Credit Demand and Supply
A Two-way Feedback Relation

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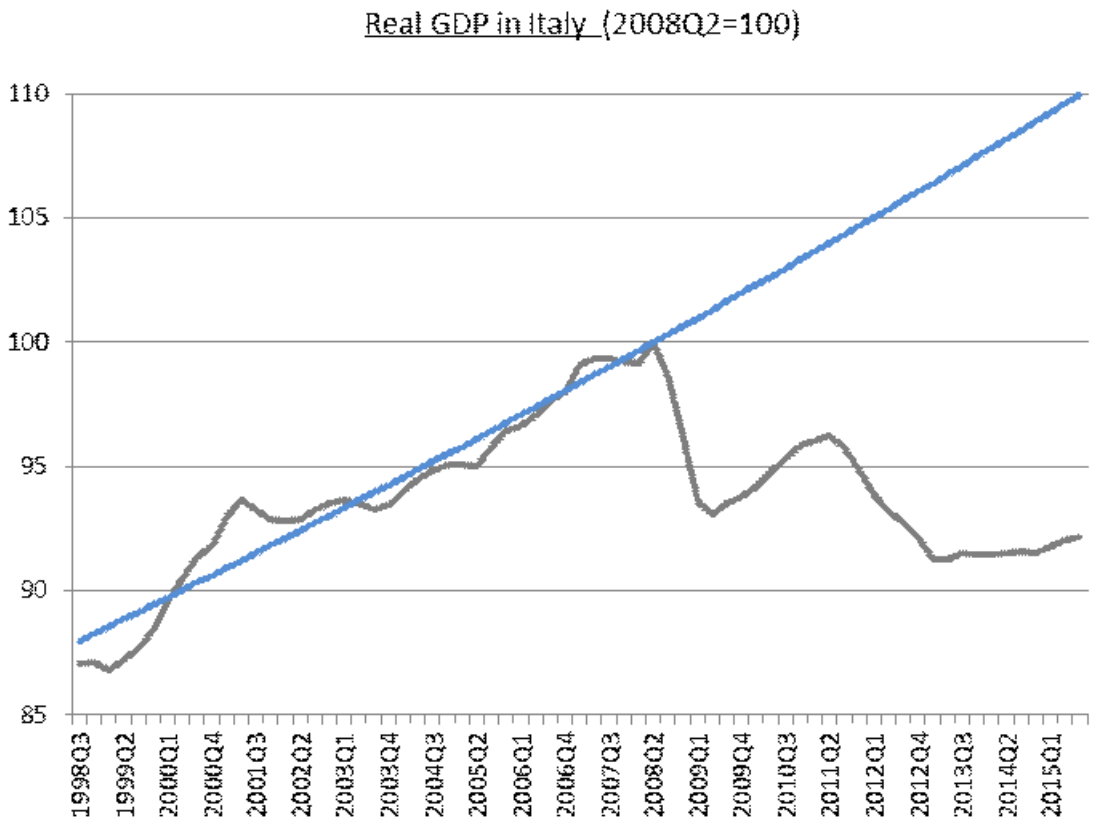
Workshop on "Secular Stagnation and Financial Cycles", Rome

