University of Wisconsin Madison

AAE 706: Applied Risk Analysis

3 credits

Spring Semester, 2023

Thomas F. Rutherford

Lectures
MW 10-11:15pm, Taylor Hall (room B30)

Office Hours
Thursdays 9-11am, Taylor Hall, room 323 and/or on Zoom), and

by appointment – rutherford@aae.wisc.edu

1 Instructional Information

Learning Objectives

The course focuses on the economics of risk and the role of risk in resource allocation. It covers conceptual as well as empirical analyses of economic behavior under risk and its implications for management and policy decisions. Special attention is given to the role of imperfect information in the decision-making process of private agents. Also, the course emphasizes the importance of risk in the analysis of tax policy, environmental policy and public institutions.

The course has four segments. The first segment (based on readings posted on the course web page) will introduce nonlinear optimization, nonlinear complementarity and their application to deterministic models arising in economic equilibrium analysis. The second segment of the course (based on selected chapters from Chavas, 2004) addresses underlying *mathematics of risk preferences*: subjective probability, axiomatic characterizations of risk preferences, expected utility and Bayesian learning. The third segment (based on selected chapters from Zenios and Markowitz, 2008 and Consiglio et al, 2009) introduces *mathematical programming methods* for financial decision making. A sequence of illustrative numerical models cover classical mean-variance analysis, portfolio immunization, scenario-based models and multi-period portfolio optimization. The fourth and final segment of the course is on *representing risk in market equilibrium models for policy analysis.* Canonical models show how stochastic features can be introduced into market equilibrium models with applications to electricity markets, agricultural decisions and integrated assessment of climate change.

The course involves lectures, homework assignments based on mathematical programming models implemented in either Julia/JuMP or the GAMS mathematical modeling language. JuMP is modeling language and collection of supporting packages for mathematical optimization in Julia, the open source programming language. GAMS is commercially provided programming framework which is widely employed by professional economists and is freely available for university students. Both of these pacakges make it easy to formulate and solve a range of problem classes, including linear programs, integer programs, constrained nonlinear programs and complementarity problems.

Upon completion of the course, students will have gained an understanding the economics of risk and practical experience with applied research examining private as well as public decision making related to risk management.

Prerequisites

The class has an intermediate microeconomics class as a prerequisite (AAE 635 or equivalent). Microeconomics is used extensively in the economic evaluation of risk management.

The class also assumes statistical knowledge from at least one course in probability and statistics. Probability theory is used extensively in the class as basic tools of risk assessment and risk analysis. The class will include reviews of both the relevant material in probability and statistics and the fundamentals ideas of applied optimization and mathematical programming.

Required Texts

Chavas, Jean-Paul. *Risk Analysis in Theory and Practice.* Elsevier Academic Press, New York, 2004. ISBN: 0121796214

Zenios, Stavros A. and Harry M. Markowitz. *Practical Financial Optimization: Decision Making for Financial Engineers Practical Financial Optimization: Decision Making for Financial Engineers*, Wiley-Blackwell, 2008. ISBN: 978-1-405-13200-8

Consiglio, Andrea, Søren Nielsen, and Stavros A. Zenios, *Practical Financial Optimization: A Library of GAMS Models* Wiley, 2009. ISBN: 978-1-4051-3371-5.

Additional Readings will be assigned during the class. See Course URL for updates and announcements.

Course Requirements

- Class Participation

  Students are expected to attend class and contribute to the discussion. Class sessions will include short quizzes and computational exercies intended to evaluate student understanding of the material and computational methods and to establish expectations of material to be covered on the final exam.

- Assignments

  Six homework assignments will be given, amounting to about one homework every two weeks. The homework assignments are an important part of the class. They have three objectives:

  i. give the students a chance to refine their understanding of the analytical tools discussed in class

  ii. apply these tools to specific projects on the economics of risk

  iii. get practical experience in conducting applied research on the evaluation and management of risk.

