14.03/003 Microeconomic Theory & Public Policy, Fall 2022

Lecture 20. Private Information and Adverse Selection

David Autor (Prof), MIT Economics and NBER

Jonathan Cohen (TA), MIT Economics

Motivation: A Wal-Mart Story

NYT, October 29, 2005:

"The Wal-Mart work force reflects a growing fear of many employers that the people who work for them are increasingly at risk for health problems [...] The prevalence of [diabetes and heart disease] among Wal-Mart employees is increasing much faster than the national average [...]"

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"A risk that a company like Wal-Mart faces, especially when it competes with smaller retailers that offer no insurance at all, Ms. Rowland said, is attracting too many workers who want the job primarily for the health coverage."

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The memo suggests that the company could require all jobs to include some component of physical activity, like making cashiers gather shopping carts. It also recommends redesigning and expanding benefits to appeal to a different type of worker, someone more interested in buying a home, say, than in getting health insurance. These moves would also dissuade unhealthy people from coming to work at Wal-Mart, the memo said."

The Economics of Information:

What Makes Information Different from Other Goods?

Private Information

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5. This last property naturally gives rise to strategic behavior: concealment, selective revelation, elicitation mechanisms

Example I of III:
A Market for Lemons

Private Information

- Where there is **private information**, there is an incentive for agents to engage in strategic behavior.
- If you're selling a product, and your buyer knows the distribution of product quality but not the quality of the individual product that you possess, how much should the buyer be willing to pay?
- Intuitive answer: the **expected value** of the product, or perhaps the certainty equivalent of this lottery
- But this answer ignores that the choice of what product you sell may depend on what price the buyer offers. And the price that the buyer offers may depend on what product she thinks you'll sell at that price

Adverse Selection: The Market for Lemons

1. When owners/sellers of goods know more about their goods' quality than do buyers, there is asymmetric information, and agents engage in strategic behavior.
2. This creates the potential for **adverse selection**: the market attracts the worse kind of sellers.
3. Adverse selection can lead to market failure: there may be *no trade* for a given good, although:
   - At any given price p_0, there are sellers with valuations below that price.
   - At price p_0, there are buyers with valuations above p_0.

Adverse Selection: The Market for Lemons

George Akerlof (1970) was the first economist to analyze this paradox rigorously. His paper was nominally about the market for used cars

- It has always been common wisdom that it is a bad idea to buy used cars. But why should this be true?
- If used cars are just like new cars only a few years older, why should someone else's used car be any more problematic than *your* new car after it ages a few years?

Stylized example: Part 1. New car benchmark

- There are 2 types of *new* cars: good cars and lemons, which break down often
- Dealers do not distinguish (perhaps by law) between good cars versus lemons; they sell what's on the lot at the sticker price.
- Buyers cannot tell good cars and lemons apart based on a test drive. But they know that some fraction $\lambda \in [0, 1]$ of cars are lemons.
- Assume that good cars are worth $B_N^G = \$2,000$ to buyers and lemons are worth $B_N^L = \$1,000$ to buyers.
- Assume that cars do not deteriorate and that buyers are risk neutral

Stylized example: Part 1. New car benchmark

Market clearing in the new car market

- Assume that good cars are worth $B_N^G = \$2,000$ to buyers
- Lemons are worth $B_N^L = \$1,000$ to buyers.
- Cars do not deteriorate
- Buyers are risk neutral
- **Question:** What is the equilibrium price in the *new car* market?

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- Lemons are worth $B_N^L = \$1,000$ to buyers.
- Cars do not deteriorate
- Buyers are risk neutral
- **Question:** What is the equilibrium price in the *new car* market?

$$P_N = (1 - \lambda) \cdot 2,000 + \lambda \cdot 1,000.$$

- Since dealers sell *all* new cars at the same price, buyers are willing to pay the *expected value* of a new car

Stylized example: Part 2. Used car sellers

Next, consider the used car market

- Assume that used car sellers know the quality of their car, and are willing to part with their cars at 20 percent below their new value:

$$S_U^G = \$1,600 \text{ and } S_U^L = \$800.$$

- Since cars don't deteriorate, used car buyers will be willing to pay $B_U^G = \$2,000$ and $B_U^L = \$1,000$ respectively for used good cars and lemons
- Notice: there is a surplus of $\$400$ or $\$200$ — *a gain from trade* — from each sale
- **Question**: What will be the equilibrium price of used cars?

