Syllabus, Spring 2023, for OIDD 3190:
Advanced Decision Systems:
Agents, Games, and Evolution (AGE)

1:45–3:15p.m., Tuesdays and Thursdays. Room: TBA

Canvas:

https://canvas.upenn.edu/courses/1689796

GitHub:

https://github.com/stevenokimbrough/AGE/

Professor Steven O. Kimbrough, Instructor
Office hours: T & R 10:00–11:30 and by appointment

October 29, 2023

Masking in class is required until further notice, due to the ongoing community transmission of Covid, flu, monkey pox and polio.

Contents

1 Highlights

- This course is about interdependent (alias strategic) decision making. In these situations there are at least two players (alias agents, decision makers) who make choices and receive rewards in part based on the choices made by other decision makers.
- Interdependent decision making suffuses business, government, politics, and everyday life.
- Doing strategic decision making well is often hugely challenging. The course is in part about making good decisions in strategic contexts.
- Game theory is a branch of applied mathematics that models contexts of strategic interaction (CSIs, alias games). We will advert to game theory as appropriate, but our scope of attention is much broader than game theory in the narrow sense. (More broadly, people speak of the theory of games.)
- There are many reasons to study interdependent decision making. In this course we will focus on:
  a. Supporting individual decision making ("the problems of players")
  b. Explaining and understanding social phenomena ("problems of societies")
  c. Supporting interventions, especially design of institutions

2 In a nutshell...

OIDD 3190, "Agents, Games, and Evolution," is about interdependent decision making, also known as strategic or game-theoretic decision making. This kind of decision situation arises everywhere there is social interaction. It is a lively area of study, with negotiation just one of many contexts of strategic interaction. It has been studied and applied in business, government, military, policy, interpersonal, and many other contexts. The main goal of the course is to survey the topic of strategic decision making and, in doing so, to teach how to do it well by arranging for experiences and reflections on them (i.e., we'll play games in the course). The course has two main foci. The first is strategic decision making "in the wild," as evidenced in war, foreign policy, business, governance, romance, etc. The second is modeling of contexts of strategic interaction. Here our principal tools will be Game Theory and its analytics results, and game simulations. We shall touch lightly on Game Theory, although we will cover its basics and its essential concepts will be useful throughout

the course. We will conduct simulations using Agent-Based Modeling and NetLogo. Prior programming experience is not required. Students will, however, be exposed to agent-based models (ABM) and related AI techniques.

3 Class Description

OPIM 3190, "Agents, Games, and Evolution," explores applications and fundamentals of strategic behavior.

The course is about strategic decision making in the sense of game theory. That is, we study decision making situations in which what an agent gets depends upon its decisions as well as decisions made by other agents.

The main goal of the class is:

- To deepen the student's understanding of strategic interactions—games—in the social and economic spheres.

To this end, our objectives are to study and explore:

1. The key concepts and findings of the theory of games (broadly, the study of interdependent decision making, subsuming game theory).

   These will be useful for understanding and analyzing contexts of strategic interaction.

2. Strategic analysis.

   This is the interpretation of circumstances in terms of agents, interests, strategies, and interaction. We will study good examples of strategic analysis and we will undertake exercises in it.

3. Strategy discovery and selection.

   This is about how to play games and play them successfully. We will study this by playing games and by observing computational investigations of games.

4. Institution design.

   This is about choosing rules of play that result in desired outcomes. We will focus on common pool resource problems.

5. Strategic modeling and explanation.

   This is about developing game models that can explain observed phenomena. We focus on problems of cooperation as well as a variety of other phenomena.

The design of the course emphasizes learning about decision making in games by actually playing (making decisions in) games and reflecting upon what ensues. Thus, the new design of the course makes it resemble in many ways the design of the negotiations courses. There, students

engage in a series of negotiations and discussions about them. Here, we will engage in a series of games calling for careful strategic decision making, and we will discuss what happened after play is complete. The games we play and discuss will range across a variety of applications, including business applications. Throughout, we will emphasize games that are realistic representations of real world situations, rather than stylized, very abstract games.

