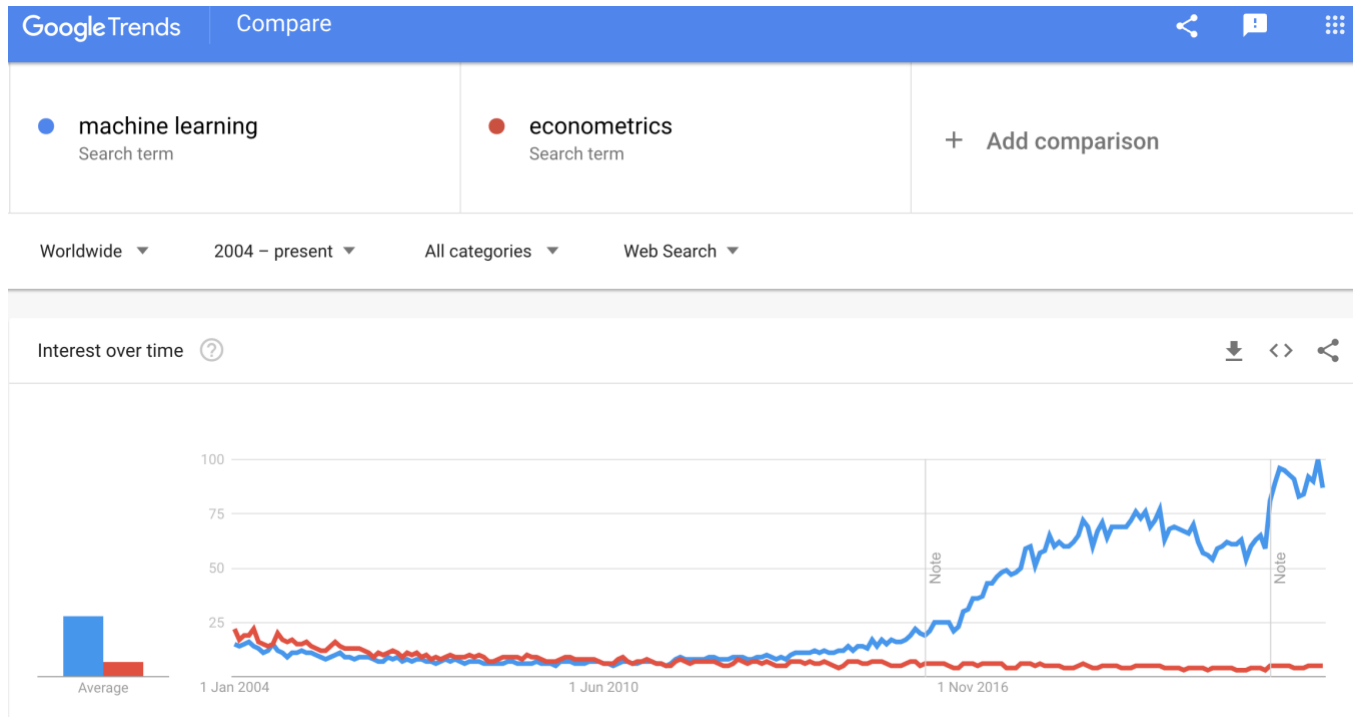


University of Waterloo
Department of Economics
Preliminary Course Outline
Winter 2024

Econ 424
Machine Learning for Economists



Course Introduction: This course is an introduction to machine learning methods and applications for economists. Main focus is on supervised learning. Additional topics include text analysis, ML applications in economics, large language models, and impact of ML/AI on society. We also compare how machine learning differs from traditional econometric analysis. Students compete in prediction competitions throughout the semester, giving an opportunity and incentive to learn how to implement different ML models. The final exam is also structured as a prediction competition. Students are expected to make extensive use of ChatGPT/GPT4 when competing in these prediction competitions.

Course Objectives: The main objective is to provide students an opportunity to become familiar with learning and implementing key machine learning algorithms. A secondary aim is to demonstrate how economists use machine learning in their work.

Instructor: Mikko Packalen, Associate Professor

Course Pre-requisites: Familiarity with data analysis and causal inference.

Office Hours: Tuesdays 11:30pm-1pm, HH205, and by appointment (please email me).

Email: packalen@uwaterloo.ca; subject line should state "ECON 626" and come from your .uwaterloo account.

