Moral Hazard and contracts

Watson §13, pages 139-152

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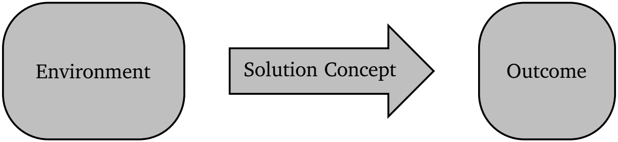
Mechanism design



- Thus far we have taken the environment as given and studied the outcomes predicted by different solution concepts
- Now we will take the solution concept as given and study the outcomes that can result from different environments
- We study two problems:
  1. *Implementation:* Is there a mechanism that induces a desired outcome?
  2. *Optimal mechanism design:* Which mechanism maximizes an objective function over outcomes?

Mechanism design

- We focus on the principal-agent setting.
  - The principal first chooses a mechanism (game, specification of the environment)
  - Agents then choose whether to participate or not
  - Those agents who participate play the game chosen by the principal
- When we think of the implementation problem we think of the principal as a benevolent social planer (government?) that wishes to implement a "socially optimal" outcome.
- In this class socially optimal means Pareto efficient
- This problem is known as: efficient mechanism design
- When we think of optimal mechanism design we think of the principal as the owner/chief of an institution who wants to maximize profits

Poor mechanisms

- Farm productivity in the USSR
- Braess' paradox
- Academic publications
- Prohibition
- Elections
- Standardized exams
- Medical insurance
- Commissions in personal credit sales
- Point system in soccer

Pareto efficiency

- Defining what it means for an outcome to be socially optimal is a complicated problem addressed by Social Choice Theory
- Adding up utilities across agents does not make any sense without some specific assumptions and it is not allowed in this class. If you ever add up utilities in this class you will loose points
- The only notion of social optimality that we will use is Pareto efficiency (cf Pareto 1927)

Definition

We say that an outcome x (eg strategy profile, terminal node) Pareto dominates an outcome y if *someone* is strictly better of and *no-one* is *strictly* worse off at x.

Pareto efficiency

Definition

An outcome is Pareto efficient if and only if it is not Pareto dominated by any other outcome.

- Everyone would agree to switch from a Pareto inefficient outcome to a different outcome that Pareto dominates it
- Pareto efficiency says nothing about social justice
- The Pareto frontier (set of Pareto outcomes) is similar to the PPF
- Sometimes I might forget to say Pareto efficient and will simply say efficient. In this class efficiency always means Pareto efficiency

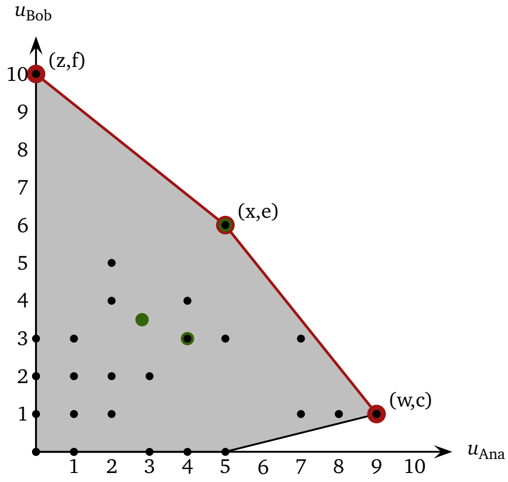
Example: a 5 × 6 game

Bob

Ana		a	b	c	d	e	f
	v	0, 2	1, 3	8, 1	1, 2	0, 3	9, 1
	w	1, 0	4, 3	$\boxed{9, 1}$	5, 3	2, 1	0, 1
	x	7, 3	2, 4	3, 0	7, 1	$\boxed{5, 6}$	1, 1
	y	2, 2	0, 2	2, 5	3, 2	4, 4	8, 1
	z	0, 0	1, 0	0, 0	5, 0	4, 0	$\boxed{0, 10}$

Example: a 5 × 6 game

Pareto frontier



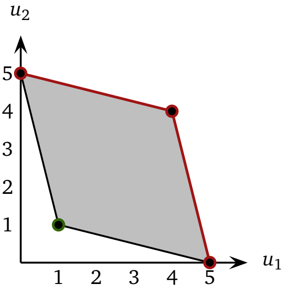
Moral Hazard

- Everybody agrees that Pareto efficiency is desirable, but we might fail to achieve efficient outcomes because of:
  1. *Bounded rationality*: players might fail to fully understand the situation or the consequences of their choices
  2. *Incomplete information*: the required information to make Pareto efficient choices might not be publicly available
  3. *Moral hazard*: agents have individual incentives to make choices that are socially sub-optimal