The course will continue to include topics that arise throughout the social sciences. The topics include—and we shall study—trust, cooperation, market-related phenomena (including price equilibria and distribution of wealth), norms, conventions, commitment, coalition formation, and negotiation. They also include such applied matters as design of logistics systems, auctions, and markets generally (for example, markets for electric power generation).

In addressing these topics we focus on the practical problem of finding effective strategies for agents in strategic situations (or games). Our method of exploration will be experimental: we review and discuss experiments on the behavior of agents in strategic (or game-theoretic) situations.

Computer programming in NetLogo is introduced in the course. The instructor invites, and will support, projects using NetLogo (as well as other environments). Many of the computational demonstrations and experiments we will examine are available as NetLogo programs (`http://ccl.northwestern.edu/netlogo/`).

Students completing the course can expect to come away with:

- Substantial experience with decision making in realistic games.
- Solid understanding of what is known and what is not known about the problem of designing procedures for strategic behavior,
- Familiarity with the principal methods, and results of applying those methods, for the modeling of human agents and design of artificial agents in strategic contexts, and
- Deepened appreciation for contexts of strategic interaction.

* * *

Strategic, or game-theoretic, topics arise throughout the social sciences. The topics include—and we shall study—trust, cooperation, market-related phenomena (including price equilibria and distribution of wealth), norms, conventions, commitment, coalition formation, and negotiation. They also include such applied matters as design of logistics systems, auctions, and markets generally (for example, markets for electric power generation).

In addressing these topics we focus on the practical problem of finding effective strategies for agents in strategic situations (or games). Our method of exploration will be experimental: we review and discuss experiments on the behavior of agents in strategic (or game-theoretic) situations.

In focusing on the design and behavior of artificial agents in strategic (or game-theoretic) situations, we will be especially concerned with strategic contexts of commercial import, such as markets, bargaining, and repeated play. We shall dwell on effective agent learning techniques, including evolutionary methods and reinforcement learning. A main theme in the course is the inherent difficulty, even unknowability, of the problem of strategy acquisition.

We will rely mainly on computational experiments (or simulations), in distinction to analytic mathematical methods, for studying strategy formation and strategic behavior (either by individuals or by groups). Much of the class work will be devoted to discussing and interpreting computational experiments that have been reported in the literature, or that can be undertaken with tools provided in class. In doing so, we draw upon the rapidly growing literature in agent-based modeling and agent-based simulation. Agent-Based Computational Economics (for example, `http://www.econ.iastate.edu/tesfatsi/ace.htm`) and other terms have come to denote active communities of research and application. We shall draw upon them.

4 Required Texts and Materials

There is nothing necessary to purchase. Our main texts will be:

- *Agents, Games, and Evolution,* by Steven Orla Kimbrough, (Kimbrough, 2012). ISBN-13: 9781439834701, ISBN-10: 1439834709

  This should be available as an ebook on Canvas via the library.

  See `https://github.com/stevenokimbrough/AGE/` *errata1.zip* for fixes to earlier printings of the book.

- NetLogo. Software tool for agent-based modeling. Available at `https://ccl.northwestern.edu/netlogo/`.

- *Lecture Notes* are posted on Canvas. These notes are required or suggested readings, as indicated.

- *Programming NetLogo* (alias the PNbook) by Steven O. Kimbrough, available on Canvas as a free PDF file.

In addition, various other readings will be assigned. These will generally be handed out or made available online.

Other readings and handouts will be freely available on Canvas.

5 Class Schedule

5.1 Interdependent decision making

Main topics:

- Core concepts: strategic decisions, parametric decisions, etc.

