Games & Behavior
ECON 511H

Sérgio O. Parreiras

Department of Economics
University of North Carolina

Fall, 2016

THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

Outline

THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

Outline

THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

Course Objectives

The course main goal is to provide tools to enable you to:

1. construct models of strategic behavior,
2. identify their (built-in) limitations and
3. think about how to apply them to real-life problems.

On Exactitude in Science
Jorge Luis Borges, *Collected Fictions*, translated by Andrew Hurley.

"In that Empire, the Art of Cartography attained such Perfection that the map of a single Province occupied the entirety of a City, and the map of the Empire, the entirety of a Province. In time, those Unconscionable Maps no longer satisfied, and the Cartographers Guilds struck a Map of the Empire whose size was that of the Empire, and which coincided point for point with it. The following Generations, who were not so fond of the Study of Cartography as their Forebears had been, saw that that vast Map was Useless, and not without some Pitilessness was it, that they delivered it up to the Inclemencies of Sun and Winters. In the Deserts of the West, still today, there are Tattered Ruins of that Map, inhabited by Animals and Beggars; in all the Land there is no other Relic of the Disciplines of Geography.

Suarez Miranda,Viajes de varones prudentes, Libro IV,Cap. XLV, Lerida, 1658."

THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

On Exactitude in Science
Jorge Luis Borges, *Collected Fictions*, **translated by Andrew Hurley.**

"In that Empire, the Art of Cartography attained such Perfection that the map of a single Province occupied the entirety of a City, and the map of the Empire, the entirety of a Province. In time, those Unconscionable Maps no longer satisfied, and the Cartographers Guilds struck a Map of the Empire whose size was that of the Empire, and which coincided point for point with it. The following Generations, who were not so fond of the Study of Cartography as their Forebears had been, saw that that vast Map was Useless, and not without some Pitilessness was it, that they delivered it up to the Inclemencies of Sun and Winters. In the Deserts of the West, still today, there are Tattered Ruins of that Map, inhabited by Animals and Beggars; in all the Land there is no other Relic of the Disciplines of Geography.

Suarez Miranda,Viajes de varones prudentes, Libro IV,Cap. XLV, Lerida, 1658."

THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

On Exactitude in Science
Jorge Luis Borges, *Collected Fictions*, translated by Andrew Hurley.

"In that Empire, the Art of Cartography attained such Perfection that the map of a single Province occupied the entirety of a City, and the map of the Empire, the entirety of a Province. In time, those Unconscionable Maps no longer satisfied, and the Cartographers Guilds struck a Map of the Empire whose size was that of the Empire, and which coincided point for point with it. The following Generations, who were not so fond of the Study of Cartography as their Forebears had been, saw that that vast Map was Useless, and not without some Pitilessness was it, that they delivered it up to the Inclemencies of Sun and Winters. In the Deserts of the West, still today, there are Tattered Ruins of that Map, inhabited by Animals and Beggars; in all the Land there is no other Relic of the Disciplines of Geography.

Suarez Miranda,Viajes de varones prudentes, Libro IV,Cap. XLV, Lerida, 1658."

THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

Mont Sainte Victoire
Photography vs Cézanne

Mont Sainte Victoire
Photography vs Cézanne

Reaching Our Goals

To achieve our goals, we rely on:

1. Class discussion.
2. Problem Solving.

THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

Reaching Our Goals

To achieve our goals, we rely on:

1. Class discussion.
2. Problem Solving.

Recommended Texbook

Osborne, Martin J. (2004)

An Introduction to Game Theory, Oxford University Press.

This is an excellent textbook, although it is not required, it provides a very nice companion to our course and is a great reference source.

THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

Tentative Coverage

1. Decision Theory: Expected Utility and Information Partitions
2. Games: Non-Cooperative and Cooperative Games
3. Non-Cooperative Games: Solution Concepts: Nash Equilibrium
4. Non-Cooperative Games: Solution Concepts: Iterative Deletion of Strictly Dominant Strategies
5. Pareto Efficiency
6. Cooperative Games: Solution Concepts: The Core
7. Cooperative Games Applications: Matching and Trading
8. Non-Cooperative Games: Applications of Nash Equilibrium

Coverage
continued

9. Constrained Optimization

10. Non-Cooperative Games: Solution Concepts: Mixed Strategy Nash Equilibrium

11. Non-Cooperative Games: Solution Concepts: Correlated Equilibrium

12. Non-Cooperative Games: Extensive Games: Solution Concept: Subgame Perfection

13. Non-Cooperative Games: Extensive Games: Repeated Games

14. Non-Cooperative Games: Extensive Games with Imperfect Information

15. Non-Cooperative Games: Solution Concepts: Perfect Bayesian Equilibrium

16. Super Modular Games

17. Mechanism Design

Class Information

• We meet Tuesdays and Thursdays, from 2PM to 3:15PM, at Murphey Hall, room 314.

• Whenever possible, please bring your laptop loaded with Mathematica to class.

• Sakai will be used to post grades, course announcements and links. However, e-mail and problem sets will not be managed thru Sakai.

Contact Info and Office Hours

1. Email: `sergiop@unc.edu`.
2. Do not sent e-mail thru Sakai.
3. PLEASE: subject line in any email must be `E511`
4. Office hours (OH) are by Google Calendar appointment only:

   Monday 11AM-1PM
   Wednesday 3-5PM
   Friday 12AM-2PM

5. Do not email me to schedule appointment during OHs.
6. To schedule an OH meeting use Google calendar:
   1. Login name: sergiop@email.unc.edu
   2. Password: given in class.
   3. Create an event with: your name, start and finish times.
   4. The calendar name is OH.
7. Email-me to schedule meetings **outside** OH.

Evaluation

- **September 29th** — 1st Midterm
- **October 27th** — 2nd Midterm
- **Friday, December 9th** at noon (time differs from class time) — Final Examination
- Midterm grades account for 30% of the final grade.
- Final examination grade is worth 35% of the final grade.
- Ten or more problem sets and writing assignments: 20%.
- Final Essay: 10%.
- Participation and initiative: 5%
- There are no make-ups.
- The weight of any missing midterm (with justification) is transferred towards the final exam.

Computing Grades

- Grades are not "curved".
- Scale: `Score = Exam Grade+100−Max Exam Grade`.
- Course grades are computed accordingly to the table:

letter grade	min. score
A+	100
A	95
A-	90
B+	87
B	83
B-	80
C+	77
C	73
C-	70
D+	67
D	63
D-	60

To do list for the first week

1. If you are eligible for taking exams with Accessibility Resources, please schedule with them within the first or second week of classes and notify me.

2. If a) you have more than 3 final exams in more than 24 hours; b) ECON511 is one of these exams; and c) you wish to re-schedule one of your exams; then you **MUST** ask for an alternative date during the *first two weeks of classes*. If you do not follow these procedures your request will not be accommodated.

3. Place an order for the software *Mathematica* throughout software.sites.unc.edu/software/mathematica/. The *student license is free.* However, you must place an order.

To do list for the first week

1. If you are eligible for taking exams with Accessibility Resources, please schedule with them within the first or second week of classes and notify me.

2. If a) you have more than 3 final exams in more than 24 hours; b) ECON511 is one of these exams; and c) you wish to re-schedule one of your exams; then you **MUST** ask for an alternative date during the *first two weeks of classes*. If you do not follow these procedures your request will not be accommodated.

3. Place an order for the software *Mathematica* throughout software.sites.unc.edu/software/mathematica/. The *student license is free*. However, you must place an order.

To do list for the first week

1. If you are eligible for taking exams with Accessibility Resources, please schedule with them within the first or second week of classes and notify me.

2. If a) you have more than 3 final exams in more than 24 hours; b) ECON511 is one of these exams; and c) you wish to re-schedule one of your exams; then you **MUST** ask for an alternative date during the *first two weeks of classes*. If you do not follow these procedures your request will not be accommodated.

3. Place an order for the software *Mathematica* throughout software.sites.unc.edu/software/mathematica/. The *student license is free.* However, you must place an order.

Class Discussion

During this course, we shall employ additional material from TV, movies, or literature to discuss strategic related issues.

