

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

An Agent-Based Computational Approach

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Outline

- ◇ The complexity of real-world decentralized market processes
- ◇ Advantages and disadvantages of *Agent-based computational economics (ACE)* for the study of real-world decentralized market processes

What is a “Market”?

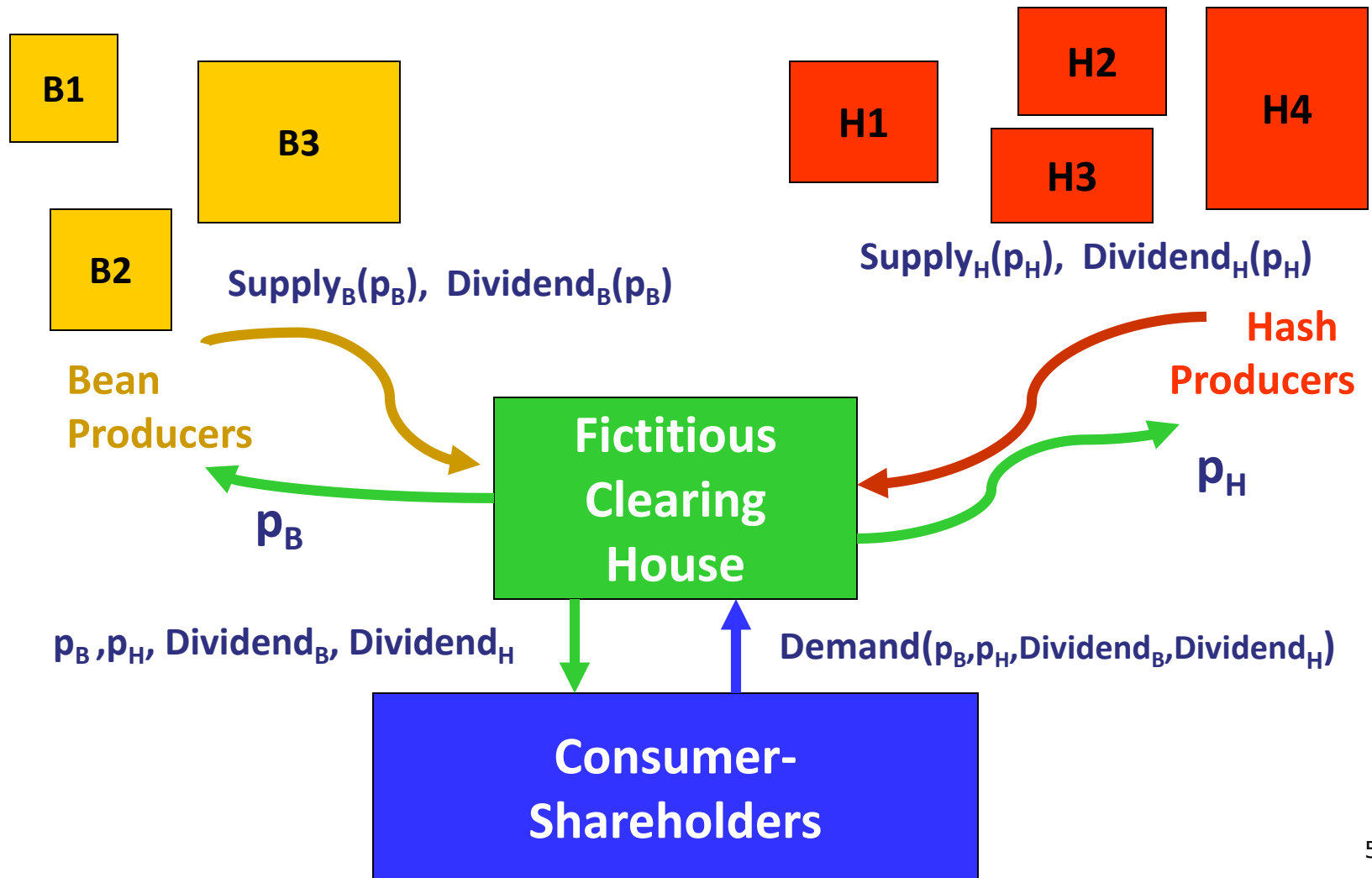
- ❑ An **asset** is anything of durable value in physical or financial form.
Examples: Apple; gasoline; water; computer; stock share; insurance contract, ...
- ❑ A **service** is any action taken by an entity that provides benefit to another entity.
Examples: Haircut; health-care; labor; ...
- ❑ A **market** 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

