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Learning, Market Clearing and Trading Institutions

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Learning, Market Clearing, and Trading Institutions

Theory and Experiments

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Introduction

Market Institutions

- Market institution:

  trading rules that determine the matching and price formation process

- Market institutions matter for efficiency, surplus distribution, and convergence to market clearing outcome (Plott 1982, Holt 1993, Ockenfels and Roth 2002)

- Questions:
  - 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?

Market Institutions

Two approaches:

(I) How do institutions emerge? Which are the properties of these emerging institutions?

- Market institutions as Networks: Bala and Goyal (2000), Jackson (2002), Kranton and Minehart (2001)
- Experimental literature: Kirchsteiger, Niederle and Potters (2005)

(II) If several trading institutions exist, which one survives in the long run?

- Claim (Hayek etc.):

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

- Question of this paper:

  If traders have to choose between different trading institutions, will they learn to choose a market-clearing (efficient) one?

Basic Approach

- Traders are boundedly rational

  They follow myopic behavioral rules to choose the institution they are active in.

- The learning process is dynamic

  Institution choice can (potentially) be revised every period (discrete time).

- Techniques: Stochastic Stability.

  The basic learning process is a Markov Chain, perturbed with small-probability (vanishing) mistakes.

Related Literature

- Choice of Market Institution:
  - Gerber and Bettzüge (2007): Alternative (market clearing) asset markets
  - Alós-Ferrer and Kirchsteiger (2010): Alternative platforms in GE-Models
  - Alós-Ferrer, Kirchsteiger, and Walzl (2010) → Tomorrow
- Learning in Coordination Games and Oligopolies:
  - Kandori, Mailath, and Rob (1993), Young (1993), Ellison (2000)
  - Alós-Ferrer (2004), Alós-Ferrer and Ania (2005).
- Price Rigidities in Exchange Models:
  - Drèze (1975)
  - Herings and Konovalov (2009)

The Model

Primitives of the Model

- One homogenous good (partial equilibrium model)
- n identical buyers and m identical sellers
- Demand function $d(p) \geq 0$, $d(0) > 0$,
  continuous and strictly decreasing where $d(p) > 0$, $\lim_{p\to\infty} d(p) = 0$
- Supply function $s(p)$, $s(0) = 0$, continuous and strictly increasing.
- Market outcome: (p, q_B, q_S); *rationing possible*
- Evaluation of the outcome ($\sim$ payoff functions):

$$v_B(p, q_B) \quad \text{and} \quad v_S(p, q_S)$$

- Examples:
  - ◊ Standard demand/supply derived from utility/profit maximization.
  - ◊ Consumer/producer surplus.
  - ◊ BUT: allows for more general modes of behavior.

Behavioral Assumptions

(A1) In absence of rationing, a lower price is better for buyers and worse for sellers:

$$v_B(d(p),p) > v_B(d(p'),p') \quad \text{and} \quad v_S(s(p),p) < v_S(s(p'),p')$$

for all $p < p'$ with $d(p) > 0$.

(A2) Given the price, traders prefer not to be rationed:

$$v_B(d(p),p) > v_B(q_B,p) \quad \text{and} \quad v_S(s(p),p) > v_S(q_S,p)$$

for all $p > 0$ and all $0 < q_B < d(p)$, $0 < q_S < s(p)$

(A3) Given the price, traders prefer being rationed to not being able to trade:

$$v_B(q_B,p) > v_B(0,p') \quad \text{and} \quad v_S(q_S,p) > v_S(0,p')$$

for all $p > 0$, p' and all $0 < q_B < d(p)$, $0 < q_S < s(p)$

A1-A3 fulfilled by Examples 1, 2.

Trading Institutions

- Good traded at different institutions.
  Traders choose the institution at which they want to trade.
  m_z, n_z denote sellers and buyers who choose institution z.
- Market clearing price $p^*(n_z, m_z)$ for z: Solution of $\boxed{m_z \cdot s(p) = n_z \cdot d(p)}$
- z characterized by bias function β_z. Actual price at z:

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

- $\beta_z \equiv 1$: market clearing institution.
- $\beta_z(n_z, m_z) \neq 1$: non-market clearing institution.
  Short market side not rationed; Traders at the long market side equally rationed.

$$\beta_z > 1: \quad q_B^z = d(p_z) \qquad q_S^z = \frac{n_z}{m_z} d(p_z)$$

$$\beta_z < 1: \quad q_B^z = \frac{m_z}{n_z} s(p_z) \quad q_S^z = s(p_z)$$

Examples

- Example 1: Constant-bias institutions.

$$\beta_z(n_z, m_z) = \beta_z \quad \forall\, n_z, m_z$$

- Example 2: Oligopolistic institutions.
  Sellers compete in quantities taking demand functions as given.

$$\beta_z(n_z, m_z) = \frac{p^C(n_z, m_z)}{p^*(n_z, m_z)}$$

  where p^C is the Cournot price.

