# Lecture 4: Asymmetric Information

TIØ4285 Production and Network Economics

Spring 2021

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Check-in registration is mandatory when physically attending the lecture in G1.

# Outline

- Asymmetric information
  - Definition
  - Why is it a problem?
- Adverse selection
  - Definition
  - Problems arising from adverse selection
    - Market for “Lemons”
    - Price discrimination
    - Market power
- Principal-Agent problems / Moral Hazard
  - Definition
  - Production efficiency
  - Risk sharing/ trade-off with production efficiency
  - Contract design

# Definition – asymmetric information

- Some player has useful private information
  - An information partition that is different and not worse than another player's
- In contrast: in the case of symmetric information no player has an informational advantage
- Example: seller knows the quality of a product whilst the buyer does not
- In a competitive market with full information, consumers can buy whatever quality good they want at its marginal cost
  - This may not be the case when we have asymmetric information

# Opportunistic behavior

- Taking selfish advantage of circumstances
  - little regard for principles
- The more informed party exploits the less informed party
  - Takes advantage of the information asymmetry
- Leads to market failures

# Problems arising from asymmetric information

- There are two main form of problems arising from asymmetric information
  - Adverse selection
  - Moral hazard

- Both exist because of opportunistic behavior

# Adverse selection

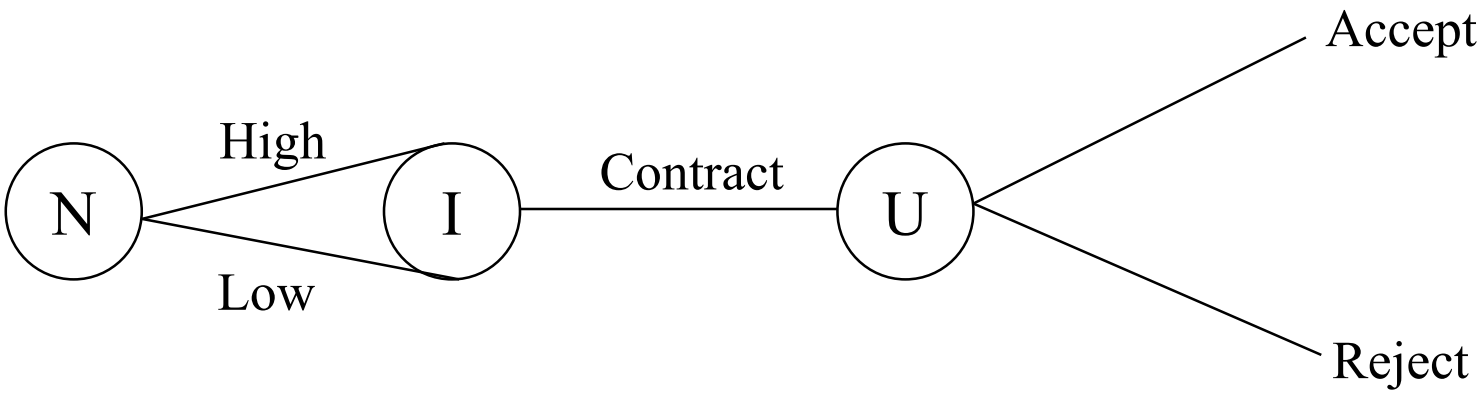
- An informed person benefiting from trading with a less informed person through an unobserved characteristic of the informed person

- Example:
  - Insurance
  - Market for “Lemons”
  - Maternity leave

- Creates market failure by reducing the size of a market
  - Prevents desirable transactions

# Adverse selection – game tree

- N = Nature
- I = Informed player
- U = Uninformed player



# Moral hazard

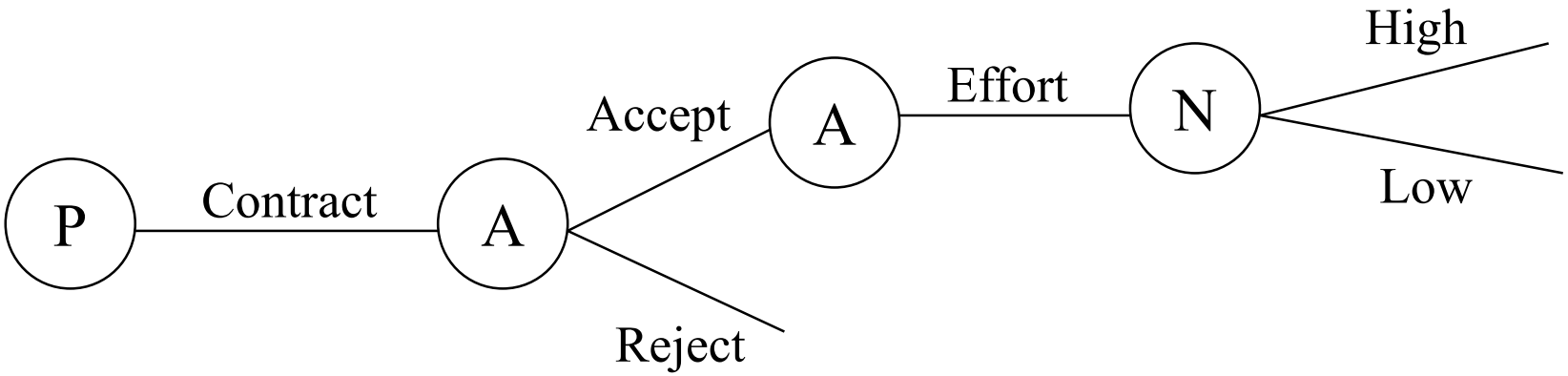
- An informed person benefiting from trading with a less informed person through an unobserved action or through unobserved information

