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Needed Financial Infrastructure: Innovations in Emerging Markets and Guidelines from Theory for Optimal Infrastructure Design
(Lecture 6)

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Gaps on the Ground in Financial infrastructure, Featuring Thai Application

❖Missing an opportunity for regional risk sharing, need more insurance

➢Low risk premium for idiosyncratic shocks due to pooling, gift giving in networks (Samphantharak and Townsend, 2015)

➢High risk premium for aggregate shocks

➢Yet aggregates differ across villages, could be pooled, but so far are not

❖Cash management: Huge welfare losses, potential gains from reforms

❖Incomplete contracts, limited financial regimes

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Interventions helped, but limited to informal trust systems, missing cross-village formal

❖ Interventions such as Million Baht Fund
  ➢ Who got the money – "corrupt" village committee and those connected to that committee (Vera-Cossio 2018)
  ➢ Costly state verification regime – costs are lower if have kin in the village (Ru and Townsend 2018)

❖ Village partitioned into with/without kin (Kinnan et al 2018)-contagion
  ➢ With: almost perfect insurance for illness/expenditure shock
  ➢ Without: More vulnerable in consumption fluctuations, but also production impact spills into input providers (laborers who lose work), inputs are others' outputs, lower sales (build inventory),
  ➢ Contagion, as in financial crises

❖ Networks especially limited across villages: Wider geographic infrastructure, markets and mechanisms are still missing, need designs for these

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Financial Infrastructure: The Needed Smart Contracts and Optimized Competition

❖Innovation in two forms

❖Individual smart contracts, overcome obstacles (each individual contract can be quite useful)

- o Escrow with non-banks; savings products for automated deposit and portfolio management; securitized waterfall payments along the path of supply chains from buyer to seller; seller to employee loans; capitalize wage payments. All with commitment, immutable

❖A platform for contract competition

- o As in general equilibrium models with an intermediary broker sector (Prescott and Townsend 1984a, 1984b)

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EvryNet for SEA: Featured example of innovation

❖ Provide open-source banking services and financial contracts to unbanked and underbanked populations

❖ An interoperable smart contract platform that enables not only traditional banks but also micro-finance institutions and others to initiate and execute banking products and financial contracts, with KYC and other regulatory links

General Competitive Analysis in an Economy with Private Information by Prescott and Townsend (IER 84)

- This paper extends the theory of general equilibrium in pure exchange economies to a prototype class of environments with **private information.**

and

- examines again the role of securities in the optimal allocation of risk-bearing.
- The first welfare theorem holds in this economy:
  - competitive equilibrium allocations are Pareto optimal.
- The second fundamental welfare theorem however does not hold:
  - Not all Pareto optimal allocations can be supported as competitive equilibria.

Motivating Example

- at $T = 0$ all agents are the same
- at $T = 1$ fraction $\lambda(\theta)$ of agents receive a private shock $\theta \in \Theta = \theta_1, \theta_2$
- and their utility from consumption becomes $U(c, \theta)$
    - $U(c, \theta)$ is increasing, concave and continuously differentiable in c
    - $U'(\infty, \theta_1) = 0$ and $U(c, \theta_2) = \theta_2 c$, $(\theta_2 > 0)$
        - We only require type1 to be more risk averse than type2
- all agents recieve endowment e of consumption good with certainty and $U'(e, \theta_1) < \theta_2$.

Pareto Optimal Allocation

If θ were public, Pareto optimal allocation problem at $T = 0$ is:

$$\max_{c_1, c_2} \quad \lambda(\theta_1)U(c_1, \theta_1) + \lambda(\theta_2) \times (\theta_2 c_2)$$

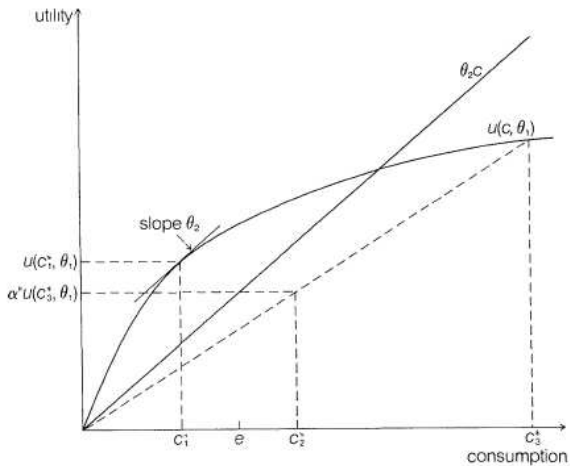$$s.t. \; \lambda(\theta_1)c_1 + \lambda(\theta_2)c_2 \leq e$$

