Lecture 10: Market Experiments and Competition between Trading Institutions

1. Market Experiments

Trading requires an institutional framework that determines the matching, the information, and the price formation process.

Huge variety of market institutions exists in the field

But: Walrasian equilibrium independent of the institution

Is market outcome independent of institutional framework?

Which institutions enhance market clearing outcomes?

Game theoretic solution only feasible for some institutions (in particular auctions) - for many institutions, game too complex.

Empirical analysis with field data (Ockenfels and Roth 2002, Ariely et al 2003): Institution matters for realized prices and quantities

Experimental analysis: Market experiments

1.1. The Building Blocks of Market Experiments

Several buyers and sellers are active on the market

In general, each trader may trade several goods; simplest design: single unit trader

Role of buyer and seller may be exogenous (in most exp.) or endogenous (in financial market exp).

in most exp. homogenous good - identity of trading partner irrelevant, no morale hazard or adverse selection problems

r_{jk}: "resale-value" of the k^{th} good buyer j buys; exogenously given

p_{jk}: price of the k^{th} good buyer j buys; endogenously determined

net-earnings of buyer j from buying the k^{th} good

$$\pi_{jk} = r_{jk} - p_{jk}$$

overall earnings of buyer j buying L goods

$$\pi_j = \sum_{k \in L} \pi_{jk}$$

c_{ik}: "production costs" of the k^{th} good seller i sells; exogenously given

p_{ik}: price of the k^{th} good seller i sells; endogenously determined

net-earnings of seller i from buying the k^{th} good

$$\pi_{ik} = p_{ik} - c_{ik}$$

overall earnings of seller i selling L goods

$$\pi_i = \sum_{k \in L} \pi_{ik}$$

exogenously given production costs (plus price taking behavior) determine the supply function

exogenously given resale values (plus price taking behavior) determine the demand function

$\Longrightarrow$ Market-clearing (Walrasian) equilibrium controled by the experimenter.

Trade takes place according to certain matching, information, and price formation rules (the trading institution)

market repeated to allow for learning, often with same production costs and resale values.

most of the time anonymity

1.2. "Posted Price" Institutions

Stage 1: all traders of one market side make offers simultaneously.

"posted bid" institution: offers made by buyers

"posted offer" institution: offers made by sellers

Stage 2: all traders of other markets side decide in predetermined order which of the available offers to pick (or whether to reject all).

in stage 2, offer and acceptance behavior is "common knowledge"

offers cannot be revised.

SPE: compared to market-clearing price, the price predicted by SPE is better for the offering market side.

Experimental results (Plot 1982)

Realized prices converge relatively slowly to the market clearing level. At the posted offer institution prices converge from above, at the posted bid from below.

Institution more efficient than decentralized bargaining market (see 1.4), but less efficient than double auction (see 1.3) - not all gains of trade were reaped.

1.3. Double Auction (Smith 1962)

each trader can make an offer

each trader can accept any unaccepted offer from the other market side

unaccepted offers can be revised.

offers and acceptance are "common knowledge"

SPE not characterized, only market clearing applicable

Experimental Results

Prices and quantities converge quickly to market clearing levels.

High efficiency levels.

Results hold also for few market participants, private knowledge of production costs and resale values, etc

One-sided auction: only one market side makes offer. Prices and quantities converge quickly to market clearing levels, high efficiency

1.4. Decentralized Bargaining Market (Chamberlain 1948)

Traders from both market side can make offers, but each offer applies only to one particular trader of other market side.

Each trader informed only about his own offers and those offers which apply to him.

Each offer which one receives can be accepted

Only concerned traders know of acceptance.

Experimental results

Prices and quantities converges slowly to market clearing level, even slower than at posted price institutions.

Low efficiency levels.

2. Competition between Trading Institutions

2.1. Introduction

Market institutions matter $\Longrightarrow$

How do market institutions evolve?

What are the driving forces behind the evolution of market institutions?

Is there any mechanism that guarantees that existing market institutions support market-clearing outcomes?

Is there any mechanism that guarantees that actual markets are characterized by efficient institutions?

