

Introduction to Game Theory

General Principles

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2024

Outline

- Introductions
- What is EC327?
 - Syllabus
 - Schedule & Assignments
 - Office Hours
- What is Game Theory?
 - What are strategic games?
 - How can we classify games?

Introductions

Welcome to the Class!

About Me:

- **Preferred Name:** Dante
- **Preferred Pronouns:** he, him
- 4th year Econ Phd student
- Davis, CA -> Portland, OR -> Eugene, OR

Introduce Yourselves

IntroQuiz

- Your preferred name, pronouns; to help me get to know you
- Why did you choose this class?
- Song recommendation for class playlist

What is EC327?

Syllabus Document

- Most up to date version on github
- I will also upload to Canvas
- print, sign, and upload as your first assignment

Class Expectations

Prerequisites

- **Courses:** EC201 or EC202
- **Knowledge:** This class will require you to use some graphing skills. If you felt uncomfortable with the material in EC201, I recommend that you review how to solve equations, inequalities, and fractions.
 - There are great free resources out there like Khan Academy. You can always feel free to reach out for help or other resources.

Student Expectations

- **Come to class**
 - Pay attention to lectures, take notes, review to prepare
 - Participate in group work & activities
 - **Ask questions!**
- **Read the textbook**
- **Communicate respectfully**
 - With your classmates
 - With me & grader
- **Have academic integrity**¹
 - Verify that all submitted work is your own
 - Provide sources for all information that you find

¹ see UQ's Student Conduct Code

Instructor Expectations

- **Provide course material**
 - Slides will be updated on github
 - I will also try to post them on Canvas, but not all
 - Assignments posted on Canvas w/ due dates,
- **Face-to-face Interaction**
 - **Classes**
 - Ask me to clarify if something doesn't make sense
 - Ask me to slow down if I'm going too fast
 - **Office Hours**
 - Use them!!

Admin Stuff

Problem Sets

You will practice what we learn in class on independent assignments.

Each homework assignment will include a few problems that are similar to what you will see on exams.

- Learning something new takes practice, so these assignments help you keep up with the concepts
- You will be graded not only on whether you got the right answer, but also more importantly on *how you communicate your work*.
 - See Canvas rubric for more info

Class Activities

- Sometimes I will ask you to play the types of games in lectures
 - Record the strategies you chose and the outcome
 - Reflect on how you played the game
 - Relate it to lecture concepts

Exams

You will demonstrate how well you understand course concepts through
a **midterm** and a **final** exam

- **Midterm**

- sometime around week 5 (Oct. 28th or 30th)
- Will test you on definitions, solution concepts, and critical thinking problems

- **Final**

- finals week of December 9 (check duckweb for details)
- Covers everything we learned in the quarter, with some concepts from the 2nd half

Grading

Problem Sets	30%
In-class Activities	10%
Midterm	30%
Final	30%

Policies

- **No make-up exams!**
 - if you absolutely cannot attend midterm, you final exam
- Problem set keys posted automatically after deadline
 - -> no late submissions accepted

Campus Resources

- **Accessible Education Center**
 - aec.uoregon.edu
- **Support for victims of assault, harassment, stalking**
 - safe.uoregon.edu
 - 24/7 hotline: (+1) 541-346-SAFE (7244)
- **Health and Wellbeing**
 - University Counseling Services
 - Basic Needs Program
- **Religious Observance Accommodations**
 - Provost website

Course Pages

<https://canvas.uoregon.edu/courses/251353> - submit
check deadlines

github.com/dyasui/EC327 - Find up-to-date version
assignments - *let me know if links are broken*

What is Game Theory

Motivation

What is the goal of **Game Theory**?

To understand social behavior

Why do economists study Game Theory?

We are *social* scientists

To make models, predictions, hypotheses, etc. of research

Motivation

Why should **you** study game theory?

Practice your strategic decision-making in a safe environment

Develop your intuition for social interactions in a structured way

Feed your curiosity for economics, social science, and political science questions!