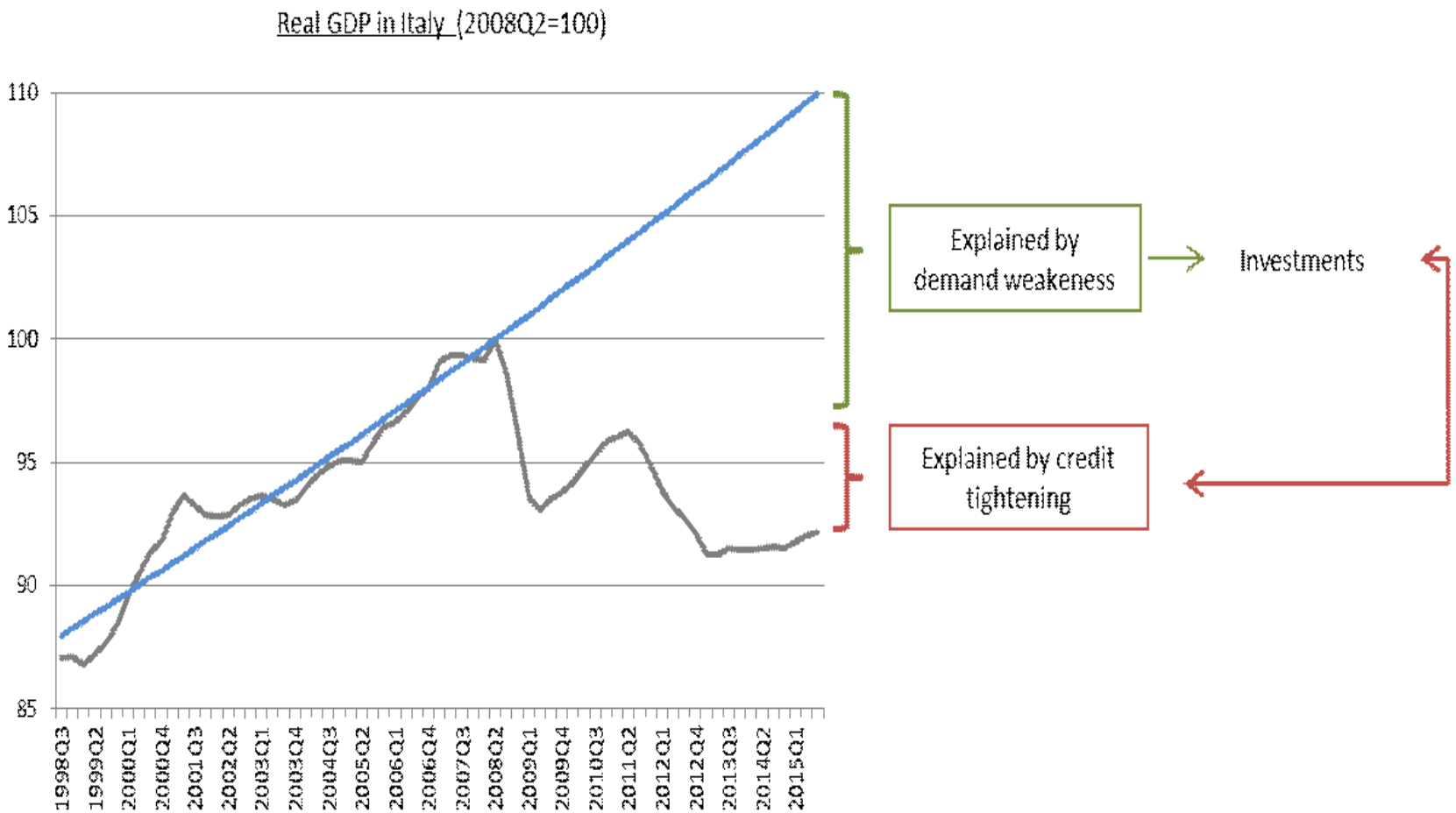
Motivation

Strong and persistent deviations of output growth from its historical trend after the collapse of Lehman Brothers



Motivation

Studies documenting a significant impact of the downward shift of credit supply (Cingano et al, 2016) explain only a (small) part of the observed loss in output-investment



Motivation

Other explanations of the persistent weakness in economic activity based on:

- **structural factors** (labor market rigidities, excessive length of trials and legal proceedings, gaps in human capital etc...).

$\Longrightarrow$ all factors that pre-existed the crisis and if anything improved thereafter

- **reassessment of potential output** after pre-crisis unsustainable output growth

$\Longrightarrow$ relvant for Italy? (no credit boom, economy has been underperforming its peers since mid-90s)

- **weakness of the aggregate demand, confidence** (Caivano et al, 2011)

Question: why did such downward shift of aggregate demand occur in the context of a financial crisis? Is there any relation between the two?

Research Questions

We develop a model that allows to answer the following questions:

1. Could **credit supply impairment** be the **driving force of the drop aggregate demand**, in particular of its investment component?
   $\longrightarrow$ Yes, it can.
2. Is it plausible that, in turn, a low aggregate demand weakens credit supply?
   $\longrightarrow$ Yes, it is (**two-way feedback loop** between low credit demand and low credit supply)
3. What are the implications of this feedback loop for **countries** that are **financially integrated**? What is the role of **the degree of indebtness**?

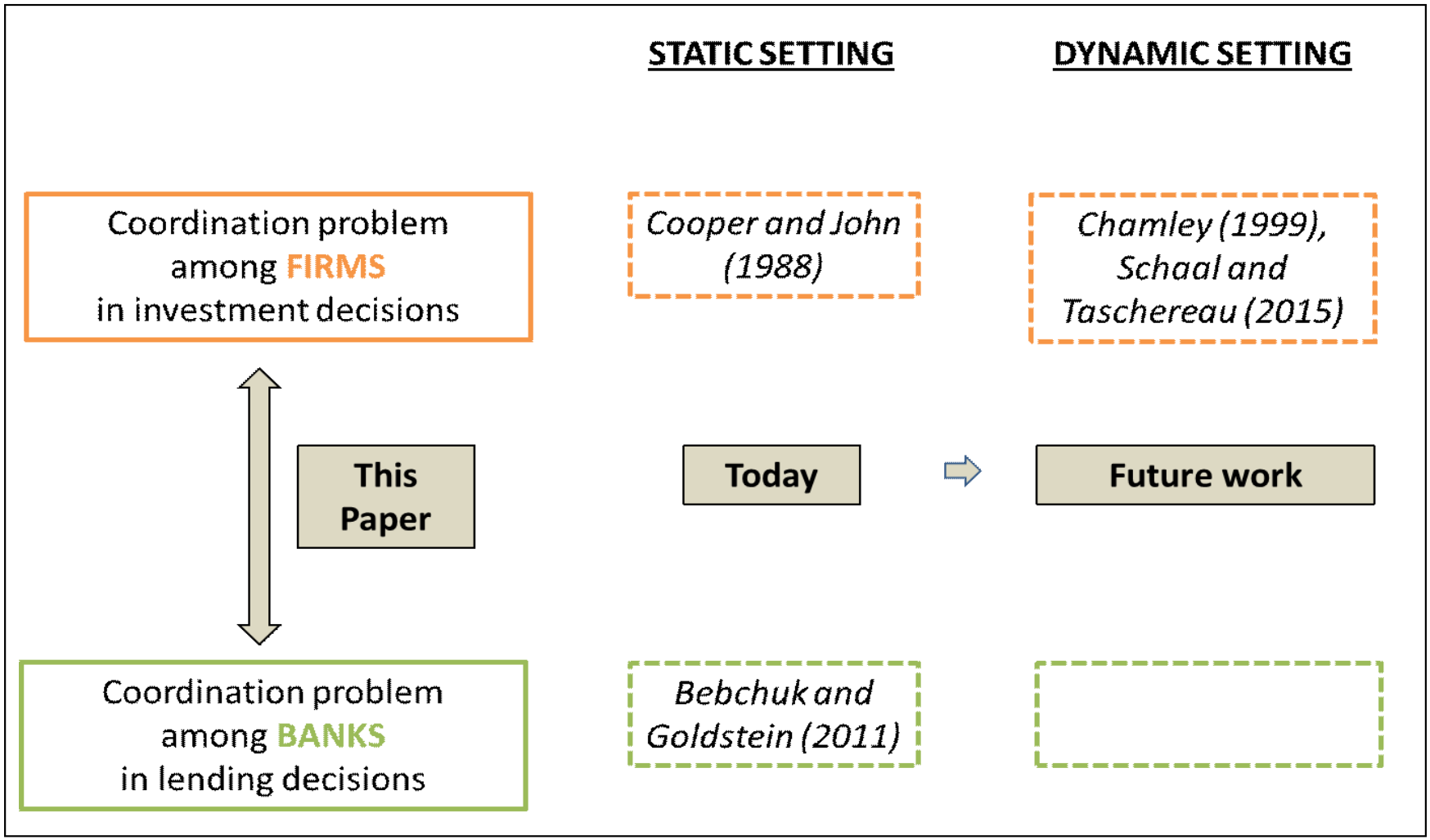
NOTES:

