Mikro II, lecture 4a

Asymmetric Information: Adverse selection, signaling and screening

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Plan for the lecture

1. The classic model for asymmetric information exemplified with used cars
2. A more extreme version of the model motivated by the insurance market
3. Nechyba's graphical model for asymmetric information (section A)
4. Screening and signaling in Nechyba's model (section A)

   (Read about the model yourselves in Nechyba's section B; there will be a lot of the same points as in Birgitte Sloth's notes)

The market for lemons

- We start with the most classic example of asymmetric information:
- George Akerlof (nobel prize 2001): "The Market for Lemons"
- Note: In American you use the term “lemon” for a bad car (or good more generally) you have (accidentally) come to buy
- Akerlof’s model is about a used car market

The model

- In a particular used car market, there are N potential sellers with one car each and $K > N$ potential buyers without cars; everyone also has an income I

- The cars are of different quality: half are of high quality h and the other half is low quality l (lemons)

- Sellers and buyers have different utility functions which depend on the car quality, that is whether quality $q = 0$, l or h and how much other consumption c they have:

$$u_S(q,c) = \begin{cases} c & \text{if} \quad q = 0 \\ 1000 + c & \text{if} \quad q = l \\ 2000 + c & \text{if} \quad q = h \end{cases} \qquad u_K(q,c) = \begin{cases} c & \text{if} \quad q = 0 \\ 1200 + c & \text{if} \quad q = l \\ 2400 + c & \text{if} \quad q = h \end{cases}$$

Interpretation and efficiency

- Seller's utility in DKK is 1000 for a bad car and 2000 for a good car
- Buyer's utility is higher: 1200 for a bad car, 2400 for a good car
- Obviously there are many (N) potential good trades
- Socially efficient if everyone trades (the buyer likes the car more than the seller)

Complete information

- We are interested in finding market equilibria under different assumptions regarding who knows what about the cars

- We start with complete information: Everyone can immediately determine if a car is good $\Rightarrow$ price depends on quality $\Rightarrow$ two prices in the market: p_h and p_l

- How is trading in practice? We assume:
  1. All sellers in the market meet a random buyer
  2. The seller and buyer must then decide whether they want to say yes to a trade given the relevant market price p_h^* or p_l^*
  3. If both agree they trade, otherwise no trading will happen

Buyer's decision, a good car

- Start by looking at a buyer who meets a seller with a high-quality car and takes the price p_h^* as given

- Discrete utility maximization: Choice variable is s, where $s = 1$ means that the buyer agrees to trade and $s = 0$ means that the buyer does not agree

$$\max_{s \in \{0,1\}} \; s \cdot u_K(h, I - p_h^*) + (1 - s) \cdot u_K(0, I)$$

- Easy solution: Agree to trade if the utility from trading is greater than the utility from not trading

$$u_K(h, I - p_h^*) \geq u_K(0, I) \quad \Longleftrightarrow$$
$$2400 + I - p_h^* \geq I \quad \Longleftrightarrow$$
$$2400 \geq p_h^*$$

Seller's decision, a good car

- Discrete utility maximization: Choice variable is s, where $s = 1$ means that the seller agrees to trade and $s = 0$ means that the seller does not agree

$$\max_{s \in \{0,1\}} \; s \cdot u_S(0, I + p_h^*) + (1 - s) \cdot u_S(h, I)$$

- Easy solution: Agree to trade if the utility from trading is greater than the utility from not trading

$$\begin{aligned} u_S(0, I + p_h^*) &\geq u_S(h, I) \quad \Longleftrightarrow \\ I + p_h^* &\geq 2000 + I \quad \Longleftrightarrow \\ p_h^* &\geq 2000 \end{aligned}$$

Bad cars

- The same calculations for bad cars result in the buyer agreeing to buy a bad car if $p_l^* \leq 1200$ and seller agreeing to sell a bad car if $p_l^* \geq 1000$
- Note: Here we have been very thorough and expressed the utility function mathematically
  - We could instead have reached the same conclusions if we had put forth some simple assumptions about "willingness to pay for the good car is..."

