Asymmetric Information

Weeks 11 and 12

(Chapter 30)

Information in Competitive Markets

- In purely competitive markets, all agents are fully informed about traded commodities and other aspects of the market
- In reality, agents have imperfect information (as opposed to perfect information)
- This lecture deals with one particular type of imperfect information: asymmetric information
- Markets with one side better informed than the other

Examples of Asymmetric Information

- Examples:
  - Doctor knows more about medical services than does patient
  - Insurance buyer knows more about her riskiness than does seller
  - Appliance repairer knows more about the degree of malfunction than homeowner
  - Job candidate has more information on her skills and abilities than does employer
  - Used car’s owner knows more about the car than does potential buyer

- Asymmetric information typically leads to market failure (i.e., market fails to allocate resources efficiently)

Two Types of Asymmetric Information

- **Adverse selection**
  - Hidden “type”
  - Private information on some innate characteristics
  - Signaling as a solution to adverse selection

- Moral hazard
  - Hidden/unverifiable action
  - Private information on choices made
  - One side of the market cannot observe/verify actions of the other

Adverse Selection

- Consider a second-hand car market
- Two types of cars: “lemons” (bad) and “peaches” (good)
- Each lemon seller will accept $1,000; a buyer will pay at most $1,200
- Each peach seller will accept $2,000; a buyer will pay at most $2,400

Under Full Information

- If every buyer can tell a peach from a lemon, then lemons sell for between $1,000 and $1,200, and peaches sell for between $2,000 and $2,400

- Both types of cars are traded (and both should be traded)
  - $2400>$2000
  - $1200>$1000

- Gains-from-trade are generated when buyers are well informed

Under Asymmetric Information

- Let q be the fraction of peaches
- $1 - q$ is the fraction of lemons

- Everyone (buyers + sellers) knows q
- But buyer does not know if a car is peach or lemon before buying

- Expected value to a buyer of any car is

  $EV = \$1200\ (1 - q) + \$2400q$

- Suppose that buyers are risk neutral

Adverse Selection

- For buyer, $EV = \$1200\ (1 - q) + \$2400q$
- Suppose q is sufficiently high, then $EV > \$2000$
- Every seller can negotiate a price between $2000 and $EV
- All cars will be sold (Gains from trade to be generated)

Adverse Selection

- But if q is sufficiently low, then $EV < \$2000$
- Peach sellers will exit the market
- Buyers know that remaining sellers own lemons only
  - Buyers will pay at most $1200
  - Only lemons are sold
- Too many lemons *crowd out* peaches from the market
- Gains-from-trade are reduced since no peaches are traded

Adverse Selection

- Low-quality goods *crowd out* high-quality goods

- Market fails
  - Low-quality goods dominate the market
  - None or too little high-quality goods are sold
  - Inefficiency

How much is too much?

- How many lemons can be in the market without crowding out the peaches?

- Buyers will pay $2000 for a car only if

  $EV = \$1200\,(1 - q) + \$2400q \geq \$2000$

  $\Rightarrow q \geq \frac{2}{3}$

- If over one-third of all cars are lemons, then only lemons are traded.

