# FINANCIAL FRICTIONS, INNOVATION, AND ECONOMIC GROWTH

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# Motivation

◇ The innovation and implementation of new ideas, or knowledge, are key for economic growth (Schumpeter 1934).

◇ A big issue: *Technology Transfer*

- How to get ideas into the hands of those best suited to implement them?

◇ Financial development plays a key role in facilitating this process (Levine 2004).

◇ This project is an attempt to contribute to these issues.

# What We Do

Build a growth model where advances in knowledge lead to increases in productivity

- ◇ Individual producers have access to the frontier technology $Z$, which is in the public domain.
- ◇ They also come up with ideas for innovations that increase their own knowledge and productivity $z$.
- ◇ This new idea can also be transferred to other better implementors.
- ◇ Financial frictions can impede this idea market and hence hinder the advancement of knowledge and economic growth.

# Related Work

- ◇ Transfer of Ideas:

  e.g. Holmes and Schmitz (1990), Chatterjee and Rossi-Hansberg (2007), Silveira and Wright (2008), Chiu and Meh (2008).

- ◇ Ideas and Growth:

  e.g. Romer (1990), Jones (1997), Kortum (1997), Lucas (2008).

- ◇ Financial Development and Growth:

  e.g. Greenwood and Jovanovic (1990), Greenwood and Smith (1997), Levine (2004).

- ◇ Monetary Policy and Growth:

  e.g. Gomme (1993), Boyd and Champ (2003), Berentsen, Breu and Shi (2009).

# Overview

1. Basic Growth Model
2. Technology Transfer
3. Financial Frictions
4. Modeling Financial Activity
5. Some Empirical Evidence
6. Conclusion and Extensions

# Basic Growth Model

# Environment

◇ Infinite horizon: $t = 1, 2, 3, ...$

◇ Measure 1 of agents

◇ Preference:

$$u(c) - \chi h,$$

where $c$ : consumption, $h$ : labor supply

◇ Technology

$$y = zf(H),$$

where $z$ : **individual** productivity, $H$ : labor demand

# Innovation

- ◇ At the beginning of each period, every agent has access to the frontier technology $Z$.
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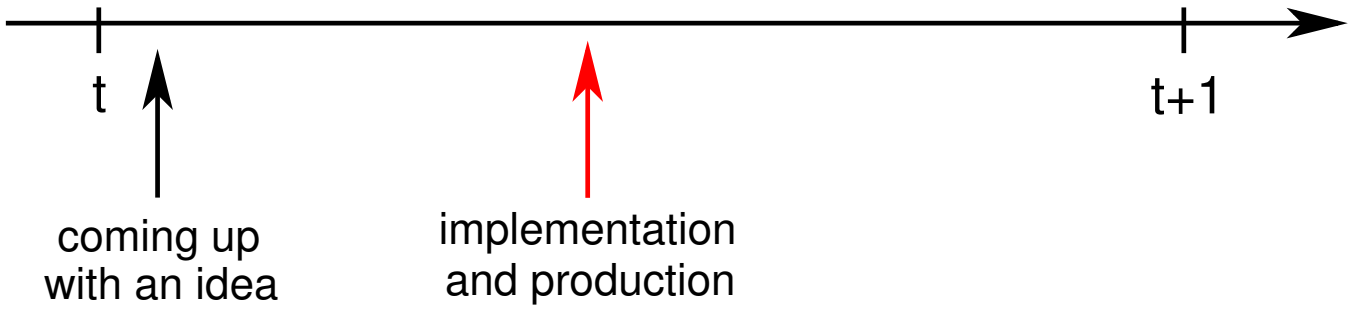
- ◇ The idea can be implemented to increase individual productivity $z$.



