

Lecture 13: Asymmetric information

EC 105. Industrial Organization.

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Asymmetric information in markets

- Many markets characterized by *asymmetric information*:
 - firms and consumers are differentially informed.
- Previously, focus on *consumers' information costs* (search)
- Here: focus on types of *verification costs*
 - Difficulties of consumers to verify seller quality
 - Difficulties in verifying that both sides are abiding by contract

Two scenarios of asymmetric information

Adverse selection: individuals have different, but unobserved types. “Hidden information”: information is asymmetric at time of transaction.

- 1 Used cars: only seller knows true quality of car
- 2 Similar in spirit to 2-degree price discrimination (airline pricing)

Moral hazard: individuals can take unobserved actions which affect market outcome. “Hidden action”: information becomes asymmetric *after* transaction.

- 1 Insurance markets: insured people may not take necessary precautions — raises the avg. payment of insurance company and, therefore, average premium
- 2 Labor markets: when employees work in teams where individual effort not observable, each employee has incentive to “free-ride”

Additional examples?

Adverse selection

Example: the used car market

- Two types of used cars: “good” and “bad”, providing utility of u_G and u_B . Proportion p are “bad”.
- In competitive market, with perfect information: $p_B = u_B$, $p_G = u_G$.
- Consider asymmetric information: only seller knows car type, buyer doesn't know.
- “Average” used car in the market yields expected utility $\tilde{u} \equiv (1 - p) * u_G + p * u_B$. Buyer is willing to offer \tilde{u} for any given car; by doing so, break even “on average”.
- At \tilde{u} : only owners of bad cars willing to sell, since $u_b < \tilde{u}$. Owners of good cars stay out of market, since $u_G > \tilde{u}$.
- Outcome: buyer offers u_B , and only bad cars in the market. “Lemons market”. Market outcome “selects” only the bad cars: adverse selection.

Adverse selection: winner's curse in auctions

- Winner is bidder with *most optimistic* information
- most likely to have *overbid* in auction
- Consider the “wallet game”
 - 3 students with amounts ($\$x_1, \$x_2, \$x_3$) in wallets
 - They each submit a bid; winner (highest bid) wins all 3 wallets
 - Consider naive (but sensible) bidding strategy: each student i bids $3x_i$.
 - Winner will be student with largest amount of money in wallet: student i^* who has $x_{i^*} = \max(x_1, x_2, x_3)$.
 - He will pay $3x_{i^*} \geq x_1 + x_2 + x_3$. Always lose money!
- Should “shade bid” relative to information.

Bidding in “second-price auction”

- Second-price auction: winner is highest bidder, she pays *second highest price* (“Vickery auction”)
- Two bidders: $i = 1, 2$
- True value of object V , unobserved by bidders
- Each bidder observes X_i , noisy signal of V
- (V, X_1, X_2) jointly distributed with *positive correlation*.

Equilibrium bidding

- Assume there is a symmetric monotonic differentiable bidding strategy $\bar{b}(X)$. In equilibrium, $b_i = \bar{b}(X_i)$.
- Hence the winning event $b_2 < b_1$ is equivalently $X_2 < X_1 = \bar{b}^{-1}(b_1)$
- Choose bid to maximize expected profit: for bidder 1

$$\begin{aligned} & \max_{b_1} E_{V, b_2} [(V - b_2)) \mathbf{1}(b_1 \geq b_2) | X_1] \\ &= \max_{b_1} E_{V, X_2} [(V - \bar{b}(X_2)) \mathbf{1}(b_1 \geq \bar{b}(X_2)) | X_1] \\ &= \int_{-\infty}^{\bar{b}^{-1}(b_1)} E[(V - \bar{b}(X_2)) | X_1 = x_1, X_2] f(X_2 | X_1) dX_2. \end{aligned}$$

- b_1 enters only through integration bound. Thus FOC is:

$$\left[\frac{\partial \bar{b}^{-1}(b_1)}{\partial b_1} E[(V - \bar{b}(X_2)) | X_1 = x_1, X_2] f(X_2 | X_1) \right]_{X_2 = \bar{b}^{-1}(b_1)} = 0$$

Second-price auction: equilibrium bidding

- Using $\bar{b}(X_1) = b_1$ we have $\bar{b}^{-1}(b_1) = X_1$ so that:

$$E[V|X_1, X_2 = X_1] = \bar{b}(X_1).$$

- Compare this versus “naive” bid: $E[V|X_1]$.
- Conditioning event $\{X_1, X_2 = X_1\}$ is (almost) the event that bidder 1 wins the auction, which would be $\{X_1, X_2 \leq X_1\}$.
- Bidder i bids as if she were to win the auction.
 - This makes sense, as her bid affects her profits only in the event that she wins.
 - Her bid not relevant to profits in the event that she loses.
- Analogously, with N bidders, bidder 1 would bid

$$\bar{b}(X_1) = E[V|X_1, \max_{j \in \{2,3,\dots,N\}} X_j = X_1].$$

By positive correlation assumption, this is *decreasing* in N : the winner's curse becomes worse as the competition increases!