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- Notice: there is a surplus of $\$400$ or $\$200$ — *a gain from trade* — from each sale
- **Question**: What will be the equilibrium price of used cars?
- **One intuitive answer** is

$$P_U = E\left[S_U\right] = (1-\lambda)\cdot 1,600 + \lambda \cdot 800.$$

- But this is *not necessarily* correct

Stylized example: Part 2. Used car buyers

What are used car buyers willing to pay?

- Recall that buyers **cannot distinguish good cars from lemons**
- Sellers know which is which
- Reservation selling prices $S_U^L = 800$, $S_U^G = 1,600$
- For $P_U \geq 800$ owners of lemons will gladly sell their cars
- However, for $P_U < 1,600$, owners of good cars will keep their cars

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- For $P_U \geq 800$ owners of lemons will gladly sell their cars
- However, for $P_U < 1,600$, owners of good cars will keep their cars
- **Implication: the quality of cars available depends on the price**

Stylized example: Part 2. What should buyers expect?

The quality of cars for sale depends on the price

- The share of lemons is:

$$\Pr(\text{Lemon}|P_U) = \begin{cases} 1 & \text{if } P_U < 1,600 \\ \lambda & \text{if } P_U \geq 1,600 \end{cases}$$

- The expected reservation selling price reflects the price offered

$$E[S_U|P_U] = \begin{cases} 800 & \text{if } P_U < 1,600 \\ 800 \cdot \lambda + (1-\lambda) \cdot 1,600 & \text{if } P_U \geq 1,600 \end{cases}$$

Stylized example: Part 2. Seeking equilibrium

What is the equilibrium in this market?

- Write buyers' willingness to pay for a used car as B_U
- B_U depends on the quality of cars — a function of the expected reservation selling price

$$B_U = 1.25 \times (E[S_U|P_U])$$

- For trade to occur, buyers' willingness to pay must satisfy

$$B_U\left(E[S_U|P_U]\right) \geq P_U$$

- The value to buyers of cars for sale as a function of price is:

$$B_U\left(E[S_U|P_U]\right) = \begin{cases} 1,000 & \text{if } P_U < 1,600 \\ 1,000 \cdot \lambda + (1-\lambda) \cdot 2,000 & \text{if } P_U \geq 1,600 \end{cases}$$

- *Buyers' willingness to pay for used cars depends upon the market price*

Nash Equilibrium

- Here, the notion of equilibrium is strategic
- We think of parties on the different sides of the market (e.g., buyers v. sellers) as choosing strategies (feasible actions) that maximize their payoffs given the chosen strategies of the players on the other side of the market.
- But of course, the players on the other side of the market are likewise choosing strategies to maximize their payoffs given the actions (or anticipated actions) of the other players.
- An equilibrium in this setting is a set of complementary strategies such that neither side wants to unilaterally change its strategy given the strategy of the other side.

Nash Equilibrium

- This notion is what is called a Nash Equilibrium after John Forbes Nash, who developed the idea and proved its existence in a 28 page 1950 Princeton doctoral dissertation, which eventually won him the Nobel prize in Economics in 1994.

Nash Equilibrium

- An **informal definition** of the Nash Equilibrium:
  1. Suppose n players meet in a room and an each player claims she will play according to some strategy.
  2. If, when they leave the room, each player is better off *not* changing her plans assuming others will do what they said they'll do, we have a Nash equilibrium.