# Idea Implementation

◇ Successful idea **implementation** can improve individual productivity:

$$z = \begin{cases} Z(1+\eta) & \text{w/prob. } \lambda \\ Z & \text{w/prob. } 1-\lambda \end{cases}$$

where

$Z$: frontier productivity

$z$: individual productivity **after** implementation

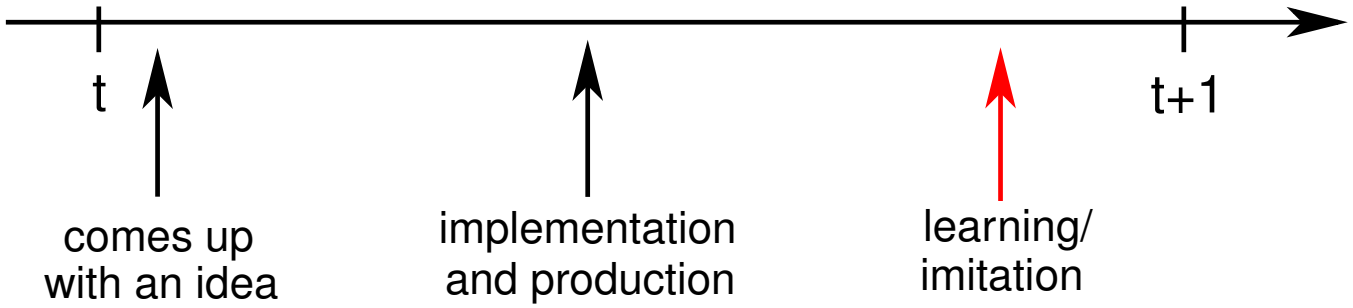
◇ $\lambda \sim F_i(\lambda)$: capture the match between idea and agent's skill

◇ Successful implementation increases individual profit in the short-run

# Technology Diffusion

◇ At end of the period, knowledge will enter the public domain, freely available to other agents to imitate/learn

◇ As a result, all agents will start the next period with the same frontier technology $Z_{t+1}$



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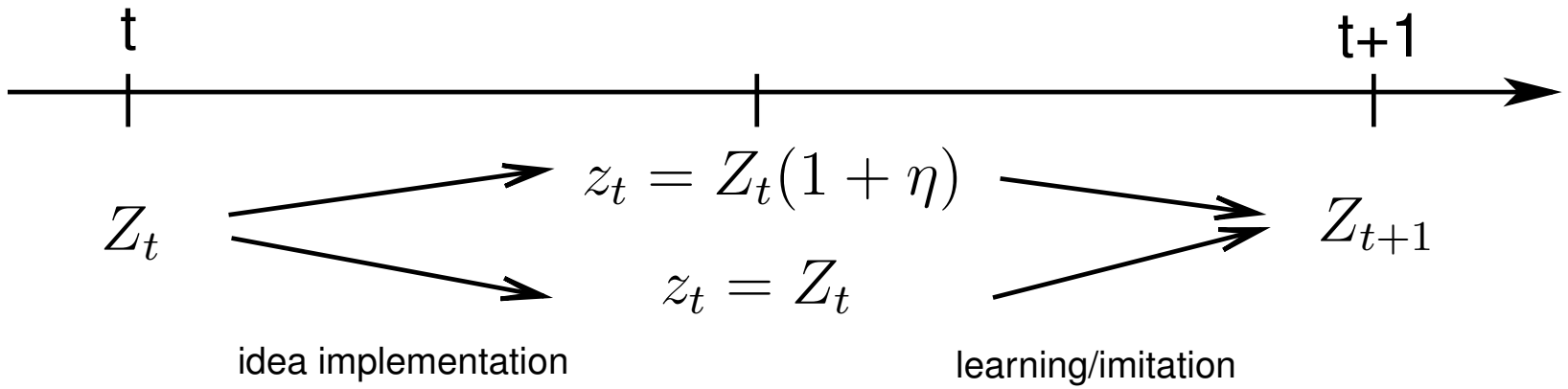

# Technology Diffusion (Cont'd)

Assume the learning/imitation process is captured by

$$Z_{t+1} = \rho \left[ \int_0^1 z_t(j)^{\varepsilon} dj \right]^{\frac{1}{\varepsilon}},$$

where

$z_t$ : individual productivity at the end of $t$

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Our result relies only on:

◇ Frontier technology $Z_{t+1}$ increasing in individual productivity $z_t(j)$

# Technology Diffusion (Cont'd)

$$Z_{t+1} = \rho \left[ \int_0^1 z_t(j)^{\varepsilon} dj \right]^{\frac{1}{\varepsilon}},$$

- $\varepsilon = \infty$:

  frontier technology is determined by the most productive agent.

