Chapter 9

THE ECONOMICS OF INFORMATION

Properties of Information

- Information is not easy to define
  - it is difficult to measure the quantity of information obtainable from different actions
  - there are too many forms of useful information to permit the standard price-quantity characterization used in supply and demand analysis

Properties of Information

- Studying information also becomes difficult due to some technical properties of information
  - it is durable and retains value after its use
  - it can be nonrival and nonexclusive
    - in this manner it can be considered a public good

The Value of Information

- In many respects, lack of information does represent a problem involving uncertainty for a decision maker
  - the individual may not know exactly what the consequences of a particular action will be
- Better information can reduce uncertainty and lead to better decisions and higher utility

The Value of Information

- Assume an individual forms subjective opinions about the probabilities of two states of the world
  - "good times" (probability = π_g) and "bad times" (probability = π_b)
- Information is valuable because it helps the individual revise his estimates of these probabilities

The Value of Information

- Assume that information can be measured by the number of “messages” (*m*) purchased
  - π_g and π_b will be functions of *m*

The Value of Information

- The individual's goal will be to maximize

$$E(U) = \pi_g U(W_g) + \pi_b U(W_b)$$

subject to

$$I = p_g W_g + p_b W_b + p_m m$$

- We need to set up the Lagrangian

$$\mathbf{L} = \pi_g U(W_g) + \pi_b U(W_b) + \lambda(I - p_g W_g - p_b W_b - p_m m)$$

The Value of Information

- First-order conditions for a constrained maximum are:

$$\frac{\partial \mathbf{L}}{\partial W_g} = \pi_g U'(W_g) - \lambda p_g = 0$$

$$\frac{\partial \mathbf{L}}{\partial W_b} = \pi_b U'(W_b) - \lambda p_b = 0$$

$$\frac{\partial \mathbf{L}}{\partial \lambda} = I - p_g W_g - p_b W_b - p_m m = 0$$

The Value of Information

- First-order conditions for a constrained maximum are:

$$\frac{\partial \mathbf{L}}{\partial m} = \pi_g U'(W_g)\frac{dW_g}{dm} + \pi_b U'(W_b)\frac{dW_b}{dm}$$
$$+ U(W_g)\frac{d\pi_g}{dm} + U(W_b)\frac{d\pi_b}{dm} - \lambda p_g \frac{dW_g}{dm}$$
$$- \lambda p_b \frac{dW_b}{dm} - \lambda p_m = 0$$

The Value of Information

- The first two equations show that the individual will maximize utility at a point where the subjective ratio of expected marginal utilities is equal to the price ratio (p_g / p_b)
- The last equation shows the utility-maximizing level of information to buy

Asymmetry of Information

- The level of information that a person buys will depend on the price per unit
- Information costs may differ significantly across individuals
  - some may possess specific skills for acquiring information
  - some may have experience that is relevant
  - some may have made different former investments in information services

Information and Insurance

- There are a number of information asymmetries in the market for insurance
- Buyers are often in a better position to know the likelihood of uncertain events
  - may also be able to take actions that impact these probabilities

Moral Hazard

- Moral hazard is the effect of insurance coverage on individuals' decisions to take activities that may change the likelihood or size of losses
  - parking an insured car in an unsafe area
  - choosing not to install a sprinkler system in an insured home

Moral Hazard

- Suppose a risk-averse individual faces the risk of a loss (l) that will lower wealth
  - the probability of a loss is π
  - this probability can be lowered by the amount the person spends on preventive measures (a)

Moral Hazard

- Wealth in the two states is given by

$$W_1 = W_0 - a$$

$$W_2 = W_0 - a - l$$

- The individual chooses a to maximize

$$E(U) = E = (1-\pi)U(W_1) + \pi U(W_2)$$

Moral Hazard

- The first-order condition for a maximum is

$$\frac{\partial E}{\partial a} = -U(W_1)\frac{\partial \pi}{\partial a} - (1-\pi)U'(W_1) + U(W_2)\frac{\partial \pi}{\partial a} - \pi U'(W_2) = 0$$

$$\pi U'(W_2) + (1-\pi)U'(W_1) = [U(W_2) - U(W_1)]\frac{\partial \pi}{\partial a}$$

  - the optimal point is where the expected marginal utility cost from spending one additional dollar on prevention is equal to the reduction in the expected value of the utility loss that may be encountered in bad times

Behavior with Insurance and Perfect Monitoring (skipped)

- Suppose that the individual may purchase insurance (premium = p) that pays x if a loss occurs
- Wealth in each state becomes

$$W_1 = W_0 - a - p$$

$$W_2 = W_0 - a - p - l + x$$

- A fair premium would be equal to

$$p = \pi x$$

Behavior with Insurance and Perfect Monitoring

- The person can maximize expected utility by choosing x such that $W_1 = W_2$
- The first-order condition is

$$\frac{\partial E}{\partial a} = -(1-\pi)U'(W_1)\left(1+l\frac{\partial \pi}{\partial a}\right) - U(W_1)\frac{\partial \pi}{\partial a}$$

$$-\pi U'(W_2)\left(1+l\frac{\partial \pi}{\partial a}\right) + U(W_2)\frac{\partial \pi}{\partial a} = 0$$

Behavior with Insurance and Perfect Monitoring

- Since $W_1 = W_2$, this condition becomes

$$1 = -l\frac{\partial \pi}{\partial a}$$

  - at the utility maximizing choice, the marginal cost of an extra unit of prevention should equal the marginal reduction in the expected loss provided by the extra spending
  - with full insurance and actuarially fair premiums, precautionary purchases still occur at the optimal level