- We are considering comovements of demand and supply schedules (not equilibrium quantities)
- Model focuses on demand and supply of credit

Key Assumptions

- *Coordination motive:* The return of a project is positive only if a critical mass of investment is reached, i.e. enough other firms invest
- *Bank-based economy*: Firms can invest only if they receive funding from a bank
- *Moral hazard*: Adjustment of prices in credit market (interest rate margins) is limited by incentive issues à la Stiglitz Weiss (1981)

Related Literature



The Model

- There is a continuum $[0, F]$ of **identical (non-financial) firms**. They have access to investment projects that require an investment of €1 but only have resouces equal to €$E < 1$. Firms rely on bank lending for the remaining necessary funds.
- There is a continuum $[0, K]$ of **identical banks**. Each bank has €1 worth of capital. Banks can choose to invest their capital in government bonds that generates $1 + r$ dollars next period, or lend it to firms.
- We assume that the $F = K / (1 - E)$

Investment Return

Firms have projects that generate a gross return of $1 + R$, when a sufficient number of operating firms decide to invest conditional on receiving loans

$1 + R$	$if\ \ aL^* + \theta \geq b$
0	$if\ \ aL^* + \theta < b$

- θ is a random variable capturing **macroeconomic conditions** (consumers' demand and the cost of imported oil)
- $L^* = \min\left\{L^S, L^D\right\}$ **is the mass of firms that want to invest and receive credit to finance their project** (rationing)
- a is a parameter capturing the importance of complementarities versus fundamentals in making projects profitable
- b is a parameter capturing firms' productivity

Banks' and Firms' Payoffs

Firms and Banks choose actions to maximise their expected payoffs (risk-neutrality)

Banks	*Succes*	*Failure*
Credit	$(1+r+m)-\overline{\rho}k$	0
Gov Bonds	$1+r$	$1+r$

Firms	*Succes*	*Failure*
Invest	$((1+R)-(1+r+m)(1-E))/E$	0
Not Invest	$1+r$	$1+r$

k not too large; R large enough

Information Structure

The fundamental θ is not publicly known, but both Banks and Firms observe private signal

$$x_i = \theta + \sigma\varepsilon_i$$

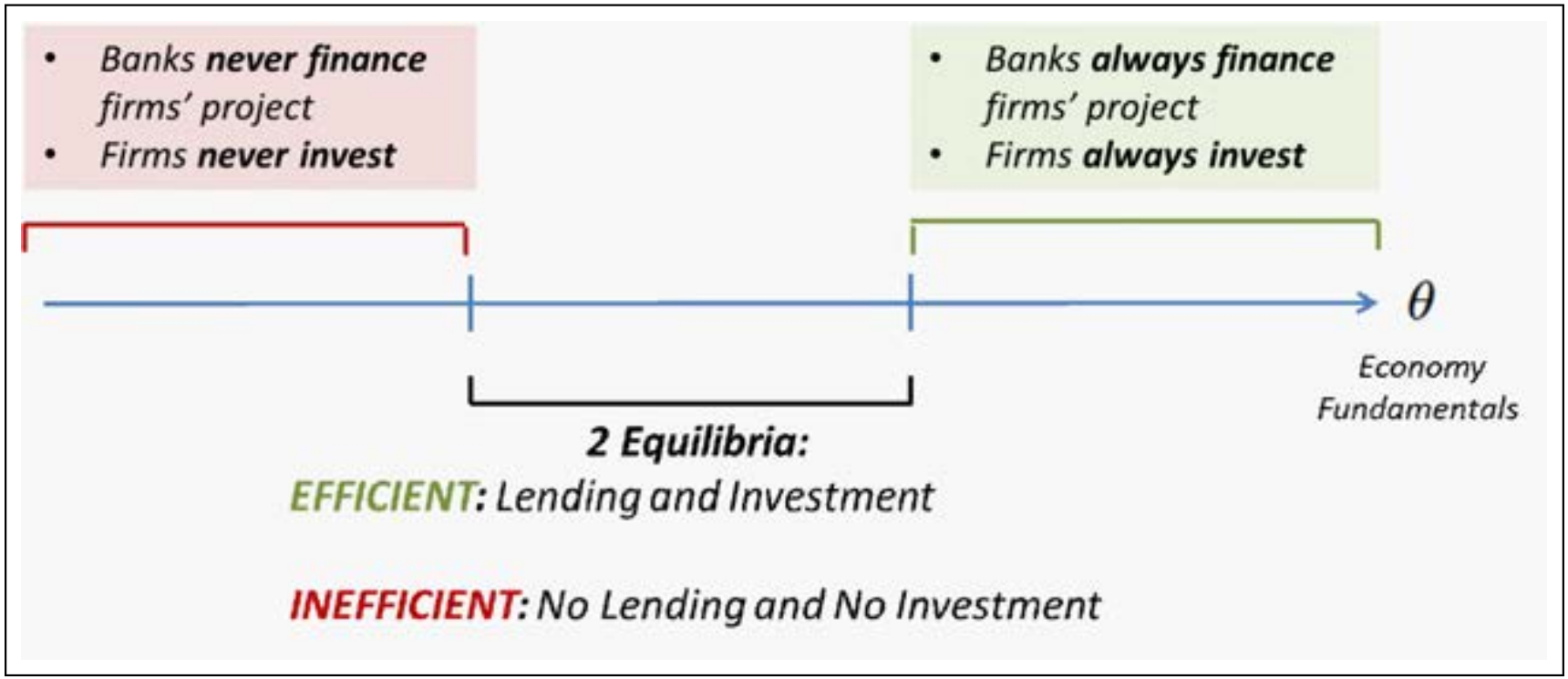
where the ε_i are i.i.d. independent of θ and $\frac{1}{\sigma}$ is the precision of private information.

