NU Econ 101 Lecture 17: Information

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Where are we now?

1. Uncertainty
2. Adverse selection and the market for lemons
3. Spence signaling and screening
4. Moral hazard
5. Useful problems

Lotteries

We talked briefly about **lotteries** in the first lecture.

Lotteries

A lottery is a discrete probability distribution on a set of outcomes.

- Lotteries are used to describe environments with uncertainty.
- Defining preferences over lotteries motivated the **von-Neumann Morgernstern utility theorem**.

An example of a lottery

Suppose you have a salary of \$40000. Your boss offers you to exchange this salary for a lottery (L). You will flip a fair coin. If it is heads, you get \$60000. If tails, you get only \$20000.

What is the expected value of this lottery?

$$EV(L) = 0.5 \cdot 20000 + 0.5 \cdot 60000 = 40000$$

- Because the expected value equals the cost, we would call the gamble **actuarially fair**.

Would you accept this deal?

Would you accept the deal? (1)

If we denote the lottery by L, and say your utility (as a function of income) is u, then you would accept the deal if $U(L) \geq u(40000)$

- We use a capital U to denote **expected utility**.

The **von-Neumann Morgernstern utility theorem** tells us that:

$$\begin{aligned} U(L) &= Pr(20000) \cdot u(20000) + Pr(60000) \cdot u(60000) \\ &= 0.5 \cdot u(20000) + 0.5 \cdot u(60000) \end{aligned}$$

So accept if:

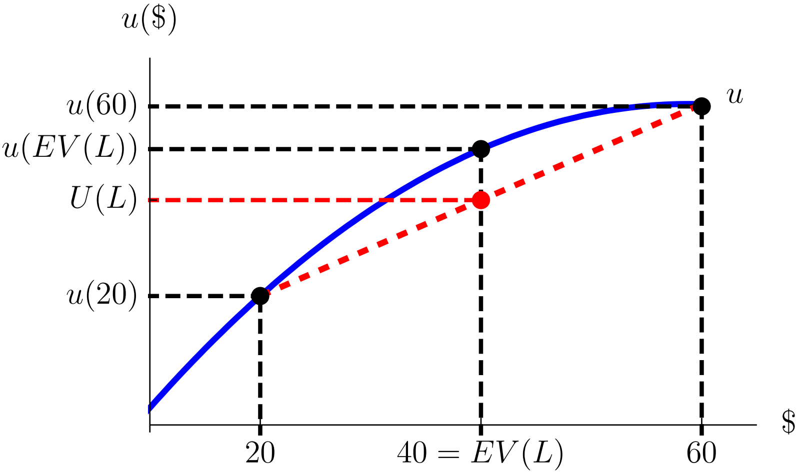
$$0.5 \cdot u(20000) + 0.5 \cdot u(60000) \geq u(40000)$$

Would you accept the deal? (2)

Whether you would accept the deal or not depends on the shape of your utility function. If your utility function is . . .

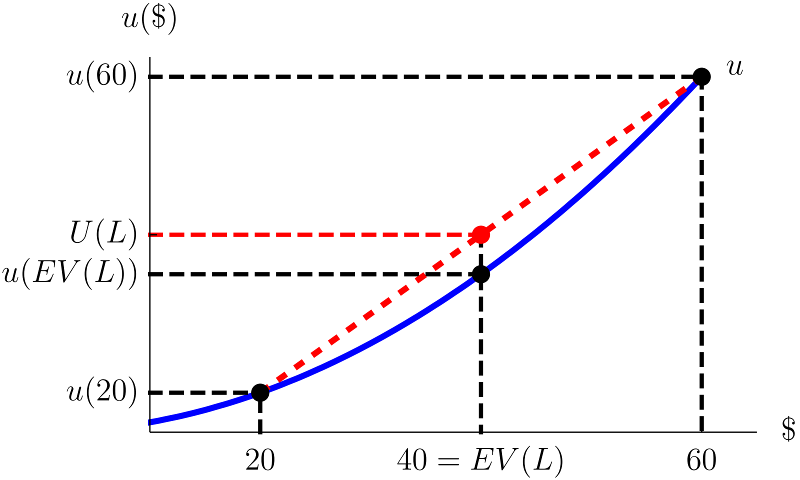
- **concave**, you will reject.
  - We would call you **risk averse**.
- **convex**, you will accept.
  - We would call you **risk loving**.
- **linear**, you are indifferent.
  - We would call you **risk neutral**.

