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Market selection by boundedly-rational traders under constant returns to scale

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HIGHLIGHTS

- We consider a dynamic, stochastic model of trading-institution selection.
- Traders are boundedly-rational and focus on past performance of observed trades.
- Sellers are producers endowed with constant unit costs.
- Traders fail to coordinate exclusively on market-clearing institutions.
- Any institution biasing the price upwards is also stochastically stable.

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ABSTRACT

We consider a dynamic, stochastic model of trading-institution selection with boundedly-rational traders where sellers produce with constant unit costs. Traders will in general fail to coordinate exclusively on market-clearing institutions. Rather, any institution biasing the price upwards is stochastically stable.

1. Introduction

Most products can be typically traded in different ways. Examples range from different Business-To-Business trading platforms to the alternative of buying a book from an electronic platform or at a local bookshop. There is a large literature on market institutions, conceived of as the set of trading rules determining the matching and price formation process. Alternative market institutions are often characterized by frictions which prevent market clearing, hence creating biases and rationing. It is well-known that market institutions matter for efficiency, surplus distribution, and convergence to market-clearing outcomes (Plott, 1982; Holt, 1995; Ockenfels and Roth, 2006).

Alós-Ferrer and Kirchsteiger (2010, 2015) and Alós-Ferrer et al. (2010) considered evolutionary models for the long-run selection and stability of market institutions, focusing on alternative institutions for the same good when traders are boundedly rational. The main question in the research agenda is which trading institutions survive in the long run, if several of them exist. In particular, if traders have to choose between different trading institutions, will they learn to choose a market-clearing (efficient) one? The approach is characterized by two modeling decisions. First, traders follow myopic behavioral rules to choose the institution they are active in, focusing on past performance. Second, the learning process is explicitly dynamic, with the choice of institution being potentially revised every period (in discrete time). The techniques rely on *stochastic stability* (Kandori et al., 1993; Young, 1993). That is, the basic learning process is a Markov Chain, perturbed with small-probability (vanishing) mistakes, and the long-run equilibria are the states having positive probability in the (limit) invariant distribution.

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The results of Alós-Ferrer and Kirchsteiger (2010, 2015) indicate that market-clearing institutions are stochastically stable even in the presence of an arbitrary number of alternative institutions, no matter what the characteristics of the latter are. However, depending on considerations as relative market power of buyers and sellers, elasticity of demand, or speed of the learning dynamics, other, alternative institutions might also be stable. This potential multiplicity of outcomes gives rise to questions of market design (Alós-Ferrer et al., 2010).

In this work, we look at a buyers–sellers model as in Alós-Ferrer and Kirchsteiger (2015), but concentrate on a benchmark case which was explicitly excluded in that work. It has been argued that the concept of market clearing is particularly convincing for technologies with constant returns to scale, since in this case the market-clearing price does not depend on an exogenously given number of firms. Furthermore, technologies with constant returns to scale are often assumed, for example in industrial economics. Also, Alós-Ferrer et al. (2010) considered a market-design problem with boundedly-rational traders where sellers produced with constant unit costs. Hence, it seems worthwhile to extend the analysis to this case. The analysis will also show that for this case the set of stable institutions remains unchanged as market size increases.

2. The model

2.1. Buyers and sellers

There is a homogeneous good to be traded by n buyers and m sellers, $n, m \geq 2$. We denote the price of the good by p. Alós-Ferrer and Kirchsteiger (2015) assumed that sellers are characterized by a strictly increasing supply function $s(p)$. Here, we will assume profit-maximizing firms with constant unit cost of production $c > 0$, which hence are willing to satisfy any demand at $p \geq c$ and no demand at $p < c$ (which, formally, yields a supply correspondence). Sellers hence evaluate observed outcomes with price p and sold quantity q through the function $v_S(p, q) = (p - c)q$.

Buyers are assumed to have decreasing demand functions d with $d(c) > 0$, and are endowed with evaluation functions $v_B(p, q)$ depending on the price and quantity associated to an actual trade. Those functions fulfill assumptions A1–A3 as spelled out in Alós-Ferrer and Kirchsteiger (2015). As shown in that work, utility-maximizing consumers fulfill A1–A3.

A1. In the absence of rationing, a lower price is better for buyers. That is, for all p, p' with $p < p'$, $v_B(d(p), p) > v_B(d(p'), p')$ whenever $d(p) > 0$.

A2. Given the price, buyers prefer not to be rationed. That is, for all $p > 0$ and all $0 < q_B < d(p)$, $v_B(d(p), p) > v_B(q_B, p)$.

A3. Given the price, buyers prefer being rationed to not being able to trade. That is, for all $p > 0$ and all $0 < q_B < d(p)$, $v_B(q_B, p) > v_B(0, p')$ for all (hypothetical) $p' \geq 0$.

2.2. Trading institutions

The good can be traded at a finite number of alternative market institutions. For any institution z, denote by n_z, m_z the number of buyers and sellers present at z. If either $n_z = 0$ or $m_z = 0$ then no trade takes place at z. If $n_z, m_z > 0$, since sellers produce with constant unit costs c, the market-clearing price is simply $p = c$.

For simplicity, we consider here only constant-bias institutions, which provide a parametric family capturing the idea of biased institutions leading to rationing. A constant-bias institution z is characterized by a bias parameter $\beta_z > 0$, such that the actual price becomes

$$p_z = \beta_z c.$$

In general, a price bias implies that a market side has to be rationed. In this framework, however, sellers are willing to satisfy any demand as long as $p \geq c$. Hence, if $\beta_z < 1$, there will be simply no trade at z. On the contrary, if $\beta_z > 1$, sellers will be willing to satisfy the demand. Hence, buyers, if they get to trade, are never rationed.