Stepwise solution

1. Perfect information (and no moral hazard)
2. Private information with exogenous margins (and no moral hazard)
3. Private information with endoenous margins (and moral hazard)

Perfect Information (and no moral hazard)

- If $\theta < b - aK$, not lend/invest is dominant strategy
- If $\theta > b$, lend/not invest is dominant strategy (the return is guaranteed to be $1 + R$)
- If $b - aK > \theta > b$ the optimal decision depends on expectations on other banks and firms' actions $\Longrightarrow$ multiple self-fulfilling equilibria



Private Info. with exog. margin (and no moral hazard)

- Equlibrium: $\{x_B^*, x_F^*, \theta^*\}$
- *Bank i* lends if and only if
  $\Pr(\theta \geq \theta^* \mid x_i, \theta^*) * ((1+r+m) - \overline{\rho}k) \geqslant 1+r$
  ... $\longrightarrow x_i \geqslant \Phi^{-1}((1+r)/((1+r+m) - \overline{\rho}k))\sigma + \theta^* = x_B^*$
  $\longrightarrow$ **Loan Supply** (mass of banks with $x_i \geqslant x_B^*$):
  $L^S = \Pr(x_i \geqslant x_B^* \mid \theta^*) = 1 - (1+r)/((1+r+m) - \overline{\rho}k)$, *increasing* in m
- *Firm i* borrow invests if and only if
  $\Pr(\theta \geq \theta^* \mid x_i, \theta^*) * ((1+R) - (1+r+m)(1-E))/E \geqslant 1+r$
  ... $\longrightarrow$ **Loan Demand**:
  $L^D = 1 - (1+r)E/((1+R) - (1+r+m)(1-E))$, *decreasing* in m

Private Info. with exog. margin (and no moral hazard)

Define m^*: $L^S(m^*) = L^D(m^*) = L^*$

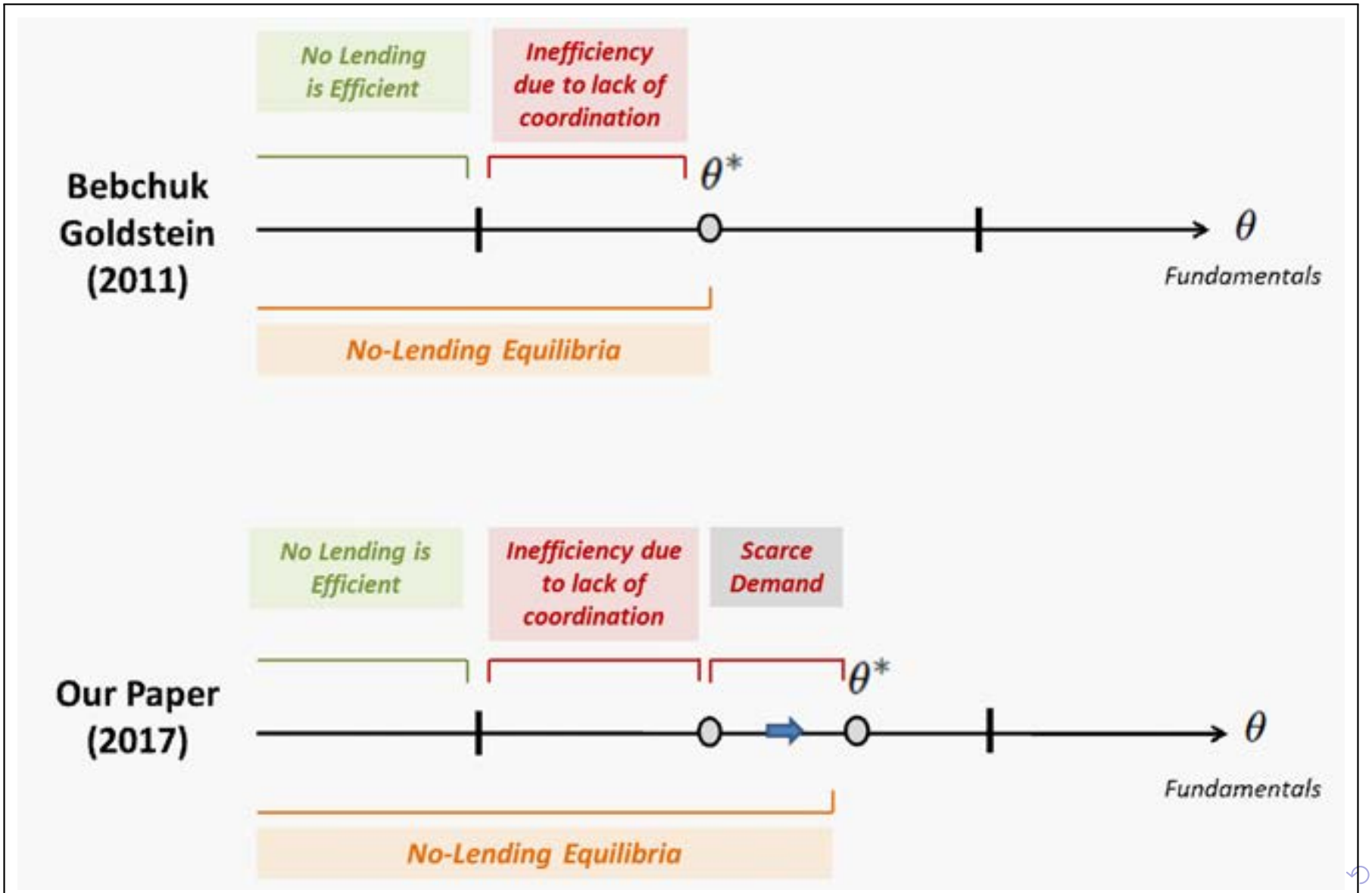
- If $m = m^*$: strategies imply that projects are successful whenever
  $a \min\left(L^D, L^S\right) + \theta \geqslant b \longrightarrow$
  $\theta \geqslant b - aL^* \longrightarrow \theta \geqslant b - ak + ak\left(1 - L^*\right) > b - ak$
  threshold for successful projects larger than in perfect info. benchmark

