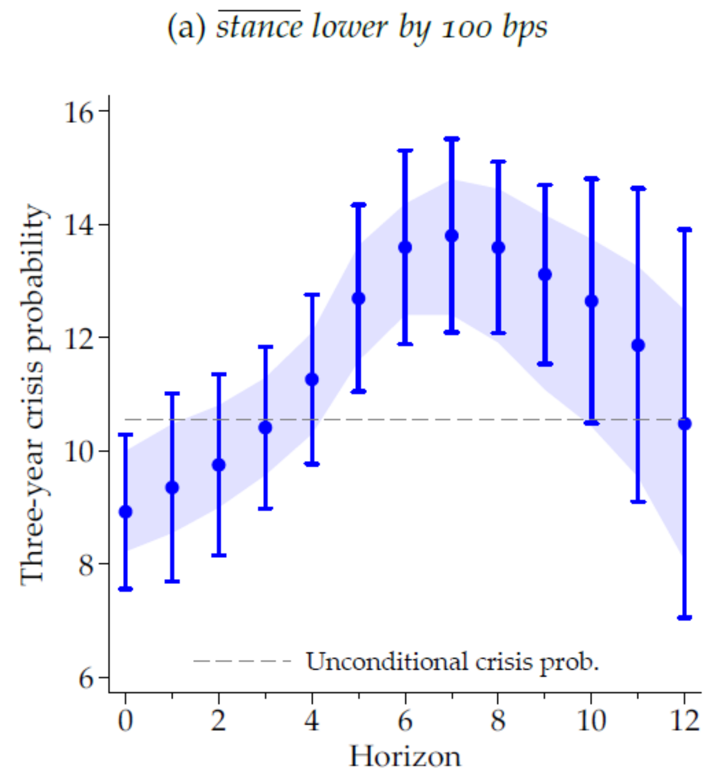
$$1 + i_t = \frac{1}{\beta}(1 + \pi_t)^{\phi_\pi} \left(\frac{Y_t}{Y}\right)^{\phi_y} \exp\{v_t\}$$

- Loose monetary policy as a source of financial crises
- The "late reaction curse"

Figure 7: Rates too Low for too Long May Lead to a Crisis

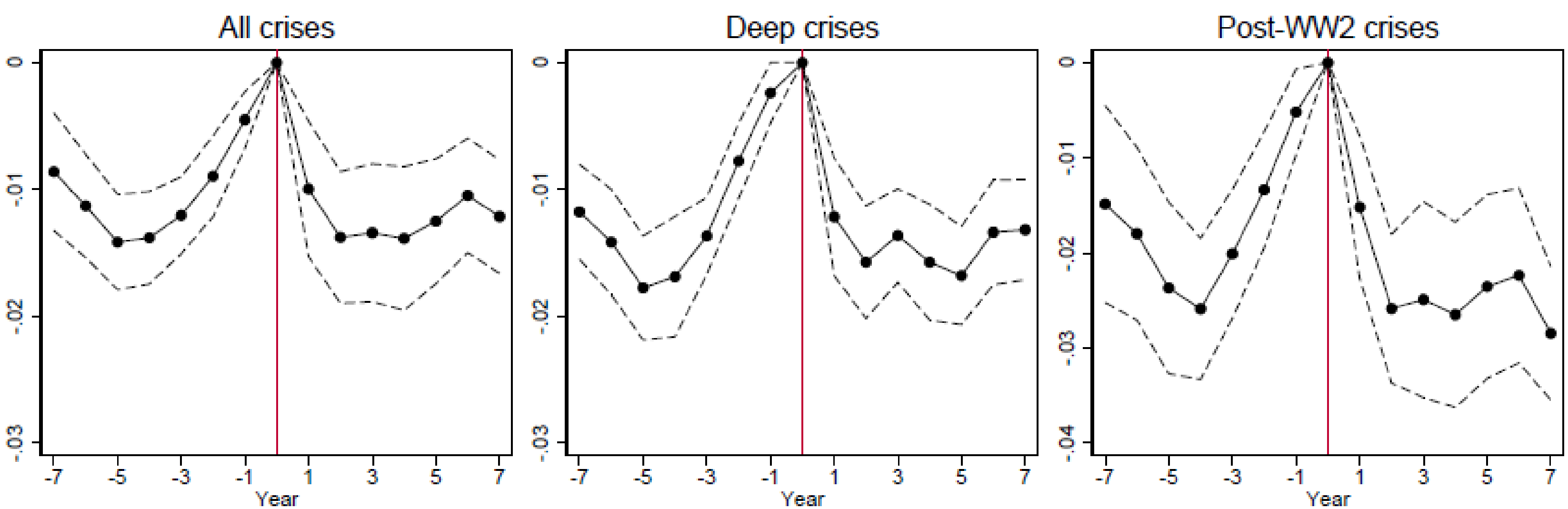






Source: Grimm-Jordà-Schularick-Taylor (2023)

