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
- 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

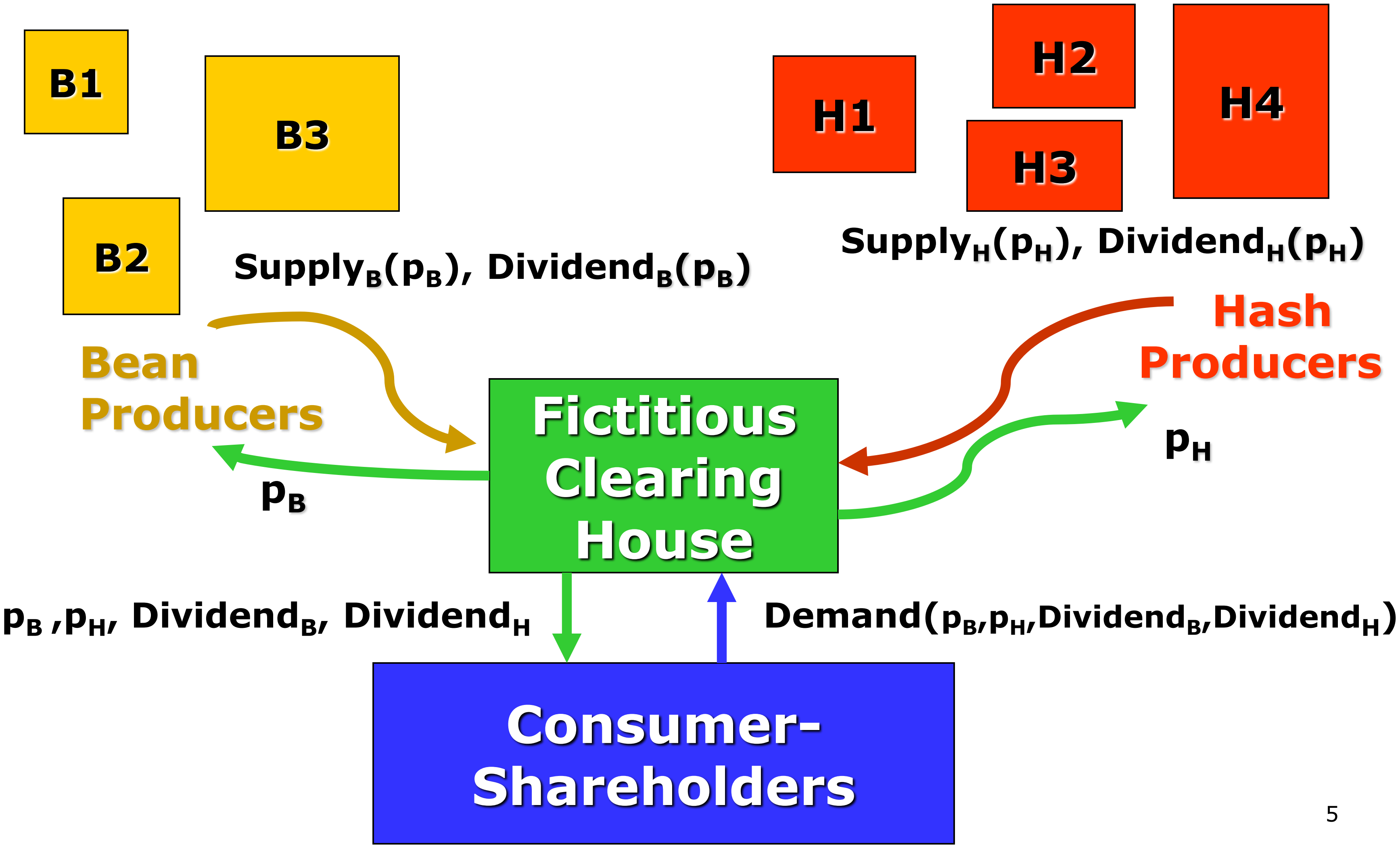
  Micro ↔ *Agent Interactions* ↔ *Macro*

- **Strategic behaviour & uncertainty**

- Possible existence of **multiple equilibria**

- Critical role of **institutional constraints**

Simple Example of a Standard “Competitive” Decentralized Market Economy



Plucking Out the Fictitious Clearing House!

