Spatial Competition among Financial Service Providers and Optimal Contract Design

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Banking and Financial Intermediation: Frictions, Regulation and Optimal Design
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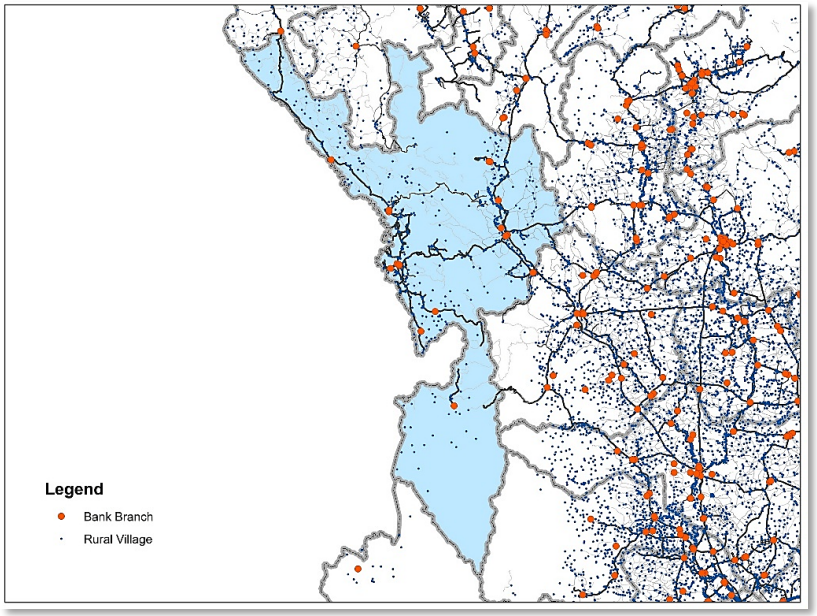
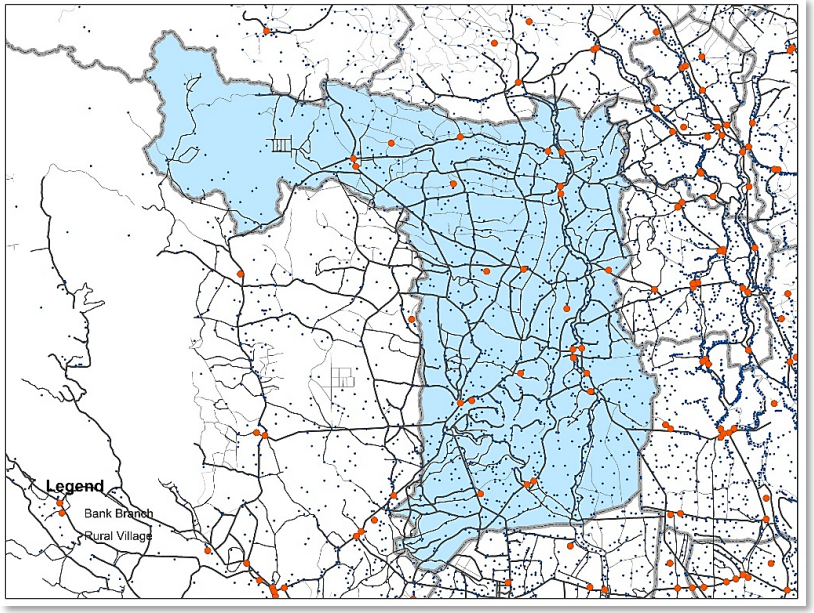
Density of Road Networks





Environment with spatial cost: Linear Hotelling case

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 $\overline{L} * |x - x_i|$, x is location of the agent, x_i is location of bank i, $\overline{L}$ is a spatial cost or disutility from accepting a contract. The agents of type θ 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'

$$V_{diff} = u_i(\theta) - \overline{L} * |x - x_i| \geq u_{i'}(\theta) - \overline{L} * |x - x_{i'}| \geq \hat{u_0}(\theta)$$

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

Micro foundations: contracts for household enterprise

- utility of consumption computed from first principles: underlying preferences and technology
- agents of type θ 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 θ 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.
- θ is a multidimensional object that allows to consider different risk aversion, different risk types and different aversion to effort
- a subset of θ 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:

$$S\{\overline{u(\theta)}\} := \underset{\pi(q,c,k,a|\theta)}{\text{maximize}} \left[\sum_{\theta} \sum_{q,c,k,a} \pi\left(q, c, k, a|\theta\right)\left[q - c - k\right] \right]$$

where $\pi(q, c, k, a|\theta)$ is a probability distribution over the vector (q, c, k, a) given the agent's type θ.
Mother Nature/Technology Constraints:
$\forall \left\{\overline{q}, \overline{k}, \overline{a}\right\} \in Q \times K \times A$ and $\forall\ \theta \in \Theta$

$$\sum_{c} \pi(\overline{q}, c, \overline{k}, \overline{a}|\theta) = \qquad P\left(\overline{q}|\overline{k}, \overline{a}, \theta\right) \sum_{q,c} \pi(q, c, \overline{k}, \overline{a}|\theta)$$

