Syllabus, Fall 2023, for OIDD 3190:
Advanced Decision Systems:
Agents, Games, and Evolution (AGE)
TR 1:45pm–3:14pm in JMHH 360 (8/29 to 12/11)
Canvas:
https://canvas.upenn.edu/courses/1739846
GitHub:
https://github.com/stevenokimbrough/AGE/

Professor Steven O. Kimbrough, Instructor
Office hours: JMHH 565 T & R 10:00–11:30 and by appointment

August 19, 2023

Masking in class is encouraged not required until further notice. The instructor intends to wear a mask during class.

Contents

1 Highlights

- This course is about interdependent (alias strategic) decision making (alias games). 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.
- The course has three principal facets. The first is traditional game theory (TGT).
- TGT is a branch of applied mathematics that models contexts of strategic interaction (CSIs, alias games). It offers invaluable concepts for and insights into interdependent decision making. We shall draw from these throughout.
- The scope of practical application of TGT, however, is surprisingly narrow, therefore we explore two other approaches to understanding strategic interaction: computational modeling (facet two) and games in the wild (facet three).
- Facet two focuses on computational modeling of interdependent decision making, including evolutionary game theory and agents other than humans. As a major part of this study we will use and build agent-based models. Agent-based modeling (ABM) is a natural computational paradigm for modeling interdependent decision making. We shall do ABM using the NetLogo development environment.
- In facet three we focus on strategic topics and cases occurring in the real world: voting systems, common pool resources, and strategic decision making in foreign policy and the American Civil War.
- Throughout the course, we shall attend to the problems of cooperation, of understanding how it occurs and is sustained (or not).
- 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/`.

- *AGE Lecture Notes (2023C)*, 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.

- Izquierdo, L. R., Izquierdo, S. S., & Sandholm, W. H. (2019). Agent-Based Evolutionary Game Dynamics. https://wisc.pb.unizin.org/agent-based-evolutionary-game-dynamics/ (Izquierdo et al., 2019)
- Freedman, L. (2013). Strategy: A History. Oxford University Press (Freedman, 2013). Available online from the Penn library system.

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 Traditional Game Theory, 1

Main topics:

1. Non-Cooperative and cooperative game theory.
2. Strategic (normal) form games.

3. Games in extensive form
4. Other game forms
5. Nash equilibrium
6. Pareto optimality
7. Conditions of play: one-shot, anonymous, payoffs, utility, rationality, mutual knowledge of play
8. Solution as equilibrium
9. Pure and mixed equilibria
10. Discuss some standard games, canonical games. IPD, Stag Hunt, Chicken, public goods games, ultimatum, dictator.

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

a. (Izquierdo et al., 2019, §0.1, pages 2–5)

b. (Kimbrough, 2012, Appendix A; B.3).

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/`.

5.3 Traditional Game Theory, 2

Continued from previous class.
Applications: two-sided matching, auctions, etc.

5.4 Utility, Rational Choice Theory (RCT), and their Discontents.

Challenges to TGT.
Main topics:

- Certainty, risk, ignorance, uncertainty, ambiguity
- Utility
- Challenges to RCT and TGT

Assigned reading(s):

a. *AGE Lecture Notes*, chapter 3.

b. *Strategy: A History* (Freedman, 2013, chapter 36)

Reference material:

a. "Rationality in Games" Bicchieri (1993).

b. Peterson Peterson (2017) chapters 3 and 4.

c. Peterson Peterson (2017) chapters 5 and 11.

5.5 Evolutionary Game Theory (EGT)

Main topics:

- Models of evolution
- Evolution and game theory
- Replicator dynamics

Assigned reading(s):

a. (Izquierdo et al., 2019, §3, pages 6–13)

Slides: AGE-evolution.pdf
Reference material:

a. Darwin, concluding chapter (#14) of *The Evolution of Species*. Darwin-Origin-Chapt14-1st-ed.pdf on Canvas, online at `http://www.literature.org/authors/darwin-charles/the-origin-of-species/chapter-14.html`.

5.6 Evolutionary Models and Skyrms

Main topics:

- "Sex and Justice"
- "Commitment"
- Stag Hunt game

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"

Both posted in skyrms-evo-soc-contract-1and2.pdf on Canvas.
Slides: AGE-skyrms-evosoccontract-beamer.pdf
Recommended reference material:

a. Brian Skyrms, *The Stag Hunt and the Evolution of Social Structure,* Skyrms (2004) "Preface" (pp. xi-xiv) and chapter 1, "The Stag Hunt" (pp. 1-14), Cambridge University Press, 2004. (File: `Skyrms-StagHunt-Pref-Ch1.pdf`.)

b. Slides: AGE-skyrms-staghunt-beamer.pdf

5.7 The Problem(s) of Cooperation

Main topics:

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

Slides: AGE-cooperation-1-beamer.pdf

Assigned reading(s):

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

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`.