Equilibrium I

- Back to the equilibrium for used cars:
  - High quality cars: Buyers agrees if $p_h^* \leq 2400$, seller if $p_h^* \geq 2000$
  - Low quality cars: Buyer agrees if $p_l^* \leq 1200$, seller if $p_l^* \geq 1000$

- Any set of prices where $1000 \leq p_l^* \leq 1200$ and $2000 \leq p_h^* \leq 2400$ is an equilibrium where all good and bad cars are traded

- We have assumed that there are more buyers than sellers, so most reasonable to assume that in practice we end up with the highest price (the seller can always threaten to go to another potential buyer who has not found a seller to trade with)

- Conclusion: All cars are traded at $p_l^* = 1200$ or $p_h^* = 2400$; efficient!

Symmetric imperfect information

- Now imperfect but symmetric information: No one can see the difference between good and bad cars (but everyone knows that half of all cars are good)

- If all cars look the same then there can only be a single market price, p^*:
  1. All sellers in the market meet a random buyer
  2. The seller and the buyer must then decide whether to accept a trade given market price p^*
  3. If both say yes they trade, otherwise no trading will happen

- When the buyer and seller evaluate the deal they only know the probability that the car is of high quality: decision under uncertainty

Buyer's decision, uncertainty I

- Buyer knows that the probability of the car being good is $\frac{1}{2}$; must choose between trading and not trading
- Decision under uncertainty: Maximize expected utility (u_K is Bernoulli utility)
- Expected utility from buying the car:

$$\frac{1}{2}u_K(h, I-p^*) + \frac{1}{2}u_K(l, I-p^*) = \left(\frac{1}{2}\cdot 2400 + \frac{1}{2}\cdot 1200\right) + I - p^* = 1800 + I - p^*$$

- Maximization problem:

$$\max_{s\in\{0,1\}} s\cdot\left(\frac{1}{2}u_K(h, I-p^*) + \frac{1}{2}u_K(l, I-p^*)\right) + (1-s)\cdot u_K(0, I)$$

Buyer's decision, uncertainty II

- As before: optimal to say yes if the expected utility from buying is at least as high as otherwise:

$$\frac{1}{2}u_K(h, I - p^*) + \frac{1}{2}u_K(l, I - p^*) \geq u_K(0, I) \iff 1800 \geq p^*$$

- Again quite obvious: Expected value (willingness to pay) is $\frac{1}{2} \cdot 2400 + \frac{1}{2}1200 = 1800$

Seller's decision, uncertainty

- Same argument for seller (who also doesn't know the quality)
- Maximize expected utility (u_S Bernoulli utility):

$$\max_{s\in\{0,1\}} \; s\cdot u_S(0,I+p^*)+(1-s)\cdot\left(\frac{1}{2}u_S(h,I)+\frac{1}{2}u_S(0,I)\right)$$

- Willing to sell if:

$$\frac{1}{2}u_S(h,I)+\frac{1}{2}u_S(l,I)\leq u_S(0,I+p^*) \iff p^*\geq 1500$$

Equilibrium II

- Sellers say yes if $p^* \geq 1500$, buyer if $p^* \leq 1800$
- Any price $1500 \leq p^* \leq 1800$ is an equilibrium where all cars are traded
- As before, it is most reasonable to assume that in practice we end up with the highest price (the seller can always threaten to go to another buyer who "is in surplus")
- Conclusion: All cars are traded at $p^* = 1800$; efficient!

Socrative quiz question

True or false: If the fraction of bad cars increases, the equilibrium price of cars decreases.

Asymmetric information

- Finally, the realistic situation of asymmetric information: Seller knows the quality of his or her own car, the buyer can find out about the quality only after the trade has happened ("experience good")

- All cars look the same to the buyer, so there can still only be one market price here, p^* (note: if good cars are traded at a higher price, everyone would argue that their car was good, more later):
  1. All sellers in the market meet a random buyer
  2. The seller and the buyer must then decide whether to accept a trade given the market price p^*,
  3. If both agree they will trade, otherwise no trading will happen

- Important: When the buyer and seller assess the deal, the seller knows the car's quality, while the buyer does not know the quality

Buyer's decision, asymmetric information

- The buyer does not know the quality of the car, but must assess the expected utility
- If all cars are traded then the likelihood that the car is good equals $\frac{1}{2}$
- In that case, we can completely re-use our analysis from before
- The buyer agrees if $p^* \leq 1800$

Seller's decision, asymmetric information

- The seller now knows the quality of the car
- We can re-use our analysis from the "complete" information scenario:
  - Sellers with good cars agree if $p^* \geq 2000$
  - Sellers with bad cars agree if $p^* \geq 1000$

Equilibrium?