- Course overview

- A quick overview of decision theory

Assigned reading(s):

a. AGEbook, chapter 1. (Kimbrough, 2012, chapter 1)

Slide deck: AGE-classintro-beamer.pdf
Reference material:

a. Chapter 1: Peterson, M. (2017). An Introduction to Decision Theory (second). Cambridge University Press.

b. Hansson, S. O. (2005). Decision Theory: A Brief Introduction. `https://people.kth.se/~soh/decisiontheory.pdf`

c. Extended reading: Steele and Stefnsson (2020)

5.2 Non-Cooperative Game Theory

Main topics:

1. Strategic (normal) form games.
2. Games in extensive form
3. Other game forms
4. Nash equilibrium
5. Pareto optimality
6. Conditions of play: one-shot, anonymous, payoffs, utility, rationality, mutual knowledge of play
7. Solution as equilibrium
8. Discuss some standard games, canonical games. Use existing slides if possible. IPD, Stag Hunt, Chicken, public goods games, ultimatum, dictator.

Slide deck: Brief_Orthodox_Game_Theory-beamer.pdf
Assigned reading(s):

a. Required reading (Kimbrough, 2012, Appendix A; B.3).

5.3 Utility and Rational Choice Theory (RCT)

Main topics:

- Certainty, risk, ignorance, uncertainty, ambiguity
- Utility

Assigned reading(s):

a. *AGE Lecture Notes*, chapter 3.

Reference material:

a. "Rationality in Games" Bicchieri (1993).
b. Peterson Peterson (2017) chapters 3 and 4.
c. Peterson Peterson (2017) chapters 5 and 11.

Recommended reading:

a. Ross, Don, "Game Theory", *The Stanford Encyclopedia of Philosophy (Spring 2006 Edition),* Edward N. Zalta (ed.), URL = `https://plato.stanford.edu/entries/game-theory/`.

5.4 The Problem of Cooperation

Main topics:

- Problems of cooperation
- The tragedy of the commons
- Introducing NetLogo

Assigned reading(s):

a. "The Tragedy of the Commons," by Garrett Hardin Hardin (1968). File: `hardin-tragedy-commons.pdf`

b. PNbook, chapter 0, "Getting Started Using NetLogo."

Reference material:

a. "Cues of Being Watched Enhance Cooperation in a Real-World Setting" Bateson et al. (2006). File on Canvas: `Biology Letters 2006 Bateson.pdf`.

5.5 Axelrod on Cooperation

Main topics:

- Prisoner's Dilemma game
- Axelrod on the problem of cooperation

Assigned reading(s):

a. *The Evolution of Cooperation* (Axelrod, 1984, chapter 1)

Reference material:

a. *The Evolution of Cooperation* (Axelrod, 1984, Appendix B)

5.6 Axelrod's Tounaments

Main topics:

- Prisoner's Dilemma tournaments
- Axelrod's interpretation of the results

Assigned reading(s):

a. *The Evolution of Cooperation* (Axelrod, 1984, chapter 2)

b. *Agents, Games, and Evolution* (Kimbrough, 2012, chapter 3)

Reference material:

a. *The Evolution of Cooperation* (Axelrod, 1984, Appendix A)

5.7 NetLogo, Replicator Dynamics, BehaviorSpace

Main topics:

- Introduction to NetLogo
- The replicator dynamics
- BehaviorSpace in NetLogo

Assigned reading(s):

a. PNbook, chapter 0, "Getting Started Using NetLogo."

b. PNbook, appendix G, "BehaviorSpace."

5.8 Evolutionary Models and Skyrms

Main topics:

- Beyond tournaments, replicator dynamics
- "Sex and Justice"
- "Commitment"

Assigned reading(s):

a. Skyrms, *Evolution of the Social Contract* Skyrms (1996) chapter 1, "Sex and Justice"

b. Skyrms, *Evolution of the Social Contract* Skyrms (1996) chapter 2, "Commitment"

5.9 Territorial Models

Main topics:

- Spatial considerations and the differences they make
- Local interaction
- The shadow of society

Assigned reading(s):

a. (Kimbrough, 2012, chapters 4 and 5)

