# Optimal Bank Reserve Remuneration and Capital Control Policy

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# Starting Point

- Existing open-economy models with a pecuniary externality due to collateral constraints assume that domestic agents borrow directly from foreign lenders.

- In reality, private agents seldom borrow directly from foreign lenders. Instead, capital inflows are intermediated by banks operating in domestic markets.

- **Questions**

How does abstracting from bank intermediation affect the predictions of this class of models? Specifically, what does
– optimal macroprudential policy and
– optimal bank reserve remuneration policy
look like?

**This paper** studies an open economy with:

**(1) a collateral constraint:** household debt is limited by a fraction of income (Mendoza, 2002; Bianchi, 2011; Korinek, 2011; Benigno et al., 2013; Schmitt-Grohé and Uribe, 2021).

**(2) bank intermediation:** banks receive deposits from foreign investors and lend them to domestic households.
— bank intermediation is costly.
— banks can mitigate the cost of originating loans by holding reserves at the central bank.
(Cúrdia and Woodford, 2011; Eggertsson et al., 2019).

**(3) a benevolent government:** sets the interest rate on bank reserves and levies capital control taxes.

# Main Results

- Under plausible calibrations, the economy **underborrows**: the economy without government intervention has too little external debt relative to the economy in which the government sets optimally the interest rate on bank reserves and capital controls.

- This result overturns the standard overborrowing result obtained in the absence of a banking channel.

- Optimal bank remuneration is countercyclical: both bank reserves and interest on bank reserves increase during contractions and decline during booms.

- Absent policy intervention bank reserves are procyclical.

# Intuition for Main Results

- look at the balance sheet of the bank:

**domestic loans + bank reserves = foreign deposits**

- bank reserves act as a buffer between loans and foreign deposits.

- when the economy suffers a negative shock that causes a sharp contraction in loans due to households being collateral constrained **(household deleveraging)**, the government expands bank reserves to avoid a collapse in external borrowing **(economy wide deleveraging)**.

- the government's increased holdings of bank reserves make their way into the household's budget constraint via a more relaxed fiscal policy (lender of last resort to households).

- this mechanism is absent in models in which households borrow directly from foreign lenders.

# Banks

The bank's sequential budget constraint

$$l_t + r_t + (1 + i^d_{t-1})d_{t-1} + \pi_t + \Gamma(\underset{+}{l_t}, \underset{-}{r_t}) = (1 + i^l_{t-1})l_{t-1} + (1 + i^r_{t-1})r_{t-1} + d_t$$

**Notation:**

$d_t, l_t, r_t$ = deposits, loans, and bank reserves
$i^d_t, i^l_t, i^r_t$ = interest rates on deposits, loans, and reserves
$\pi_t$ = bank dividends
$\Gamma(l_t, r_t)$ = convex bank operating costs

## Dividend Policy

$$\pi_t = (1 + i^l_{t-1})l_{t-1} + (1 + i^r_{t-1})r_{t-1} - (1 + i^d_{t-1})d_{t-1}$$

# Households

$$\max E_0 \sum_{t=0}^{\infty} \beta^t u(c_t),$$

subject to the aggregation technology

$$c_t = A(c_t^T, c_t^N),$$

to the sequential budget constraint,

$$c_t^T + p_t c_t^N + (1 + i_{t-1}^l) l_{t-1} = (1 - \tau_t)[y_t^T + p_t y_t^N + \pi_t] + l_t,$$

and to the collateral constraint

$$l_t \leq \kappa (y_t^T + p_t y_t^N).$$

**Pecuniary Externality:** $p_t$ on the RHS of the collateral constraint is taken as given by households, but is endogenously determined in equilibrium.

**Notation:**
$c_t, c_t^T, c_t^N =$ consumption, consumption of tradables/nontradables;
$p_t =$ relative price of nontradables in terms of tradables;
$y_t^T, y_t^N =$ exogenous endowments of tradables/nontradables;
$\tau_t =$ income tax (subsidy) rate.

# The Government

— levies income taxes at the rate $\tau_t$
— levies capital control taxes at the rate $\tau_t^c$
— remunerates bank reserves at the interest rate $i_t^r$
— incurs a cost $\Gamma^r(r_t)$ of running the bank reserve facility

Its budget constraint is

$$\tau_t(y_t^T + p_t y_t^N + \pi_t) + \tau_{t-1}^c(1+i^*)d_{t-1} + r_t = (1+i_{t-1}^r)r_{t-1} + \Gamma^r(\underset{+}{r_t}),$$

with $\Gamma^r(\cdot)$ increasing and convex.

# Foreign Lenders

Banks take deposits from foreign lenders at the world interest rate $i^*$ and pay capital control taxes at the rate $\tau_t^c$.