An institution is *active* if trade occurs at it and, hence, a price is actually realized. An institution will be inactive if either market side is absent from it, but even if $n_z > 0$ and $m_z > 0$, the institution will be inactive if either $\beta_z < 1$ (hence there is no supply) or $d(\beta_z c) = 0$ (hence there is no demand).

2.3. Dynamics

The dynamics is as in Alós-Ferrer and Kirchsteiger (2015).

D0. Each period, traders who receive the opportunity to revise observe prices and traded quantities at all active institutions. Then they choose the institution which yields the best outcome as evaluated by their own evaluation functions, and go there next period (ties broken randomly). If no institution is active, traders stay at their respective institutions.

This behavior can be interpreted as imitation of successful traders of the own type. In addition, traders might make mistakes with a given probability $\varepsilon > 0$, and we study stochastically stable states as in Kandori et al. (1993) and Young (1993), that is, long-run outcomes of the process as noise vanishes ($\varepsilon \to 0$). An institution z is called stochastically stable if the state where all traders are at z ($n_z = n$ and $m_z = m$), is stochastically stable.

Revision opportunities arrive following a general process, which encompasses standard examples from the literature as independent inertia or asynchronous learning. Specifically, we assume the following properties (see Alós-Ferrer and Kirchsteiger, 2015 for formal statements; D2' is a weakening of property D2 there).

D1. For each trader k, and every state of the dynamics, there is a (possibly very small) positive probability that k is the only trader of his type receiving the opportunity to revise.

D2'. For each trader k, and every state of the dynamics, either there is positive probability that k and any given trader k' of the other type are the only ones receiving the opportunity to revise, or whenever k is the only trader of his type revising, there is positive probability that no trader of the other type can revise.

3. Results

In an active market-clearing institution z_0,

$$q_B^0 = d(c) \text{ and } q_S^0 = \frac{n_0}{m_0} d(c).$$

In an active, biased institution z with bias parameter $\beta_z > 1$, the actual price is $p_z = \beta_z c$ and

$$q_B^z = d(\beta_z c) \text{ and } q_S^z = \frac{n_z}{m_z} d(\beta_z c).$$

It follows from A1 that $v_B\left(q_B^0, c\right) > v_B\left(q_B^z, p_z\right)$, i.e. buyers always prefer z_0. The profits of the sellers are given by

$$(\beta_z - 1)\, c \frac{n_z}{m_z} d(\beta_z c) > 0$$

and hence, independently of market size, sellers always prefer z to z_0.

If a biased institution with $\beta_z > 1$ is such that $d(\beta_z c) = 0$, there is no trade and the institution is inactive. Likewise, in a biased institution with bias parameter $\beta_z < 1$, the actual price is $p_z = \beta_z c < c$ and there is no trade.

These properties suffice to complete the analysis of stochastically stable institutions using standard "mutation-counting" techniques as in Alós-Ferrer and Kirchsteiger (2015).

Proposition 1. *Consider n buyers satisfying* A1–A3 *and m profit-maximizing producers with constant unit costs $c > 0$ and no fixed costs. Consider a market-clearing institution z_0 and any finite number of constant-bias institutions. For any dynamics satisfying* D0–D2', *the set of stochastically stable institutions is given by the market-clearing institution and all the institutions z with $\beta_z > 1$ such that $d(\beta_z c) > 0$.*

Proof. States where all traders coordinate at a single active institution cannot be left with a single mistake by D0. From any state of the dynamics, however, two mistakes by which a trader and a seller make a market-clearing institution z_0 active suffice to construct a positive-probability, mistake-free path where all buyers eventually move to z_0. At each step in this path, D1 makes it possible that at least one buyer switches from some $z \neq z_0$ to z_0, while D2' makes it possible that no seller already in z_0 receives the opportunity to revise. Once all buyers are in z_0, by D0 and D1 sellers eventually follow suit. A simple radius–coradius analysis (apply, e.g., Alós-Ferrer and Kirchsteiger, 2015, Lemma 4(i)) shows that the state where all traders coordinate at z_0 is stochastically stable. However, for any institution with $\beta_z > 1$ such that $d(\beta_z c) > 0$, a symmetric argument shows that two mistakes at z_0 suffice to initiate a mistake-free path leading to full coordination on z, which implies that the latter state is also stochastically stable (apply Alós-Ferrer and Kirchsteiger, 2015, Lemma 4(iii)). □

A symmetric result where all the institutions with $\beta_z < 1$ are stable could be constructed postulating strictly increasing supply functions fulfilling the analogous A1–A3 and a horizontal inverse demand function (with payoffs given by consumer surplus). This case, though, cannot be derived from utility maximization.

These results show that inefficient institutions can survive in the long run. For the case illustrated here, sellers earn positive profits, but there is of course a reduction in buyers' surplus. It has to be remarked that such institutions can be extremely inefficient. For concreteness, suppose the demand function approaches zero asymptotically as the price grows to infinity, but remains strictly positive. Then, an institution z with $\beta_z > 1$ will be stochastically stable even if β_z is very large. The resulting price will be very large, but the demand will be close to zero. Hence, one can construct examples where the traded quantity will be very small and the overall surplus will be close to zero.

4. Conclusion

The result above is based on the assumption of constant returns to scale, but is independent of market size. Hence, the stability of biased institutions does not "go away" for large markets. It is worth noticing that this holds for all kinds of dynamics and even if we restrict ourselves to the standard framework where demand and supply are derived from utility and profit maximization. Hence, we conclude that not even for slow learning dynamics and large markets will traders necessarily learn to coordinate exclusively on market-clearing trading institutions.

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