

Lecture 3: Game theory, asymmetric information and principal agent models

- Objectives
 - ▶ introduce basic game theoretic concepts of relevance to environmental regulation
 - ▶ enable students to see these in context

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Outline

- Basic concepts in game theory and the Nash equilibrium
- Principal-agent models
 - ▶ the basic model
- Resource allocation mechanisms (RAMs)
 - ▶ a modern perspective that "replaces"/extends the principal-agent modeling framework
- Examples
 - ▶ tradable emission permits as a RAM

Nash equilibrium (1)

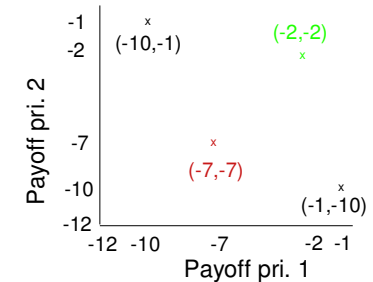
- Definition of the Nash equilibrium
 - ▶ The outcome that results when a player plays his/-her **best reply strategy** given that all the other players play their best reply strategy
 - ▶ Nash equilibria are rarely Pareto-optimal (an illustration is the Prisoners' dilemma, where the chosen strategy for the two prisoners {don't cooperate, don't cooperate} gives higher penalties than {cooperate, cooperate})
 - ▶ The Prisoners' dilemma is a bit special
 - crucial part of the outcome \leftarrow info. structure (no communication between the two prisoners)

... Nash equilibrium (2)

The prisoners' dilemma:

Two prisoners are captured by the police, and cannot communicate with each other. The police does not have sufficient evidence against the prisoners to sentence them without one of the prisoners accusing the other prisoner (payoff 1, payoff 2)

		Prisoner 1	
		Don't accuse	Accuse
Prisoner 2:	Don't accuse	(-2,-2)	(-1,-10)
	Accuse	(-10,-1)	(-7,-7)



Principal - Agent models (1)

In environmental economics -
the principal (P) (the regulator):

has coarser (less accurate) information than
the agents (A) (those to be regulated):
who has more accurate information about
him-/herself

Two types of P/A models:

1. Adverse selection models
(hard for P to observe A's characteristics)
2. Moral hazard models
(hard for P to observe A's actions)

... Principal - Agent models (2)

Environmental economics applications

- adverse selection:
P does not know how costly it is for A to follow
environmental regulations that P initiates
- moral hazard:
P is unable to perfectly monitor A's actions
(or perfect monitoring is so costly it does not pay to
monitor at such an accurate level)
- joint adverse selection and moral hazard
quite common (and some time hard to distinguish
from each other)

Principal - Agent models (3)

Principal: max social welfare choosing policy variables

subject to: actions, a_i , of the various types of agents i
given the chosen policy variable(s)

Symbolically:

Principal: max SWF(a_i)
{var}

s.t.(1): agents max $V_i(\mathbf{p}, M_i; z_i) \quad \forall i \in I$ [agents' behavior]
{ $\mathbf{x}_i, \mathbf{z}_i$ }

s.t.(2): set of policy variable constraints [if quantity instr.]

embedded in prices and money income [if taxes]

RAMs (1)

Any economic system or mechanism is a communication process where messages are exchanged between economic agents.

Necessary features of resource allocation mechanisms (RAMs):

1. the participation constraint (individual rationality) is satisfied
2. informational viability
info. demand not exceeded (does not require P knowledge of A's private info.)
3. incentive compatibility is satisfied
in A's self interest to act as P prescribes

... RAMs (2)

RAMs being a communication process (between P and A), this goes to the general notion of **truth telling**

Desirable features of RAMs (part 1):

4. informational efficiency met

- ▶ if a mechanism requires more costly information collection than necessary, costs can be saved by collecting information in a less costly fashion
- ▶ by the first welfare theorem, someone can be made better off without anyone made worse off, i.e., social welfare can be increased

This is related to desirable criterion 5

... RAMs (3)

Desirable features of RAMs (part 2):

5. social welfare is maximized = Pareto optimality (alternatively, social costs are minimized)

- ▶ is important as it measures the RAM's performance
- ▶ but incentive compatibility and PO may not be jointly feasible

- ▶ alternative: Second Best Pareto Optimality

6. the budget constraint of P is not exceeded

- ▶ the RAM is not so costly to P that P spends all of his/her allocated resources on pursuing the policy
- ▶ if the budget constraint "bites" it implies that welfare is reduced -- what is most important?

... RAMs (4)

- moral hazard in PA resolved by incentive compatibility in RAMs
- adverse selection in PA resolved (partly) by the participation constraint in RAMs
- RAM insight: in practical environmental policy both incentive compatibility and the participation constraint need to be met for the RAM to yield a predictable outcome
- incentive compatibility is more important than PO (if not incentive compatible, what allocation will actually take place?)
- budget balancing of minor relevance in theory
 - ▶ but important in practice (f.ex. developing countries)

... RAMs (5)

Same principle as for principal agent models (see P/A models (3)), but with the additional constraints

Symbolically:

Principal: $\max_{\{\text{var}\}} \text{SWF}(a_i)$

s.t.(1): agents $\max_{\{\mathbf{x}_i, \mathbf{z}_i\}} V_i(\mathbf{p}, M_i; z_i) \quad \forall i \in I$ [agents' behavior]

s.t.(2): set of policy constraints (or new price vector, \mathbf{p} , if policy is a price constraint [incentive comp. contr]

s.t.(3): $V_i(\mathbf{p}, M_i; z_i) \geq V_{i0}$ [part.constraint]

Example: tradable emission permits

- Necessary criteria (= predictable outcome)
- incentive compatibility OK
 - ▶ firms with $MAC(z') < MAC(z^*) = p^* \Rightarrow$ sell permits
 - ▶ firms with $MAC(z') > MAC(z^*) = p^* \Rightarrow$ buy permits
- participation constraint OK
 - ▶ from above (it pays to engage in trades given that $MAC(z') \neq MAC(z^*)$)
- informational viability OK
 - ▶ does not require regulator access to agents' private information (= their MACs)

Summary

- RAMs - a "modern" extension of P/A models must distinguish between:
 - ▶ necessary criteria (to get predictable outcomes)
 - ▶ desirable criteria (to enhance social welfare)
- RAMs - systemizes the communication process (parallel to the "truth telling" issue in parts of the mechanism design literature not assigned in this course)
- RAMs used in P/A settings where there is a "within one jurisdiction" (= there exists a principal)
- Must understand that incentive compatibility does not come for free