

Syllabus for Econ 573, Spring 2023

Machine Learning and Econometrics

Professor Peter Reinhard Hansen

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Lectures: Tue & Thu 09:30-10:45 in Gardner Hall 007.

Office Hours: Wednesdays at (time TBD)

Prerequisites:

Econ 410, 420 and 470 with a grade of C or higher. It is assumed that you are familiar with regression model estimation and related hypothesis testing techniques.

Course Objective:

Students will learn how to explore, visualize, and analyze high-dimensional datasets, build predictive models, and estimate causal effects. The course introduces key concepts and tools that are in high demand in the business environment. Examples of techniques include an advanced overview of linear and logistic regression, regularization, LASSO, cross-validation, classification, model selection, random forests, and more. Students will learn basic underlying concepts and will build practical programming skills in R. Heavy emphasis is placed on the analysis of actual datasets, and on applications of specific methodologies. Examples may include consumer choice data, housing prices, asset pricing, network data, internet and social media data, sports analytics.

Econ 573 satisfies the "Research and Discovery" objective of the IDEAs in action curriculum. Students immerse themselves in a research project and experience the reflection and revision involved in producing and disseminating original scholarship or creative works.

Learning Outcomes

These are the learning outcomes that are expected of students after completing a course.

-  Frame a topic, develop an original research question or creative goal, and establish a point of view, creative approach, or hypothesis.
-  Obtain a procedural understanding of how conclusions can be reached in a field and gather appropriate evidence.
-  Evaluate the quality of the arguments and/or evidence in support of the emerging product.
-  Communicate findings in clear and compelling ways.
-  Critique and identify the limits of the conclusions of the project and generate ideas for future work.

Questions for Students

These are the types of questions you should be able to answer after completing a course.

-  How do I establish my point of view, take intellectual risks, and begin producing original scholarship or creative works?
-  How do I evaluate my findings and communicate my conclusions?
-  How do I narrow my topic, critique current scholarship, and gather evidence in systematic and responsible ways?

Course Website:

Assignments, announcements, grades, readings, and other information will be posted on Canvas. It is your responsibility to check Canvas and your UNC email regularly to stay informed about the course content and course schedule, as well as possible changes to these.

Textbooks

The main textbook for this course is:

ISL An Introduction to Statistical Learning with Applications in R (2nd ed). By Gareth James, Daniela Witten, Trevor Hastie, and Rob Tibshirani. [Download free copy of textbook](#)

If you need a paper copy of the book, it is available for about \$75. Two other excellent textbooks, which cover the same material, are the two listed below. (Almost the same book, because MBA is largely a revised version BDS.

BDS Business Data Science: Combining Machine Learning and Economics to Optimize, Automate, and Accelerate Business Decisions by Matt Taddy. (~\$25)

MBA Modern Business Analytics (1st ed). By Matt Taddy, Leslie Hendrix, and Matthew Harding. ISBN10: 1264071671 (~\$140)

Problem Sets

There will be about nine problem sets during the semester, and you must submit your own individual solution/answer to each problem set. Late problem sets will be marked down by 50%, and will receive no credit once feedback has gone out to class mates.

Software

Problem sets will involve data analysis using R. R is a very flexible, powerful, and popular language and environment for statistical computing and graphics. You can download and install it from <https://www.r-project.org/>. You may also want to check the R Studio GUI from <https://rstudio.com/products/rstudio/>.

The course does not assume that you have used R in a previous class. Resources are available below and will be supplemented by in-class demonstrations and shared code to accompany lectures and assignments. However, this is not a class on R. Like any language, R is only learned by doing. You should install it as soon as possible and familiarize yourself with basic operations.

Some useful R resources:

1. R Tutorial: <http://r-tutorial.nl/>
2. R in Action: <https://livebook.manning.com/book/r-in-action-third-edition/welcome/v-2/>
3. R Resources at [Princeton](#):
4. YouTube tutorials, e.g., from [Google Developers](#) (search for it if link does not work)
5. Web search: "do X in R". Try variations of X until you find an answer. You will find many answers on <https://stackoverflow.com/>. Also ask your classmates and me.

Research project

For the research project, you will analyze a prediction or a causal inference question using methods learned in the course. You will write a paper, approximately 15 pages long, where you will explain the research question, data, methodology, and results. One possibility is to focus on a prediction problem trying various techniques learned in this class. Another possibility is to estimate causal effects. For the former numerous datasets can be found at <https://www.kaggle.com/datasets>, which is an online community of data scientists and machine learners.

Each group will give an presentations of their project during the last two weeks of the semester. The grade will be based the project paper you turn in and the oral project presentation.

Grading policy

Your final grade will be based on:

- 35% problem sets and research project
- 5% quizzes and active class participation
- 20% midterm exam
- 40% final exam

There will be no make-up exam for the midterm. If you miss a midterm exam because of a medical or family emergency, the final exam will count for 60% of your final grade.

