

## Lecture 9

### Part 2: Screening and Signaling in Games with Incomplete Information.

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## Lecture Outline

- Screening and signaling incentives arise in games where uncertainty is exogenous and some players are better informed.
- Private information and self-selection or adverse selection.
- Separating versus Pooling.
- Screening versus signaling.
- Insurance markets and screening.
- Adverse selection and the market for lemons.

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## Exogenous Uncertainty and Types

- When uncertainty is "exogenous" (Determined by "nature") and some agents are better informed than others we can think of the informed players with different information as different "types" of agents.
- Example 1: If nature chooses whether an employee is hardworking or soft-working, we have two "types" of agents, Hard and Soft.

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## Exogenous Uncertainty and Types

- Example 2: If the choice of whether a company's product is exogenous, the company knows if it is reliable, average or unreliable, then the company can be a reliable product type, average product type or unreliable product type

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## Exogenous Uncertainty and Types

- Example 3: Suppose that in the population, 30% of the people are at high risk of early death. Suppose also that this higher risk is solely the consequence of having been a teenage smoker but that only people 30 years old or greater buy life insurance.
- Although the decision to smoke as a teenager, might be thought of as endogenous, (though the anti-tobacco regulation disputes this), by the time a client is over 30, whether or not he smoked as a teenager is exogenous.
- From the standpoint of the insurance market, we have two types of clients: teen smokers or non-teen smokers.

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## Exogenous Uncertainty and Types

- In all of these examples, we can imagine two different types of incentives.
- Uninformed players may want to find ways of learning the private information of the informed types:
  - Employers wish to know if the employee is hardworking or not and may pay a different salary depending on her belief.
  - Consumers wish to learn if the product is reliable or not and will be willing to pay a different price depending on her belief.
  - Insurance firms wish to know if the client is high-risk or not and will charge a different premium depending on the belief.

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## Exogenous Uncertainty and Types

- Some informed players may want to find ways of revealing their private information:
  - Since employers are willing to pay a higher salary for hardworking employees, hardworking employees wish to reveal their type
  - Since firms wish to charge higher prices, they will wish to lead consumers to believe they are the reliable type.
  - Since clients prefer lower insurance premia, they will wish to have insurance companies believe they are low risk.

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## Exogenous Uncertainty and Types

- Furthermore, because of equilibrium responses, some types will want to “separate” themselves from other types.
- Notice that we now start thinking about a game with yourself.
- An unreliable firm wishes to mimic the version of itself which is an unreliable firm while the reliable firm wants to separate from the version of itself which is the unreliable firm.
- These various incentives lead to screening and separating devices.

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## Adverse Selection and the Need to Screen: An Example

- Suppose that the auto insurance industry is competitive enough that it makes exactly zero expected profits on its contracts.
- Suppose that 50% of the population are high risk and have a probability of an auto accident of 90% resulting in an insurance payout of \$10K. (All drivers are assumed to drive equally safely.)
- 50% of the population are low risk and have a probability of an accident of 10% resulting in an insurance payout of \$10K.
- Therefore, on average, 50% ( $=.5*90 + .5*10$ ) of the population has a risk of an accident.

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## Adverse Selection and the Need to Screen: An Example

- All drivers start out with wealth of 20K and have expected utility function  $u(x)=x^{.5}$
- Therefore, high risk drivers have expected utility of  $.9*(10000)^{.5} + .1*(20000)^{.5} = 104.1$
- And low risk drivers have expected utility of  $.1*(10000)^{.5} + .9*(20000)^{.5} = 137.3$
- Recall that the economy-wide probability of an accident is .5. What if an insurance company offers to fully insure the drivers for a premium \$5000?
- The company is trying to "pool" the market into one contract. Will it succeed?