Continuum of types

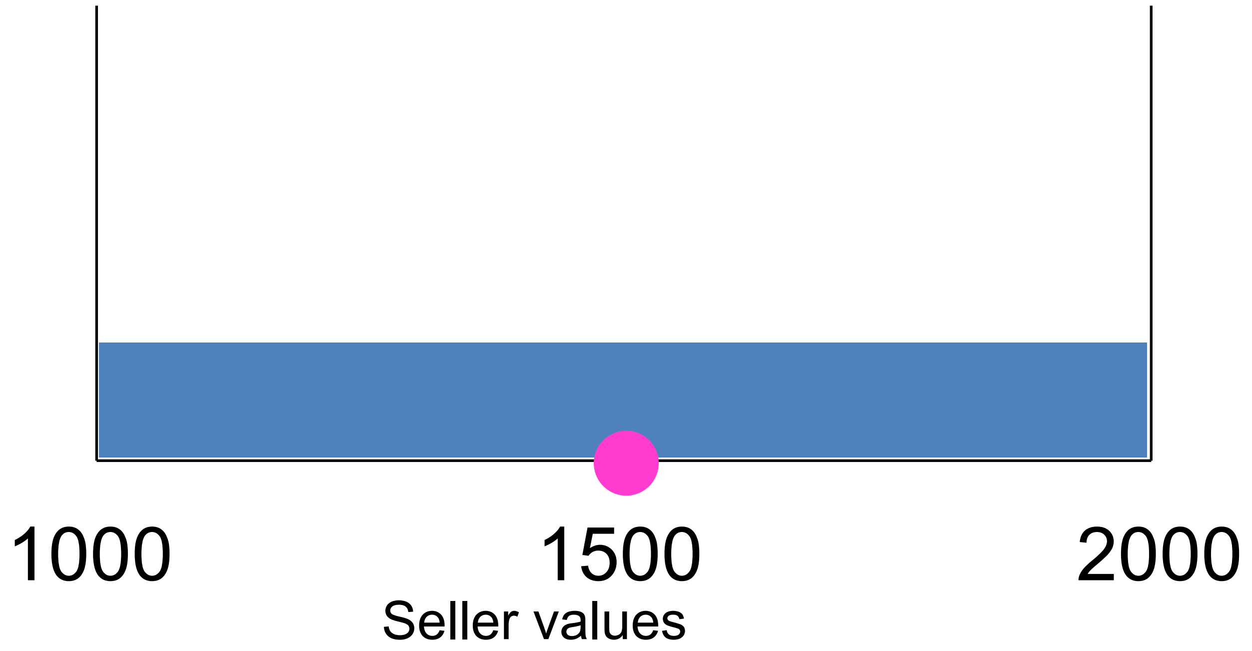
- What if there is more than two types of cars?

- Suppose that
  - car quality is *uniformly distributed* between \$1000 and \$2000 (seller's valuation)
  - A car that seller values at \$x is valued by buyer at \$x+300

- All cars should be traded

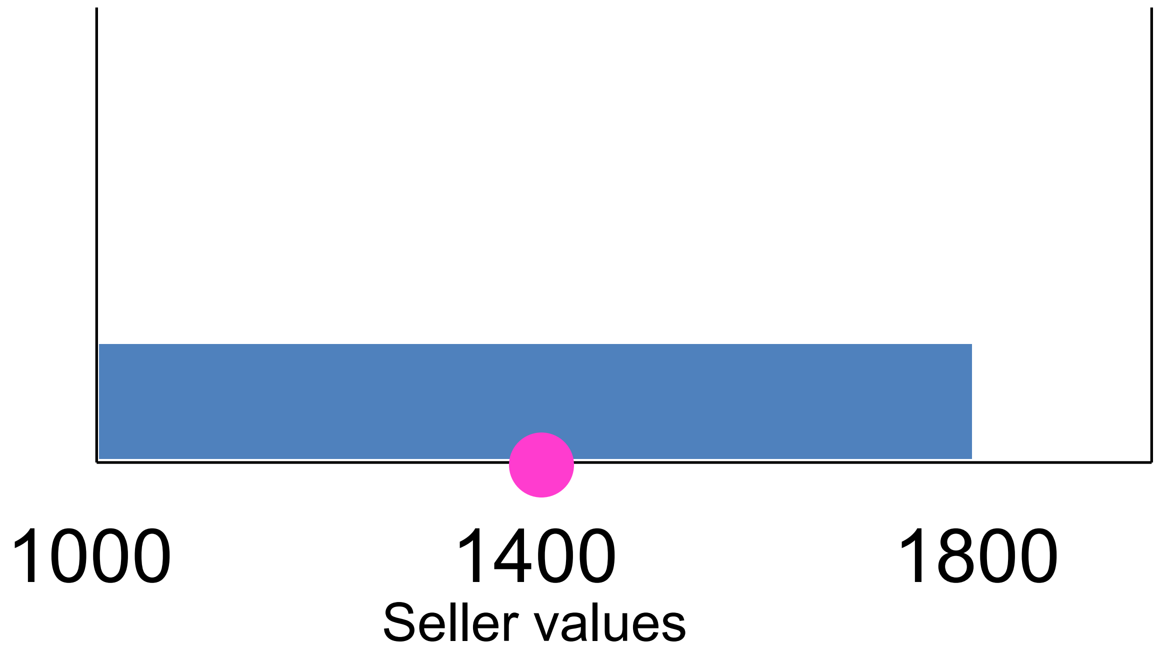
- But with asymmetric info, which cars will be traded?