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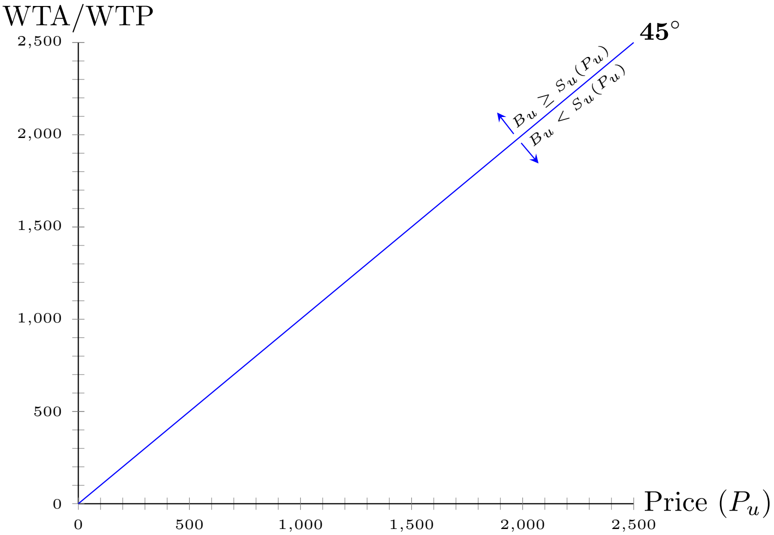
- **Another definition** (Wikipedia)
  - If each player in a game has chosen a strategy — an action plan based on what has happened so far in the game — and no one can increase one's own expected payoff by changing one's strategy while the other players keep theirs unchanged, then the current set of strategy choices constitutes a Nash equilibrium.

Figure 1 : Potential Nash Equilibria of Used Car Market with $\lambda = 0.3$



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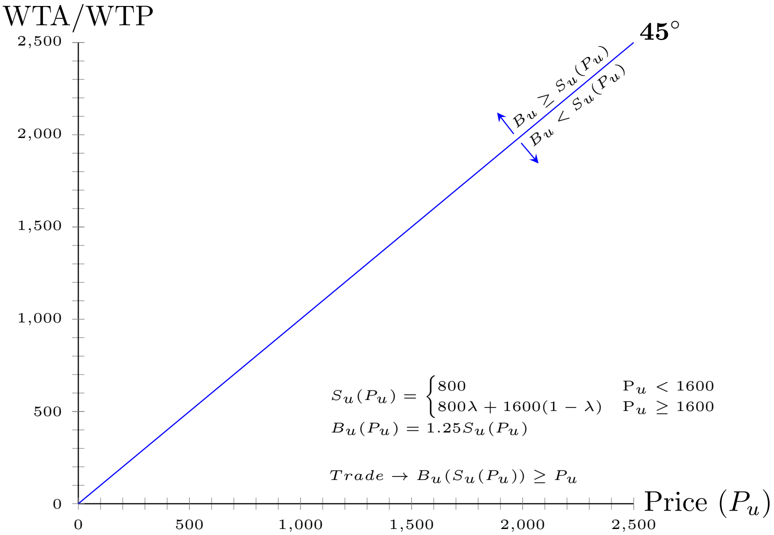

Stylized example: Part 3. Equilibrium with all cars trading

Is there trade in equilibrium?

- Assume $\lambda = 0.3$.
- Consider the price $P_U = 1,600$
- Will both good used cars and lemons sell?

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Is there trade in equilibrium?

- Assume $\lambda = 0.3$.
- Consider the price $P_U = 1,600$
- Will both good used cars and lemons sell?
- At this price, the expected value (to a buyer) of a randomly chosen used car would be

$$B_U\left(P_U = 1,600, \lambda = 0.3\right) = (1 - 0.3) \cdot 2000 + 0.3 \cdot 1000 = 1,700.$$

- Used *good* cars sell at \$100 above the average price at which potential sellers value them
- **Owners of good cars are receive a \$100 surplus, owners of lemons get a** $\$900$ **surplus**
- This equation therefore satisfies

$$B_U\left(E[S_U|P_U]\right) \geq P_U$$

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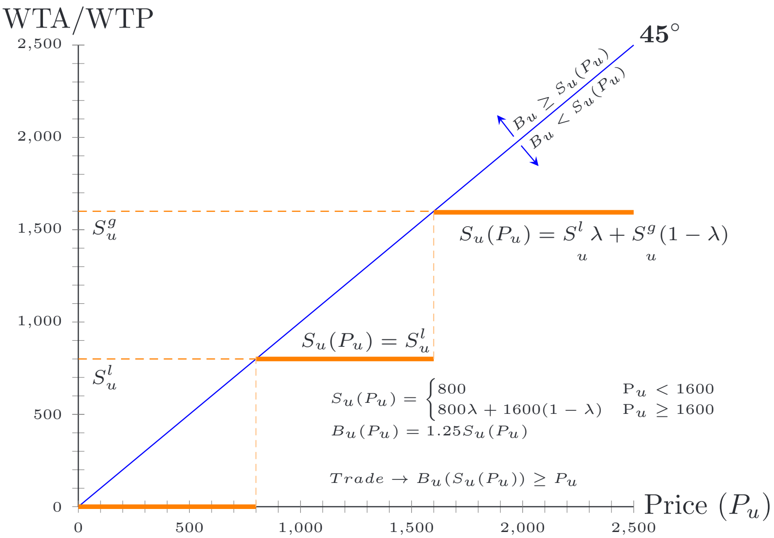

