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
  - Normative Analysis
    *Example:* ACE double-auction market performance study
  - Qualitative Analysis/Theory Generation:
    *Example:* An ACE two-sector trading world
What is a “Market”?  

- An **asset** is anything of durable value in physical or financial form.  
  *Examples:* Apple; gasoline; water; computer; stock share; insurance contract, ...  

- A **service** is any action taken by an entity that provides benefit to another entity.  
  *Examples:* Haircut; health-care; labor; ...  

- A **market** is any context in which trading (buying and selling) of an asset or service takes place.  
  *Examples:* Farmers’ market; e-Bay; Stock exchange; ...  

- A **commodity** is an asset with a standard unit of measurement that permits one unit to be substituted for another with no change in valuation, conditional on location and time of availability.  
  *Examples:* HoneyCrisp-brand apples (lbs); Henry Hub Natural Gas (mmBtu); Champagne (ml); Google stock shares (number of shares), ...
The Complexity of Real-World Decentralized Market Processes

- Distributed local interactions
- Two-way feedbacks mediated by interactions
  
  Micro ↔ Agent Interactions ↔ Macro

- Strategic behaviour & uncertainty
- Possible existence of multiple equilibria or no equilibria
- Critical role of institutional constraints
Standard Type of Macroeconomic Model

A “Competitive” Market-Based Economy with Two Produced Commodities (Hash & Beans)
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:*  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.
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.