Networks II: Market Design—Lecture 22 Information and Networked Behavior

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Recap: Information asymmetry and SFEE

- Information asymmetry with 'hidden information':
  1. What 'should' happen? (Efficient outcome; achievability with complete information)
  2. Reasoning about outcome with asymmetric information
- A model to explore information asymmetry:
  - Identical buyers; sellers choosing whether to enter market
  - Items of different qualities; sellers informed, buyers uninformed
- What 'happens' in such a market?
  - Prices buyers are willing to offer depends on *which sellers sell*
  - Which sellers are willing to sell depends on prices buyers are willing to offer

Information asymmetry: Adverse selection and inefficiency

- Self-fulfilling expectations equilibria (SFEE): 'Consistent' belief about distribution of qualities *on market*
  - Simple market with two kinds of items: SFEE h, fraction of good items on market
  - h is SFEE if there is a price $p^*(h)$ that 'supports' it:
    - Buyers willing to offer $p^*(h)$ *if* h is accurate
    - Sellers willing to sell at $p^*(h)$ corresponds to outcome h
  - SFEE with 3 quality levels; continuum of qualities
- Information asymmetry leads to *adverse selection* phenomenon:
  - Buyers cannot distinguish quality: Offer uniform price
  - 'Lower half' of market participates: Drives down average quality, prices
  - **Uniform prices 'select'** worst traders into market

Information asymmetry: Adverse selection and inefficiency

- Inefficiency due to adverse selection
  - First example (two types of items): Only bad cars traded
  - Second example (three types of items): Complete failure (only lemons traded)
  - Third example (continuum of qualities): Equilibrium $p = 0$
- Asymmetric information: Market can completely unravel and collapse!
- Recall asymmetric vs incomplete information: Inefficiency **not** due to *incomplete* information **alone**
  - If *neither* buyers nor sellers know quality: No inefficiency!

Recap: A richer example

- A richer example: Continuous distribution of item qualities
  - Sellers' values V_s uniformly distributed between 0 and 1
  - Buyer's value, *if* quality were discernible: $V_b = 1.5V_s$
  - With complete information: All cars would be sold
- What is self-fulfilling expectations equilibrium in this market?
  - SFEE is belief about distribution of quality: Threshold V_s^* with sellers in $[0, V_s^*]$ in market (Why?)
  - At p: Sellers with values $V_s \leq p$ will sell; rest don't
  - Expected value to buyers, **given** sellers who sell at p:

$$E[V_b|p] = 1.5E[V_s|p] = 1.5 * p/2 = 0.75p$$

  - For equilibrium, $E[V_b|p] \geq p$: Only solution is $p = 0$!

Information asymmetry and inefficient outcomes

- Will market always fail with asymmetric information?
- No! Market failure depends on:
  - Distribution of item qualities: More low-quality items 'worse'
    - Recall example with $g < 2/3$
  - Buyer and seller valuations: 'Smaller gap' between buyer and seller values worse
- Consider uniform distribution example, with $V_b = \gamma V_s$: For which of the following $\gamma = V_b/V_s$ does market **fail**?
  - A All $\gamma \geq 0$
  - B $0 \leq \gamma < 2$
  - C $\gamma \geq 2$
  - D $1 \leq \gamma < 2$

  (Tie-breaking rule: Sellers who are indifferent ($p = V_s$) choose to sell)

Information asymmetry and inefficient outcomes

- Uniform distribution example: For what ratios of $\gamma = V_b/V_s$ does market fail?
  - $p = \gamma E[V_s|p] = \gamma \cdot \frac{p}{2}$
  - If $\gamma \geq 2$: Highest value seller with $V_s = 1$ is willing to sell, and therefore so are all other sellers
    - Efficient outcome (no market failure)!
  - $\gamma < 2$: No trade in equilibrium
    - (No SFEE with $p \neq 0$)
  - Market *failure*: Only for γ between 1 and 2
    - No trade is indeed efficient if $\gamma < 1$!

