Spatial Competition among Financial Service Providers and Optimal Contract Design

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Density of Road Networks
The agents are distributed uniformly in $\mathbb{R}^1 : [0; 1]$ with total market mass set to one. The household cost to access financial services is $\bar{L} \cdot |x - x_i|$, $x$ is location of the agent, $x_i$ is location of bank $i$, $\bar{L}$ is a spatial cost or disutility from accepting a contract. The agents of type $\theta$ at location $x$ choose to go to bank $i$ if contract utility from bank $i$ satisfies participation constraint and the real value offered is better than the one from bank $i'$.

$$V_{\text{diff}} = u_i(\theta) - \bar{L} \cdot |x - x_i| \geq u_i'(\theta) - \bar{L} \cdot |x - x_i'| \geq \hat{u}_0(\theta)$$

where $\hat{u}_0(\theta)$ is autarky value.

- simplification: additive disutility
- can restrict choice by finite number of potential locations (even easier) - but we want to know if unrestricted competition in space delivers interesting patterns
- not yet including spatially different agent’s characteristics, all we need to do is to integrate over densities and we have that already built-in
- we see sequential entry transition in practice: Thailand, Brazil, Bangladesh
- we have good measure of cost
- can do $\mathbb{R}^2$, put in roads just like on real maps - not shown here
Optimal Contracts with Limited Information
and varying market structures

OBSTACLES TO TRADE/LIMITED INFORMATION

- full information - full commitment: contract breaks into pieces
  - credit at market interest $r$, equity and credit
  - full insurance with ex-post premium and indemnity, $s = q - c$
- moral hazard - effort is unobserved, two pieces are inseparable
- adverse selection
  - unobserved types
  - menu of contracts, agents choose subject to truth-telling
- adverse selection plus moral hazard: honesty and obedience - interact in optimal design

MARKET STRUCTURE

- collusion (two-branch monopoly)
- simultaneous Nash in contracts at fixed location (no commitment)
  - welfare implications of liberalization
- full commitment to location and simultaneous Nash on contracts (partial commitment)
- sequential Nash equilibrium (SNE) with full commitment to location and contract (business model)
  - local informed player vs outside entrant facing adverse selection
• utility of consumption computed from first principles: underlying preferences and technology
• agents of type \( \theta \) have preferences

\[ u(c, a|\theta), \]

where \( c \) is consumption, and \( a \) is hidden or observed effort

• technology \( P(q|k, a, \theta) \) is a probability to reach the output \( q \) that depends on agent’s type \( \theta \) and the effort \( a \) exercised by an agent.

• agents can borrow capital \( k \) from the intermediaries to augment their labor effort. Investment can be observed or unobserved.

• \( \theta \) is a multidimensional object that allows to consider different risk aversion, different risk types and different aversion to effort

• a subset of \( \theta \) may not be observable, hence adverse selection
Building block - standard mechanism design problem

The optimal contract to maximize the bank surplus extracted from each agent:

\[ S\{u(\theta)\} := \max_{\pi(q,c,k,a|\theta)} \left[ \sum_{\theta} \sum_{q,c,k,a} \pi(q,c,k,a|\theta) [q - c - k] \right] \]

where \( \pi(q,c,k,a|\theta) \) is a probability distribution over the vector \((q,c,k,a)\) given the agent's type \(\theta\).

Mother Nature/Technology Constraints:
\[ \forall \{\bar{q}, \bar{k}, \bar{a}\} \in Q \times K \times A \text{ and } \forall \theta \in \Theta \]
\[ \sum_{c} \pi(\bar{q}, c, \bar{k}, \bar{a}|\theta) = \mathbb{P}(\bar{q}|\bar{k}, \bar{a}, \theta) \sum_{q,c} \pi(q,c,k,a|\theta) \]

Incentive Compatibility Constraints for action variables:
\[ \forall a, \hat{a} \in A \times A \text{ and } \forall k \in K \text{ and } \forall \theta \in \Theta: \]
\[ \sum_{q,c} \pi(q,c,k,a|\theta) u(c,a|\theta) \geq \sum_{q,c} \pi(q,c,k,a|\theta) \frac{P(q,k,\hat{a},\theta)}{P(q,k,a,\theta)} u(c,\hat{a}|\theta) \]

Utility Assignment Constraints:
\[ \forall \theta \in \Theta \]
\[ \sum_{q,c,k,a} \pi(q,c,k,a|\theta) u(c,a|\theta) = u(\theta); u(\theta) \geq \hat{u}_0(\theta) \]