Moral Hazard

- So far, we have assumed that insurance providers know the probability of a loss and can charge the actuarially fair premium
  - this is doubtful when individuals can undertake precautionary activities
  - the insurance provider would have to constantly monitor each person's activities to determine the correct probability of loss

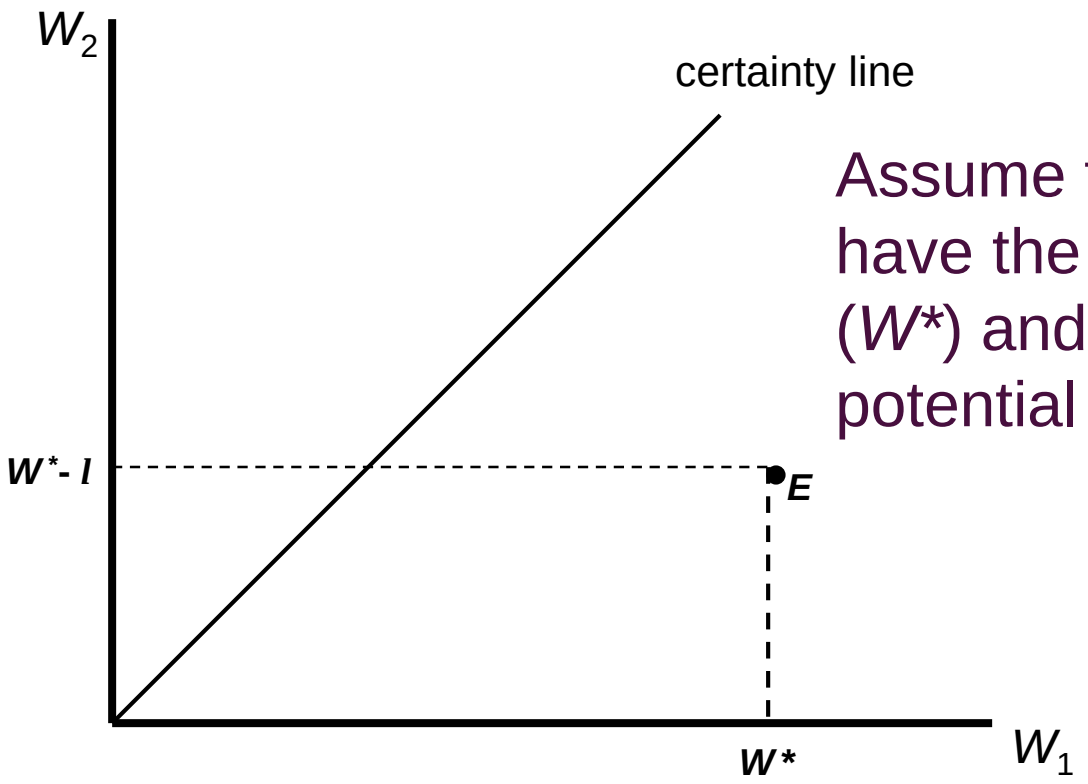
Moral Hazard

- In the simplest case, the insurer might set a premium based on the average probability of loss experienced by some group of people
  - no variation in premiums allowed for specific precautionary activities
    - each individual would have an incentive to reduce his level of precautionary activities

Adverse Selection

- Individuals may have different probabilities of experiencing a loss
- If individuals know the probabilities more accurately than insurers, insurance markets may not function properly
  - it will be difficult for insurers to set premiums based on accurate measures of expected loss