- Example 3: Price regulation.
  There exists $p^H > 0$ such that

$$\beta_z(n_z, m_z) \leq \frac{p^H}{p^*(n_z, m_z)}.$$

Choice of the Institution

- Traders choose simultaneously among a finite set of feasible institutions; at least one 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 Eq., even coordination at institution leading to Pareto-inferior outcome.
- Q: Do traders learn to coordinate on market clearing institutions?

The Learning Process

- States ω describe institutions chosen by each trader.
- 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" (in term of realized price and quantity for traders of the same type).

  This determines the distribution of traders over institutions for period $t+1$ (Markovian).

  Myopic behavior: move to institutions currently perceived as best.

- At $t+1$, trade is conducted and outcomes are evaluated again.
- Note: since buyers/sellers are homogenous, this behavior is equivalent to *imitation learning*.

- Random revision opportunities.

$E(k,\omega)$	event that trader k receives revision opportunity at state ω.
$E^*(k,\omega) \subseteq E(k,\omega)$	event that k is the only trader of his type with revision opportunity at ω.

- For every trader k and state ω,

(D1) $Pr(E^*(k,\omega)) > 0$.

(D2) either $Pr(E^*(k,\omega) \bigcap E^*(k',\omega)) > 0$ for any trader k' of the other type, or $Pr(E^*(k,\omega) \bigcap E(k',\omega)) = 0$ for all such k'.

- Encompasses many standard learning models, like those with
  - ◊ independent inertia: Exogenous, independent, strictly positive probability that an agent cannot revise.
  - ◊ asynchronous learning: only one agent per period has positive probability of revision.

Stochastically Stable Institutions

- Small experimentation probability $\varepsilon > 0$.

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

- Unique invariant distribution $\mu(\varepsilon)$ with full support on the state space. (state: distribution of traders over institutions)

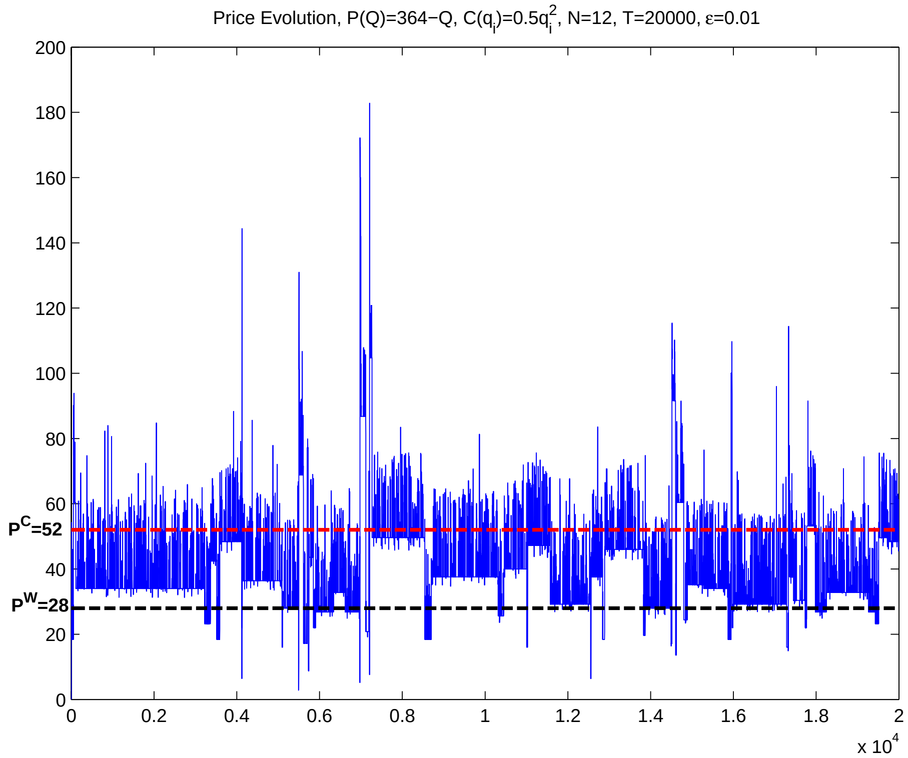
- Limit invariant distribution

$$\mu^* = \lim_{\varepsilon \to 0} \mu(\varepsilon)$$

  Stochastically stable states: those in the support of μ^*.