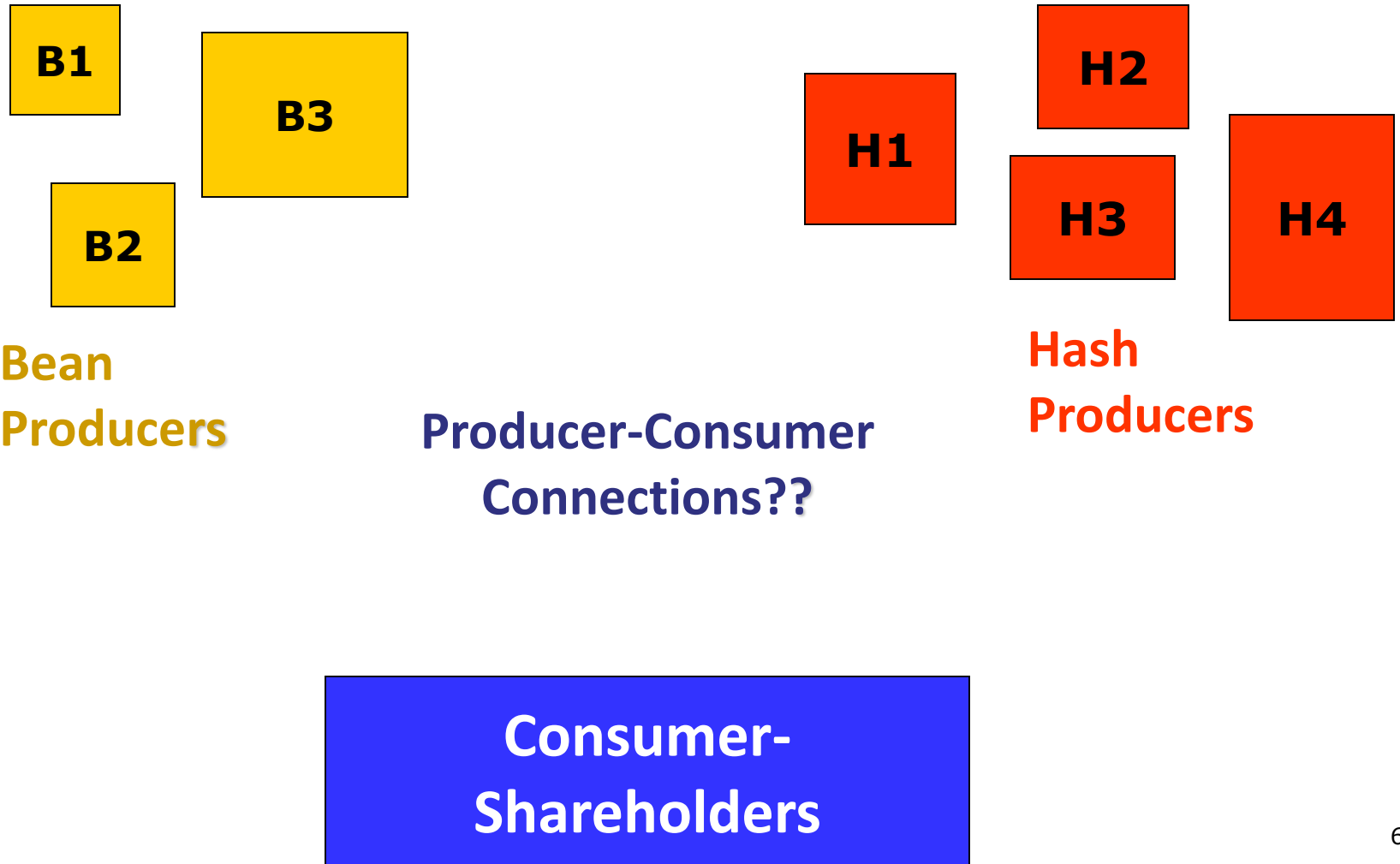
- ◆ Distributed local interactions
- ◆ Two-way feedbacks mediated by interactions
Micro ↔ Agent Interactions ↔ Macro
- ◆ Strategic behaviour & uncertainty
- ◆ Possible existence of multiple equilibria or no equilibria
- ◆ Critical role of institutional constraints

Standard Type of Macroeconomic Model

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



Plucking Out the Fictitious Clearing House!