- Example:
  - Insurance
  - Employee

- Creates market failures by reducing efficiency/ harm society

# Moral hazard with hidden action

- N = Nature
- P = Principal
- A = Agent



# Moral hazard with hidden information

- N = Nature
- P = Principal
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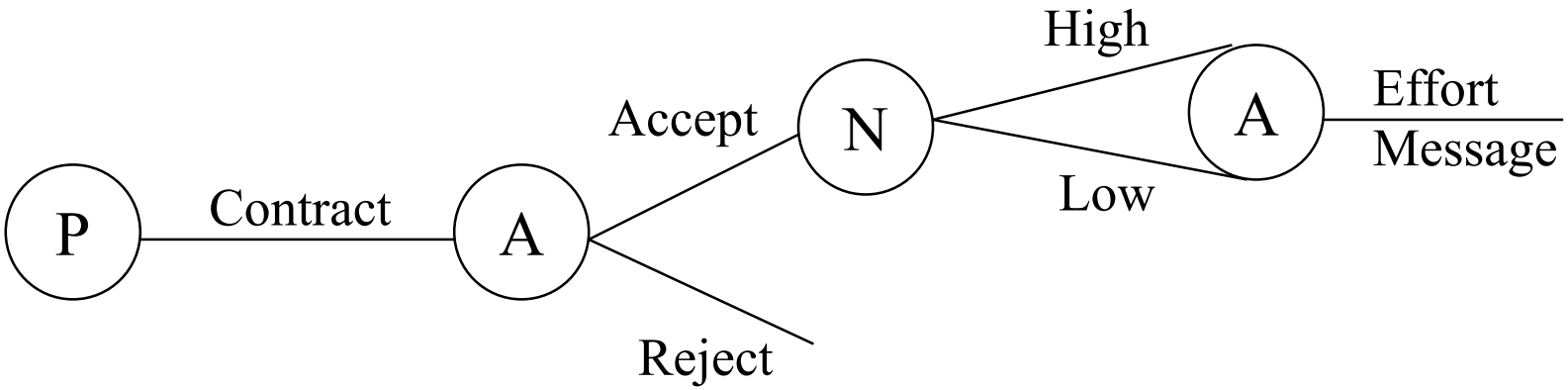


# Example: Difference between moral hazard and adverse selection

- George and Marge both enjoy skydiving (which is unknown to the insurance company)
- Both wish to sign a life insurance because of the high risk associated with skydiving
- George will skydive whether or not he has a life insurance
- Marge will only skydive if she has a life insurance

- Consider the insurance company:
  - Is adverse selection a problem here?
  - What about moral hazard?

# Consequences of adverse selection

# Drive out high quality goods

- Sellers have more information than buyers
- Good quality products are driven out of the market by lower quality products

- Example:
  - Used cars (Lemons)

# Example: Market for Lemons

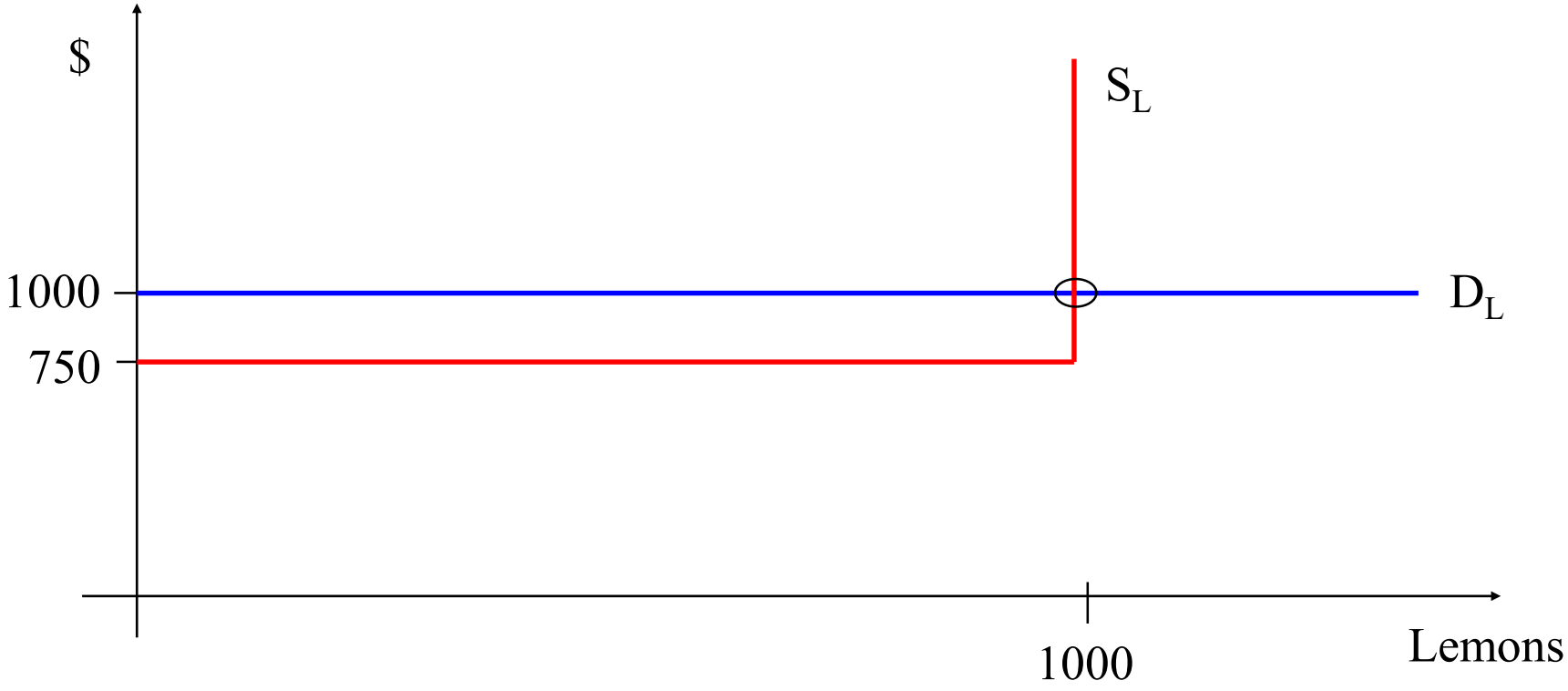
- Used cars market
- Assumptions:
  - All cars look the same (you can not see the quality by studying the car)
  - There are two groups of qualities: good cars and lemons
  - Many potential buyers, each will pay
    - 1000 $ for a lemon
    - 2000 $ for a good car
  - There are 1000 lemons and 1000 good cars for sale
  - The reservation price for the sellers are
    - 750 $ for lemons
    - v $ for good cars (v is less than 2000 $)