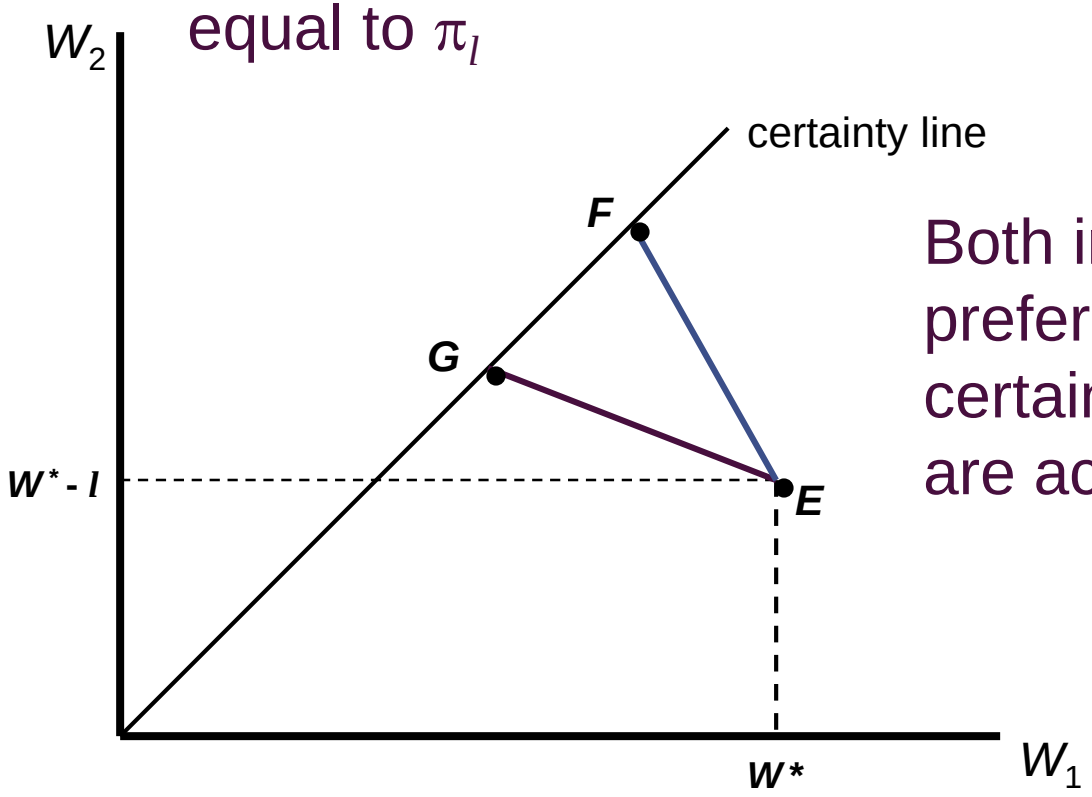
Adverse Selection



Assume that two individuals have the same initial wealth (W^*) and each face a potential loss of l

Adverse Selection

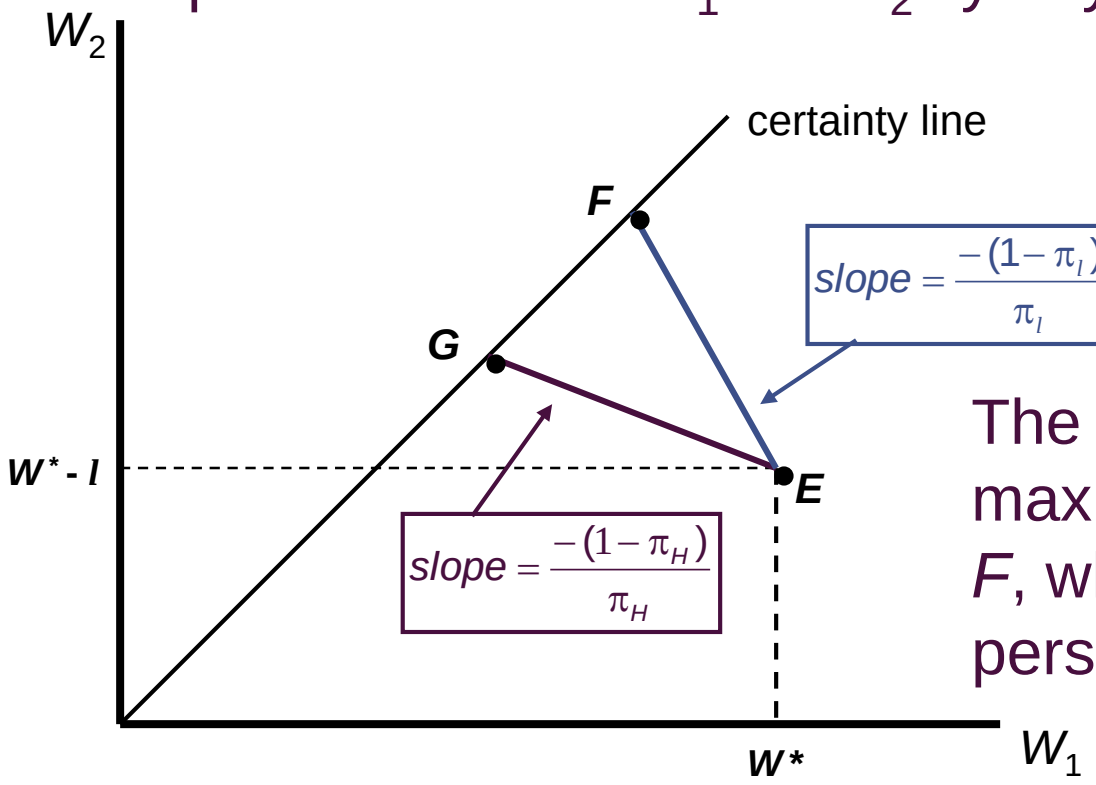
Suppose that one person has a probability of loss equal to π_H, while the other has a probability of loss equal to π_l



Both individuals would prefer to move to the certainty line if premiums are actuarially fair

Adverse Selection

The lines show the market opportunities for each person to trade W_1 for W_2 by buying fair insurance



