Uncertainty, Risk and Private Information

Noemi Pace
Facoltá di Scienze Politiche
npace@unite.it

Outline

- Why is risk a key feature of the economy?
- Why does diminishing marginal utility make people risk averse, and how does it determine what they are willing to pay to reduce risk?
- How do insurance markets lead to mutually beneficial trades of risk?
- What is private information, and what special problems does it pose for markets?
- Implications of risk aversion in developments

Extreme Wheather

- During 2017, 2018, and 2019, wildfires across the west and Alaska burned several million acres, claimed 163 lives, and destroyed tens of thousands of buildings, resulting in a cumulative loss of over $53 billion.
- In 2019, Tropical Storm Imelda, Hurricane Dorian, and a few tornadoes caused a cumulative loss of $18 billion to the U.S. economy.
- In the Midwest, floods caused losses totaling $20 billion.
- Uncertainty is a feature of the real world.

The Economics of Risk Aversion

- In general, people don't like risk and are willing to pay a price to avoid it.
- Americans pay insurance companies more than $1 trillion in premiums every year to avoid risk.
- But what is risk? And why don't most people like it?

Expectations and Uncertainty

- To understand risk, we need to look at the concept of expected value and the meaning of uncertainty.

- **Random variable:** a variable with an uncertain future value

- No one can predict a random variable, but we can calculate the **expected value** of a random variable—the weighted average of all possible values, where the weights correspond to probabilities of possible values.

Expectations and Uncertainty

- To find the expected value of a random variable, we imagine that there are a number of different **states of the world**, or possible future events.

- You don't know which state of the world will occur, but you can assign probabilities, one for each state of the world.

- P_1 is the probability of state 1, P_2 the probability of state 2, and so on.

- You know the realized value of the random value in each state of the world: S_1 in state 1, S_2 in state 2, and so on.

- There are N possible states.

Expectations and Uncertainty

Expected value of a random variable:

$$EV = (P_1 \times S_1) + (P_2 \times S_2) + \ldots + (P_N \times S_N)$$

- If the Lee family faces a 50% chance of no medical expenses and a 50% chance of $10,000 of expenses, the expected value of its medical expenses is

$(0.5 \times 0) + (0.5 \times \$10{,}000) = \$5{,}000.$

- **Risk:** uncertainty about future outcomes

- When the uncertainty is about monetary outcomes, it becomes **financial risk.**

Learn by doing: practice question #1

Mark does not know how large his automobile repair expenses will be for the coming year. If he's lucky, his car will need no repairs and his car repair costs will be zero. But if he has a wreck and the car is destroyed, his car repair expenses will equal $20,000. (Assume that these are the only two possible states of the world.)

If there's a 20% chance that Mark will have a serious car accident, what is the expected value of Mark's car repair expenses for the coming year?

a) zero
b) $20,000
c) $10,000
d) $4,000

Learn by doing: practice question #1

Mark does not know how large his automobile repair expenses will be for the coming year. If he's lucky, his car will need no repairs and his car repair costs will be zero. But if he has a wreck and the car is destroyed, his car repair expenses will equal $20,000. (Assume that these are the only two possible states of the world.)

If there's a 20% chance that Mark will have a serious car accident, what is the expected value of Mark's car repair expenses for the coming year?

a) zero
b) $20,000
c) $10,000
d) $4,000 (correct answer)

UNIVERSITÁ DEGLI STUDI DI TERAMO

Assessing Risk

- Example: Greg schedules an outdoor event
  - If it doesn't rain, he'll make $15 in profit
  - If it does rain, he'll make -$5 in profit (loss)
  - There is a 50% chance of rain.
- Greg's expected value (outdoor event):

$$\begin{aligned} EV &= \left[Pr(\text{no rain}) \times \text{Value}(\text{no rain})\right] + \left[Pr(\text{rain}) \times \text{Value}(\text{rain})\right] \\ &= \left(\tfrac{1}{2} \times \$15\right) + \left[\tfrac{1}{2} \times (-\$5)\right] = \$5 \end{aligned}$$

- Variance (outdoor eve

$$\begin{aligned} \sigma^2 &= \left[\theta_1 \times (V_1 - EV)^2\right] + \left[\theta_2 \times (V_2 - EV)^2\right] \\ &= \left[\tfrac{1}{2} \times (\$15 - \$5)^2\right] + \left[\tfrac{1}{2} \times (-\$5 - \$5)^2\right] \\ &= \left[\tfrac{1}{2} \times (\$10)^2\right] + \left[\tfrac{1}{2} \times (-\$10)^2\right] = \$100. \end{aligned}$$

  - Standard deviation = $10

Assessing Risk

- Example, continued: Greg schedules an indoor event
  - If it doesn't rain, he'll make $10 in profit
  - If it does rain, he'll make $0 in profit
  - There is still a 50% chance of rain.
- Greg's expected value (indoor event)… is the same!

$$EV = \left(\frac{1}{2} \times \$10\right) + \left(\frac{1}{2} \times \$0\right) = \$5$$

- Variance (indoor event)… is much smaller:

$$\sigma^2 = \left[\frac{1}{2} \times (\$10 - \$5)^2\right] + \left[\frac{1}{2} \times (\$0 - \$5)^2\right]$$
$$= \left[\frac{1}{2} \times (\$5)^2\right] + \left[\frac{1}{2} \times (-\$5)^2\right] = \$25$$

  - Standard deviation = $5
  - Much less risky to schedule the event indoors!