  Each homework will cover a different part of the class. All assignments will involve conducting applied research on risk analysis. Each homework consists in analyzing data with the goal of evaluating specific risky projects, assessing the economic implications of risk and making recommendations to decision makers.

- Exam

  There will be a final exam on Monday, May 8 at 5 pm. which cover all the material discussed in class. The exam questions will be closely related to the homework assignments.

2 Grading

The grading will rely on the six homework assignments and the exam.

The following grading scheme will be used:

- Homework: 60 percent of the final grade
- Class attendance and participation: 10 percent of the final grade
- Exam: 30 percent of the final grade

3 Course Organization and Topics

i. Useful methods for optimization and equilibrium analysis (3 weeks):
   - Linear and nonlinear programming
   - Spatial price equilibrium and integrability
   - Calibrated choice models: representing technology and preferences
   - Mathiesen's complementarity format
   - Dynamic equilibrium models
   - Putty-clay technology and preferences
   - Social welfare

ii. The modeling of economic behavior under risk – underlying ideas and mathematics (3 weeks):
   - review of probability theory
   - ideas related to the measurement of risk
   - the expected utility hypothesis
   - risk preferences:
     - absolute and relative risk aversion
     - the risk premium
   - the nature of risk aversion: the decreasing absolute risk aversion hypothesis
   - stochastic dominance

iii. Mathematical programming methods for financial decision making under uncertainty – (3 weeks)
   - Basics of optimization and optimization models used by financial engineers
   - Mean-variance analysis - portfolio revisions with transactions costs, factor models.
   - Portfolio models for fixed income – cashflow matching, diversification, bootstrapping, immunization
   - Portfolio optimization with stochastic programming and stochastic control

iv. Markets, public policy and risk (3 weeks)
   - uncertainty in electricity markets
   - agricultural decision making under uncertainty
   - greenhouse gas mitigation – buying greenhouse insurance

4 Other information

Plagiarism

Plagiarism is a serious offense. All sources and assistance used in preparing your papers must be precisely and explicitly acknowledged. Ignorance of what constitutes plagiarism or academic misconduct is not a defense. It is your responsibility to be sure. The web creates special risks.

Cutting and pasting even a few words from a web page or paraphrasing material without a reference constitutes plagiarism. If you are not sure how to refer to something you find on the internet, you can always give the URL. It is generally better to quote than to paraphrase from material on the web, because in the absence of page numbers it can be hard to find passages that are paraphrased rather than quoted. For more information on writing and source citation, the following may be helpful http://writing.wisc.edu/Handbook/Documentation.html

Academic Integrity

By enrolling in this course, each student assumes the responsibilities of an active participant in UW-Madison's community of scholars in which everyone's academic work and behavior are held to the highest academic integrity standards. Academic misconduct comprises the integrity of the university. Cheating, fabrication, plagiarism, unauthorized collaboration, and helping others commit these acts are examples of academic misconduct, which can result in disciplinary action. This includes but is not limited to failure on the assignment/course, disciplinary probation, or suspension. Substantial or repeated cases of misconduct will be forwarded to the Office of Student Conduct & Community Standards for additional review. If you have any questions about what constitutes academic misconduct, please read the following information http://students.wisc.edu/doso/acadintegrity.html or come talk with one of the instructors.

Accommodations for students with disabilities

The University of Wisconsin-Madison supports the right of all enrolled students to a full and equal educational opportunity. The Americans with Disabilities Act (ADA), Wisconsin State Statute (36.12), and UW-Madison policy (Faculty Document 1071) require that students with disabilities be reasonably accommodated in instruction and campus life. Reasonable accommodations for students with disabilities is a shared faculty and student responsibility. Students are expected to inform faculty [me] of their need for instructional accommodations by the end of the third week of the semester, or as soon as possible after a disability has been incurred or recognized. Faculty [I], will work either directly with the student [you] or in coordination with the McBurney Center to identify and provide reasonable instructional accommodations. Disability information, including instructional accommodations as part of a student's educational record, is confidential and protected under FERPA. http://mcburney.wisc.edu/facstaffother/faculty/syllabus.php