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

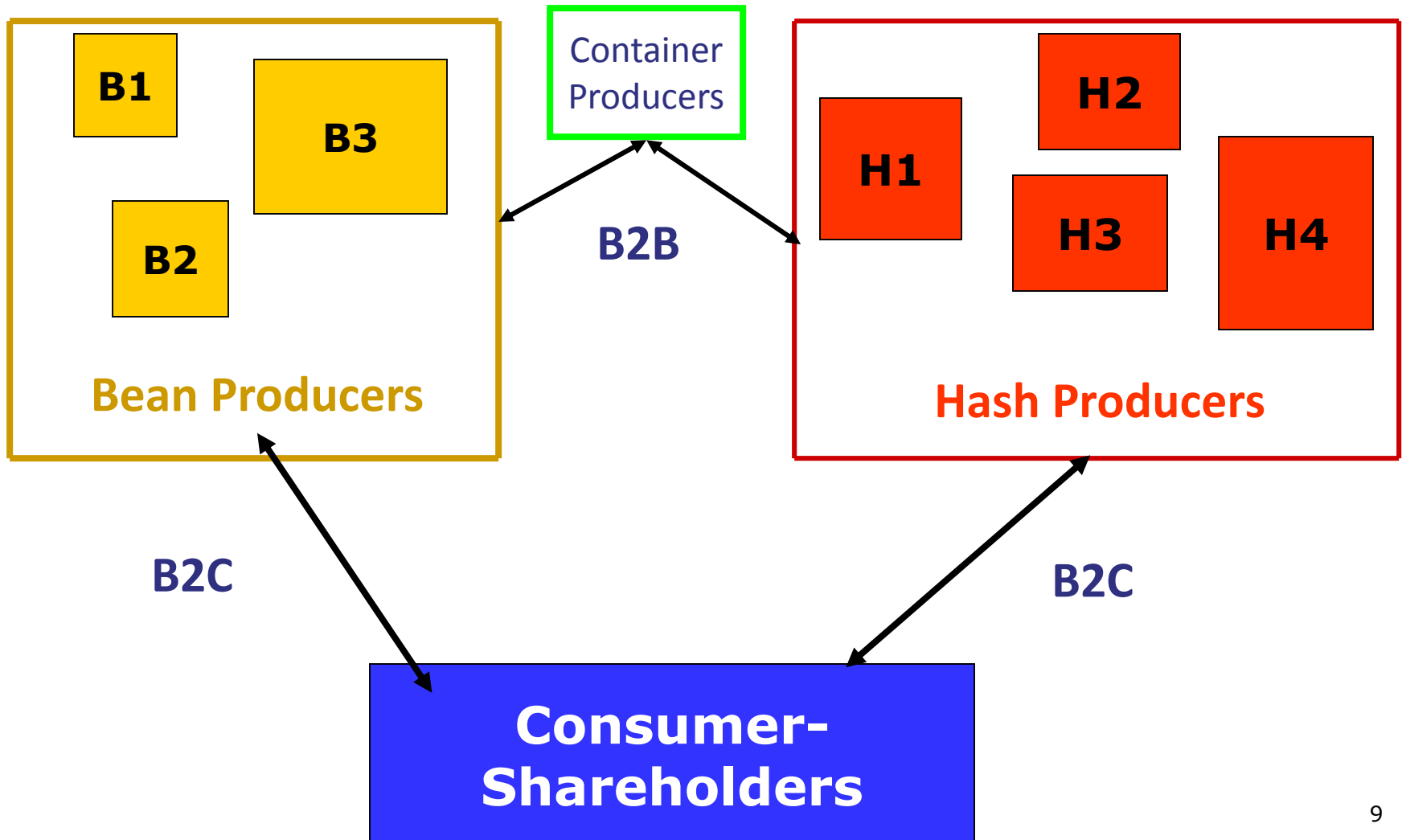
(Seller ↔ Buyer)

2. *Mediated* trading

(Seller ↔ Mediator ↔ Buyer)