- Pareto optimal allocation requires:

$$U'(c_1^*, \theta_1) = \theta_2$$

$$\lambda(\theta_1)c_1^* + \lambda(\theta_2)c_2^* = e$$

  - i.e. marginal utilities are equated across states and the endowment is exhausted

- But with our assumptions, this requires $c_1^* < c_2^*$.
- If θ is private knowledge, we cannot implement this allocation since type1 is always better off reporting her type is 2.

Graphical Illustration

Pareto Optimal Allocation with Lotteries

- Lotteries can solve this incentive compatibility problem.
- Since type2 is risk neutral, she is indifferent between:
  - recieving c_2^* with certainty
  - recieving c_3^* with probability $\alpha^* = c_2^*/c_3^*$ and consumption 0 with probability $1 - \alpha^*$.
- But for c_3^* sufficiently large, type1 agents prefer consuming c_1^* for sure instead of type2 agents allocation.
- Thus with lotteries we can achieve an allocation that is both Pareto optimal and incentive compatible.

Competitive Market Implementation

- Imagine households can buy and sell contracts (make commitments) in a planning period ($T = 0$) market.
- Commitments can be conditional on households' individual circumstances (i.e. their private shocks θ)
  - of course, households will choose the option which is best given its individual circumstance.
  - W.L.O.G. we can restrict to options such that household announce its individual shocks truthfully.
- We allow options to affect random allocation of consumption good.

Contracts as a Bundle-I

Without Lotteries. Simplest notation is one good, but here to make sense need vector, otherwise no trade without lotteries.

- $c(\theta)$ is the contract contingent on θ, $[c(\theta), \theta]$
- Then $U[c(\theta), \theta] \geq U[c(\theta'), \theta]$ for all $\theta, \theta' \in \Theta$
- The expected utility of contract $[c(\theta), \theta]$ for $\theta \in \Theta$ is:

$$W\{[c(\theta), \theta]\} = \sum_{\theta} \lambda(\theta) U[c(\theta), \theta]$$

- Competitive Market
    - Households maximize in the standard problem by purchasing incentive compatible contracts $[c(\theta), \theta] \theta \in \Theta$, taking some pricing function $p(\theta) \theta \in \Theta$ as given:

$$\max \sum_{\theta} \lambda(\theta) U[c(\theta), \theta]$$

$$\text{s.t. } \sum_{\theta} p(\theta) c(\theta) \leq \sum_{\theta} p(\theta) \varsigma$$

    - So it is as if selling endowment (ς) and buying θ contingent consumption back
    - Equivalent with excess demand, or supply, for each θ, hence insurance

Contracts as a Bundle-II

- A broker dealer offering contracts $[y(\theta), \theta \in \Theta]$, where $y(\theta) > 0$: broker dealer is giving out to those who announce ϑ, indemnity, ex-post
- $y(\theta) < 0$: broker dealer is taking in from those who announce θ, premium, ex-post
  - Revenue is $\sum_{\theta} p(\theta) y(\theta)$
  - Feasible trading set is defined by $\sum_{\theta} \lambda(\theta) y(\theta) \leq 0$

Competitive Market

Formally an insurance contract can be shown by

$$x(c, \theta), c \in C, \theta \in \Theta$$

- If household announce its shock θ, in the consumption period receive c with probability $x(c, \theta)$.
  - of course $0 \le x(c, \theta) \le 1$ and $\sum_c x(c, \theta) = 1$
- Households buy these insurance contracts in the planning period market.
- Households endowments can be shown by probability measures $\zeta(c, \theta), \theta \in \Theta$ each putting mass one on the endowment point e.
- These endowments are sold in the planning period market.

Competitive Market

- In summary households maximize:

$$\max_{x(c,\theta)} \quad \sum_{\theta} \lambda(\theta) \sum_{c} x(c,\theta) U(c,\theta)$$

$$s.t. \quad \sum_{\theta} \sum_{c} p(c,\theta) x(c,\theta) \le \sum_{\theta} \sum_{c} p(c,\theta) \zeta(c,\theta)$$

and   incentive compatibility

- We also assume there are firms or intermediaries that make commitments to buy and sell the consumption good.