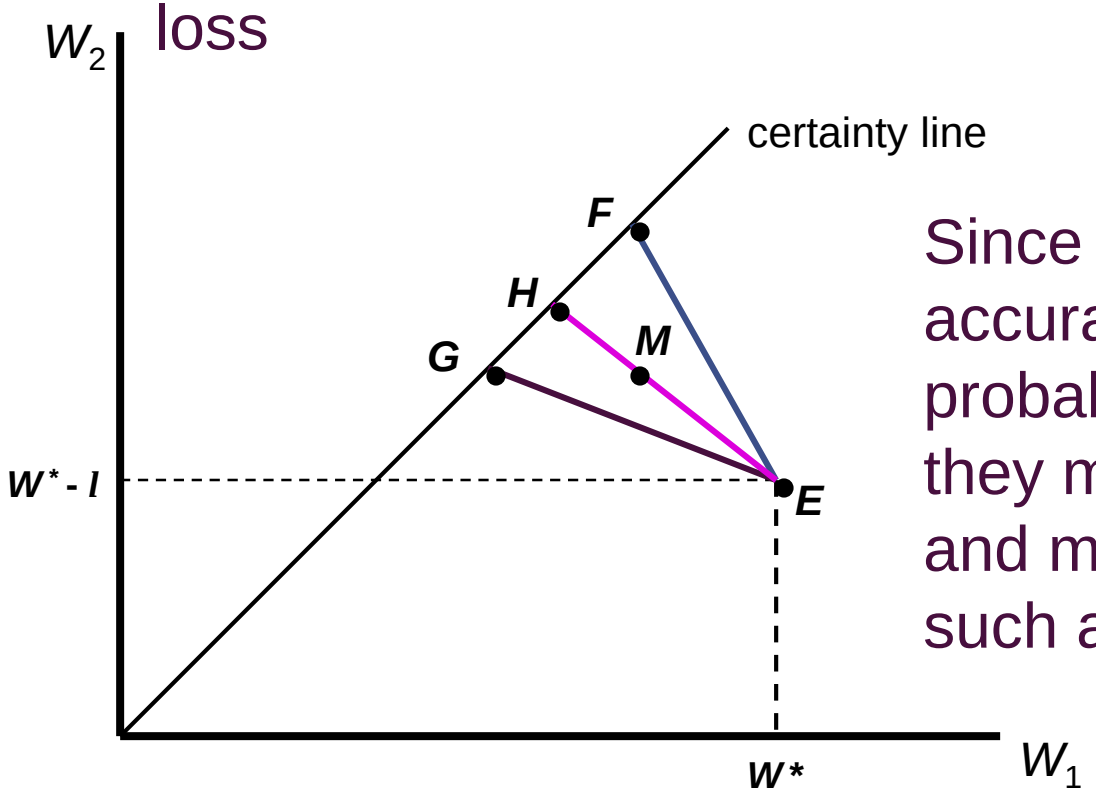
The low-risk person will maximize utility at point *F*, while the high-risk person will choose *G*

Adverse Selection

- If insurers have imperfect information about which individuals fall into low- and high-risk categories, this solution is unstable
  - point *F* provides more wealth in both states
  - high-risk individuals will want to buy insurance that is intended for low-risk individuals
  - insurers will lose money on each policy sold

Adverse Selection

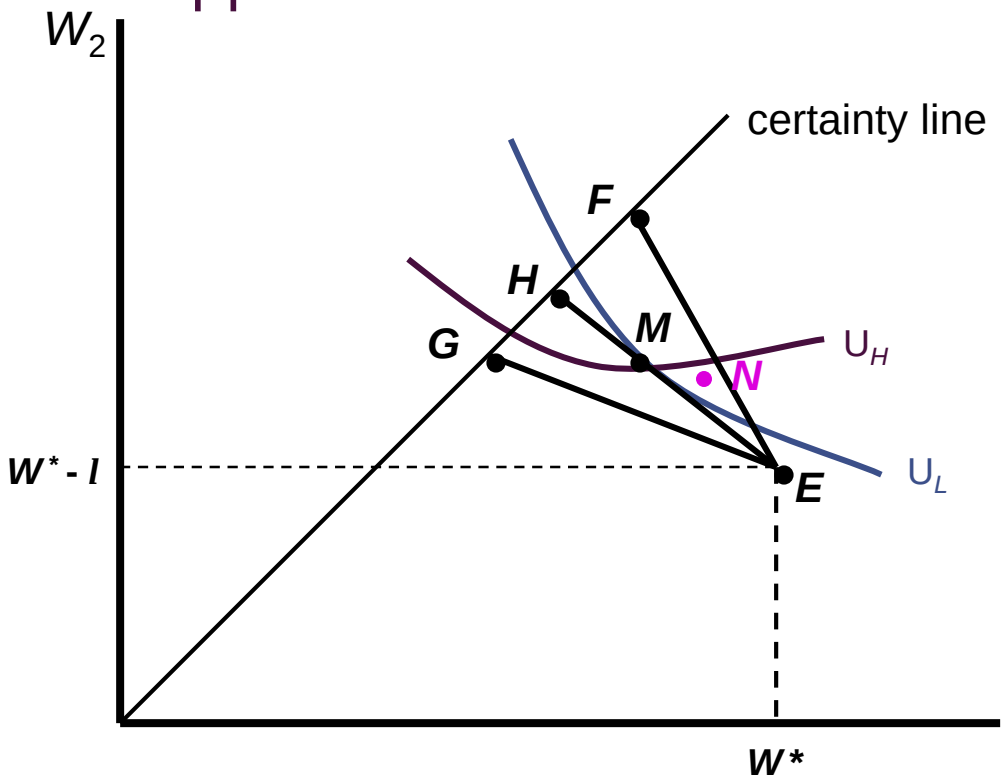
One possible solution would be for the insurer to offer premiums based on the average probability of loss



Since *EH* does not accurately reflect the true probabilities of each buyer, they may not fully insure and may choose a point such as *M*

Adverse Selection

Point *M* is not an equilibrium because further trading opportunities exist for low-risk individuals