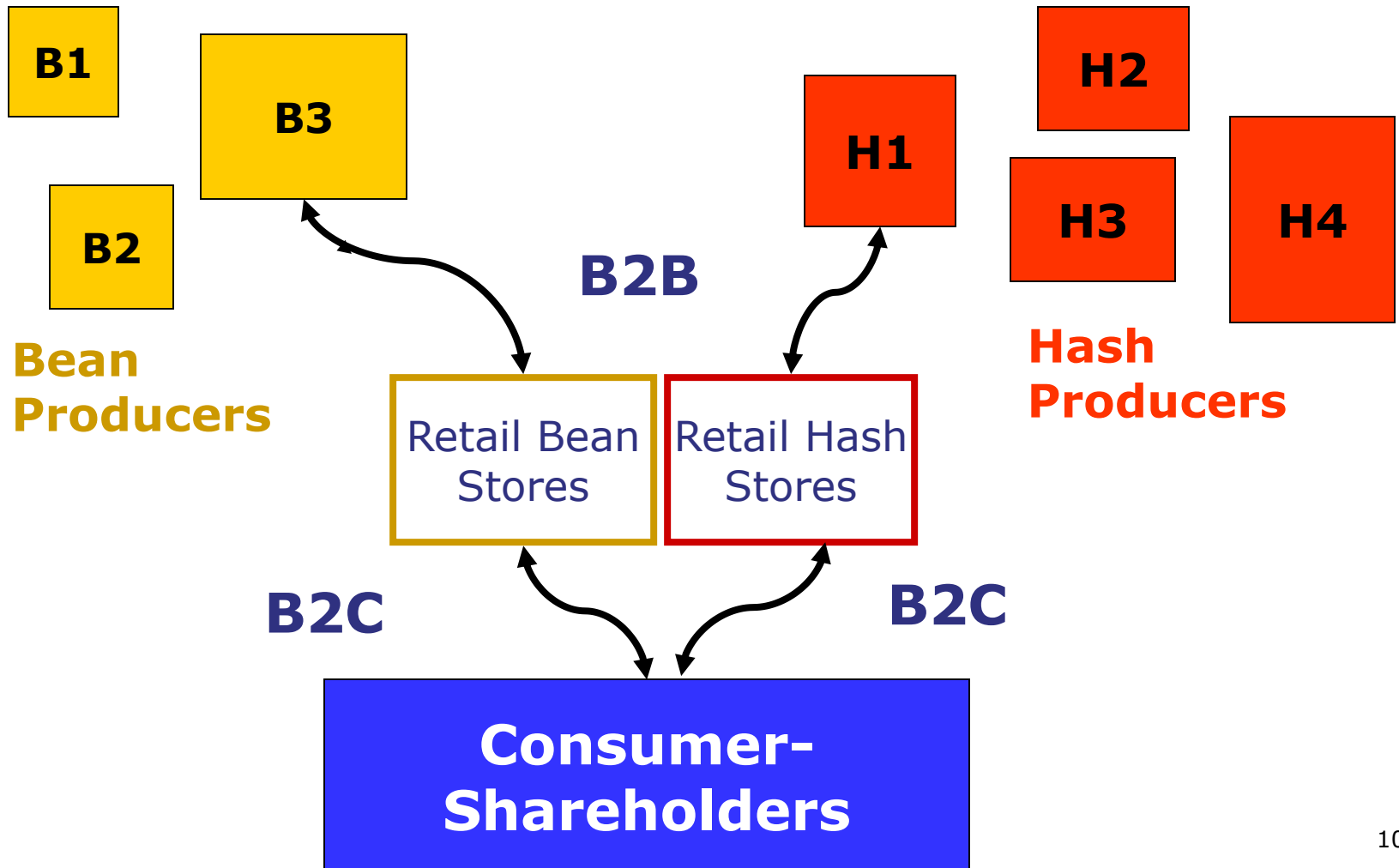
Example 1: Bilateral B2B & B2C Trade

(B2B=Business To Business, B2C=Business To Consumer)



Example 2: Mediated Trade

(Producers \longleftrightarrow Retail Stores \longleftrightarrow 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.

ACE and Qualitative Market Analysis

Illustrative Issue: What are the performance capabilities of decentralized markets? (*Adam Smith, L. von Mises, 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.