Competitive Market

- Firm production $y(c, \theta)$ delivers c units of consumption if agent announce her type is θ.
- Production set of each firm is defined by

$$Y = \left\{ y(c, \theta), c \in C, \theta \in \Theta : \sum_\theta \lambda(\theta) \sum_c cy(c, \theta) \leq 0 \right\}$$

- (intermediary effectively facing aggregate resource constraint)
- This requires each firm not deliver more of the single consumption good in the consumption period than it takes in.
- Y displays constant return to scale. So we can assume we only have one price taker firm.
- $y(c, \theta)$ is passive:
    - $y(c, \theta) > 0$: firm is giving away.
    - $y(c, \theta) < 0$: firm is taking in.

Competitive Market

- Firm problem is:

$$\max \sum_{\theta} \sum_{c} p(c, \theta) y(c, \theta)$$

- Equilibrium price system $p^*(c, \theta)$ must satisfy

$$p^*(c, \theta) = \lambda(\theta) c$$

- This corresponds to actuarially fare insurance.
  - Price of A-D security which pays c at state θ is just equal probability of the state $\times$ consumption in that state

Welfare Theorems-I

- An allocation (x_i) is implementable if it satisfies the resource constraints and a no-envy constraint

$$W(x_i, i) \geq W(x_j, i) \, \forall i, j$$

- An allocation is a Pareto optimum if it is implementable and there does not exist an implementable allocation (x_i') such that $W(x_i', i) \geq W(x_i, i)$ with a strict inequality for some i.
- Definition of Competitive Equilibrium
  - A competitive equilibrium is
    - a state$[(x_i^*), y^*]$
    - a price system $v*$
  - such that:
    1. for every i, x_i^* maximizes $W(x_i, i)$ subject to $x_i \in X$ and $v^*(x_i) \leq v^*(\zeta)$
    2. $y*$ maximizes $v * (y)$ subject to $y \in Y$
    3. $\sum_{i=1}^{n} \lambda(i) x_i^* - y^* = \zeta$

Welfare Theorems-Limitations

- First Welfare Theorem
    - If the allocation $[(x_i^*), y^*]$, together with the price system v^*, is a competitive equilibrium and if no x_i^* is a local saturation point, then $[(x_i^*), y^*]$ is a Pareto optimum.
- Second Welfare Theorem
    - With private information, there is no guarantee that every Pareto optimum can be supported by a quasi-competitive equilibrium with an appropriate redistribution of wealth.
    - It is true that a separating hyperplane exists such that y^* maximizes value subject to the technology constraint, but x_i^* does not necessarily minimize value over the set
    $\{x_i \in X_i : \ W(x_i, i) \geq W(x_i^*, i)\}$. Rather, it minimizes value over the set $\left\{ x_i \in X_i : \ W(x_i, i) \geq W(x_i^*, i) \text{ and } W(x_i, j) \leq W(x_j^*, j) \text{ for } j \neq i \right\}$.
    - Need no envy condition.

Some Limitations

❖Makowski (1980)

ABSTRACT/SUMMARY

Uses an theoretical economic model to examine the efficiency of the Profit Criterion for perfect competition. Factors that will influence any perfectly competitive firm to maximize profits if it is operating according to shareholders' interests; Strategies in receiving positive profits to any unilateral marketing decision.

➢ Xandri (2010) "Notes on 'Perfect Competition, the Profit Criterion, and the Organization of Economic Activity' by Louis Makowski (1980)"

Main Idea: The author introduces a very general framework to study endogenous determination of commodity spaces in general equilibrium. The paper studies Walrasian equilibrium and given its shortcomings on stability of innovations, the concept of "Full Walrasian Equilibrium" is introduced, as one in which no firm has incentives to market new commodities. The author then investigates conditions on equilibria for them to be efficient, and then find conditions on fundamentals to guarantee efficiency (namely, convexity and smoothness of the aggregate production technology and trading possibilities spaces). Finally, the author studies how mergers between firms can help achieve efficiency in exploiting innovation complementarities

Some Limitations

❖ Pesendorfer (1995)

We develop a model of financial innovation, in which intermediaries can issue new financial securities against collateral in the form of standard securities. Intermediaries have to market their innovations and marketing is costly. We show that the equilibrium asset structure may exhibit redundancies as frequently observed on financial markets. We give conditions for efficiency of financial innovation and show that with small innovation costs the indeterminacy of equilibrium allocations has small utility consequences. *Journal of Economic Literature* Classification numbers: D52, G10. © 1995 Academic Press, Inc.

