Bus Q783: Game Theory and Decision Analysis
Fall 2023 Course Outline
Dr. Mahmut Parlar

Operations Management Area
DeGroote School of Business
McMaster University

1 COURSE OBJECTIVE

This course is designed to familiarize Business PhD students with the fundamental tools used in game theory to solve operations management and related problems.

2 PREREQUISITES

- Registration in the PhD program at DeGroote School of Business, or permission of the instructor.

3 INSTRUCTOR AND CONTACT INFORMATION

Dr. Mahmut Parlar
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https://avenue.mcmaster.ca/

- **All classes will take place on Mondays from 11:30–14:30.**
  - **The first class will be on September 11, 2023.**

4 CLASS TIME and ROOM

- **The following three classes will be cancelled, but we will have weekend make-up classes to replace them. Dates for make-up classes TBA.**
  - **September 18, 2023 (EMBA teaching)**
  - **September 25, 2023 (EMBA teaching)**
  - **October 9, 2023 (Thanksgiving holiday)**

5 COURSE WEBSITE (reachable from. . .)

https://avenue.mcmaster.ca/

- Please upload a recent photo to Avenue.

6 COURSE DESCRIPTION

Game theory is concerned with the analysis of situations involving conflict and cooperation. This course will introduce the business students to the important game-theoretic solution concepts which have become indispensable research tools in supply chain and operations management. The course will cover static and dynamic complete information games for which Nash and subgame perfect equilibria are the solution concepts. The static incomplete information games will be analyzed using Bayesian Nash equilibrium. Cooperative games will be examined

by using the Shapley value and nucleolus. The course will also cover incentive mechanism design and include a discussion of adverse selection and moral hazard. The final material to be covered is Bayesian decision analysis including, value of information, single- and multi-attribute utility theory and decision trees.

7 LEARNING OUTCOMES

At the end of the course the students will be able to formulate competitive and cooperative operations management and related problems involving multiple decision makers arising. They will solve these problems using the solution concepts of Nash, subgame perfect, Bayesian Nash equilibria, Shapley value and nucleolus. They will also learn to formulate and solve incentive design problems and problems involving a single-decision maker using Bayesian decision analysis.

8 COURSE MATERIALS AND READINGS

8.1 Books

- Gibbons [11]. Important for the discussion of static and dynamic games under complete and incomplete information. HB 144 .G49 1992. This will be in reserve.
- Peters [21]. Some university libraries have free access to an eBook version of this text. Check the McMaster library!
- Winkler [26]. A classic reference for Bayesian inference and decision theory.

8.2 Papers

- Cachon and Netessine [3]. A recent review paper.
- Gerchak and Parlar [10]. Game theory in R&D. Uses Nash and Stackelberg equilibria.
- Leng and Parlar [15]. A recent review paper.
- Leng and Parlar [16]. An application of zero-sum games to an historical problem.
- Leng and Parlar [17]. An application of cooperative game theory to SCM.
- Leng and Parlar [18]. An *analytic* method for the nucleolus.

- Parlar [20]. An early paper applying noncooperative game theory to stochastic inventory management.
- Parlar and Wang [25]. An early paper applying cooperative game theory to stochastic inventory management.
- Wu and Parlar [28]. A tutorial on incomplete information games.

8.3 SUGGESTED READING & SOFTWARE / WEB LINKS

8.3.1 Technical

- Barron [1]: Medium level of difficulty. Errata at
  - < `http://www.math.luc.edu/~enb/GameTheoryErrata.pdf` >.
- Binmore [2].
- Carmichael [4]. Simple explanations.
- Chatterjee and Samuelson [5]. Collection of articles.
- Dixit, Skeath and Reiley [6]. Undergraduate level game theory book.
- Dutta [8]
- Harrington [12]. Simple reading. Lots of examples.
- Kelly [14].
- Mendelson [19].
- Rasmusen [23]. Written for economics graduate students.
- Straffin [24]. A very basic textbook with clear explanations.
- Winston [27, Ch. 14]. Basic OR book with a chapter on game theory.

8.3.2 Non-Technical

- Dixit and Nalebuff [7]
- Fisher [9]
- Poundstone [22]

8.3.3 Software and web resources

Main software resource

- ★ `Gambit` (v. 16)
  - `http://gambit.sourceforge.net/`
    - Please download and install the `Gambit 16` software.

Supplementary online resources

- ✓ Burkey Academy (Nice videos)
  - `http://gametheory.burkeyacademy.com/`
- ✓ Game Theory Net
  - `www.gametheory.net/`
- ✓ Game Theory Society
  - `http://www.gametheorysociety.org/`
- ✓ MIT OpenCourseWare
  - `https://ocw.mit.edu/courses/economics/14-126-game-theory-spring-2016/`
- ✓ R packages
  - I didn't test them yet, but there are two R packages that perform computations for cooperative games solutions: (i) `GameTheory`, and (ii) `GameTheoryAllocation`. If you are familiar with R, you can try them.
- ✓ Roger McCain's "Strategy and Conflict: An Introductory Sketch of Game Theory" website
  - `http://faculty.lebow.drexel.edu/McCainR/top/eco/game/game-toc.html`
- ✓ Stanford Encyclopedia of Philosophy
  - `http://stanford.library.usyd.edu.au/entries/game-theory/`
- ✓ Wikipedia article
  - `http://en.wikipedia.org/wiki/Game_theory`

9 EVALUATION

9.1 Components and Weights

The components of the course grade will be weighted as follows.

