Week 1 Introduction

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Outline

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Contents and Purpose

This book is about noncooperative game theory and asymmetric information.

The **aim** is to present current *game theory* and *information economics* in a way that shows how to build simple model using a standard format.

This book is divided into two parts.

1. Game Theory
2. Information Economics

History

In 1944 Game Theory begun with *The Theory of Games and Economic Behavior* written by von Neumann and Morgenstern.

The above book is about cooperative game theory.

In 1950s *Noncooperative game theory* emerges.

Tucker developed Prisoners' Dilemma.

Nash proved the existence of *Nash Equilibrium* and laid the foundation for modern noncooperative game theory.

Until 70s GT remained a subdiscipline of economics and did not attract much attention from the mainstream economics.

History

70s and 80s GT made progress in two directions:

Selten A temporal sequence of actions

Harsanyi Asymmetric information

From 80s to now GT is swallowing up microeconomics.

Facts:

(1) John Nash, Reinhard Selten, and John Harsanyi are Nobel Prize laureates in 1994;

(2) In 2020 Nobel Prize laureates are also game theorists: Paul Milgrom and Robert Wilson.

Cooperative and Noncooperative Games

A **cooperative game** is a game in which the players can make binding commitments, as opposed to a **noncooperative game**, in which they cannot.

Both kinds of games start off with the same rules of the game, but look for different solutions.

- cooperative: appeal to Pareto optimal, fairness, equity
- noncooperative: maximize self-interest

Example for cooperative game

Members of a team choose equally arduous tasks to undertake to best coordinate with each other.

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What Kind of Assumptions to Make?

All economics start with **primitive assumptions** on preferences, strategies, and information, etc. That is, we start with assumptions on

- what people want
- what people can do
- what people know

The Paradigm of GT

Analyze "behavior" under basic assumptions

We make primitive assumptions and see what happens when they pick strategies in their own interests.

Advantage of making primitive assumptions

Compared to *high-level assumptions*, it is easier to judge whether primitive assumptions are sensible or not.

The Development of Theorems

The modeling process sets up "If-Then" statements.

If Premises

Then Conclusions

Both the premises and conclusions need to be verified by *empiricism*.

Discard an idea when

- the assumptions are contrived
- the premises or conclusions contradict reality

Economists are more interested in *explaining* and *understanding* than *predicting*.

The process of proof helps show how the hypothesis should be formulated.

Exemplifying Theory

"Exemplifying theory" or "modeling by example" reflects the trend towards **simplicity**.

The heart of this approach is to discover the *simplest* assumptions needed to generate an interesting conclusion.

Good theory uses Occam's razor and *ceteris paribus* assumption.

Occam's razor cuts out superfluous explanations

ceteris paribus restrict attention to one issue at a time

Tell a Story

The style of the book is to make things as simple as possible.

Keep in mind: Substance and style are closely related.

- What matters more than what a model says is what we understand it to say.

A Model is a Story Made Precise

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Major and Regional Airlines

An example from the book "**Prediction Machines: The Simple Economics of Artificial Intelligence**" (Agrawal, Gans, and Goldfarb)

Two types of airline companies

Major Airline and Regional Airline

- Advantage of MA: retain control under the uncertainty of *weather*
- Advantage of RA: lower operational costs

Opinion of the Authors

AI technology could influence their business models.

Five questions to ask

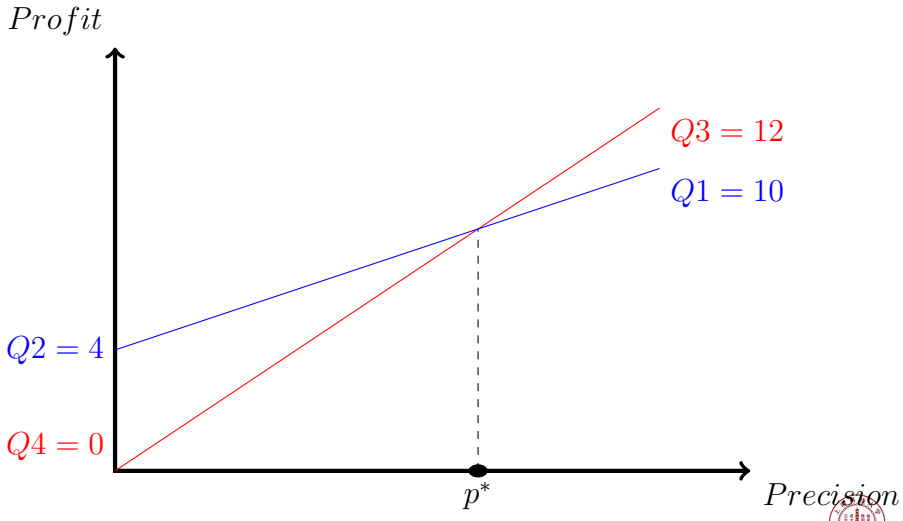
1. MA's profit in regular weather?
2. MA's profit in unexpected weather?
3. RA's profit in regular weather?
4. RA's profit in unexpected weather?
5. Precision of prediction of weather?