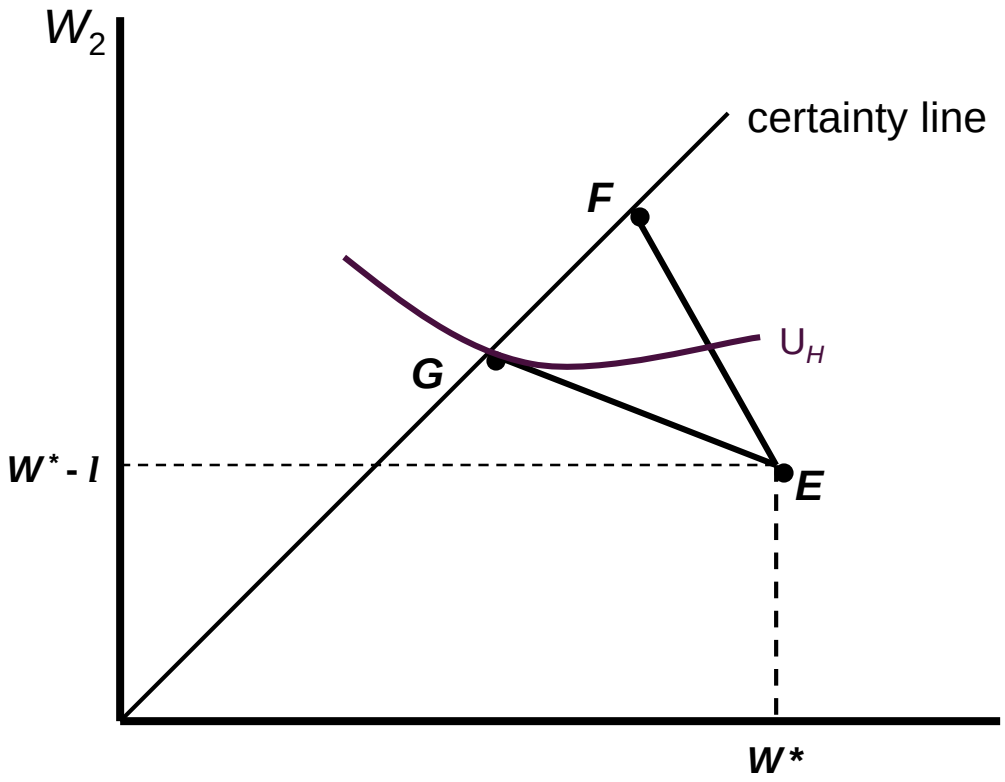
An insurance policy such as *N* would be unattractive to high-risk individuals, but attractive to low-risk individuals and profitable for insurers

Adverse Selection

- If a market has asymmetric information, the equilibria must be separated in some way
  - high-risk individuals must have an incentive to purchase one type of insurance, while low-risk purchase another

Adverse Selection

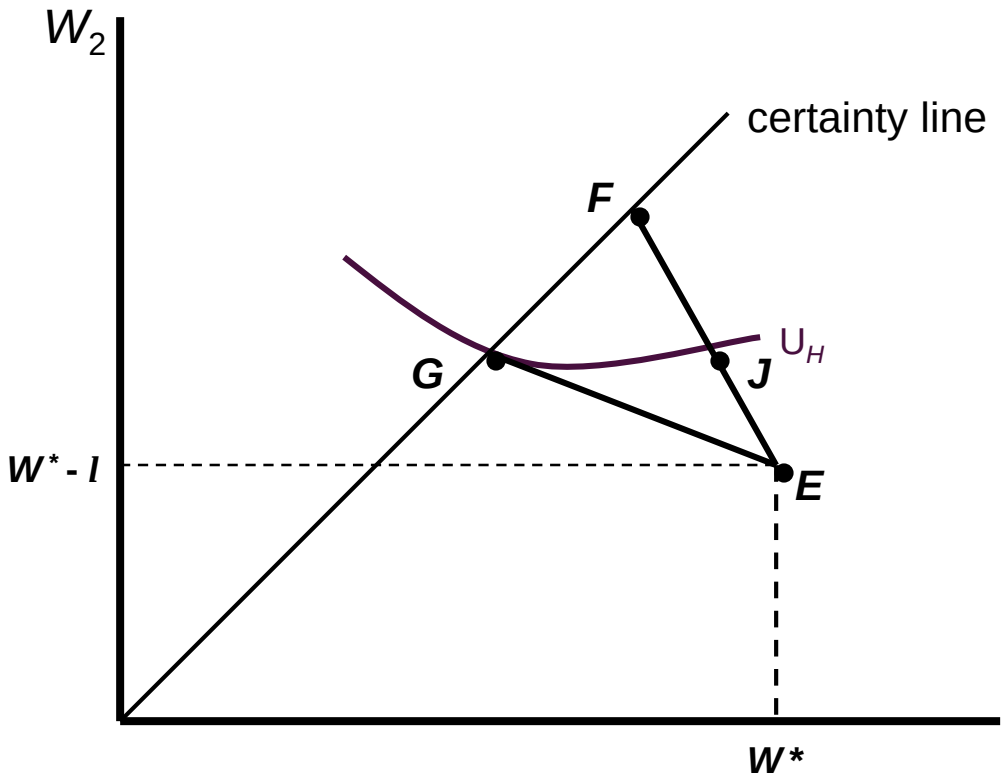
Suppose that insurers offer policy *G*. High-risk individuals will opt for full insurance.