Thus, the effective rate banks pay on deposits is

$$1 + i_t^d = (1 + \tau_t^c)(1 + i^*)$$

# Calibration of Financial Frictions

Collateral constraint: $l_t \leq \kappa(y_t^T + p_t y_t^N)$
Bank cost function: $\Gamma(l_t, r_t) = A l_t^{1+\alpha}[1 + \phi(r_t - \bar{r})^2 I(r_t < \bar{r})]$
Central bank cost function: $\Gamma^r(r_t) = B r_t^{1+\alpha}$

The 6 parameters defining these financial frictions, $\kappa$, $A$, $\alpha$, $\phi$, $\bar{r}$, and $B$, are set by SMM to match 6 empirical first moments in emerging countries under laissez faire:

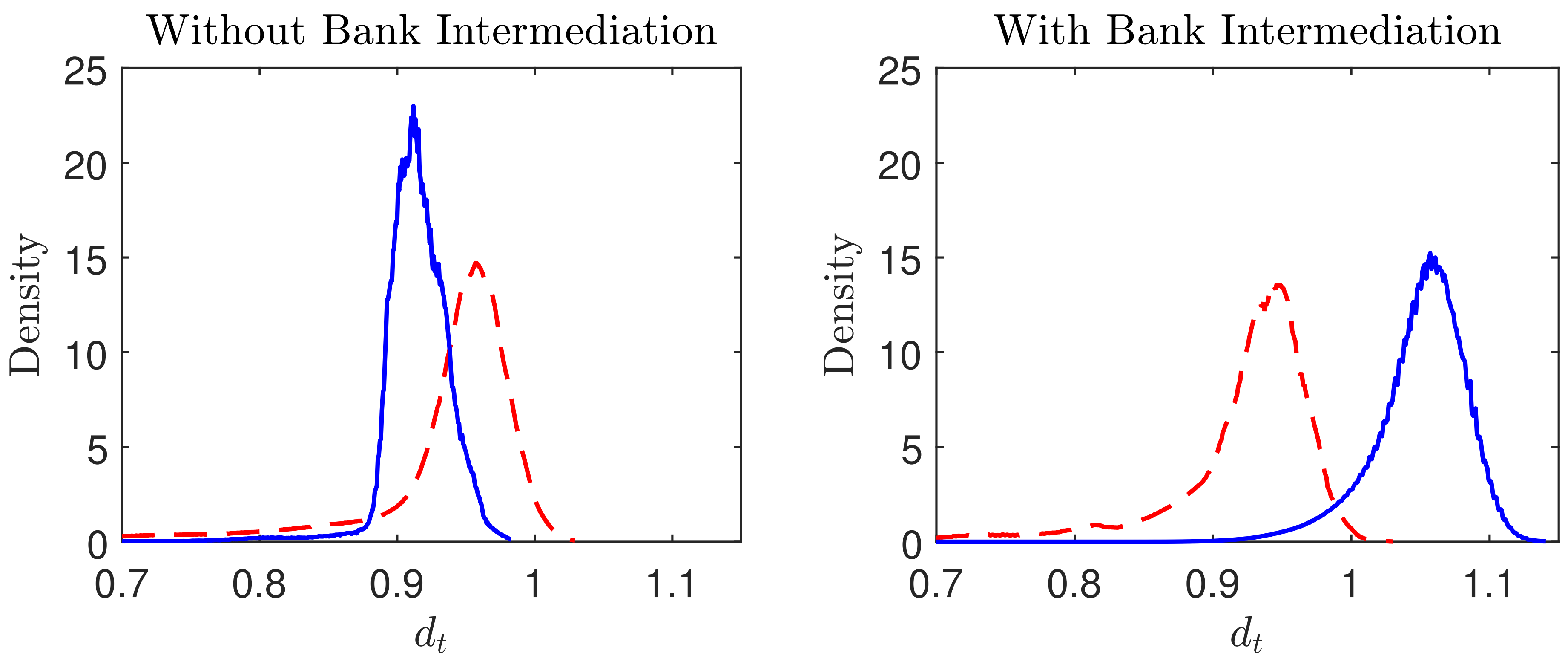
(1) The lending spread, $(i^l - i^d)/(1 + i^d) = 0.0499$
(2) The reserve-to-deposit ratio, $r/d = 0.0644$
(3) Debt to GDP ratio, $d/(y^T + py^N) = 0.29$
(4) The bank operating cost as a fraction of the volume of deposits, $\Gamma(l, r)/d = 0.0175$
(5) The central bank's operating cost as a fraction of reserves, $\Gamma^r(r)/r = 0.0205$.
(6) The frequency of a binding collateral constraint, 0.05

This results in $\kappa = 0.3205$, $A = 0.0089$, $\alpha = 1.8104$, $\phi = 6.7983$, $\bar{r} = 0.5848$, $B = 2.6852$.