Sometimes, you may find the political or religious views; or the profanity contained in the additional material offensive or objectionable and you may feel uncomfortable.

I do not endorse any particular views ex but ...

Class Discussion

During this course, we shall employ additional material from TV, movies, or literature to discuss strategic related issues.

Sometimes, you may find the political or religious views; or the profanity contained in the additional material offensive or objectionable and you may feel uncomfortable.

I do not endorse any particular views ex but ...
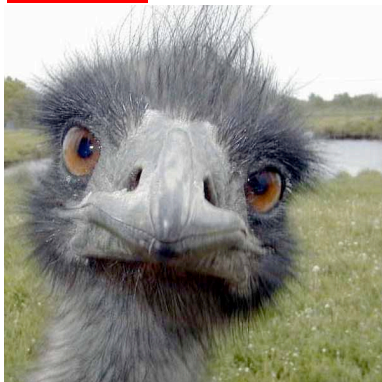
Class Discussion

During this course, we shall employ additional material from TV, movies, or literature to discuss strategic related issues.

Sometimes, you may find the political or religious views; or the profanity contained in the additional material offensive or objectionable and you may feel uncomfortable.

I **do not** endorse any particular views ex but ...

Class Discussion

I believe that as part of your university education, it is important you

engage in critical thinking ,
and also respect different opinions expressed by your classmates.

Real-life Applications

To discuss real-life applications, it is recommended that read at least one newspaper regularly, follow major current events and also pay attention to socio-economic or political events that have strategic content. Moreover, if you are heading to graduation and job-market I suggest you subscribe to one of these newspapers:

1. NY Times
2. Wall Street Journal

Another good source of news is the NPR podcast Planet Money.

Problem Sets (PS)

1. PS are posted on
   http://www.unc.edu/~sergiop/E511H_PS.html.

2. PS are posted after every class and are due at the next class.

3. Past due date PS are not accepted.

4. Please be prepared to present and discuss the PS.

5. You are **strongly** encouraged to work in groups of at most four. In this case, please submit only one copy.

6. The grading criteria for the PS are:

grade	solutions	work	presentation
4.0	correct	explained	reasonable
3.5	comput. err.	explained	reasonable
3.0	concept. err.	explained	reasonable
2.0	–	omitted	reasonable
1.0	–	–	poor
0	–	–	–

Problem Sets (PS)

1. PS are posted on
   http://www.unc.edu/~sergiop/E511H_PS.html.
2. PS are posted after every class and are due at the next class.
3. Past due date PS are not accepted.
4. Please be prepared to present and discuss the PS.
5. You are **strongly** encouraged to work in groups of at most four. In this case, please submit only one copy.
6. The grading criteria for the PS are:

grade	solutions	work	presentation
4.0	correct	explained	reasonable
3.5	comput. err.	explained	reasonable
3.0	concept. err.	explained	reasonable
2.0	–	omitted	reasonable
1.0	–	–	poor
0	–	–	–

Problem Sets (PS)

1. PS are posted on
   http://www.unc.edu/~sergiop/E511H_PS.html.
2. PS are posted after every class and are due at the next class.
3. Past due date PS are not accepted.
4. Please be prepared to present and discuss the PS.
5. You are **strongly** encouraged to work in groups of at most four. In this case, please submit only one copy.
6. The grading criteria for the PS are:

grade	solutions	work	presentation
4.0	correct	explained	reasonable
3.5	comput. err.	explained	reasonable
3.0	concept. err.	explained	reasonable
2.0	–	omitted	reasonable
1.0	–	–	poor
0	–	–	–

Problem Sets (PS)

1. PS are posted on
   `http://www.unc.edu/~sergiop/E511H_PS.html`.
2. PS are posted after every class and are due at the next class.
3. Past due date PS are not accepted.
4. Please be prepared to present and discuss the PS.
5. You are **strongly** encouraged to work in groups of at most four. In this case, please submit only one copy.
6. The grading criteria for the PS are:

grade	solutions	work	presentation
4.0	correct	explained	reasonable
3.5	comput. err.	explained	reasonable
3.0	concept. err.	explained	reasonable
2.0	–	omitted	reasonable
1.0	–	–	poor
0	–	–	–