Recommended reference material:

a. Axelrod chapter 8, pages 158–168

b. Skyrms, from *The Stag Hunt and the Evolution of Social Structure* Skyrms (2004), Preface, chapters 1, "The Stag Hunt," 2, "Bargaining with Neighbors," and 3, "Stag Hunt with Neighbors"

5.10 Quiz #1 and Positional Goods

Main topics:

- Quiz, 50 minutes, closed book, one two-sided crib sheet permitted.
- The positional goods game
- Hirsch and positional goods

Assigned reading(s):

a. *Social Limits to Growth* (Hirsch, 1976, chapter 1). File *Fred Hirsch - selections for FRG.pdf* on Canvas.

Reference material:

a. *Social Limits to Growth* (Hirsch, 1976, chapter 2). File *Fred Hirsch - selections for FRG.pdf* on Canvas.

5.11 Framing and the Cooperation Afforder Game

Main topics:

- Framing
- The cooperation afforder game

Assigned reading(s):

a. AGEbook, (Kimbrough, 2012, chapter 7)

5.12 Naturalizing Cooperation

Main topics:

- Summary and review on cooperation
- The evolving preferences account of cooperation
- The cultural affiliation account of cooperation

Assigned reading(s):

a. Freedman, (Freedman, 2013, chapter 37) "Beyond Rational Choice"

5.13 Heuristics and ABMs

Main topics:

- Heuristics
- ABMs and interdependent decision making
- Heuristic choice science

Assigned reading(s):

a. Teaching notes, this chapter

Reference material:

a. Bicchieri, C. (2004). Rationality and Game Theory. In The Oxford Handbook of Rationality (pp. 182–205). OUP. Bicchieri (2004)

5.14 Self-Organization and Emergence

Main topics:

- Self-organization
- Emergence
- Applications in interdependent decision making

Assigned reading(s):

a. *Growing Artificial Societies: Social Science from the Bottom Up* by Joshua Epstein and Robert Axtell (Epstein and Axtell, 1996, chapter II), "Life and Death on the Sugarscape."

   Epstein, J. M., & Axtell, R. (1996). Growing Artificial Societies: Social Science from the Bottom Up. The MIT Press.

b. *Micromotives and Macrobehavior* (Schelling, 1978, pages 11–43).
   (File: `MicromotivesAndMacrobehavior.pdf`.) pp. 11-43 of *Micromotives and Macrobehavior,* Thomas C. Schelling, W.W. Norton & Co., New York, 1978

   Note: Schelling (10 October 2005) won a Nobel Prize for doing this sort of work. `http://nobelprize.org/economics/laureates/2005/press.html`.

5.15 Quiz #2 and TBA

Quiz, 50 minutes, closed book, one two-sided crib sheet permitted.

5.16 ABM, 1: NetLogo

Main topics:

- Introduction to agent-based modeling
- Introduction to NetLogo programming

Assigned reading(s):

a. Romanowska, I., Wren, C. D., & Crabtree, S. A. (2021). Agent-Based Modeling for Archaeology: Simulating the Complexity of Societies. SFI Press. (Romanowska et al., 2021, chapters 1 and 2) `https://www.santafe.edu/news-center/news/new-book-agent-based-modeling-archa`
   (Has free PDF at this location. File: ABMA_color_version.pdf posted on Canvas.)

b. PNbook, chapter 1

Reference material:

a. *NetLogo Users Manual*

5.17 ABM, 2: NetLogo

Main topics:

- Programming in NetLogo

Assigned reading(s):

a. Romanowska, I., Wren, C. D., & Crabtree, S. A. (2021). Agent-Based Modeling for Archaeology: Simulating the Complexity of Societies. SFI Press. (Romanowska et al., 2021, chapters 3 and 4)
`https://www.santafe.edu/news-center/news/new-book-agent-based-modeling-archaeolo`
(Has free PDF at this location. File ABMA_color_version.pdf posted on Canvas.)

b. PNbook, chapter 2.