- By the Ergodic Theorem, the stochastically stable states are the only ones observed a significant proportion of time in the long run (for ε very small).

- Techniques in the proofs: Ellison (2000).



Stochastically Stable Institutions

- **Lemma:** Under A1-A3, D1 and D2, only states with full coordination on one institution can be stochastically stable.

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

- Suppose there is a market clearing institution and any number of non-market clearing ones.

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

- Message: coordination in the market-clearing institution will always be observed a significant part of the time.

Key Idea of the Proof

Lemma: Let a market clearing institution 0 and another institution z be active at state ω. Let $p_0 = p(n_0, m_0)$, $p_z = p(n_z, m_z)$, $\beta_z(n_z, m_z) \neq 1$.
Then, either $v_B(q_B^0, p_0) > v_B(q_B^z, p_z)$ or $v_S(q_S^0, p_0) > v_S(q_S^z, p_z)$;

At least one market side always strictly prefers switching to a market-clearing institution.

Proof. Let $\beta_z(n_z, m_z) < 1$ (> 1 analogous)

Buyers (not sellers) are rationed at $z \longrightarrow q_S^0 = s(p_0)$, $q_S^z = s(p_z)$.

Suppose $v_S(q_S^0, p_0) \leq v_S(q_S^z, p_z)$.

By A1 (sellers): $p_0 \leq p_z$.

By A1 (buyers): $v_B(q_B^0, p_0) \geq v_B(d(p_z), p_z)$.

Since $d(p_z) > q_B^z$ (buyers are rationed): By A2, $v_B(d(p_z), p_z) > v_B(q_B^z, p_z)$. ∎

Other stable institutions

- Focus on constant-bias institutions. Assume there is at least one market-clearing institution.
- For $\beta_z > 1$, sellers get higher price than with market clearing but are rationed. Effect is unclear. Intuition?

  Think of a standard case with demand/supply coming from utility/profit maximization. Monopoly/cartel price is above competitive eq. price. Further, profits are increasing at the competitive price.
  Hence, for $\beta_z > 1$ but close to 1, we expect the direct effect of higher prices to overcome the indirect effect of lower quantities (rationing).

- Let $V_B(\beta_z, m_z, n_z)$, $V_S(\beta_z, m_z, n_z)$ be the buyers', sellers' payoff, if they trade at z and n_z, m_z traders have chosen z.

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

for all $\underline{\beta}(m_z, n_z) < \beta_z < 1$, $V_B(\beta_z, m_z, n_z) > V_B(1, m_z, n_z)$ and

for all $1 < \beta_z < \overline{\beta}(m_z, n_z)$, $V_S(\beta_z, m_z, n_z) > V_S(1, m_z, n_z)$

Other stable institutions

- A non-market clearing institution z is called favored, if, at *any* state,

$$\text{either} \quad v_B(q_z^B, p_z) > v_B(q_0^B, p_0) \quad \text{or} \quad v_S(q_z^S, p_s) > v_S(q_0^S, p_s).$$

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

- **Theorem 2:** Under A1-A4, D1 and D2, there exist favored institutions and every favored institution is stochastically stable.

Model's Message

- Traders will learn to coordinate on market clearing institutions, at least part of the time...
- ... but in general other, non-market clearing institutions will also be observed.

Experimental Test

Design

- 2 Treatments × 6 experimental markets × 14 participants
- Participants: University of Konstanz students (no econ, no psych)
- Experiment at LakeLab (Univ. Konstanz), recruitment with ORSEE, programmed with z-Tree.

- In each experimental market:
  - 7 buyers and 7 sellers choose between 2 trading platforms
  - 90 trading rounds (with same, anonymous partners)
  - Choice of platforms completely determines payment (no actual trade)
  - Payments: demand and supply determined by maximization of utility function and profit function, payments equal utility/profit for realized prices and quantities.
  - Participants provided with payoff matrices.

