DEPOSIT INSURANCE AND MONEY MARKET FREEZES

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Introduction

We examine the causes & consequences of money market (MM) freezes

- Money markets (MM) facilitate reallocation of funds across regions...
- Deposit insurance (DI) creates an asymmetry in marginal funding costs across banks...
- The asymmetry only becomes aparent when the risk of bank failure becomes significant:
  - Borrowers who depend on deposit-poor banks face large financing costs & cut down on investment...
  - The MM freezes

Key ingredients

1. Interregional savings/investment *imbalances*:

- Regions with heterogeneous endowments of savings
- Regionally segmented labor & retail bank markets

$\Rightarrow$ Banks use MM to reallocate savings across regions

2. Deposits are insured

3. Crisis $=$ *exogenous* rise in counterparty risk:

$\Rightarrow$ Lending banks remain financed at cheap deposit rate
Borrowing banks pay high MM spread (or high deposit rate)

$\Rightarrow$ The allocation of capital across regions becomes asymmetric

[Spreads of $\simeq 200$bp $\rightarrow$ reductions $\simeq 75$% in MM volumes]

Related literature

- On interbank market freezes:

  Bhattacharya-Gale (87); Freixas-Holthausen (04); Freixas-Jorge (08); Heider-Hoerova-Holthausen (09); Allen-Carletti-Gale (09)

- On financial market freezes, more generally:

  Huang-Ratnovski (08); Brunnermeier-Pedersen (09); Acharya-Gale-Yorulmazer (09); Diamond-Rajan (09)

- Other:

  – On DI: many papers, but this distortion is not mentioned

  – On banks&macroeconomics: no paper looks at interbank markets

    [Romer (85), , Bernanke-Gertler (87), Williamson (87), Holmstrom-Tirole (97), Chen (01), Bolton-Freixas (06), Van den Heuvel (08)]

Features of the model

- Tractable general equilibrium model with regionally-segmented bank-based financial system
- Perfect competition, t=0,1, $j \in [0, 1]$ regions, single good per period, risk-neutral agents
- Representative household in each region, exogenous savings, inelastic labor supply at $t = 0$
- Continnum of firms in each region, CRS technologies, failure risk (idiosyncratic + regional component)
- Representative shareholder-managed bank subject to diversification & capital requirements
- Interregional MM in which lenders require expected return r and borrowers pay spread s
- Baseline no-DI economy compared with DI economy

The Model*

Perfect competition, t=0,1, $j \in [0,1]$ regions, single good per period, risk-neutral agents

A representative household (in each j)

- Exogenous initial savings:

$$\begin{cases} S_H & \text{in fraction } \pi \text{ of savings-rich regions} \\ S_L < S_H & \text{in fraction } 1-\pi \text{ of savings-poor regions} \end{cases}$$

[$\Rightarrow$ in the aggregate $\overline{S}$]

- Inelastically supply labor $n_j = 1$ at (pre-paid) wage w_j
- Only means of transferring wealth are
  - Regional deposits d_j with expected return r_{dj}
  - Bank equity e_j (residual claim)

A continuum of firms (owned by penniless *entrepreneurs*)*

- CRS technology

$$(k_i, n_i) \to \widetilde{z}_{ij}[AF(k_i, n_i) + (1-\delta)k_i] + (1-\widetilde{z}_{ij})(1-\lambda)k_i$$

where: $\widetilde{z}_{ij} \in \{0, 1\}$ indicates success or failure
$F(k_i, n_i) = k_i^{\alpha} n_i^{1-\alpha}$, with $\alpha \in (0, 1)$
δ, λ are depreciation rates
A is TFP

- Regional failure rate is

$$x_j = \begin{cases} 1 & \text{with prob. } \varepsilon & \text{(all firms fail at once)} \\ p & \text{with prob. } 1-\varepsilon & \text{(iid failures with pr } p\text{)} \end{cases}$$

- Firms pay in advance for (k_i, n_i) using a bank loan

Obtain $l_{ij} = k_{ij} + w_j n_{ij} \;\longrightarrow\;$ Pay $\min\{R_{ij}, (1-\lambda)k_{ij}\}$