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## Adverse Selection and the Need to Screen: An Example

- Note that  $\$5000 = .5 * 10,000 + .5 * 0$  which is the expected cost of taking on the risk economy-wide.
- If high risk drivers buy the insurance, they get expected utility of  $.9 * (20K - 5K)^{.5} + .1 * (20K - 5K)^{.5} = (15K)^{.5} = 122.5 > 104$
- If low risk drivers buy the insurance, they get expected utility of  $.1 * (20K - 5K)^{.5} + .9 * (20K - 5K)^{.5} = (15K)^{.5} = 122.5 < 137.1$

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## Adverse Selection and the Need to Screen: An Example

- Therefore, high-risk drivers will buy but low risk drivers will prefer to take on their own risk.
- What happens to the insurance company profits?
- Since only high-risk drivers "self-select" into the contract, the actual probability of loss is 90%.
- Expected profits are  $5000 - .9 * 10,000 = -4,000$
- If the insurance company ignores this "adverse selection", it will lose money.

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## **Adverse Selection and the Need to Screen: An Example**

- Notice that one thing the insurance company could do is charge a premium of 9,000.
- We can argue that high risk drivers will still buy the contract (why?) and low risk drivers will not (why?)
- This contract will allow the insurance company to exactly break even.

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## **Adverse Selection and the Need to Screen: An Example**

- Although this market will break even, notice that it is inefficient.
- Low risk drivers do not get any insurance even though they are exposed to risk and even though there is a risk neutral insurance company.
- There is an incentive for the insurance company to "screen" for low risk clients.
- There is an incentive for low-risk clients to "signal" they are low risk.

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## Adverse Selection and the Need to Screen: An Example

- How can the company screen?
- It could offer two contracts. One contract offers full insurance at \$9000 premium.
- Another contract offers a premium  $P$  and a deductible  $D$ . If an accident occurs, the insurance firm pays  $10,000-D$ .
- If low risk drivers buy the contract with the deductible, they get expected utility  $.1*(20,000-P-D)^5 + .9*(20,000-P)^5$  that is, they always lose the premium,  $P$  and in the event of the accident, they receive 10K minus a deductible.

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## Adverse Selection and the Need to Screen: An Example

- Zero profits means we need to have  $P = .1*(10,000-D) = 1000 - .1*D$  assuming only low risk drivers buy this contract.
- This means that low risk drivers receive expected utility  $.1*(19,000 - .9*D)^5 + .9*(19,000 + .1D)^5$  if they buy the contract.
- High risk drivers receive expected utility  $.9*(19,000 - .9*D)^5 + .1*(19,000 + .1D)^5$  if they buy the contract.
- At  $D=0$ , the high risk buyers would obviously buy the contract. But for larger values of  $D$ , this contract is too risky compared to the one which gives full insurance (\$11,000 for sure.)

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## Adverse Selection and the Need to Screen: An Example

- The insurance company simply needs to find the value of the deductible,  $D$  which just makes the high risk driver unwilling to accept the riskier contract.
- That is find  $D$  so that  $(11,000)^5 = 104.9 = .9*(19,000 - .9*D)^5 + .1*(19,000 + .1D)^5$
- This is called the self-selection constraint or incentive constraint. Trial and error gives  $D = \$9810.4$
- Using the fact that  $P = .1*(10,000 - D) = 18.96$ , we have that a pair of contracts such that one contract offers full insurance for a premium of \$9,000.

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## Adverse Selection and the Need to Screen: An Example

- The other offers partial insurance for a premium of \$  $18.96$  and pays only  $\$189.6 (= 10,000 - 9810.4)$  in the event of accident.
- The contracts have the feature that each makes zero expected profits.
- Furthermore, they "screen" clients using self-selection. High risk agents voluntarily select the more expensive full insurance contract.
- Low risk agents voluntarily select the cheaper but riskier contract.

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## Adverse Selection and Signaling

- If the insurance industry failed to realize this type of contract portfolio is possible what might happen?
- Notice that offering only the full insurance high risk contract means that the low-risk type are uninsured.
- They have an incentive to “signal” their type to the insurance company by offering to take a cheaper contract.
- As long as the insurance companies recognize that only low-risk types would offer such contracts, they may accept.
- Here low-risk separate from high risk by signaling their type with a deductible.

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## Adverse Selection and Signaling

- Similar stories can be told in a wide variety of cases.
- Dixit and Skeath describe graduate schooling as a screening or signaling device.
- Skilled students find the sacrifice of graduate school less costly than unskilled students.
- Even if graduate schools offered no skills, an employer by offering higher salaries only if a candidate has been to graduate school can use this condition to “screen” skilled from unskilled employees.