- The term "moral hazard" has different (but similar) definitions in different areas of Economics
- For us, we say that an environment has moral hazard if and only if *all* the Nash equilibria (or SPNE) lead to Pareto inefficient outcomes

Example: Prisoner's dilemma

	C	D
C	$\boxed{4, 4}$	$\boxed{0, 5}$
D	$\boxed{5, 0}$	1 , 1



Example: Contribution to public goods

- A public good is being built
- Each player provides a voluntary contribution $c_i \in [0, 10]$
- It takes 5$ in contributions to produce a unit of the public good, so that the total amount of the public good that is produced is:

$$P = \frac{1}{5} \sum_i c_i$$

- Agents preferences are given by:

$$u_i(c) = P - c_i$$

- Each player gets a benefit of 1/5 for each dollar provided so that the unique Nash equilibrium has $c_i = 0$ for all players
- If the number of players is greater than 5, this outcome is Pareto dominated by the outcome where everyone provides $c_i = 10$
- This happens because players only consider the private benefit of their contributions ignoring the "social benefit" to others

Example: Teamwork

- Teamwork is a particular example of public goods provision: the fruits of the joint effort are shared by all
- Suppose that Anna and Bob are partners in a firm and provide levels of effort e_A and e_B
- They split the total revenue of the project given by:

$$f(e) = 2e_A + 2e_B + \frac{1}{10} e_A e_B$$

- The cost of effort is:

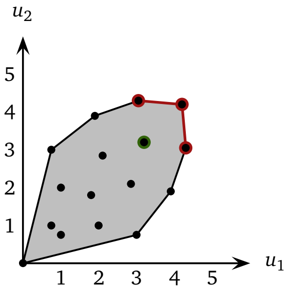
$$c_i(e) = \frac{1}{4} e_i^2$$

- Payoffs are then given by:

$$u_i(e) = \frac{1}{2} f(e) - c_i(e) = e_A + e_B + \frac{1}{20} e_A e_B - \frac{1}{4} e_i^2$$

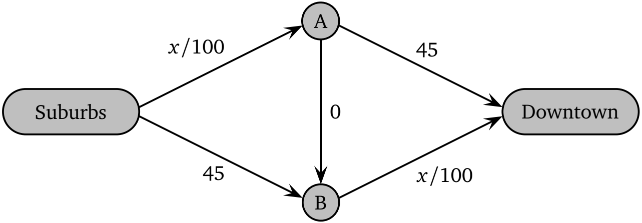
Example: Teamwork

	1	2	3	4
1	0 , 0	1 , 0.75	2 , 1	3 , 0.75
2	0.75 , 1	1.8 , 1.8	2.85 , 2.1	3.9 , 1.9
3	1 , 2	2.1 , 2.85	$\boxed{3.2 , 3.2}$	$\boxed{4.3 , 3.05}$
4	0.75 , 3	1.9 , 3.9	$\boxed{3.05 , 4.3}$	$\boxed{4.2 , 4.2}$



Example: Braess' Paradox

- There are 4000 people driving daily from the suburbs to downtown
- There are different routes and the travel time in each route depends on the amount of people using it Each person wants to minimize his/her commuting time



Example: Braess' Paradox

- Since $4000/100 = 40 < 45$ the route (Suburbs,A,B,Downtown) is always the fastest route
- Hence the unique Nash equilibrium has everybody using this rout which results in a total time of 80min for everyone
- This outcome is Pareto dominated by the outcome in which half the drivers use the northern route (Suburbs,A,Downtown) and half the drivers use the southern route the route (Suburbs,B,Downtown) resulting in a total time of 65min for everyone

- If the road from A to B where closed, then the Pareto efficient allocation would be the unique pure strategy Nash equilibrium
- This is an instance of Braess' paradox: *adding more resources to a network can make it less efficient*

Example: Cournot competition

- Consider a Cournt duopoly with firms 1 and 2 producing the same good with constant marginal cost $c = 10$ and inverse demand function:

$$P(q_1, q_2) = 100 - q_1 - q_2$$

- Each firm wishes to maximize its profits:

$$u_i(q_1, q_2) = (90 - q_1 - q_2)q_i$$

- Best response functions are given by:

$$BR_i(q_{-i}) = \frac{90 - q_{-1}}{2} = 45 - \frac{1}{2}q_{-i}$$

- The unique Nash equilibrium is $(q_1^C, q_2^C) = (30, 30)$

Example: Cournot competition

- If there was only one firm (a monopolist) it would seek to maximize:

$$u(q) = (90 - q)q$$

- And the optimal quantity would be $q^M = 45$
- An outcome of the Cournot environment is Pareto efficient if and only if the total supply equals q^M
- If each firm produced $q^M/2$ then profits for each firm would be:

$$u^* = u_1\left(q^M/2, q^M/2\right) = (90 - 45)\frac{45}{2} = 1012.5$$

- In contrast, in the Cournot equilibrium each firm makes:

$$u^C = u_1(q^C, q^C) = (90 - 60)30 = 900$$

- From the perspective of the firms, the Cournot equilibrium is inefficient
- (From a social perspective that takes into account consumers the Cournot equilibrium is better because its closest to the competitive equilibrium)