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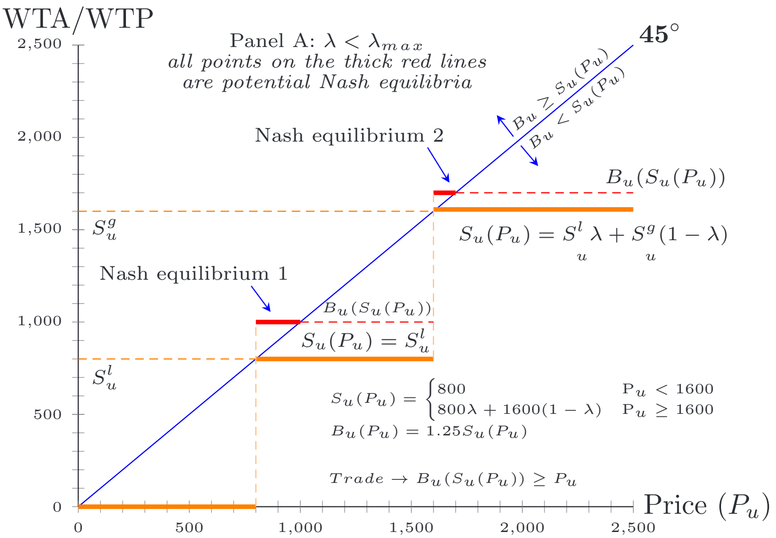

Stylized example: Part 4. Market unraveling

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- Assume instead that $\lambda = 0.5$
- Will both good used cars and lemons sell?

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- Will both good used cars and lemons sell?
- At price $P_U = 1,600$,

$$B_U\left(P_U = 1,600, \lambda = 0.5\right) = (1 - .5) \cdot 2000 + .5 \cdot 1000 = 1,500$$

- Observe that $B_U\left(E[S_U|P_U]\right) < P_U$

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  - This cannot be an equilibrium
  - Owners of good used cars demand $\$1,600$ and will not sell at $\$1,500$
  - But $P_U = 1,500$ is the maximum price that buyers are WTP, given that 50% of used cars are lemons

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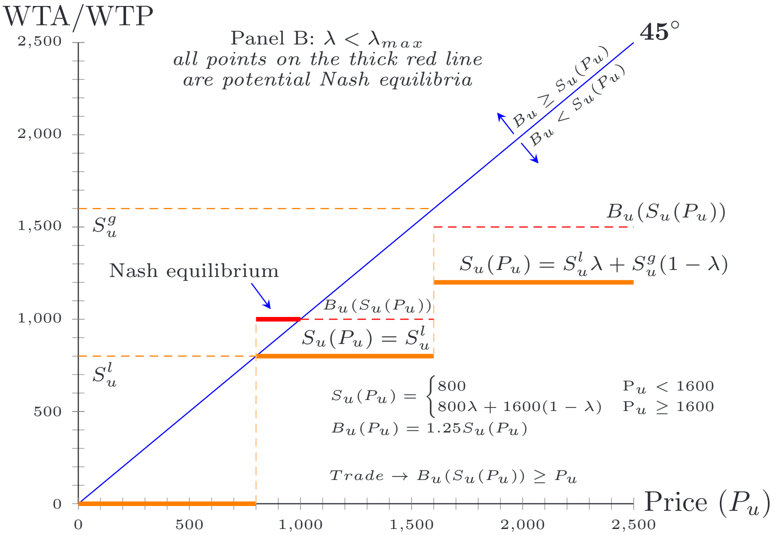
  - Owners of good used cars demand $\$1,600$ and will not sell at $\$1,500$
  - But $P_U = 1,500$ is the maximum price that buyers are WTP, given that 50% of used cars are lemons
- **Question**: What's the equilibrium?
  - *Only lemons sell!*