Figure 3: *Monetary policy rates – crisis window regressions*



Notes: These graphs show the regression coefficients and 90% confidence intervals from regressing monetary policy rates on the crisis dummy for horizons $h = -7, ..., 0, ...7$, with 0 corresponding to the beginning of the crisis according to the Jordà et al. (2016) chronology. Deep crises are those with -3% or less GDP growth in one year, or average -1% or less GDP growth over 3 years in the $t-1$ to $t+3$ crisis window. Post-WW2 crises are those that started after 1945.

Source: Jiménez-Kuvshinov-Peydró-Richter (2023)

Robustness

- Demand shocks
- Intermediated finance
- Infinitely-lived, ex-ante heterogenous firms
- One financial friction only (not robust)

- asymmetric information
- limited enforceability

Conclusion

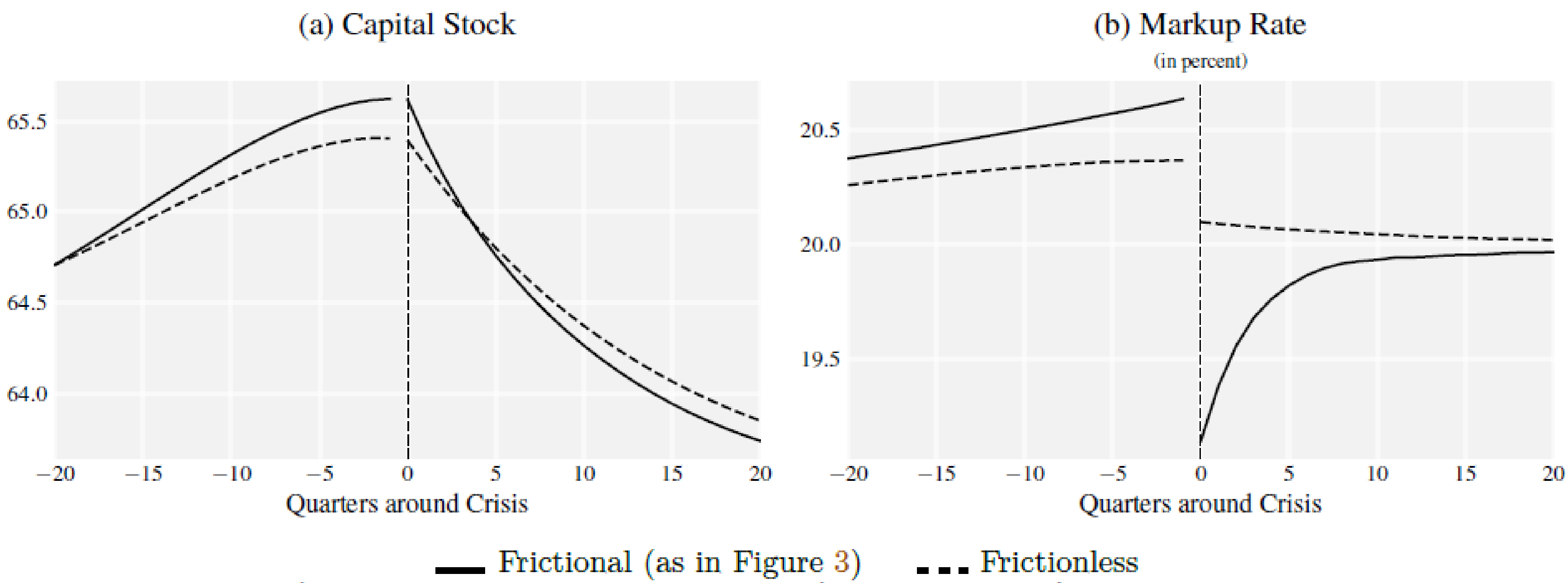
- Extension of the basic NK model with financial frictions and endogenous financial crises
- Focus on one dimension of financial crises: misallocation (and loss in productivity) resulting from failure of credit markets.
- Proximate source of the crisis: low returns on productive investment resulting from a capital overhang following a protracted investment boom.
- Rationale for deviating from price stability as a single focus of monetary policy