Incentive Compatibility Constraints for action variables:
$\forall\ a, \hat{a} \in A \times A$ and $\forall\ k \in K$ and $\forall\ \theta \in \Theta$:

$$\sum_{q,c} \pi\left(q, c, k, a|\theta\right) u\left(c, a|\theta\right) \geq \qquad \sum_{q,c} \pi\left(q, c, k, a|\theta\right) \frac{P(q, |k, \hat{a}, \theta)}{P(q, |k, a, \theta)} u(c, \hat{a}|\theta)$$

Utility Assignment Constraints:
$\forall\ \theta \in \Theta$

$$\sum_{q,c,k,a} \pi(q, c, k, a|\theta) u(c, a|\theta) = \overline{u(\theta)}; \overline{u(\theta)} \geq \hat{u_0}(\theta)$$

Truth-Telling Conditions in Adverse Selection - type θ must not announce type θ' (can add to unobserved a and k):
$\forall\ \theta, \theta' \in \Theta$

$$\sum_{q,c,k,a} \pi(q, c, k, a|\theta) u(c, a|\theta) \geq \sum_{q,c,k,a} \left[\pi\left(q, c, k, a|\theta'\right) \frac{P(q, |k, a, \theta)}{P(q, |k, a, \theta')} u(c, a|\theta') \right]$$

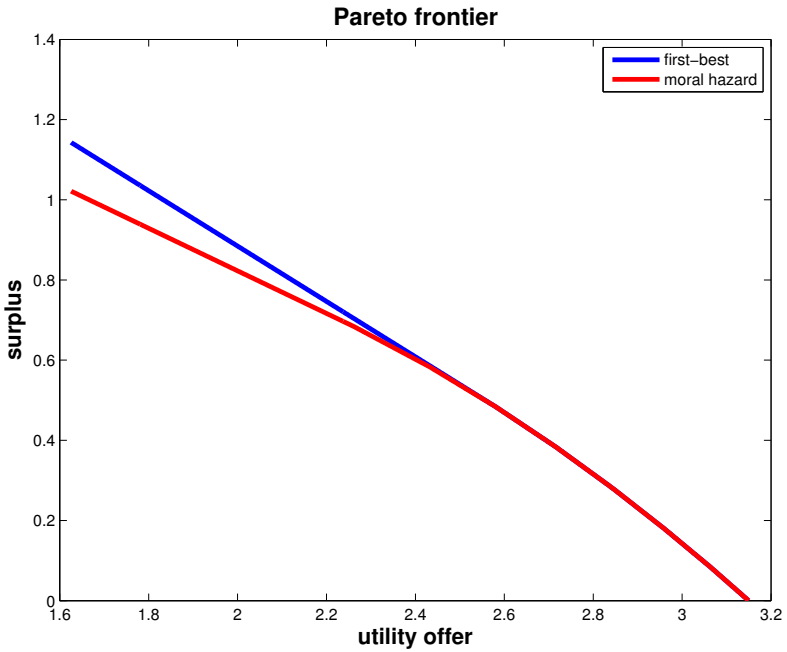
Pareto frontier with single type

calibrated example - generates key examples

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

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

effort and capital are complements
$f(\theta)$ maps agent's ability θ to probability of reaching higher output, lower ability θ requires higher effort to reach the same output at higher variance - higher production risk, here $f(\theta)$ is linear function of θ, can be non-parametric



structural parameter	σ	χ	γ
value	0.5	1.4	1.2

Technology relating action to probability of each output

a	$p(q = low)$	$p(q = high)$
0	.9	.1
.2	.75	.25
.4	.6	.4
.6	.4	.6
.8	.25	.75
1	.1	.9