Figure 2 : Potential Nash Equilibria of Used Car Market with $\lambda = 0.5$



Used Cars: Market Unraveling

Analytic summary

- If share of lemons in the overall car population is high enough, bad cars drive out the good ones
- If $\lambda > 0.4$, then **good used cars** are not sold and $P_U \in [800, 1000]$
- In this price range, $B_U\left(E[S_U|P_U]\right) \geq P_U$
    - Buyers are WTP $\$2,000$ for a good used car
    - But asymmetric info means that buyers not WTP $1,500$ for *any* used car
    - With λ high enough, no good cars are sold
    - Equilibrium price must fall to exclusively reflect the value of lemons

Summary: Akerlof 1970

- The key insight of Akerlof's paper is that market quality is *endogenous*, it depends on price
- When sellers have private information about products' intrinsic worth, they will only bring *good* products to market when prices are high
- Buyers understand this, and so must adjust the price they are willing to pay to reflect the quality of the goods they expect to buy at that price
- *In equilibrium, goods available at a given price must be worth that price*

Example II of III:
The Market for ‘Fine Art’

and the *Full Disclosure Principle*

Adverse selection: A richer example – the market for 'fine' art

Consider the market for 'fine' art

- Imagine that sellers value paintings at between $\$0$ and $\$100,000$, denoted as V_s
- These values are uniformly distributed: $V_s \sim \mathrm{U}\,[0, 100, 000]$
- Assume that buyers value paintings at 50% above the seller's price. Denote this valuation as V_b.
- If a painting has $V_s = \$1,000$, then $V_b = \$1,500$
- Buyers cannot tell masterpieces from junk. Sellers can.
- The only way to know the value of a painting is to buy it and have it appraised.

Question: What is the equilibrium price of paintings in this market?

Example continued

Take the seller's side first

- A seller will sell a painting if $P \geq V_s$
- **Q**: What is the *expected* seller's value of paintings for sale as a function of P?

Example continued

Take the seller's side first

- A seller will sell a painting if $P \geq V_s$
- **Q**: What is the *expected* seller's value of paintings for sale as a function of P?
- Given that paintings are distributed uniformly:

$$E\left[V_s|P\right] = \frac{(0+P)}{2}$$

- So, if $P = \$100,000$ then *all* paintings are available for sale and their expected value to sellers is $\$50,000$
- If $P = \$50,000$, the expected seller value of paintings for sale is $\$25,000$

Example continued

Now take the buyer's side

- An equilibrium price must satisfy the condition that the goods that sellers sell at this price are worth that price to buyers
- Since $V_b = 1.5 \cdot V_s$, buyers' willingness to pay for paintings as a function of their price is

$$V_b = 1.5 \cdot E\left[V_s | P\right] = 1.5 \cdot \left(\frac{0+P}{2}\right) = \frac{3}{4} \cdot P < P.$$

- In this example, **there is no trade**
- Since buyers' valuation of paintings lies strictly above sellers' valuations, **this outcome is economically inefficient**—gains from trade are unrealized.
- **Question: What's going wrong?**

Example continued

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- Since buyers' valuation of paintings lies strictly above sellers' valuations, **this outcome is economically inefficient—**gains from trade are unrealized.
- **Question: What's going wrong?**
  - Sellers of low-quality goods generate a negative externality for sellers of high quality goods.

Example continued

Is there a way around this result?

- Sellers of *good* products have an incentive to demonstrate the quality of their products so that they can sell them at their true value
- (Sellers of bad products have an incentive to not disclose quality, and this is what ‘spoils’ the market.)
- **Needed**: A means to disclose information credibly
    - If there is an inexpensive means to credibly disclose the quality of paintings, sellers of *above average* quality paintings will probably want to do that
    - But is that the full story?

Costless verification

Imagine that a seller of a painting can get a free appraisal

- This appraisal will credibly convey the true seller's value of the painting (and so the buyer's willingness to pay will be 1.5 times this value)
- **Q:** Who will choose to get their paintings appraised?