Two aspects of the evolution of trading platforms

The emergence of new institutions: see lecture 11 and 12.

Survival of (i.e. competition between) existing trading institutions

Claims

Because of efficiency reasons, only trading institutions that guarantee market clearing survive in the long run.

In the long run, traders learn to use market-clearing institutions.

Question: If traders have to choose between different trading institutions, will they learn to choose a market-clearing one?

2.2. The Model

one homogenous good (partial equilibrium model)

n identical buyers with demand function $d(p)$; m identical sellers with supply function $s(p)$ (identical only for ease of exposition)

$$\begin{aligned} d'(p) &< 0;\ s'(p) > 0 \\ d(0) &> 0;\ s(0) = 0 \\ \lim_{p\to\infty} d(p) &= 0 \end{aligned}$$

rationing possible $\implies$ market outcomes (p, q_B), (p, q_S)

evaluation of the outcome - payoff-functions

$$v_B(p, q_B);\ \ v_S(p, q_S)$$

Note: our framework more general than standard demand/supply derived from utility/profit maximization.

$A1$: It holds for all for all p, p' with $0 < p < p'$ and $d(p) > 0$ that

$$\begin{aligned} v_B(p, d(p)) &> v_B(p', d(p')) \\ v_S(p, s(p)) &< v_S(p', s'(p)) \end{aligned}$$

In absence of rationing, a lower price is better for the buyer and worse for the seller.

$A2$: It holds for all for all p and all $q_B < d(p)$, $q_S < s(p)$ that

$$\begin{aligned} v_B(p, d(p)) &> v_B(p, q_B) \\ v_S(p, s(p)) &> v_S(p, q_S) \end{aligned}$$

Given the price, traders prefer not to be rationed.

$A3$: It holds for all for all p, p' and all q_B, q_S with $0 < q_B < d(p)$, $0 < q_S < s(p)$ that

$$\begin{aligned} v_B(p, q_B) &> v_B(p', 0) \\ v_S(p, q_S) &> v_S(p', 0) \end{aligned}$$

Traders prefer rationed trade at a price with strictly positive demand and supply, respectively, over not being able to trade.

$A1$-$A3$ fulfilled by standard model

Trading Institutions

good traded at different institutions

traders have to choose the institution at which they want to trade

m_z and n_z denote numbers of sellers and buyers who have chosen institution z

market clearing price $p^*(m_z, n_z)$ of z is given by solution of

$$m_z s(p) = n_z d(p)$$

institution z characterized by bias β_z

actual realized price at z

$$p_z(m_z, n_z, \beta_z) = \beta_z p^*(m_z, n_z)$$

$\beta_z = 1$: market-clearing institution

$\beta_z \neq 1$: non-market clearing institution - all traders at the long market side equally rationed:

$\beta_z > 1$: $q_{zB} = d(p_z(m_z, n_z, \beta_z))$; $q_{zS} = \frac{n_z}{m_z} d(p_z(m_z, n_z, \beta_z))$

$\beta_z < 1$: $q_{zB} = \frac{m_z}{n_z} s(p_z(m_z, n_z, \beta_z))$; $q_{zS} = s(p_z(m_z, n_z, \beta_z))$

$V_B(m_z, n_z, \beta_z)$, $V_S(m_z, n_z, \beta_z)$: buyer's and seller's payoff realized on z, if m_z, n_z sellers and buyers, respectively, have chosen z.

$A4$: For any fixed m_z, n_z with $m_z > 0$, $n_z > 0$, there exist a $\underline{\beta}(m_z, n_z) < 1 < \overline{\beta}(m_z, n_z)$ such that

$$\begin{aligned} V_B(m_z, n_z, \beta_z) &> V_B(m_z, n_z, 1) \text{ for all } \beta_z \in (\underline{\beta}(m_z, n_z), 1) \\ V_S(m_z, n_z, \beta_z) &> V_S(m_z, n_z, 1) \text{ for all } \beta_z \in (1, \overline{\beta}(m_z, n_z)) \end{aligned}$$

Lemma 1: Consider any distribution of traders where both a market-clearing institution 0 and a non-market clearing institution z are active. Under $A1$, $A2$ it hold that

$$v_B(p_z q_{zB}) \geq v_B(p_0 q_{0B},) \implies v_S(p_0 q_{0S}) > v_S(p_z q_{zS}).$$

Definition: A non-market clearing institution z is favored, if

$$v_B(p_0 q_{0B},) \geq v_B(p_z q_{zB}) \implies v_S(p_z q_{zS}) > v_S(p_0 q_{0S}).$$

Lemma 2: If $A1$ and $A4$ holds, then for a given number of buyers and sellers there exist favored institutions with a β that is in an open neighbourhood of 1.

