Networks II: Market Design—Lecture 19 Information and Networked Behavior

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Where we are

Where we are: Previous class

- Properties of stable matchings:
  - Incentive properties: Proving that man-proposing DA is strategyproof for men
  - Unmatched agents across stable matchings
- The theory-practice connection: NRMP and stability

Where we are: What have we seen so far?

- One-sided markets: Binary preferences; rank-order preferences with and without initial endowments
- Two-sided markets: Marriage model (one-to-one matching); multi-unit demand (many-to-one)

What's next?

Stepping back: The big picture

- Markets (networked economies): Analysis and design
  - Analyzing outcomes: What happens?
  - Defining 'good' outcomes: What would you *like* to happen?
  - Design: How do you make it happen?
- Markets quite generally:
  - Markets: A very general term for any institution/setting with exchange between agents
  - (Not restricted to two-sided matching markets without money!)
  - Examples: Markets for consumer goods, personal services, collectibles, insurance, ...

Market design: Allocation and information

Central question so far:

- **Allocation** in markets—'who gets what'?
- What are good outcomes, and how do we find them?
  - Specific setting: Matching markets "without money" (Non-transferable utilities)
  - Which matchings are good? (Pareto-efficiency, stability, . . .)
  - Mechanisms: How do we find 'good' matchings?
  - Incentives: How do agents respond to the mechanisms used to choose matchings?

Now, on to another aspect:

- **Information** in markets—'who *knows* what'?
- How does information structure affect outcomes?
  - Specific setting: Matching markets *with* money

Markets and information structure: Sneak preview

- Spoiler alert: Information structure in market can change outcome
- Information *asymmetry*: Some subset of agents in market have more information about goods or services exchanged
  - Used goods: Sellers have more information
  - Insurance: Buyers have more information
  - Hiring: Candidates have more information than firm
  - ...
- What we'll see: **Endogeneity** in quality of what is *brought* to market!
  - Market design question so far: Who gets what, *given* market
  - Market design and information structure: Who *comes* to market?

Why study information asymmetry?

Information asymmetries arise in many important markets:

- Markets for lending and mortgages
  - Banks know less about creditworthiness than borrower
- Markets for insurance: Health, life, vehicle, property, fire, ...
  - Buyer has more information about self than insurer
  - Also has more control over actions post-insurance
- Labor markets: Traditional jobs; online labor markets (oDesk, crowdwork platforms, ...)
  - Employers less informed about candidate's skills, productivity
  - Employee can also choose effort
- Charitable giving

Why study information asymmetry?

Strong information asymmetries in online markets as well:

- E-commerce: eBay, Amazon, . . . ,
  - Buyers cannot physically inspect good being sold
  - Sellers know more about specific product offered for sale
- Online markets for services: Craigslist, Thumbtack
- Social (peer-to-peer) lending: Prosper, Zopa, . . .
  - Borrowers know more about creditworthiness, repayment ability than lenders
- Crowdfunding: Kickstarter, Indiegogo, . . .
  - Fundraisers better informed than investors about project quality, success probability

Market design: Allocation and information

Central question so far:

- **Allocation** in markets—'who gets what'?
- What are good outcomes, and how do we find them?
  - Specific setting: Matching markets "without money" (non-transferable utilities)

Switching gears:

- **Information** in markets—'who *knows* what'?
- How does information structure affect outcomes?
  - Specific setting: Matching markets *with* money

Market structure

- Key features in our markets until now:
  - Ordinal instead of cardinal valuations: Rank-order preferences instead of v_{ij}
    - New questions about what *are* good allocations (and how to implement them)
  - No transferable utilities: No currency (e.g. money) that can be traded amongst agents
  - Centralized authority making allocations
- Next: (Non-centralized) matching markets with money

Matching markets with money

Recap: Matching markets with money (Networks I)

- Market with n agents (buyers) and n items
- Buyer i has *cardinal* valuation v_{ij} for item j
- Two immediate questions:
  - What 'should' happen: What is a good allocation of items to buyers?
  - Market without central authority: How to resolve contention amongst buyers over items?

Markets with money: Market-clearing prices

First, Q2: How to resolve contention amongst buyers over items?

- Market-clearing prices: Let p_j denote price for item j
  - Suppose every buyer i points to (all) items that maximize $v_{ij} - p_j$: Consider induced bipartite graph
  - (Informally:) p_j are market-clearing prices if induced graph has perfect matching
- Theorem: For any set of buyer valuations $v_{ij} \geq 0$, there exists a set of market-clearing prices. (!)
- *Observe magic of money*: Prices remove contention in buyers' preferences over items!

Markets with money: Market-clearing prices

- Market with 3 buyers and 3 items; buyers' values are:
  1. Buyer 1: $(5, 7, 1)$
  2. Buyer 2: $(2, 3, 1)$
  3. Buyer 3: $(5, 4, 4)$

  [A] Yes [B] No

  Is price vector $p = (2, 2, 1)$ market-clearing? What about $p' = (1, 3, 1)$?