Adverse Selection



- Average value of cars to a seller is $1500
- Expected value of any car to a buyer is $1500 + $300 = $1800
- So sellers who value their cars at more than $1800 exit the market

Adverse Selection



- Sellers who value their cars above $1800 exit
- Average value of remaining cars to a seller is $1400; expected value of any remaining car to a buyer is $1400 + $300 = $1700
- So now sellers who value their cars between $1700 and $1800 exit the market

Adverse Selection

- When does this unraveling of the market end?
- Let v_H be the highest seller value of any car remaining in the market
- Expected seller value of a car is ½ (1000 + v_H)
- So a buyer will pay at most ½ (1000 + v_H) + 300

Adverse Selection

- So a buyer will pay at most ½ $(1000 + v_H) + 300$
- This must be the price which the seller of the highest value car remaining in the market will just accept;

  i.e. ½ $(1000 + v_H) + 300 = v_H$

  $\Rightarrow v_H = \$1600$
- Adverse selection drives out all cars valued by sellers at more than $1600

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Signaling

- Adverse selection is an outcome of an informational deficiency
- What if information can be improved by high-quality sellers signaling credibly that they are high-quality?

Signaling

- Some examples of signaling

  1. Warranties
  2. References from previous clients
  3. Professional credentials
  4. Education

Education as Signaling

- Labor market has 2 types of workers: high- and low-ability

- A high-ability worker's marginal product is a_H
- A low-ability worker's marginal product is $a_L < a_H$

- A fraction h of all workers are high-ability
- 1 - h is the fraction of low-ability workers
- (Firms know h, but cannot distinguish between the two types)

Signaling

- Assume that the product market and labor market are competitive
- Each worker is paid his expected marginal product

- If firms knew each worker's type, they would pay
  - high-ability worker $w_H = a_H$
  - low-ability worker $w_L = a_L$

Signaling

- Suppose firms cannot tell workers' types
- Every worker is paid his expected marginal product
  $$w_P = (1 - h)a_L + ha_H$$
- $w_P = (1 - h)a_L + ha_H < a_H$, the wage rate paid when the firm knows a worker is high-ability
- So high-ability workers have incentive to find a credible signal

Education as Signaling

- Workers can acquire “education”
- Education costs a high-ability worker c_H per unit
- Education costs a low-ability worker c_L per unit, where $c_L > c_H$
- Suppose cost of education is a deadweight loss,
  - education has no effect on workers’ productivities
  - education does not increase a_L and a_H

Signaling as a Sequential Game

- Stage 1
  - Workers learn their types and choose whether or not to acquire education
- Stage 2
  - Firms observe workers’ education level (but not their types) and offer each worker a wage
- Is there an equilibrium in which all high-type workers acquire education while all low-type workers do not?

Wages Paid to Workers with/out Education

- Suppose such an equilibrium exists, backward induction…

- In stage 2
  - For a worker with education
    - Firms believe the worker is a high-type
    - Wage for the worker is $w_H = a_H$

  - For a worker without education
    - Firms believe the worker is a low-type
    - Wage for the worker is $w_L = a_L$

Should a high-type acquire education?

- In stage 1, a high-type worker knows that
  - If he acquires education
    - His/her wage will be $w_H = a_H$
    - His/her total payoff is $a_H - c_H$
  - If he does not
    - His/her wage will be $w_L = a_L$
    - His/her total payoff will be a_L
- Acquire education if $a_H - c_H > a_L$

Should a low-type acquire education?

