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

An Agent-Based Computational Approach

Presenter:

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The complexity of real-world decentralized market processes

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

- Normative Analysis

  *Example:* ACE double-auction market performance study

- 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

Fictitious Clearing House

Bean Producers

Supply_B(p_B), Dividend_B(p_B)

p_B

Hash Producers

Supply_H(p_H), Dividend_H(p_H)

p_H

p_B, p_H, Dividend_B, Dividend_H

Demand(p_B, p_H, Dividend_B, Dividend_H)

Consumer-Shareholders
Plucking Out the Fictitious Clearing House!

Producer-Consumer Connections??

Bean Producers

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)

Bean Producers

Retail Bean Stores

Retail Hash Stores

Hash Producers

Consumer-Shareholders
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:** Stockbroker; 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) models facilitate the study of real-world 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 are often needed to attain robust findings)

- **Multi-peaked rather than central-tendency outcome distributions can arise**
  (strong path dependence is possible)

- **Can be difficult to ensure model robustness**
  (i.e., results that are independent of the hardware and/or software implementation of a model)

- **Effort needed to acquire appropriate computer modeling skills can be significant**
  (e.g., creative computer modeling skills are needed for original research that cannot be carried out by means of existing computational laboratories)
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.