- The buyer will pay a maximum of 1800
- At that price, sellers with good cars will not agree to sell!
- Sellers of bad cars are willing to sell so only bad cars will be traded
- Is it an equilibrium that only the bad cars are traded at $p^* = 1800$?

Equilibrium

- Not a realistic equilibrium! When we derived the willingness to pay for buyers we assumed that half of the *traded* cars were good
- If the sellers only say yes to selling the bad cars, the buyers actually lose money on each trade $(1800 > 1200)$
- In equilibrium, no one should make systematic errors in this way (see Micro III, later)
- Instead: If only bad cars are traded, the buyer will pay a maximum of 1200 $\longrightarrow$ the equilibrium price is $p^* = 1200$ (more generally $1000 \leq p^* \leq 1200$)

Inefficiency

- With asymmetric information, only the bad cars are traded; inefficient!
- Asymmetric information destroys the market for good cars and creates inefficiency:
  1. Sellers with good cars cannot prove to the buyer that the car is good
  2. Thus, the buyer knows that the car can be bad and will not pay as much for it
  3. At the lower price, it may be better for sellers to keep the good car (even if the car is worth more to the buyer)

Socrative quiz question

Could we also think of the used-car market as a Principal Agent model? If yes, who would be the Principal? Who would be the Agent?

- a) Not possible to analyze this in the context of a P-A model.
- b) Yes, the seller would be the Principal and the buyer would be the Agent.
- c) Yes, the buyer would be the Principal and the seller would be the Agent.

Asymmetric information in practice

- Asymmetric information (buyer / seller knows more) leading to adverse selection is relevant in many cases:
  - Markets for used goods (for other goods than cars)
  - Health (treatments / medicines)

- Another place where adverse selection is very important is insurance (and financial markets):

  Those who buy insurance (or borrow money for a project) often know more about the risk than those who sell the insurance (or lend money)

A bad insurance example

- A very large number of consumers are considering buying insurance for breaking the leg:
  - They have an income of I kr regardless if they break the leg, but lose 1 kr if they break the leg
  - The insurance covers (pays) 1 kr if the leg breaks (full insurance) and costs y kr
- Consumers have different probabilities of breaking their leg p: distributed as uniform variable between 0 and 1:
  - Every consumer has a certain probability of breaking her leg, p, as they know themselves (different behavior: ski, motorcycle, $\ldots$)
  - The composition of consumers is such that p is a random variable that is uniformly distributed.

Expected utility

- Consumers' (Bernoulli) benefits are just equal to their consumption ($u(c) = c$) so a consumer with probability p with no insurance has an expected utility of

$$p \cdot (I - 1) + (1 - p) \cdot I = I - p$$

- With insurance (price y) the expected utility is:

$$p \cdot (I - 1 + 1) + (1 - p) \cdot I - y = I - y$$

- A consumer at risk p is willing to pay $y = p$ for insurance

  (NB the model here is a bit simple: for simplicity we assume implicitly risk neutrality so why buy insurance? Can be "fixed" by setting: $u(c) = c^{\gamma}$ with $0 < \gamma < 1$)

Supply of insurance

- An insurance company offers insurance in the market; They do not know consumers' individual leg risk so they have to offer insurance at a common price y

- If q consumers buy, the price is y and the average leg risk among the buyers is $\bar{p}$, and the insurer's expected profit becomes

$$qy - q\bar{p} \cdot 1$$

- The insurance company will offer insurance if profits are positive:

$$qy - q\bar{p} \cdot 1 \geq 0 \iff y \geq \bar{p}$$

The markets unravels I

- Let's look at what the equilibrium in this market could be; First, let's assume everyone buys insurance. Can this be an equilibrium?
  - If everyone buys, the average risk among the buyers is $\bar{p} = \frac{1}{2}$
  - In that case, the insurance company will set a price of at least $y = \bar{p} = \frac{1}{2}$
  - At this price, it will only be the most risky half of the consumers (with $p \geq y = \frac{1}{2}$) who buys.
  - In that case, the insurance company will have to set a price of least $y = \bar{p} = \frac{3}{4}$
  - But at that price only the most risky quarter ($p \geq y = \frac{3}{4}$) will buy which means that $\bar{p} = \frac{7}{8}$

    ...
  - The insurance company sets the price $y = 1$ and no one will buy.