# Example (cont.)
# - symmetric information

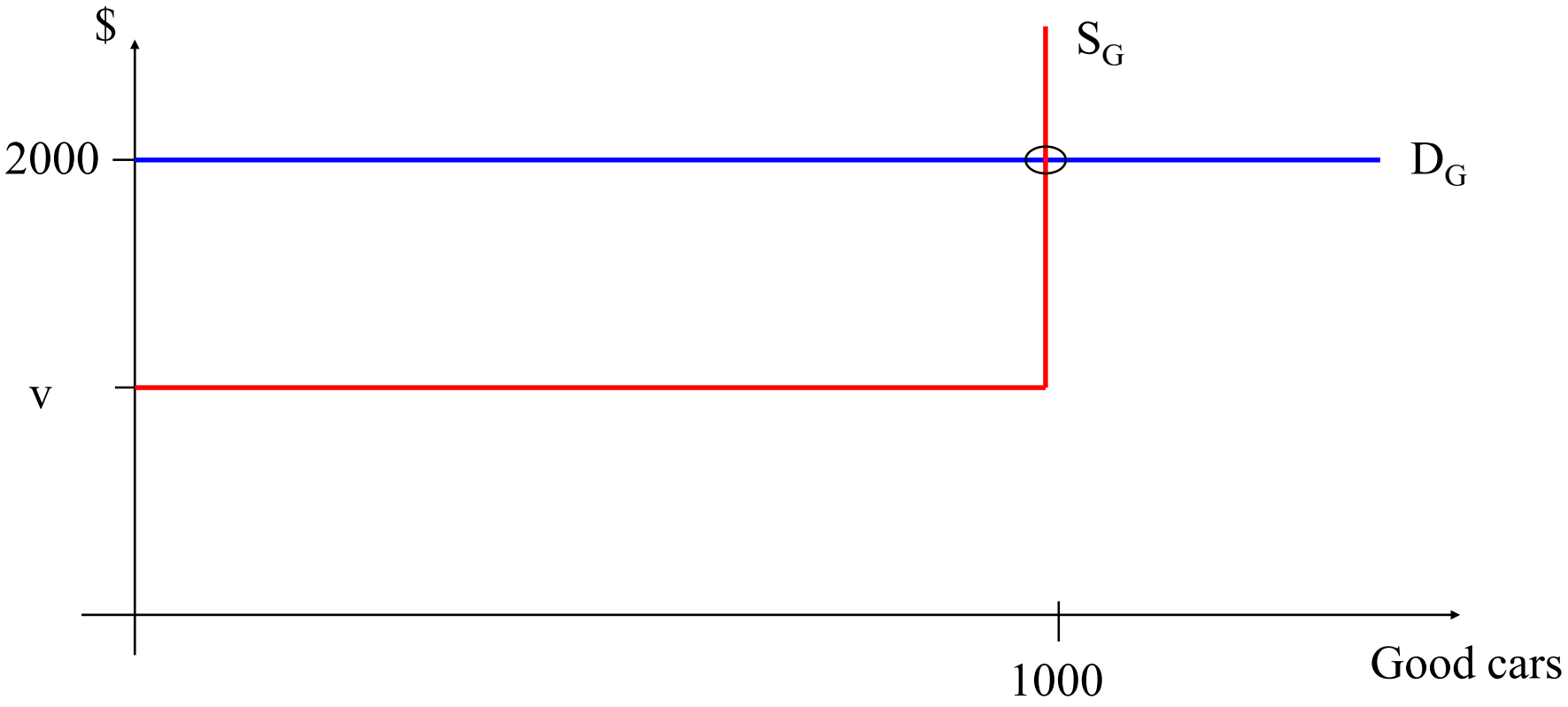
- Both sellers and buyers know the quality of the cars