What is theory?

What is the point of *theory*?

Simplify complex systems - understanding one easier than trying to

Generate *falsifiable* hypotheses - good economy
good theory

Theory in a data-driven world?

“The theory of economics does not furnish a body of conclusions immediately applicable to policy. It is rather a method of approaching certain complex economic problems, one which helps its possessor to draw correct conclusions.”

What are the limits to theory?

- Our models will never be perfect representation
- But we should know how well they *approximate* what we want to understand
- Theory is very useful for generating *falsifiable hypotheses* which can then be used to guide experimental or statistical analysis
- As we play games in class, we will observe the difference between our theoretical predictions

What is a *game* of strategy?

Game theory: It's not all fun and games!

Examples of strategic games:

Where in the goal should you kick a penalty shot?



Examples of *strategic games*:

Where in the goal should you kick a penalty shot?

- Left, Right, Center? Up or Down?
- Is there one best place to kick?
- What if you always choose top right corner?
- Besides soccer;
 - Which offensive play in football?
 - Where to serve in a tennis court?

Examples of *strategic games*:

If 100% of your grade in this class is decided by a class average, should you study?

- If you can all agree to take a chill quarter and not study, will everyone get A's?
- But what if there's at least one try-hard?
- Now how much should you study, even if you already know you won't?
- Do you think everyone else will keep their promise?

Examples of *strategic games*:

Should you give an engagement ring to the person

- Why buy an expensive trinket when you could save a house, etc?
- Does it matter if your recently engaged friends give engagement rings?
- Does your paycheck vs. how much your fiancee receives matter?

Examples of *strategic games*:

In economics, why do we say there is a **law of one**

Imagine I set up a competing Starbucks franchise

- If they sell PSL for \$6.50, what happens if I sell the same?
- What if I sell for \$6.51?

This has been your EC201 review!

Examples of *strategic games*:

Should the US try to defeat its rivals through global war?

- Why did the US and USSR amass massive nuclear arsenals?
- Why has a nuclear weapon never been used in a war?
- Are anti-ballistic missiles destabilizing to international relations?

'GAMES' REFERS TO MODELS, SIMULATIONS AND COMPUTER PROGRAMS WHICH HAVE TACTICAL AND STRATEGIC APPLICATIONS

List Games

FALKEN'S MAZE

BLACK JACK

GIN RUMMY

HEARTS

BRIDGE

CHECKERS

CHESS

POKER

FIGHTER COMBAT

GUERRILLA ENGAGEMENT

DESERT WARFARE

AIR-TO-GROUND ACTIONS

THEATERWIDE TACTICAL WARFARE

THEATERWIDE BIOTOXIC AND CHEMICAL WARFARE

GLOBAL THERMONUCLEAR WAR



Examples of *strategic games*:

What do these examples have in common?

What is a Game? Def

What do all these questions have in common?

- They all involve people making choices which depend on the actions of others
- In other words, they are questions of **strategy**:

Strategic interdependence is present in a social situation if what is best for someone *depends* on what someone else does.

Strategic Choice vs. other types

- Economics is the study of **constrained choice**; in the *utility maximization problem* as the workhorse
 - These types of problems usually only involve consumer, who is only constrained by their budget
- We use the term **strategic games** to distinguish agent optimization problems

A **game** is a type of problem featuring multiple agents

- in which their optimal choice **depends on the other players.**

A definition of a game¹

A **Game** consists of:

- a collection of decision-makers, called **players**;
- the set of **information** available to each player;
- the **strategies** available to each player in each information set;
- a mapping from the intersection strategies of all players to payoffs;
- **preferences** of the individual players over all possible payoffs.

Who are the players

What defines a player?

- **Preferences:**

- In economics, we say people have *unlimited wants*
- Therefore, we have to think about how people *prioritize* more

- **Beliefs:**

What defines a player?