The markets unravels II

- In this setup things become even worse than in our car example: the asymmetric information completely shuts down the market

- The problem here is that the seller can't tell the difference between how expensive it will be to insure different consumers ...

- ... and the higher the price offered, the "worse" is the composition of those who buy; example of *adverse selection*

  (the fact that the car market did not completely break down before but the insurance market does is due to our assumptions about the unobservable variable, which is discrete (50-50 good / bad) or continuous (uniform between 0 and 1), respectively)

Policy solutions

- Asymmetric information in the form of adverse selection can create inefficiency and can actually shut down entire markets (e.g. for insurance)

- Can the policymaker / agents do anything to counteract this? Yes! More later when we take a look at Nechyba's model for asymmetric information

- But note the quick fix if you want to get the "market up and running": force everyone to join!
  - Let the government provide the insurance: unemployment insurance (unemployment insurance), public health care (health insurance)
  - Or make insurance compulsory: car insurance, health insurance in the United States (individual mandate in ObamaCare)
  - These changes do not necessarily improve efficiency but they can

Nechyba's graphical insurance model

- Two equal groups of consumers are considering buying insurance: high-risk (1) and low-risk (2), they always know their own risk type

- Same willingness to pay within both groups: two demand functions decreasing in price p, i.e. $x_1(p) = x_2(p)$

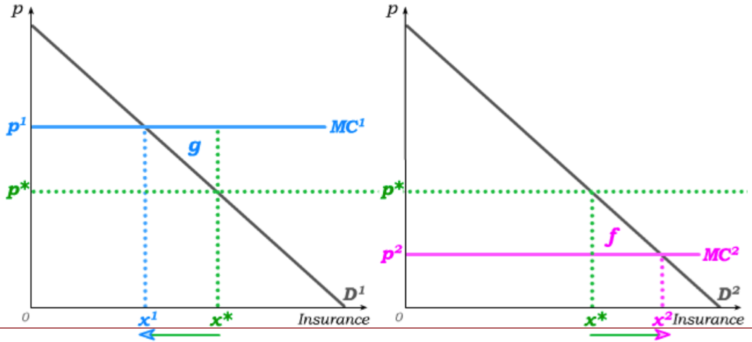
- Insurance company sells (produces) insurance to the two groups with different constant marginal costs ($MC_1 > MC_2$)

- Interpretation (as before):
  Marginal cost = probability of damage · disbursement in case of damage

Perfect information

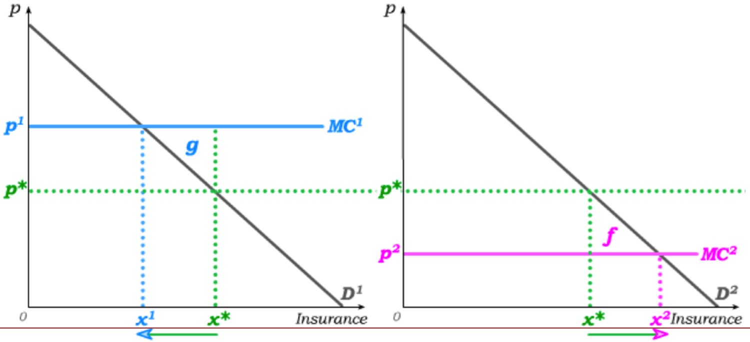
- First look at the situation where the insurance company knows about the type of each potential buyer and thus offers different insurance to each type

- I.e. there are two markets with perfectly elastic supply; equilibrium: higher cost and less insurance for the high-risk types ($p^1 > p^2$ and $x^1 < x^2$)

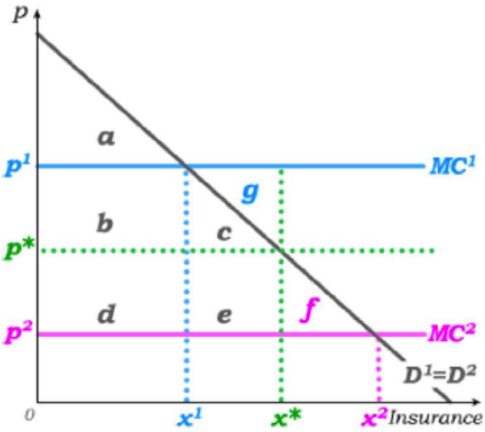


Asymmetric information

- If the insurance company does not know the consumers' types then it can only offer a fixed price p^*
- Identical demand curves in the two groups and the groups are equal in size; MC in the overall market equals $\frac{1}{2}MC_1 + \frac{1}{2}MC_2$ so again perfectly elastic supply