5.8 Cooperation, 2: 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, chapters 1–2)

Slide deck: AGE-coperation-2-axelrod.pdf
Reference material:

a. *The Evolution of Cooperation* (Axelrod, 1984, chapter 3, Appendix B)

b. (Axelrod and Hamilton, 1981) (posted on Canvas as Axelrod-Hamilton-Science-1981-1685895.pdf).

5.9 Tournaments

Main topics:

- Prisoner's Dilemma tournaments
- Axelrod's interpretation of the results
- The idea of tournaments
- Maybe: Exercise on strategy design.
- Quick introduction—at least a start—to evolutionary computing and genetic algorithms (more to come)

Assigned reading(s):

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

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

Slide deck: AGE_tournaments.pdf
Reference material:

a. Recommended: (Kimbrough, 2012, Chapter 4) on other games.

b. YouTube videos on evolutionary computing

`https://www.youtube.com/watch?v=9zfeTw-uFCw` 12 minutes

`https://www.youtube.com/watch?v=RxTfc4JLYKs` 23 minutes

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

5.10 Quiz #1

Quiz #1, Sept. 28

Main topics:

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

5.11 ABM, 1: Introduction: ABM & NetLogo

In-class NetLogo exercise.

For the NetLogo classes, come to class with a laptop and NetLogo installed on it. Main topics:

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

Assigned readings for introduction to agent-based modeling:

a. *Agent-Based Evolutionary Game Dynamics* (ABEGD) (Izquierdo et al., 2019, pages 14–20) "0.2. Introduction to agent-based modeling."[1]

b. PNbook: preface and chapter 1.

Assigned readings for introduction to NetLogo programming:

a. *NetLogo Users Manual* Learning NetLogo:
Tutorial #1: Models
Tutorial #2: Commands
Tutorial #3: Procedures

b. *Agent-Based Evolutionary Game Dynamics* (ABEGD) (Izquierdo et al., 2019, pages 21–31) "0.3. Introduction to NetLogo" and into "0.4. Fundamentals of NetLogo." `https://wisc.pb.unizin.org/agent-based-evolutionary-game-dynamics/`

c. PNbook: chapter 2.

d. "NETLOGO 6.0 — QUICK GUIDE"
`http://luis.izqui.org/resources/NetLogo-6-0-QuickGuide.pdf`

Reference material:

a. Wilensky and Rand (2015). Wilensky, U., & Rand, W. (2015). An Introduction to Agent-Based Modeling. The MIT Press. Available on JSTOR as a series of PDFs: `http://www.jstor.org/stable/j.ctt17kk851`

b. 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) [2] File: ABMA_color_version.pdf posted on Canvas.

c. AIMES (2022). AIMES (Director). (2022, March 23). Episode 1: Agent Based Modeling of Land Use Change. `https://www.youtube.com/watch?v=w_q2yJlDwDQ`

d. Complexity Explorer (2018). Complexity Explorer (Director). (2018, June 26). Agent-Based Modeling: An Introduction from Uri Wilensky. `https://www.youtube.com/watch?v=ocp3OdOvrZM`

5.12 ABM, 2: NetLogo

We will have an in-class exercise. Come to class with a laptop and NetLogo installed on it.
Main topics:

In-class NetLogo exercise.

[1] `https://wisc.pb.unizin.org/agent-based-evolutionary-game-dynamics/`

[2] `https://www.santafe.edu/news-center/news/new-book-agent-based-modeling-archaeology` Has free PDF at this location.

- Programming in NetLogo

Assigned reading(s):

a. *Agent-Based Evolutionary Game Dynamics* (ABEGD) (Izquierdo et al., 2019, pages 35–40) "0.4. Fundamentals of NetLogo."
`https://wisc.pb.unizin.org/agent-based-evolutionary-game-dynamics/`

b. "NETLOGO 6.0 — QUICK GUIDE"
`http://luis.izqui.org/resources/NetLogo-6-0-QuickGuide.pdf`

c. "The Fire Model," (Wilensky and Rand, 2015, chapter 3, pages 101–118). Wilensky, U., & Rand, W. (2015). An Introduction to Agent-Based Modeling.

Reference material:

a. *NetLogo User Manual* (read it)
Reference
Interface Guide
Interface Tab Guide
Info Tab Guide
Code Tab Guide
Programming Guide
And the NetLogo Dictionary should be your constant companion while programming.

b. 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)
`https://www.santafe.edu/news-center/news/new-book-agent-based-modeling-archaeolo`
Or tiny URL: `https://tinyurl.com/329azsje`. (Has free PDF at this location. File ABMA_color_version.pdf posted on Canvas.)