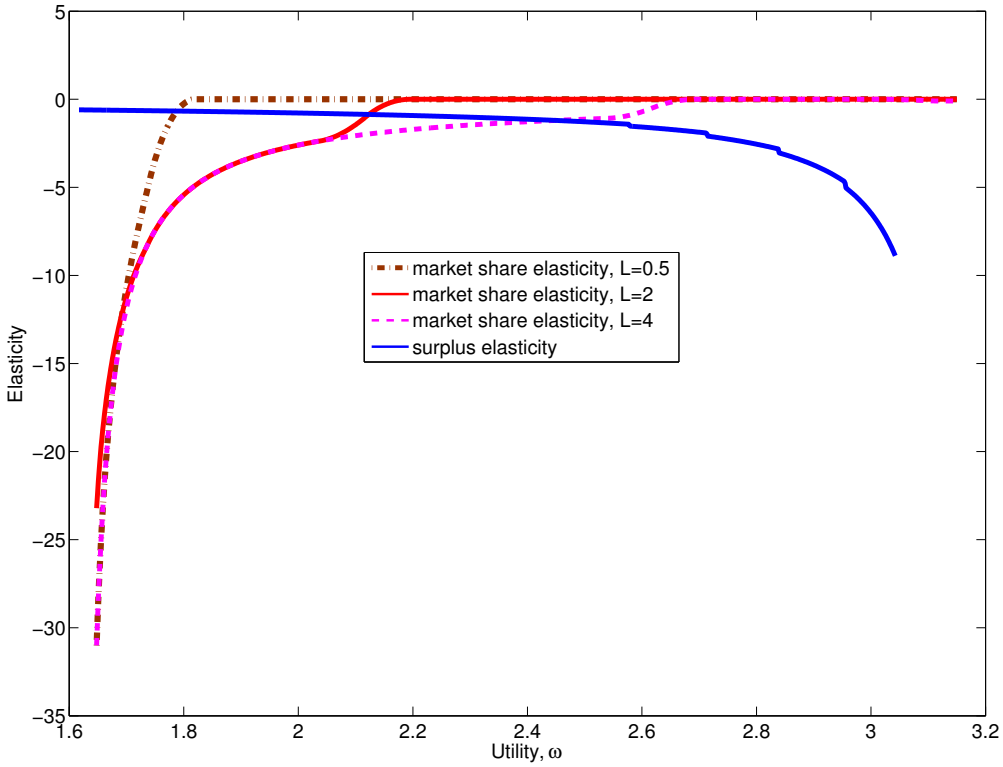
Local Monopoly: Surplus and Market Share elasticity

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

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

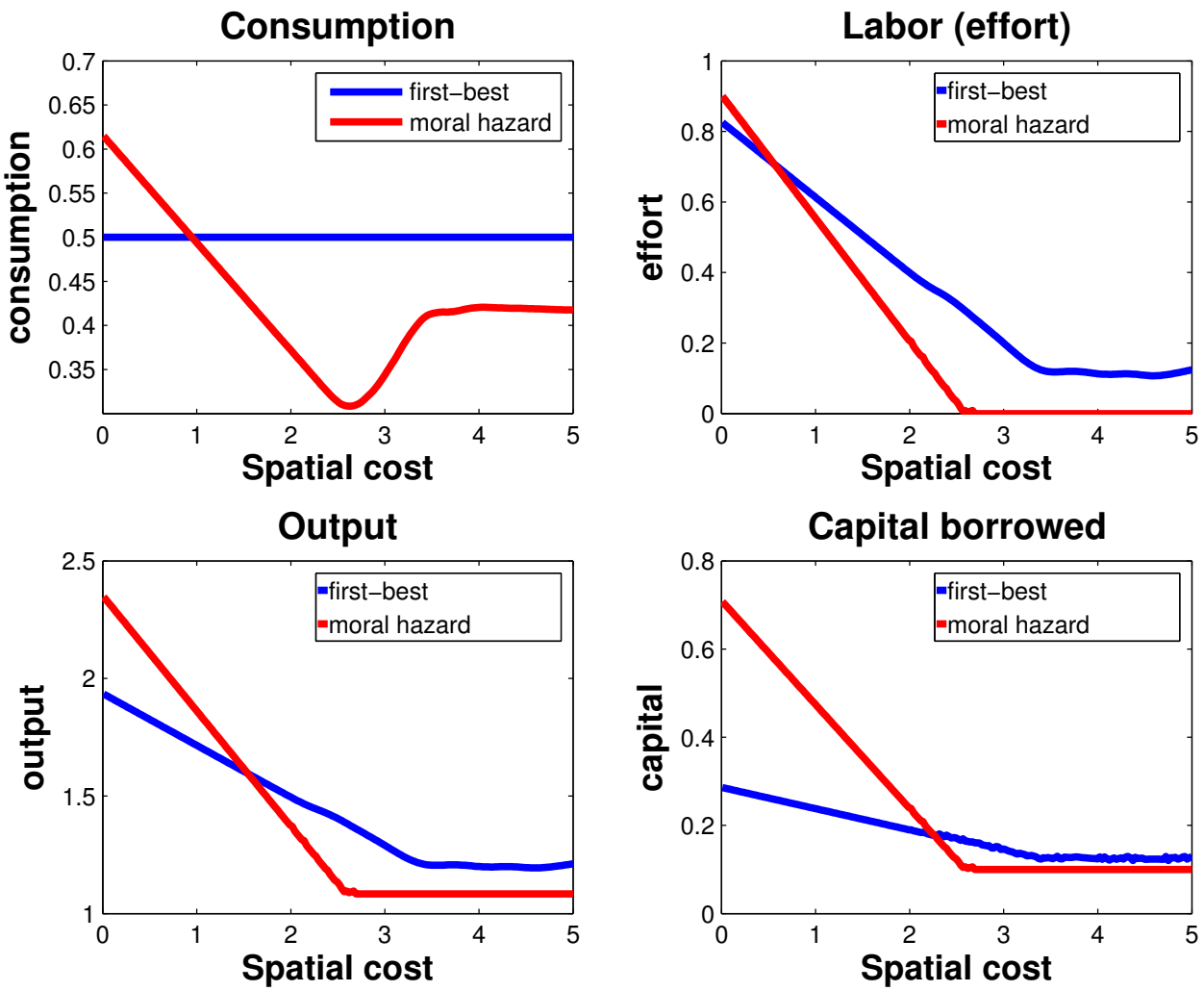
increase in promise w decreases surplus and increase market share (if solution is interior)