Effect of asymmetric information I



- Perfect info:
  - Consumer surplus 1: $\mathfrak{a}$
  - Consumer surplus 2: $\mathfrak{a}+\mathfrak{b}+\mathfrak{c}+\mathfrak{d}+\mathfrak{e}+\mathfrak{f}$
- Asym. info:
  - Consumer surplus 1: $\mathfrak{a}+\mathfrak{b}+\mathfrak{c}$
  - Consumer surplus 2: $\mathfrak{a}+\mathfrak{b}+\mathfrak{c}$
  - Producer surplus from consumers 1: $-\mathfrak{b}-\mathfrak{c}-\mathfrak{g}$
  - Producer surplus from consumers 2: $\mathfrak{d}+\mathfrak{e}$
- Deadweight loss: $\mathfrak{g}+\mathfrak{f}$ (over/under-insurance; note $\mathfrak{b}=\mathfrak{d}$ and $\mathfrak{c}+\mathfrak{g}=\mathfrak{e}$)

Effect of asymmetric information II

- Asymmetric information pushes the price for the low-risk group up and the price for the high-risk group down

- This leads to redistribution of consumer surplus ...

- ... and to over-insurance of the high-risk group plus under-insurance of the low-risk group

- Both together cause a deadweight loss (inefficiency)

Socrative quiz question

True or false: If demand for insurance becomes more elastic, the deadweight loss from the asymmetric information increases.

Fixing asymmetric information

- With asymmetric info the agents will often have an incentive to try to do something about the information situation:
  - In the car market from earlier, sellers with good cars, for example, will want to convince buyers that the car they offer is good
  - In Nechyba's model, the low-risk group prefers a scenario with more information

- It turns out that the insurance company in Nechyba's model also has an incentive to do something:
  - Nechyba: Constant MC $\Rightarrow$ Perfectly elastic supply $\Rightarrow$ Always zero profit
  - However, we can still think about the company's incentives by thinking about whether another company could enter the market and "do something" that pushed the original company out (negative profit)

Screening I

- Suppose insurance companies can choose to screen consumers and thus identify their true risk free of charge

- If a new insurance company enters the market and screens:
  - It can choose to offer insurance for the two groups at prices as in the perfect info. case (p^1, p^2)
  - All low-risk customers will thus leave the existing company $(p^2 < p^*)$
  - The existing company now gets a negative profit at p^* (they only have high-risk customers)

Screening II

- If companies can screen free of charge then they will have an incentive to do so
- This allows us to restore efficiency.
- In practice, perfect and costless screening is unrealistic, but imperfect screening is empirically relevant:
  - Offer insurance through unions
  - Car insurance that depends on age and / or fall in price over time
  - Can also provide incentives for *statistical discrimination* against certain groups (Cheaper car insurance for women?)

Screening with costs I

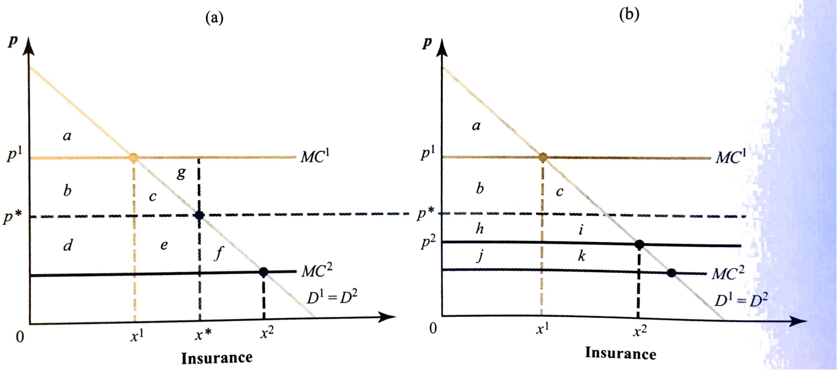
- Now imagine that screening is costly.
- The insurance company can begin to screen all customers, thus moving the market into a separating equilibrium ...
- ... but it will cost something. At the same prices from before (p^1, p^2), the company will have a negative profit if they screen
- The company must set the price to maintain non-negative profits if they screen