Costless verification

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- **Q:** Who will choose to get their paintings appraised?
  - Since buyers are willing to pay $\$75,000$ for a painting of average quality...
  - One idea: any seller with a painting that would sell for at least $\$75,000$ if appraised
- **This intuition is incomplete**

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  - Since buyers are willing to pay $\$75,000$ for a painting of average quality...
  - One idea: any seller with a painting that would sell for at least $\$75,000$ if appraised
- **This intuition is incomplete**
  - If sellers with $V_s \geq 75,000$ get appraisals, the market price of non-appraised paintings is

$$1.5 \cdot E\left[V_s | V_s < 75,000\right] = 56,250.$$

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$$1.5 \cdot E\left[V_s | V_s < 75,000\right] = 56,250.$$

  - But then sellers with paintings worth $\geq 56,250$ will also get them appraised
  - What is the new market price of non-appraised paintings?

$$1.5 \cdot E\left[V_s | V_s < 56,250\right] = 42,888.$$

  - And so on...

The Full Disclosure Principle

- Unraveling in the other direction
  - *All* sellers will have their paintings appraised because each successive seller who gets an appraisal devalues the paintings of those who do not.
  - In the limit, the only seller who doesn't have an incentive to get an appraisal is the seller with $V_s = 0$. (This seller is indifferent)
- **Full-Disclosure Principle**:

  If there is a credible means for an individual to disclose that he is above the average of a group, she will do so. This disclosure will implicitly reveal that other non-disclosers are below the average, which will give them the incentive to disclose, and so on...
- The Full Disclosure Principle is essentially the *inverse* of the 'Lemons Principle'
  - In the **Lemons environment**, bad products drive down the price of good ones
  - In the **Full Disclosure environment**, good products drive down the price of bad ones

Example III of III:
Public Insurance Provision

Adverse Selection with Risk Averse Consumers

Public Insurance Provision: Setup

- Consider a unit mass of consumers i indexed from $i \in [0, 1]$,
- Each has a VNM expected utility function of the form $U(w_i) = \ln(w_i)$
- Each consumer i has initial wealth $w_{0i} = 150$
- And i faces a 50% probability of suffering loss $L_i = i \times 100$

Public Insurance Provision: Setup

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- Each has a VNM expected utility function of the form $U(w_i) = \ln(w_i)$
- Each consumer i has initial wealth $w_{0i} = 150$
- And i faces a 50% probability of suffering loss $L_i = i \times 100$
- Thus, for consumer $i = 0.60$:

$$E[w_i] = 150 - 0.5 \times L_i = \$120$$

$$E[w_i] = 150 - 0.5 \times 60 = \$120$$

$$U(E[w_i]) = \ln(120) = 4.79$$

$$E[U(w_i)] = 0.5 \times \ln(150) + 0.5 \ln(90) = 4.76$$

$$CE(E[U(w_i)]) = \exp(4.76) = \$116$$

Public Insurance Provision: Setup

Generalizing to any consumer i

- Can write that i has the following wealth, expected utility, certainty equivalent income, etc.:

$$E\left[w_i\right] = 150 - 0.5 \times 100 \times i$$

$$U\left(E\left[w_i\right]\right) = \ln\left(150 - 0.5 \times 100 \times i\right)$$
$$E\left[U\left(w_i\right)\right] = 0.5 \times \ln\left(150\right) + 0.5 \ln\left(150 - 100 \times i\right)$$
$$CE\left(E\left[U\left(w_i\right)\right]\right) = \exp\left(E\left[U\left(w_i\right)\right]\right).$$

- Can also calculate $i's$ willingness to pay for insurance *in excess of its actuarially fair value*

$$\begin{aligned} E[w_i] - \exp\left(E\left[U\left(w_i\right)\right]\right) = &\left(150 - 0.5 \times 100 \times i\right) \\ &- \exp\left(0.5 \times \ln\left(150\right) + 0.5 \ln\left(150 - 100 \times i\right)\right) \end{aligned}$$

Public Insurance Provision: Setup

- Consider a policy that pays each consumer the same L in the event of a loss
- That is, if i loses $100 \times i$, the insurer pays L to i to compensate her for the loss.
- A naive insurer decides to offer this policy at the price of $\$25$
- Why? Average expected loss across the full population is $\$25$ per consumer (since $L_i \sim U[0, 100]$ and each consumer faces a 50% probability of loss)

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- That is, if i loses $100 \times i$, the insurer pays L to i to compensate her for the loss.
- A naive insurer decides to offer this policy at the price of $\$25$
- Why? Average expected loss across the full population is $\$25$ per consumer (since $L_i \sim U[0, 100]$ and each consumer faces a 50% probability of loss)
- **Question:**

  Which consumers will buy insurance, and what are the expected profits or losses of the policy?