B1

B3

B2

H2

H1

H3

H4

Bean Producers

Hash Producers

Producer-Consumer Connections??

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

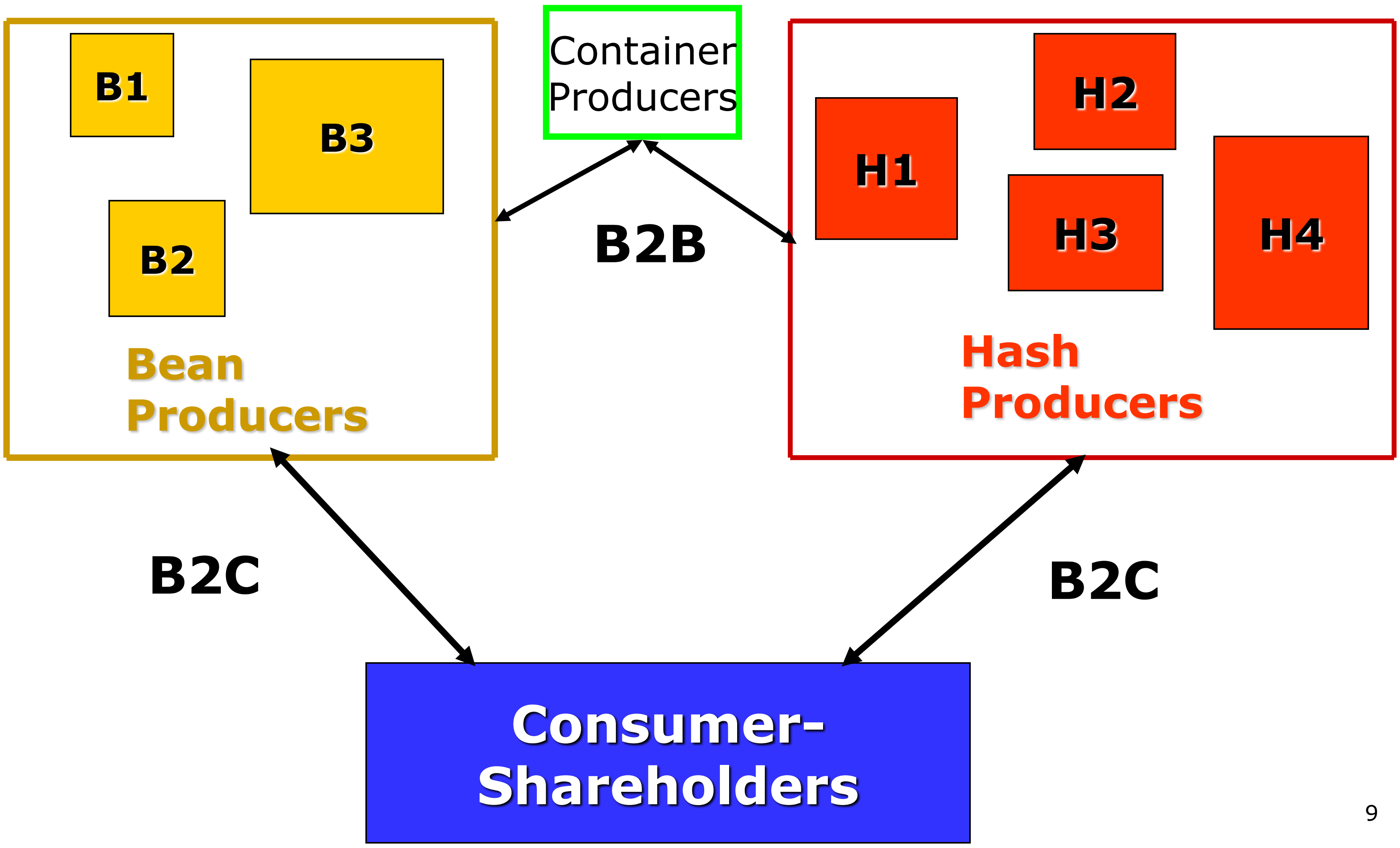
- Two basic forms of trading:
  - 1. *Bilateral* trading