Attitudes Toward Risk

- Although indoor and outdoor events have the same expected value, the outdoor event involves more risk.
- He'll schedule the event outdoors only if he likes to gamble.
- People can be classified according to attitudes toward risk.
- A *fair bet* is a wager with an expected value of zero.
  - Example: You receive $1 if a flipped coin comes up heads and you pay $1 if a flipped coin comes up tails.
  - Someone who is unwilling to make a fair bet is *risk averse*.
  - Someone who is indifferent about a fair bet is *risk neutral*.
  - Someone who is *risk preferring* will make a fair bet.

San Petersburg Paradox

- A fair coin is tossed until a tail comes up.

- Suppose n tosses are needed.

- You get paid €2^n
- What is the fair price to pay to play this game?
- Expected winnings are
- (1/2)*2+(1/4)*4+(1/8)*8+…
- 1+1+1+…=∞
- In practice people are not willing to pay more than a very few euros to play this game
- What does this imply?
- People are not looking at expected winnings

THE LOGIC OF RISK AVERSION

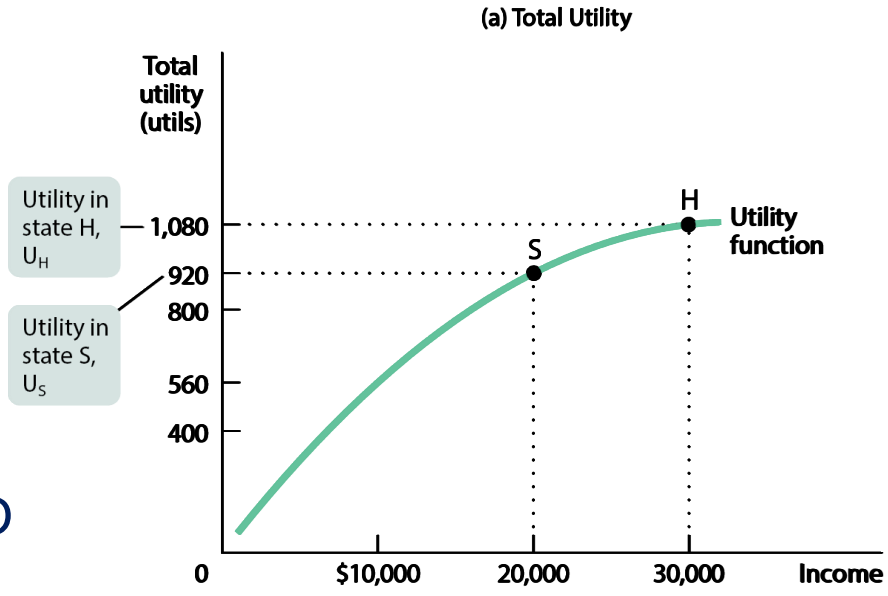
- Why is risk a bad thing? It's tied to the concept of diminishing marginal utility.
- To understand how the two are linked, we need to look not only at the medical costs but also at how those costs affect the income the family has left after medical expenses.
- If we assume that the family income is $30,000, the expected income after medical expenses is

$$(0.5 \times \$30{,}000) + (0.5 \times \$20{,}000) = \$25{,}000.$$

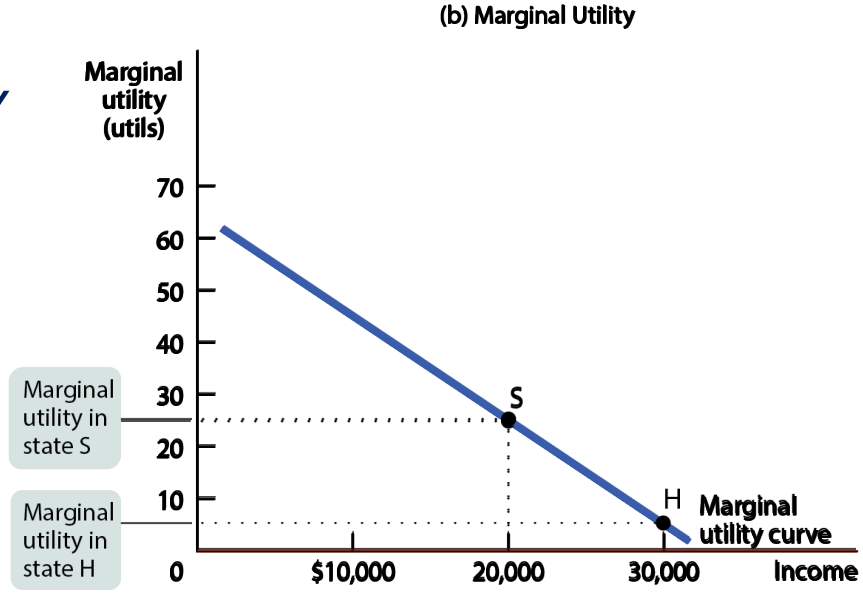
THE LOGIC OF RISK AVERSION

- **Expected utility:** the expected value of an individual's total utility, given uncertainty about future outcomes
- Expected utility of the family is less than it would be if the family didn't face any risk and knew with certainty that its income after medical expenses would be $25,000.