Truth-Telling Conditions in Adverse Selection - type \(\theta\) must not announce type \(\theta'\) (can add to unobserved \(a\) and \(k\)):
\[ \forall \theta, \theta' \in \Theta \]
\[ \sum_{q,c,k,a} \pi(q,c,k,a|\theta) u(c,a|\theta) \geq \sum_{q,c,k,a} \left[ \pi(q,c,k,a|\theta') \frac{P(q,k,a,\theta)}{P(q,k,a,\theta')} u(c,a|\theta') \right] \]
Pareto frontier with single type calibrated example - generates key examples

\[ u(c, a) = \frac{c(1 - \sigma(\theta))}{(1 - \sigma(\theta))} + \chi(\theta) \frac{(1 - a)\gamma(\theta)}{\gamma(\theta)} \]

\[ P(q = \text{high}|k, a, \theta) = p(q = \text{high}|a)f(\theta)k^\alpha, \alpha = 1/3 \]

effort and capital are complements

\( f(\theta) \) maps agent’s ability \( \theta \) to probability of reaching higher output, lower ability \( \theta \) requires higher effort to reach the same output at higher variance - higher production risk, here \( f(\theta) \) is linear function of \( \theta \), can be non-parametric
Local Monopoly: Surplus and Market Share elasticity

From FOC for one branch monopoly wrt to utility promise for one type

$$\frac{S'(u)}{S(u)} = -\frac{\mu'(u)}{\mu(u)}$$

increase in promise $w$ decreases surplus and increase market share (if solution is interior)

Movement in spatial cost moves demand and we trace out supply
Two Branch Monopoly: optimal contracts

locations of branches are symmetric at $[1/4; 3/4]$
Nash equilibrium in case of two market entrants defined by \( \{ u_1^*, \overline{x}_1, u_2^*, \overline{x}_2 \} \) that satisfy

\[
S(u_2^*)\mu_2(u_2^*, \overline{x}_2, u_1^*, \overline{x}_1) \geq S(u_2)\mu_2(u_2, \overline{x}_2, u_1^*, \overline{x}_1)
\]
\[
S(u_1^*)\mu_1(u_2^*, \overline{x}_2, u_1^*, \overline{x}_1) \geq S(u_1)\mu_1(u_2^*, \overline{x}_2, u_1, \overline{x}_1)
\]

\[\forall \{u_1, u_2\}, \overline{x}_1 = \frac{1}{4}, \overline{x}_2 = \frac{3}{4}\]

- standard simultaneous Nash as in game theory literature
- the Fan-Glicksberg fixed point theorem: we have continuity, local quazi-concavity
- new: numerical minimax algorithm to rank order possible strategies based on "distance to Nash" concept
- requires computing out of equilibrium deviation in two continuos choice variables
- algorithm converges when it finds a set of strategies with minimum deviation (ideally zero) for both players
- or embrace \( \epsilon \)-neighborhood equilibrium (and we can report what \( \epsilon \) is numerically)
Competitive Nash equilibrium in contracts
keeping the branches of the two banks separated

- allow heterogeneity in types
- as spatial costs increase, profits first increase and then decrease, and utilities of households/firms decrease and then increase
  - low spatial costs imply intense competition and hence low profit
  - at intermediate costs, banks struggle to retain customers in their respective hinterlands
  - at high spatial costs active market segments do not overlap, and we move toward and obtain local branch monopolies
- in sum, though higher spatial costs is a worse physical environment over all, competing banks can actually gain from this in certain ranges
  - related effort, capitalization (borrowing), and expected output are now each non-monotonic with spatial costs
  - financial information regime matters
Competitive Nash equilibrium in contracts
keeping the branches of the two banks separated
Welfare implications of financial liberalization

- real value computed for risky and safe households at all locations
- local two-branch monopoly at fixed locations \([1/4; 3/4]\)
- at relatively low spatial costs the switch from monopoly to competition increases the household utility, but with some twists
- with full information the biggest gain is for the risky type
- with adverse selection it is much harder to distinguish across types, so the overall gain from liberalization/competition is similar for both types
- safe type gains more from liberalization in the adverse selection regime than in the full information regime
- at yet higher spatial costs there is no gain for either type

(a) Full Information

(b) Adverse Selection

![Graphs showing welfare implications](image-url)
Competition with full commitment on location choice and contracts

