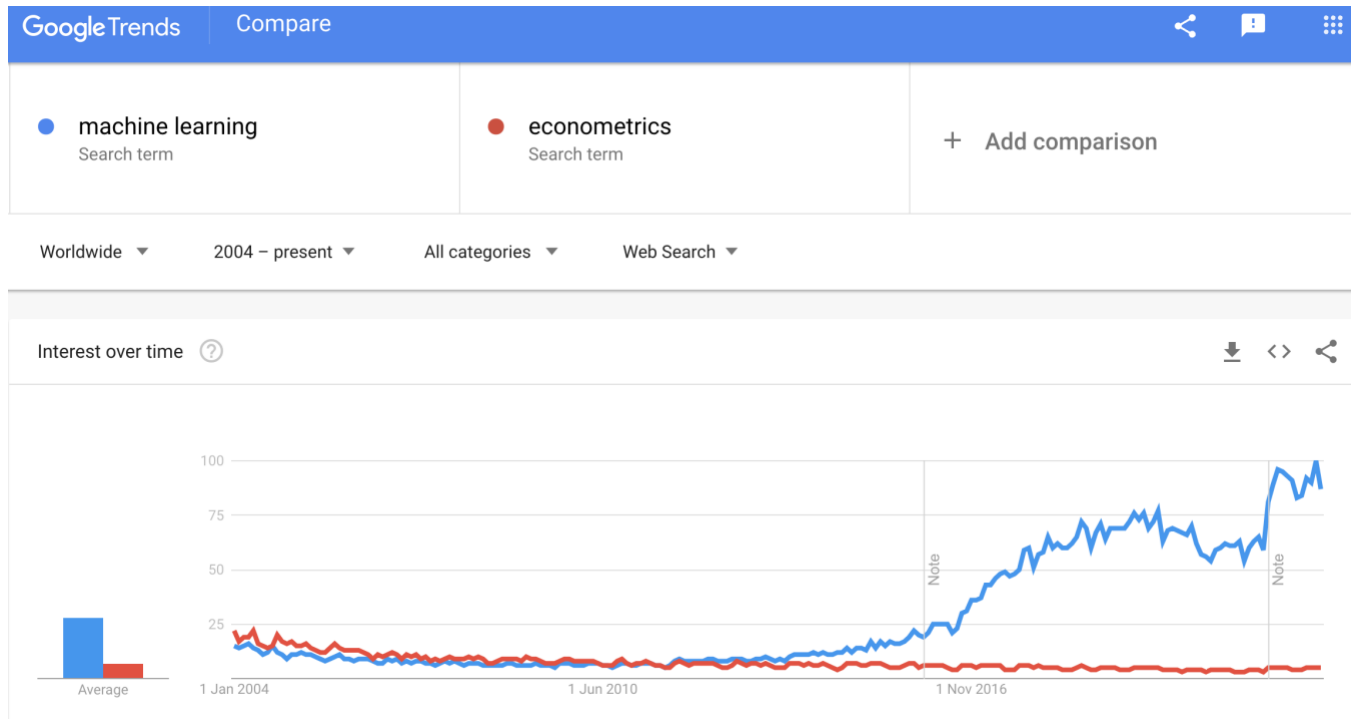


University of Waterloo
Department of Economics
Preliminary Course Outline
Fall 2023

Econ 626
Machine Learning for Economists



Course Introduction: This course is an introduction to machine learning for economists. The main focus is on supervised learning methods. Additional topics include using text as data and cloud computing. We also compare how machine learning differs from traditional econometric analysis. The course is structured in 7 modules. At the conclusion of each module students compete in a prediction competition. The final exam is also structured as a prediction competition.

Course Objectives: The main objective is to provide students an opportunity to become familiar with key machine learning concepts and methods. A secondary aim is to demonstrate how economists are using machine learning.

Instructor: Mikko Packalen, Associate Professor

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

Office Hours: Thursdays 11am-12.30pm, HH205, and by appointment (please email me).

Email: packalen@uwaterloo.ca; subject line should state “ECON 424” and come from your .uwaterloo account.

1. Course Materials

The core course materials are: Lectures, Problem Sets, Textbook, Scientific Journal Articles, Policy Papers and Newspaper Articles, and Computer Software (e.g. Python or R)..

2. Lectures

Tue/Thu 1:00-2:20pm, DWE 3157.