THE UTILITY FUNCTION AND MARGINAL UTILITY CURVE OF A RISK-AVERSE FAMILY



Income	Total utility (utils)
$20,000	920
21,000	945
22,000	968
23,000	989
24,000	1,008
25,000	1,025
26,000	1,040
27,000	1,053
28,000	1,064
29,000	1,073
30,000	1,080



UNIVERSITÁ DEGLI STUDI DI TERAMO

THE LOGIC OF RISK AVERSION

- Most people are **risk-averse:**
- They will choose to reduce the risk when the cost of that reduction leaves the expected value of their income or wealth unchanged.
- They would be willing to purchase a **fair insurance policy**: a policy for which the premium is equal to the expected value of the claims.

THE EFFECT OF FAIR INSURANCE ON THE LEE'S FAMILY INCOME AND EXPECTED UTILITY

Expected utility =

(Probability of state H × Total utility in state H) +

(Probability of state S × Total utility in state S)

	Income in different states of the world			
	$0 in medical expenses (0.5 probability)	$10,000 in medical expenses (0.5 probability)	Expected value of income available for consumption	Expected utility
Without insurance	$30,000	$20,000	(0.5 × $30,000) + (0.5 × $20,000) = $25,000	(0.5 × 1,080 utils) + (0.5 × 920 utils) = 1,000 utils
With fair insurance	$25,000	$25,000	(0.5 × $25,000) + (0.5 × $25,000) = $25,000	(0.5 × 1,025 utils) + (0.5 × 1,025 utils) = 1,025 utils

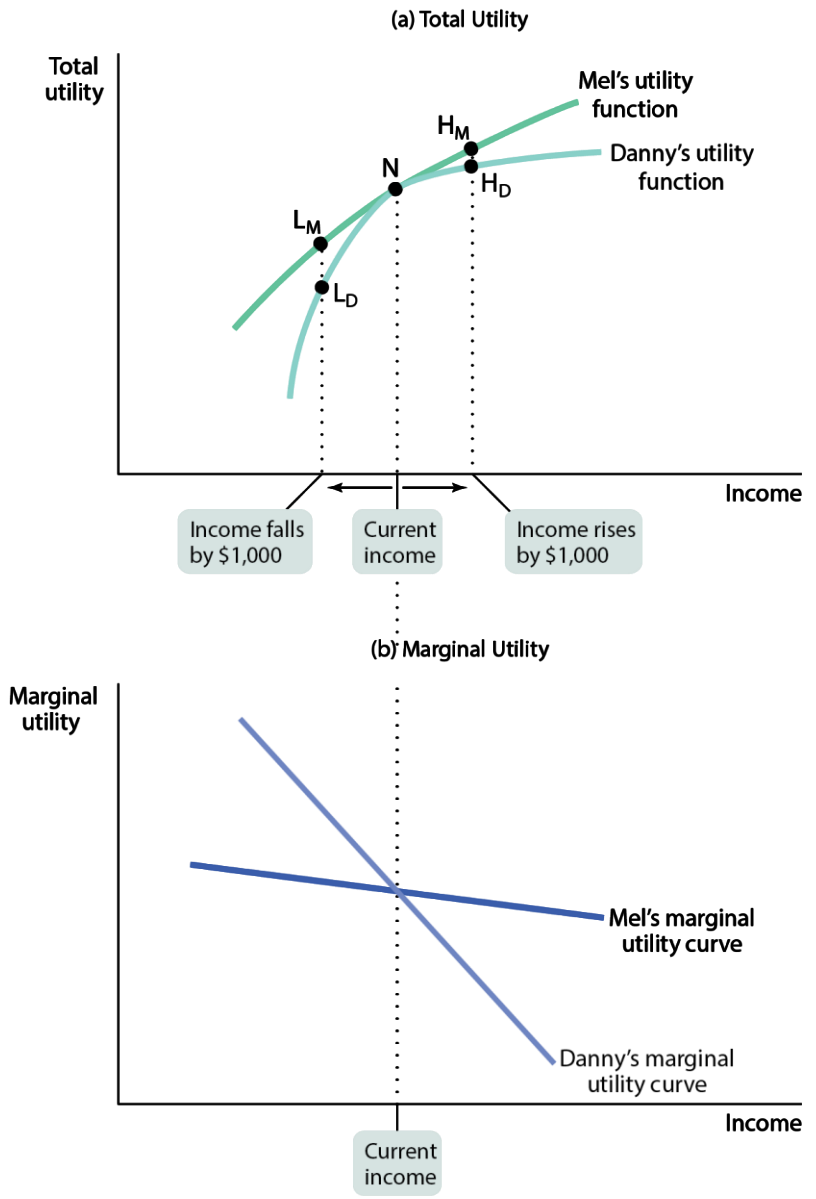
THE LOGIC OF RISK AVERSION

- Almost everyone is risk averse because almost everyone has **diminishing marginal utility:** a dollar gained when income is low adds more to utility than a dollar gained when income is high.
- Having an additional dollar matters more when you are facing hard times than when you are facing good times.
  - Some people are more risk averse than others.
- A **risk-neutral** person is completely insensitive to risk.
- Individuals differ in risk aversion for two main reasons:

1. Differences in preferences. People differ in how much their marginal utility is affected by income.
2. Differences in initial income or wealth. The possible loss of $1,000 makes a big difference to a family living below the poverty threshold; it makes very little difference to someone who earns $1 million a year.