A risk-averse agent has a concave utility function



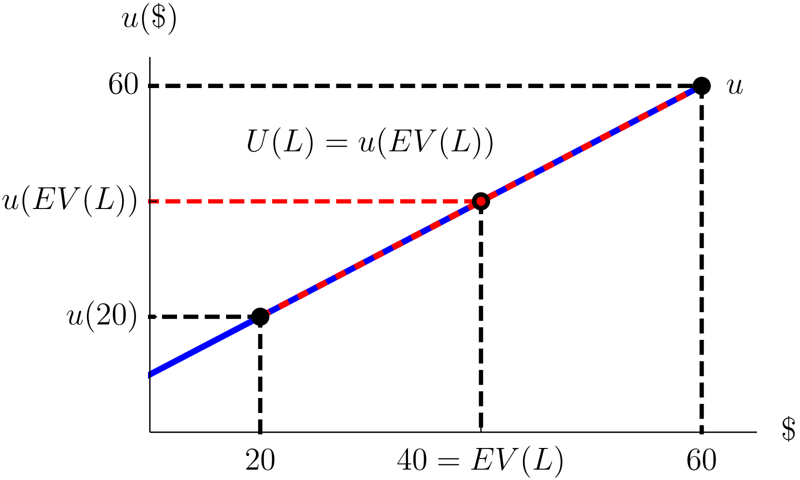
For a risk-averse agent, $U(L) \leq u(EV(L))$.

A risk-loving agent has a convex utility function



For a risk-loving agent, $U(L) \geq u(EV(L))$.

A risk-neutral agent has a linear utility function



For a risk-neutral agent, $U(L) = u(EV(L))$.

Risk aversion

Note that concavity of the utility function is equivalent to diminishing marginal utility.

In most settings, most people are risk averse.

- People at a casino, or those buying lottery tickets, are risk loving, at least in that setting.

Given that people are risk averse, there exist companies that we can pay to take risk out of our lives . . .

- **Insurance companies**

Insurance companies

There is some probability (e.g. one percent) your house burns down this year.

Suppose the house is worth \$100 000 and the insurance company will pay out that amount if it burns down.

What is the actuarially fair premium (price you pay) for this coverage?

- $0.01 \cdot \$100\,000 = \$1\,000$

Insurance company wants to make a profit, so charges slightly more. Risk averse agents will still accept.

Insurance companies and diversification (1)

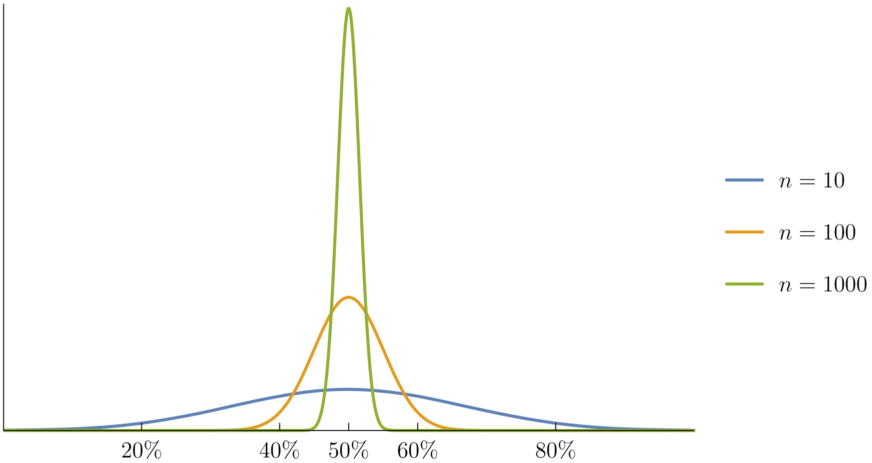
Aren't insurance companies also risk averse? They are!

- But they benefit from **the law of large numbers (LLN).**

Let's illustrate the LLN with coin tosses. Suppose you toss a fair coin n times. What are the probabilities you get a percentage of heads in each of the following ranges:

	[40%,60%]	[45%,55%]	[48%,52%]
$n = 10$	0.66	0.25	0.25
$n = 100$	0.96	0.73	0.38
$n = 1000$	1.00	1.00	0.81
$n = 10000$	1.00	1.00	1.00

Probability mass function for % of heads from n tosses



Insurance companies and diversification (2)

Since insurance companies insure many homes, their risk is not that great.

- If we have a large number of homes, each of which has a 1% chance of burning down, the percentage that will burn down will very likely be very close to 1%.

This assumes the homes are independent random variables.

- If they are correlated, as they might well be, risk is far greater.

Where are we now?

Asymmetric information and incomplete information

Uncertainty involved randomness in the outcome, but objective probabilities were known by all parties.