A representative bank (owned by coalition of households)*

Assets		Liabilities	
l_j	Loans	Deposits	d_j
a_j	Net MM assets	Equity	e_j

[a_j: net lending (>0) or net borrowing (<0)]

- Perfect competition (free entry)
- Owners contribute e_j (and require expected return r_{dj})
- Firm-bank contract sets $(k_{ij}, n_{ij}, l_{ij}, R_{ij})$

  By virtue of competition:

  – Entrepreneur's surplus is maximized

  – Bank breaks even: $\max E[\text{final net worth}] - (1 + r_{dj})e_j = 0$

The money market*

- MM liabilities = unsecured debt, junior to deposit liabilities
- Banks fail with pr. ε (upon negative regional shock)
- MM lending requires an (endogenous) expected return r

$\Rightarrow$ MM lending charges a spread s over r

$\Rightarrow$ In parameterizations with no recovery, the *spread* is flat

$$(1-\varepsilon)(1+r+s) = 1+r \;\Rightarrow\; s = \frac{\varepsilon}{1-\varepsilon}(1+r)$$

Prudential regulation & the government*

- Government imposes
  - Diversification of MM lending
  - Diversification of lending across regional firms
  - Minimum capital requirement: $e_j \geq \gamma l_j$
- Two economies:
  - Without DI
  - With DI (funded with lump-sum taxes at $t = 1$)

Banks' participation constraints in economy without DI*

- MM borrower

$$(1-\varepsilon)[(1-p)R+p(1-\lambda)k-(1+r+s)(l-d-e)-(1+r_d+s_d)d] \geq (1+r_d)e$$

$$\textbf{with } (1-\varepsilon)(1+r_d+s_d)d+\varepsilon(1-\lambda)k = (1+r_d)d$$

- MM lender

$$(1-\varepsilon)[(1-p)R + p(1-\lambda)k+(1+r)(d+e-l)-(1+r_d+s_d)d] \geq (1+r_d)e$$

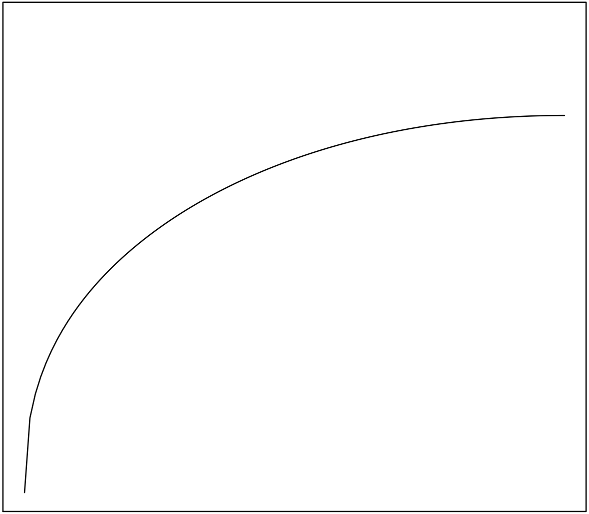
$$\textbf{with } (1-\varepsilon)(1+r_d+s_d)d+\varepsilon[(1-\lambda)k+(1+r)(d+e-l)] = (1+r_d)d$$