DIFFERENCES IN RISK AVERSION

- Danny would gain a little from a rise in income but lose a lot from a fall in income. He is highly risk averse.
- Mel would gain as much from higher income as he would lose from lower income. He is barely risk averse.
- Danny would gain more from insurance than Mel will.



PAYING TO AVOID RISK

- People would be better off taking out a fair insurance policy—a policy that leaves their expected income unchanged but eliminates their risk.
- Real insurance policies are rarely fair because insurance companies have to cover other costs, so they charge more than they expect to pay in claims.
- Will people still want to buy an “unfair” insurance policy? It depends on the size of the premium.
- Risk-averse individuals are willing to pay a premium that exceeds their expected claim. A risk-neutral person is unwilling to pay at all to reduce their risk.

BUYING, SELLING, AND REDUCING RISK

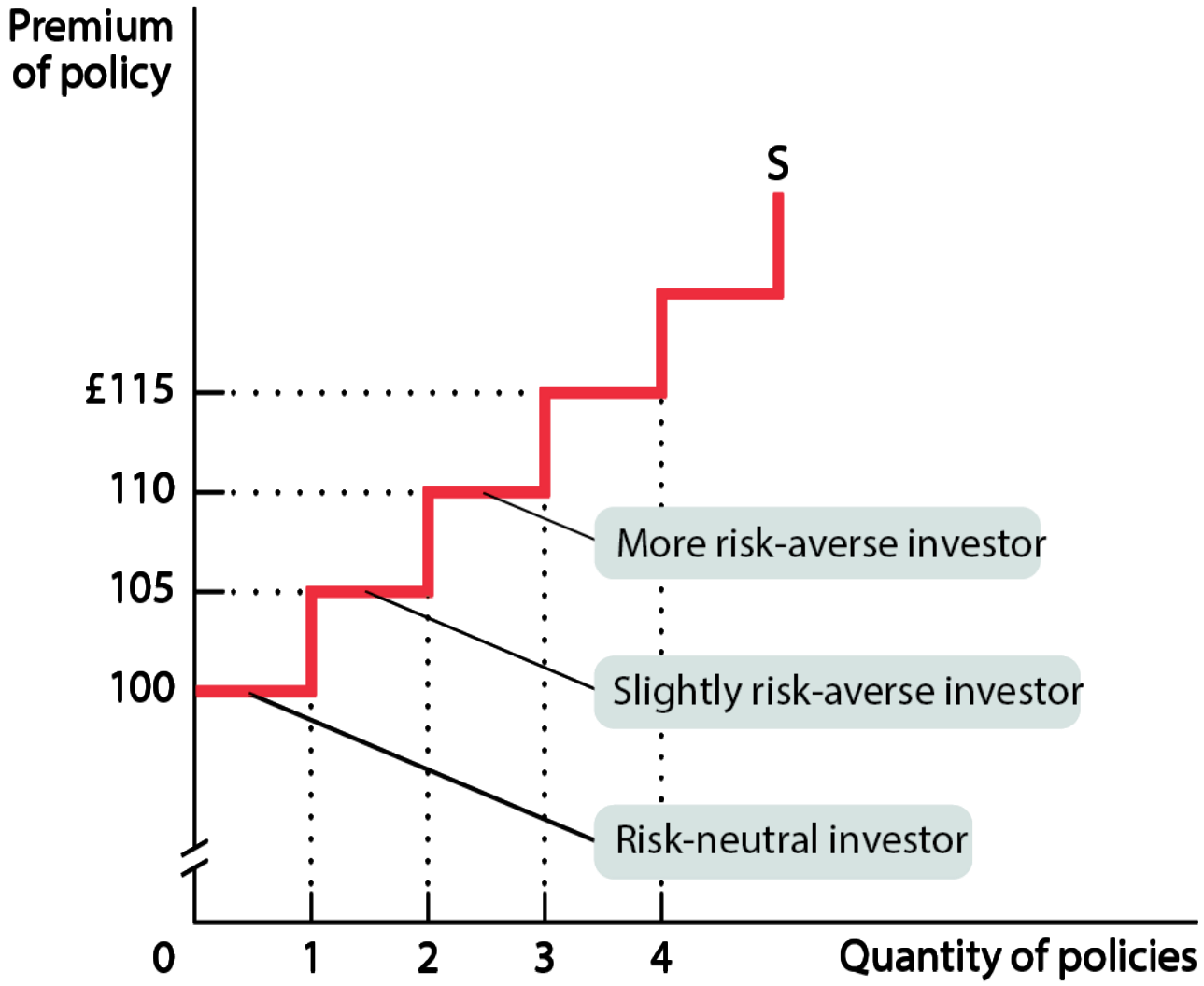
- The insurance industry rests on two principles:
  1. Trading risk can produce mutual gains.
     - People who want less risk transfer it to people who are more willing to bear it.
  2. Some risk can be made to disappear through *diversification.*

TRADING RISK

- People have different sensitivities to risk.
- People who want to reduce their risk pay other people who are less sensitive to risk to take some of their risk away.
- Lloyd's of London, the oldest insurance company, made money by matching wealthy investors who were more risk tolerant with less wealthy (and therefore more risk-averse) ship owners who wanted to purchase insurance.
- **Capital at risk:** the funds that an insurer places at risk when providing insurance
- Lloyd's wealthy investors placed capital at risk in return for premiums.