# Fit of SMM Conditions

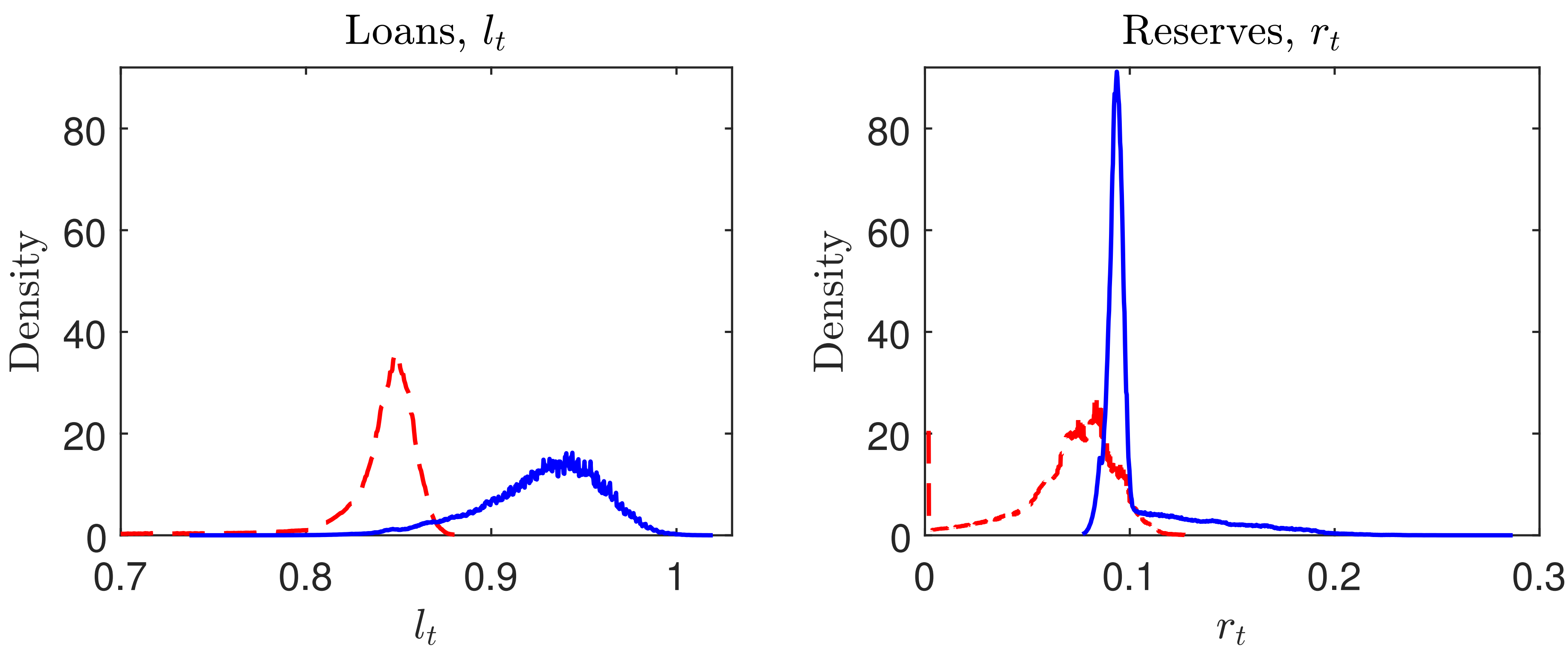
| | Moment | Formula | Observed | Predicted |
|---|---|---|---|---|
| (1) | Lending spread | $\frac{i^l - i^d}{1+i^d}$ | 0.0499 | 0.0509 |
| (2) | Reserve-to-deposit ratio | $\frac{r}{d}$ | 0.0644 | 0.0712 |
| (3) | Debt-to-output ratio | $\frac{d}{y^T + p y^N}$ | 0.2900 | 0.2992 |
| (4) | Intermediation-cost-to-deposit ratio | $\frac{\Gamma(l,r)}{d}$ | 0.0175 | 0.0165 |
| (5) | Central-bank-operating-cost-to-reserve ratio | $\frac{\Gamma^r(r)}{r}$ | 0.0205 | 0.0228 |
| (6) | Frequency of binding collateral constraint | | 0.0500 | 0.0530 |

## Unconditional Distributions of Debt With and Without a Bank Intermediation Channel




Solid lines: constrained optimal allocation
Broken lines: unregulated economy
The figure shows that in the absence of the banking channel there is **overborrowing**, whereas in its presence there is **underborrowing**.