5.13 ABM, 3: NetLogo

Main topics:

- Conventional programming in NetLogo

Assigned reading(s):

a. PNbook: skim programming material after chapter 3.

Reference material:

a. NetLogo User Manual

5.14 ABM, 4: NetLogo

Main topics:

- BehaviorSpace
- Pivot tables in Google Sheets
- Plotting in NetLogo

Assigned reading(s):

a. PNbook: chapter 3, appendix A.

Slide deck: ABM-4-beamer.pdf.
Recommended readings (before class):

a. (Wilensky and Rand, 2015, Chapter 6), especially pages 288–296.

b. (Kimbrough and Lau, 2016, chapter 1), file Chapter1BAbook.pdf on Canvas.

Reference material:

a. NetLogo User Manual

b. `https://support.google.com/docs/answer/1272900?hl=en&co=GENIE.Platform%3DDesktop` pivot table Google Sheets

5.15 Territorial Models

Homework exercise handed out. Due November 16, 2023, 11:59 p.m.

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)

Slides: AGE-fanning-out-beamer.pdf
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"

5.16 Foraging, 1

Main topics:

- The problem of foraging
- Examples with NetLogo models

5.17 Foraging, 2

Main topics:

- Foraging and games
- Ideal Free Distribution
- Duck economics

Slides: DuckEconomics.pdf
Assigned reading(s):

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

5.18 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).

Slides: AGE-markets1-beamer.tex

5.19 Monopoly and Oligopoly Markets

Note: This class might be held over Zoom. Information forthcoming.
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)

Slide deck: AGE-markets2-monopoly-oligopoly-beamer.pdf
Recommended material:

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

5.20 Two-Sided stable matching

Main topics:

- Stable matching problems
- Computational solutions
- Applications

Slide deck: AGE-stable-matching-beamer.pdf
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)

5.21 Quiz #2

5.22 Framing and the Cooperation Afforder Game

Quiz #2, November 9

Main topics:

- Framing
- The cooperation afforder game

Slides: AGE-analysis-framing-beamer.pdf and AGE-coop-afforder-beamer.pdf
Assigned reading(s):

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

Reference material:

a. Selections from Freedman, *Strategy: A history* Freedman (2013)

5.22.1 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"

5.23 Voting

Main topics:

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

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.

b. (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.

c. (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 Narrative and Argumentation

Main topics:

- Prominence of narrative
- Reasons and strategy
- Arguments: valid, invalid, sound, enthymemes
- Backward induction

Assigned reading(s):

a. *Agents, Games, and Evolution* "Lying and Related Abuses" (Kimbrough, 2012, chapter 17)

Reference material:

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

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

5.28 Quiz #3 and Last Class: Summary and Outlook

Quiz #3. December 7, 2023.

Main topics:

- Quiz #3.
- Summing up and looking forward.
- End of term essay/project assignment handed out and discussed.

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.

15% Homework assignment, with NetLogo. Groups of 2 self-formed. Due November 16, 2023, 11:59 p.m., class 23.

60% Three quizzes, 20% each. Classes 10 (September 28), 21 (November 9), and 28 (December 7, last class).

15% End of term essay/project, due Thursday, December 21, 2023, 11:59 p.m. Groups of two, self-organized.

10% Class participation (including attendance, comments, in-class exercises).

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 (slightly) change as we go along. I'll let you know when it does. The quiz and assignment 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 Calendar, fall 2023

Last class is on Thursday, December 7, 2023.

References

AIMES (2022). Episode 1: Agent Based Modeling of Land Use Change. https://www.youtube.com/watch?v=w_q2yJlDwDQ.

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

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0	—	R: 2023-09-28	T: 2023-11-07
1	T: 2023-08-29	T: 2023-10-03	R: 2023-11-09
2	R: 2023-08-31	R: 2023-10-05	T: 2023-11-14
3	T: 2023-09-05	T: 2023-10-10	R 2023-11-16
4	R: 2023-09-07	T: 2023-10-17	T: 2023-11-21
5	T: 2023-09-12	R: 2023-10-19	T: 2023-11-28
6	R: 2023-09-14	T: 2023-10-24	R: 2023-11-30
7	T: 2023-09-19	R 2023-10-26	T: 2023-12-05
8	R: 2023-09-21	T: 2023-10-31	R: 2023-12-07
9	T: 2023-09-26	R: 2023-11-02	—

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

Axelrod, R. and Hamilton, W. (1981). The Evolution of Cooperation. *Science*, 211:1390–1396.

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