- $\varepsilon = -\infty$:

  frontier technology is determined by the least productive agent.

- $\varepsilon = 1$:

  frontier technology is the average of all agents'.

# Real Asset

- ◇ To facilitate later discussion, introduce a fixed stock $A$ of real asset.
- ◇ Each share, $a$, has a price $\phi$ and yields dividend $\delta$.
- ◇ Dividend $\delta$ can be turned into $Z\delta$ consumption good.

# Balanced Growth Path

Aim to construct the BGP s.t.

- $1 + g = \frac{Z_{t+1}}{Z_t} = \frac{Y_{t+1}}{Y_t} = \frac{C_{t+1}}{C_t} = \frac{w_{t+1}}{w_t} = \frac{\phi_{t+1}}{\phi_t}$.
- Utility function: $u(c) = \log(c)$

# Agent's Problem

After $z$ realizes, each agent solves:

$$W(a, z; Z) = \max_{c,h,a'} \{u(c) - \chi h + \beta V(a', Z')\}$$

$$\text{s.t. } c + \phi a' = wh + (\phi + \delta^a Z)a + \pi(z),$$

where $V$ is the value function at the beginning of the next period.

$$\pi(z) = \max_H \{zf(H) - wH\}$$

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where $V$ is the value function at the beginning of the next period.

$$V(a, Z) = \int_0^1 \lambda W(a, Z(1+\eta); Z) + (1-\lambda) W(a, Z; Z) dF_i(\lambda)$$

$$\pi(z) = \max_H \{z f(H) - wH\}$$

# Return to implementing idea

*Expected gain from implementing an idea with* $\lambda$

$$\lambda\Delta \equiv \lambda \underbrace{(\pi_1 - \pi_0)\frac{\chi}{w}}_{\Delta},$$

*where*

$\pi_1$: profit for high productivity agents

$\pi_0$: profit for low productivity agents.

# Result

The equilibrium growth rate of the economy is:

$$1 + g = \rho \left[ N(1+\eta)^{\varepsilon} + (1 - N) \right]^{1/\varepsilon}$$

where $N$ is the measure of ideas successfully implemented:

$$N = \mathbb{E}\lambda = \int_0^1 \lambda dF_i(\lambda)$$

Note: $N$ is determined only by the exogenous distribution $F_i(\lambda)$

# Technology Transfer

# Entrepreneurs

- ◇ Introduce measure $n_e$ of entrepreneurs (endogenize later)
- ◇ Entrepreneurs do not innovate.
- ◇ But potentially better in implementing ideas: $\lambda_e \sim F_e(\lambda_e)$.