1. Course Materials

The core course materials: Lectures, Prediction Competition Assignments, 2 Textbooks, Scientific Journal Articles, Policy Papers and Newspaper Articles, and Computer Software (e.g. Python or R).

2. Lectures

Tue/Thu 10:00-11:20am.

3. ChatGPT/GPT4

Students are expected to use ChatGPT/GPT4 extensively during the course. No prior experience is necessary.

4. Expectations

Attending class is mandatory and (hopefully) fun. Class meetings are an introduction to each topic; attendance should represent less than 30% of the student's weekly effort for the class. The course material is cumulative both in terms of what is studied during the semester and what is studied in the prerequisite classes. Success in the course generally requires weekly effort from the student outside of class and a good understanding of the data analysis and econometrics topics covered in prerequisite classes.

5. Tentative Schedule

Each class meeting begins with a discussion on latest ML/AI developments.

Part I. Introduction to ML

Lecture 1: Introduction to the Course: How is ML Different from Econometrics?

Lecture 2: Introduction to ML: What is the Key Goal of ML?

Prediction Competition 1

Part II: The ML Basics

Lecture 3: Overfitting

Lecture 4: Cross-Validation

Lecture 5: Regression Trees

Prediction Competition 2

Lecture 6: Penalized Regression

Lecture 7: Classification

Prediction Competition 3

Lecture 8: Bagging, Boosting and Random Forests

Prediction Competition 4

Lecture 9: Unsupervised Learning

Lecture 10: Support Vector Machines

Lecture 11: Neural Networks

Prediction Competition 5

Lecture 12: Parallel Processing and Cloud Computing

Part III: Text Analysis

Lecture 13: Text as Data

Lecture 14: Sentiment Analysis

Prediction Competition 6

Lecture 15: Word and Document Embedding Methods

Part IV: Deep Learning and Generative AI

Lecture 16: Deep Learning

Lecture 17: Large Language Models/ChatGPT/GPT4

Lecture 18: Reinforcement Learning

Part V: ML Applications and Impact

Lecture 19: ML Applications in Economics

Lecture 20: ML/AI Impact on Productivity, Jobs, and Inequality

Lecture 21: ML/AI Impact on Privacy and Future of Society

Final Prediction Competition

6. Prediction Competition Assignments

Assignments are distributed through learn.uwaterloo.ca. Each assignment is a prediction competition. Grade depends on accuracy of predictions and on how well the submission is documented.

7. Prediction Competition Final

Instead of a final exam or term paper, students submit answers to the final prediction competition. Grade for the Prediction Competition Final will depend on accuracy of the predictions (70%) and on how well the submission is documented (30%). Further details will be discussed in class.

8. Software

Python and R are free.

9. Textbooks and Scientific Articles

We will use the following **free** textbooks on machine learning and deep learning:

[ISLR] James G., Witten, D., Hastie, T. and R. Tibshirani (2021) *An Introduction to Statistical Learning with Applications in R*. Springer. 2nd edition. Available at:
<https://www.statlearning.com/>

[ISLP] James G., Witten, D., Hastie, T., Tibshirani, R. and J. Taylor (2023) *An Introduction to Statistical Learning with Applications in Python*. Springer. 2nd edition. Available at:
<https://www.statlearning.com/>

Nielsen, M. (2015) *Neural Networks and Deep Learning*. Determination Press. Available at:
<http://neuralnetworksanddeeplearning.com/>

We will also use various **freely accessible** scientific journal articles and book chapters, including:

Varian, H. R. (2014) “New Tricks for Economists,” *Journal of Economic Perspectives*, 28(2): 3-28. Available at: <https://pubs.aeaweb.org/doi/pdf/10.1257/jep.28.2.3>

Mullainathan, S. and J. Spiess (2017) “Machine Learning: An Applied Econometric Approach,” *Journal of Economic Perspectives*, 31(2): 87-106. Available at:
<https://pubs.aeaweb.org/doi/pdf/10.1257/jep.31.2.87>

Domingos, P. (2012) “A Few Useful Things to Know About Machine Learning,” *Communications of the ACM*, 55(10): 78-87. Available at:
<https://homes.cs.washington.edu/~pedrod/papers/cacm12.pdf>