- In stage 1, a low-type worker knows that
  - If he acquires education
    - His/her wage will be $w_H = a_H$
    - His/her total payoff is $a_H - c_L$
  - If he does not
    - His/her wage will be $w_L = a_L$
    - His/her total payoff will be a_L
- Avoid acquiring education if $a_H - c_L < a_L$

Equilibrium Conditions

- When $a_H - c_H > a_L, \quad a_H - c_L < a_L$

- All high-type workers acquire education, all low-type workers do not
  - No high-type worker wants to deviate
    - It is worthwhile to acquire education
  - No low-type worker wants to deviate
    - It is too costly to “pretend” to be high-type

Interpreting Equilibrium Conditions

$$a_H - a_L > c_H, \quad a_H - a_L < c_L$$

- The increase in wage for workers after education must be higher than the cost of education for the high-type workers
  - So high-type workers will acquire education

- The increase in wage for workers after education must be lower than the cost of education for the low-type workers
  - So low-type workers will not acquire education

Separating Equilibrium

- Such an equilibrium is called a *separating equilibrium*
  - An equilibrium in which workers can be distinguished by firms

- If one or both equilibrium conditions violated, we have a *pooling equilibrium*
  - No worker acquires education
  - Workers cannot be distinguished by firms
  - Every worker is paid $w_P = (1 - h)a_L + ha_H$

Signaling is inefficient

- With signaling, if outcome is a separating equilibrium
  - High-type's wage is a_H
  - Low-type's wage is a_L
- With signaling, if outcome is a pooling equilibrium
  - High-type's wage is $(1 - h)a_\mathrm{L} + ha_\mathrm{H}$
  - Low-type's wage is $(1 - h)a_\mathrm{L} + ha_\mathrm{H}$
- Total output and firms' profit do not change
- But education is costly to workers
  - Cost of education is a deadweight loss in this example

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Moral Hazard

- Consider e.g. of a health insurance company
- Unhealthy people more willing to buy insurance
- This is Adverse Selection (A.S.)
- Another kind of asymmetric information: consumers may drive more recklessly after purchasing insurance
- This is an example of Moral Hazard (M.H.)

Moral Hazard

- M.H. refers to situations when one side of the market cannot observe actions of the other
- A.S. refers to situation when one side of the market cannot observe the “type” or quality of goods on the other side
- M.H. a hidden action problem, A.S. a hidden information problem
- M.H. often leads to rationing, firms would like to provide more, but will not do so as this will change the incentive of their customers

Principal-Agent Problem

- Principal
  - Owner of the firm
  - Anyone who hires someone to work for him/her
- Agent
  - Manager/worker
  - Anyone who is hired by the principal

- Agent takes actions that affect the profit of the firm

Principal-Agent Problem

- If principal cannot observe agent’s actions (moral hazard)
- If principal and the agent have unaligned interests (different objective functions)

- We have the principal-agent problem
  - Agent pursue her own interest instead of principal’s interest

- To induce optimal effort, one possible solution is to make the worker the residual claimant: the last dollar earned goes entirely to her
  - E.g., landlord rents out land to tenant in exchange for a fixed rent; franchising; tax farmers

A Principal-Agent Model with Moral Hazard

- Principal
  - The owner of a firm

- Agent
  - A manager hired by the owner
  - Assume *reservation utility* of the agent is 0

- Profit of the firm depends on
  - Agent's effort: low or high (two-action)
  - Luck: good or bad, each with 0.5 probability

- The principal observes profit but not effort

Effort Level and Profit

- High effort leads to higher expected profit

- If agent exerts low effort
  - Profit=$1000 under bad luck
  - Profit=$2000 under good luck

- If agent exerts high effort
  - Profit=$2000 under bad luck
  - Profit=$4000 under good luck

- If profit is $2000
  - Principal does not know if it is bad luck or low effort

Risk Attitudes and Objective Functions

- Suppose both principal and agent are risk neutral
  - Principal maximizes expected net profit $E\big(\pi(e) - w\big)$
  - Agent's utility is $u(w, e) = w - c(e)$
  - Agent maximizes expected utility $E(w) - c(e)$

- High effort costs more than low effort: $c(e_H) = 20, \quad c(e_L) = 0$

The Game

- Stage 1
  - Principal decides the wage for the agent

- Stage 2
  - Agent decides whether to accept employment offer
  - Agent receives $0 if he declines the offer

- Stage 3
  - Agent chooses effort level if accepts

(Assume that agent accepts offer/exerts high effort when indifferent)

Under Full Information

- Suppose principal observes agent's effort

- If principal wants low effort
  - He should pay the agent \$0 if the agent chooses low effort and 0 otherwise
  - Expected net profit is $0.5 \times 1000 + 0.5 \times 2000 = \$1500$