Insurers cannot offer any policy that lies above U_H because they cannot prevent high-risk individuals from taking advantage of it

Adverse Selection

The best policy that low-risk individuals can obtain is one such as *J*



The policies *G* and *J* represent a separating equilibrium

Adverse Selection

- Low-risk individuals could try to signal insurers their true probabilities of loss
  - insurers must be able to determine if the signals are believable
  - insurers may be able to infer accurate probabilities by observing their clients' market behavior
  - the separating equilibrium identifies an individual's risk category

Adverse Selection

- Market signals can be drawn from a number of sources
  - the economic behavior must accurately reflect risk categories
  - the costs to individuals of taking the signaling action must be related to the probability of loss

The Principal-Agent Relationship

- One important way in which asymmetric information may affect the allocation of resources is when one person hires another person to make decisions
  - patients hiring physicians
  - investors hiring financial advisors
  - car owners hiring mechanics
  - stockholders hiring managers

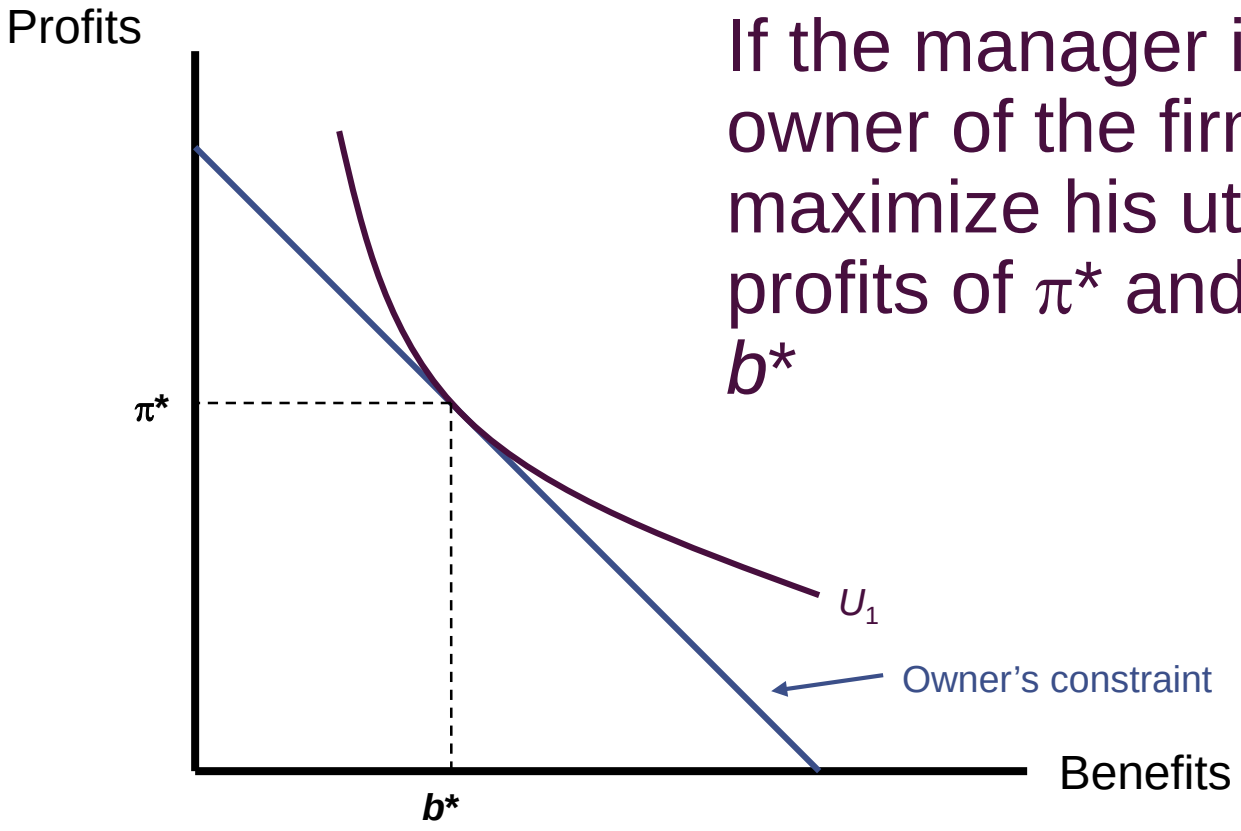
The Principal-Agent Relationship

- In each of these cases, a person with less information (the principal) is hiring a more informed person (the agent) to make decisions that will directly affect the principal's own well-being

