

Spatial Competition among Financial Service Providers and Optimal Contract Design

Robert M. Townsend and Victor V. Zhorin

American Economic Association Annual Meeting
Boston
January 03, 2015

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 $\bar{L} * |x - x_i|$, 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 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'

$$V_{diff} = u_i(\theta) - \bar{L} * |x - x_i| \geq u_{i'}(\theta) - \bar{L} * |x - x_{i'}| \geq \hat{u}_0(\theta)$$

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:

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

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

Mother Nature/Technology Constraints:

$$\forall \{\bar{q}, \bar{k}, \bar{a}\} \in Q \times K \times A \text{ and } \forall \theta \in \Theta$$

$$\sum_c \pi(\bar{q}, c, \bar{k}, \bar{a}|\theta) = P(\bar{q}|\bar{k}, \bar{a}, \theta) \sum_{q,c} \pi(q, c, \bar{k}, \bar{a}|\theta)$$

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:

$$\forall \theta \in \Theta$$

$$\sum_{q,c,k,a} \pi(q, c, k, a|\theta) u(c, a|\theta) = \overline{u(\theta)}; \overline{u(\theta)} \geq \hat{u}_0(\theta)$$

Truth-Telling Conditions in Adverse Selection - type θ must not announce type θ' (can add to unobserved a and k):

$$\forall \theta, \theta' \in \Theta$$

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

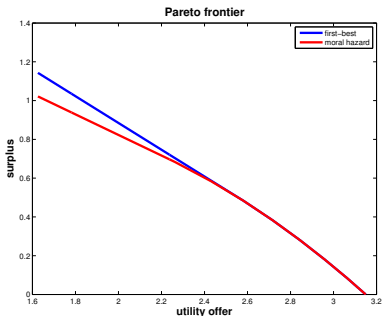
Pareto frontier with single type calibrated example - generates key examples

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

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

effort and capital are complements

$f(\theta)$ maps agent's ability 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	$p(q = \text{low})$	$p(q = \text{high})$
0	.9	.1
.2	.75	.25
.4	.6	.4
.6	.4	.6
.8	.25	.75
1	.1	.9

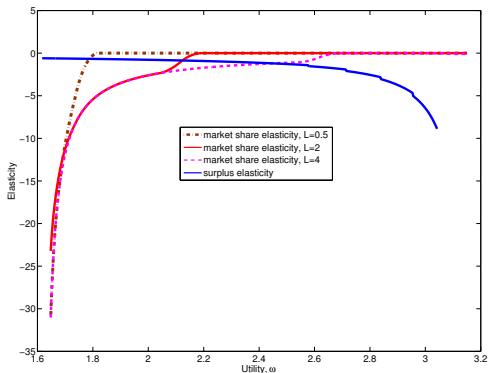
Local Monopoly: Surplus and Market Share elasticity

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)

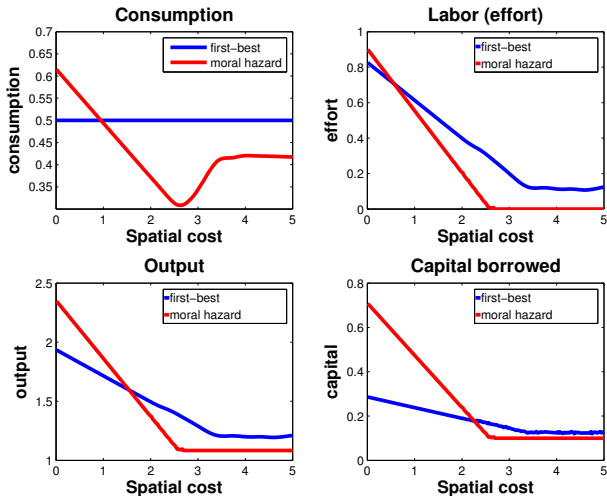
Movement in spatial cost moves demand and we trace out supply