Exams are closed-book, but you may bring a sheet with your own notes (one side of a letter-sized sheet of paper for the midterm, both sides for the final exam).

You are expected to have read the assigned material prior to each lecture. Active class participation and quizzes are also factored into your grade. You are expected to attend and participate in all lectures, in accordance with UNC policy, which reads: “[...] no right or privilege exists that permits a student to be absent from any class meetings, except for the University Approved Absences” (see below).

Classroom Etiquette and Electronics Policy

To maintain a good learning environment for everyone, you must turn off all cell phones, laptops, and other electronic devices during class, except when you are told to

Recommended Readings

- Susan Athey and Guido Imbens (2019). Machine learning methods economists should know about, *Annual Review of Economics*, 11:685-725, <https://arxiv.org/abs/1903.10075>.
- Leo Breiman. Statistical modeling: the two cultures (2001) (with comments and a rejoinder by the author). *Statistical Science*, 16:199-231.
- Matthew Getzkow, Bryan Kelly, and Matt Taddy (2019). Text as data. *Journal of Economic Literature*, 57:535-574.
- Sendhil Mullainathan and Jann Spiess (2017). Machine learning: an applied econometric approach. *Journal of Economic Perspectives*, 31(2):87-106.

Schedule (tentative)

Week 1: Introduction

1/10 ILS 1+2 (BDS00, MBA00)

1/12 ...

Week 2: Regression

1/17 ILS 3.1-3.2 (BDS02, MBA01)

1/19 ...

Week 3: Regression

1/24 ILS 3.3-3.6 (BDS02, MBA01)

1/26 ...

Week 4: Classification

1/31 ILS 4.1-4.3 (MBA04)

2/2 ...

Week 5: Classification

2/7 ILS 4.4-4.7 (MBA04)

2/9 ...

Week 6: Resampling methods

2/14 Wellness day

2/16 ILS 5.1 (BDS03,MBA02)

Week 7: Resampling methods

2/21 ILS 5.2-5.3 (BDS03,MBA02)

2/23 Midterm Exam

Week 8: Regularization

2/28 ILS 6 (BDS03,MBA02)

3/2 ...

Week 9: Regularization

3/7 ILS 6 (BDS03,MBA02)

3/9 ...

Week 10: Spring break

3/14

3/16

Week 11: Regression beyond Linearity

3/21 ILS07 (BDS03,MBA02)

3/23 ...Project

Week 12: Regression Trees

3/28 ILS08 (BDS09,MBA027)

3/30 ...

Week 13: Project consulting

4/4 ...

4/6 Wellness day

Week 14: Advanced topics (Deep learning?)

4/11 TBD

4/13 TBD Project Due

Week 15: Project presentations

4/18 Presentations

4/20 Presentations

Week 16: Project presentations

4/25 Presentations

4/27 Review

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Information for Undergraduate Classes
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Syllabus Changes

The professor reserves the right to make changes to the syllabus including project due dates and test dates. These changes will be announced as early as possible.

Attendance Policy

University Policy: As stated in the University's [Class Attendance Policy](#), no right or privilege exists that permits a student to be absent from any class meetings, except for these University Approved Absences:

1. Authorized University activities
2. Disability/religious observance/pregnancy, as required by law and approved by [Accessibility Resources and Service](#) and/or the [Equal Opportunity and Compliance Office](#) (EOC)
3. Significant health condition and/or personal/family emergency as approved by the [Office of the Dean of Students](#), [Gender Violence Service Coordinators](#), and/or the [Equal Opportunity and Compliance Office](#) (EOC).

Class Policy: Instructors may work with students to meet attendance needs that do not fall within University approved absences. For situations when an absence is not University approved (e.g., a job interview or club activity), instructors determine their own approach to missed classes and make-up assessment and assignments.

University Approved Absence Office (UAAO): The [UAAO](#) website provides information and FAQs for students and faculty related to University Approved Absences.

Note: Instructors have the authority to make academic adjustments without official notice from the UAAO. In other words, it is not required for instructors to receive a University Approved Absence notification in order to work with a student. In fact, instructors are encouraged to work directly with students when possible.

Honor Code

All students are expected to follow the guidelines of the UNC Honor Code. In particular, students are expected to refrain from "lying, cheating, or stealing" in the academic context. If you are unsure about which actions violate the Honor Code, please see me or consult studentconduct.unc.edu.