Public Insurance Provision: Setup

- **To solve this problem, identify consumer i' who is indifferent between buying this policy and having no insurance**
- Formally, we want to find i' such that

$$E\left[U\left(w_{i'}\right)\right] = 0.5 \times \ln\left(150\right) + 0.5 \ln\left(150 - 100 \times i'\right) = \mathsf{ln}\left(150 - 25\right).$$

- Left-hand side of this equation is the expected utility of i' if uninsured
- Right-hand side is wealth of i' if insured. In that case, i' pays the $\$25$ premium and so faces no risk of losing L_i

Public Insurance Provision: Setup

Who purchases the $25 policy?

$$
\begin{aligned}
0.5 \times \ln(150) + 0.5 \ln(150 - 100 \times i') &= \ln(125) \\
\ln(150 - 100 \times i') &= (2 \times \ln(125) - \ln(150)) \\
150 - 100 \times i' &= \exp[2 \times \ln(125) - \ln(150)] \\
i' &= [\exp[2 \times \ln(125) - \ln(150)] - 150] / (-100) \\
i' &= 0.46
\end{aligned}
$$

- Consumers on the interval $i' \in [0.46, 1]$ will buy the policy

Public Insurance Provision: Setup

Who purchases the \$25 policy?

$$
\begin{aligned}
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- **This policy will lose money on average**
    - Expected costs per insured consumer are $E[L_i | i \geq 0.46] = 100 \times 0.5 \times \left(\frac{1+0.46}{2}\right) = \$36.50$
    - Unfortunately, this "naive" policy cannot be an equilibrium

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- All consumers with greater expected losses than i'' will also buy the policy
- Thus, the expected costs per insured of a policy sold to consumers with $i \geq i''$ is

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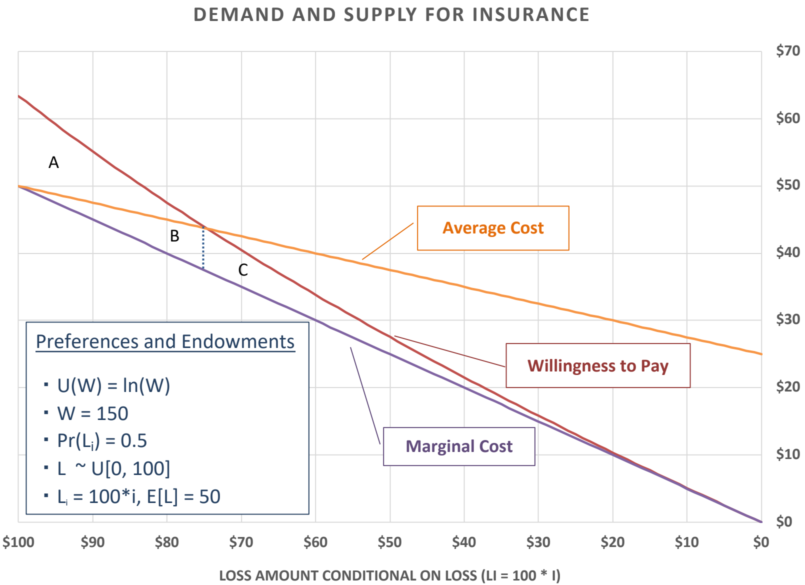
Following the logic above, we can solve for i''

$$0.5 \times \ln(150) + 0.5 \ln(150 - 100 \times i'') = \ln(150 - 25 \times (1 + i'')).$$

- This equation is solved by $i'' = 0.75$
- **Only one quarter of the population buys insurance**

Insurance equilibrium in the free market



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  - The problem is *adverse selection*
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Q: Why does the market not completely unravel — leading to no one buying insurance?

  - Because some consumers will sign up for the policy even though it is actuarially unfair *for them*. They prefer a 'bad deal' on insurance to no insurance at all

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- All consumers place positive value on insurance (except consumer $i = 0$, who has zero risk)
- An efficient market solution involves all consumers obtaining insurance
- Since the marginal cost of insuring each consumer is less than or equal to her willingness to pay for this insurance, all consumers should be insured.
- As with the naive policy, the efficient policy has a premium of $\$25$, but this policy is *mandatory*.