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]



Competition: no commitment

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 ϵ-neighborhood equilibrium (and we can report what ϵ is numerically)

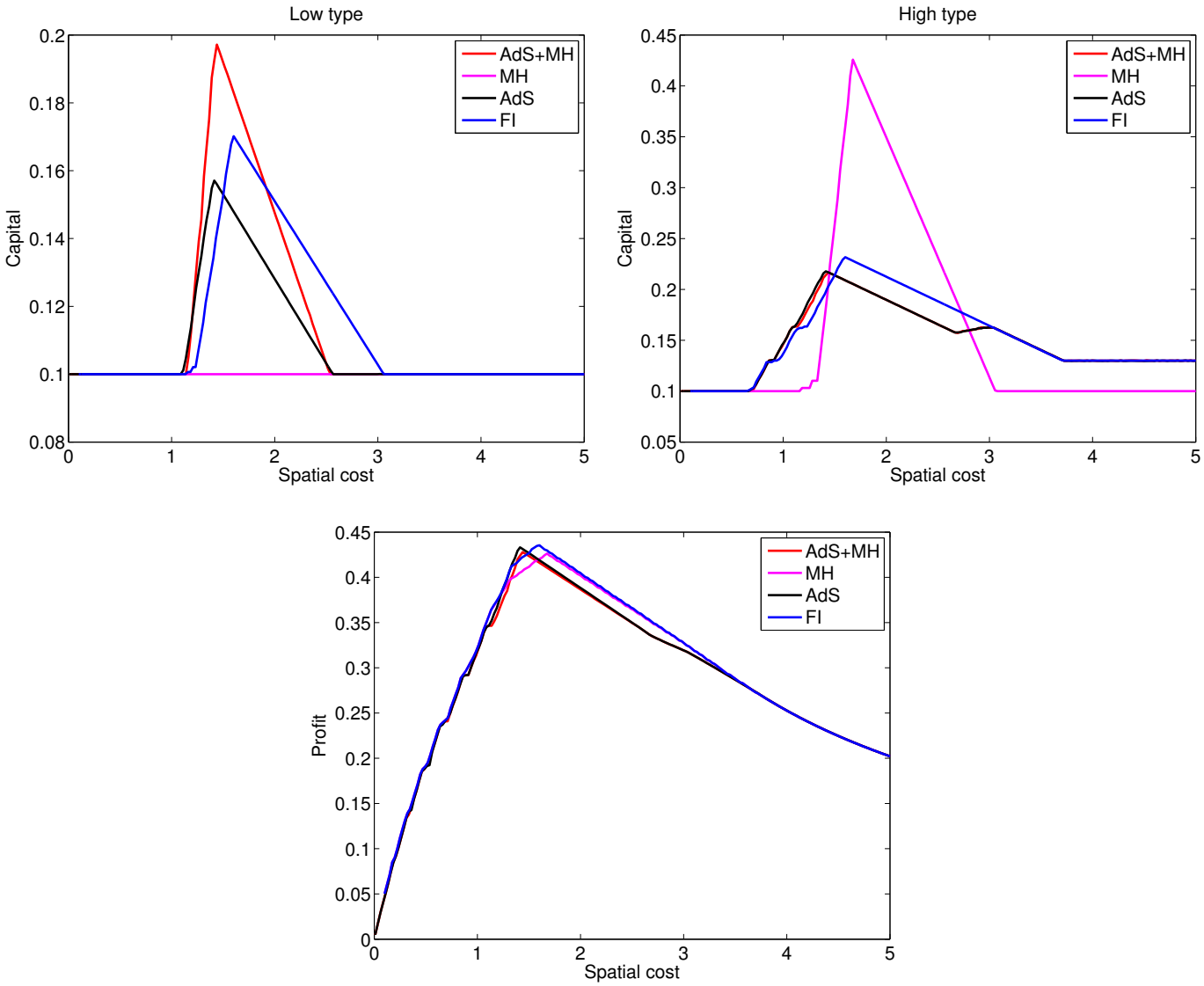
Competitive Nash equilibrium in contracts