➤ Xandri (2010) "Notes on 'Financial Innovation in a General Equilibrium Model' by Wolfgang Pesendorfer (1995)"

Main idea: Given a set of nominal securities, intermediaries have a technology to create financial derivatives. An equilibrium concept is proposed and characterized. Moreover, the author investigates efficiency of the outcome, the effects on real indeterminacy and explores the possibility of redundant assets in equilibrium

Regulation and Design of Financial Markets

Robert Townsend (MIT) and Juan Xandri (Princeton University)

Introduction

Financial Intermediation in Endogenous Incomplete Markets:

- They play the role of creating assets for agents to invest in
- Non-convexities in aggregate production set, such as trading fix costs (Pesendorfer (95), Bisin (98))
- In general, financial intermediaries have a coordination purpose: obtain resources from consumers and invest them in the productive sector.
- If there are economies of scale in aggregate risk sharing, intermediaries help coordinate investment.
- In this paper, we study a (very simple) model of constrained efficient incomplete markets, (from min scale constraints)
- We also study optimal financial regulation = optimal arrangements for intermediation (contracts, institutions and rules of competition)

Introduction

- The paper is divided in two parts

1. An optimal mechanism design problem: Abstracting away from markets, choose optimal
   1. span of assets (or technologies)
   2. investment portfolio
   3. "deposit" insurance for consumers

2. Implementation: Decentralize the optimal allocation with familiar institutions
   1. Broker - Dealers (acting as commercial banks) with free entry
   2. Firms (with free entry)

   - However, this institutions must be regulated in order to implement the optimal mechanism.
   - In our simple example, these are quite stark: shut down consumer $\leftrightarrow$ firms channel.

Setup
Households

- Diamond-Dygvig model
- Continuum set of households I, with measure 1.
- One consumption good, which is perishable. Households live for 3 periods $t = 0, 1, 2$.
- At $t = 0$, all households are identical, and receive an endowment of $\omega > 0$ units of $t = 0$ consumption
- Consumers have no endowment in $t = 1, 2$.
- Only derive utility from c_1, c_2
- Private Information:
    - Ex-ante identical households.
    - At $t = 1$ a taste shock $\theta \in \Theta$ is drawn from a distribution $F(\theta)$ (compact, Banach space)
- At $t = 1$ there is also a publicly observed shock $s \sim \text{Uniform}[0, 1]$

Setup
Technology

Two types of securities:

- Storage (short): Safe, that pays only 1 unit of next period consumption.
- Long assets, or productive technology, that pay off in period 2 only.
- For each $\hat{s} \in [0,1]$ there is an asset $A_{\hat{s}}$ that pays a rate of return $r_{\hat{s}}(s)$

$$r_{\hat{s}}(s) = \begin{cases} 0 & \text{if } s \neq \hat{s} \\ R > 1 & \text{if } s = \hat{s} \end{cases}$$

- If invest y in all long technologies equally, then gets Ry w.p.1
- This would map directly to classical Diamond-Dygvig model

Setup
Minimum Scale

- **Constraint:** Minimum scale requirement for investment $y(s)$ in asset s:

$$r_s(\hat{s} = s) = R \iff y(s) \geq M(s)$$

- This constraint is binding in the aggregate; i.e. there is not enough endowment to invest in all technologies

$$\int_0^1 M(s) > \omega$$

- Acemoglu and Zilibotti (1997): model of endogenous incomplete markets.
- Extra assumptions:
  - $M(s)$ is weakly increasing (w.l.o.g)
  - Continuous
  - $M(s) = 0$ for all $s \in [0, \delta]$ for some $\delta > 0$

Timeline

- $t = 0$:
  - agents ex-ante identical, have $\omega > 0$ for investing
  - investments made in storage (x) and long technologies $(y(s))$
- $t = 1$:
  - Aggregate shocks s (publicly observed) and θ_i (private) are realized
  - Agents report types $\hat{\theta}_i$ and receive consumption $c_1\left(\hat{\theta}_i, s\right)$
  - Invest remainder $= x - \int c_1(\theta, s) \, dF(\theta)$ to storage technology again
- $t = 2$
  - Agents consume $c_2\left(\hat{\theta}_i, s\right)$