    (Seller ↔ Buyer)
  - 2. *Mediated* trading

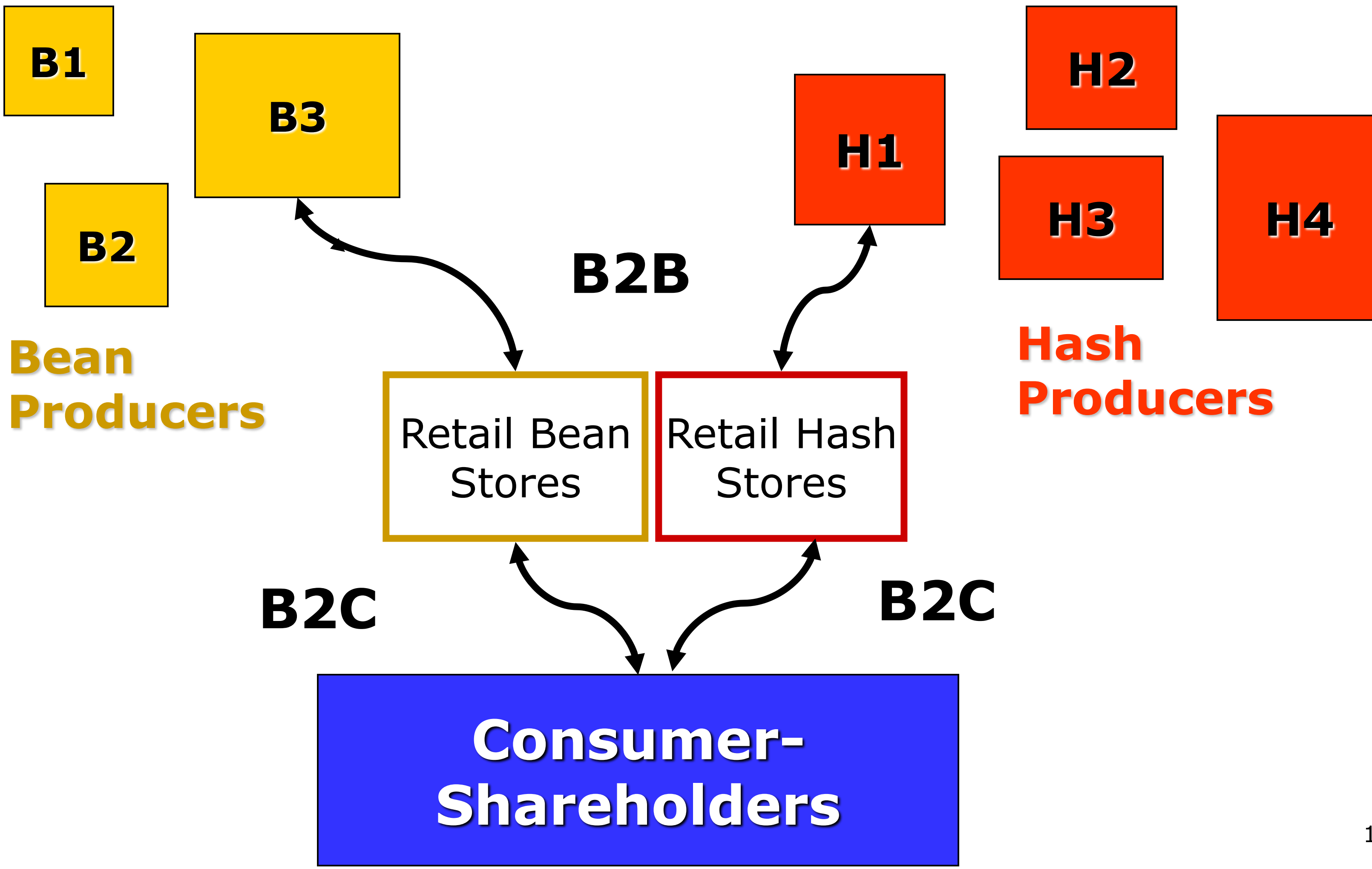
    (Seller ↔ Mediator ↔ Buyer)

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 ***A***gent-based ***C***omputational ***E***conomics (***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.