Domingos, P. (2015) “The Machine-Learning Revolution,” chapter 1 in *The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World*. Basic Books. Available (Click “read more”) at: <https://www.basicbooks.com/titles/pedro-domingos/the-master-algorithm/9780465061921>

Athey, S. (2018) “The Impact of Machine Learning on Economics”, in Agrawal, A. K., Gans, J. and A. Goldfarb (eds.) *The Economics of Artificial Intelligence*. University of Chicago Press. Available at: <https://www.nber.org/chapters/c14009.pdf>

Athey, S. and G. Imbens (2019) “Machine Learning Methods Economists Should Know About”, Manuscript. Available at: <https://arxiv.org/pdf/1903.10075.pdf>

Angrist, J. D. and J.-S. Pischke (2017) Undergraduate Econometrics Instruction: Through Our Glasses, Darkly. *Journal of Economic Perspectives*, 31(2): 125-44. Available at: <https://pubs.aeaweb.org/doi/pdf/10.1257/jep.31.2.125>

Christopher, R. (2018) “Shackling the Identification Police,” Manuscript. Available at (from campus only): <https://www.nber.org/papers/w25320>

Deaton, A. (2021) “Randomization in the tropics revisited: a theme and eleven variations,” Manuscript. Available at: https://www.nber.org/system/files/working_papers/w27600/w27600.pdf

Pritchett, L. (2021) “Randomizing Development: Method or Madness,” Manuscript. Available at: https://lantpritchett.org/wp-content/uploads/2019/12/RCTs-and-the-big-questions_10000words_june30.pdf

Sansone, D. (2021) “Machine Learning for Economists,” (Note: this is a list of machine learning papers and resources for economists). Available at: <https://sites.google.com/view/dariosansone/resources/machine-learning>

10. Assessments

Final grade components and weights:

Prediction Competition Assignments	55%
In-Class Participation	20%
Prediction Competition Final	25%

Notes:

- Prediction Competition Final submissions are due on April 10th, no late submissions are accepted.

11. Additional Information

1. Missing a Problem Set Deadline or Quiz Due to Illness During Term
 - If a student misses a problem set deadline or quiz due to illness and has valid documentation (approval required), the weight of the missed problem set or quiz will be shifted to other problem sets. Without valid and timely submitted documentation, the student will receive zero for the missed problem set/quiz.
2. Fee-Arranged Issues

Students are responsible for administrative matters concerning their course registration including fee arrangements. No make-up work or remedies will be given for losses of access to LEARN and academic consequences arising from administrative issues with the Registrar's Office.

3. Classroom Protocols
 - Photographic devices are not permitted in class; this is a University regulation.

12. University Required Statements

[Economics Department Deferred Final Exam Policy](#)

Academic Integrity

In order to maintain a culture of academic integrity, members of the University of Waterloo are expected to promote honesty, trust, fairness, respect and responsibility. See the [Office of Academic Integrity webpage](#) for more information.

Discipline

A student is expected to know what constitutes academic integrity to avoid committing an academic offence and to take responsibility for his/her actions. Check [the Office of Academic Integrity](#) for more information. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about “rules” for group work/collaboration should seek guidance from the course professor, academic advisor, or the undergraduate associate dean. When misconduct has been found to have occurred, disciplinary penalties will be imposed under Policy 71 – Student Discipline. For information on categories of offenses and types of penalties, students should refer to [Policy 71 - Student Discipline](#). For typical penalties check [Guidelines for the Assessment of Penalties](#).

Grievance

A student who believes that a decision affecting some aspect of their university life has been unfair or unreasonable may have grounds for initiating a grievance. Read [Policy 70 - Student Petitions and Grievances](#), Section 4. When in doubt, please be certain to contact the department's administrative assistant who will provide further assistance.

Appeals

A decision made or penalty imposed under Policy 70 - Student Petitions and Grievances (other than a petition) or Policy 71 - Student Discipline may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to [Policy 72 - Student Appeals](#).

Note for Students with Disabilities

[AccessAbility Services](#), located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.

Turnitin.com

Text matching software (Turnitin®) may be used to screen assignments in this course. Turnitin® is used to verify that all materials and sources in assignments are documented. Students' submissions are stored

on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography), if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the term and/or at the time assignment details are provided, about arrangements and alternatives for the use of Turnitin in this course.

It is the responsibility of the student to notify the instructor if they, in the first week of term or at the time assignment details are provided, wish to submit alternate assignment.