Planners Problem

- **Planner Problem:** Choose optimal "consumption allocation" and "portfolio plan" to maximize consumers ex-ante expected utility
  - Consumption Allocation: Functions $c_1(\theta, s), c_2(\theta, s)$
  - Portfolio Allocation: Investment in short technology $x \geq 0$ and in long technologies $(y(s))_{s \in [0,1]}$

Planners Problem

$$W^* = \max_{c_1(\theta,s),c_2(\theta,s),x,y(s)} \int_0^1 ds \int U(c_1(\theta,s),c_2(\theta,s)) \, dF(\theta)$$

1 Inter-temporal RC: for all $s \in [0,1]$:

$$\int [c_1(\theta,s) + c_2(\theta,s)] \, dF(\theta) \leq x + Ry(s) \qquad (2)$$

2 IC constraints: for all $s \in [0,1]$ and all $\theta, \hat{\theta} \in \Theta$:

$$U(c_1(\theta,s), c_2(\theta,s), \theta) \geq U(c_1(\hat{\theta},s), c_2(\hat{\theta},s), \theta) \qquad (3)$$

3 Minimum scale constraints:

$$x \geq 0 \text{ and } y(s) \geq M(s) \text{ whenever } y(s) > 0 \qquad (4)$$

4 Portfolio Budget:

$$x + \int_0^1 y(s) \, ds \leq \omega \qquad (5)$$

Separate into two Programs

1. **Incentive program:** Given output $Y \geq 0$:

$$V(Y) := \max_{c_1(\theta), c_2(\theta)} \int U(c_1(\theta), c_2(\theta), \theta) \, dF(\theta)$$

$$\int [c_1(\theta) + c_2(\theta)] \, dF(\theta) \leq Y \qquad (6)$$

$$U(c_1(\theta, s), c_2(\theta, s), \theta) \geq U(c_1(\hat{\theta}, s), c_2(\hat{\theta}, s), \theta) \text{ for all } \theta, \hat{\theta} \in \Theta \quad (7)$$

2. **Investment program:** Given $V(\cdot)$, choose investments:

$$W^* = \max_{x, (y(s))_{s \in [0,1]}} \int_0^1 V(x + Ry(s)) \, ds \qquad (8)$$

$$x \geq 0 \text{ and } y(s) \geq M(s) \text{ whenever } y(s) > 0 \qquad (9)$$

$$x + \int_0^1 y(s) \, ds = \omega \qquad (10)$$
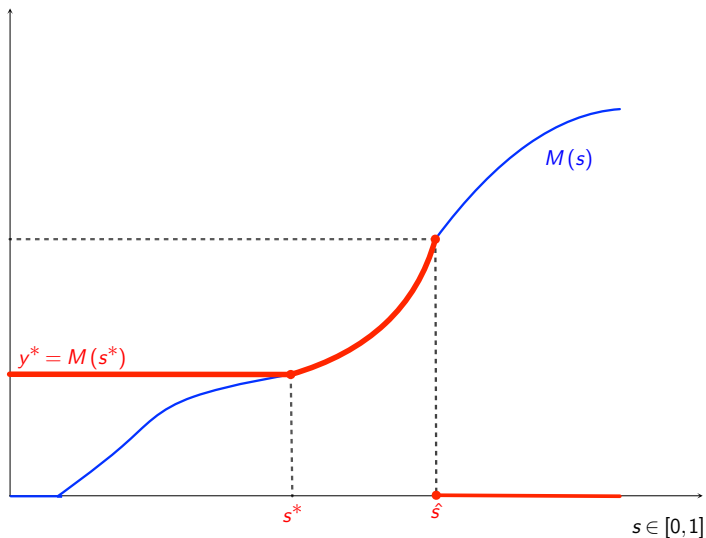
Investment Program

Figure: Optimal $y^*(s)$ schedule

Decentralization

- We propose a decentralization with three distinct sectors:

1. <u>Consumers:</u> Buy (lotteries) over deposit contracts
2. <u>Firms:</u> They manage short and long productive technologies (free entry)
3. <u>Broker-dealers</u> (or financial intermediaries): They sell contracts, and invest directly in firms

- There is free entry in all sectors (anyone can run a firm or be a financial intermediary)
- Endogenous markets:
    - Study first equilibria for a given set of contracts and financial intermediaries
    - Then determine set of contracts traded in equilibrium

Financial Sector

Invests (lends) wealth endowments to

Gives Insurance Contracts to

Invests in projects managed by

Pays dividends to

Households

Productive Sector

(1) – Households cannot trade with Productive sector