- If $m > m^*$ (**scarce demand regime:** $L^D(m) < L^* < L^S(m)$)
  projects are successful whenever
  $\theta \geqslant b - ak + ak\left(1 - L^D(m)\right) > b - ak + ak\left(1 - L^*\right)$
  threshold for successful projects even larger than level with $m = m^*$

- If $m < m^*$ (**scarce supply regime** $L^D(m) > L^* > L^S(m)$) projects are successful whenever
  $\theta \geqslant b - ak + ak\left(1 - L^S(m)\right) > b - ak + ak\left(1 - L^*\right)$
  threshold for successful projects even larger than level with $m = m^*$

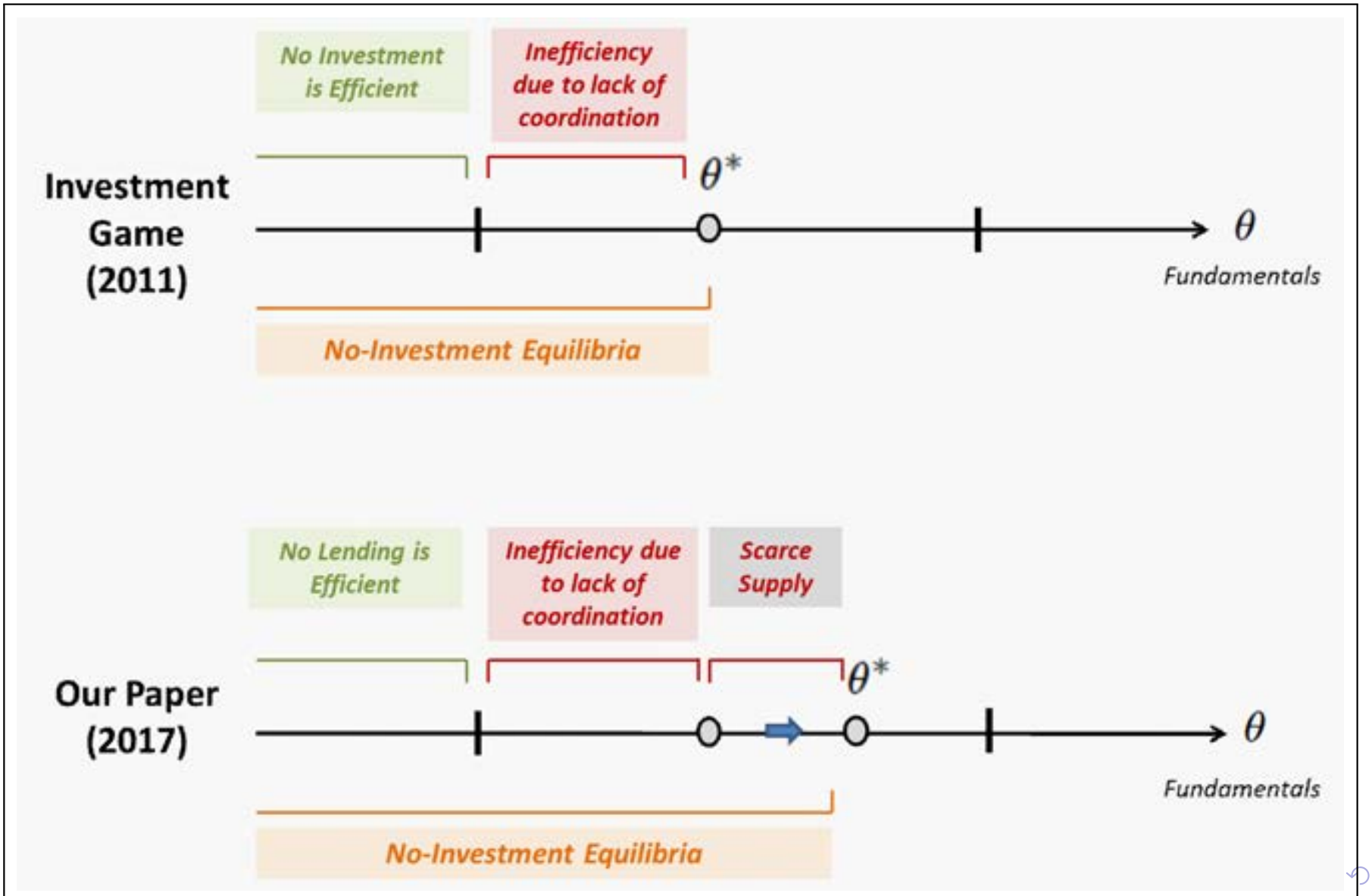
Private Info. with exog. margin (and no moral hazard)

Coordination among Banks with Scarce Credit Demand



Private Info. with exog. margin (and no moral hazard)

Coordination among Firms with Scarce Credit Supply



Private info. with end. margins (and moral hazard)

Moral hazard for Firms

Conditional on coordination being successful, in the second period firms and banks need to exert an adequate level of effort in order for their own project to be remunerative.

• **For firms**, a low level of effort entails private benefits B_F but produces project return $\tilde{R} = 0$; a high level of effort entails no private benefits but produces high returns $\tilde{R} = R$.

$$\begin{array}{rcl} \textit{high effort} & | & \textit{investing} \rightarrow \left((1+R) - (1+r+m)(1-E) \right) / E \\ \textit{low effort} & | & \textit{investing} \rightarrow B_F \end{array}$$

The incentive compatibility for the firms requires:

$$\frac{(1+R) - (1+r+m)(1-E)}{E} \geq B_F$$

• **For banks**, a low level of effort entails private benefits equal to B_B but the return on their loans is nil; if instead bank's effort is high, it enjoys no private benefits but the borrower is enforced to meet his debt obligations.

$$\begin{array}{rcl} \textit{high effort} & | & \textit{lending} \longrightarrow (1 + r + m) - \overline{\rho} k \\ \textit{low effort} & | & \textit{lending} \longrightarrow B_B \end{array}$$

The incentive compatibility for the bank requires:

$$(1 + r + m) - \overline{\rho} k \geq B_B$$

Definition *The equilibrium of the model with endogenous margin is characterized by the following set of quantities:*

$$\left\{\tilde{x}_F, \tilde{x}_B, \tilde{\theta}, \tilde{m}\right\}$$

where $\tilde{x}_B$ is the signal threshold for banks; $\tilde{x}_F$ is the signal threshold for firms; $\tilde{\theta}$ is the value of θ which makes the regime change possible. In particular, for any $x_i \geq \tilde{x}_B$ bank i gives credit; for any $x_i \geq \tilde{x}_F$ firm i invests; for any $\theta \geq \tilde{\theta}$ the aggregate investment is remunerative. $\tilde{m}$ is such that loan demand and loan supply clears ($\tilde{m} = m^*$) unless this violates one of the two incentive compatibility constraints. In the latter case, $\tilde{m}$ is such that such constraint is satisfied with equality.