- **Preferences:**
- **Beliefs:**
- My beliefs about the world define how I act
- If I am exposed to new *information* it can potent beliefs, and therefore change my actions
- Information and beliefs of players will define lat

Preferences

Preferences describe the subjective ranking that we make among alternatives.

For example, on the set of Eugene boba stores, my ranking goes like this;

1. Tea 4 - major chain, good quality and selection
2. Day & Night - they have mango sago, cute location
3. Bobahead - no more campus location 😞
4. No boba
5. Rabbit Hole - no hate, just not for me

Rational Preferences

The **rational model** of choice is the foundation of ...
Its assumptions are that:

- People have **complete preferences**
 - for every pair of options, you can either tell me that you prefer one or that you are *indifferent*
 - for any pair of deserts, { ,  }, either ( > ) or ( ~ )
- Preferences are **transitive**
 - if (, ) and (, ) then (, , ) ∈ 

Rationality

One key proposition of rationality is that we can represent our preferences by real numbers.

A **utility function** maps a choice to a single number representing its value.

For example, let $u(\cdot)$ be the utility function from earlier.

- I can have $u(\text{beer}) = 5$, $u(\text{cigarette}) = 10$, $u(\text{gym}) = 25$
- I can also have $u(\text{beer}, \text{cigarette}) = 20$, $u(\text{beer}, \text{cigarette}, \text{gym}) = 40$

Ordinal vs. Cardinal numbers

- **Cardinal:** amounts which can be measured in *magnitude*
▪ examples: \$9.99, 80 students, 50:50 odds
- **Ordinal:** all that matters is the *relative ranking*
▪ examples: utility; what does 100 utility mean?

Don't worry!

- For this class, you won't need to worry about utility (if you want to, take EC311).
- I will almost always give you specific values of utility functions, called **payoffs**.

Payoffs

What is a player's goal in a game?

To maximize their expected **payoff**

- A payoff can represent many things which come outcome
- Whenever you see a payoff, assume that it represents that outcome which an agent cares about
- For example, your payoff to giving to charity would be the emotional benefit you feel towards giving to others

Payoffs

What is true of payoffs?

Higher numbers are more preferred

They are **Ordinal**; i.e., the relative units don't matter

They capture *everything* in a game that a player cares about

Payoffs

- Sometimes my enjoyment of a thing depends on
socially-dependent preferences

My choice	My friends' choice	
Duck's game	Duck's game	3
Duck's game	Stay home	2
Stay home	Duck's game	1
Stay home	Stay home	2

- Is this an example of a **strategic** or **non-strategic**

Expected Payoffs

Often games involve some amount of *chance*; with
of each outcome happening

- We need tools for thinking about how people th

Expected Payoffs

In math, an **expected value** is the average value of a *variable*, weighted by the probability of each value.

Expected Payoffs

For example, suppose X is a random variable which

- **1** with **50%** probability,
- **2** with **25%** probability,
- **3** with **25%** probability

What is the *expected value* of X ? ($E(X)$)

$$\begin{aligned}E(X) &= .5(1) + .25(2) + .25 \\&= .5 + .5 + .75 = 2.75\end{aligned}$$

Expected Payoffs

An **Expected Payoff** is just the *expected value* of p

An average of the payoffs associated with every weighted by the corresponding probability of each happening

Expected Payoffs

Consider the following choice:

Option A:

I flip two coins; - if both land **heads**, you win \$100 - otherwise you get :

Option B:

You just get \$25 for sure

Expected Payoffs

- If you choose **Option A**, we call you **risk averse**
- If you choose **Option B**, you are **risk loving**
- If you are *indifferent* between the two options, you are **neutral**

All of these difference preferences can be incorporated into a model with the right *utility function*

Beliefs

Our theories will have to make assumptions about
All of our games will at least assume that **all players follow the rules.**

Beliefs

We will assume that all players know¹:

- Who else is playing,
- all of the strategies each player could *potentially*,
- everyone's payoffs for all possible combinations of players,
- and that everyone else is maximizing their payoffs.