Mandate

- Notice that **not** every consumer is better off under the mandatory policy
- Recall the naive policy, consumers with $i' < 0.46$ would prefer not to buy the $\$25$ policy
- **So, in what sense is it efficient to require them to buy insurance?**

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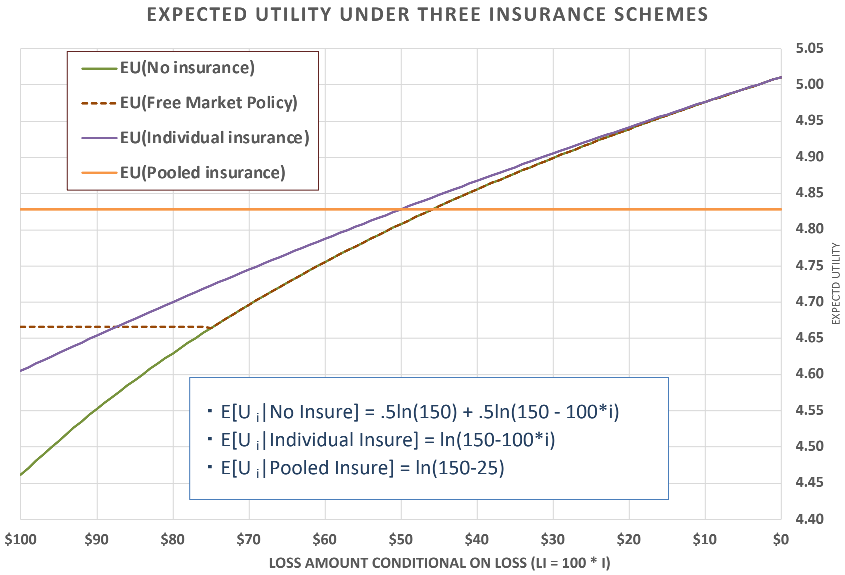
  - And for consumers with $i < 0.46$, the net effect of the insurance and transfer is to lower utility relative to a case with no insurance
- **Average consumer welfare** is higher under the *mandatory* insurance policy than either the *no-insurance* or the *free market insurance* case

Welfare consequences of an insurance mandate



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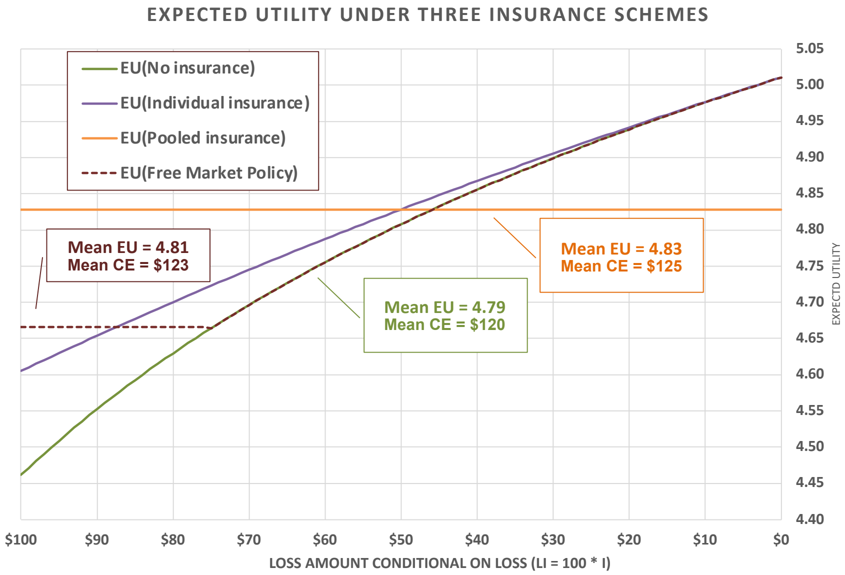

Free Screening

Imagine that a free *voluntary* test is introduced that will reveal the risk type of each consumer i who takes the test. Once i is tested, insurers will offer i an actuarially fair insurance policy at cost $0.5L_i = 50 \times i$.

- **Question 1:** Who will take the test?
- **Question 2:** Will the testing equilibrium yield higher or lower average welfare than the mandatory plan (everyone pays $25)?

Mandatory plan yields higher average welfare than individual plan!