Considering the two incentives compatibility constraints, the admissible region for the equilibrium margin $\tilde{m}$ is given by:

$$B_B + \bar{\rho}k - (1+r) \equiv m_B \leq \tilde{m} \leq m_F \equiv \frac{(1+R) - B_F}{(1-E)} - (1+r)$$

Whenever the market clearing margin m^* does not belong to this region of parameters, the equilibrium with market clearing is not feasible and the unique equilibrium of the model is characterized by either scarce demand or scarce supply. In fact, if $m^* < m_B$, then banks' incentive compatibility creates a scarce demand regime. If $m^* > m_F$, firms' incentive compatibility imposes a scarce supply regime.

Private info. with end. margins (and moral hazard)

Comparative statics

- Erosion of firm equity (E) makes **firms'IC** more likely to be binding
- Increase of bank cost of equity ($\overline{\rho}$) makes **banks'IC** more likely to be binding
- Monetary policy:
  - increases both L^S and L^D (reduce value of outside option)
  - always effective in relaxing **firms'IC**
  - makes **banks'IC** tighter but effect more than compensated by direct impact on L^S and L^D

Extensions

- Two-Region Model
- Model with Debt
- Empirical evidence

Conclusions

- Strategic complementarities possible on both demand and supply side
- They reinforce each other, in models with rationing
- Monetary policy effective
- Evidence of quantitative relevance

Thanks!

Background slides

Proposition 1

For any $\sigma > 0$, the model with exogenous margin m admits a unique equilibrium. Let $m^* \equiv R - r + Ek(1 + r + \rho)$.
When $m = m^*$ credit market clears and the equilibrium thresholds are

$$\theta^* = b - aK + aK\left\{\pi^*\right\}$$

$$x_B^* = x_F^* = x^* = \theta^* + \sigma\Phi^{-1}\left(\pi^*\right)$$

where $\pi^* = \frac{1+r}{1+R-k(1+r+\rho)(1-E)}$

Proposition 1 (continued)

When $m < m^*$ credit supply is scarce and the equilibrium thresholds are

$$\begin{aligned} \theta^* &= b - aK + aK\left\{\pi_B\left(m\right)\right\} \\ x_B^* &= \theta^* + \sigma\Phi^{-1}\left(\pi_B\left(m\right)\right) \\ x_F^* &= \theta^* + \sigma\Phi^{-1}\left(\pi_F\left(m\right)\right) \end{aligned}$$

where $\pi_B\left(m\right) = \frac{1+r}{(1+r+m)-(1+r+\rho)k} > \pi^* > \pi_F\left(m\right)$.

Proposition 1 (continued)

When $m > m^*$ credit demand is scarce and the equilibrium thresholds are

$$\begin{aligned} \theta^* &= b - aK + aK\left\{\pi_F(m)\right\} \\ x_B^* &= \theta^* + \sigma\Phi^{-1}\left(\pi_B(m)\right) \\ x_F^* &= \theta^* + \sigma\Phi^{-1}\left(\pi_F(m)\right) \end{aligned}$$

where $\pi_F(m) = \frac{(1+r)E}{(1+R)-(1+r+m)(1-E)} > \pi^* > \pi_B(m)$.
In the limit as $\sigma \longrightarrow 0$, the signal thresholds x_B^* and x_F^* converge to the fundamental threshold θ^*, $\forall m$.

$$\begin{aligned} x_B^* &\longrightarrow \theta^* \\ x_F^* &\longrightarrow \theta^* \end{aligned}$$

Private Info. with exog. margin (and no moral hazard)

- *Bank i* lends if and only if*:*
  $\Pr(\theta \geq \theta^* \mid x_i, \theta^*) * ((1+r+m) - \overline{\rho}k) \geqslant 1+r$
  $\underset{x_i=\theta+\sigma\varepsilon_i;\varepsilon_i\sim\Phi}{\longrightarrow} \Phi\left(\frac{x_i-\theta^*}{\sigma}\right) \geqslant (1+r) / ((1+r+m) - \overline{\rho}k)$
  $\longrightarrow x_i \geqslant \Phi^{-1}((1+r) / ((1+r+m) - \overline{\rho}k))\,\sigma + \theta^* = x_B^*$ (threshold for signal in banks' decision, conditional on θ^*)
  $\longrightarrow$ **Loan Supply** (mass of banks with $x_i \geqslant x_B^*$):
  $L^S = \Pr(x_i \geqslant x_B^* \mid \theta^*) = 1 - \Phi\left(\frac{x_B^*-\theta^*}{\sigma}\right) =$
  $1 - (1+r) / ((1+r+m) - \overline{\rho}k)$ (*increasing* in m; independent from θ^*)
- *Firm i* borrow invests if and only if*:*
  $\Pr(\theta \geq \theta^* \mid x_i, \theta^*) * ((1+R) - (1+r+m)(1-E))/E \geqslant 1+r$
  ... $\longrightarrow$ **Loan Demand**:
  $L^D = 1 - (1+r)E / ((1+R) - (1+r+m)(1-E))$ (*decreasing* in m; independent from θ^*)

Private Info. with exog. margin (and no moral hazard)