- Efficient market
  - The goods go to the people who value them the most

# Example – symmetric information (equilibrium in the market for lemons)



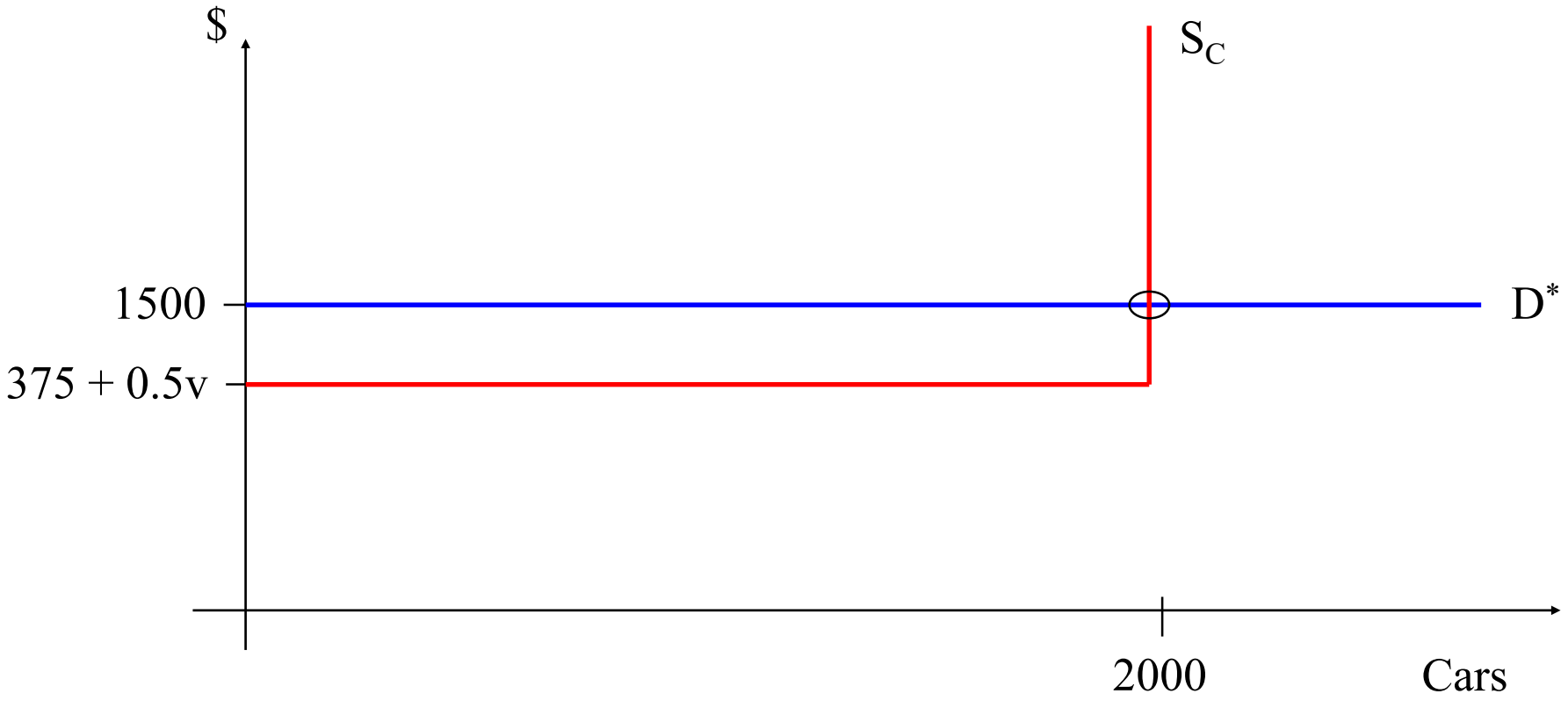
# Example – symmetric information (equilibrium in the market for good cars)



# Example (cont.)
# - symmetric information

- Neither sellers nor buyers know the quality of the cars
- Assume sellers and buyers are risk neutral
- Expected value is 1500 $

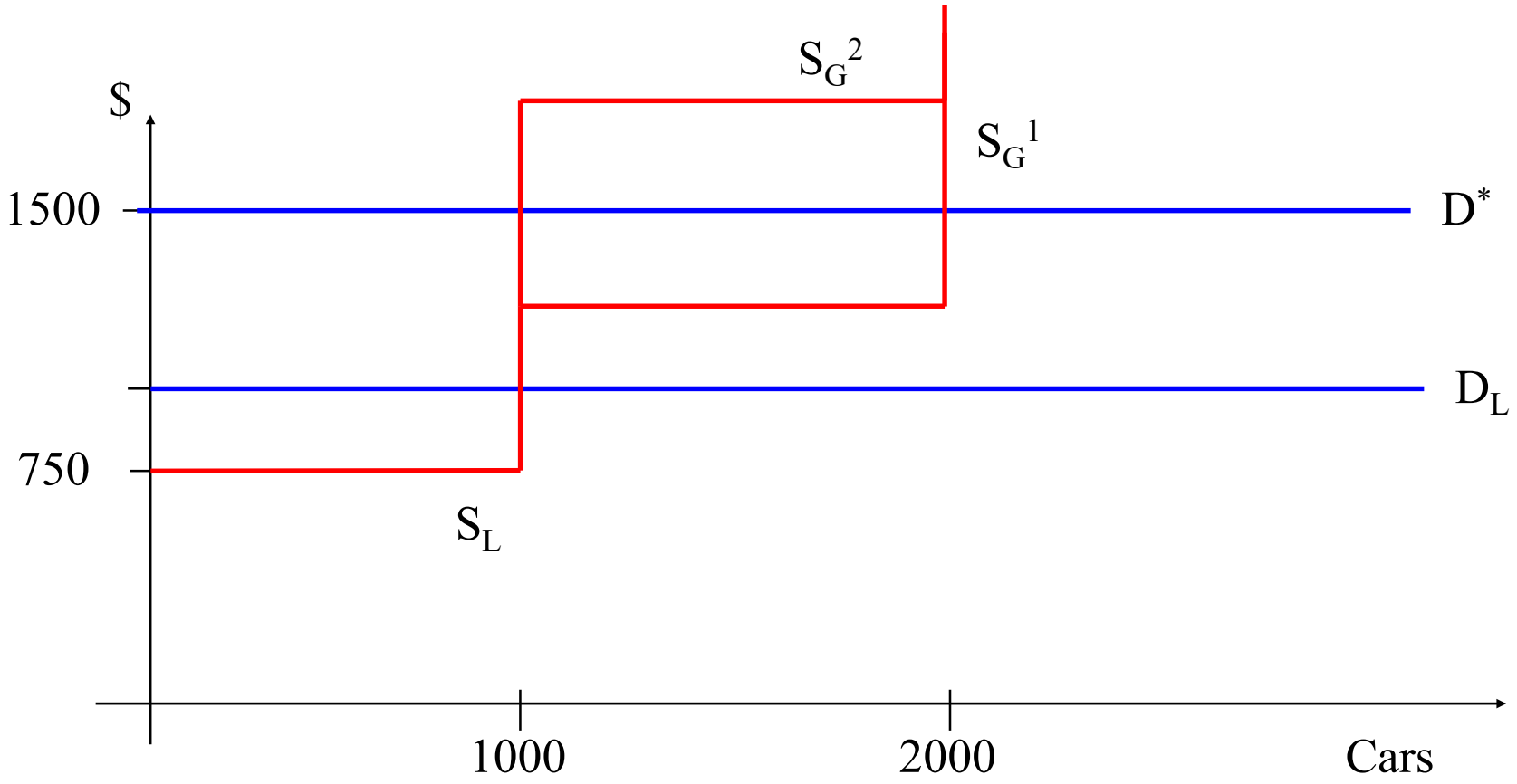
# Example – symmetric information (equilibrium when quality is unknown)