¹ and believe

Taxonomy of Games

General Categorical Terms

- **Sequential** or **Simultaneous**?
- **Zero-sum** or not
- **Perfect** or **Imperfect** information?
 - is info **symmetric** or **asymmetric**?
- **One-shot** or **Repeated**?
- ‘**Noncooperative**’ or ‘**Cooperative**’?

Sequential vs. Simultaneous

Sequential Games

- players make their moves one after the other
- **Chapter 3**
- **Visual tool:** game trees
- **Solution Method:** backwards induction

Simultaneous

- players make their moves at the same time
- **Chapter 4**
- **Visual tool:** normal form games
- **Solution Method:** dominant strategy deletion or best response functions

Sequential Games

In **sequential** games, you have to think about how to affect what your opponent will do in the **future**.

This hierarchy of thinking will make these types easier for us to think through, so they will be our games.

- We'll see that sometimes **moving first** can be advantageous
- While other times it's best to **wait and see** what the other player does

Simultaneous Games

In **simultaneous** games, you have to figure out what your opponent is thinking about what your opponent is thinking you

This circular thinking can get confusing, so we'll learn new methods for organizing these games in chapter 2.

Conflicting vs. Common Interests

Many games you are familiar with have distinct winners and losers.
But in other types of games, it's possible for everyone to win ahead.

Zero-sum (or constant-sum) Games

When the *total payoffs of all players sum to 0*¹

- i.e, one player's gain is another player's loss
- Examples: NCAA Football Championship, Scrabble (technically constant-sum)

...

Not all games are fixed or zero sum;

- Examples: Hiring a tutor (mutual gains), International trade

Are strategic interactions Repeated?

A **one-shot** game is played only once by the same players.

- If you've never played against someone before, you have **beliefs** about them
- Secrecy or surprise are potentially good strategies

A game is called **repeated** if the same players play many times.

- If you know your opponent, then your **reputation** matters. You want to cooperate

Full or Equal Information

How much does each player know when they decide?

- **Perfect Information:** when players know all previous moves and external circumstances
 - players may have **imperfect info**; uncertainty about the world, previous' moves, or other player's 'type'
- **Asymmetric Info:** when one player has access to information that other players do not
 - Examples: hand in poker, used car salesmen
 - Topics: Signaling, Screening

Can agreements be Enforced?

- Self-interest and common good can often conflict
- In these situations, players need to form agreements to achieve cooperative outcomes.

But can people actually be held to those agreements?

For example:

- Paris Climate accords; who polices nation-state's actions?
- Public goods; why do we need the Internal Revenue Service?

Can agreements be Enforced?

Two broad categories of the field are **cooperative** game theory and **noncooperative** game theory¹

Cooperative games are those in which agreements can be enforced

In **Noncooperative** games, no-one can be forced to keep their own self-interest

Equilibrium

In each of these different categories of games, we make predictions as to how rational agents will behave

- Our methods of solving each type of game will be able to find types of **equilibria**

Equilibrium

Where every player's strategy is a **best-response** to the other player(s)

Equilibrium

Why study equilibria?

- They are **stable**: if nobody has anything better to do than what they are doing now then why change?
- We can adapt our models to all types of equilibria
 - Market or non-market
 - Dynamic or static

Equilibrium

A few different types of equilibria in this class:

- **Nash equilibrium**
 - **Subgame perfect NE**
 - **Mixed strategy NE**
 - **Bayes-Nash** equilibrium

Tentative Schedule

Week	Chapter(s)	Topic
1	1, 2	Intro & General Principles
2	3	Sequential Move Games
3	4	Simultaneous Move Games
4	6	Combining Sequential and Simultaneous Games
5	6	Review & Midterm
6	5	Simultaneous Games: Continuous Strategies, Discussion, and Evidence
7	7	Mixed Strategies
8	8	Strategic Moves
9	9	Uncertainty and Information
10	10	Repeated Games