# Unconditional Distributions of Loans and Reserves



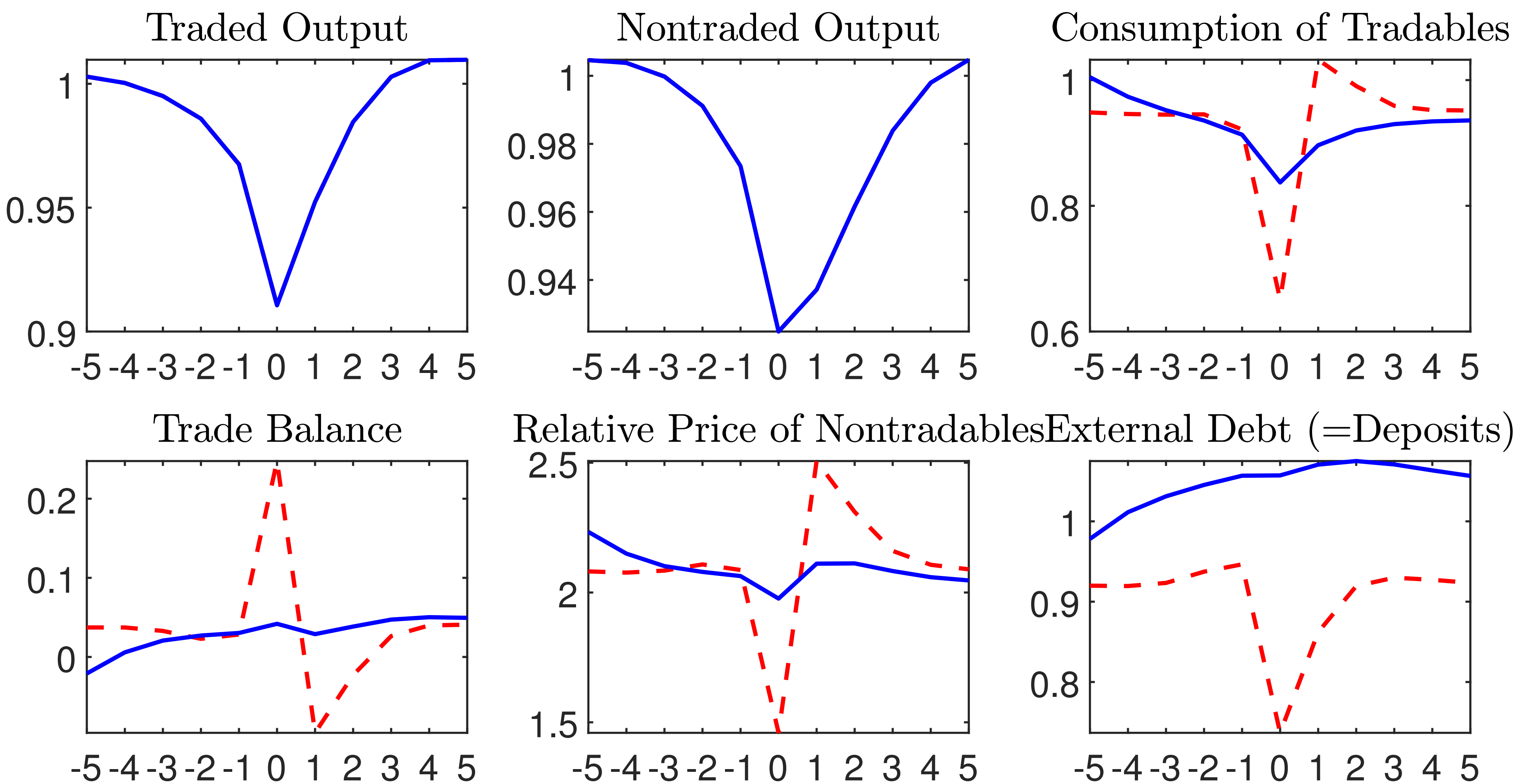

Solid lines: constrained optimal allocation ($i_t^r$ and $\tau_t^c$ set optimally).
Broken lines: unregulated economy ($i_t^r = \tau_t^c = 0$).
The figure shows that households borrow more under the optimal macroprudential policy. Of particular interest is the fat right tail of bank reserves under the optimal policy, reflecting their insurance role.

# Unconditional Correlations of Reserves with Loans and Output

| | Laissez-faire | Constrained optimal |
|---|---|---|
| corr$(r_t, l_t)$ | 0.81 | $-0.38$ |
| corr$(r_t, y_t^T + p_t y_t^N)$ | 0.30 | $-0.75$ |

