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**

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

Micro ↔ *Agent Interactions* ↔ *Macro*

◆ **Strategic behaviour & uncertainty**

◆ Possible existence of **multiple equilibria**

◆ Critical role of **institutional constraints**
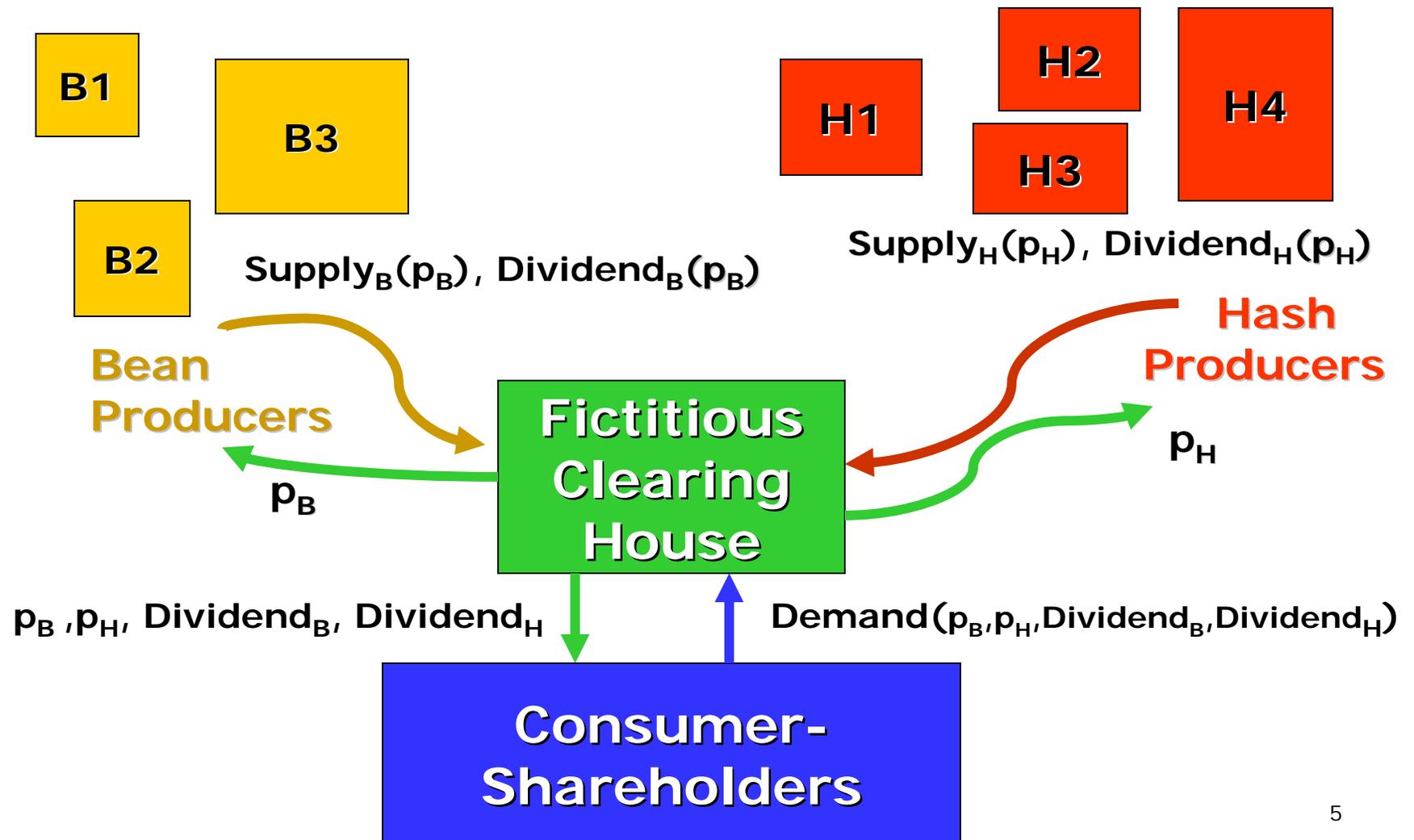
Plucking Out the Fictitious Clearing House!

B1

B3

B2

Bean Producers

H2

H1

H3

H4

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.]