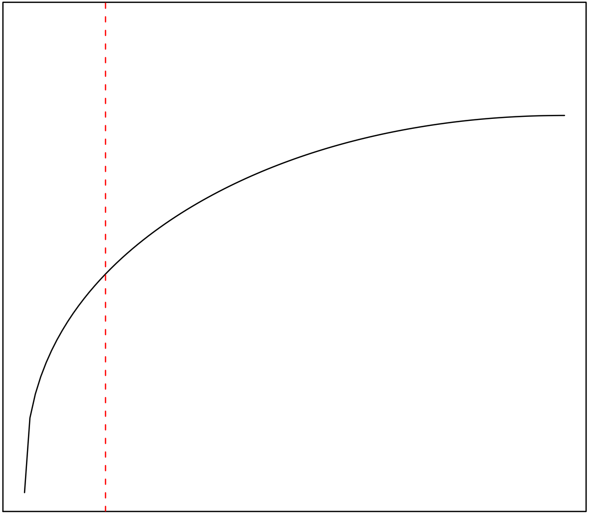
$$\Downarrow$$

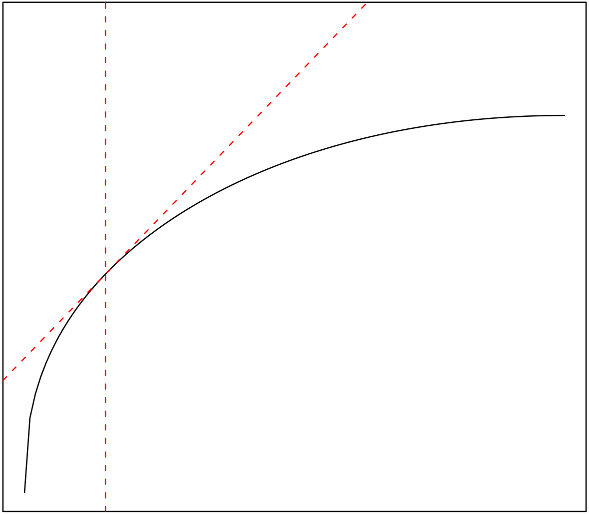
$$(1-\varepsilon)[(1-p)R+p(1-\lambda)k]-\varepsilon(1-\lambda)k-(1+r)(l-d-e)-(1+r_d)d \geq (1+r_d)e$$

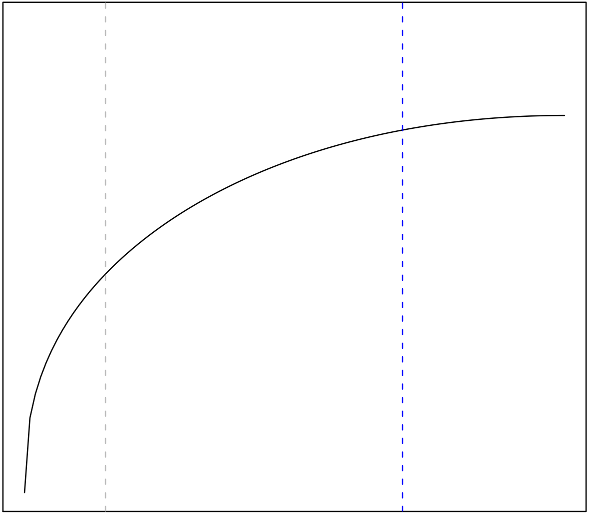
Equilibrium in the economy without DI

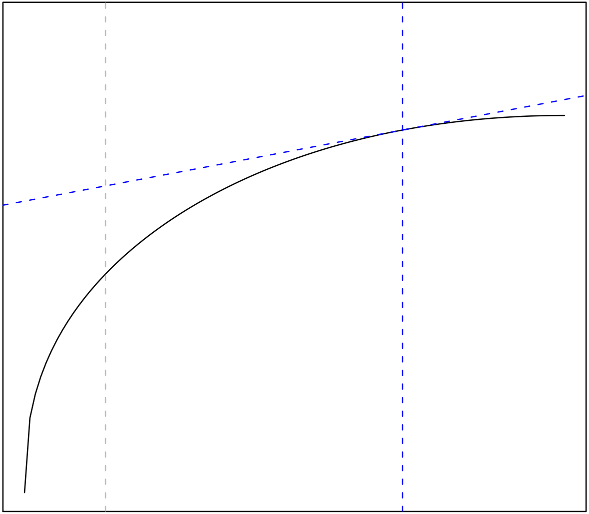
- $r_d = r$ & capital requirement is not binding
- Firm-bank problems internalize all expected returns from production
- Relevant gross *marginal cost of funds* is $c(r) = 1 + r$ for all firms
- Capital $k = k(r)$, wages w & output y are equal in all regions
- Market clearing leads to $k(r^*) = \overline{S}$ & MM is always operative