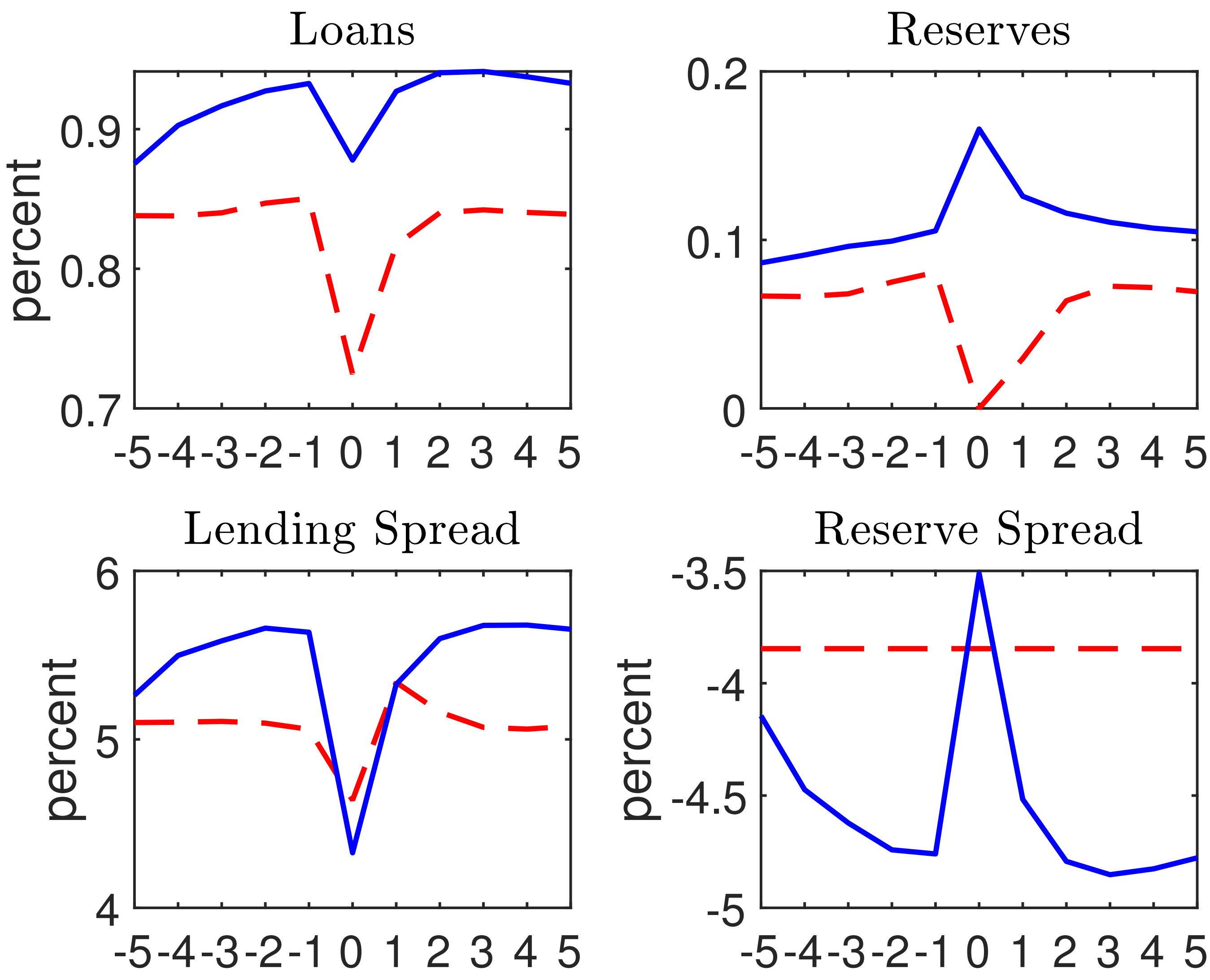
Note. The column labeled laissez-faire corresponds to the competitive equilibrium with $i_t^r = \tau_t^c = 0$ and the column labeled constrained optimal to the competitive equilibrium with $i_t^r$ and $\tau_t^c$ chosen optimally.

# The Typical Sudden Stop with Optimal Policy




**Broken lines: unregulated economy** **Solid lines: constrained optimal allocation**

# The Typical Sudden Stop with Optimal Policy (ctd.)




**Broken lines: unregulated economy** **Solid lines: constrained optimal allocation**

# Conclusion

• This paper adds bank intermediation to an open economy in which household borrowing is limited by a fraction of income.

• It shows that under plausible calibrations, the unregulated economy underborrows, that is, its external debt is lower than in the economy with optimal reserve remuneration and capital control policy.

• This result overturns the standard overborrowing result obtained absent bank intermediation.

• The paper shows that under optimal policy bank reserves are countercyclical, whereas absent policy intervention bank reserves are procyclical.

• **Intuition** By raising bank reserves during episodes in which the collateral constraint binds, the government acts as a lender of last resort to households allowing the economy to continue to have access to external funding in spite of the fact that households are being forced to deleverage.

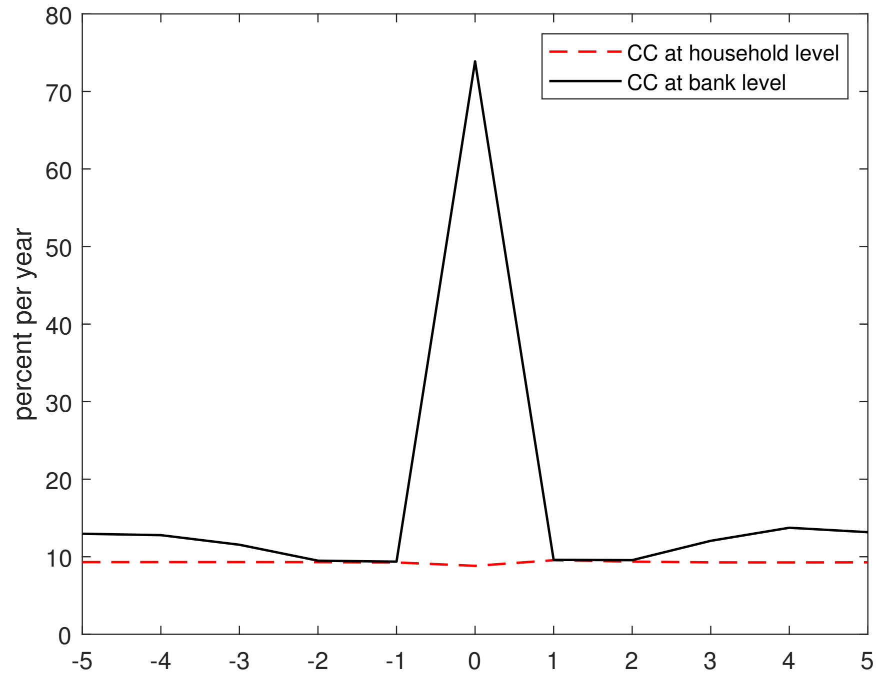
# EXTRAS

- The model predicts that lending spreads fail to rise during a crisis.

