

LECTURE 9:  
MECHANISM DESIGN



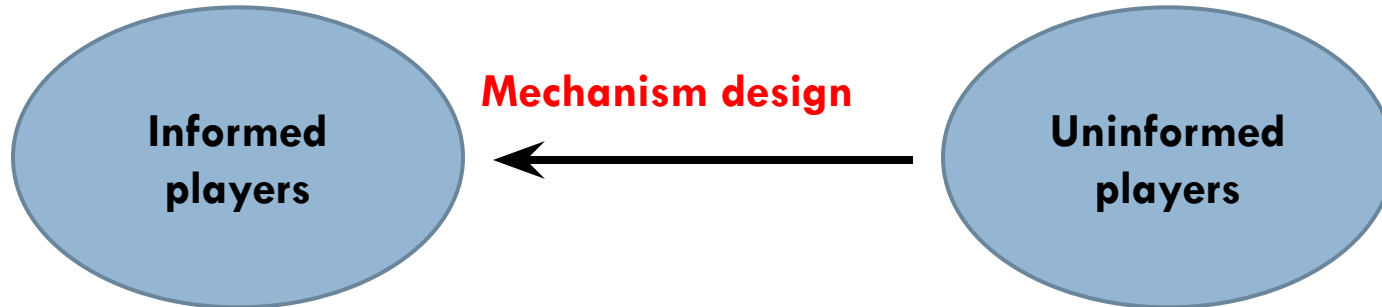
# Recap

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- Players may have the possibility to “communicate” to alter the outcome of the game.
- They may announce the intended action (cheap talk) in order to facilitate coordination.
- In games with incomplete information, players may consider taking actions that signal their type (signaling), or find out the type of the other player (screening).
  - e.g. provide warranties to signal the quality of your products.
  - e.g. go to university to signal your skills.

# Mechanism design

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**Mechanism design:** system put in place by the less-informed player to create motives for the more-informed player to take actions beneficial to the less-informed player.

# Mechanism design examples

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## □ **Price discrimination**

- Seller/buyer.
- Source of incomplete information: buyers' willingness to pay is unknown to the seller.
- Mechanism design: price system that makes buyers with high willingness-to-pay buy higher quality products at a higher price.

## □ **Incentives for effort**

- Manager/employee.
- Source of incomplete information: the manager cannot observe how hard employees work.
- Mechanism design: align the incentives of employees to the incentives of the manager, and induce employees to exert high effort.

# Mechanism design: the 2 constraints

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- **Incentive compatibility**
  - Make sure that the agents (the informed players) do what we want them to do.
- **Participation constraint**
  - Make sure that the agents have sufficient payoff, otherwise they may go elsewhere.

# Example 1: Price discrimination

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- Different consumers have different valuations for the same product.
  - Bob willing to pay \$20; Bill willing to pay \$10.
- Is it optimal to charge the same price (\$10) to both consumers?
- To maximize profit, the seller will try to sell the good for \$20 to Bob; and for \$10 to Bill.
- **Price discrimination**

# Price discrimination in practice...

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# Price discrimination: limitations and solution

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- Price discrimination is often not feasible: sellers may not observe individual consumers' willingness to pay.
- Then what? Seller may design a price system to implement some sort of price discrimination:
  - Price system that will separate buyers into different groups and allow the seller to increase profit.



# Price discrimination: airlines

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- Two types of seats: Economy and first-class.
- Two types of travellers: tourists (#70) and business travellers (#30).
- Business travellers are willing to pay a higher price than tourists.