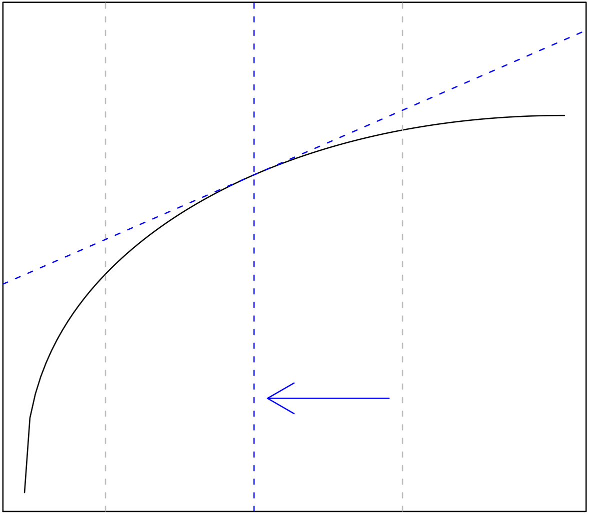


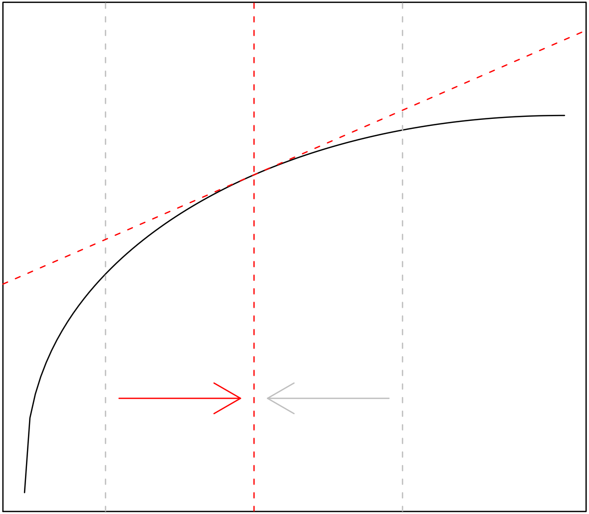












Banks' participation constraints in economy with DI*

- MM borrower

$$(1-\varepsilon)\{(1-p)R+p(1-\lambda)k-[(1+r_d)d+(1+r+s)(l-d-e)]\} \geq (1+r_d)e$$

with $(1-\varepsilon)(1+r+s) = (1+r)$

- MM lender

$$(1-\varepsilon)\{(1-p)R+p(1-\lambda)k-[(1+r_d)d-(1+r)(d+e-l)]\} \geq (1+r_d)e$$

$$\Downarrow$$

Do not collapse into the same expression!

Equilibrium in the economy with DI

- $r_d = r + \xi s$ & capital requirement is binding

- Firm-bank problems do not internalize bank-failure returns

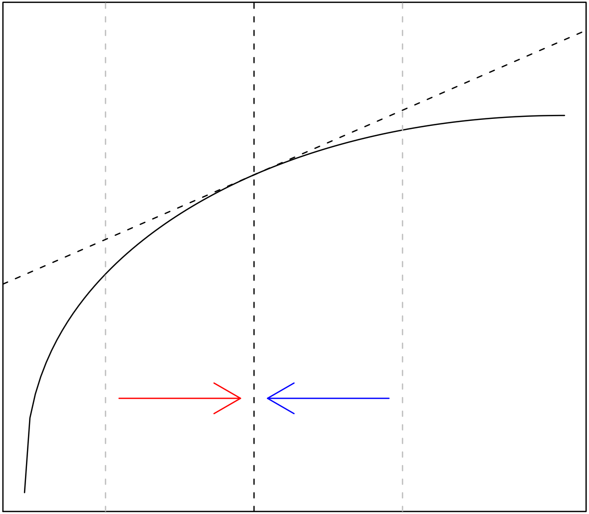
- Gross *marginal cost of funds* is $c(r + \xi s) = (1 + r + s\xi)[1 - \varepsilon(1 - \gamma)]$