“No trade” in financial markets

Thin financial markets: Asset markets with few traders

- real estate in emerging markets
- thinly traded stocks
- Offer to sell is “bad news”
- Offer to buy is “good news”
- Who will trade in these markets?

Remedies for Adverse selection

- Consider used car market again.
- What is the problem? Buyer can set only one price. How can relaxing this solve the problem?
- Via 2-degree price discrimination. Example: third party certifications
 - Buyer pays different price depending on whether or not a used car is certified (p_C , p_{NC}).
 - Effective if certification is substantially more costly for bad cars (ie. high required repairs for bad cars).
 - So that sellers only go through the hassle of certifying good cars. (Prices p_C , p_{NC} must satisfy self-selection constraints)
 - Certification becomes “signal” of quality
- Furthermore, problem mitigated if buyer/seller differ in intrinsic valuation of used car.
 - Best time to buy used car is at beginning/end of school year.

Cost quality signalling: examples

- 3rd-party certification in labor markets: Ability signaling via education.
 - Only hi-ability individuals willing to spend \$\$\$ on education
 - Explains high cost of MBA degrees?
 - “Burning Money” .
- Price and advertising as signal of product quality
 - Expensive hi-end, brand-name products
 - Status signalling via conspicuous consumption (Veblen)

Moral hazard

Example: incentives of individuals with home insurance to install preventive device.
Main idea: insurance reduces the incentives of policy-holders to take necessary precautions

- Probability of fire with prevention is p , without prevention is p^* , so that $p^* > p$. It costs C to install prevention device.
- Individual decides first whether or not to purchase fire insurance, then decides whether or not to install prevention measures
- Individual has income M . Pays K_1 premium for insurance, loses K_2 in case of fire. W/insurance, individual paid K_2 in case of fire.
- Insurance is “fair”, so that insurance company makes zero expected profit:

$$K_1 - pK_2 = 0 \implies K_1 = pK_2 \quad (1)$$

Assume: insurance company cannot know whether individual takes necessary precautions (“hidden action”)

Moral hazard 2

Individual's payoffs summed up by following matrix, where $U(\cdot)$ is her utility function

Outcome	No fire	Fire
Insurance/No prevention	$U(M - K_1) = U(M - pK_2)$	$U(M - K_1) = U(M - pK_2)$
No insurance/No prevention	$U(M)$	$U(M - K_2)$
Insurance/Prevention	$U(M - pK_2 - C)$	$U(M - pK_2 - C)$
No insurance/Prevention	$U(M - C)$	$U(M - K_2 - C)$

Moral hazard 3

- Insured individuals will install prevention measures if

$$EU(\text{Insur/Prev}) > EU(\text{Insur/No prev}) \quad (2)$$

- For fair premium:

$$\begin{aligned} EU(\text{Insur/Prev}) &= U(M - pK_2 - C) \\ EU(\text{Insur/No prev}) &= U(M - pK_2) \end{aligned} \quad (3)$$

So never take preventive measures.

- Similar outcome as in “lemons market”: insured never take precautions, so that in long run insurance company will not break even if it sets “fair” premium.
- Problem: Perfect insurance makes individual indifferent about whether a fire occurs or not, since she gets same utility whether or not a fire occurs. Strengthen incentives by removing this indifference. One way is to offer only incomplete insurance.

Remedies for Moral hazard

- Offer a deductible $D < K_2$: so that in event of fire, individual only recovers $K_2 - D$. Now:

$$\begin{aligned}EU(\text{Insur/Prev}) &= p * U(M - pK_2 - C - D) + (1 - p) * U(M - pK_2 - C) \\EU(\text{Insur/No prev}) &= p^* * U(M - pK_2 - D) + (1 - p^*) * U(M - pK_2)\end{aligned}\tag{4}$$

- In some cases (depending on shape of $U(\cdot)$, deductible will be enough to make $EU(\text{Insur/Prev}) > EU(\text{Insur/No prev})$, so that insured people also take preventive measures.
- Interpretation: Strengthen incentives by imposing risk on individual (ie. remove indifference between states of the world).