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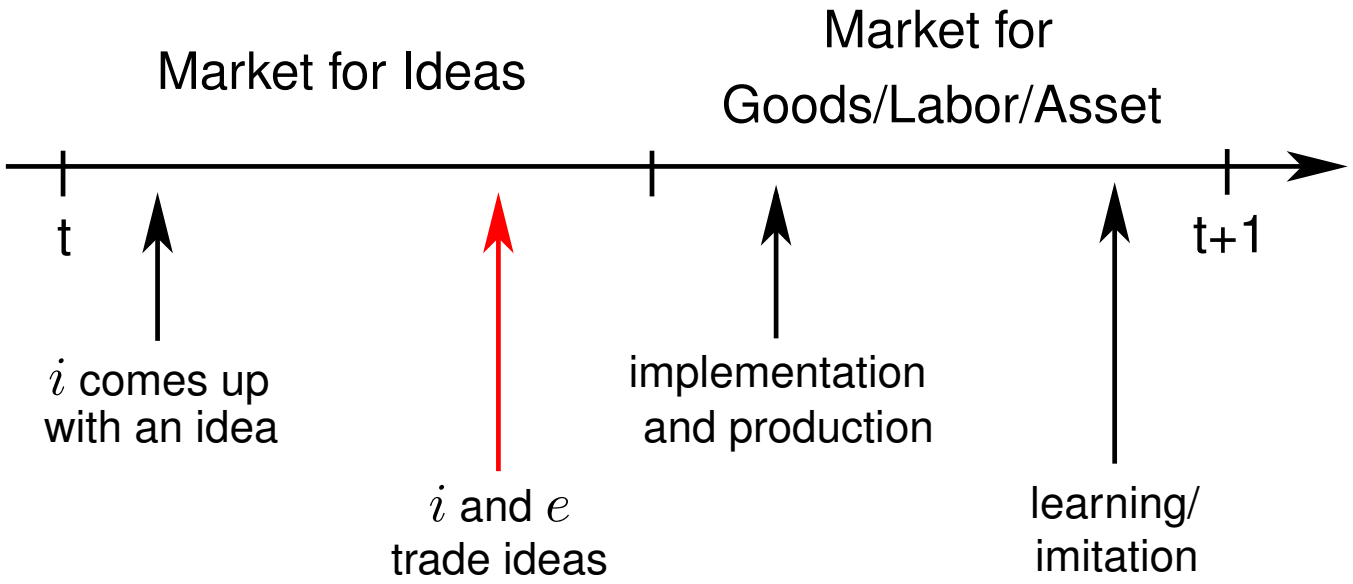


# Market for Ideas

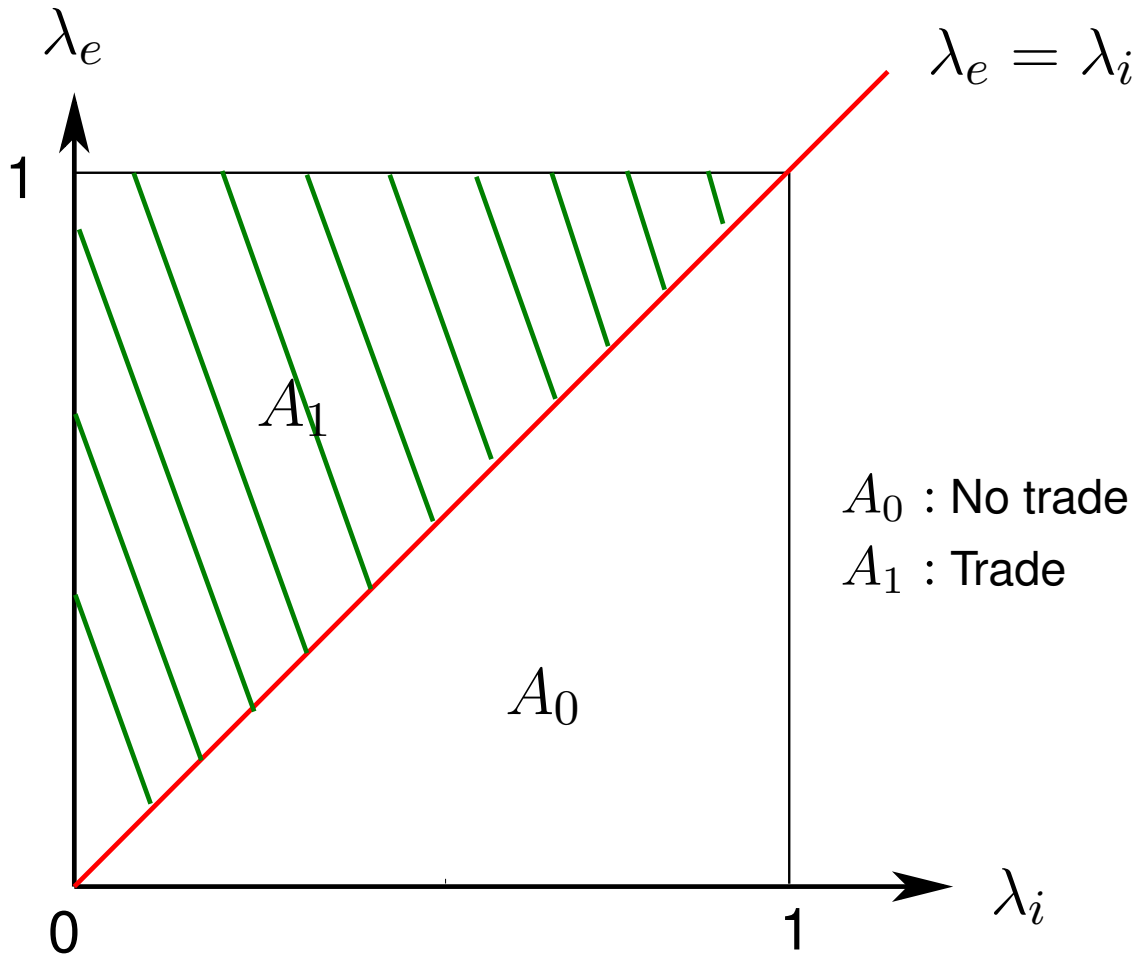
◇ Bilateral random matching:

- $e$ meets with $i$ w/prob. $\alpha_e$
- $i$ meets with $e$ w/prob. $\alpha_i$

◇ Terms of trade determined by Nash bargaining.

$$\max_p \left[\lambda_e \Delta - p\right]^\theta \left[p - \lambda_i \Delta\right]^{1-\theta}$$

◇ No financial frictions




An idea is traded whenever $\lambda_e > \lambda_i$.

# Result

◇ Growth rate:

$$1 + g = \rho \left[ N(1+\eta)^{\varepsilon} + 1 - N \right]^{1/\varepsilon}$$

◇ Only difference is more ideas are successfully implemented:

$$N = \mathbb{E}\lambda_i + \underbrace{n_e \alpha_e \hat{\mathbb{E}}(\lambda_e - \lambda_i)}_{\text{Additional success due to trade}},$$

where $\hat{\mathbb{E}}(\lambda_e - \lambda_i) = \mathbb{E}(\lambda_e - \lambda_i | \lambda_e > \lambda_i) \Pr(\lambda_e > \lambda_i)$.

# Result

- *Transferring ideas increases growth rate.*

- *Growth rate depends on*
  - ◇ *number of innovators and entrepreneurs ($n_i, n_e$)*
  - ◇ *quality of innovation ($\eta$)*
  - ◇ *matching frictions between agents ($\alpha_i, \alpha_e$)*
  - ◇ *matching distribution between ideas and agents ($F_i, F_e$)*
  - ◇ *diffusion technology ($\rho, \varepsilon$)*

- *Growth rate independent of $A\delta$*

# Free Entry of Entrepreneurs

Endogenize $n_e$

- Suppose $e$ has to pay cost $\kappa$ to enter the idea market.
- Free entry equates entry cost to the expected gain from trade:

$$\kappa = \alpha_e \theta \Delta \hat{\mathbb{E}}(\lambda_e - \lambda_i).$$

- Exogenous drop in $\kappa$ (e.g. gov't subsidy):
  - ◇ More entrepreneurs ($n_e$)
  - ◇ More ideas successfully implemented ($N$)
  - ◇ Higher economic growth ($g$)

# Financial Frictions

# Liquid Asset

- ◇ Suppose a fraction $A_0$ of the asset is *liquid*: can be traded in the idea market. Remaining fraction is illiquid.
- ◇ The rate of return on liquid asset: $1 + \tilde{i} = \frac{\phi' + Z'\delta}{\phi}$.
- ◇ The rate of return on illiquid asset: $1 + \bar{i} = \frac{1+g}{\beta}$.
- ◇ Define the interest spread as

$$s = \frac{\bar{i} - \tilde{i}}{1 + \tilde{i}},$$

measuring the cost of holding liquid asset $a_0$.