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

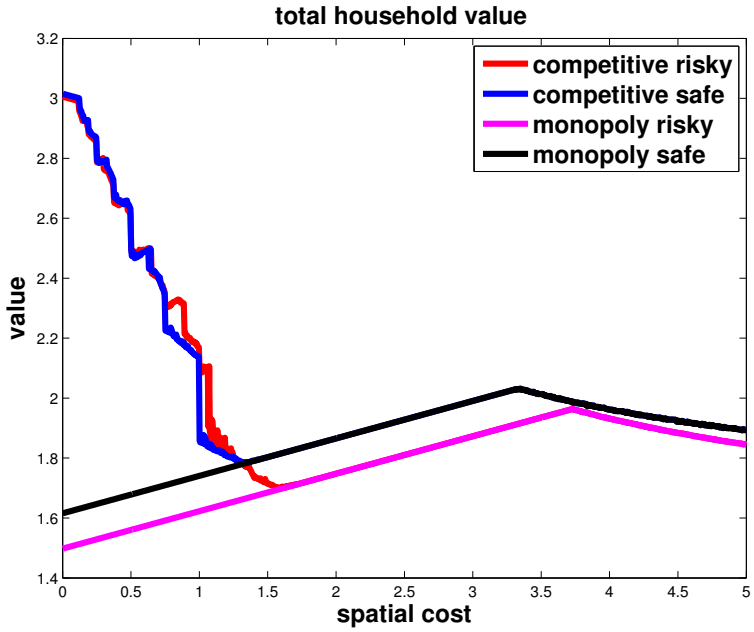
keeping the branches of the two banks separated



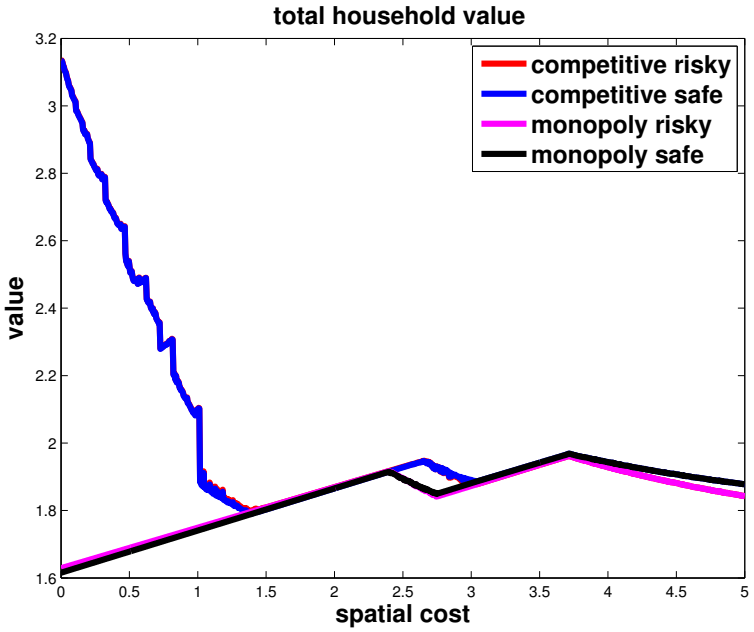
Welfare implications of financial liberalization

- 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

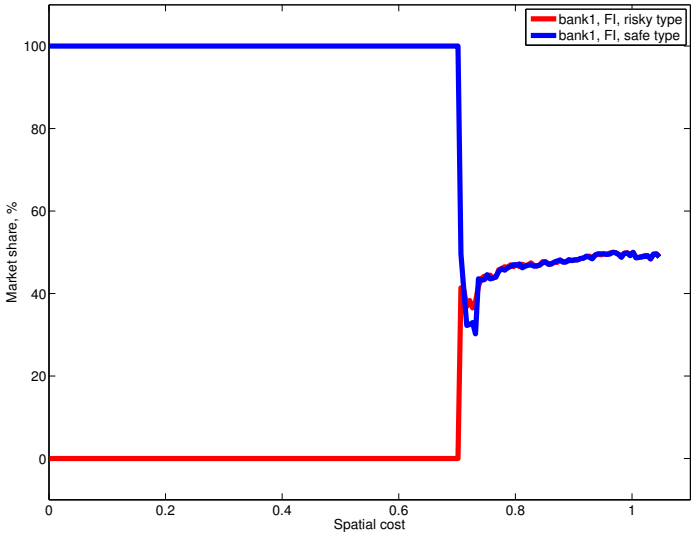


- we postulate that the first-mover has an information advantage, knowing firm types whereas the second entrant suffers an adverse selection problem
- at a low range of spatial costs, the informed incumbent ends up dealing exclusively with the safer type, and the entrant with the risky type
- at low 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