Treatments

- Treatment 1:
  - Platform A: market clearing (hence stochastically stable)
  - Platform B: non-market clearing and not stochastically stable.
  - Prediction: Convergence to coordination in Platform 1.
- Treatment 2:
  - Platform A: market clearing (hence stochastically stable)
  - Platform B: non-market clearing but also stochastically stable.
  - Prediction: Both platforms active over time.

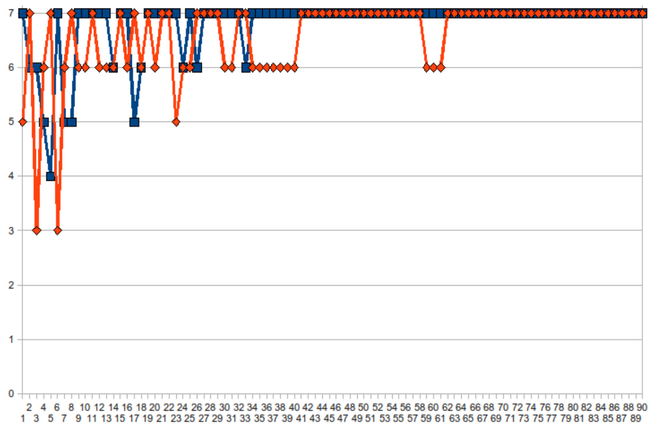
Plots

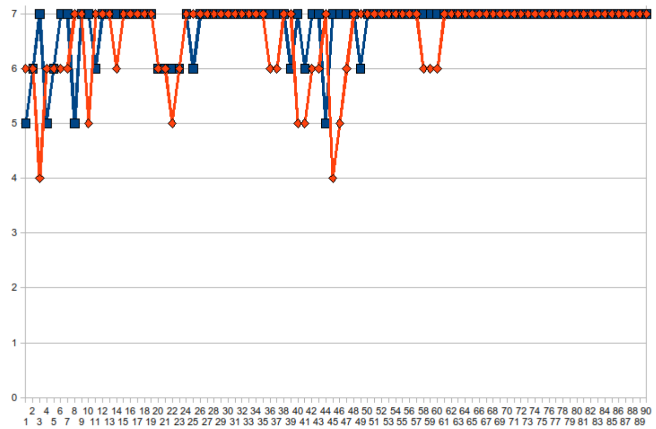
- Show the evolution in time of the number of traders in Platform A.

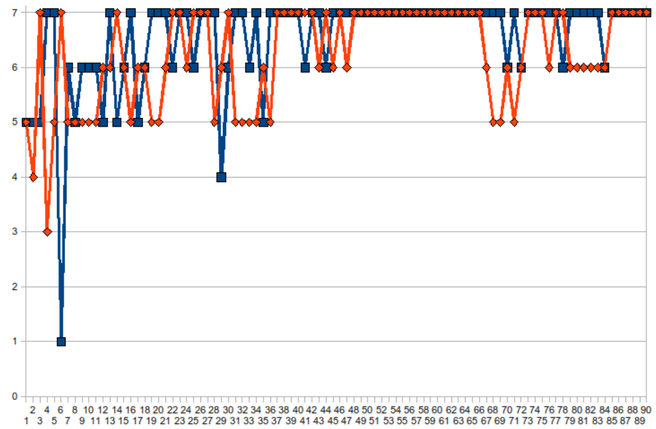
- Vertical axis: number of traders
- Horizontal axis: Time period.