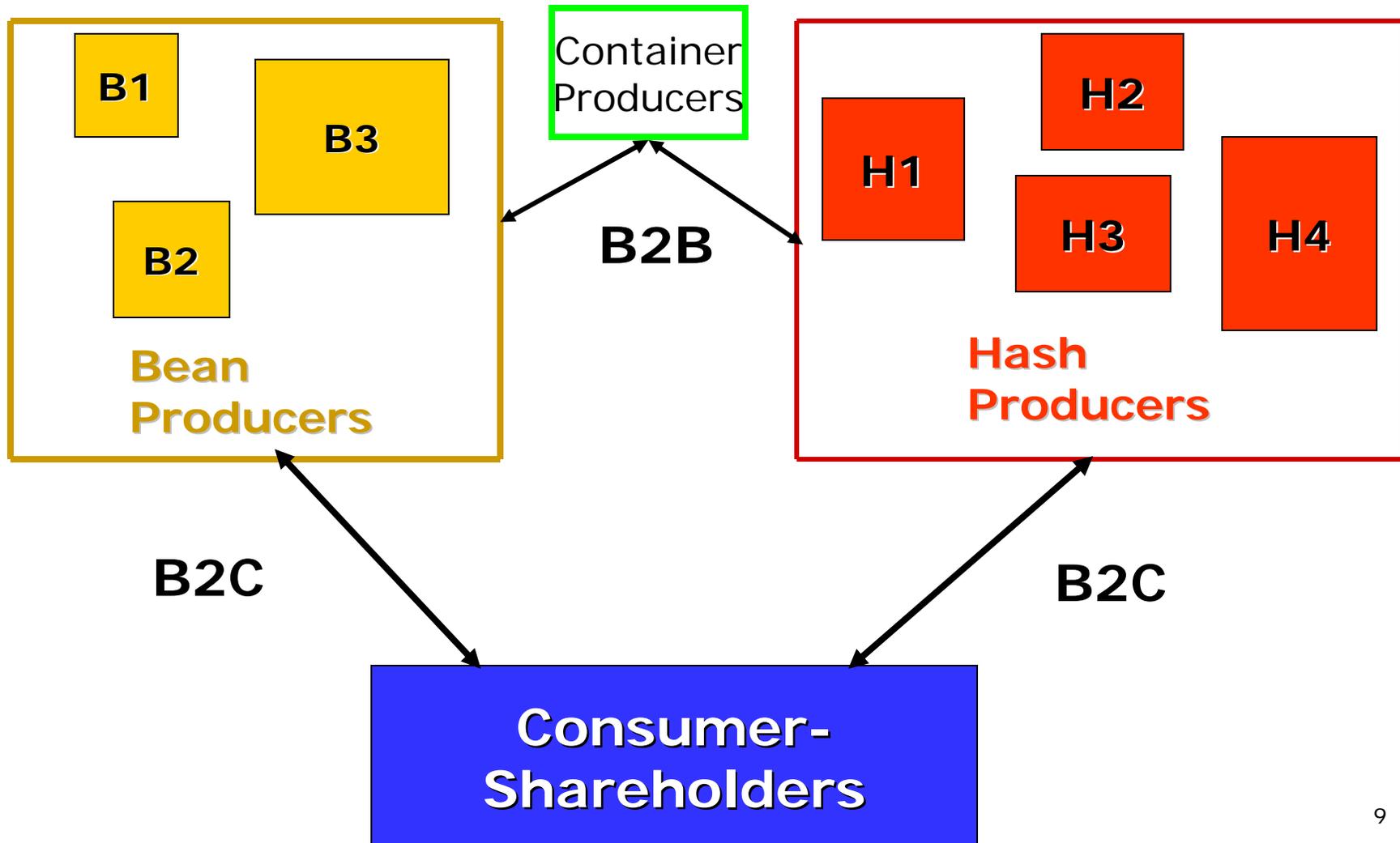- **Learning Behavior and Strategic Interaction**
  - Price/quantity discovery processes
  - Formation of buyer-seller interaction networks

Market Organization

- Two basic forms of trading:

  - **1. Bilateral** trading (Seller ↔ Buyer)