Problem Sets (PS)

1. PS are posted on
   `http://www.unc.edu/~sergiop/E511H_PS.html`.
2. PS are posted after every class and are due at the next class.
3. Past due date PS are not accepted.
4. Please be prepared to present and discuss the PS.
5. You are **strongly** encouraged to work in groups of at most four.
   In this case, please submit only one copy.
6. The grading criteria for the PS are:

grade	solutions	work	presentation
4.0	correct	explained	reasonable
3.5	comput. err.	explained	reasonable
3.0	concept. err.	explained	reasonable
2.0	–	omitted	reasonable
1.0	–	–	poor
0	–	–	–

Problem Sets (PS)

1. PS are posted on
   http://www.unc.edu/~sergiop/E511H_PS.html.
2. PS are posted after every class and are due at the next class.
3. Past due date PS are not accepted.
4. Please be prepared to present and discuss the PS.
5. You are **strongly** encouraged to work in groups of at most four.
   In this case, please submit only one copy.
6. The grading criteria for the PS are:

grade	solutions	work	presentation
4.0	correct	explained	reasonable
3.5	comput. err.	explained	reasonable
3.0	concept. err.	explained	reasonable
2.0	–	omitted	reasonable
1.0	–	–	poor
0	–	–	–

Some words about math.

We will cover bits of optimization, set theory and proof reasoning but I assume you have knowledge equivalent to Osborne's (suggested reading) mathematical appendix – please browse it – and please, do report any doubts or questions to me as soon as possible I can help you. Or check topics 1 to 2.3 in Martin Osborne's tutorial.

- Language of Set Theory
- Basic Calculus (derivation and integration).
- Probability (expectation of random variables)
- Reading Proofs.
- Finding Maxima and Minima.

Mathematics is a tool (language)

Mathematics is a tool (language)

If $f : [a, b] \to \mathbb{R}$ satisfies $[\forall x \in [a, b]$ and $\forall \varepsilon > 0, \exists \delta > 0;$ such that $|x - y| < \delta \Rightarrow |f(x) - f(y)| < \varepsilon]$
$\Rightarrow \exists z \in [a, b]; \forall x \in [a, b] \; f(z) \geq f(x).$

If a real-function defined on a closed interval on the real line is continuous then it attains a maximum on the interval.

Mathematics is a tool (language)

If $f : [a, b] \to \mathbb{R}$ satisfies $[\forall x \in [a, b]$ and $\forall \varepsilon > 0, \exists \delta > 0$; such that $|x - y| < \delta \Rightarrow |f(x) - f(y)| < \varepsilon]$
$\Rightarrow \exists z \in [a, b]; \forall x \in [a, b]\, f(z) \geq f(x).$

If a real-function defined on a closed interval on the real line is continuous then it attains a maximum on the interval.

Questions & Answers

This course is called Game Theory. I like games!
The course sounds/looks fun !!
Should I take this class?

Sorry for curbing your enthusiasm...
But playing a game often is more fun than studying one... ☺

Questions & Answers

This course is called Game Theory. I like games!
The course sounds/looks fun !!
Should I take this class?

Sorry for curbing your enthusiasm...
But playing a game often is more fun than studying one... ☺

I understand the lecture notes but during the exams I am not able to answer the questions. What am I doing wrong? How should I study for this class?

The only way to make sure you understood the material is to solve problems. Try to work in groups and try to solve as many problems as you can. Do not be frustrated if you get stuck with a problem. The problems where you get stuck are precisely the ones that are useful for your study. They should serve as a guide to where the focus of your reading should go and to which questions you should bring to class.

Questions & Answers

I am trying to solve problems but many of the posted or suggested problems lack an answer key. How can I check if my work is correct? What use is to solve a problem if I do not know whether my solution is correct?

The point of solving problems is not to come up with a right answer but

rather to elicit questions that you may have about the material. If you are unsure about your work or answer this is good signal. Please do bring the problem to class and express your doubts. If you faced a challenge when trying to solve a problem and you are not sure of your answer or not sure on how to proceed at some step, chances are, your colleagues have similar questions and it is worth to discuss it in class.