Reference material:

a. *NetLogo Users Manual*

5.18 Two-Sided Matching

Main topics:

- Stable matching problems
- Computational solutions
- Applications

Assigned reading(s):

a. Gale, D., & Shapley, L. S. (1962). College Admissions and the Stability of Marriage. The American Mathematical Monthly, 69(1), 9–15. Gale and Shapley (1962)

b. AGEbook: (Kimbrough, 2012, chapter 13)

5.19 Competitive Markets

Main topics:

- The standard account
- Variants
- Zero-intelligence Agents
- Trade on the Sugarscape

Assigned reading(s):

a. "Competitive Markets" (Kimbrough, 2012, chapter 8)

b. "Zero-Intelligence Agents," Gode and Sunder (1993) (file: `gode-sunder-1993.pdf` on Canvas).

5.20 Monopoly and Oligopoly Markets

Main topics:

- Monopoloy and PROBE AND ADJUST
- Cournot competition in oligopolies with PROBE AND ADJUST
- Bertrand competition with PROBE AND ADJUST
- Supply curve bidding with PROBE AND ADJUST

Assigned reading(s):

a. "Monopoly Stories" (Kimbrough, 2012, chapter 9)

b. "Oligopoly: Cournot Competition" (Kimbrough, 2012, chapter 10)

Recommended material:

a. "Oligopoly: Bertrand Competition" (Kimbrough, 2012, chapter 11)

5.21 Foraging

Main topics:

- Ideal Free Distribution
- Duck economics

Assigned reading(s):

a. "Foraging Games: Ideal and Not" Clark and Kimbrough (2022)

5.22 Quiz #3 and Voting, 1

Main topics:

1. Quiz, 45 minutes, closed book, one two-sided crib sheet permitted.
2. The problems of voting
3. The problem of designing voting systems

Assigned reading(s):

a. (Poundstone, 2009, chapter 2). Poundstone, W. (2009). Gaming the Vote: Why Elections Aren't Fair (and What We Can Do About It). Hill and Wang. Available online in Canvas.

5.23 Voting, 2

Main topics:

- Comparison of voting methods
- Voting systems based on ratings
- Approval voting
- Range voting

Assigned reading(s):

a. (Poundstone, 2009, chapter 7). Poundstone, W. (2009). Gaming the Vote: Why Elections Aren't Fair (and What We Can Do About It). Hill and Wang. Available online in Canvas.

b. (Poundstone, 2009, chapter 11). Poundstone, W. (2009). Gaming the Vote: Why Elections Aren't Fair (and What We Can Do About It). Hill and Wang. Available online in Canvas.

5.24 Meade at Gettysburg

Main topics:

- Overview of the campaign: Lee invades Pennsylvania in 1863.
- The battle of Gettysburg, standard story
- The battle of Gettysburg, told strategically

Assigned reading(s):

a. Video: Gettysburg Animated Map, American Battlefield Trust https://www.battlefields.org/learn/civil-war/battles/gettysburg

b. Reading: (Selby, 2018, chapter 2)

c. Audio: Civil War Podcast https://civilwarpodcast.org/ #357.

d. Jeffrey the Librarian (Director). (2020, July 3). Gettysburg Battle with Maps — History with Maps: American Civil War — Strategy — Pickett's Charge. https://www.youtube.com/watch?v=Km7fIGYMbuQ

5.25 Grant, Paducah, and Grand Strategy

Main topics:

- The South's strategic blunder at Columbus, KY
- Grant's response: Paducah
- Fort Henry and Fort Donelson fall, the South's cordon defense is punctured
- Levels of strategy
- Grand strategy
- Grand strategy in the Civil War

Assigned reading(s):

a. Jeffrey the Librarian (Director). (2021, June 21). Grant takes Fort Henry & Fort Donelson — American Civil War — Foote ironclads — mapping history. https://www.youtube.com/watch?v=1YPzxhBrGX4 (Video, about 30 minutes).