Reconcile facts to yield a specific answer

	MA	RA
Regular	Q1	Q3
Unexpected	Q2	Q4

If AI improves the precision of prediction, what is the threshold at which it could lead to a strategic change?

A Parametric Example



Outline

A Chinese Fable

Let us tell a game theoretic story about

一个和尚挑水喝，两个和尚抬水喝，三个和尚没水喝。

Thought on this old story

What do we learn from this story?

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Difference cooperation maintains when the number of people is not too large.

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Comparison with the Prisoner's Dilemma

Similarity cooperation fails because of the selfishness of people.

Difference cooperation maintains when the number of people is not too large.

We are going to build a model that *fully* explains the story.

Primitive Assumptions

1. *Water* is a **common resource**.
   - non-excludable: every monk can drink
   - rival: the more one monk drinks, the less the other monks can drink

2. Diminishing Marginal Return of Labor
   - One monk works: amount of water $= H$
   - Two monks work: amount of water $= aH$
   - Three monks work: amount of water $= bH$
   - $a \leq 2$ and $b - a \leq a - 1$

Primitive Assumptions

3. Every monk can choose between **work** and **shirk**.
   - If he chooses *work*, a labor cost L incurs.
   - If he chooses *shirk*, the labor cost is 0.

4. Every monk's payoff function = water he drinks - labor cost
   - All water is shared equally among monks.

The Case of One Monk

一个和尚挑水喝

$H > L$.

The Case of Two Monks

	work	*shirk*
work	$\frac{a}{2}H - L, \frac{a}{2}H - L$	$\frac{1}{2}H - L, \frac{1}{2}H$
shirk	$\frac{1}{2}H, \frac{1}{2}H - L$	$0, 0$

两个和尚抬水喝

Let (work, work) be an equilibrium.

When both monks work, each of them gets $\frac{a}{2}H - L$. If one monk turns to *shirk*, he will get $\frac{1}{2}H$.

We need $\frac{a}{2}H - L > \frac{1}{2}H$, i.e., $H > \frac{2}{a-1}L$.

The Case of Two Monks

一个和尚挑水，另一个和尚偷懒

Let (work, shirk) be an equilibrium.
The working monk does not want to shirk: $\frac{1}{2}H - L > 0$, i.e., $H > 2L$.
The shirking monk does not want to work: $\frac{1}{2}H > \frac{a}{2}H - L$, i.e., $H < \frac{2}{a-1}L$.

两个和尚没水喝

Let (shirk, shirk) be an equilibrium.
We need $0 > \frac{1}{2}H - L$, i.e., $H < 2L$.

The Case of Three Monks

三个和尚打水喝

No monk want to shirk. We need $\frac{b}{3}H - L > \frac{a}{3}H$, i.e., $H > \frac{3}{b-a}L$.

三个和尚两个抬水，一个偷懒

The working monks do not want to shirk. We need $\frac{a}{3}H - L > \frac{1}{3}H$,i.e.,$H > \frac{3}{a-1}L$.

三个和尚一个挑水，两个偷懒

The working monk does not want to shirk. We need $\frac{1}{3}H - L > 0$,i.e., $H > 3L$.

三个和尚没水喝

We need $0 > \frac{1}{3}H - L$, i.e., $H < 3L$.

The Condition for the Story

一个和尚打水喝，两个和尚挑水喝，三个和尚没水喝。

The situation depicted by the story only occurs when $H > \frac{2}{a-1}L$ and $H < 3L$. It is possible only when $\frac{2}{a-1} < 3$, that is, when

$$\frac{5}{3} < a$$

The Complete Story

Under the condition that $a > \frac{5}{3}$,

Value of H	Equilibrium
$< 2L$	两个和尚没水喝，三个和尚没水喝。
$2L, \frac{2}{a-1}L$	两个和尚一个挑水一个偷懒，三个和尚没水喝。
$\frac{2}{a-1}L, 3L$	两个和尚抬水喝，三个和尚没水喝。
$3L, \frac{3}{a-1}L$	两个和尚抬水喝，三个和尚一个挑水两个偷懒。
$\frac{3}{a-1}L, \frac{3}{b-a}L$	两个和尚抬水喝，三个和尚两个挑水一个偷懒。
$> \frac{3}{b-a}L$	两个和尚抬水喝，三个和尚打水喝。

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$\frac{3}{a-1}L, \frac{3}{b-a}L$	两个和尚抬水喝，三个和尚两个挑水一个偷懒。
$> \frac{3}{b-a}L$	两个和尚抬水喝，三个和尚打水喝。

Remark: The assumption of diminishing marginal productivity guarantees that the criteria are well ordered.

What does this Model Tell us?

A different insight from the traditional view

- Productivity is crucial for *cooperating* behavior.
- Higher productivity leads to more cooperation among people.