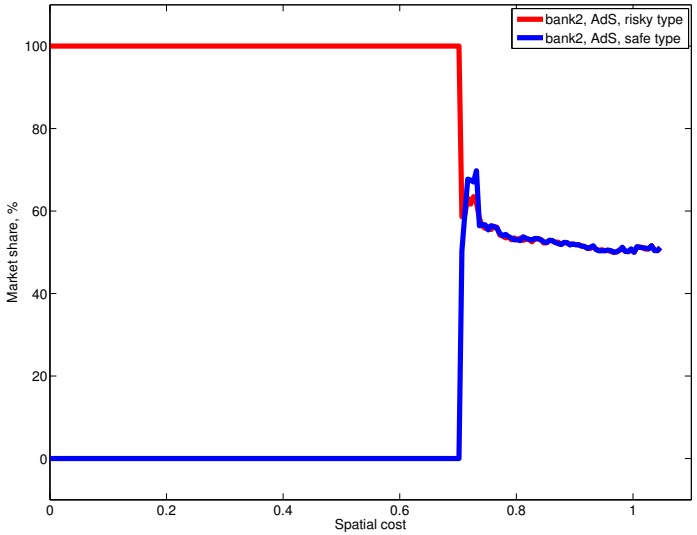
Local Information Advantage:

market segmentation, no logits

(a) Market shares of bank1 (FI)

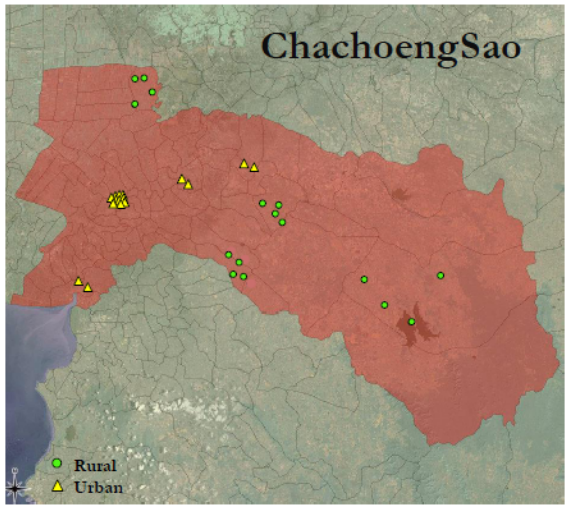


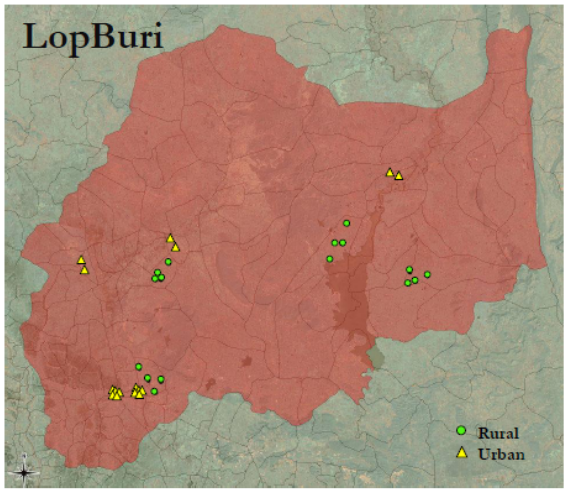
(b) Market shares of bank2 (AdS)