The Principal-Agent Relationship

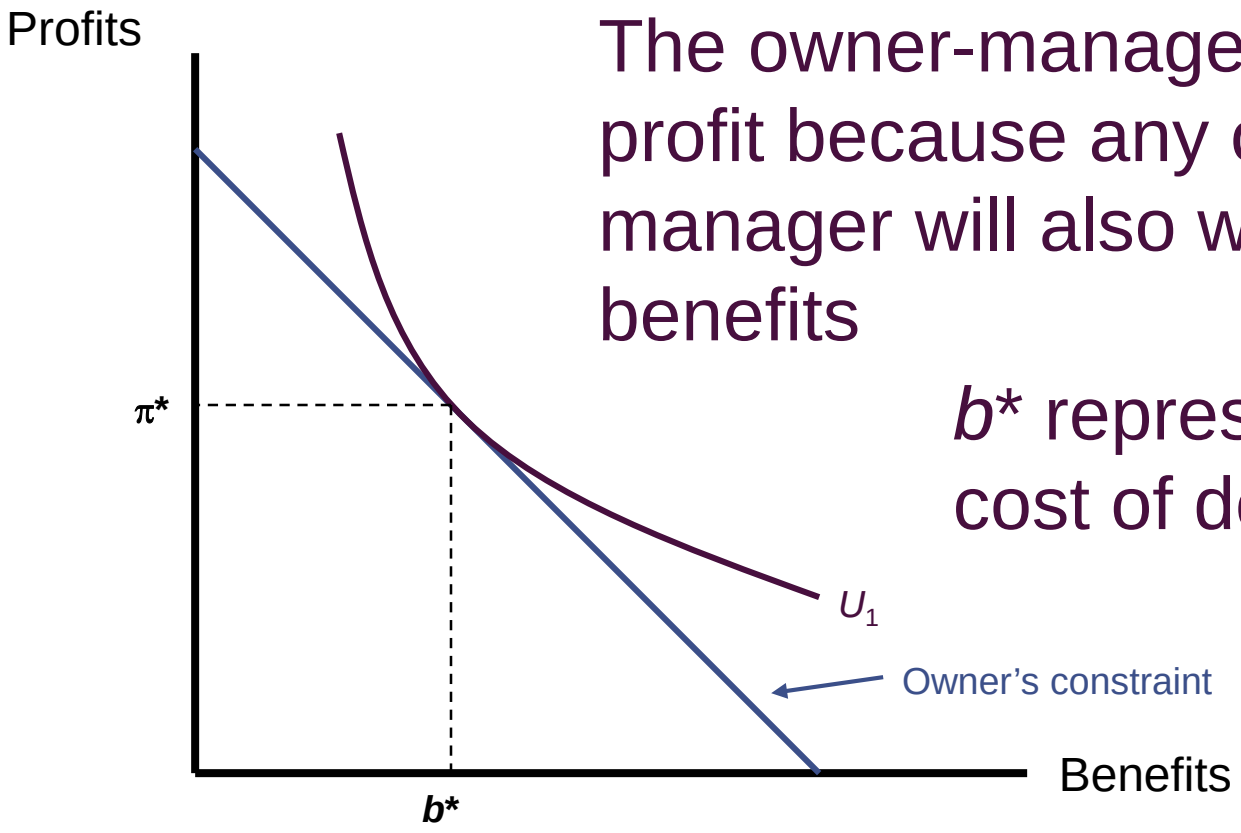
- Assume that we can show a graph of the owner's (or manager's) preferences in terms of profits and various benefits (such as fancy offices or use of the corporate jet)
- The owner's budget constraint will have a slope of -1
  - each $1 of benefits reduces profit by $1

The Principal-Agent Relationship



If the manager is also the owner of the firm, he will maximize his utility at profits of π^* and benefits of b^*

The Principal-Agent Relationship



The owner-manager maximizes profit because any other owner-manager will also want *b** in benefits

*b** represents a true cost of doing business

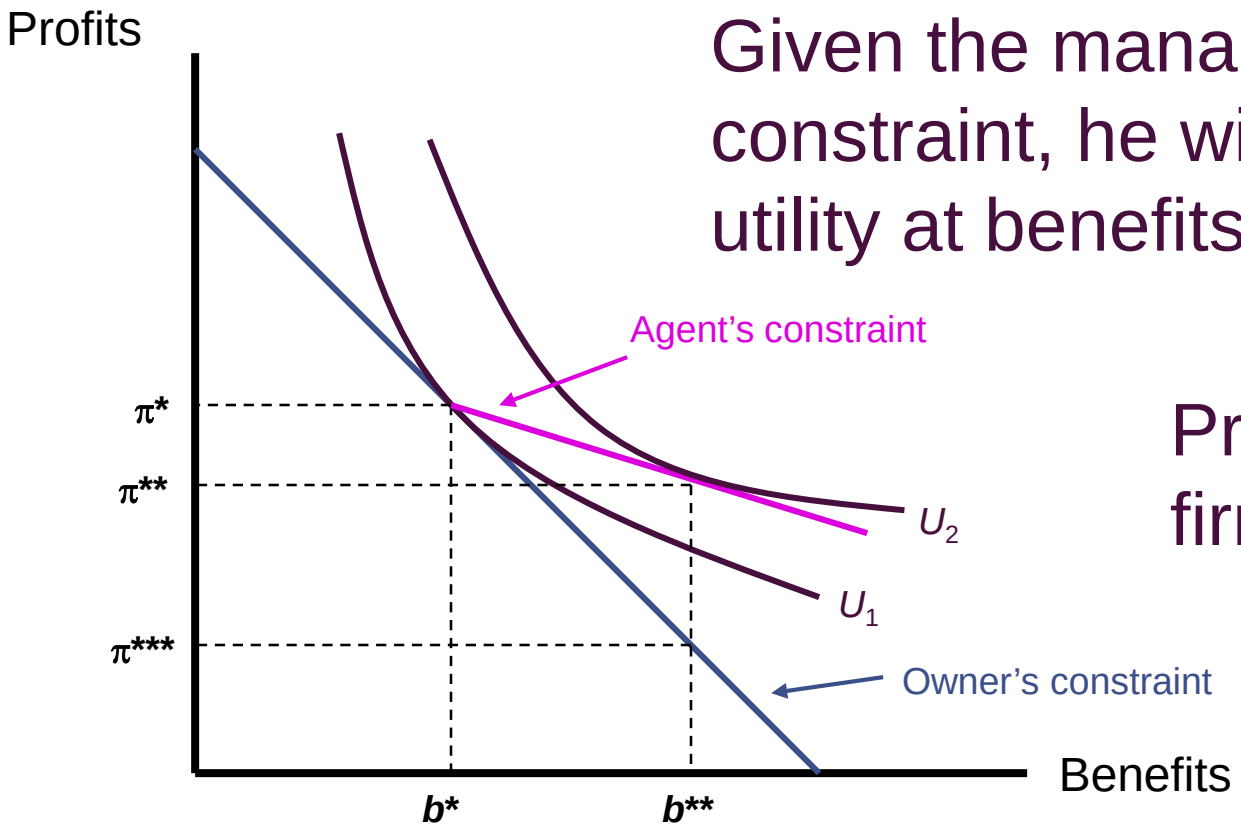
The Principal-Agent Relationship

- Suppose that the manager is not the sole owner of the firm
  - suppose there are two other owners who play no role in operating the firm
- $1 in benefits only costs the manager $0.33 in profits
  - the other $0.67 is effectively paid by the other owners in terms of reduced profits