# Example (asymmetric information)

- Only sellers know the exact quality of a car
- Two possible solutions/ equilibriums:
  - All cars sell at the same price
  - Only the lemons are sold
- What determines which equilibrium we reach?

# Example
# (equilibrium with asymmetric information)



# Summary, Example

- If the reservation prices of the sellers with good cars are below 1500, all cars are sold at a price of 1500

- If the reservation prices of the sellers of good cars are above 1500, no cars of good quality will be sold
  - In this case, the buyers realize that only lemons are on the market
  - The market price will then be 1000, and all the lemons will be sold at this price
  - As a consequence, the market decreases – there are potential transactions with buyers willing to buy and the sellers willing to sell that are not carried out due to information asymmetry

# Lemons market with variable quality

- Social value is not necessarily maximized simultaneously with private value

- Example:
  - Five firms produce a product
  - The per unit cost of production is C
  - The price per unit is R
  - One firm considers increasing the quality of their product, giving it a value of R + Q
  - The cost of this new production is q
  - Given that there exists a market for higher quality than currently produced, will the firm increase the quality of their product in a market with asymmetric information?

# Price discrimination

- Same quality is sold to different product groups for different prices
- Consumers are willing to pay more for higher quality
  - When information asymmetry exists the seller can exploit this fact
- Company creates uncertainty by adding noise
  - Different names
  - Different design

# Market power

- Even in a highly competitive market, asymmetric information can give the companies market power

- Consider the following example:
  - Many stores in a town sell the same product
  - The competitive price of the product (MC) is equal to p*
    - What happens to a store charging more than p* in a market with symmetric information?
  - The consumers have limited information and a searching/ traveling cost of c (cost of going from store to store)
    - What happens to a store charging more than p* now?

# Example (cont.)

- Is the price p* an equilibrium price?
- Which price is the equilibrium price (given that enough stores are present)?
- If there are an insufficient amount of firms there might be either no equilibrium or equilibriums with multiple prices

# Example: Earthquake Insurance

- The state of California set up its own earthquake insurance program for homeowners in 1997. The rates vary by ZIP code, depending on the proximity of the nearest fault line. However, critics claim that the people who set the rates ignored soil type. Some houses rest on bedrock; others sit on unstable soil

- What can be the implications of such a policy?

- What kind of a problem is this?

# Example: Safety Investment Game

- Firm have more information regarding job safety than potential employees
  - Injury rate for the industry as a whole is available, but not for individual firms
- A risk premium is required to attract employees to high risk jobs
- Each firm must decide how safe it wants to make it's plant

| | No investment | Investment |
|---|---|---|
| **No investment** | $200 / $200 | $250 / $100 |
| **Investment** | $100 / $250 | $225 / $225 |

# Example: Cheap Talk

- Workers have more information regarding their own ability than firms do
- When does it work to send inexpensive signals?
- Two jobs are available – one demanding and one undemanding
- The worker has one of two ability levels: High or Low
- Before the company decides on which job to offer the worker, the worker can send a signal

| **Cheap talk works** | **Demanding** | **Undemanding** |
|---|---|---|
| **High** | **3** / 2 | 1 / 1 |
| **Low** | 1 / 1 | **2** / 4 |

| **Cheap talk fails** | **Demanding** | **Undemanding** |
|---|---|---|
| **High** | **3** / 2 | 1 / 1 |
| **Low** | **3** / 1 | 2 / 4 |

# Limiting lemons

- Laws
  - Merchandise Marks Act 1887
- Consumer screening
  - Objective experts
    - A mechanic to appraise a used car
  - Learn of a firm's reputation from other consumers
  - Third party comparisons
- Standard and certification
  - Climbing equipment / safety equipment
  - What is the potential reaction to a standard with only a high versus low quality rating?
- Signaling by firms
  - Brand names
  - Guarantess and warranties
  - The signals must be credible

# Responses to adverse selection

- There are two main approaches
  - Restrict opportunistic behavior
  - Equalize information

- Examples:
  - Mandatory insurance
    - All car owners must have an insurance
  - Health insurance as benefit
    - Companies pay a lower wage and include health insurance
      - Firms reduce the adverse selection problem and can buy the insurance at a low price
      - Both healthy and unhealthy people are insured
  - Signaling
    - The informed person takes an action to send information to the uninformed person
  - Screening
    - The uninformed person takes an action to determine the information possessed by the informed person

# Screening

- Equalize information
- Collect more information
  - Uncover hidden information
- Possible to uncover all hidden information?
- Beneficial to uncover all hidden information?