# Bargaining Problem

◇ Entrepreneur brings $x = \frac{\phi+Z\delta}{Z} a_0$ (normalized) units of liquid asset to idea market.

◇ Liquidity constraint: $p \leq x$

◇ Bargaining problem:

$$\max_{p \leq x} \left(-p + \lambda_e \Delta\right)^{\theta} \left(p - \lambda_i \Delta\right)^{1-\theta},$$

◇ If $x \leq \lambda_i \Delta$:

$e$ does not have enough liquidity to cover reservation price of $i$.

◇ Liquidity constraint binds if

$$\lambda_e \leq B(\lambda_i, x) \equiv \frac{1}{1-\theta}\left[\frac{x}{\pi_1 - \pi_0} - \theta\lambda_i\right].$$

◇ **Bargaining Outcome**

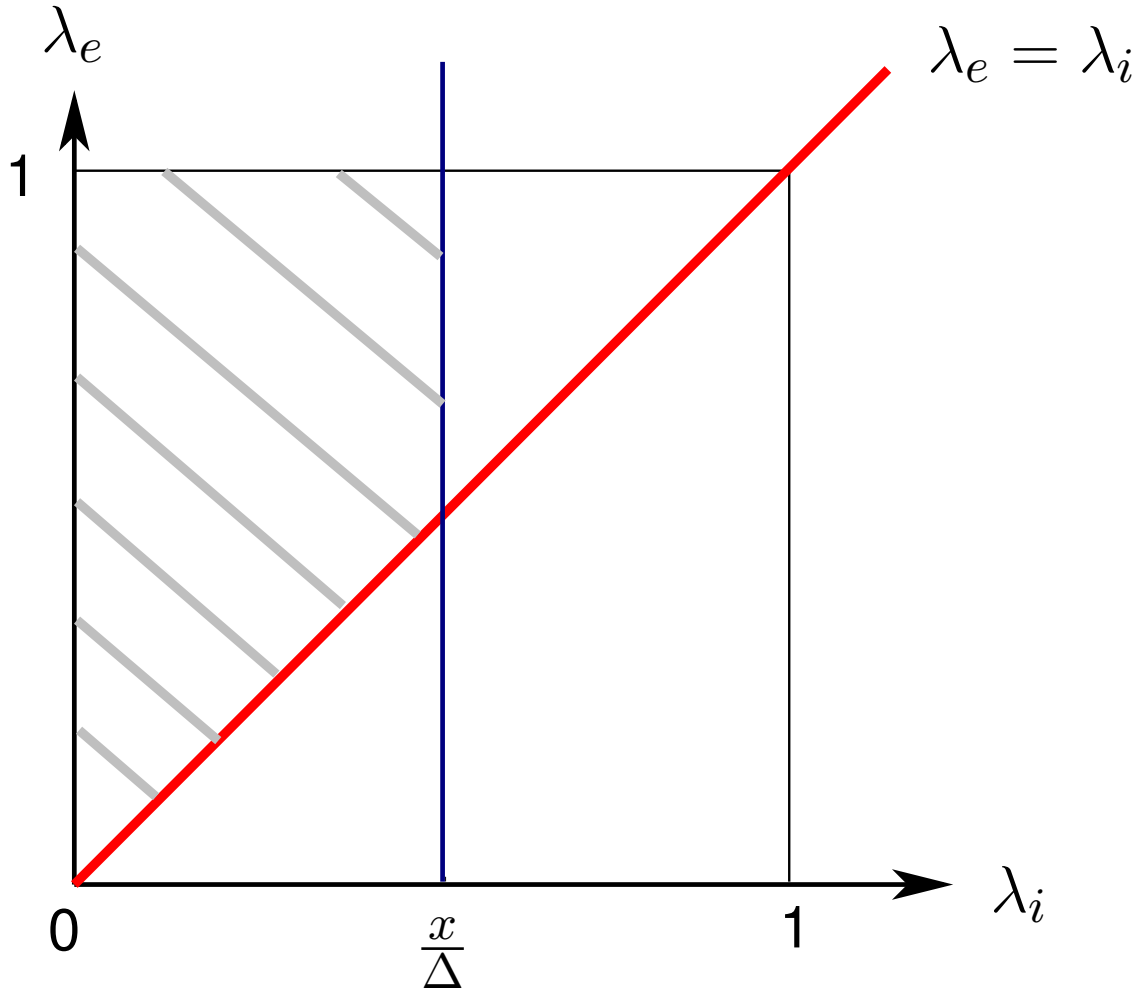
If $\lambda_e < \lambda_i$: no gains from trade.