	Cost to the airlines	Reservation price		Airline's profit	
		Tourists	Business	Tourists	Business
Economy	100	140	225	40	125
First class	150	175	300	25	150

# Price discrimination: profit

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- Selling to a business traveller
  - Profit for first-class ticket:  $300-150=150$
  - Profit for economy ticket:  $225-100=125$
- Selling to a tourist
  - Profit for first-class ticket:  $175-150=25$
  - Profit for economy ticket:  $140-100=40$

**Better sell first-class tickets to business travellers,  
and economy tickets to tourists....**

**Problem: individual travellers' type is unknown**

# Price discrimination may not be simple to implement...

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- The airline initially does not have enough information on types of customers, and cannot ask different prices to different travellers.
- Demographics (age; gender etc.) may provide information on the type...but it may be illegal/unethical to use this information.
- If the airline asks 300 for a first-class seat, business travellers will rather buy an economy class ticket.
  - If the economy ticket is at 140, business travellers would prefer pay 140 for an economy seat, rather than pay 300 for a first-class seat.
  - If the economy ticket is at 140, business travellers have consumer surplus of  $225 - 140 = 85$  in economy class ticket.

# Solution?

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- Design a price mechanism such that business travellers choose to buy first-class tickets, and tourists choose to buy economy class tickets.
- Suppose the airline charges  $X$  for economy, and  $Y$  for first-class.
- $X$  and  $Y$  should be such that tourists choose economy, and business travellers choose first-class.
- Two constraints.
- Constraint #1: **Participation constraint**
  - Charge maximum 140 for economy class, otherwise tourists drop off. **( $X < 140$ )**
  - Charge maximum 300 for first-class. **( $Y < 300$ )**

# Incentive compatibility (Constraint #2)

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- Prices have to be such that business travellers prefer buying first-class tickets:

$$225 - X < 300 - Y$$

surplus of business travellers  
if buy economy

surplus of business travellers  
if buy first-class

$$\Rightarrow Y < X + 75$$

- i.e. the first-class ticket should not be more than \$75 more expensive than the economy ticket

# Incentive compatibility (Constraint #2)

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- Prices have to be such that tourists prefer buying economy tickets:

$$140 - X > 175 - Y$$

$$\Rightarrow Y > X + 35$$

- i.e. the first-class ticket should be between \$35 and \$75 more expensive than the economy ticket.

# Outcome...

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- Since  $X=140$  (maximum price), then  $Y=215$  at maximum ( $140+75$ ).
- By pricing first-class seats at 215 and economy seats at 140, the airline can separate the two types.
- Note that business travellers have a surplus of  $85=300-215$ 
  - First-class seats are sold at rebate price (215 vs. 300).
- Total profit:  $(140-100)70+(215-150)30=4,750$

# Application: iPhone 6S

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- 16GB model: cost of components is \$208, price is \$649
- 64GB model: cost of components is \$229, price is \$749
- 128GB model: cost of components is \$265, price is \$849
- (\$30-40 cost differential, but a \$100 price differential)