- FI vs FI 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

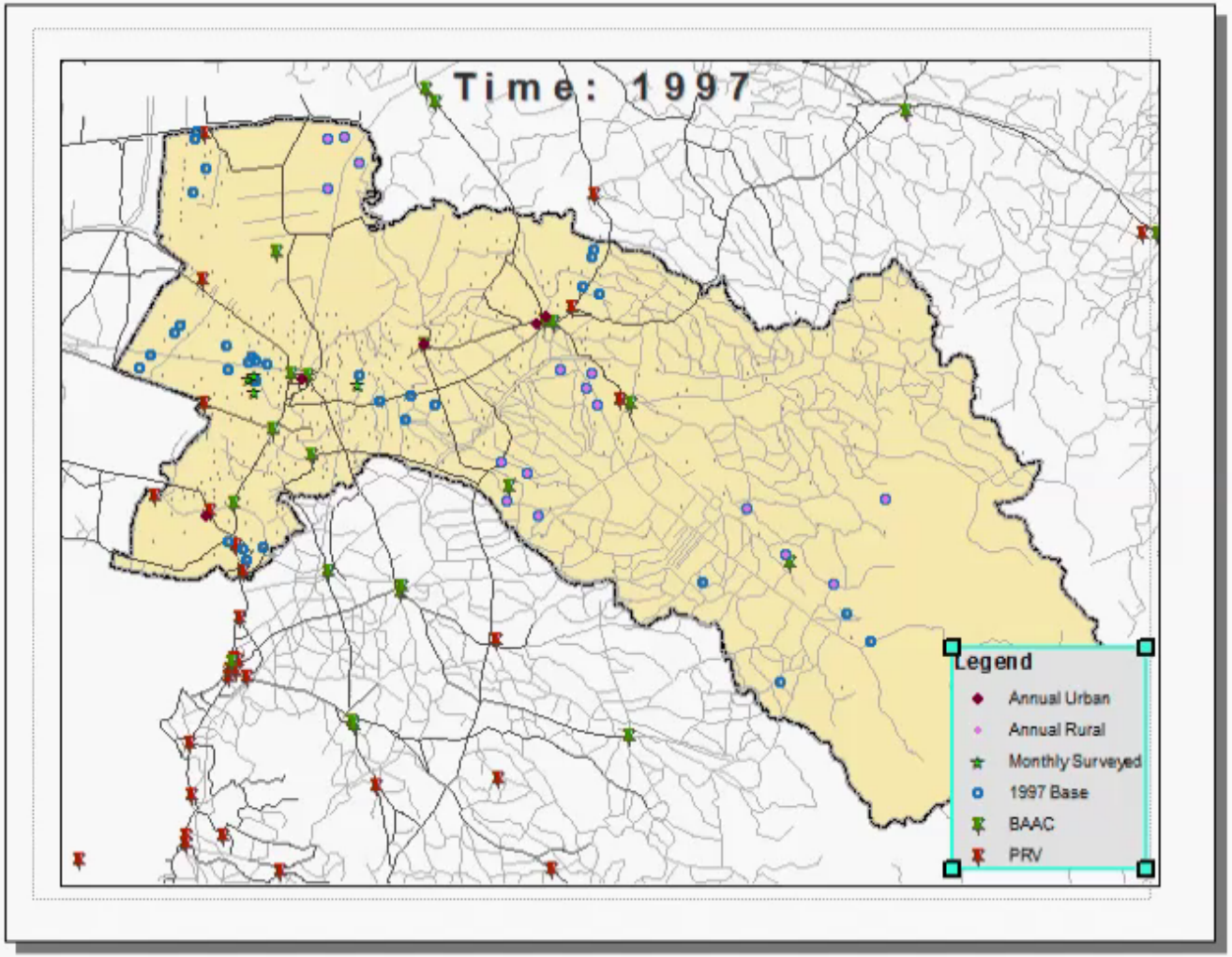
Monthly Survey

- 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



Key Variables

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:

$$\theta = (\gamma_{ME}, \sigma, \theta, \mu_w^1, \gamma_w^1, ..., \mu_w^S, \gamma_w^S)$$

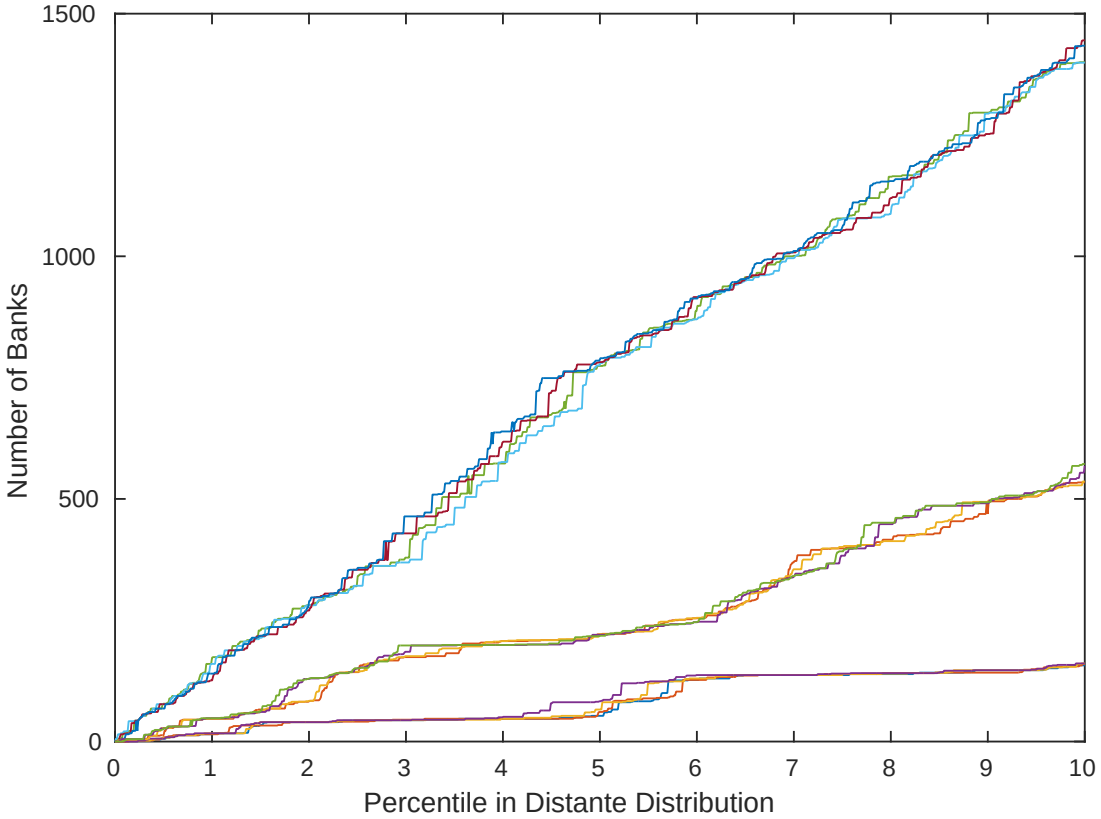
- Results here are generated using a MH regime for 1999 (c, q) for 392 rural households from 3 provinces (12 villages).