5.26 Kennan and Containment

Main topics:

- Context: Creating U.S. foreign policy after World War II.
- The Marshall Plan and containment.
- Video of interview with Kennan in 1988.

Assigned reading(s):

a. "The Sources of Soviet Conduct" X and George F. Kennan (1947)

b. *Lecture Notes*

5.27 Argumentation

Main topics:

- Reasons and strategy
- Arguments: valid, invalid, sound, enthymemes
- Backwards induction

Assigned reading(s):

a. *Agents, Games, and Evolution* (Kimbrough, 2012, chapter 19), be sure to read the "errata" version with errors fixed.

Reference material:

a. Freedman, *Strategy: A History* (Freedman, 2013, chapters 35–8)

5.28 Last Class: Summary and Outlook

Main topics:

- Summing up: from rational choice to heuristic choice
- Looking forward: ABM, common pool resources, role playing
- End of term essay assignment handed out and discused.

6 Grades and Conduct of Class

Attendance: Mandatory. Please email me in advance if you have a good reason not to attend a particular session.

Electronics: No phones, laptops, tablets or other electronics, unless specifically directed otherwise.

Grading will be based on several components, as follows.

30% Homework assignments and class participation.

45% Three quizzes, 15% each.

25% End of term essay, due the last day of finals, May 9, 2023. Groups of two, self-organized.

Grading: $x > 95\%$, A+; $91\% \leq 95\%$, A; $85\% < x \leq 91\%$, A-/B+, $75\% < x \leq 85\%$, B; $65\% < x \leq 75\%$, C; $55\% < x \leq 65\%$, D; $x \leq 55\%$, F. With the caveat that I can give lots of As if merited but it's very unlikely I can give lots of A+s.

Most of all, I want to see you engaged and involved in the class. I'll prepare lectures for the classes, but much prefer to conduct class with lots of interactive, give and take, and discussion.

Also: I like jazz and will improvise during the semester. The syllabus may well (will likely) change as we go along. I'll let you know when it does and the quiz dates will *not* be changed.

Two further items/requirements:

- Every student should come chat with me at least once during (online) office hours. If my posted hours conflict with your schedule, let me know and we'll make arrangements. Also, you need not come alone. It's fine to come with a group of up to four.
- You will occasionally need your laptop in class. I'll let you know ahead of time. However, during lectures and similar periods when we are not actively using them, use of laptops, PDAs, etc. are forbidden.

7 Computer Access for Non-Wharton Students

Here is the link you should include with your announcements and instructions on future syllabi.

This link works:

`https://whartonstudentsupport.zendesk.com/hc/en-us/articles/203165417-Create-Your-W`

In plain text:

https://whartonstudentsupport.zendesk.com/hc/en-us/articles/203165417-Create-Your-Wharton-Account

*Wharton Class Accounts are needed so that when students try to login into the computers in the labs with their PennKey these PennKey link to active Wharton Class accounts. These class accounts also are needed if students intend to use the public printers.

*I have confirmed Study.net materials are all PennKey authentication now.

Also (for non-Wharton students): After you follow the link above and create a Wharton Class Account, you will then log in to the computers with your PennKey account. (But wait an hour the first time you try this.)

8 Calendar, spring 2023

Last class is on Tuesday, April 25, 2023.

	0	1	2
0	—	T: 2023-02-14	T: 2023-03-28
1	R: 2023-01-12	R: 2023-02-16	R: 2023-03-30
2	T: 2023-01-17	T: 2023-02-21	T: 2023-04-04
3	R: 2023-01-19	R: 2023-02-23	R 2023-04-06
4	T: 2023-01-24	T: 2023-02-28	T: 2023-04-11
5	R: 2023-09-26	R: 2023-03-02	R 2023-04-13
6	T: 2023-01-31	T: 2023-04-14	T: 2023-04-18
7	R: 2023-02-02	R 2023-03-16	R: 2023-04-20
8	T: 2023-02-07	T: 2023-03-21	T: 2023-04-25
9	R: 2023-02-09	R: 2023-03-23	—

Table 1: Class number :: date correlation, for Tuesday (T) and Thursday (R) classes, spring 2023. Penn academic calendar `https://almanac.upenn.edu/penn-academic-calendar`

References

Axelrod, R. (1984). *The Evolution of Cooperation*. Basic Books, Inc., New York, NY.