- Again, there are 3 buyers and 3 items; now buyer values are:
  1. Buyer 1: $(12, 4, 2)$
  2. Buyer 2: $(12, 4, 2)$
  3. Buyer 3: $(12, 4, 2)$

  Is price vector $(12, 4, 2)$ market-clearing? What about $(11, 4, 1)$? What is the set of all possible market-clearing prices?

Markets with money: Market-clearing prices

On to Q1 next: What 'should' happen?

- Good outcomes: Choose allocation that maximizes total value $\sum_i v_{ij(i)}$
  - "Welfare maximization": Same as maximizing total value $\sum_i v_{ij(i)}$
  - Allocation: Buyer i gets item $j(i)$
- How to 'implement' good allocations (without central authority)?
- Theorem (Optimality of Market-Clearing Prices): For any set of market-clearing prices, a perfect matching in the induced graph achieves the maximum total value.
  - Welfare maximization: Decentralized implementation via prices!

Information structure in markets

- Market-clearing prices, welfare maximization address *allocation*
- But we want to study *information*: How to proceed?
  1. *Subtract* a feature (simplify): Make buyers identical
  2. *Add* a feature: Consider *sellers* instead of items
     - Sellers are agents making choices
     - Seller (of item) j values his item at s_j
     - Seller's choice: Whether or not to part with item
- Questions to ask:
  - What *should* happen?
  - Can information structure affect what *does* happen?

But before that, an aside...

Markets with and without money: Are they at all related?

- Does cardinal valuations (v_{ij}) model relate at all to ordinal preferences?
- One connection: Recall house allocation model $(A, H, \succ)$
  - Agent a_i has rank-order preferences $\succ_i$ over houses h_i
- Valuations v_{ij} in markets with money relate to rank-order preferences $\succ_i$
  - $h_j \succeq_i h_{j'}$ iff $v_{ij} \geq v_{ij'}$
  - (Let's just think about strict preferences, for simplicity: Assume $v_{ij} \neq v_{ij'}$ for all i)

An aside: Markets with and without money

- Does Pareto-efficiency in $(A, H, \succ)$ have any relation to welfare maximization with cardinal preferences v_{ij}?
- Yes! Consider any market $(A, H, \succ)$':
  - **Proposition 1**: No matching which is Pareto-dominated in $(A, H, \succ)$ can be welfare-maximizing for *any* valuation profile v_{ij} that induces preferences $\succ$.
  - **Proposition 2**: For every Pareto-efficient matching M in $(A, H, \succ)$, there is a valuation profile $v_{ij}(M)$ (agreeing with ordinal preferences $\succ$) such that M is a welfare-maximizing allocation for v_{ij}.

    (Proofs omitted)

Back to information structure in markets

- Market-clearing prices, welfare maximization: Allocation
- But we want to study *information*: How to proceed?
  1. *Simplify*: Make buyers identical
  2. *Modify*: Consider *sellers* instead of items
     - Sellers are agents making choices
     - Seller (of item) j values his item at s_j
     - Seller's choice: Whether or not to part with item
- Questions to ask:
  - What *should* happen?
  - Can information structure affect what *does* happen?

The basics of trade

'What should happen': Understanding the basics of trade

- First consider just one seller and one buyer: When is trade a good idea?
- Suppose seller values her item at v_s, buyer values at v_b
- Basics: What does 'value' mean?
  - Buyer value v_b:
    - Prefer to get item, paying p, to not buying if $p < v_b$
    - Prefer not getting item and keeping money for all $p > v_b$
    - Indifferent at $p = v_b$
  - Seller value v_s:
    - Prefer keeping item to getting money for all $p < v_s$
    - Prefer to sell item and receive p over keeping item if $p > v_s$
    - Indifferent at $p = v_s$

The basics of trade

- Seller with value v_s for her item; buyer with value v_b
- When is trade efficient?
  - No trade: Seller's utility is v_s $(+W_s)$, buyer's is 0 $(+W_b)$
  - After trade at price p: Seller's utility is p $(+W_s)$, buyer's utility is $v_b - p$ $(+W_b)$
- Outcome $(p, v_b - p)$ Pareto-dominates $(v_s, 0)$ if
  - $p \geq v_s$; $v_b - p \geq 0$; and at least one inequality is strict
  - This happens if price p satisfies $v_s \leq p$ *and* $p \leq v_b$ (with one strict inequality)
- Trade is efficient (*Pareto-dominates* no-trade) if $v_s < v_b$
  - Pareto-dominance is everywhere: Very general concept!
  - 'Gains from trade': $v_b - v_s$

'What should happen', more generally

Moving on beyond one buyer and one seller:

- Choose allocation to maximize total gains from trade $\sum_i v_{ij(i)} - s_{j(i)}$
  - 'Core of assignment game' (Shapley-Shubik 1972): Not in syllabus!
- For our purpose: A very special case of general model will suffice

Coming up next:

- Understanding information asymmetry: The Market for Lemons model (Akerlof)