If something important is known by only one agent in a transaction, we call that **asymmetric information.**

Asymmetric information is one example of **incomplete information**, where agents may be missing critical information about other agents.

The market for lemons (Akerloff 1970) (1)

Let's take the used car market as an example. Say there are three types of cars: good cars, decent cars, and bad cars (lemons).

Each seller knows the type of car she is selling. Buyers know only that a third of the cars on the market are of each quality level.

Buyers and sellers have the following values for each car:

	Buyer	**Seller**
Good	90	80
Medium	60	50
Bad	30	20

- These values are known by all parties.

Note that it is Pareto optimal for all cars to be sold.

The market for lemons (Akerloff 1970) (2)

When a buyer and a seller meet, why doesn't the seller just tell the buyer the quality of the car?

- All sellers would say that the car is good.
- We call this **cheap talk**.

Not knowing the car quality, and assuming risk neutrality, what is the maximum amount the buyer would be willing to pay?

$$\frac{1}{3} \cdot 90 + \frac{1}{3} \cdot 60 + \frac{1}{3} \cdot 30 = 60$$

Would the buyer actually be willing to offer 60?

The market for lemons (Akerloff 1970) (3)

If the buyer offers 60, he knows that only sellers of the decent and bad cars would accept, hence his expected value is

$$\frac{1}{2} \cdot 60 + \frac{1}{2} \cdot 30 = 45 < 60$$

- **No, buyer would not offer 60.**

Good cars will not be sold (despite it being Pareto optimal to sell).

Given this, the buyer would be willing to pay a maximum of 45 for the 50/50 chance of a decent or bad car.

Would the buyer actually be willing to offer 45?

The market for lemons (Akerloff 1970) (4)

If the buyer offers 45, only the sellers of bad cars (lemons) will sell, hence the buyer's expected value is just $30 < 45$.

- **No, buyer would not offer 45.**

Medium cars will also not be sold. The only cars that will be sold at market are the bad cars, for a price between 30 and 20.

We call this phenomenon **unraveling** and it is another instance of **market failure**.

Adverse selection and health insurance

Health insurance may also have asymmetric information.

- The buyer knows more about her health than the insurer.

If an insurer offers an insurance contract based on the average person, it is likely to be purchased only by those with below-average health, so the insurer would lose money.

Possible consequence: Only the least healthy get health insurance and it is very expensive.

Possible solution: Mandate that everybody buys health insurance. The healthy essentially subsidize healthcare for the less healthy.

Where are we now?

Signaling and screening

In adverse selection, we assumed there was an informational asymmetry and neither party could correct it.

But maybe someone can correct the asymmetry:

- If the informed party can, we call this **signaling**.
- If the uninformed party can, we call this **screening**.

Signaling in the used car market

How can a seller of a good car prove that her car is good?

- She can't just say it is good. Anybody could do that.
- She must do something that sellers of decent and bad cars would not be willing to do.

Suppose the quality of the car would be revealed to the buyer within x days of the transaction.

The seller could offer a full money-back guarantee – the buyer could return the car after day x if he was unsatisfied.

- Sellers of decent and bad cars would not want to do this. Hence, the signal is effective. Good car would be sold.

Spence job-market signaling (1973) (1)

Let's suppose university has absolutely no intrinsic value to us – you leave exactly as smart and productive as when you started.

- And also assume that attending university is costly, both in terms of funds and mentally from the hard work.

If this is the case, would society have universities?

- It would be Pareto inefficient to have universities.

Spence shows, indeed, we may still have them!

Spence job-market signaling (1973) (2)

Suppose there are two types of workers, good workers and bad workers, and each worker knows his type.

- **Informational asymmetry:** Employers know that half of workers are good and half are bad, but cannot tell them apart before hiring them.

A firm is willing to pay. . .

- good workers a salary of 100.
- bad workers a salary of 50.
- workers of unknown quality a salary of 75.

Spence job-market signaling (1973) (3)

There are two types of equilibria in these problems:

Pooling equilibria

Equilibria in which both types of agents take the same actions and reach the same outcomes.

Separating equilibria

Equilibria in which different types of agents take different actions, thereby revealing their types and achieving different outcomes.

Spence job-market signaling (1973) (4)

How can a good worker credibly show she is good?

- She must do something that a bad worker would not be willing to do.

Suppose attending university is more costly/difficult for the bad worker than the good worker.

- Say the cost for a bad worker is 60 and cost for a good worker is only 30.

Then, there exists a separating equilibrium.

- The good workers go to university and get paid 100 and the bad workers don't and get paid 50.

Spence job-market signaling (1973) (5)

To show that this is a separating equilibrium, we need to show that neither type of worker has an incentive to deviate.