The Principal-Agent Relationship

- The new budget constraint continues to include the point b^*, π^*
  - the manager could still make the same decision that a sole owner could)
- For benefits greater than b^*, the slope of the budget constraint is only -1/3

The Principal-Agent Relationship



Given the manager's budget constraint, he will maximize utility at benefits of *b***

Profits for the firm will be π***

The Principal-Agent Relationship

- The firm's owners are harmed by having to rely on an agency relationship with the firm's manager
- The smaller the fraction of the firm that is owned by the manager, the greater the distortions that will be induced by this relationship

Using the Corporate Jet

- A firm owns a fleet of corporate jets used mainly for business purposes
  - the firm has just fired a CEO for misusing the corporate fleet
- The firm wants to structure a management contract that provides better incentives for cost control

Using the Corporate Jet

- Suppose that all would-be applicants have the same utility function

$$U(s,j) = 0.1s^{0.5} + j$$

  where s is salary and j is jet use (0 or 1)
- All applicants have job offers from other firms promising them a utility level of at most 2.0

Using the Corporate Jet

- Because jet use is expensive, $\pi = 800$ (thousand) if $j = 0$ and $\pi = 162$ if $j = 1$
  - the directors will be willing to pay the new CEO up to 638 providing that they can guarantee that he will not use the corporate jet for personal use
  - a salary of more than 400 will just be sufficient to get a potential candidate to accept the job without jet usage

Using the Corporate Jet

- If the directors find it difficult to monitor the CEO's jet usage, this could mean that the firm ends up with $\pi < 0$
- The owner's may therefore want to create a contract where the compensation of the new CEO is tied to profit

The Owner-Manager Relationship

- Suppose that the gross profits of the firm depend on some specific action that a hired manager might take (a)

$$\text{net profits} = \pi' = \pi(a) - s[\pi(a)]$$

- Both gross and net profits are maximized when $\partial\pi/\partial a = 0$
  - the owners' problem is to design a salary structure that provides an incentive for the manager to choose a that maximizes π

The Owner-Manager Relationship

- The owners face two issues
  - they must know the agent's utility function which depends on net income (I^M)

$$I^M = s[\pi(a)] = c(a) = c_0$$

    - where $c(a)$ represents the cost to the manager of undertaking a
  - they must design the compensation system so that the agent is willing to take the job
    - this requires that $I^M \geq 0$

The Owner-Manager Relationship

- One option would be to pay no compensation unless the manager chooses a^* and to pay an amount equal to $c(a^*) + c_0$ if a^* is chosen
- Another possible scheme is $s(a) = \pi(a) - f$, where $f = \pi(a) - c(a^*) - c_0$
  - with this compensation package, the manager's income is maximized by setting $\partial s(a)/\partial a = \partial \pi/\partial a = 0$

The Owner-Manager Relationship

- The manager will choose a^* and receive an income that just covers costs

$$I^M = s(a^*) - c(a^*) - c_0 = \pi(a^*) - f - c(a^*) - c_0 = 0$$

- This compensation plan makes the agent the "residual claimant" to the firm's profits

Asymmetric Information

- Models of the principal-agent relationship have introduced asymmetric information into this problem in two ways
  - it is assumed that a manager's action is not directly observed and cannot be perfectly inferred from the firm's profits
    - referred to as "hidden action"
  - the agent-manager's objective function is not directly observed
    - referred to as "hidden information"

Hidden Action

- The primary reason that the manager's action may be hidden is that profits depend on random factors that cannot be observed by the firm's owner
- Suppose that profits depend on both the manager's action and on a random variable (u)

$$\pi(a) = \pi'(a) + u$$

where π' represents expected profits

Hidden Action

- Because owners observe only π and not π', they can only use actual profits in their compensation function
  - a risk averse manager will be concerned that actual profits will turn out badly and may decline the job
- The owner might need to design a compensation scheme that allows for profit-sharing

Hidden Information

- When the principal does not know the incentive structure of the agent, the incentive scheme must be designed using some initial assumptions about the agent's motivation
  - will be adapted as new information becomes available

Important Points to Note:

- Information is valuable because it permits individuals to increase the expected utility of their decisions
  - individuals might be willing to pay something to acquire additional information

Important Points to Note:

- Information has a number of special properties that suggest that inefficiencies associated with imperfect and asymmetric information may be quite prevalent
  - differing costs of acquisition
  - some aspects of a public good

Important Points to Note:

- The presence of asymmetric information may affect a variety of market outcomes, many of which are illustrated in the context of insurance theory
  - insurers may have less information about potential risks than do insurance purchasers

Important Points to Note:

- If insurers are unable to monitor the behavior of insured individuals accurately, moral hazard may arise
  - being insured will affect the willingness to make precautionary expenditures
  - such behavioral effects can arise in any contractual situation in which monitoring costs are high

Important Points to Note:

- Informational asymmetries can also lead to adverse selection in insurance markets
  - the resulting equilibria may often be inefficient because low-risk individuals will be worse off than in the full information case
  - market signaling may be able to reduce these inefficiencies

Important Points to Note:

- Asymmetric information may also cause some (principal) economic actors to hire others (agents) to make decisions for them
  - providing the correct incentives to the agent is a difficult problem