- Example:
  - Insurance

# Signaling

- Used by informed parties to eliminate adverse selection
- The informed party try to signal information to the uninformed party

- Why would the informed parties want to share information?
- Which informed parties would want to share information?

- Example:
  - Physical examination
  - Education

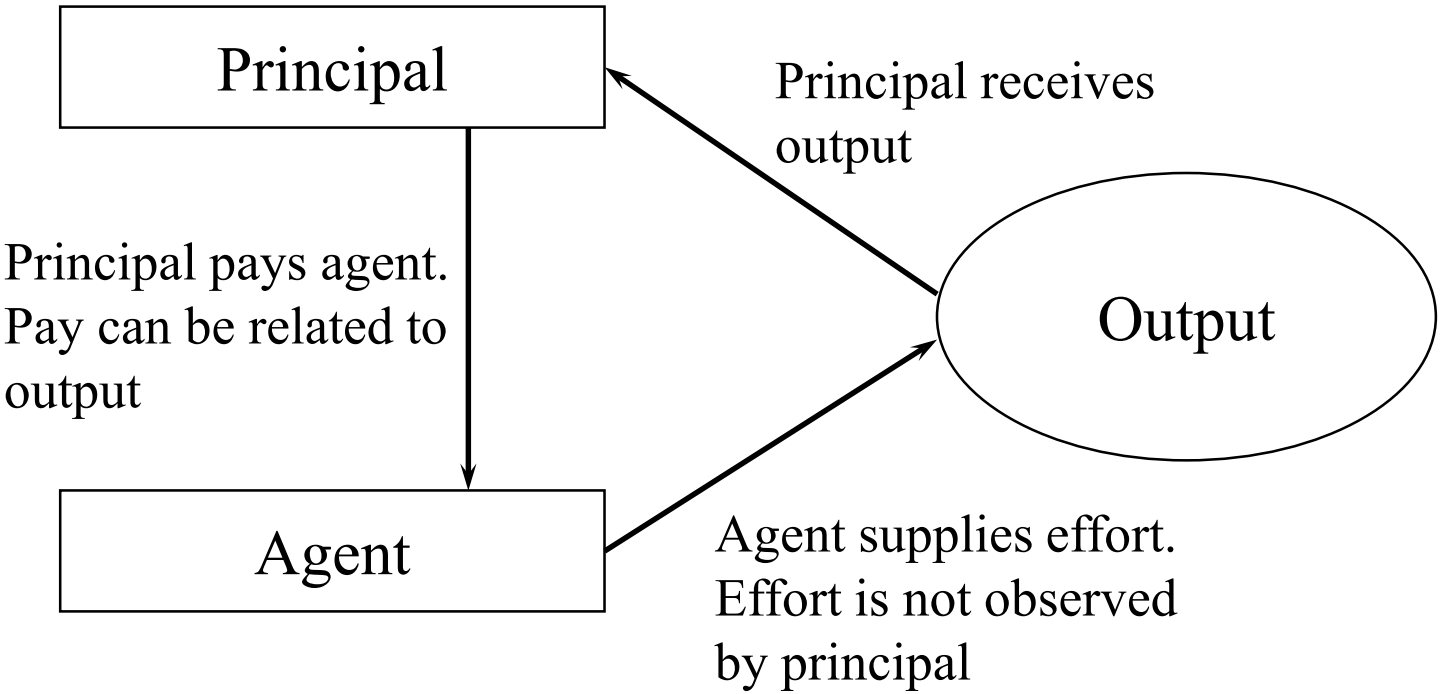
# Principal-Agent theory
# Moral Hazard

Contracts, production efficiency and risk-sharing

# Principal-Agent setting

- A principal contracts with an agent to take some action that benefits the principal
- The actions made by the agent influences the payoff to the principal
- The actions of the agent are unobservable to the principal

# Principal-Agent relationship:

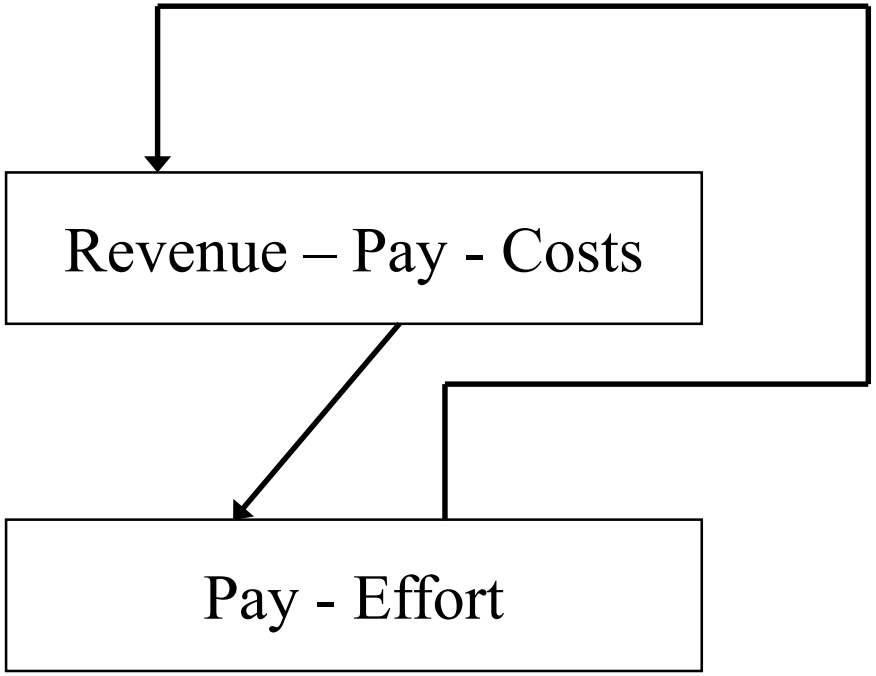


# Examples

| Principal | Agent |
| --- | --- |
| Owner | Manager |
| Employer | Employee |
| Client | Lawyer |
| Insurance company | Client |