Two Branch Monopoly: optimal contracts

Full Information vs Moral Hazard

locations of branches are symmetric at $[1/4; 3/4]$



Competition: no commitment

Nash equilibrium in case of two market entrants defined by $\{u_1^*, \bar{x}_1, u_2^*, \bar{x}_2\}$ that satisfy

$$\begin{aligned} S(u_2^*)\mu_2(u_2^*, \bar{x}_2, u_1^*, \bar{x}_1) &\geq S(u_2)\mu_2(u_2, \bar{x}_2, u_1^*, \bar{x}_1) \\ S(u_1^*)\mu_1(u_2^*, \bar{x}_2, u_1^*, \bar{x}_1) &\geq S(u_1)\mu_1(u_2^*, \bar{x}_2, u_1, \bar{x}_1) \\ \forall \{u_1, u_2\}, \bar{x}_1 &= \frac{1}{4}, \bar{x}_2 = \frac{3}{4} \end{aligned}$$

- standard simultaneous Nash as in game theory literature
- the Fan-Glicksberg fixed point theorem: we have continuity, local quasi-concavity
- new: numerical minimax algorithm to rank order possible strategies based on "distance to Nash" concept
- requires computing out of equilibrium deviation in two continuous 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)

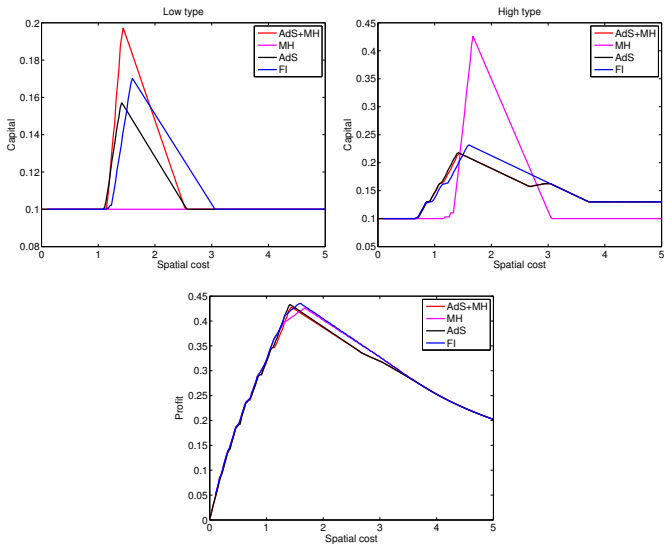
Competitive Nash equilibrium in contracts

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

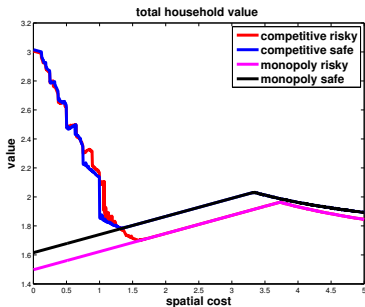
keeping the branches of the two banks separated



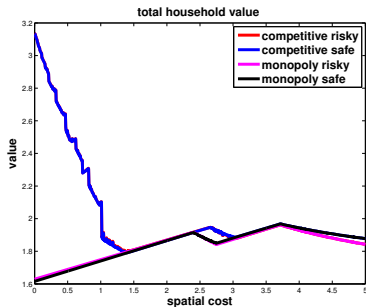
Welfare implications of financial liberalization

- 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

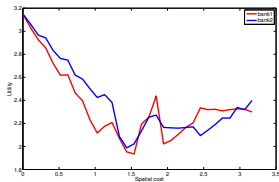


Competition: partial commitment

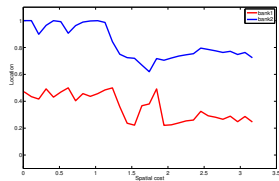
- we make endogenous not only contracts but also locations, and then the timing of entry begins to matter
- common assumption in IO literature: ex-ante investment with ex-post price competition, similar to Doraszelski and Pakes (2007)
- the first entrant into a province chooses a branch location in a first stage, before a second entrant does so in a second stage, and before both compete on contracts in a third stage
- at relatively low spatial costs, the first bank has an incumbency, first-mover advantage
- second entrant separates to go for the market segment at the margin
- second entrant makes higher offer, gets lower surplus and lower market share due to inferior location
- with intermediate and higher spatial costs, this first-mover advantage can be lost sometimes, but not always
- moving toward economically advantageous environments with lower spatial costs, as with the emergence of electronic banking is not straightforward