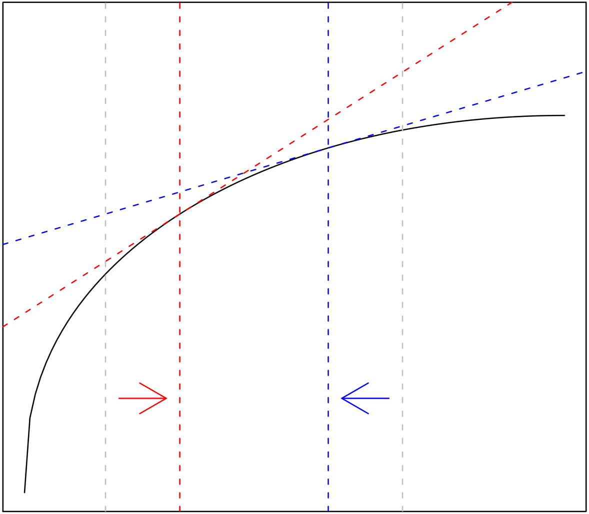
- Capital $k = k_{DI}(r + \xi s)$, wages w & output y differ across regions

- Market clearing leads to $\pi k_{DI}(r_H) + (1 - \pi)k_{DI}(r_L) = \overline{S}$

- MM may or may not be operative

[$\xi = 1$: borrower; $\xi = 0$: lender]





Quantitative analysis

We compare pre-crisis scenario ($\varepsilon = 0$) with some crisis scenarios ($\varepsilon > 0$)

Table 1: Calibration

Table 2: Counterparty risk

Table 3: Amplification via demand externalities

Table 1: Calibration

Parameters		Baseline
Measure of savings-rich regions	π	0.5
Savings asymmetry	$\mu \equiv \pi S_H / \bar{S}$	0.6
Capital elasticity parameter in F	α	0.3
Depreciation rate if success	δ	4.5%
Depreciation rate if failure	λ	35%
Probability of idiosyncratic firm failure	p	3%
Probability of regional solvency shock	ε	0%-2%
Capital requirement	γ	8%

Comments on Table 1 (calibration)

$\varepsilon = 2\%$ $\rightarrow$ crisis spread $\simeq 200$bp

$\pi = 0.5$, $\pi S_H/\overline{S}$ =60% $\rightarrow$ suff. large pre-crisis MM (30% of GDP)

$\overline{S}$ $\rightarrow$ pre-crisis $r_H = r_L$ =4%.

α $\rightarrow$ 30% capital share

δ, λ $\rightarrow$ capital-to-output ratio $\simeq$3, LGD$\simeq$45%.

p $\rightarrow$ PD: 3% (pre-crisis) to 5% (crisis)

γ =8%

Table 2: Counterparty risk

Levels (%)		$\varepsilon = 0\%$	1%	2%	3%
Deposit rates	H	4.00	3.43	2.92	2.62
	L	4.00	4.48	5.02	5.33
MM / baseline GDP	Aggr.	31.86	19.29	6.93	0.00
DI costs / baseline GDP	H	0.00	1.70	3.53	5.41
	L	0.00	1.14	2.63	4.24
	Aggr.	0.00	1.42	3.08	4.83

Changes (%)		1%	2%	3%
Capital	H	7.89	15.65	20.00
GDP	H	1.28	2.37	2.45
	L	-3.41	-6.88	-9.28
	Aggr.	-1.06	-2.25	-3.41

Comments on Table 2 (counterparty risk)

Subsequently larger crisis: $\varepsilon = 1\%$, 2%, 3%

- Deposit rates & (k_H, k_L) become asymmetric across regions
- MM freezes
- Channel: cost of loans
- Output & wages variations:
  - very asymmetric across regions
  - rather modest in the aggregate
- DI costs: 3% of pre-crisis GDP

Amplification via demand externalities

Regions' interdependence (e.g. due to trade) is captured by making A a CES aggregator of the levels of activity of the various regions:

$$A = \left[\int_0^1 k_j^\rho dj \right]^{\frac{\tau}{\rho}}$$

where k_j : activity in region j

$\rho \leq 1$: importance of regional interdependencies

$\tau < 1 - \alpha$: (innocuous) returns-to-scale parameter

Table 3: Amplification via demand externalities

Levels (%)		$\varepsilon = 0\%$	1%	2%	3%
Deposit rates	H	4.00	3.36	2.64	2.23
	L	4.00	4.40	4.73	4.82
MM / baseline GDP	Aggr.	31.86	19.20	6.22	0.00
DI costs / baseline GDP	H	0.00	1.69	3.48	5.27
	L	0.00	1.13	2.60	4.12
	Aggr.	0.00	1.41	3.04	4.70