Define m^*: $L^S(m^*) = L^D(m^*)$

- If $m = m^*$: strategies imply that projects are successful whenever $a \min\left(L^D, L^S\right) + \theta \geqslant b \longrightarrow$
  $\theta \geqslant b - aL^D(m^*) \longrightarrow \theta \geqslant a - ak + ak\left(1 - L^D(m^*)\right) > a - ak$
  threshold for successful projects larger than in perfect info. benchmark

- If $m > m^*$ $\left(L^D(m) < L^D(m^*) < L^S(m)\right)$ we are in a **scarce demand regime** and projects are successful whenever
  $aL^D(m) + \theta \geqslant b \longrightarrow \theta \geqslant b - aL^D(m^*) \longrightarrow \theta \geqslant$
  $a - ak + ak\left(1 - L^D(m)\right) > a - ak + ak\left(1 - L^D(m^*)\right)$
  threshold for successful projects even larger than level with $m = m^*$

- If $m < m^*$ $\left(L^D(m) > L^D(m^*) > L^S(m)\right)$ we are in a **scarce supply regime** and projects are successful whenever
  $aL^S(m) + \theta \geqslant b \longrightarrow \theta \geqslant b - aL^S(m^*) \longrightarrow \theta \geqslant$
  $a - ak + ak\left(1 - L^S(m)\right) > a - ak + ak\left(1 - L^D(m^*)\right)$
  threshold for successful projects even larger than level with $m = m^*$

The Two-Way Feedback Loop

The **decision of a firm** on whether to invest depends not only on the firm's assessment of whether other firms will invest but also on their ability to obtain bank financing

$$\text{Expectations of a credit supply tightening} \quad \Rightarrow \quad \text{weaken credit demand}$$

The **decision of a bank** on whether to lend to an operating firm depends not only on the bank's expectations of wheather other banks will give credit but also on the bank's assessment of wheather firms are willing to invest

$$\text{Expectations of low credit demand} \quad \Rightarrow \quad \text{weaken credit supply}$$

Proposition 2

For any $\sigma > 0$, the model with endogenous margin m admits a unique equilibrium.
When $m^* \in [m_B, m_F]$ credit market clears and the equilibrium thresholds are

$$\begin{aligned} \tilde{m} &= m^* \\ \tilde{\theta} &= b - aK + aK\{\pi^*\} \\ \tilde{x}_B &= \tilde{x}_F = x^* = \tilde{\theta} + \sigma\Phi^{-1}(\pi^*) \end{aligned}$$

where m^* and π^* are defined as in Proposition (1).

Proposition 2 (continued)

When $m^* < m_B$ credit demand is scarce and the equilibrium thresholds are

$$\begin{aligned} \tilde{m} &= m_B \\ \tilde{\theta} &= b - aK + aK\left\{\pi_F\left(m_B\right)\right\} \\ \tilde{x}_B &= \tilde{\theta} + \sigma\Phi^{-1}\left(\pi_B\left(m_B\right)\right) \\ \tilde{x}_F &= \tilde{\theta} + \sigma\Phi^{-1}\left(\pi_F\left(m_B\right)\right) \end{aligned}$$

where $\pi_F\left(m_B\right) = \frac{(1+r)E}{(1+R)-(B_B+(1+r+\rho)k)(1-E)} > \pi^* > \pi_B\left(m_B\right)$.

Proposition 2 (continued)

When $m^* > m_F$ credit supply is scarce and the equilibrium thresholds are

$$\begin{aligned} \tilde{m} &= m_F \\ \tilde{\theta} &= b - aK + aK\left\{\pi_B\left(m_F\right)\right\} \\ \tilde{x}_B &= \tilde{\theta} + \sigma\Phi^{-1}\left(\pi_B\left(m_F\right)\right) \\ \tilde{x}_F &= \tilde{\theta} + \sigma\Phi^{-1}\left(\pi_F\left(m_F\right)\right) \end{aligned}$$

where $\pi_B\left(m_F\right) = \frac{1+r}{\frac{(1+R)-B_F}{(1-E)} - (1+r+\rho)k} > \pi^* > \pi_F\left(m_F\right)$.

In the limit as $\sigma \longrightarrow 0$, the signal thresholds x_B^* and x_F^* converge to the fundamental threshold θ^*, $\forall m$.

$$\begin{aligned} \tilde{x}_B &\longrightarrow \tilde{\theta} \\ \tilde{x}_F &\longrightarrow \tilde{\theta} \end{aligned}$$

Two-Regions Model

We consider an extension of the model with exogenous margin m (and no moral hazard) in which there are two regions characterized by different levels of productivity, high and low ($i = H, L$).
Firms are financed by an integrated banking sector that can costlessly allocate funds in either region.
As in the benchmark model, in each region firms coordinate on investment opportunities under the following local regime change conditions:

$$a \min \left\{ L_L^S, L_L^D \right\} + \theta > b_L$$

$$a \min \left\{ L_H^S, L_H^D \right\} + \theta > b_H$$

where $b_L = \frac{1}{productivity_L} > \frac{1}{productivity_H} = b_H$.
Firms' payoff, conditional on a given strategy and on coordination success or failure, is identical in the two countries.
The (international) banks have to decide if they want to finance firms in country H or in country L and the payoff, again conditional on coordination success or failure, is the same.