# Principal vs Agent objectives

Principal chooses pay to maximize:




Agent chooses effort to maximize:

# Model for analysis

$\pi = \pi(a,\theta)$

$\pi$ is the payoff

a is the action taken by the agent

$\theta$ is a random variable

# Efficiency

- No party can be made better off without harming the other party
- Requires both efficiency in production and in risk sharing
- Efficiency in production means that the payoff is maximized
- Efficiency in risk means that the least risk-averse person bears most of the risk

# Production efficiency

- To ensure production efficiency each contract has to satisfy two criteria:
  - Provide a large enough payoff for the agent to participate
  - Be incentive compatible

# Example
# Buy – A – Duck

- Paula owns the store Buy-A-Duck (Principal)
- Arthur is the manager of the store (Agent)
- The store sells wood carvings of ducks
- The demand and joint profit function is:

$$p = 24 - 0.5a$$
$$\pi(a) = 24a - 0.5a^2 - 12a$$

- Arthur has a cost of 12 $ in obtaining and selling each duck

- What is the optimal amount of carvings for the joint profit function?

# Example
# Buy – A – Duck

- What kind of contract should Paula offer Arthur?

- Alternatives:
  - Fixed-fee rental contract
    - Arthur rents the store from Paula for a fixed fee
  - Hire contract
    - Paula contracts to pay Arthur for each carving he sells
  - Revenue-Sharing contract
    - Paula and Arthur share the revenue from the store
  - Profit-Sharing contract
    - Paula and Arthur share the economic profit $\pi$

# Example (symmetric information) Buy – A – Duck

1. Fixed-fee rental contract
   - Arthur gets the difference between the profit and the rent F
   - Paula gets the profit F
   - Leads to an efficient solution

2. Hire contract
   - Payment lower than 12$
     - Leads to Arthur refusing the contract
   - Payment equal to 12$
     - Can give an efficient solution if Arthur is supervised
   - Payment higher than 12$
     - Leads to an inefficient solution
   - Will generally not lead to an efficient solution

# Example (symmetric information) Buy – A – Duck

3. Revenue sharing contract
   - MR for Arthur is lower than the original MR
   - Will not lead to an efficient solution

4. Profit sharing contract
   - Is incentive compatible and will lead to an efficient solution

# Example (asymmetric information) Buy – A – Duck

- Paula has less information than the agent – she cannot observe sales or revenues
  - Moral hazard problem

1. Fixed-fee rental contract
   - Will the solution be efficient in this case?

2. Hire contract
   - Efficient solution?
   - What will happen with pay equal to, lower than or higher than 12$?

# Example (asymmetric information) Buy – A – Duck

3. Revenue sharing contract
   - Can this contract lead to an efficient solution?
   - What will influence the potential underproduction?

4. Profit sharing contract
   - Under which assumptions can this contract be efficient?

- With the assumptions in this example, what is the only efficient solution?

# What is the best contract?

- Varies from case to case
- Depends on risk profile of the participants
- Difficulties of monitoring

# Efficiency in risk bearing

- The least risk-averse party should bear most of the risk
- Usually there is no optimal solution that ensures efficiency both in production and in risk sharing
- A trade-off is needed

# Example

- A company's future value is either 10 or 20 million dollars
- The probability of each outcome is equally likely
- The utility function of the manager is $(\text{Income})^{0.5}$
  - He is risk averse
- He need a utility level of a least 1000 in order to accept a contract
  - Otherwise he will accept an offer from a different company

# Example (cont.)

- Alternative 1: fixed payment of 1 mill. dollars
  - Gives the manager a utility of 1000
  - Expected value of the company is 14 mill. Dollars

- Alternative 2: an owner share in the company
  - Solves the following equation:

$$0.5(10.000.000x)^{0.5} + 0.5(20.000.000x)^{0.5} = 1000$$

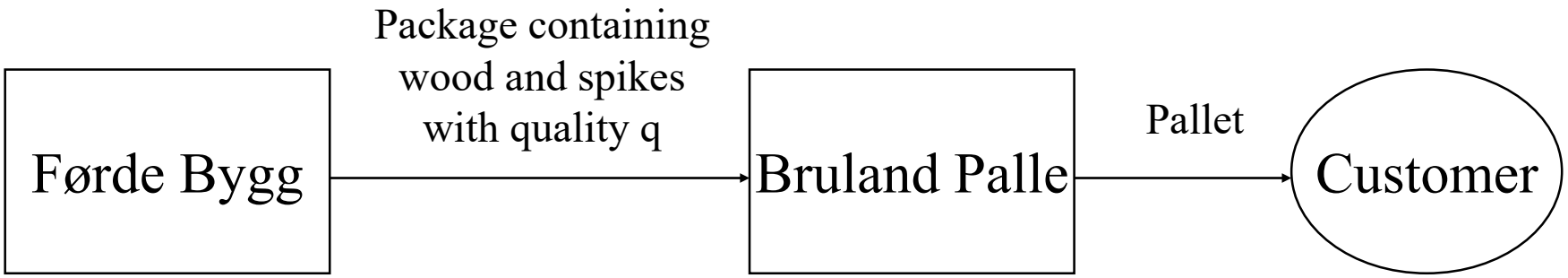
  - Gets the following solution: x = 0.06863

# Example (cont.)

- Expected value of the owner share: 1.029.450
- Why is this value higher than the fixed payment?
- Expected value of the company (for the owners): 13.970.550
- Which alternative would you have chosen
  - …if you were the manager?
  - …if you were the owners of the company?