Component	Weight
Three Marked Assignments	30%
Midterm exam	30%
Final exam	40%
TOTAL	100%

9.2 Conversion

At the end of the course your overall percentage grade will be converted to your letter grade in accordance with the following conversion scheme.

- `https://academiccalendars.romcmaster.ca/content.php?catoid=39&navoid=8154#2.6.1_Averaging_of_Letter_Grades`

Grade (Points)	Percent
A+ (12)	90–100
A (11)	85–89
A− (10)	80–84
B+ (9)	77–79
B (8)	73–76
B− (7)	70–72
F (0)	0–69

10 COURSE SCHEDULE

What is Game Theory?

- Definition. History. A brief introduction to zero-sum games, nonzero-sum games, extensive form games, cooperative games and bargaining games.
- Chinese horse race paper by Leng and Parlar [16].

10.1 Static Games Under Complete Information

- Normal form games and Nash equilibrium. Cournot model and discussion of Parlar [20] and Wu and Parlar [28].

10.2 Dynamic Games Under Complete Information

- Subgame perfect equilibrium and Stackelberg model of duopoly. Discussion of Parlar [20] and Wu and Parlar [28].

10.3 Static Games Under Incomplete Information

- Bayesian Nash equilibrium of the Cournot model. Discussion of Wu and Parlar [28].

10.4 Mechanism Design

- A simple model of adverse selection as an example of incentive mechanism design (Dixit, Skeath and Reiley [6, Ch. 16]).

10.5 Cooperative Game Theory Models

- Imputation, the core, the Shapley value. Discussion of Leng and Parlar [17] and [18].

10.6 Decision Theory

- Bayesian inference for discrete and continuous probability models. Conjugate prior distributions for the Bernoulli process. Decision making under uncertainty and risk. Decision trees. Utility and decision making. Value of information. (See, Keefer, Kirkwood and J. L. Corner [13] for a nice review.)

11 ACADEMIC DISHONESTY

It is the student's responsibility to understand what constitutes academic dishonesty. Please refer to the University Senate Academic Integrity Policy at the following URL:

★`http://www.mcmaster.ca/policy/Students-AcademicStudies/AcademicIntegrity.pdf`

This policy describes the responsibilities, procedures, and guidelines for students and faculty should a case of academic dishonesty arise. Academic dishonesty is defined as to knowingly act

or fail to act in a way that results or could result in unearned academic credit or advantage. Please refer to the policy for a list of examples. The policy also provides faculty with procedures to follow in cases of academic dishonesty as well as general guidelines for penalties. For further information related to the policy, please refer to the Office of Academic Integrity at:

★http://www.mcmaster.ca/academicintegrity

12 COPYRIGHT

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★http://www.copyright.mcmaster.ca/Access_Copyright_Agreement

13 MISSED ACADEMIC WORK

Late assignments will not be accepted. No extensions are available except under extraordinary circumstances. Please discuss any extenuating situation with your instructor at the earliest possible opportunity.

14 STUDENT ACCESSIBILITY SERVICES

Student Accessibility Services (SAS) offers various support services for students with disabilities. Students are required to inform SAS of accommodation needs for course work at the outset of term. Students must forward a copy of such SAS accommodation to the instructor normally, within the first three (3) weeks of classes by setting up an appointment with the instructor. If a student with a disability chooses NOT to take advantage of an SAS accommodation and chooses to sit for a regular exam, a petition for relief may not be filed after the examination is complete. The SAS website is:

★http://sas.mcmaster.ca

15 POTENTIAL MODIFICATIONS TO THE COURSE

The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes.

16 PLACES YOU GET HELP WITH YOUR WORK

The instructor will be available to answer questions **during office hours** (TBA).

17 GENERATIVE AI: USE PROHIBITED

Students are not permitted to use generative AI in this course. In alignment with McMaster academic integrity policy[1], it "**shall be an offence knowingly to ... submit academic work for assessment that was purchased or acquired from another source**". **This includes work created by generative AI tools.** Also state in the policy is the following, "Contract Cheating is the act of "outsourcing of student work to third parties" (Lancaster & Clarke, 2016, p. 639) with or without payment." Using Generative AI tools is a form of contract cheating. Charges of academic dishonesty will be brought forward to the Office of Academic Integrity.

[1] https://secretariat.mcmaster.ca/app/uploads/Academic-Integrity-Policy-1-1.pdf

References

[1] E. N. Barron. *Game Theory: An Introduction.* Wiley-Interscience, 2007.

[2] K. Binmore. *Game Theory: A Very Short Introduction.* Oxford University Press, New York, 2007.

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[10] Y. Gerchak and M. Parlar. Allocating resources to research and development projects in a competitive environment. *IIE Transactions on Operations Engineering*, 31:827–834, 1999.

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[26] R. L. Winkler. *Introduction to Bayesian Inference and Decision.* Holt, Rinehart and Winston, New York, 1972.

[27] W. L. Winston. *Operations Research : Applications and Algorithms.* Thomson Brooks/Cole, Belmont, CA, 4th edition, 2004.

[28] H. Wu and M. Parlar. Games with incomplete information: A simplified exposition with inventory management applications. *International Journal of Production Economics*, 133:562–577, 2011.