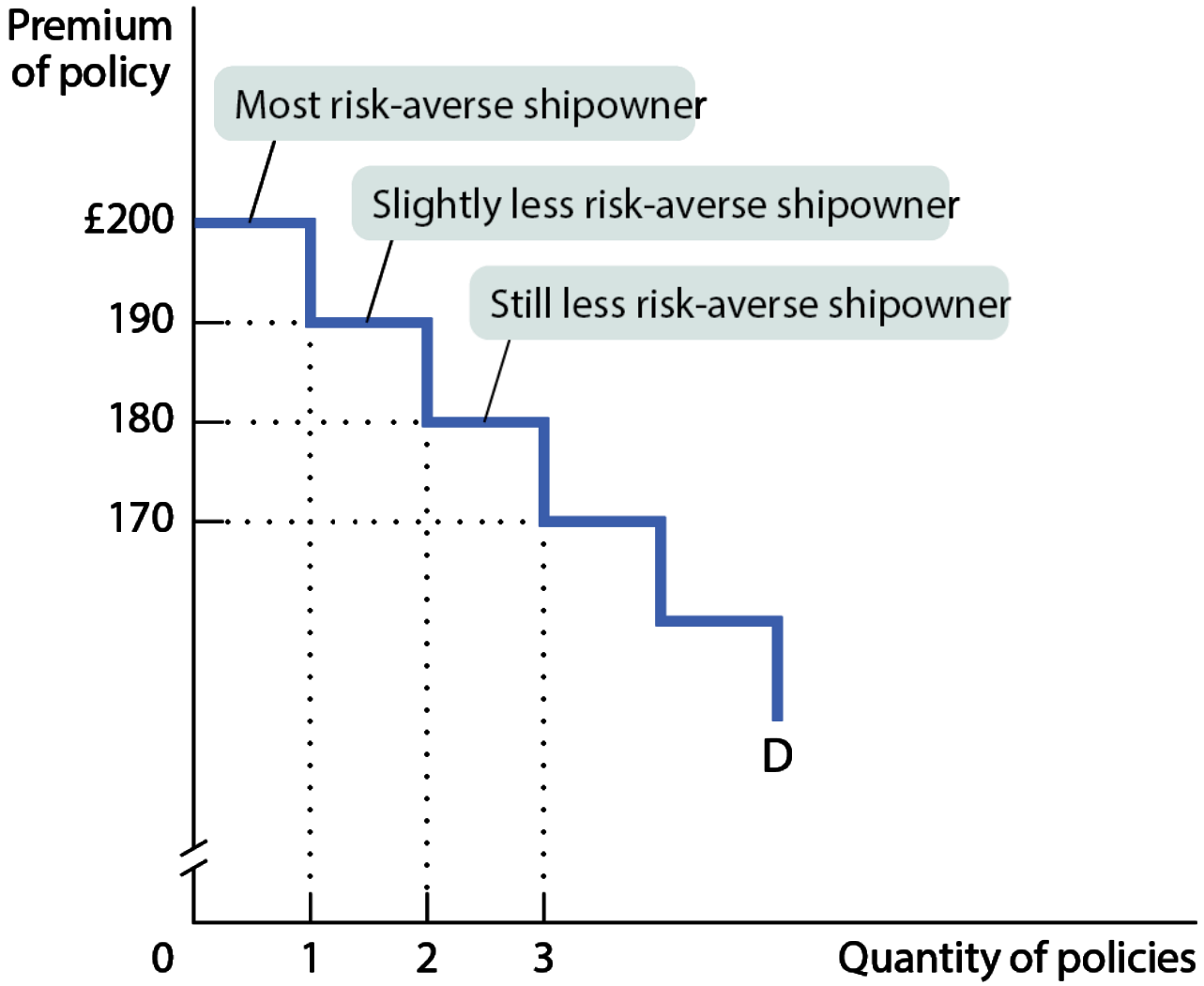
THE SUPPLY OF INSURANCE

Figure 20-3



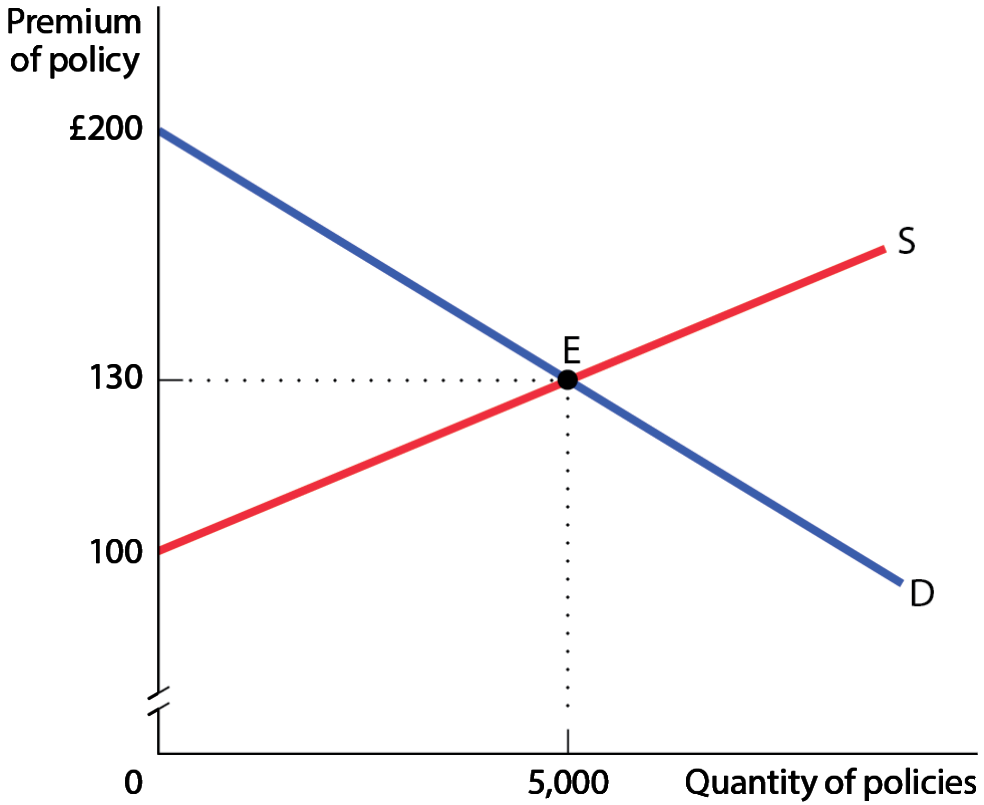
THE DEMAND FOR INSURANCE

Figure 20-4



THE INSURANCE MARKET

- An **efficient allocation of risk:** an allocation of risk in which those who are most willing to bear risk are those who end up bearing it



MAKING RISK DISAPPEAR: THE POWER OF DIVERSIFICATION

- A strategy of investing that reduces the probability of severe losses is known as diversification.
- Diversification can often make some risks disappear.
- If events are independent, diversification reduces risk.
- **Independent events:** one is no more likely to happen if the other does than if it does not.
- How were the British merchants able to survive the risky routes they took?
  - By sending different ships to different destinations, they could reduce the probability that all of their ships would be lost.

HOW DIVERSIFICATION REDUCES RISK

If both ships are sent to the same destination			
State	**Probability**	**Payoff**	**Expected payoff**
Both ships arrive	0.9 = 90%	£2,000	
Both ships lost	0.1 = 10%	0	(0.9 × £2,000) + (0.1 × £0) = £1,800
If one ship is sent east, the other west			
State	**Probability**	**Payoff**	**Expected payoff**
Both ships arrive	0.9 × 0.9 = 81%	£2,000	
Both ships lost	0.1 × 0.1 = 1%	0	
One ship arrives	(0.9 × 0.1+ (0.1 × 0.9) = 18%	1,000	(0.81 × £2,000) + (0.01 × £0) + (0.18 × £1,000) = £1,800

MAKING RISK DISAPPEAR: THE POWER OF DIVERSIFICATION

- **Diversification:** investing in several things, where the possible losses are independent events
- In the modern economy, diversification is made easier for investors because they can easily buy shares in many companies.
- A **share** in a company is partial ownership of that company.
- In some cases, an investor can make risk almost entirely disappear by using the strategy known as pooling.
- **Pooling** is a strong form of diversification, in which an investor takes a small share of the risk in many independent events.