Asymmetric information and adverse selection: Labor markets

- Another setting for adverse selection: Labor markets
  - Firm hires workers from pool of potential employees
  - Workers can be productive or unproductive
  - Productive workers: Can generate $\$f_p$ for firm; $\$s_p$ self-employed
  - Unproductive workers: Can generate $\$f_u$ for firm; $\$s_u$ self-employed
  - Assume more firms than workers
- How is this analogous to the used-car market?
  - 'Buyer' $\sim$ firm, 'seller' $\sim$ worker, 'quality' $\sim$ productivity
  - v_b: Value generated by worker for firm (f_p or f_u)
  - v_s: Value to worker for her 'good', *i.e.*, labor (s_p or s_u)
  - Price: Salary paid by firm to worker for her labor
  - More firms than workers: Price driven up to firms' values for workers' output

Asymmetric information and inefficiency: Labor markets

- Complete information: Firms know workers' types (productivities)
  - If $v_s < v_b$: Offer worker-specific salary s_w in range $[v_s, v_b]$
  - All offers accepted: Efficient outcome is full trade
- Asymmetric information: Firms don't know workers' types, offer uniform salaries s
- Trouble if inadequate high-productivity workers in *population*
  - Salaries $s < s_p$ too low for productive workers
  - Adverse selection due to information asymmetry: Inefficiency!

Asymmetric information: Health insurance

- Information asymmetry with better-informed *buyers*:
  - Buyers of insurance know about their health conditions
  - Insurance companies (sellers) less informed
- Uniform price for insurance: Price must be sufficient to cover average cost of insuring *all* buyers
  - Large fraction of high-risk buyers: Expected cost to insurance company, and so price of insurance, is high
  - Drives out low-risk buyers who prefer to self-insure: Adverse selection
  - Raises prices further, since expected costs to insure now increase
- Market for insurance can collapse due to asymmetric information!

So far

- Markets with information asymmetries (of 'hidden information') are everywhere
  - Used goods, labor markets, insurance, ...
  - 'Hidden information': **Exogenous** (unknown) qualities

- What we've seen: Information asymmetry (can) substantially affect equilibrium outcome
  - Asymmetry **endogenously** determines qualities traded in market
  - 'Bad' agents drive 'good' agents out of market; complete collapse can occur, with no agents willing to trade!

Alleviating information asymmetry

- Information asymmetry can induce extreme inefficiencies: Mechanisms to at least partly alleviate issue must be in place!
- Legally mandating disclosure of relevant information
  - Insurance markets: Buyer must answer questions about factors pertinent to risk profile, cost of insuring
    - Vehicle insurance (past driving record, accidents, age, commute, . . .); health (medical history, habits), . . .
    - Insurance company uses information to estimate risk and price insurance differentially (payment may be denied if false answers provided)
  - Loans: Credit history, finances, income, . . .

Credible disclosure

- *Mandating* disclosure may not always be feasible
- Sellers of *good* items have incentive to demonstrate quality
  - Known quality: Buyers value all items more than sellers
  - Uniform prices harm better sellers, benefit worse sellers
- *Suppose* there is a means to disclose information **credibly**
  - Inspection by third party
  - Trial periods
  - *Samples*
  - ...
- Which sellers will choose to disclose?

Credible disclosure

A simple version: Costless verification

- Recall used car market with continuous distribution of quality
  - V_s uniformly distributed on $[0, 1]$
  - Buyer values $V_b = 1.5V_s$
- Every seller can (choose to) have car **appraised** for free
- Which sellers would choose to appraise?
  - A Some set of 'high-value' sellers $V \geq V_h$
  - B Some set of 'low-value' sellers $V \leq V_l$
  - C Sellers in some interval in the (strict) interior of $[0, 1]$
  - D That's too hard for this sleep-deprived point in the semester!

Credible disclosure

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- Every seller can (choose to) have car **appraised** for free
- Which sellers would choose to appraise?
  - Appraisal beneficial **if** price with (credibly) disclosed quality higher than with undisclosed quality
  - Price with (credibly) disclosed quality for seller with value V_s: $V_b = 1.5V_s$
  - (Recall more buyers than sellers)

Equilibrium with credible disclosure

- What price will seller receive if not disclosing quality?
  - Undisclosed qualities: Items indistinguishable to buyers; **uniform price**
  - Uniform price equals expected value to buyers **over** sellers who choose non-disclosure
  - Expected price from non-disclosure *depends* on decisions of other sellers: Which sellers disclose, as well as which ones don't

Equilibrium with credible disclosure

- Disclosure is *equilibrium* decision:
  - Disclosure beneficial if expected price with (credibly) disclosed quality higher than with undisclosed quality
  - Whether appraisal is beneficial or not must be determined *in equilibrium*!
- Which of the following is the set of sellers that choose to appraise in equilibrium?
  - $V_s = 1$
  - $V_s \geq 0.75$
  - $V_s \leq 2/3$
  - $V_s \in [0.25, 0.75]$
  - None of the above

Equilibrium with credible disclosure

Which sellers would choose to appraise *in equilibrium*?