$\Rightarrow$ need to avert financial fragility

Table 1: Parametrization

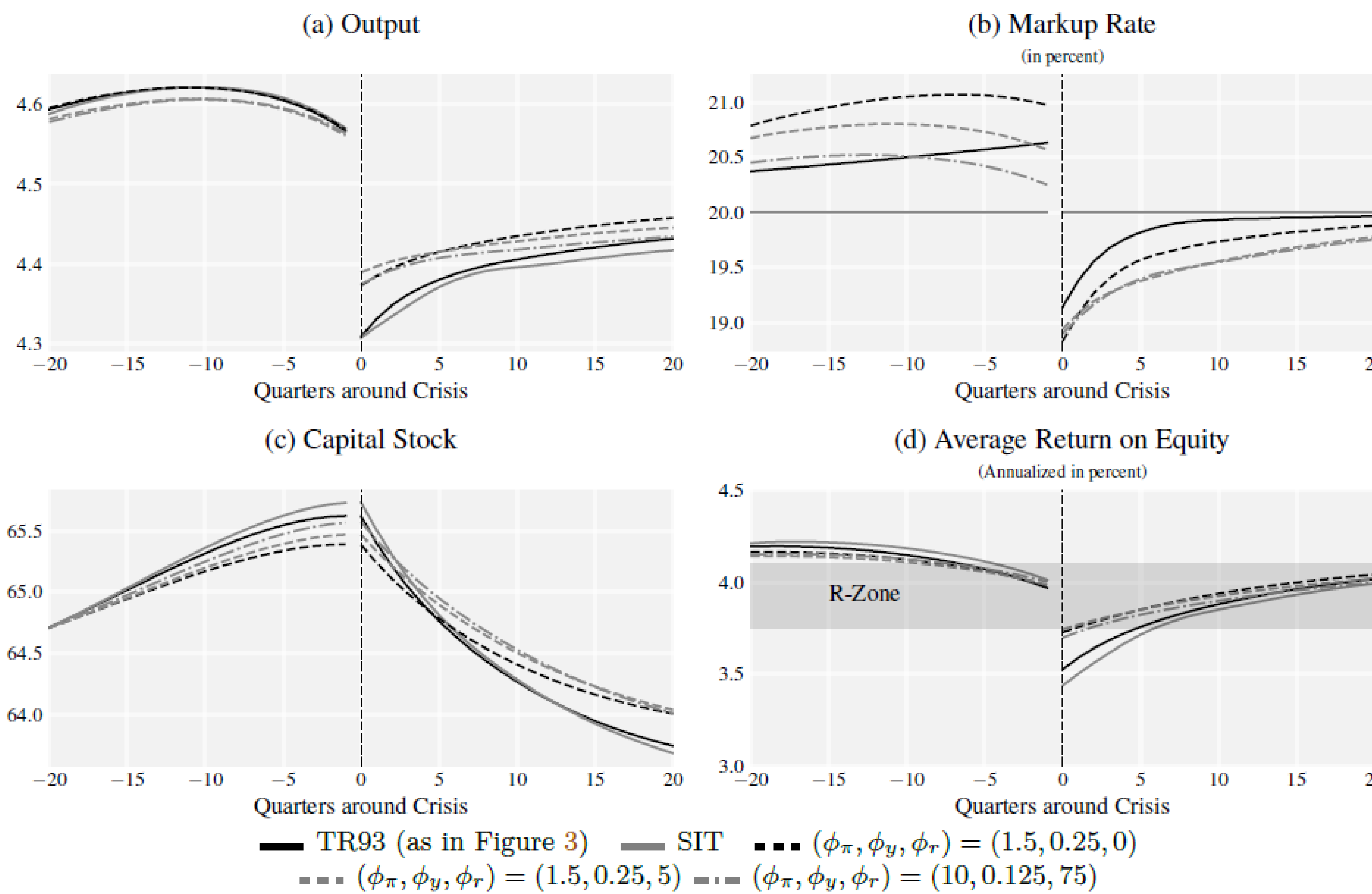
Parameter	Target	Value
Preferences		
β	4% annual real interest rate	0.989
σ	Logarithmic utility on consumption	1
φ	Inverse Frish elasticity equals 2	0.5
χ	Steady state hours equal 1	0.81
Technology and price setting		
α	64% labor share	0.36
δ	6% annual capital depreciation rate	0.015
ϱ	Same slope of the Phillips curve as with Calvo price setting	58.22
ϵ	20% markup rate	6
Aggregate TFP (supply) shocks		
ρ_a	Standard persistence	0.95
σ_a	Volatility of inflation and output in normal times (in %)	0.81
Aggregate Demand shocks		
ρ_z	Standard persistence	0.95
σ_z	Volatility of inflation and output in normal times (in %)	0.16
Interest rate rule		
ϕ_π	Response to inflation under TR93	1.5
ϕ_y	Response to output under TR93	0.125
Financial Frictions		
μ	Productivity falls by 1.8% due to financial frictions during a crisis	0.05
θ	The economy spends 10% of the time in a crisis	0.52