Partial commitment: results

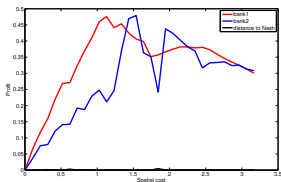
(a) Utility offer choice



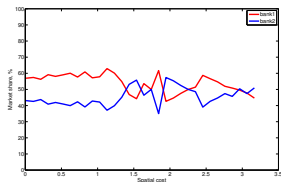
(b) Location choice



(c) Profit



(d) Market share



Competition with full commitment on location choice and contracts

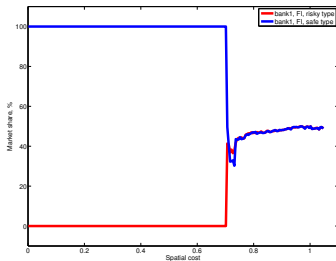
local information advantage and type segmentation

- 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

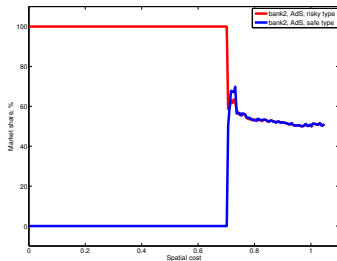
Local Information Advantage:

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

Toolkit for Applied Work: computation, estimation

- to move beyond calibrated example we need to compute solutions for arbitrary information regimes, arbitrary preferences, technology, estimate parameters
- the contracting problem is one of maximizing surplus, that is, maximizing profit subject to a fixed utility of the household/firm for each type
- the lottery formulation of contract problem for agents is solved for continuously varying promised utility using LP solver Gurobi with up to hundreds of thousands of variables for accuracy control of discretization errors
- optimized tensor products are used in a globally convergent Augmented Lagrangian Pattern Search algorithm for bi-level sequential and simultaneous Nash profit computations
- varying promised utility for the household/firm as in a cross section, one gets implications from the model for what should be observed in cross-sectional data: histograms of lending/capitalization, output, consumption
- distribution of promised utilities faced by households/firms as an outcome as exogenous and estimated by MLE in Karaivanov and Townsend (2014), now endogenous along with branch locations, profits, and market shares from the equilibrium IO of financial service providers
- the entire structure can thus be estimated with FI ML, comparing both information regimes and market structures
- we make clear what we know about existence of equilibria, multiplicity, the continuity of comparative static exercises

- we use promised utilities as state variables, see also Armstrong and Vickers (2001)
 - ▶ thus we allow an infinite number of contract characteristics and do our analysis directly in that space of type-dependent constrained utilities.
 - ▶ we do not assume an additively separate cash good
 - ▶ using observed contracts in an equilibrium as a basis for restricting the contract space can be misleading
- the equilibrium is determined by out-of-equilibrium, counterfactual contract possibilities, at least in the absence of regulation
- our welfare metrics also differ from some of the applied literature, but see Mas-Colell et al. (1995)
 - ▶ even in oligopoly, financial firms operate on obstacle-constrained Pareto frontiers, without price distortions or loss of social surplus
 - ▶ the equilibrium outcomes on Pareto frontiers, the contracts, and the division of gains between households and firms, are determined by obstacles and the degree and nature of market competition
 - ▶ the two branch monopoly equilibrium and the Bertrand competitive outcome are each Pareto optimal and the comparison between the two is Pareto non-comparable