If $\lambda_e \geq \lambda_i$: gains from trade.

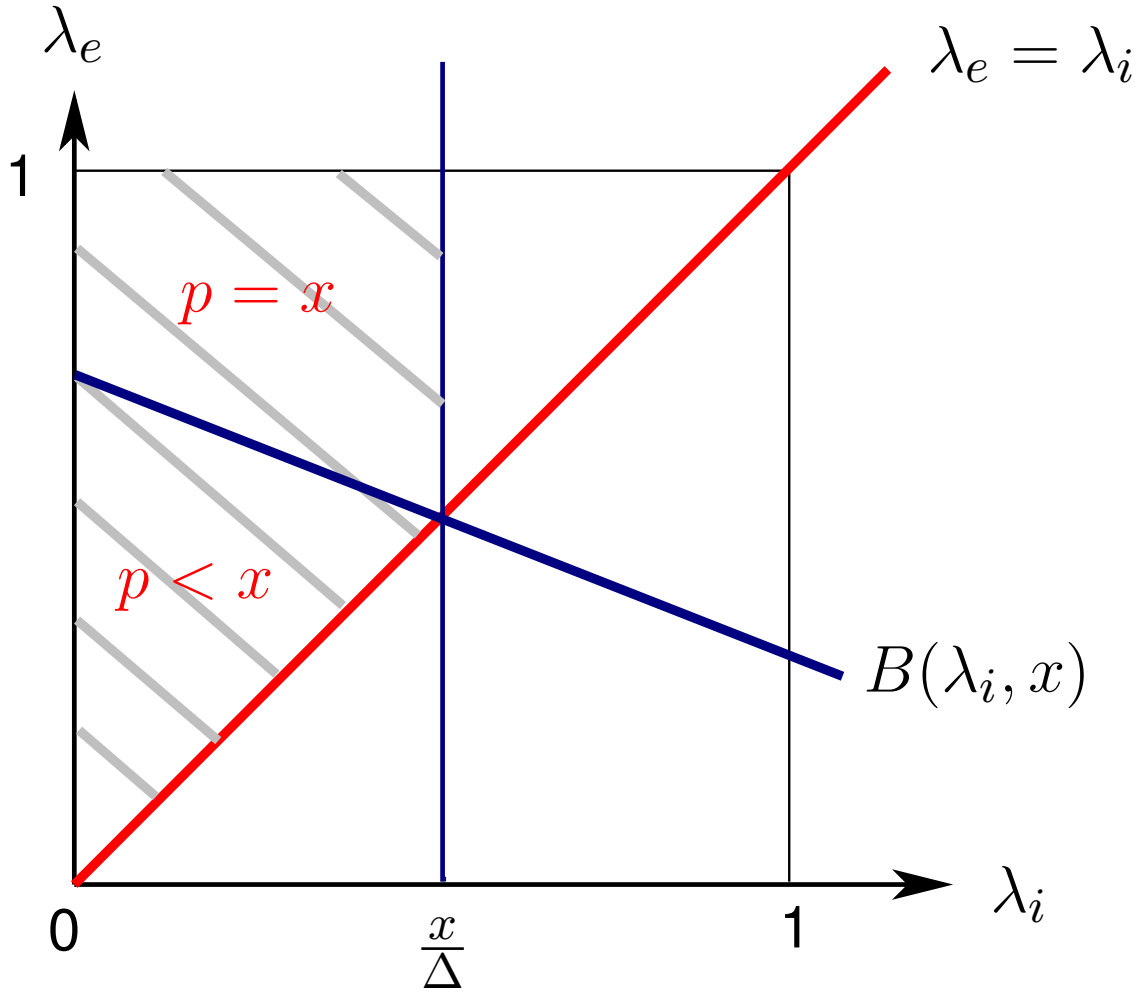
(i) no trade when $\lambda_i > \frac{x}{\Delta}$: insufficient liquidity