Asymmetric information: traditional vs. internet markets

- Traditional markets have higher search costs
 - Very costly to find out prices at all gasoline stations, restaurants, etc.
 - But verification costs smaller since transactions done in person.
- For internet retailers, search costs are much smaller ...
 - Due to search engines, price comparison websites
- But internet markets have higher quality verification costs
 - Potential buyers and sellers located very far apart
 - Product quality difficult to verify on virtual marketplaces
 - fraud, counterfeits, used products labelled as “new”
- Remedies:
 - Feedback and reputation
 - Penalties on bad reputation incentive “lemons” to improve, or leave market
 - “Escrow” system (Taobao): buyer’s payment held in escrow until product is received and verified.
 - “Amazon is in the insurance business”

Moral hazard in organizations: Principal-Agent problems

3 main ingredients:

- 1 Conflict of interest between *principals* (managers) and *agents* (employees)
- 2 Exchange between principal and agent must be mutually gainful
- 3 Hidden actions (or costly monitoring). Since action is hidden, payment to agent cannot be made contingent on action. Agent then has incentive to “shirk” in his action since payoff doesn't depend on his action.

Example: Deposit insurance and incentives for ill-investments

- For example, in late 1980s in US, S&L industry went bankrupt, and the billions of dollars in losses paid by taxpayers.
- 3-way agency relationship: banks, depositors, govt.
 - ① Depositors vs. govt.: depositors won't monitor banks, since govt. guarantees them their money no matter what they do.
 - ② Depositors vs. banks: depositor ignorance concerning bank investment activity allows banks to invest irresponsibly.
 - ③ Govt. vs. banks: banks have little incentive to make prudent investments due to presence of govt. insurance

Incentive contracts

Incentive contracts are one remedy for moral hazard: works by explicitly tying agent's payoff to an indicator of hidden effort

Incentives provided by increasing the *risk* faced by an agent:

- Risk denotes random fluctuations in payoff stream.
- In presence of overall uncertainty (i.e. if outcome is uncertain even controlling for agent's effort), agent's payoff becomes *riskier*.
- If agent is *risk-averse*, then incentive contract has to guarantee agent a higher expected payoff than non-incentive contract in order for agent to accept the contract.

Incentive contracts: Example w/o risk aversion

We consider this running example:

- Employer is designing an optimal incentive contract for worker.
- Worker has two effort levels: $e = 1$ or $e = 2$
- Worker's effort yields two possible revenue levels, according to the following table:

	$R = 10$	$R = 30$
$e = 1$	2/3	1/3
$e = 2$	1/3	2/3

Note that effort raises the probability of high-revenue outcome, although inherent uncertainty remains.

- Worker's utility fxn: $U(w, e) = w - (e - 1)$.
- Reservation utility is 1.

Incentive contracts: First-best

If effort were observable:

- pay agent w for hi-effort and 0 otherwise
- w must satisfy *participation constraint*:

$$U(w, 2) = w - 1 \geq 1 \iff w \geq 2.$$

- Since principal wants to maximize expected revenue, he will offer the lowest wage which makes the agent willing to work, i.e. offer 2 for hi-effort. Worker gets utility of 1 from the contract.
- Principal's payoff is: $(1/3) * 8 + (2/3) * 28 = (64/3)$
- Total value is: $(64/3) + 1 = (67/3)$

Incentive contract: Residual claimant principle

If effort not observable:

- Previous contract not feasible
- One alternative is to offer a *fixed (flat) wage*, \bar{w} .
- Agents will never exert hi-effort.
- Best that employer can do is to offer $w = 1$, which just keeps lo-effort agent at his reservation utility. Principal's expected payoff is $(2/3) * 9 + (1/3) * 29 = 47/3$.
- But employer can do better by offering contract which depends on output.
 - Now worker's payment depends (partially) on her effort.
 - She has incentive to exert effort to maximize the probability of a high outcome, which yields high salary.
 - **Residual claimant** principle: tie agent's outcome to effort

The optimal incentive contract

- Set outcome-dependent wages w_H and w_L so that worker exerts hi-effort.
- As in adverse selection case, w_H and w_L must satisfy *incentive compatibility* and *participation* constraints:

(IC): (exert hi effort)

$$(1/3) * (w_L - 1) + (2/3) * (w_H - 1) \geq (2/3) * (w_L) + (1/3) * (w_H)$$

(P): $(1/3) * (w_L - 1) + (2/3) * (w_H - 1) \geq 1$

- IC constraint simplifies to $(1/3)w_H - 1 \geq (1/3)w_L$. Constraints intersect at $(w_L = 0, w_H = 3)$.
- Principal's expected payoff: $(1/3) * 10 + (2/3) * 27 = 64/3$. Same as 1-best
- Worker's expected utility: $(1/3) * (0 - 1) + (2/3) * (3 - 1) = 1$.
- Total value is the same as before
 - but employee is less happy?
 - He faces risk: sometimes, thru no fault of hers, she gets punished with negative salary!
 - More complicated if agent is *risk averse*.

Summary: verification costs

- Adverse selection
 - Used car (“lemons”) market
 - Auctions: the “winners curse”
 - No trade theorem in financial markets
- Moral hazard
 - Insurance
 - Incentive employment contracts

Incentive contracts 2: risk aversion

Definition: a utility function $U(x)$ exhibits *risk aversion* if $U(Ex) > EU(x)$.
Agent's utility $U(x) = \sqrt{x}$, where x is payoff. Does this utility fcn exhibit risk aversion?

- Assume good/bad outcome occurs with probs. 0.5, 0.5.
- Consider two contracts with the same expected payoff:
 - A. Pay agent \$10 regardless of outcome
 - B. Pay agent \$0 if bad outcome, \$20 if good (incentive contract)
- Second contract is riskier, since larger variability in payoffs. Agent is risk averse if contract B yields less expected utility than contract A (i.e. $U(Ex) > EU(x)$)
- Utility from contract A: $\sqrt{10} = 3.162$
Utility from contract B: $0.5 * \sqrt{0} + 0.5 * \sqrt{20} = 2.236$
Agent is risk averse.
- Have to pay risk-averse agent higher payoff for good outcome ("risk premium"), in order to convince him to accept contract B.

Risk premium is a cost associated with incentive contracts. But incentive contract has benefits in the presence of moral hazard, as we shall see.

Incentive contracts 3: with risk aversion

We consider this running example:

- Employer is designing an optimal incentive contract for worker.
- Worker has two effort levels: $e = 1$ or $e = 2$
- Worker's effort yields two possible revenue levels, according to the following table:

	$R = 10$	$R = 30$
$e = 1$	$2/3$	$1/3$
$e = 2$	$1/3$	$2/3$

Note that effort raises the probability of high-revenue outcome, although inherent uncertainty remains.

- Worker's utility fn: $U(w, e) = \sqrt{w} - (e - 1)$. Worker is risk-averse with respect to the wage w (i.e. $U(Ew, e) > EU(w, e)$).
- Reservation utility is 1.

Incentive contracts 4: First-best w/RA

If effort were observable:

- pay agent w for hi-effort and 0 otherwise
- w must satisfy *participation constraint*:

$$U(w, 2) = \sqrt{w} - 1 \geq 1 \iff w \geq 4.$$

- Since principal wants to maximize expected revenue, he will offer the lowest wage which makes the agent willing to work, i.e. offer 4 for hi-effort. Worker gets utility of 1 from the contract.
- Principal's payoff is: $(1/3) * 6 + (2/3) * 26 = (58/3)$
- Total value is: $(58/3) + 1 = (61/3)$

The optimal second-best contract under RA

- Set outcome-dependent wages w_H and w_L so that worker exerts hi-effort.
- As in adverse selection case, w_H and w_L must satisfy *incentive compatibility* and *participation* constraints:

(IC): (exert hi effort)

$$(1/3) * (\sqrt{w_L} - 1) + (2/3) * (\sqrt{w_H} - 1) \geq (2/3) * (\sqrt{w_L}) + (1/3) * (\sqrt{w_H})$$

(P): $(1/3) * (\sqrt{w_L} - 1) + (2/3) * (\sqrt{w_H} - 1) \geq 1$

- IC constraint simplifies to $(1/3)\sqrt{w_H} - 1 \geq (1/3)\sqrt{w_L}$. Constraints intersect at $(w_L = 0, w_H = 9)$.
- Principal's expected payoff: $(1/3) * 10 + (2/3) * 21 = 52/3$. Less than under observable effort.
- Worker's expected utility: $(1/3) * (0 - 1) + (2/3) * (\sqrt{9} - 1) = 1$.
- Total value is $(52/3)+1$: less than under observable effort
 - Difference represents "information cost"
 - Leakage from system