- This is so because the borrowing constraint is placed at the household level.

- What if the borrowing constraint is placed at the level of the bank?

# Behavior of $i_t^l$ around sudden stops in the unregulated economy when collateral constraint is at the bank level



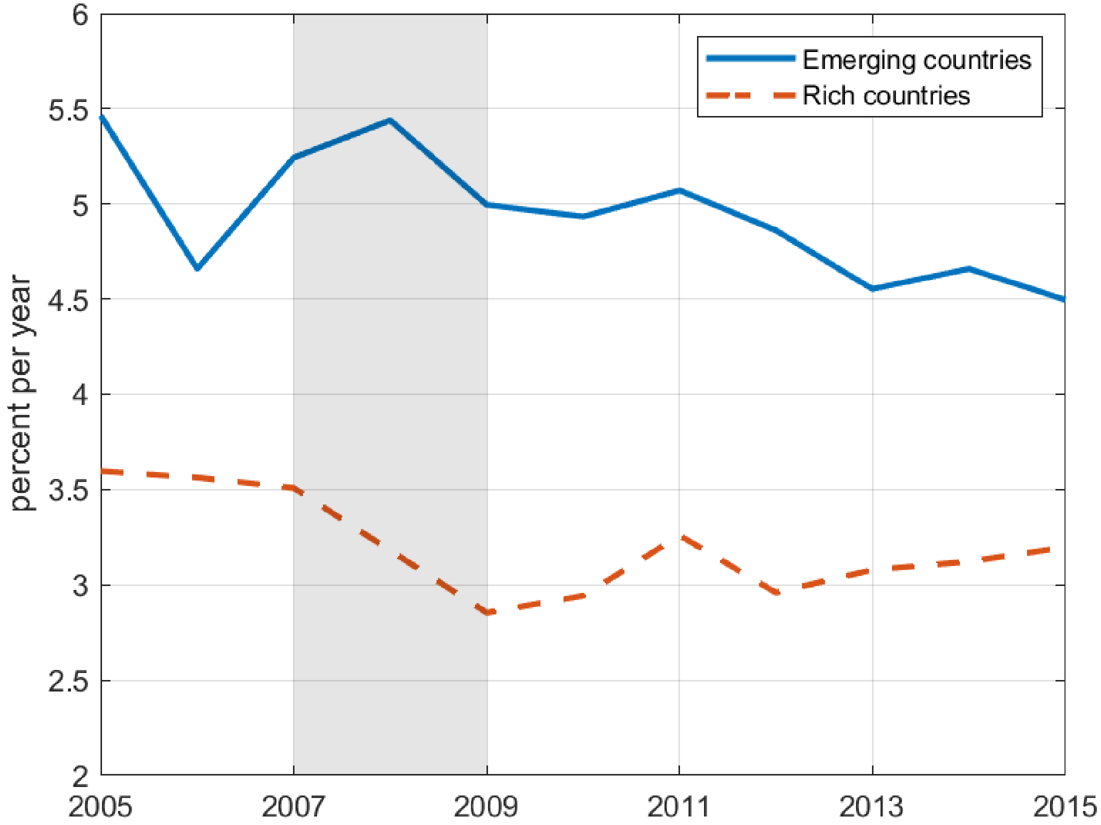

Note. The horizontal axis measures time. The collateral constraint binds in period 0.

• When the collateral constraint is placed at the level of the bank, the model predicts that in the period of a binding collateral constraint the loan rate spikes at over 70 percent. By contrast, when the collateral constraint is placed at the level of the household, then the loan rate does not spike; in fact, it declines by 45 bp.

- Rockoff (2021):