(ii) trade at $p < x$ when $\lambda_e \leq B(\lambda_i, x)$ and $\lambda_i \leq \frac{x}{\Delta}$.

(iii) trade at $p = x$ when $\lambda_e > B(\lambda_i, x)$ and $\lambda_i \leq \frac{x}{\Delta}$.




◇ An idea is traded iff $\lambda_e \geq \lambda_i$ AND $\frac{x}{\Delta} \geq \lambda_i$.




◇ An idea is traded iff $\lambda_e \geq \lambda_i$ AND $\frac{x}{\Delta} \geq \lambda_i$.

◇ Note: $x$ and $\Delta$ are endogenous objects determined in GE.

# Result

◇ Growth rate:

$$1 + g = \rho \left[ N(1+\eta)^{\varepsilon} + 1 - N \right]^{1/\varepsilon}$$

◇ Number of ideas successfully implemented:

$$N = \mathbb{E}\lambda_i + \underbrace{n_e \alpha_e \hat{\mathbb{E}}(\lambda_e - \lambda_i)}_{\text{Additional success due to trade}} ,$$

where

$$\hat{\mathbb{E}}(\lambda_e - \lambda_i) = \mathbb{E}(\lambda_e > \lambda_i | \min\{\lambda_e, \tfrac{x}{\Delta}\} > \lambda_i) \times \Pr(\min\{\lambda_e, \tfrac{x}{\Delta}\} > \lambda_i)$$

# Result

**Proposition**

*When $\theta = 1$, $\lambda_e$ and $\lambda_i$ drawn from independent uniform distributions.*

- ◇ *Exogenous reduction in the **supply of liquid asset***
  - *higher interest spread ($s$)*
  - *lower entrepreneurs' liquidity holding ($x$)*
  - *less idea traded and implemented ($N$)*
  - *lower output ($Y$)*
  - *lower wage rate ($w$)*
  - ***lower growth rate** ($g$)*

# Next Step: Endogenous Financial Activity

Analyze how financial development affects technology transfer and growth.

- ◇ Endogenize the decision for entrepreneur to postpone trade and raise additional funds (Silveira and Wright)
- ◇ Endogenize agents' decision to access costly financial intermediaries (Chiu and Meh)

# Some Evidence

- Empirical literature finds that firms' technology transfer depends on their cash holding and access to bank loans (Montalvo and Yafeh, 1994)

- World Bank Enterprize Surveys 2005:
  - ◇ Firms' decision to transfer technology is positively correlated with the financial development in a country.

# Conclusion and Extensions

- Developed a tractable endogenous growth model in which advances in knowledge lead to increases in productivity.

- Showed how this process is aided by the exchange of ideas, and how financial frictions and lack of liquidity can impede this market, hindering economic growth.

- Extensions
  - ◇ Endogenous financial activity
  - ◇ Endogenous innovation and entry
  - ◇ Role of policy

# What is an Idea?

1. Inputs into the expansion of knowledge, improving productivity.

2. Ideas are indivisible – either I tell you or I don't.

3. Ideas is nonrival goods at least in the long run when knowledge enters the public domain.

4. Ideas are difficult to collateralize, making credit problematic and motivating the consideration of liquidity.

5. The idea market is rife with information problems, motivating a general desire to transfer ideas directly.