# Application: Coach

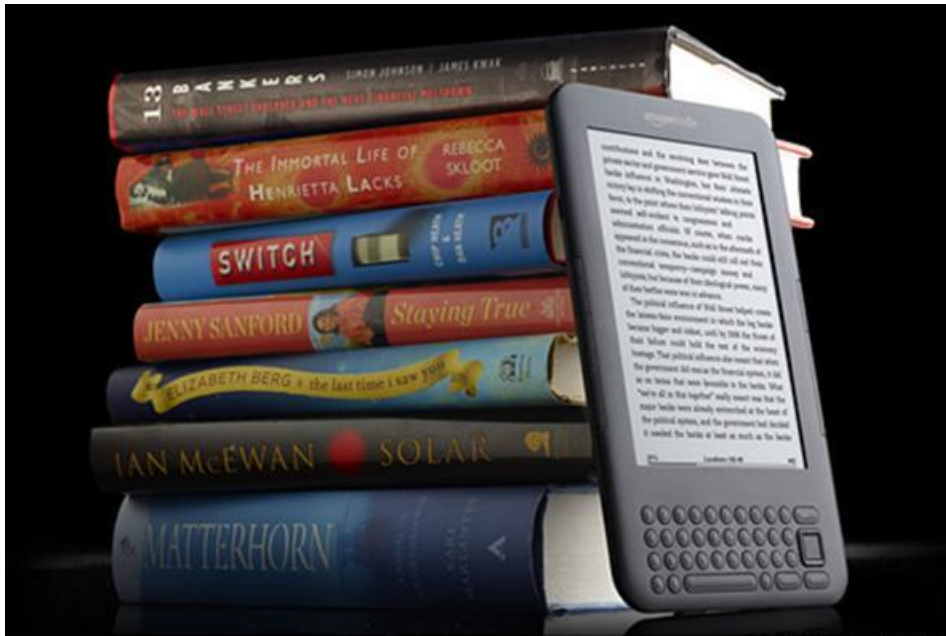


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- COACH sells designer handbags, wallets, shoes, jewelry etc. It has two methods of sale:
  1. Full price at its own stores and at selected retailers. Full price only, never any discount. Average age of shopper is 35; average expenditure is \$1,100.
  2. Discount outlet stores that sell last season's products for less. Stores usually 100km away from nearest full-price retailer. Average age of shopper is 45; average expenditure is \$770.

# Application: Kindle

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COURTESY: AMAZON

## Kindle 2's price:

- 2/09, \$399;
- 7/09, \$299
- 10/09, \$259
- 6/10, \$189

# Example 2: Incentives for effort

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## □ **Incentives for effort**

- manager/employees
- Source of incomplete information: the manager cannot observe how hard employees work, consequently employees may not work as hard as they are supposed to (moral hazard).

**MORAL HAZARD PROBLEM:** unobservable actions distort an agent's incentives after the transaction is made

- Mechanism design: align the incentives of the employee to the incentives of the manager.

# Moral hazard examples

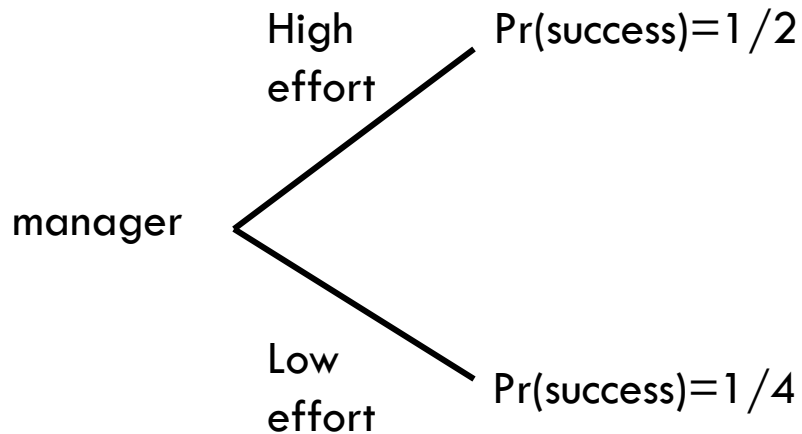
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- Insurance
  - Health Insurance -- Insured are more willing to eat poorly, smoke etc.
  - Home Insurance -- less willing to install alarms and better locks
  - Car Insurance -- take more risks while driving
- Work
  - Employees may not produce high effort, and still get paid.

# Project supervision

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- A company owner hires a manager to supervise a project.



- In case of success, the profit is \$1million. In case of failure it is \$0.

# Risk aversion and utility

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- The manager is risk averse, his utility is given by:
  - $u = \sqrt{y}$ , where  $y$  is income (in million of \$)
- The disutility of effort is 0.1.
- The outside option is \$90k, yielding utility of  $\sqrt{0.09} = 0.3$

# Observable effort

- If the firm can observe effort, contracts are simple:
  - Either work hard or be fired.
  - To induce the manager to exert high effort, we must pay him at least \$160k:
    - $u = \sqrt{0.16} - 0.1 = 0.3$
    - If we pay less than \$160k, he will resign and take the outside option
- Simple contract: The employee is paid \$160k in exchange for high effort.