Games with contracts

- The problem of efficient mechanism design is whether there exist mechanisms that induce Pareto efficient outcomes
- The questions is: *can we modify the incentives of the environment to eradicate Moral Hazard?*

- The simplest kind of mechanisms are contracts: documents in which players commit to making specific choices
- When players are rational, there are no information problems and there are complete enforceable contracts, every efficient outcome is implementable
- *Coase's conjecture*: If there are well defined property rights and no transaction costs, rational players will always reach an efficient outcome

Example: Prisoner's dilemma

Equilibrium with contracts

- Suppose that the prisoners have the option of signing the following binding contract:

Contract

Those who sign this contract commit to keeping silent in case that everyone signs the contract and confessing otherwise

- Then signing the contract would be a Nash equilibrium of the resulting game and cooperation would be implemented:

	C	D	Sign
C	4 , 4	0 , $\underline{5}$	0 , $\underline{5}$
D	$\underline{5}$, 0	$\boxed{\underline{1} , \underline{1}}$	1 , $\underline{1}$
Sign	$\underline{5}$, 0	$\underline{1}$, 1	$\boxed{\underline{4} , \underline{4}}$

Games with contracts

- The minimax payoff for player i is the minimum payoff that it can guarantee even if everyone plays against hum/her:

$$\bar{u}_i = \max_{s_i} \min_{s_{-i}} u_i(s_i, s_{-i})$$

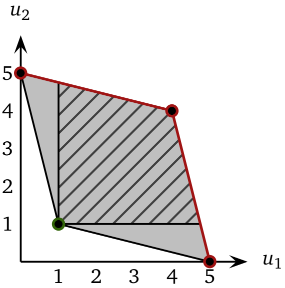
- We say that an outcome is individually rational if every player gets at least his/her minimax payoff

Theorem

There exists a game with contracts that implements an outcome as a Nash equilibrium if and only if the outcome is individually rational

Example: Prisoner's dilemma

	C	D
C	$\boxed{4, 4}$	$\boxed{0, 5}$
D	$\boxed{5, 0}$	$\boxed{1, 1}$



Example: Teamwork

	1	2	3	4
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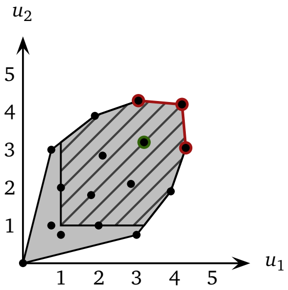


Example: Teamwork

Incomplete contracts

- Recall the teamwork example and suppose that not all contracts are possible because *effort is not verifiable in court*
- An agent cannot demand that his/her partner did not work hard enough, because he/she cannot prove this claim
- Agents can still write contracts that are contingent on the *total output*, consider for instance the following contract:

Contract

If all partners sign this contract:

- If the total revenue is at least 17 it will be split evenly
- If the total revenue is less than 17 it will be thrown away

If at least one partner does not sign this contract then the total output will be split evenly.

Example: Teamwork

Incomplete contracts

- The total outcome is greater than 17 if and only if both agents provide maximum effort
- If both agents sign the contract then the game played becomes:

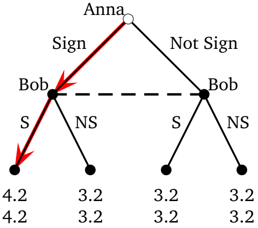
	1	2	3	4
1	$\boxed{-1, -1}$	$-1, -4$	$-1, -9$	$-1, -16$
2	$-4, -1$	$-4, -4$	$-4, -9$	$-4, -16$
3	$-9, -1$	$-9, -4$	$-9, -9$	$-9, -16$
4	$-16, -1$	$-16, -4$	$-16, -9$	$\boxed{4.2, 4.2}$

- The Pareto efficient outcome now becomes a Nash equilibrium

Example: Teamwork

Incomplete contracts

- After doing one step of backward induction the game with contracts is:



- The Pareto efficient outcome is induced by a SPNE
- Notice that "throwing away" the revenue might not be a credible threat unless there is a residual claimer
- Holmstrom (1984) used this example as a plausible explanation as to why there is private ownership over the means of production