Note: set of favored institutions might depend on n and m.

2.3. The Choice of the Institution

Players choose simultaneously among a finite set of feasible institutions (market clearing institution feasible).

Trades are conducted and outcomes evaluated (payoffs derived).

Coordination game - Due to $A3$, full coordination at any institution is a strict Nash-equilibrium, even coordination at institution leading to pareto-inferior outcome.

Do traders learn to coordinate on market clearing institution?

2.4. The Learning Process

At the end of a period t, traders observe outcome (prices and quantities) of all institutions active at t.

If a trader is allowed to revise his choice of institution, he switches to the institution with the outcome at t, which is best for him.

$\Longrightarrow$ state ω given by a distribution of traders over institutions; state in period t, ω_t, determines probabilities with which each state is reached in next period $t+1$.

given ω_{t+1}, trade is conducted, outcomes are evaluated, and learning takes place determining ω_{t+2}, etc.

Note: since traders are homogenous, this learning behavior is equivalent to imitation learning. But homogeneity assumed only for ease of exposition.

Random revision opportunity - Markov learning model

$E(k,\omega)$: event, that trader k receives revision opportunity in state ω.

$E^*(k,\omega)$: event, that k is the only agent of his type with revision opportunity in state ω.

$D1$: $Pr(E^*(k,\omega)) > 0$ for every agent k and state ω.

$D2$: For every agent k and state ω, either $Pr(E^*(k,\omega) \cap E(k',\omega)) > 0$ for any agent k' of the other market side, or $Pr(E^*(k,\omega) \cap E(k',\omega)) = 0$ for any such k'.

This general framework encompasses many standard learning models, like those with

independent inertia: Exogenous, independent, strictly positive probability, that an agent does not revise.

non-simultaneous learning: only one agent per period can revise.

experimentation probability $\epsilon > 0$

in case of experimentation: institution chosen at random, with prob. distribution with full support over institutions

$\implies$ unique invariant distribution $\mu(\epsilon)$ over the states with full support

limit invariant distribution $\mu^* = \lim_{\epsilon \to 0} \mu(\epsilon)$

2.5. Stochastically Stable Institutions

stochastically stable states are states in the support of μ^*.

Lemma 3: Under $A1$-$A3$, $D1$ and $D2$, only states with full coordination on one institution are stochastically stable.

stochastically stable institutions: institutions at which traders coordinate in stochastically stable states.

Theorem 1: Under $A1$-$A3$, $D1$ and $D2$, the market clearing institution is stochastically stable.

Theorem 2: Under $A1$-$A4$, $D1$ and $D2$, any of the favored institutions is stochastically stable.

Set of favored institutions might degenerate, if market size increases.

2.6. Stable institutions and the market size

k-replica market: kn buyers, km sellers, $k \in \mathbb{N}$

Problem with asummptions $D1$ and $D2$ when k becomes large: Portion of traders allowed to switch might converge to zero $\Rightarrow$

revision probabilities: $\text{prob}_k(k \text{ buyer revise}) > 0$; $\text{prob}_k(k \text{ seller revise}) > 0$

Theorem 3:
If $n \geq m$, all favored institutions z of the original market with $\beta_z < 1$ are stochstically stable for the k-replica market when k is large enough.
If $m \geq n$, all favored institutions z of the original market with $\beta_z > 1$ are stochstically stable for the k-replica market when k is large enough.

2.7. Conclusion

It is not excluded that traders learn to coordinate on a market clearing institution, but it is not guaranteed neither - they might as well coordinate on another, non-market clearing institution.