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

The k problem:

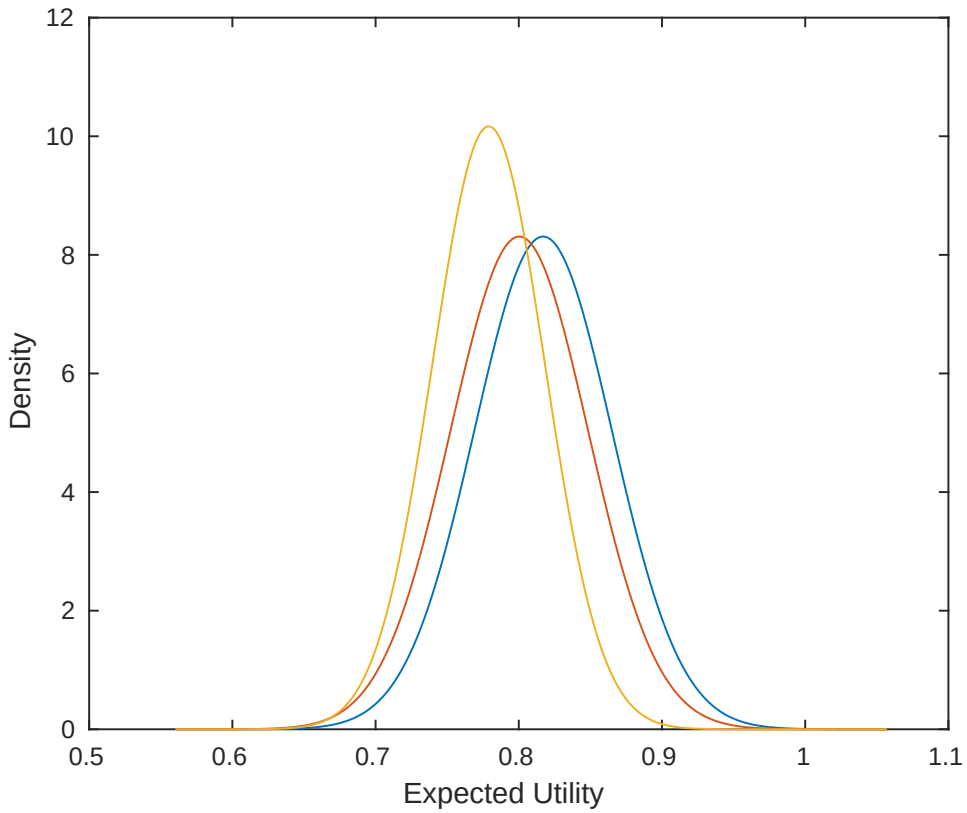
- The expected utility enters, together with capital, as a state variable in the problem of the bank.
- Mechanically, higher values of k are linked to high values of w in the promise keeping constraint.
- This effect is relevant. Expected profit of banks seems to be higher even when given a higher promised utility for the sample.
- Methodology induces a bias. Results here will be a lower bound of real effect.

Figure: Competition Measure: Banks in a Given Radius



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)

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)

$\hat{\gamma}_{ME}$		0.1256	
$\hat{\sigma}$		1.0260	
$\hat{\theta}$		1.6056	
		Province	
	(07)	(27)	(49)
$\hat{\mu}_w$	0.817	0.778	0.800
$\hat{\gamma}_w$	0.048	0.039	0.048
Avg. # banks in 0.01 Perc. of D	2.5	0	0
Avg. # banks in 0.10 Perc. of D	8.5	0.5	3
Avg. # banks in 0.20 Perc. of D	21	2	4
k 25th Percentile	0	0.01	0.0064
k Median Percentile	0.0187	0.06	0.1645
k 75th Percentile	0.4327	0.27	0.750

D: distances between village-bank in the sample.

Estimation Results: Comments

- 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.