Bateson, M., Nettle, D., and Roberts, G. (2006). Cues of being watched enhance cooperation in a real-world setting. *Biology Letters*, 2:412–414.

Bicchieri, C. (1993). *Rationality and Coordination*. Cambridge University Press, New York, NY.

Bicchieri, C. (2004). Rationality and Game Theory. In *The Oxford Handbook of Rationality*, pages 182–205. OUP.

Clark, R. and Kimbrough, S. O. (2022). Foraging Games: Ideal and Not. In *Computational Social Science 2022 (CSS 2022) Conference*, Santa Fe.

Elster, J. (1989). *The Cement of Society: A Study of Social Order*. Studies in rationality and social change. Cambridge University Press, Cambridge, UK.

Epstein, J. M. and Axtell, R. (1996). *Growing Artificial Societies: Social Science from the Bottom Up*. The MIT Press, Cambridge, MA.

Freedman, L. (2013). *Strategy: A History*. Oxford University Press, Oxford, UK.

Gale, D. and Shapley, L. S. (1962). College Admissions and the Stability of Marriage. *The American Mathematical Monthly*, 69(1):9–15.

Gode, D. K. and Sunder, S. (1993). Allocative Efficiency of Markets with Zero-Intelligence Traders: Market as a Partial Substitute for Individual Rationality. *Journal of Political Economy*, 101(1):119–137.

Hansson, S. O. (2005). *Decision Theory: A Brief Introduction*.

Hardin, G. (1968). The Tragedy of the Commons. *Science*, 162(3859):1243–1248.

Hirsch, F. (1976). *Social Limits to Growth*. Harvard University Press, Cambridge, MA.

Kimbrough, S. O. (2012). *Agents, Games, and Evolution: Strategies at Work and Play*. CRC Press, Boca Raton, FL.

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press, Cambridge, UK.

Peterson, M. (2017). *An Introduction to Decision Theory*. Cambridge University Press, Cambridge, UK, second edition.

Poundstone, W. (2009). *Gaming the Vote: Why Elections Aren't Fair (and What We Can Do About It)*. Hill and Wang.

Romanowska, I., Wren, C. D., and Crabtree, S. A. (2021). *Agent-Based Modeling for Archaeology: Simulating the Complexity of Societies*. SFI Press. https://www.santafe.edu/news-center/news/new-book-agent-based-modeling-archaeology.

Schelling, T. C. (1978). *Micromotives and Macrobahavior*. Norton, New York. File: MicromotivesAndMacrobehavior.pdf for first chapter.

Schneider, M. (2007). The Nature, History and Significance of the Concept of Positional Goods. *History of Economics Review*, (45):60–81. Num Pages: 22 Place: Hobart, United Kingdom Publisher: Taylor & Francis Ltd.

Selby, J. G. (2018). *Meade: The Price of Command*. Kent State University Press, Kent, Ohio.

Skyrms, B. (1996). *Evolution of the Social Contract*. Cambridge University Press, Cambridge, UK.

Skyrms, B. (2004). *The Stag Hunt and the Evolution of Social Structure*. Cambridge University Press, Cambridge, UK.

Steele, K. and Stefnsson, H. O. (2020). Decision Theory. In Zalta, E. N., editor, *The Stanford Encyclopedia of Philosophy*. Metaphysics Research Lab, Stanford University, winter 2020 edition.

X and George F. Kennan (1947). The Sources of Soviet Conduct. *Foreign Affairs*, 25(4):566–582.