- 'High value' sellers would certainly want to disclose
- What about low value sellers?
  - $E[V_b]$ over *all* cars: $1.5E[V_s] = 0.75$
  - *If* all cars don't disclose (and are on market), buyers would be willing to pay $p = 0.75$
  - First guess: Sellers with $V_s \geq 0.75$ would want appraisal; $V_s < 0.75$ choose no appraisal
- Equilibrium outcome: **All** sellers choose to have cars appraised!

Equilibrium with credible disclosure: A formal analysis

- Recall (i) Appraisal is free: Costless verification (ii) More buyers than sellers
- Let V_s^* be cutoff such that all sellers with $V_s \geq V_s^*$ prefer to disclose and remaining do not (Why?)
- Appraised cars sell at price $1.5V_s$, while non-appraised cars **all** sell at uniform price:

$$p_{V_s^*} = E[V_b|V_s^*] = 1.5E[V_s|V_s \leq V_s^*]$$

- Equilibrium: Value of V_s^* such that
  - No seller s with $V_s > V_s^*$ would prefer non-disclosure: $1.5V_s \geq p_{V_s^*}$
  - No seller s' with $V_{s'} \leq V_s^*$ would prefer to disclose: $1.5V_{s'} \leq p_{V_s^*}$

Equilibrium with credible disclosure

What values of V_s^* can arise in equilibrium?

- $p_{V_s^*} = 1.5E[V_s|V_s \leq V_s^*] = 1.5\frac{V_s^*}{2} = 0.75V_s^*$
- Equilibrium conditions:
  - No seller s with $V_s > V_s^*$ would prefer non-disclosure: $1.5V_s \geq p_{V_s^*} = 0.75V_s^*$ holds for all $V_s > V_s^*$
  - No seller s' with $V_{s'} \leq V_s^*$ would prefer to disclose: Must have $1.5V_{s'} \leq p_{V_s^*} = 0.75V_s^*$
  - Inequality must hold for **all** $V_{s'} \leq V_s^*$, specifically $V_{s'} = V_s^*$
  - $1.5V_{s^*} \leq 0.75V_s^*$ **only** at $V_s^* = 0$: *All* sellers choose to disclose quality in equilibrium!
- Information asymmetry disappears, **in equilibrium**: Note disclosure was *voluntary*, not mandatory!

Equilibrium with credible disclosure

All sellers disclose quality in equilibrium:

- When high-value sellers choose to appraise, set of cars with undisclosed qualities changes: Average quality of non-appraised cars drops
  - Again: Uniform prices *harm* better sellers, *benefit* worse sellers
- Expected value to buyers on *non*-appraised cars decreases: 'Upper' segment of remaining non-appraised cars want to appraise
- And so on... until all sellers want to appraise: Full disclosure!

Equilibrium with credible disclosure

- Notice similarity with market failure argument
- Asymmetric information: No disclosure (Market for lemons)
  - No disclosure: Uniform price for **all** items
  - Only lower and lower values want to sell, given who else is selling
  - Equilibrium: No one wants to sell, 'complete' inefficiency
- Asymmetric information: (Credible) information disclosure
  - Uniform price for **unappraised** items
  - Only lower and lower values want to *not disclose*, given who else is disclosing
  - **Equilibrium** outcome: No one wants to **not** disclose!
  - Contrast with market failure: Full efficiency in equilibrium

Costly verification

- Costless verification:
  - Full information disclosure: Efficient outcome (full trade) in equilibrium
- Credible disclosure may not always be free: Suppose verification costs c
  - Inefficiencies may remain with costly verification
  - High value sellers prefer to incur cost c, disclose value: Trade at high prices
  - Low-quality sellers with V_s 'small enough' compared to c:
    - May not find it beneficial to incur cost to disclose: 'No trade' outcome might arise on non-disclosed subset
    - Possibility of partial collapse on low quality segment

Signaling

- Credibly disclosing value *itself* may not always be feasible:
  - Online retail commerce: Hard to certify quality of every copy of item shipped
  - Labor markets: Employee cannot certify level of productivity on job
  - ...
- Signaling: (Potentially) sustaining trade without actually measuring and *disclosing* quality
  - Suppose there is a *signal* that is cheaper for high-value agents to acquire than low-value agents on informed side of market: May improve efficiency

Signaling mechanisms

- Online retail, e-commerce: Warranties
  - Sellers with high-quality items find it cheaper to provide warranties than sellers with low-quality items
  - Lower failure rates, repair costs if items are higher quality
- Labor markets: *Education!* (Spence'73)
  - Higher-ability workers find it 'cheaper' to get an education than low-ability workers
  - College is less difficult to complete; more scholarships, ...
- Markets for services: Money-back guarantees
- *Reputation!* (We'll touch on this)