- When an insurance company aggregates many independent events, it engages in **pooling of risks.**
- Pooling of risks often means that the owners of the insurance companies may not face much risk.

LIMITS OF DIVERSIFICATION

- Diversification can reduce and in some cases eliminate risk. But there are important limits to diversification.
- Lloyd's example: Between 1690 and 1815, Britain fought with France, which sponsored privateers—pirates with official backing—to raid British ships. So the loss of a ship to French privateers in the Caribbean and the loss of another ship to French privateers in the Indian Ocean would not be independent events.
- When an event is more likely to occur if some other event occurs, these two events are said to be **positively correlated.**
- Positively correlated financial risk:
  - severe weather
  - political events
  - business cycles
- There is always an irreducible core of risk that cannot be diversified.

PRIVATE INFORMATION: WHAT YOU DON'T KNOW CAN HURT YOU

- Markets deal well with risk when nobody knows what is going to happen.
- But markets have much more trouble with situations of **private information:** information that some people have but others do not.
- For example, you know if you are a careful driver, but your auto insurance company does not.
- Private information (also called asymmetric information) can distort economic decisions and prevent mutually beneficial economic transactions from taking place.
- Two sources of private information:
    1. Adverse selection
    2. Moral hazard

ADVERSE SELECTION: THE ECONOMICS OF LEMONS

- **Adverse selection:** because sellers know more about the quality of what they are selling than buyers, they have an incentive to select the worst things to sell.
- Private information leads buyers to expect hidden problems in items offered for sale, leading to low prices and to the best items being kept off the market.

