Modeling Behavior, Learning, and Interaction Networks in Dynamic Market Economies

An Agent-Based Computational Approach

Presenter:

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Outline

◊ The complexity of real-world decentralized market processes

◊ Agent-based computational economics (ACE) and dynamic market modeling

1. Normative Analysis: Example
   ACE double-auction market performance study

2. Qualitative Analysis/Theory Generation: Example
   An ACE two-sector trading world
What is a “Market”? 

- In modern usage, a commodity is anything of use that is available for purchase and sale in standardized form.

Examples: Haircut (service), Compaq Presario 6000 PC (physical asset), Australian dollar (financial asset), cell phone minutes, bandwidth

- A market is any context in which trading (buying and selling) of a commodity takes place.
The Complexity of Real-World Decentralized Market Processes

- Distributed local interactions
- Two-way feedbacks mediated by interactions
  \[ \text{Micro} \leftrightarrow \text{Agent Interactions} \leftrightarrow \text{Macro} \]
- Strategic behaviour & uncertainty
- Possible existence of multiple equilibria
- Critical role of institutional constraints
Simple Example of a Standard "Competitive" Decentralized Market Economy

Bean Producers

Supply\(_B(p_B), \text{Dividend}\_B(p_B)\)

Fictitious Clearing House

Supply\(_H(p_H), \text{Dividend}\_H(p_H)\)

Hash Producers

Consumer-Shareholders

Demand\((p_B, p_H, \text{Dividend}\_B, \text{Dividend}\_H)\)
Plucking Out the Fictitious Clearing House!

Bean Producers

Producer-Consumer Connections??

Hash Producers

Consumer-Shareholders
Without the Fictitious Clearing House...

Careful attention must now be paid to

- **Market Organization**
  - Who trades with whom? [e.g. business-to-business (B2B) transactions, business-to-consumer (B2C) transactions, etc.]
  - In what types of market structures does this trading take place? [e.g. double auctions, single-sided auctions, exchanges, bilateral trades, etc.]

- **Learning Behavior and Strategic Interaction**
  - Price/quantity discovery processes
  - Formation of buyer-seller interaction networks
Market Organization

- Two basic forms of trading:
  - 1. **Bilateral** trading (Seller ↔ Buyer)
  - 2. **Mediated** trading (Seller ↔ Mediator ↔ Buyer)
Example 1: Bilateral B2B & B2C Trade
(B2B=Business To Business, B2C=Business To Consumer)
Example 2: Mediated Trade
(Producers → Retail Stores → Consumers)
Key Types of Market Mediators

- **Broker**
  - Facilitates trade by matching buyers with sellers
  - Does not take a position in the assets he/she trades (i.e., does not maintain an inventory of the assets)
  - Earns profits through commissions charged to buyer/seller
  - **Examples:** Stock broker; Real estate broker

- **Dealer**
  - Facilitates trade by matching buyers with sellers
  - Takes a position in the assets traded ("makes the market")
  - Earns profits by *selling high and buying low*
  - **Examples:** Bond dealer; Car dealer; Retail store owner
Key Types of Mediated Market Forms

- **Auction markets**
  - Centralized facility (clearing house) managed by brokers
  - **Examples:** Art auctions, U.S. Treasury bill auctions, etc.

- **Over-the-Counter (OTC)**
  - Decentralized facility managed by dealers
  - **Examples:** NASDAQ stock market, gov’t bond market

- **Exchanges (Hybrid of Auction and OTC)**
  - Centralized facility conducted through specialized broker/dealer intermediaries
  - **Examples:** Retail stores, New York Stock Exchange, Wholesale Power Markets
Learning Behavior & Strategic Interaction in Markets

- **Price/Quantity Discovery**
  - For sellers, seeking to determine the most profitable amount to produce and/or the most profitable price to charge per unit in order to compete for business against rival sellers
  - For buyers, seeking to determine what items are available for purchase and which sellers are willing to accept the lowest prices for the items they wish to purchase

- **Buyer-Seller Interaction (Relational Goods)**
  - How to behave in longer-term relationships (e.g., job situations, servicing contracts, loan contracts, repeat purchases from same supplier, etc.)
  - Trust, honesty, punctuality, etc.
Key Types of Market Procurement Processes that Must Be Carried Out

- **Terms of Trade**: Set production and price levels
- **Seller-Buyer Matching**:
  - Identify potential suppliers/customers
  - Compare/evaluate opportunities
  - Make demand bids/supply offers
  - Select specific suppliers/customers
  - Negotiate supplier/customer contracts
- **Trade**: Transactions carried out
- **Settlement**: Payment processing and shake-out
- **Manage**: Long-term supplier/customer relations
Can ACE help?

How might Agent-based Computational Economics (ACE) modeling tools facilitate the study of decentralized market economies?
ACE and Normative Market Analysis

Key Issue: Does a market arrangement ensure efficient, fair, and orderly market outcomes over time despite efforts by participants to “game” it for individual advantage?

ACE Approach:
- Construct an agent-based world capturing salient aspects of the market arrangement.
- Introduce self-interested traders with learning capabilities. Let world evolve multiple times. Observe/evaluate market outcomes.
**ACE and Qualitative Market Analysis**

**Illustrative Issue:** What are the performance capabilities of decentralized markets? (Adam Smith, F. von Hayek, John Maynard Keynes, J. Schumpeter ...)

**ACE Approach:**
- *Construct an agent-based world* qualitatively capturing key aspects of decentralized market economies (firms, consumers, circular flow, limited information, ...)

- *Introduce traders with behavioral dispositions, needs, goals, beliefs, etc.* Let the world evolve. Observe the degree of coordination that results.

**EXAMPLES:** Decentralized exchange economies without a central clearing house (“Walrasian Auctioneer”), ZI agent double-auction markets,...
Potential Disadvantages of ACE for Dynamic Market Modeling

- Intensive experimentation is often needed (fine sweeps of parameter ranges to attain robust findings)
- Multi-peaked rather than central-tendency outcome distributions can arise (strong path dependence possible)
- Can be difficult to ensure platform robustness (i.e., results that are independent of the hardware and/or software implementation of a model)
- Effort needed to gain computer modeling skills can be significant (creative computer modeling as opposed to use of existing comp labs requires good programming knowledge)
Potential Advantages of ACE for Dynamic Market Modeling

- Permits systematic experimental study of empirical regularities, economic institutions, and dynamic behaviors of complex market processes.

- Facilitates creative experimentation with realistically modeled market processes:
  - Using ACE comp labs, researchers/students can evaluate interesting conjectures of their own devising, with immediate feedback and no original programming required.
  - Modular form of ACE software permits relatively easy modification/extension of features.