Changes (%)		$\varepsilon = 1\%$	2%	3%
Capital	H	7.95	16.10	20.00
GDP	H	0.51	-0.67	-2.30
	L	-4.18	-9.89	-13.49
	Aggr.	-1.84	-5.28	-7.89

Comments on Table 3 (amplification)

Same crisis scenarios with $\rho = -4$ and $\tau = 0.5$

- Small differences: Panel A variables & reallocation of capital
- Big differences: size & distribution of output losses

Discussion and robustness

- Results are robust to having a less "repressed" financial structure
- The crucial part is having some limits to banks'...
  - insured deposit taking in foreign regions
  - loan making in foreign regions
- Possible remedies
  1. Eliminating DI
  2. Charging fair risk-sensitive DI premia
  3. Subsidizing/absorbing counterparty risk

Table 4: Subsidizing counterparty risk

		$\varepsilon = 1\%$	2%	3%
Cost of subsidies / base GDP	Aggr.	0.33	0.66	0.99
Fall in DI costs / base GDP	H	0.08	0.30	0.57
	L	0.18	0.72	1.39
$\rightarrow$ Without d. externalities	Aggr.	0.13	0.51	0.98
	H	0.07	0.25	0.43
	L	0.17	0.69	1.27
$\rightarrow$ With d. externalities	Aggr.	0.12	0.47	0.85
Gain in GDP / base GDP	H	-2.28	-4.37	-5.45
	L	2.41	4.88	6.28
$\rightarrow$ Without d. externalities	Aggr.	0.06	0.25	0.41
	H	-1.51	-1.33	-0.70
	L	3.18	7.89	10.49
$\rightarrow$ With d. externalities	Aggr.	0.84	3.28	4.89

Comments on Table 4 (subsidizing counterparty risk)

- Various forms of intervention are equivalent to direct subsidization of the MM spreads by the government:
  - direct borrowing/lending by government or CB (charging no or below-market spreads)
  - extension of (cheap) guarantees on MM liabilities
- We look at the effects of full subsidization of the spreads
  - Cost of the policy is not too large (0.7% of pre-crisis GDP)
  - DI costs fall (0.5% of pre-crisis GDP)
  - With demand externalities, gains in GDP are large (3.3%)

Conclusions

- The model highlights
  - the role of money markets in providing structural funding to banks
  - the distortions arising from DI when the risk of bank failure becomes significant
- Modest rise in counterparty risk can make MM freeze, causing severe distortions to allocation of credit
- With demand externalities the implications for aggregate output can be large
- Absorption or subsidization of counterparty risk by the government can reduce the effects of the distortion

Background material

Analytical details

Economy without DI: Firm-bank problems (i)

$$\max_{(k,n,l,R)} (1-\varepsilon)(1-p)[AF(k,n)+(1-\delta)k-R]$$

s.t.

$$(1-\varepsilon)[(1-p)R+p(1-\lambda)k]-\varepsilon(1-\lambda)k-(1+r)(l-d-e)-(1+r_d)d \geq (1+r_d)e$$

$$l = k + wn$$

$$e \geq \gamma l$$

Proposition 1

Without DI, (PC) binds; $r_d = r$*; and* $e \geq \gamma l$ *is not binding*

Economy without DI: Firm-bank problems (& ii)

But, then, the problem can be compactly written as:

$$\max_{(k,n)} \; (1-\varepsilon)\{(1-p)AF(k,n)+[(1-p)(1-\delta)+p(1-\lambda)]k\}$$
$$+\varepsilon(1-\lambda)k-c(r)(k+wn)$$

where

$$c(r) = 1 + r$$

(the firm's gross *marginal cost of funds* without DI)

Economy without DI: Equilibrium (i)