# Example – risk sharing

- Setting:
  - Two firms
    - Bruland palle AS
    - Førde Bygg AS



# Example 2 (cont.)

- Quality q of the package depends on two parameters: e and ε (q = q(e, ε))
  - The parameter ε is exogenous
  - e is controlled by Førde Bygg (high e leads to high quality)
  - Førde Bygg has a cost related to producing high quality; H(e)
  - Førde Bygg is risk-averse while Bruland Palle is risk-neutral
- Bruland Palle can only observe q
- Bruland Palle gets revenue r(q)

# Example 2 (cont.)

- If BP could observe e → contract establishing e* and price p*
- What happens if they agree upon a fixed e* and p* under the assumptions in this example?
- The contract will have a price structure of p(q)
- Problem of optimal solution versus risk sharing

# Example – family farm

- You inherit the family farm, but after completion of your education at NTNU you would rather work as a consultant
- However, you do not wish to sell of the farm since it has been in the family for generations
- The solution is to hire someone to run it for you
- What kind of contract should you offer the person you hire?

# Example 3 (cont.)

- The payoff from the farm depends both on the effort by the person hired to run the farm and the price of grain

| | Low price (p = 0.5) | High price (p = 0.5) |
|---|---|---|
| Low Effort | 50.000 | 150.000 |
| High Effort | 100.000 | 200.000 |

# Example 3 (cont.)

- The person you hire to run your farm has the following utility function:

$$U = W^{0.5} - u(e)$$

- With low effort:

$$U = W^{0.5}$$

- With high effort:

$$U = W^{0.5} - 46.3$$

# Example (cont.)

- You are considering two alternatives:

1. Fixed yearly payment of 50.000 (the reservation price of the person you hire)
2. Payment varying with the profitability of the farm

1. Calculate the expected utility:
   - Low effort: E(U) = 223.6
   - High effort: E(U) = 177.3
   - Which level of effort will be chosen?

   - Your expected profit = 50000

# Example (cont.)

- E(U) with fixed payment and low effort
  = E(U) with x % of the profit and high effort
  - Need to offer utility of at least 223.6
  - Corresponds to 50% of the profits

- Your expected profit: 75000
  - (assuming high effort)

# Example (cont.)

- Will the person you hire actually choose high effort?
  - Calculates E(U) in both cases:
    - Low effort: E(U) = 216
    - High effort: E(U) = 223.6

- Which effort will be chosen?

# Example: Client – Lawyer Contracts

- Especially challenging situation: the agent knows more than the principal, the principal never learns the truth and both face risk
  - Situation often arise when contracting with an expert
- Here: Pam is injured in a traffic accident and Alfredo is her lawyer
- Uncertainty regarding the attitudes of the jury
- Asymmetric information regarding Alfredo's work effort

| Type of contract | Fixed fee to the lawyer | Fixed payment to Client | Lawer paid by the hour | Contingent contract |
|---|---|---|---|---|
| *Lawyer's payoff* | | | | |
| *Client's payoff* | | | | |
| *Production efficiency* | | | | |
| *Who bears risk* | | | | |

# How to reduce moral hazard

- Piece rates / bonuses
  - Linked to a workers individual output, or linked to the firms profitability
  - Measuring output?
  - Accept contract?
- Monitoring
  - Punch a time clock
  - Installing videocameras
  - Assembly lines (dictates the work pace)
  - Record employees' e-mail, phone calls, review computer files, etc.
- Bonding
  - Require agents to deposit funds guaranteeing their good behavior
  - Security deposits when renting an apartment
  - Costly training / sabbatical
- Deferred payments
  - Pension funds
  - Raise the cost of being fired (as with bonding)
- Efficiency wages
  - Unusually high wage – discourages shirking (loss of wage if fired)

# Example: Contract Choice

- So far the focus has been on single contracts
- A menu of contracts can be used to screen job applicants

- A firm wants to hire a salesperson
  - The potential employees are risk neutral
- A hard working salesperson generates sales of $100.000 a year, while a lazy salesperson generates sales of $60.000

| | 30 % of sales | $25 000 salary |
|---|---|---|
| Sales: | 100.000 | 100.000 |
| Salary: | -30.000 | -25.000 |
| Fixed cost: | -50.000 | -50.000 |
| Profit: | 20.000 | 25.000 |

| | 30 % of sales | $25 000 salary |
|---|---|---|
| Sales: | 60.000 | 60.000 |
| Salary: | -18.000 | -25.000 |
| Fixed cost: | -50.000 | -50.000 |
| Profit: | -8.000 | -15.000 |

# Conclusion

- Asymmetric information and opportunistic behavior can lead to market failures
- Adverse selection
  - Bad goods drive good ones out of the market
  - Price discrimination
  - Market power
  - Prevents desirable transactions
- Moral hazard
  - Poses challenges for contract design in order to achieve efficiency
    - Production
    - Risk
  - Monitoring/bonding/etc can reduce the problem