- we postulate that the first-mover has an information advantage, knowing firm types whereas the second entrant suffers an adverse selection problem.
- at a low range of spatial costs, the informed incumbent ends up dealing exclusively with the safer type, and the entrant with the risky type.
- at low spatial costs the local bank increases the gap between offers for riskier and safer types.
- the global bank loses all good types since it can’t match the offer from the local bank due to TTC binding.
- for provinces with intermediate spatial costs, there is less specialization, but now it is the incumbent taking more of the risky types.
- at yet higher spatial costs the two banks begin to mirror each other; the incumbent information advantage disappears.
Local Information Advantage:
market segmentation, no logits

(a) Market shares of bank1 (FI)
(b) Market shares of bank2 (AdS)

- FL vs FL and AdS vs AdS competition shows no such effect
- at low spatial costs the incumbent gets exactly 100% of good (safer) types
- the challenger gets exactly 100% of bad (riskier) types
Townsend Thai Surveys: Data

Longest running high-frequency panel in developing world

Annual
- Started in rural areas in 1997 with 192 villages: currently 18 years, Chachoengsao, Buriram, Lopburi, Sisaket
- Resurvey in 64 villages every year since 1998
- Expanded to North and South in 2003 and 2004: Phrae & Phetchabun (North), Satun & Yala (South)

Urban
- Extended to Urban Areas in 2005
- Recent new urban monthly survey

Monthly Survey
- Started in 1998: 204 continuous months of data for 720 households
- Survey Design: 16 villages, 45 households per village

Current scale per year:
- over 3,000 households in 200 villages and towns
Townsend Thai Data on the Map
Data series used in estimation and testing

Consumption expenditure \((c)\)
- household-level, includes owner-produced consumption (fish, rice, etc.)

Production assets \((k)\)
- business and farm equipment, exclude livestock and household durables

Income \((q)\)
- measured on accrual basis (Samphantharak and Townsend, 2009)

Investment \((i)\)
- constructed from the assets data, \(i = k_{t+1} - (1 - \delta)k_t\)
Empirical Exercise

In Karavainov and Townsend (2014), they estimated $(\gamma_{ME}, \sigma, \theta, \mu_w, \gamma_w)$ (sd of measurement error, risk-aversion, cost of effort, promised utility mean and sd). Now, we divide in sub-samples:

$$\theta = (\gamma_{ME}, \sigma, \theta, \mu_1^w, \gamma_1^w, ..., \mu_s^w, \gamma_s^w)$$

Results here are generated using a MH regime for 1999 $(c, q)$ for 392 rural households from 3 provinces (12 villages).

Results indicate that when analysing comparable villages $(k$-wise), number of banks is associated with higher promised utilities.
The $k$ problem:

- The expected utility enters, together with capital, as a state variable in the problem of the bank.

- Mechanically, higher values of $k$ are linked to high values of $w$ in the promise keeping constraint.

- This effect is relevant. Expected profit of banks seems to be higher even when given a higher promised utility for the sample.

- Methodology induces a bias. Results here will be a lower bound of real effect.
Each line is a village. The first set of lines corresponds to the village Chachoengsao (07), the second to Lop Buri (49) and The third to Buriram (27)
Empirical Exercise: Results

**Figure:** Expected (promised) utility density for each subsample

Yellow: Buriram (27), orange: Lop Buri (49), blue: Chachoengsao (07).
### Table: Estimation Results, 1999, Rural Data of \((c, q)\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>(\hat{\gamma}_{ME})</td>
<td>0.1256</td>
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<tr>
<td>(\hat{\sigma})</td>
<td>1.0260</td>
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<tr>
<td>(\hat{\theta})</td>
<td>1.6056</td>
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<tr>
<td>(\hat{\mu}_w)</td>
<td>0.817 0.778 0.800</td>
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<td>Avg. # banks in 0.01 Perc. of D</td>
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<td>8.5 0.5 3</td>
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<td>21 2 4</td>
</tr>
<tr>
<td>(k) 25th Percentile</td>
<td>0 0.01 0.0064</td>
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<tr>
<td>(k) Median Percentile</td>
<td>0.0187 0.06 0.1645</td>
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<tr>
<td>(k) 75th Percentile</td>
<td>0.4327 0.27 0.750</td>
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Province

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D: distances between village-bank in the sample.
e.g.: Chachoengsao (07) has the highest number of banks for any radius and is the one with the highest mean of the expected utility distribution.

First effort to recover the effects of competition.

Differences in $k$ reduces the observed magnitude of the effect we are interested.

Use annual data to increase the number of villages and add intra-province variation to the data.