ADVERSE SELECTION: THE ECONOMICS OF LEMONS

- Market for second-hand cars analyzed in the original article by Akerlof (Quarterly Journal of Economics,1970)

ADVERSE SELECTION: THE ECONOMICS OF LEMONS

- Purchasers and suppliers have different information about the quality of the goods being sold (The Market for Lemons)
- There are 100 people who want to sell their cars and 100 people who want to buy a car.
- Everyone knows that 50 cars are “plums” (good cars) and 50 cars are “lemons” (bad cars).
- The current owner of each car knows its quality but the perspective purchasers do not know whether any given car is a plum or a lemon

ADVERSE SELECTION: THE ECONOMICS OF LEMONS

- The owner of a lemon is willing to sell it for $1000 and the owner of a plum is willing to sell it for $2000.
- The buyers of the car are willing to pay $2400 for a plum and $1200 for a lemon.
- If it is easy to verify the quality of the cars there will be no problems in this market. The plums will be sold at some price between $2000 and $2400 and the lemons at some price between $1000 and $1200.
- But what happens to the market if the buyers cannot observe the quality of the car?

ADVERSE SELECTION: THE ECONOMICS OF LEMONS

- In this case the buyers have to guess about how much each car is worth
- We assume that, if a car is equally likely to be a plum or a lemon, then typical buyer would be willing to pay the expected value of the car.
- Using the numbers described above, this means that the buyer would be willing to pay

(1/2)*1200+(1/2)*2400=$1800

- But who would be willing to sell their car at that price?

ADVERSE SELECTION: THE ECONOMICS OF LEMONS

- The owners of the lemons certainly would, but the owners of the plums wouldn't be willing to sell their cars – by assumption they need at least $2000 to part with their cars.

- The price that the buyers are willing to pay for an "average" car is less than the price that the sellers of the plums want in order to part with their cars.

- This means that at the price of $1800 only lemons will be offered for sale.

ADVERSE SELECTION: THE ECONOMICS OF LEMONS

- But if the buyer was certain that he would get a lemon, then he would not be willing to pay $1800 for it.
- In fact, the equilibrium price in this market would have to be somewhere between $1000 and $1200. For a price in this range only owners of lemons would offer their cars.
- Even though the price at which buyers are willing to buy plums exceeds the price at which sellers are willing to sell them, no such transactions will take place.
- Why there is this market failure?

ADVERSE SELECTION: THE ECONOMICS OF LEMONS

- Why there is this market failure?

- The problem is that there is an externality between the sellers of good cars and bad cars; when an individual decides to try to sell a bad car, he affects the purchasers perception of the quality of an “average” car and thus hurts the people who are trying to sell a good car.

- The cars that are most likely to be offered for sale are the ones that people want most to get rid of. The act of offering to sell something sends a signal to the prospective buyer about its quality.

LEARN BY DOING: PRACTICE QUESTION 2

- In a particular used car market there is a 50% probability that any car for sale is a lemon (poor quality) and a 50% probability that any car for sale is a plum (high quality). A lemon in this market is worth $2,000, and a plum is worth $10,000. If buyers cannot distinguish between a lemon and a plum, what is the expected price buyers will pay for a used car?

  a) $2,500, since they will assume most of the cars are lemons

  b) $10,000, since they will assume all cars are plums

  c) $4,000, since the downside of getting a lemon is a bad outcome for buyers, so they will not be willing to pay much

  d) $6,000, since this represents the expected value of used cars in this market

LEARN BY DOING: PRACTICE QUESTION 2 (Answer)

- In a particular used car market there is a 50% probability that any car for sale is a lemon (poor quality) and a 50% probability that any car for sale is a plum (high quality). A lemon in this market is worth $2,000, and a plum is worth $10,000. If buyers cannot distinguish between a lemon and a plum, what is the expected price buyers will pay for a used car?

  a) $2,500, since they will assume most of the cars are lemons

  b) $10,000, since they will assume all cars are plums

  c) $4,000, since the downside of getting a lemon is a bad outcome for buyers, so they will not be willing to pay much

  d) $6,000, since this represents the expected value of used cars in this market (correct answer)

LEARN BY DOING: PRACTICE QUESTION 3

- Over time, if buyers cannot distinguish lemons from plums in this market:
  a) the market will eventually be composed only of plums.
  b) the market will eventually be composed only of lemons.
  c) buyers will have an equal likelihood of purchasing a lemon or a plum.
  d) buyers will exit the market and not purchase any used cars.

LEARN BY DOING: PRACTICE QUESTION 3 (Answer)

- Over time, if buyers cannot distinguish lemons from plums in this market:

  a) the market will eventually be composed only of plums.

  b) the market will eventually be composed only of lemons. (correct answer)

  c) buyers will have an equal likelihood of purchasing a lemon or a plum.

  d) buyers will exit the market and not purchase any used cars.

SOLUTIONS FOR ADVERSE SELECTION

- **Screening:** using observable information about people to make inferences about their private information
  - Women get in fewer accidents than men, so their auto insurance is cheaper.