- FOC for optimal (k, n) decisions & $n = 1$

$$\Downarrow$$

$$k = k(r) \equiv \left[\frac{(1-\varepsilon)(1-p)\alpha A}{r + (1-\varepsilon)[(1-p)\delta + p\lambda] + \varepsilon\lambda}\right]^{\frac{1}{1\text{-}\alpha}}$$

- The regional wage rate w & output y can be obtained recursively

Proposition 2

Without DI, k, w and y are equal across regions

Economy without DI: Equilibrium (& ii)

- (r, k) such that agents optimize and all markets clear at $t = 0$
- MM clearing requires

$$\pi a_H + (1-\pi)a_L = 0, \text{ with}$$

$$a_j = (d_j + e_j) - l_j = (S_j + w_j) - (k_j + w_j) = S_j - k_j$$

$$\Rightarrow \pi k(r) + (1-\pi)k(r) = \overline{S} \Rightarrow k(r) = \overline{S}$$

Proposition 3

- *MM is always operative:* $a_H = S_H - \overline{S} > 0$ *&* $a_L = S_L - \overline{S} < 0$
- *Aggregate expected output cannot be increased by reallocating capital across regions*

Economy with DI: Firm-bank problems (i)

$$\max_{(k,n,l,R)} (1-\varepsilon)(1-p)[AF(k,n)+(1-\delta)k-R]$$

s.t.:

$$(1-\varepsilon)\{(1-p)R+p(1-\lambda)k-[(1+r_d)d+(1+r+s)(l-d-e)]\} \geq (1+r_d)e$$

$$l = k + wn$$

$$e \geq \gamma l,$$

$$l - d - e > 0$$

or

$$\max_{(k,n,l,R)} (1-\varepsilon)(1-p)[AF(k,n)+(1-\delta)k-R]$$

s.t.:

$$(1-\varepsilon)\{(1-p)R+p(1-\lambda)k-[(1+r_d)d-(1+r)(d+e-l)]\} \geq (1+r_d)e$$

$$l = k + wn$$

$$e \geq \gamma l,$$

$$d + e - l > 0$$

Economy with DI: Firm-bank problems (& ii)

Proposition 4

With DI, (PC) binds; $e = \gamma l$; $r_d = r + \xi s$ *(= mg funding rate)*

Then, both problems can be compactly written as:

$$\max_{(k,n)} (1-\varepsilon)\left\{(1-p)AF(k,n) + [(1-p)(1-\delta)-p(1-\lambda)]k\right\} - c(r+\xi s)(k+wn)$$

where

$$\xi = \begin{cases} 1 & \text{if borrower} \\ 0 & \text{if lender} \end{cases}$$

$$c(r+\xi s) = (1+r+s\xi)[1-\varepsilon(1-\gamma)]$$

(the firm's gross *marginal cost of funds* with DI)

Economy with DI: Equilibrium (i)

- FOC for optimal (k, n) decisions & $n = 1$

$$\Downarrow$$

$$k{=}k_{DI}(r{+}\xi s) \equiv \left[\frac{(1-\varepsilon)(1-p)\alpha A}{(1\text{-}\varepsilon)[(1\text{-}p)\delta{+}p\lambda]{+}[1\text{-}\varepsilon(1\text{-}\gamma)](r{+}s\xi){+}\gamma\varepsilon}\right]^{\frac{1}{1\text{-}\alpha}}$$

- The regional wage rate w & output y can be obtained recursively

Proposition 5

With DI and $s > 0$, k, w and y are lower in borrowing regions (and the asymmetries are increasing in s)

Economy with DI: Equilibrium (& ii)

- $((r_H, r_L), (k_H, k_L))$ s.t. agents optimize & markets clear at $t = 0$

  [r_j :deposit rate]

- MM clearing requires

$$\pi a_H + (1 - \pi) a_L = 0$$

$$\Rightarrow \; \pi k_{DI}(r_H) + (1 - \pi) k_{DI}(r_L) = \overline{S}$$

Proposition 6

– *Two possible equilibrium configurations: with operative MM & autarkic*

– *Aggregate expected output can be increased by reallocating capital across regions*