Screening with costs II

- Note, however, that the company cannot set the price for high-risk customers due to potential competition:
  - If the company is screening and demanding more than p^1 from the high-risk group ...
  - ... then a new company can enter the market, refuse to screen and sell insurance at p^1 ...
  - ... and thus steal all high-risk customers
- The entire additional cost of the screening must therefore be passed on to the low risk group

Screening with costs III

- Screening offsets the deadweight loss from over-/under-insurance, but introduces a new loss due to screening costs (j+k); overall, DWL can go up or down depending on the size of the cost



Socrative quiz question

True or false: If the marginal cost of screening is equal to $\beta = p^* - MC^2$, then the separating equilibrium will produce higher welfare than the pooling equilibrium.

Signaling

- We can also imagine that the agents have an incentive to *signal* their type to the company

- Note: In any separating equilibrium, the company will offer the lowest price to the low risk group so the incentive is always to signal that you are low risk

- We will assume that signaling may (perhaps) cost the agents something:
  - It costs a low risk agent δ to signal that they are low risk
  - It costs a high risk agent γ to signal that they are low risk (lying!)

Signaling, interpretation

- Low risk is women; signaling consists of showing your passport: $\delta = 0$, $\gamma = \infty$ (or the price of a fake passport)
- Low risk are skilled drivers; signaling consists of explaining that one is proficient: $\gamma = \delta = 0$
- Low risk are skilled drivers; signaling consists of passing a difficult driving test which takes a long time: $\gamma > \delta > 0$
- Low risk are skilled drivers; signaling consists of participating in a course that takes a long time: $\gamma = \delta > 0$

Signaling in action I

- Assume (so far) that the insurance company always believes in the signals; then those who signal will be offered $p^2 = MC_2$, while others will be offered $p^1 = MC_1$ (Note: Slightly different from Nechyba here)

- Low risk consumers will choose to signal if $MC_1 - MC_2 \geq \delta$; high risk consumers will signal if $MC_1 - MC_2 \geq \gamma$

- Quick conclusion: if you can't lie and signaling is free ($\delta = 0$, $\gamma = \infty$) then only low risk will signal

- In that case, it will be an equilibrium that the insurer believes in the signals and we end up in the same efficient allocation as in perfect information; signaling can work!

Signaling in action II

- Another interesting conclusion: If it costs both types the same to signal $\delta = \gamma$ then either everyone will signal or no one will signal

- In either case, the signal cannot separate the two types; important point here: Signaling can *only* work if it is more expensive for the high-risk types to signal

- Finally, we can investigate what exactly needs to apply before signaling can lead to a separating equilibrium:
  - $MC_1 - MC_2 \geq \delta$ makes low-risk consumers willing to signal
  - $MC_1 - MC_2 \leq \gamma$ makes high-risk consumers unwilling to signal
  - If the above applies we end up in a separating equilibrium, but there will be a deadweight loss due to signaling costs (as with screening)

An unfortunate signaling equilibrium I

- Finally, we should note that we may end up in a very unfortunate pooling equilibrium with signaling
- If the cost of signaling is small enough for both types then both may choose to signal
- If both types signal, the company will offer the pooling equilibrium price p^* to everyone
- But it may still pay for both types to signal because the company will offer the high separating price $p^1 > p^*$ to all those who do not signal

An unfortunate signaling equilibrium II

- Thus, in such an unfortunate signaling equilibrium, all consumers choose to signal to avoid being labeled as high risk, but all end up being offered the same price

- This equilibrium is strictly worse than the pooling equilibrium without signaling because signaling is costly

- Note, however, a technical point:
  - The unfortunate equilibrium depends very much on what the company chooses to believe about a consumer who does not signal

What have we learned?

- Asymmetric information in the form of adverse selection can unravel (partially) a market and create inefficiency
- Use simple models with asymmetric information
- Examples of models with uncertainty, discrete utility maximization and multiple types of consumers
- How asymmetric information about agents' type provides screening and signaling incentives
- How the inefficiency from asymmetric information can be solved by screening and signaling