Acceptable Use Policy

By attending the University of North Carolina at Chapel Hill, you agree to abide by the University of North Carolina at Chapel Hill policies related to the acceptable use of IT systems and services. The Acceptable Use Policy (AUP) sets the expectation that you will use the University's technology resources responsibly, consistent with the University's mission. In the context of a class, it's quite likely you will participate in online activities that could include personal information about you or your peers, and the AUP addresses your obligations to protect the privacy of class participants. In addition, the AUP addresses matters of others' intellectual property, including copyright. These are only a couple of typical

examples, so you should consult the full [Information Technology Acceptable Use Policy](#), which covers topics related to using digital resources, such as privacy, confidentiality, and intellectual property.

Additionally, consult the [Safe Computing at UNC](#) website for information about data security policies, updates, and tips on keeping your identity, information, and devices safe.

Accessibility Resources and Service

The University of North Carolina at Chapel Hill facilitates the implementation of reasonable accommodations, including resources and services, for students with a disability and/or a chronic health diagnosis resulting in barriers to fully accessing University courses, programs and activities.

Accommodations are determined by the Office of Accessibility Resources and Service (ARS) through their Student and Applicant Accommodations Policy, which documents qualifying disabilities in accordance with applicable state and federal laws. See the ARS website (<https://ars.unc.edu>) for contact information or email ars@unc.edu.

Counseling and Psychological Services

UNC-Chapel Hill is strongly committed to addressing the mental health needs of a diverse student body. The [Heels Care Network](#) website is a place to access the many mental health resources at Carolina. CAPS is the primary mental health provider for students, offering timely access to consultation and connection to clinically appropriate services. Go to their website <https://caps.unc.edu/> or visit their facilities on the third floor of the Campus Health building for an initial evaluation to learn more. Students can also call CAPS 24/7 at 919-966-3658 for immediate assistance.

Title IX and Related Resources

Any student who is impacted by discrimination, harassment, interpersonal (relationship) violence, sexual violence, sexual exploitation, or stalking is encouraged to seek resources on campus or in the community. Reports can be made online to the EOC at <https://eoc.unc.edu/report-an-incident/>. Please contact the University's Title IX Coordinator (Elizabeth Hall, titleixcoordinator@unc.edu), Report and Response Coordinators in the Equal Opportunity and Compliance Office (reportandresponse@unc.edu), Counseling and Psychological Services (confidential), or the Gender Violence Services Coordinators (gvsc@unc.edu; confidential) to discuss your specific needs. Additional resources are available at safe.unc.edu.

Policy on Non-Discrimination

The University is committed to providing an inclusive and welcoming environment for all members of our community and to ensuring that educational and employment decisions are based on individuals' abilities and qualifications. Consistent with this principle and applicable laws, the University's [Policy Statement on Non-Discrimination](#) offers access to its educational programs and activities as well as employment terms and conditions without respect to race, color, gender, national origin, age, religion, genetic information, disability, veteran's status, sexual orientation, gender identity or gender expression. Such a policy ensures that only relevant factors are considered, and that equitable and consistent standards of conduct and performance are applied.

If you are experiencing harassment or discrimination, you can seek assistance and file a report through the Report and Response Coordinators (see contact info at safe.unc.edu) or the Equal Opportunity and Compliance Office at <https://eoc.unc.edu/report-an-incident/>.

Diversity Statement

I value the perspectives of individuals from all backgrounds reflecting the diversity of our students. I broadly define diversity to include race, gender identity, national origin, ethnicity, religion, social class, age, sexual orientation, political background, and physical and learning ability. I strive to make this classroom an inclusive space for all students. Please let me know if there is anything I can do to improve. I appreciate any suggestions.

Undergraduate Testing Center

The College of Arts and Sciences provides a secure, proctored environment in which exams can be taken. The center works with instructors to proctor exams for their undergraduate students who are not registered with ARS and who do not need testing accommodations as provided by ARS. In other words, the Center provides a proctored testing environment for students who are unable to take an exam at the normally scheduled time (with pre-arrangement by your instructor). For more information, visit <http://testingcenter.web.unc.edu/>.

Learning Center

Want to get the most out of this course or others this semester? Visit UNC's Learning Center at <http://learningcenter.unc.edu> to make an appointment or register for an event. Their free, popular programs will help you optimize your academic performance. Try academic coaching, peer tutoring, STEM support, ADHD/LD services, workshops and study camps, or review tips and tools available on the website.

Writing Center

For free feedback on any course writing projects, check out UNC's Writing Center. Writing Center coaches can assist with any writing project, including multimedia projects and application essays, at any stage of the writing process. You don't even need a draft to come visit. To schedule a 45-minute appointment, review quick tips, or request written feedback online, visit <http://writingcenter.unc.edu>.

Grade Appeal Process

If you feel you have been awarded an incorrect grade, please discuss with me. If we cannot resolve the issue, you may talk to our departmental director of undergraduate studies or appeal the grade through a formal university process based on arithmetic/clerical error, arbitrariness, discrimination, harassment, or personal malice. To learn more, go to the [Academic Advising Program](#) website.