SOLUTIONS FOR ADVERSE SELECTION PART

- Adverse selection can be diminished by people **signaling** their private information through actions that credibly reveal what they know.
  - For example, dealers often offer warranties—promises to repair any problems with the cars.
- A long-term reputation allows sellers to reassure others that they aren't concealing adverse private information.

PRIVATE INFORMATION: MORAL HAZARD

- **Moral hazard** occurs when someone knows more about his or her own actions than other people do. This leads to a distortion of incentives.
  - If you are insured, you might not lock your doors as reliably as you would otherwise.

SOLUTIONS FOR MORAL HAZARD

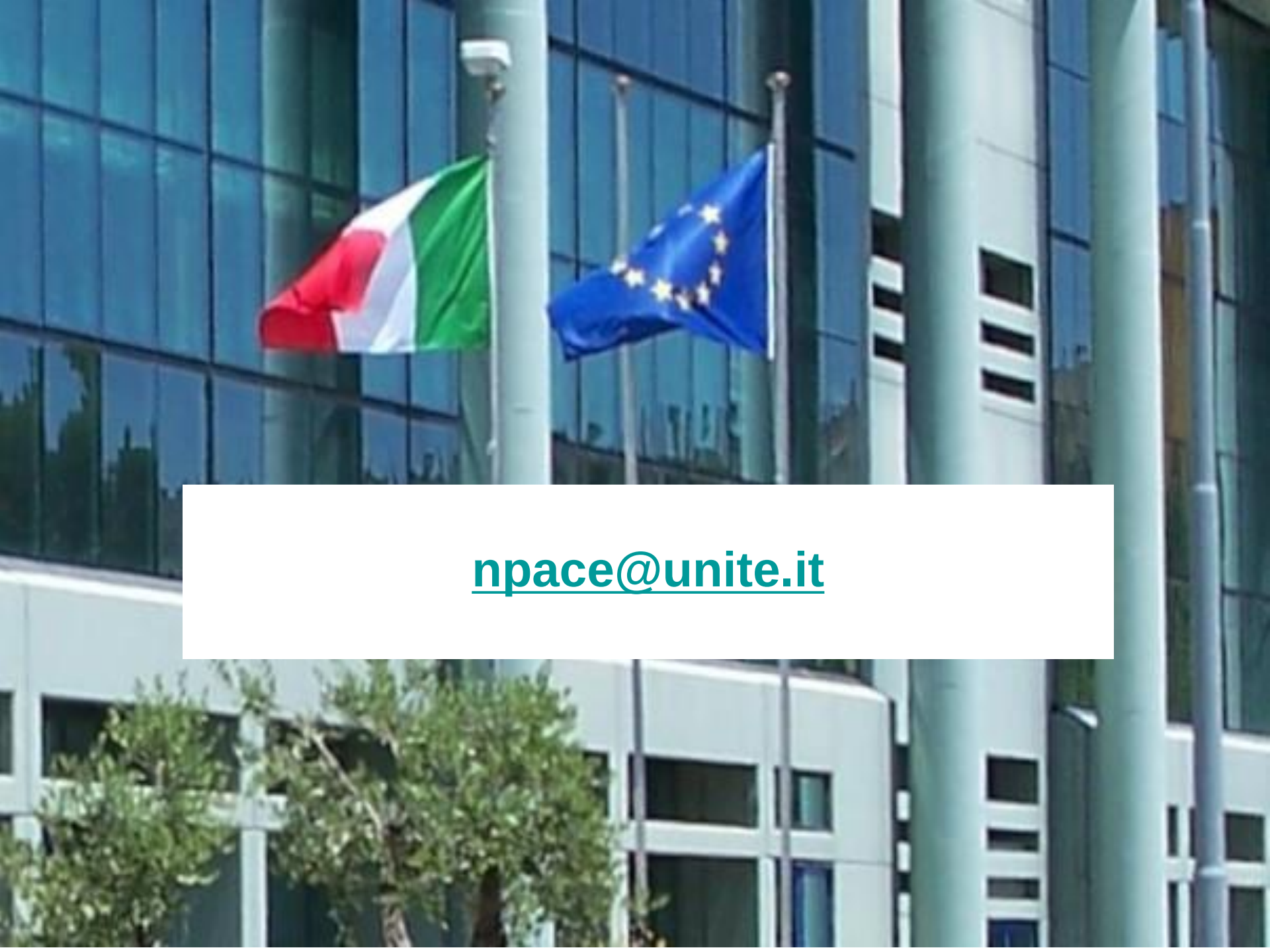
- Insurance companies deal with moral hazard by requiring a deductible: they compensate for losses only above a certain amount, so that coverage is always less than 100 percent.
- **Deductible:** a sum that the insured individual must pay before being compensated for a claim.

LEARN BY DOING: PRACTICE QUESTION 4

- Harold is starting a car insurance company and is offering to provide 100% coverage to his customers. Harold is likely to encounter:
  a) a moral hazard problem associated with this offer.
  b) an adverse selection problem associated with this offer.

LEARN BY DOING: PRACTICE QUESTION 4 (Answer)

- Harold is starting a car insurance company and is offering to provide 100% coverage to his customers. Harold is likely to encounter:
  a) **a moral hazard problem associated with this offer. (correct answer)**
  b) an adverse selection problem associated with this offer.



npace@unite.it