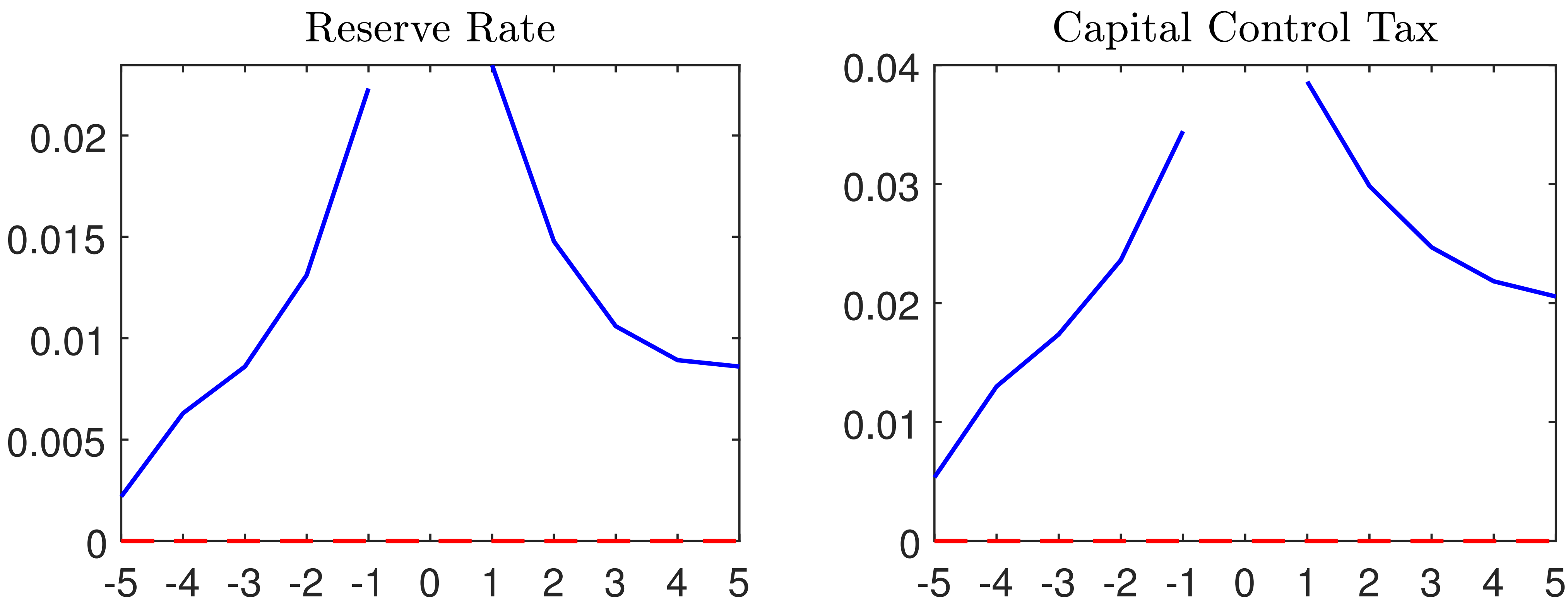
  Historically, the presumption that a key symptom of a financial crisis is a sharp increase in the lending rate has led to the misdiagnosis of major financial crises. Oliver M. W. Sprague (*the* expert on financial crises at the time) failed to recognize the 1929-1932 financial crisis for lack of an increase in lending spreads.

# Lending Spreads around the Global Financial Crisis in Emerging and Rich Countries




Notes. The lending spread, $(i_t^l - i_t^d)/(1+i_t^d)$, is computed as the median of the annual lending spread across a group of emerging and rich countries, respectively. The classification of countries follows Uribe and Schmitt-Grohé (2017). Countries with populations smaller than 1 million or with missing data over the period 2005-2015 were excluded. The 32 emerging countries included are: Albania, Algeria, Argentina, Bahrain, Bolivia, Botswana, Brazil, Bulgaria, Chile, Colombia, Costa Rica, Dominican Republic, Egypt, Greece, Guatemala, Hungary, Iran, Jordan, South Korea, Malaysia, Mexico, Namibia, New Zealand, Panama, Paraguay, Peru, Portugal, Spain, Thailand, Trinidad and Tobago, Uruguay, and Venezuela. The 9 rich countries included are: Australia, Canada, Hong Kong, Ireland, Italy, Japan, Singapore, Switzerland, and United States. The data source is IMF, International Financial Statistics, the measure for the loan rate, $i_t^l$, is the series FILR_PA and the measure for the deposit rate, $i_t^d$, is the series FIDR_PA. Shading indicates the global financial crisis of 2007 to 2009.

## Optimal $i_t^r$ and $\tau_t^c$ around sudden stops




Note. The dynamics associated with the constrained optimal allocation are shown with a solid blue line and the dynamics associated with the unregulated economy with a broken red line.

# Functional Forms and Calibration

CRRA period utility function

$$u(c_t) = \frac{c_t^{1-\sigma} - 1}{1-\sigma},$$

CES aggregator function

$$c_t = \left[ a {c_t^T}^{1-1/\xi} + (1-a) {c_t^N}^{1-1/\xi} \right]^{1/(1-1/\xi)},$$

Calibration: use standard values in the related literature:

$$\sigma = 2$$
$$\xi = 0.83$$
$$a = 0.31$$

## Functional Forms and Calibration (cont.)

• **The world interest rate:**

$$i^* = 0.04$$

This is a standard value in business-cycle analysis.

• **The subjective discount factor,** $\beta$, is set to match the average relative impatience factor, $\beta(1+i^l)$, to
(a) be consistent with that in Bianchi (2011), $\beta^B(1+i^*)$, where $\beta^B = 0.91$ is the subjective discount factor used by Bianchi; and
(b) be consistent with an observed lending spread$(1+i^l)/(1+r^*)-1$ of 0.0499.
This yields

$$\beta = 0.8667$$

## Sources of Uncertainty

- The driving forces are the exogenous endowments, $y_t^T$ and $y_t^N$, which are assumed to follow a bivariate AR(1) process.

- The stochastic process for $(y_t^T, y_t^N)$ is taken from Bianchi (2011).