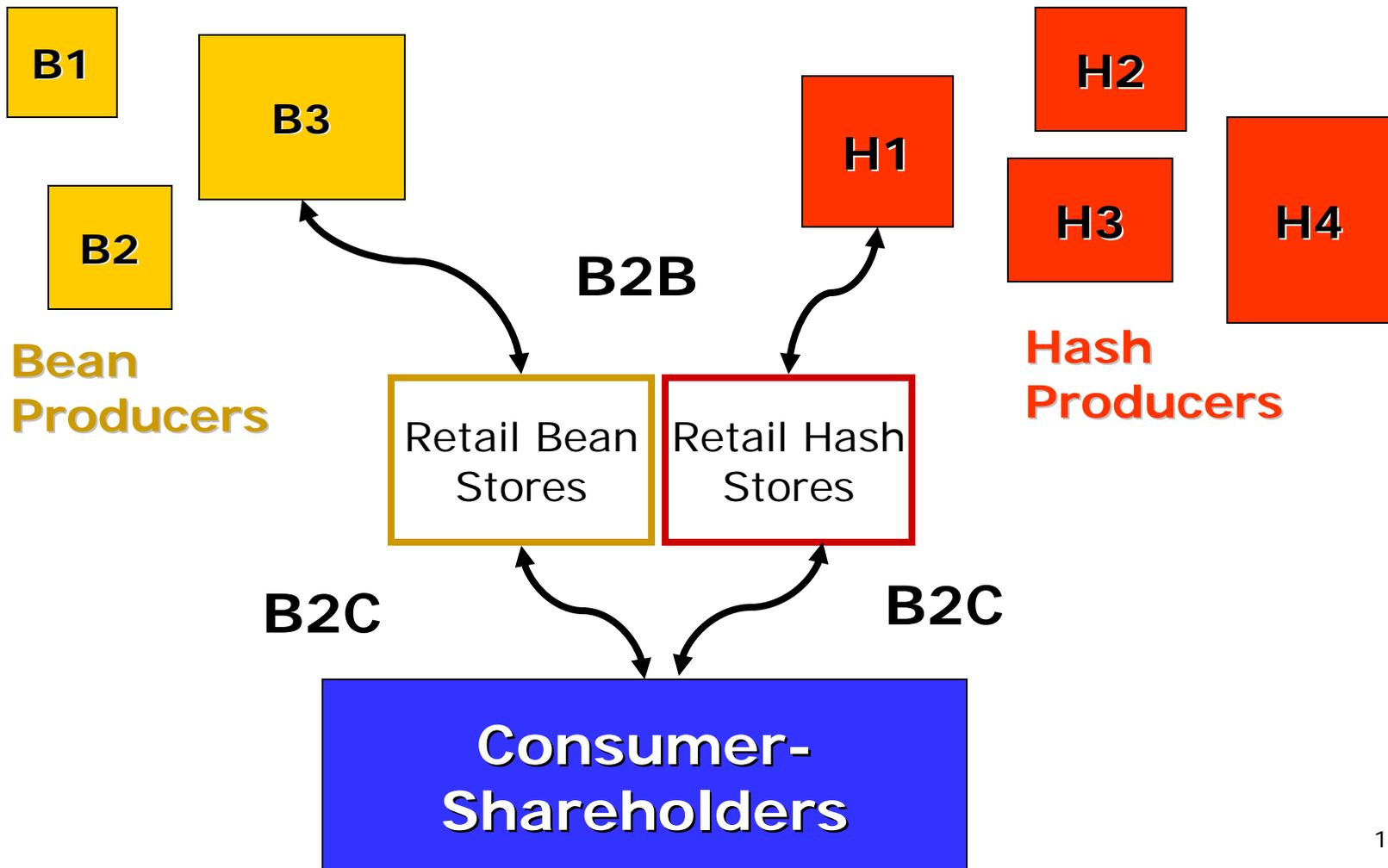 - **2. Mediated** trading
    (Seller ↔ Mediator ↔ Buyer)

Example 1: Bilateral B2B & B2C Trade
(B2B=Business To Business, B2C=Business To Consumer)

Example 2: Mediated Trade
(Producers → Retail Stores → Consumers)

B1

B3

B2

Bean Producers

H1

H2

H3

H4

Hash Producers

B2B

Retail Bean Stores

Retail Hash Stores

B2C

B2C

Consumer-Shareholders

10

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.