Figure 4: Saving Glut and Markup Externalities



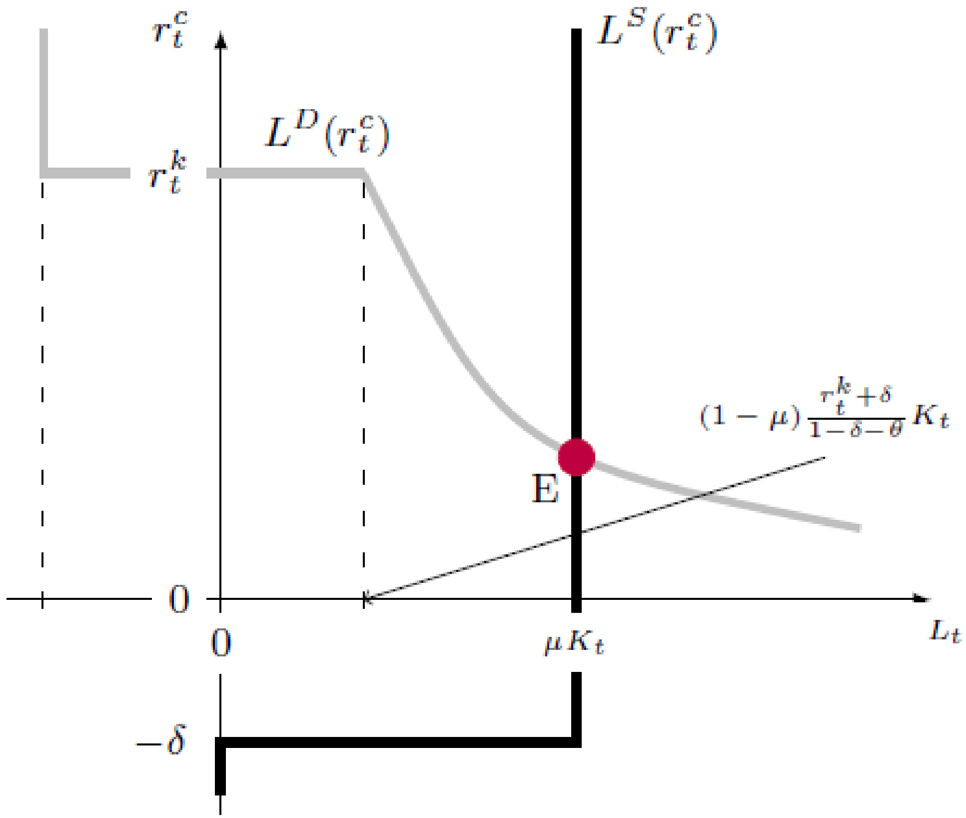
Notes: Comparison of two economies under TR93 with a frictional *versus* frictionless credit market around the beginning of a crisis (in quarter 0). For the frictional credit market economy: same average dynamics as in Figure 3. For the frictionless credit market economy: counterfactual average dynamics, when the economy starts with the same capital stock in quarter −20 and is fed with the same aggregate shocks as the frictional credit market economy.