# Calibration

| Parameter | Value | Description |
|---|---|---|
| | | Structural Parameters |
| $\sigma$ | 2 | Inverse of intertemporal elasticity of consumption |
| $a$ | 0.31 | Parameter of CES aggregator |
| $\xi$ | 0.83 | Elasticity of substitution between tradables and nontradables |
| $i^*$ | 0.04 | World interest rate |
| $\beta$ | 0.8667 | Subjective discount factor |
| $\kappa$ | 0.3205 | Parameter of collateral constraint |
| $A$ | 0.0089 | Parameter of intermediation cost function $\Gamma(l, r)$ |
| $\alpha$ | 1.8104 | Parameter of the intermediation cost functions $\Gamma(l, r)$ and $\Gamma^r(r)$ |
| $\phi$ | 6.7983 | Parameter of intermediation cost function $\Gamma(l, r)$ |
| $\bar{r}$ | 0.5848 | Parameter of intermediation cost function $\Gamma(l, r)$ |
| $B$ | 2.6852 | Parameter of intermediation cost function $\Gamma^r(r)$ |
| | | Discretization of State Space |
| $n_{y^T}$ | 13 | Number of grid points for $\ln y_t^T$, equally spaced |
| $n_{y^N}$ | 13 | Number of grid points for $\ln y_t^N$, equally spaced |
| $n_d$ | 800 | Number of grid points for $d_t$, equally spaced |
| $\left[\ln \underline{y}^T, \ln \overline{y}^T\right]$ | [-0.1093, 0.1093] | Range for logarithm of tradable output |
| $\left[\ln \underline{y}^N, \ln \overline{y}^N\right]$ | [-0.1328, 0.1328] | Range for logarithm of nontradable output |
| $[\underline{d}, \overline{d}]$ | [0.4, 1.05] | Debt range unregulated economy |

Note. The time unit is a year.

# Non-Equivalence of Reserve Remuneration and Reserve Requirements

- In many emerging markets central banks do not remunerate reserves but instead impose reserve requirements.

- Model with reserve requirements and capital controls:

  - $i_t^r = 0$

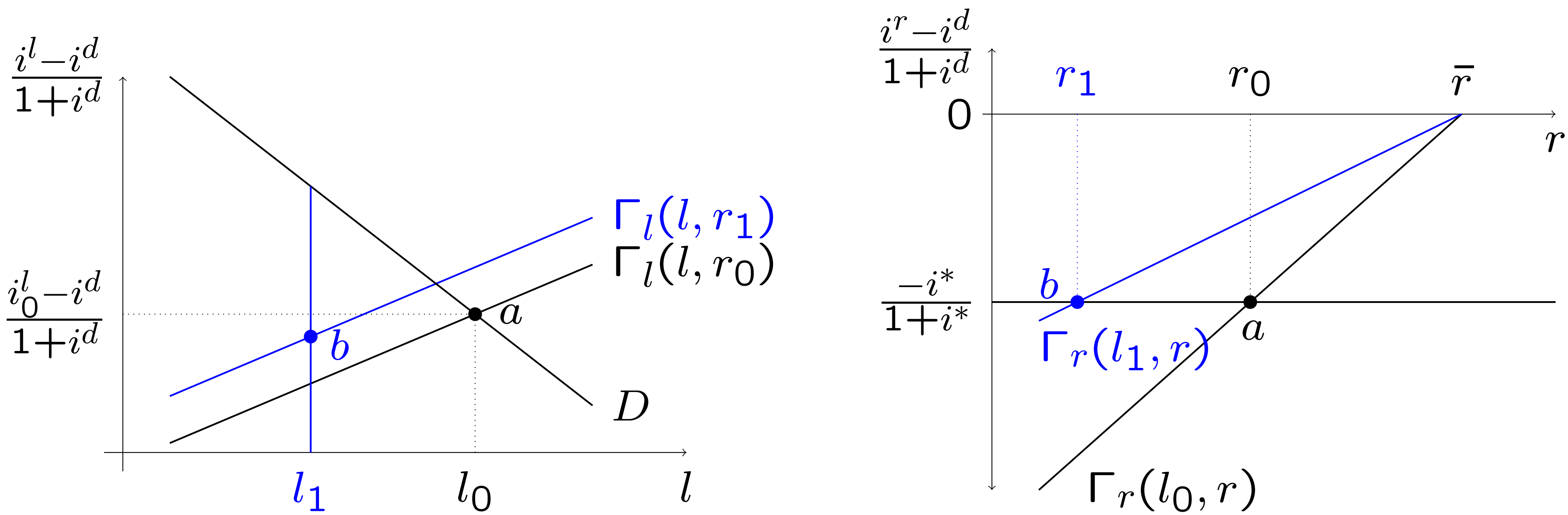
  - $r_t \geq \delta_t d_t$, with $\delta_t \in [0, 1)$

  - $\tau_t^c$

- Does reserve remuneration welfare dominate reserve requirements as a macroprudential tool? In the present environment the answer is YES.

# Graphical Interpretation

# The Loan and Reserve Markets During a Sudden Stop in the Unregulated Economy



# The Loan and Reserve Markets During a Sudden Stop in the Regulated Economy