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## Signaling and the Difficulty of Hiding Your Type.

- The opportunity to signal may prevent some types from truly hiding their characteristics.
- Suppose students may take a course Pass or Fail, or may take it for letter grade.
- If an A student expects an A, she should signal this by taking it for letter grade (this way she separates herself from the population of D's, C's, B's and A's.)
- But this leaves D's, C's, and B's taking the course for Pass and Fail. And now, B students have an incentive to take the letter grade to separate from the D's, and C's.
- Ultimately, the only people to take it for PF are D students.
- If employers are rational, they will know how to read a PF in this case. D students cannot hide using PF grades.

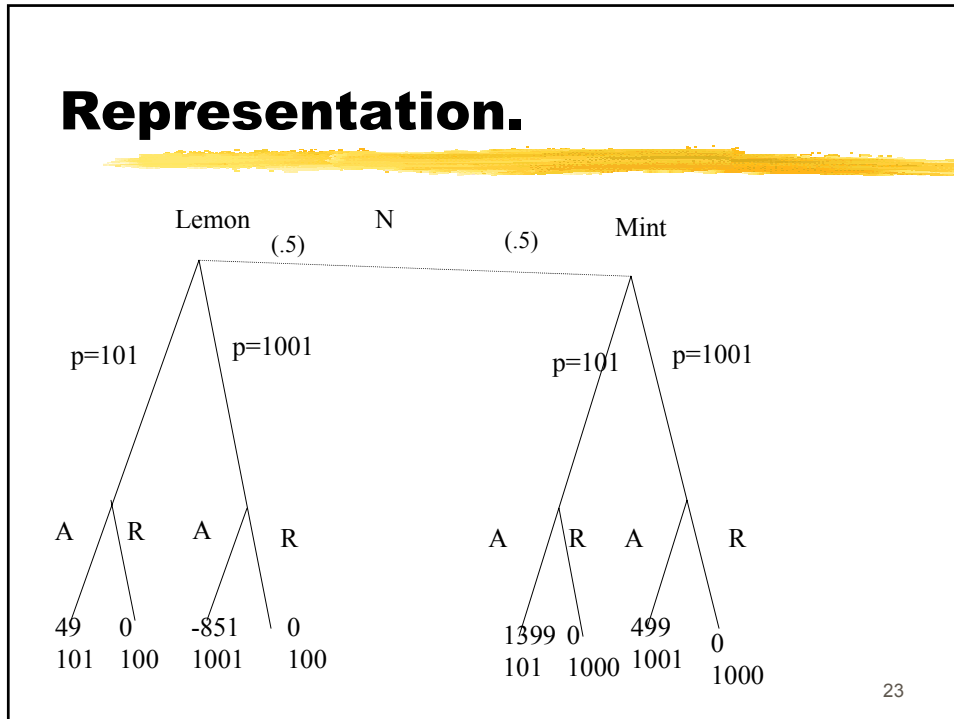
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## Adverse Selection and the Market for Lemons

- Suppose that I wish to buy a used car from an owner.
- The car may be good or bad with equal probability. I know that the owner knows the car quality. (The owner is a "good car type" or a "bad car type").
- Good cars are worth 1000 to the owner and 1500 to me and bad cars are worth 100 to the owner and 150 to me.
- I get to make a take-it-or-leave it offer. If I offer  $100 < p < 1000$ , I know only bad car types accept. So I might as well offer  $p=100$  rather than any price between 100 and 1000.
- Suppose I offer  $p$  between 1000 and 1500. Both types will accept. On average I get a car worth  $.5*150 + .5*1500 = 825 < 1000$ .
- In this case, I always lose money.

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## Representation.



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## Adverse Selection and the Market for Lemons

- The only outcome is that I offer  $p=100$  and only bad car owners ever sell.
- Bad cars drive good car owners out of the market.
- Is this why the resale price of even slightly used cars is so low?
- The problem is that there is no credible screening/signaling device.
- Suppose the car owner offered a warranty?
- Suppose the car owner rejected my offer and said she would drive the car herself for another five months and then let me decide?
- Will these work as credible signaling devices?
- We need to construct the self-selection constraint to see if bad car owners will be tempted to mimic good car owners.

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