Figure 5: Counterfactual Booms and Busts

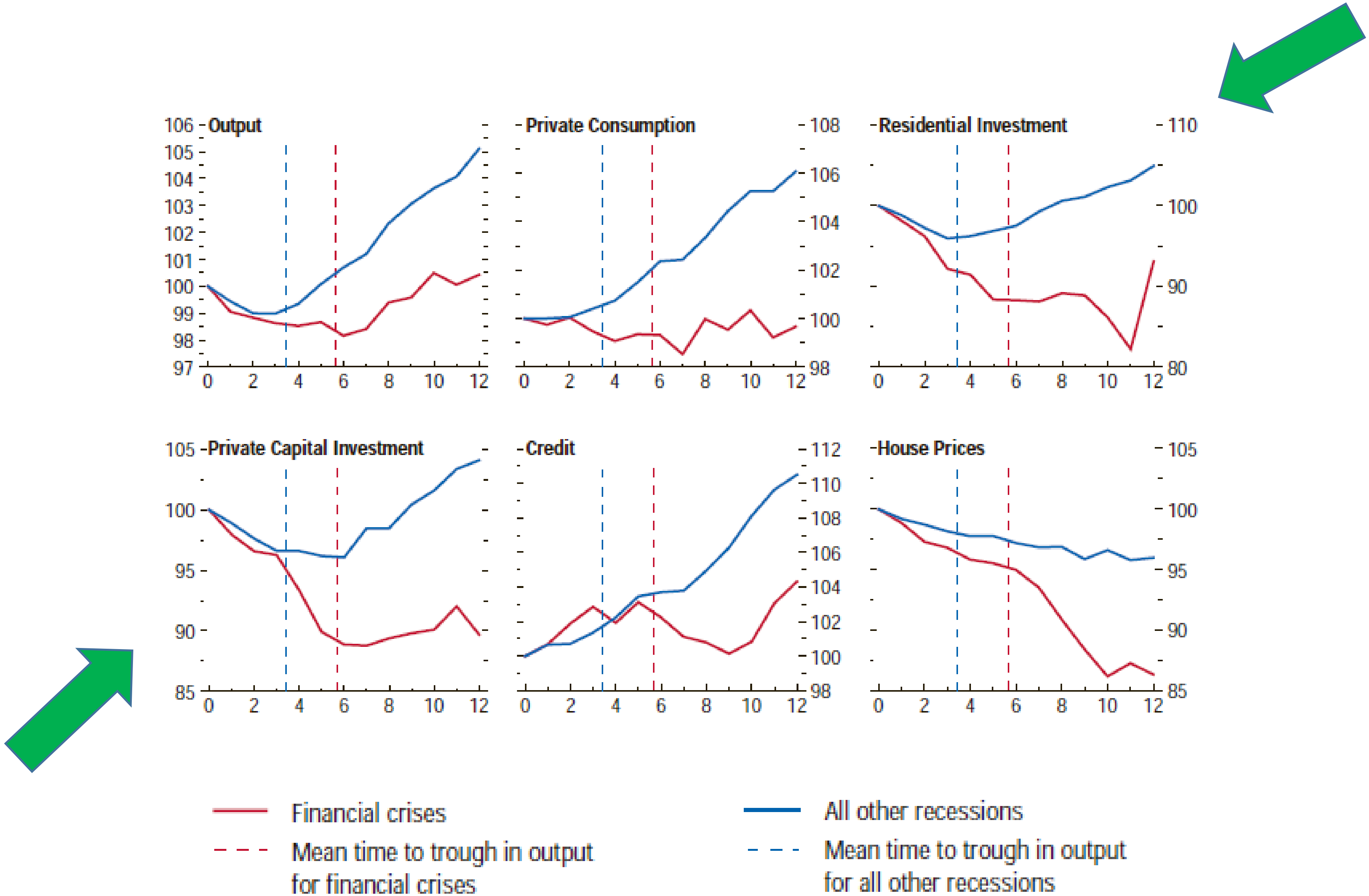


Notes: For TR93: same average dynamics as in Figure 3. For the other rules: counterfactual average dynamics, when the economy starts with the same capital stock in quarter −20 and is fed with the same aggregate shocks as the TR93 economy.

Figure 8: Credit Market Equilibrium Under Symmetric Information



Notes: This figure illustrates unproductive firms' aggregate credit supply (black) and productive firms' aggregate credit demand (gray) curves, when credit contracts are not enforceable but information is symmetric.



Source IMF WEO April 2009