Proposition 3

The model admits two self-fulfilling equilibria.
In the first equilibrium $\theta_L^* > \theta_H^*$ and $x_{L,F}^* > x_{H,F}^*$ with:

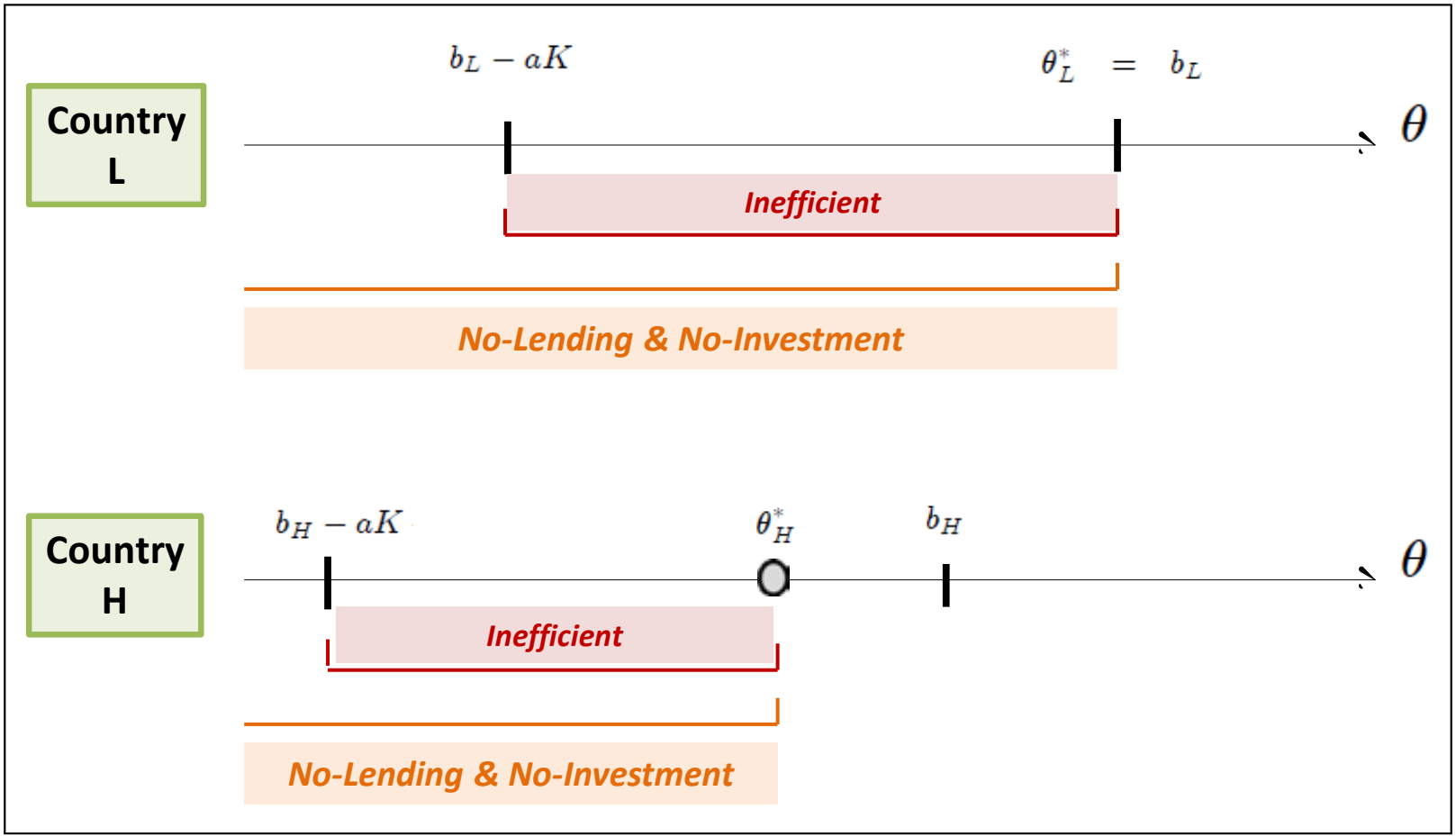
$$\begin{aligned}
\theta_L^* &= b_L > b_H \\
\theta_H^* &= b_H - aK + aK\left(\pi_F\left(m\right)\right) \\
x_{L,F}^* &= \theta_L^* + \sigma\Phi^{-1}\left(\pi_F\left(m\right)\right) \\
x_{H,F}^* &= \theta_H^* + \sigma\Phi^{-1}\left(\pi_F\left(m\right)\right)
\end{aligned}$$

Proposition 3 (continued)

In the second equilibrium $\theta_L^* < \theta_H^*$ and $x_{L,F}^* < x_{H,F}^*$ with:

$$\begin{aligned}
\theta_L^* &= b_L - aK + aK\left(\pi_F\left(m\right)\right) \\
\theta_H^* &= b_H \\
x_{L,F}^* &= \theta_L^* + \sigma\Phi^{-1}\left(\pi_F\left(m\right)\right) \\
x_{H,F}^* &= \theta_H^* + \sigma\Phi^{-1}\left(\pi_F\left(m\right)\right)
\end{aligned}$$

This equilibrium exists only if the productivity of country L is not too low compared to the productivity of country H, i.e.
$b_L - b_H < aK\left[1 - \pi_F\left(m\right)\right]$.
In the limit as $\sigma \longrightarrow 0$, $x_{L,F}^* \longrightarrow \theta_L^*$ and $x_{H,F}^* \longrightarrow \theta_H^*$, in both equilibria.


Country L
$b_L - aK$
$\theta_L^* = b_L$
θ
Inefficient
No-Lending & No-Investment
Country H
$b_H - aK$
θ_H^*
b_H
θ
Inefficient
No-Lending & No-Investment

Empirical Evidence

Coordination motive among BANKS

Table 1

Dependent variable: *probability of a tightening*	(1)	(2)	(3)	(4)	(5)
Loan supply(-i)	-1.813***	-2.146***	-1.279**	-1.566**	-1.632**
BLS: Bank B.S. conditions			-1.994***	-1.453*	-1.243
BLS: Risk factors			-0.838**	-1.186***	-1.574***
Constant	3.901***	3.902***	1.057	1.735	-41.15***
Observations	276	260	260	250	250
Bank FE	NO	YES	YES	YES	YES
MACRO controls	NO	NO	NO	YES	YES
Bank B.S. indicators	NO	NO	NO	NO	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Empirical Evidence

Coordination motive among FIRMS

Table 3

Dependent variable:	(1)		(2)	
prob (loan dem. for inv.= down/up)	down	up	down	up
BLS: Loan demand for investments(-i)	-2.419***	0.275	-1.909***	-0.00833
Constant	5.640***	-2.375	4.046***	-1.523
Observations	276	276	265	265
Bank FE	YES	YES	YES	YES
MACRO controls	NO	NO	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1