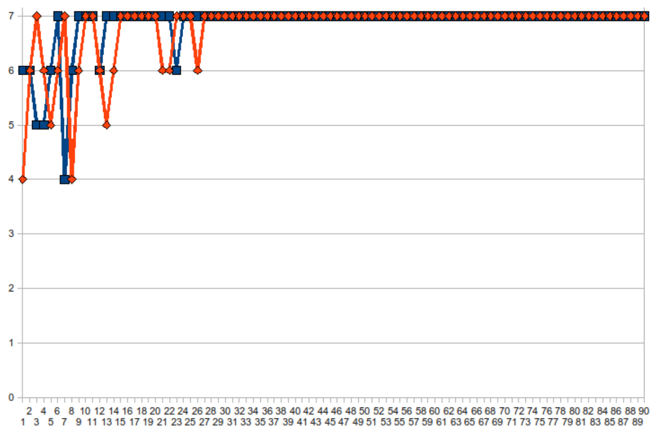
- BLUE: Sellers
- RED: Buyers

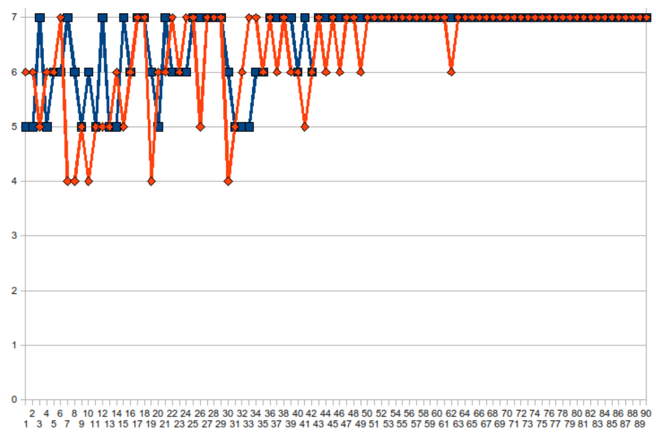
Treatment 1

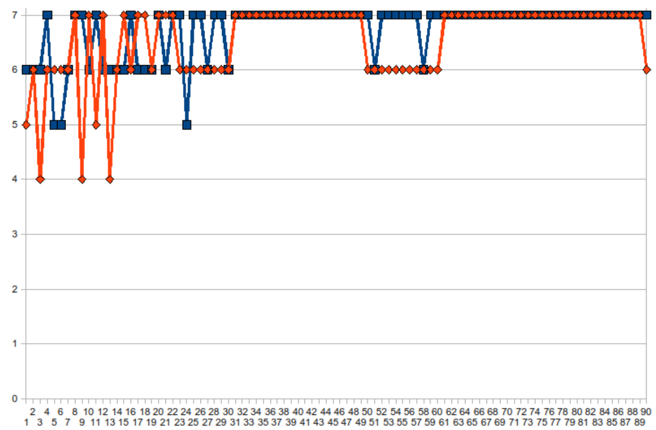




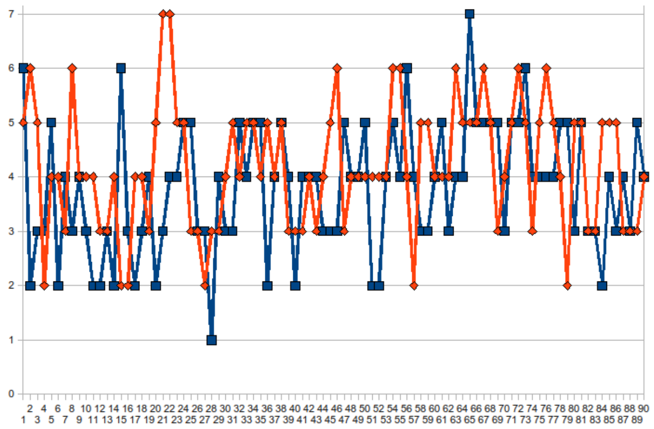


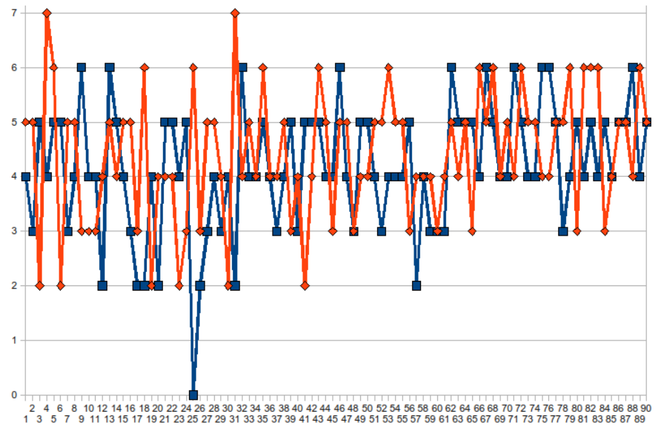


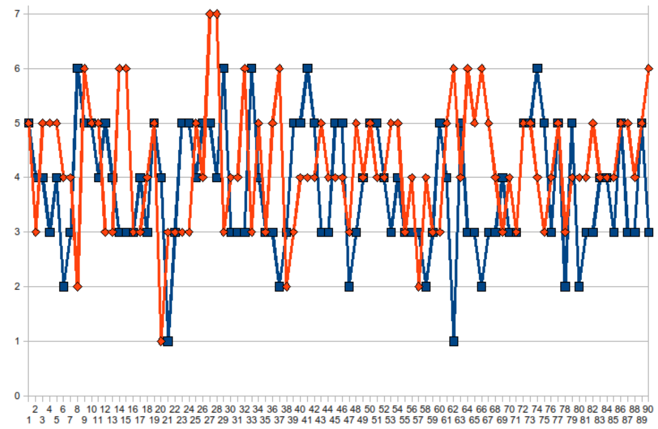


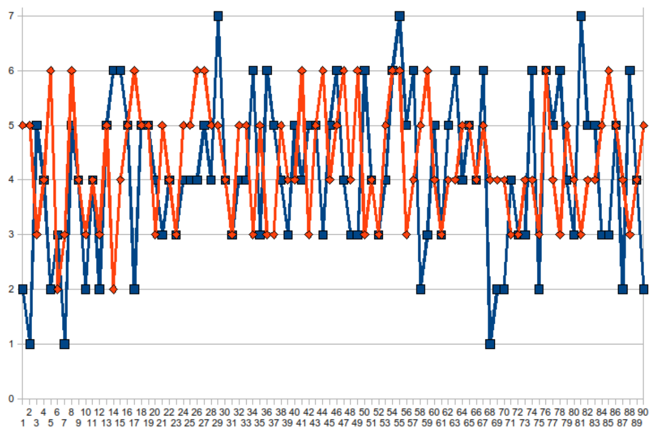


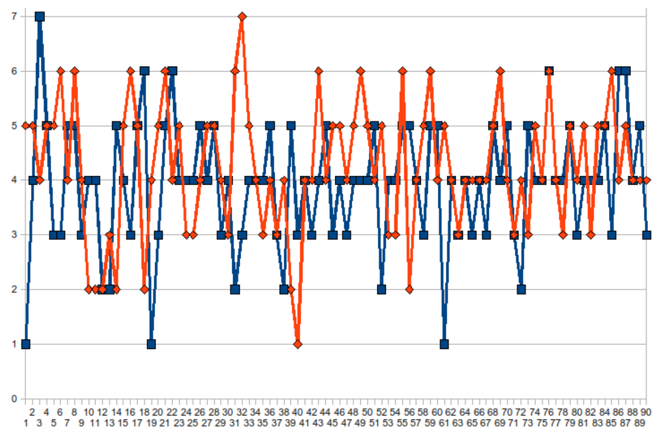
Treatment 2

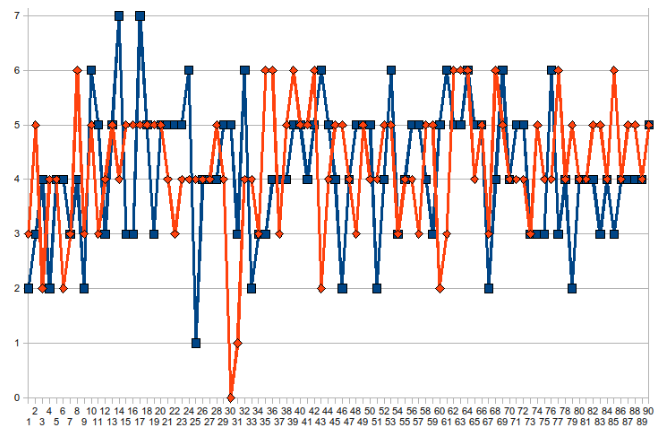




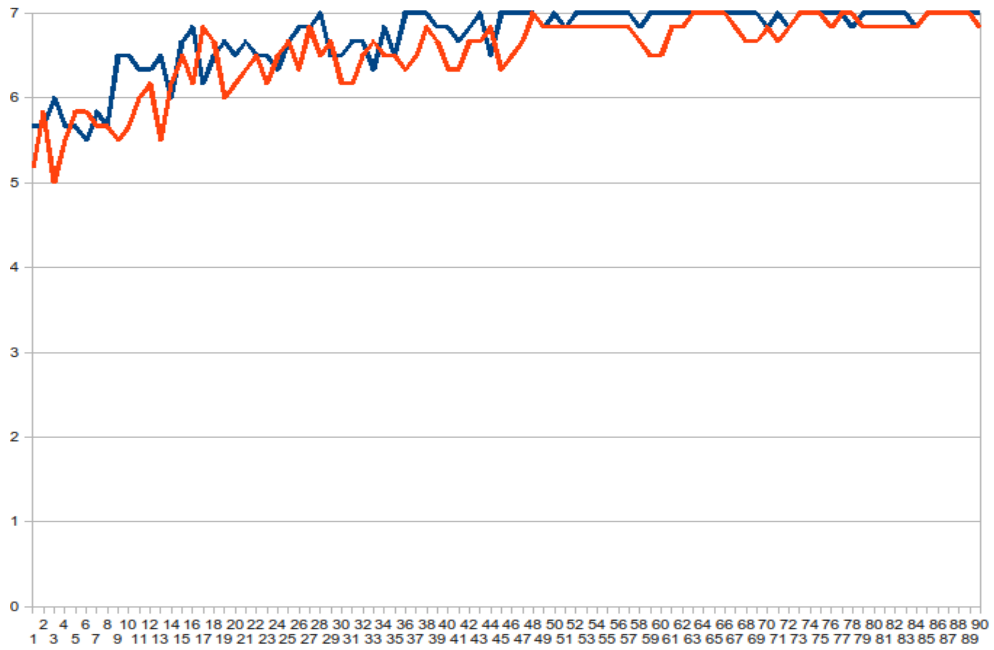




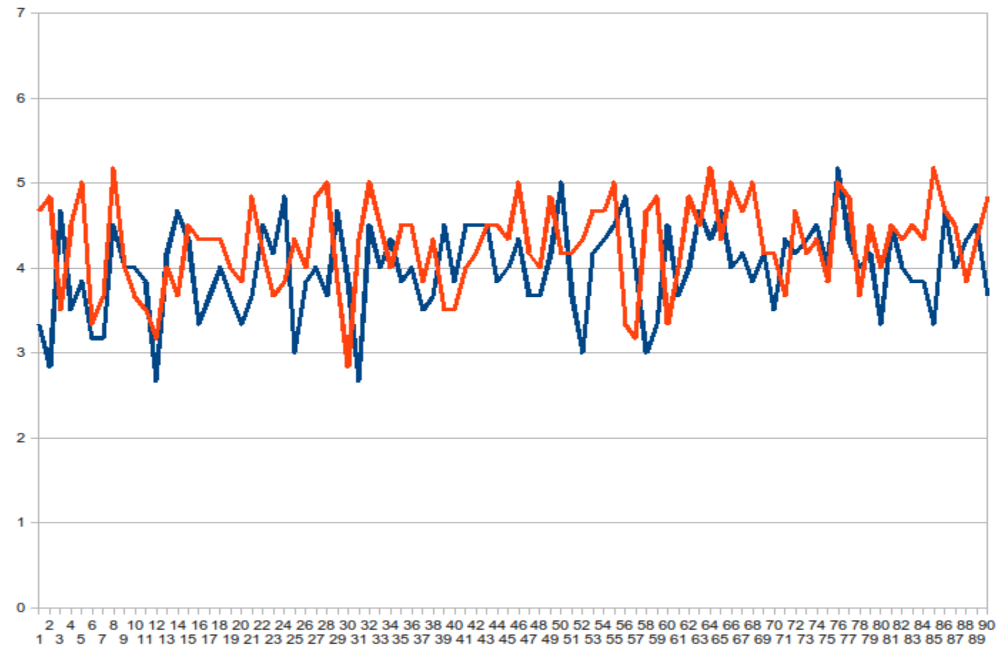




Average Plots



Treatment 1



Treatment 2

- In line with model predictions.
- If there is a unique stochastically stable institution, convergence is observed.
- If there are two stochastically stable institutions, both remain active.

Conclusion

Conclusion

- Market-clearing institutions are "dynamically attractive", they will always be observed (if available) in the long run.

  Maybe this is not good news. Are job "black markets" market-clearing?

- But, depending on design details, coordination in other market institutions might also occur.

  This has consequences for the game played among designers (Alós-Ferrer, Kirchsteiger, and Walzl 2010).

- Not just a "stylized theoretical model" result.
  - A version of this result holds for general equilibrium (exchange) settings with n goods and heterogenous traders (Alós-Ferrer and Kirchsteiger, 2010).
  - Stochastic stability entails a double limit ($t \to \infty$, $\varepsilon \to 0$) but results also have meaning in the lab.

Thank You for Your Attention