The lack of an answer key is, for most of the cases, deliberate. It is designed to give incentives for you to work the problems rather than trying to memorizing solutions.

Questions & Answers

I am trying to solve problems but many of the posted or suggested problems lack an answer key. How can I check if my work is correct? What use is to solve a problem if I do not know whether my solution is correct?
 The point of solving problems is not to come up with a right answer but

rather to elicit questions that you may have about the material. If you are unsure about your work or answer this is good signal. Please do bring the problem to class and express your doubts. If you faced a challenge when trying to solve a problem and you are not sure of your answer or not sure on how to proceed at some step, chances are, your colleagues have similar questions and it is worth to discuss it in class.

The lack of an answer key is, for most of the cases, deliberate. It is designed to give incentives for you to work the problems rather than trying to memorizing solutions.

Questions & Answers

I am trying to solve problems but many of the posted or suggested problems lack an answer key. How can I check if my work is correct? What use is to solve a problem if I do not know whether my solution is correct?
The point of solving problems is not to come up with a right answer but

rather to elicit questions that you may have about the material. If you are unsure about your work or answer this is good signal. Please do bring the problem to class and express your doubts. If you faced a challenge when trying to solve a problem and you are not sure of your answer or not sure on how to proceed at some step, chances are, your colleagues have similar questions and it is worth to discuss it in class.

The lack of an answer key is, for most of the cases, deliberate. It is designed to give incentives for you to work the problems rather than trying to memorizing solutions.

Questions & Answers

I am about to graduate. I need an upper level requirement course.
This course is the only one that fits my schedule.
Should I take this class?

It depends on your degree of risk-aversion. The variance of grades sometimes is high. Many earn A grades (in particular in the Honors version of the course) but it is a challenging course, so lower grades are not unheard of.

Questions & Answers

I am about to graduate. I need an upper level requirement course.
This course is the only one that fits my schedule.
Should I take this class?

It depends on your degree of risk-aversion. The variance of grades sometimes is high. Many earn A grades (in particular in the Honors version of the course) but it is a challenging course, so lower grades are not unheard of.

Is this course useful?
for an Econ PhD

I want to go to grad. school in Economics. Game Theory is very important for Economics, should I take this course?

No. In grad school, you will have several opportunities to take Game Theory classes. If you want to increase your chances of being accepted by a top program, you should take more classes at the Mathematics Department.

Is this course useful?
Econ and other fields

Would you recommend this course to any Econ, CS or Poli Sci major or PPE minor?

Of course: if you want to learn more about incentives in strategic environments, this is a good course for you. If you plan to go to Law School, grad school in Public Policy, Political Science, etc ... or if you just want to learn for the sake of learning, this is a terrific course for you.

Is this course useful?
Econ and other fields

Would you recommend this course to any Econ, CS or Poli Sci major or PPE minor?

Of course: if you want to learn more about incentives in strategic environments, this is a good course for you. If you plan to go to Law School, grad school in Public Policy, Political Science, etc ... or if you just want to learn for the sake of learning, this is a terrific course for you.

Is this course useful?
outside academia

I do not want to pursue (at the moment) any other future academic degree after my graduation, I want to find a job related to economics or business: industry, commerce or in the financial sector. But in real life people are not fully rational, will I be able to use any of the "equations" I learn in this class? What is the use of learning the equilibria of these artificial models?

Chances are, you will not write down a model for some concrete real-life situation, solve for its equilibrium and make accurate predictions based on it. But that does not mean that models are useless. Game theory may help you avoid real-life pitfalls. Also check this Noah Smith's article for several interesting examples of applications of GT to real-life.

Is this course useful?
outside academia

I do not want to pursue (at the moment) any other future academic degree after my graduation, I want to find a job related to economics or business: industry, commerce or in the financial sector. But in real life people are not fully rational, will I be able to use any of the "equations" I learn in this class? What is the use of learning the equilibria of these artificial models?

Chances are, you will not write down a model for some concrete real-life situation, solve for its equilibrium and make accurate predictions based on it. But that does not mean that models are useless. Game theory may help you avoid real-life pitfalls. Also check this Noah Smith's article for several interesting examples of applications of GT to real-life.