- If principal wants high effort
  - He should pay the agent \$20 if the agent chooses high effort and 0 otherwise
  - Expected net profit is

- Principal should choose high effort $0.5 \times 2000 + 0.5 \times 4000 - 20 = \$2980$

The First Best (i.e., Benchmark)

- The *first best* is the outcome that arises when principal maximizes the expected net profit under full information
  - The *first-best effort level* is the effort level chosen by principal under full information
  - The associated expected net profit is the *first-best profit*

- The contract (wage scheme) that induces the first best outcome is the *first-best contract*
  - Wage is a function of effort
  - Agent is paid a wage that equals the cost of the first-best effort

Under Asymmetric Information

- If principal wants low effort
  - Principal can still pay a fixed wage of a to the agent

- If $a < 0$, agent rejects the offer

- If $a \geq 0$, agent decides between
  - Low effort, $EU = a$
  - High effort, $EU = a - 20$

- Agent will choose low effort

Fixed Wage Induces Low Effort

- Principal chooses *a* to maximize $0.5 \times 1000 + 0.5 \times 2000 - a$
- Subject to the constraint $a \geq 0$
- The optimal fixed wage is $0
- The expected net profit is $1500
- When effort is unobservable, fixed wage induces low effort

If the Principal Wants High Effort

- Is there a wage scheme that induces high effort? Yes!

- Effort is unobservable, so wage cannot be a function of effort
  - But wage can be a function of profit

- If principal wants high effort, the following wage scheme is optimal
  - Principal pays agent the amount of $\pi - a$
  - Where a is a constant

Selling the Firm to the Agent

- Given the wage scheme $\pi - a$
- Principal retains a and gives remaining profits to Agent
  - i.e., Agent gets all profits after paying a fixed fee to principal
- Principal's net profit is always a
- Effectively, principal sells the firm to agent at the price of a
- What value of a should principal set?

The Agent's Choice

- Suppose agent accepts the offer

- If agent chooses low effort

$$E(\pi - a) - c(e_L) = 0.5 \times 1000 + 0.5 \times 2000 - a = 1500 - a$$

- If agent chooses high effort

$$E(\pi - a) - c(e_H) = 0.5 \times 2000 + 0.5 \times 4000 - a - 20 = 2980 - a$$

- Agent will choose high effort

- For agent to accept the contract, we need $2980 - a \geq 0$

The Principal’s Choice

- Principal wants to maximize a
- He will set $a = 2980$

- His profit (\$2980) is higher than \$1500
  - Principal should indeed seek high effort from agent

- Agent chooses high effort. Her expected wage is

$$E(\pi - a) = 0.5 \times 2000 + 0.5 \times 4000 - 2980 = 20$$

- The first best outcome is achieved

General Results for Risk Neutral Model

- For a P-A model with risk neutral principal and agent, the remarks below hold regardless of the number of possible effort levels

- "Selling the firm to the agent" is an optimal contract
  - The wage paid to the agent is the profit less a fee

- An optimal contract always generates the first best outcome
  - Effort choice, expected payoff for principal, and expected wage for agent are the same as under full information

Other Comments

- If high effort is the first best
  - It cannot be induced by a fixed wage when effort is unobservable
  - Incentive contract that rewards good performance should be used to induce high effort

- Who bears the risk?
  - When effort is observable, agent gets a fixed wage
  - When effort is unobservable, principal gets fixed payment
  - What happen if agent is risk averse?

Risk Neutral Principal, Risk Averse Agent

- If high effort is first best, <u>first best profit no longer attainable</u>
  - Either worthwhile but more costly to induce high effort
  - Or not worthwhile to induce high effort
  - Either way, principal's expected net profit is lower than under full information

  - Agent always get reservation utility

  - Asymmetric information causes welfare loss

Why? (Risk versus Incentive)

- To induce high effort, principal needs to provide incentive to agent
  - Agent’s wage has to be tied to performance (profit)
  - Agent has to bear some risk

- Since agent is risk averse
  - Principal has to compensate agent by offering higher expected wage than under full information
  - Hence lower expected net profit
  - If agent too risk averse, principal is better off paying wage=0 and put up with low effort