# Unobservable effort

- Suppose effort can not be observed.
  - The manager's output may be observed, but not his effort level.
- How to induce high effort?
- Compensation contract must rely on something that can be directly observed and verified.
  - Project's success or failure -- Related to effort.
  - Imperfect but relevant information.
  - Compensation rule:
    - Pay a basic wage ( $x$ ) if the project fails
    - Pay more ( $y$ ) if the project succeeds, such that  $y > x$



# Incentive compatibility and participation constraint

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Incentive compatibility	Participation constraint
Putting in high effort must be better than putting in low effort	Putting in high effort must be better than the outside option

# Incentive compatibility

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- Make sure that the manager prefers high effort to low effort

$$\frac{1}{2}\sqrt{y} + \frac{1}{2}\sqrt{x} - 0.1 \geq \frac{1}{4}\sqrt{y} + \frac{3}{4}\sqrt{x}$$

Utility if high effort

Utility if low effort

- Solves to:  $\sqrt{y} - \sqrt{x} \geq 0.4$

**In order to induce high effort, success has to be sufficiently rewarded relative to failure.**

# Participation constraint

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- Make sure that the manager is willing to work for you:

$$\frac{1}{2}\sqrt{y} + \frac{1}{2}\sqrt{x} - 0.1 \geq 0.3$$

Utility if high effort

Utility if outside option

- Solves to:  $\sqrt{y} + \sqrt{x} \geq 0.8$

**In order to keep the manager, the expected compensation has to be large enough.**

# Solving

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- Two constraints:

$$\sqrt{y} - \sqrt{x} \geq 0.4$$

$$\sqrt{y} + \sqrt{x} \geq 0.8$$

- By substitution:  $0.4 + \sqrt{x} + \sqrt{x} \geq 0.8$

$$\Rightarrow \sqrt{x} = 0.2$$

$$\Rightarrow \sqrt{y} = 0.6$$

# Solving

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- $\sqrt{y}=0.6$  means  $y=0.36$ , or \$360k
- $\sqrt{x}=0.2$  means  $x=0.04$ , or \$40k
- The manager is paid \$40k if the project fails and \$360k if it succeeds.
- The reward for success must be large enough to compensate for:
  - the cost of effort (0.1)
  - the risk of receiving no bonus in case the project fails (50%)

# Stick and carrot

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- Low base salary.
- The payment for success is very large, and just enough to induce the manager to exert high effort.



# Basic wage and bonus

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- Why not give \$0 in case of failure?
  - $x=0$
- To ensure participation,  $y$  would have to be very large:

$$\sqrt{y} + \sqrt{x} \geq 0.8 \Rightarrow \sqrt{y} \geq 0.8 \Rightarrow y \geq 0.64$$

- The compensation for success would have to be \$640k
- Better provide a base salary of \$40k.

# Applications

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- **Store managers:**
  - profitability of local outlet depends on store managers' staffing and stocking decisions (effort is important).
  - Profits are easy to measure at store level.
- **CEOs:**
  - compensation based on the stock price.
  - stock price is an imperfect measure of firm performance.



# Case study: Safelite Glass Corporation

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- Largest installer of automobile glass in the US.
- 1994: CEO Garen Staglin instituted a new compensation scheme for glass installers.
- A very competitive industry so costs and productivity really matters to get prices down and response time up.



# Previous System

- ❑ Paid an hourly wage rate and overtime.
- ❑ Pay did not vary with number of windows installed.
- ❑ Installer's job is monitored and they are required to meet minimum quality standards.
- ❑ Managers were worried that installers just did the minimum number of windows per week to keep their jobs.

# New System



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- Installers would be paid each week the maximum of:
  - Amount they would have made according to the old hourly wage system
  - A fixed amount per job completed
- Consequently, enterprising installers could do a lot better.
  - Possibility to sometimes double compensation compared to the old system.

# Outcomes



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- Increased productivity per worker
  - Number of windows installed per week increased by 44%
  - Changed behaviour
    - Technicians didn't drive as far for a job
    - Checked they had parts at beginning of day
    - Maintained tools
- Unit labour costs fell from \$44.43 to \$35.24 per window
  - Average compensation per worker rose but productivity rose even more

# Summary

- Incomplete information is the rule rather than the exception.
- Less-informed players put systems in place to create motives for the more-informed player to take actions beneficial to them. (mechanism design).
  - Discriminate between buyers
  - Encourage effort
- Mechanism design is not perfect; but it is an improvement for the less-informed compared to not using mechanism design.