- Good worker prefers to get education and high wage:

$$100 - 30 > 50$$

- Bad worker prefers to not get education and get low wage:

$$50 > 100 - 60$$

Signaling can occur when there is an action that people can take that is more costly for one type than the other.

Spence job-market signaling (1973) (6)

Note that signaling is always Pareto inefficient.

- Having agents undertake costly signals is inefficient.

Often, separating equilibria are better for the high types (the good workers, here) and worse for the low types (the bad workers) than a pooling equilibrium.

- Not always! Here, note that even the good worker is worse off in the separating equilibrium than in the pooling equilibrium:

$$100 - 30 < 75$$

Screening and health insurance

Screening is very similar, except the uninformed party is the one that can do something to correct the asymmetry.

We mentioned the problem of adverse selection in health insurance.

One way around it, besides mandating its purchase, is for the insurance company to somehow get its customers to reveal how healthy they are. **Can offer two options:**

- Plan A: Cheap, high-deductible plans for healthy people.
- Plan B: Expensive, low-deductibe plans for less healthy.

If healthy people prefer Plan A and unhealthy prefer plan B, then all people can have health insurance.

Where are we now?

Incomplete vs. imperfect information

Incomplete information is when one agent knows some characteristic about herself that another does not.

- We've been looking at instances of this since adverse selection.

Imperfect information is when one agent does not observe some action taken by another agent.

- Perhaps your boss observes the results of your work, but not whether you have worked hard or not.

The principal-agent problem (1)

Suppose all of the following is known to you and your boss:

- Your boss (principal) is risk-neutral ($u_p(\pi, w) = \pi - w$) and you (agent) are risk-averse ($u_a(w, c) = \sqrt{w} - c$).
- If you quit, you get zero utils.
- There are two possible outcomes from your work, high profits ($\pi_H = 16$) and low profits ($\pi_L = 4$).
  - If you exert good effort, probability of high profits is $3/4$.
  - If you exert bad effort, probability of high profits is $1/4$.
- Utility costs of good and bad effort: $c_G = 2$ and $c_B = 1$.

The principal-agent problem (2)

What contract would your boss offer you if she could observe your effort level (and thus condition the wage upon it)?

She wants you to exert good effort and to not want to quit. Therefore, she will pay you nothing for bad effort ($w_B = 0$) and pay you just enough for good effort:

$$u_a(w_G, c_G) = \sqrt{w_G} - 2 \geq 0$$

Therefore, she sets $w_G = 4$. Her expected utility:

$$U_p(\pi, w_G) = \frac{3}{4} \cdot 16 + \frac{1}{4} \cdot 4 - 4 = 9$$

The principal-agent problem (3)

What contract would your boss offer you if she could not observe your effort level?

If she just paid you a flat wage no matter what, you would exert bad effort.

- She offers you w just high enough so you do not quit:

$$\sqrt{w} - 1 \geq 0 \implies w^* = 1$$

- Her expected utility:

$$U_p(\pi, w) = \frac{1}{4} \cdot 16 + \frac{3}{4} \cdot 4 - 1 = 6$$

- **Bad . . . how could she still get you to work hard?**

The principal-agent problem (4)

She could have your wage depend on the profits!

1. She wants to pay you just enough so you prefer to exert high effort than to quit.

$$\frac{3}{4} \cdot \sqrt{w_H} + \frac{1}{4} \cdot \sqrt{w_L} - 2 \geq 0$$

2. She wants you to prefer high effort to low effort:

$$\frac{3}{4} \cdot \sqrt{w_H} + \frac{1}{4} \cdot \sqrt{w_L} - 2 \geq \frac{3}{4} \cdot \sqrt{w_L} + \frac{1}{4} \cdot \sqrt{w_H} - 1$$

Optimally, for her, both bind with equality.

The principal-agent problem (5)

Solving the two equations together gives:

$$w_H^* = \frac{25}{4} \qquad w_L^* = \frac{1}{4}$$

Principal's expected utility:

$$U_p = \frac{3}{4}\left(16 - \frac{25}{4}\right) + \frac{1}{4}\left(4 - \frac{1}{4}\right) = \frac{33}{4} = 8.25$$

Better than the unconditional contract, but not as good as when effort was observable.

The principal-agent problem (6)

There was a natural trade-off in this problem.

- The principal needed to have your wage depend on profits to get you to exert good effort.
- But, because you were risk-averse and the principal was risk-neutral, this was suboptimal, so less surplus was left over for the principal.

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Useful problems

Chapter 17: 2, 3, 4, 5, 8, 12, 13, 14, 15