3. Tentative Schedule

Module 1: Introduction to ML and Regression Trees

1. **The Credibility Revolution: What Economists Do with Data**
2. **Econometrics vs. Machine Learning: Parameter Estimation vs. Prediction**
3. **Regression Trees (ISLR 8.1, 8.3.1-8.3.2)**
4. **Prediction Competition 1**

Module 2: Overfitting, Model Evaluation and Penalized Regression

1. **Model Evaluation (ISLR 2.1, 2.2.1-2.2.2, 2.3,5.1.1-5.1.3,5.2,5.3.1-5.3.3)**
2. **Penalized Regression (ISLR 6.1-6.2, 6.5-6.6)**
3. **Prediction Competition 2**

Module 3: Classification and Ensemble Models

1. **KNN and LDA (ISLR 2.2.3, 4.1-4.6)**
2. **Random Forests, Bagging, Boosting (ISLR 8.2, 8.3.3-8.3.4)**
3. **Prediction Competition 3**

Module 4: SVM and Neural Networks

1. **Classification: SVM (ISLR 9.1-9.3)**
2. **Neural Networks**
3. **Word and Document Embedding Methods**
4. **Prediction Competition 4**

Module 5: Unsupervised Learning

1. **Unsupervised Learning (ISLR 10.3, 10.5.1-10.5.2)**
2. **Prediction Competition 5**

Module 6: Text As Data

1. **Text Analysis**
2. **Sentiment Analysis**
3. **Machine Learning Text Analysis Methods**
4. **Prediction Competition 6**

Module 7: Deep Learning

1. **The Basics (Nielsen 2015)**
2. **Computer Vision**
3. **Reinforcement Learning (OpenAI Five, AlphaZero/Go, Cicero)**
4. **Generative AI Models (LLMs/GPT-3/Galactica/ChatGPT, DALL-E/Stable Diffusion)**

Module 8: ML in Economics, Economy, and Society

1. ML in Economics Research
2. ML/AI and Productivity Growth
3. ML/AI and Privacy

Prediction Competition Final

2. 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.

3. 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.

4. Software

Python and Python are **free**. Stata is available at a discounted rate for registered students.

5. 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://web.stanford.edu/~hastie/ISLR2/ISLRv2_website.pdf

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”, to appear 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>

6. Assessments

Final grade components and weights:

Prediction Competition Assignments	55%
In-Class Participation	20%
Prediction Competition Final	35%

Notes:

- Prediction Competition Final submissions are due on April 14th, no late submissions are accepted.

7. 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.

8. University Statements

[Economics Department Deferred Final Exam Policy](#)

Cross-listed course

Please note that a cross-listed course will count in all respective averages no matter under which rubric it has been taken. For example, a PHIL/PSCI cross-list will count in a Philosophy major average, even if the course was taken under the Political Science rubric.

Academic Integrity

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 [UWaterloo Academic Integrity](#) webpage and the [Arts Academic Integrity](#) webpage for more information.

Discipline: A student is expected to know what constitutes academic integrity, to avoid committing academic offences, and to take responsibility for his/her actions. 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 his/her 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](#).

Accommodation for Students with Disabilities

Note for students with disabilities: [The AccessAbility Services office](#), located on the first floor of the Needles Hall extension (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 the AS office at the beginning of each academic term.

Mental Health Support

All of us need a support system. The faculty and staff in Arts encourage students to seek out mental health supports if they are needed.

On Campus

- Counselling Services: counselling.services@uwaterloo.ca / 519-888-4567 ext 32655
- [MATES](#): one-to-one peer support program offered by Federation of Students (FEDS) and Counselling Services
- Health Services Emergency service: located across the creek from Student Life Centre

Off campus, 24/7

- [Good2Talk](#): Free confidential help line for post-secondary students. Phone: 1-866-925-5454
- Grand River Hospital: Emergency care for mental health crisis. Phone: 519-749-433 ext. 6880
- [Here 24/7](#): Mental Health and Crisis Service Team. Phone: 1-844-437-3247
- [OK2BME](#): set of support services for lesbian, gay, bisexual, transgender or questioning teens in Waterloo. Phone: 519-884-0000 extension 213

Full details can be found online at the Faculty of ARTS [website](#)

Download [UWaterloo and regional mental health resources \(PDF\)](#)

Download the [WatSafe](#) app to your phone to quickly access mental health support information

Territorial Acknowledgement

We acknowledge that we are living and working on the traditional territory of the Attawandaron (also known as Neutral), Anishinaabeg and Haudenosaunee peoples. The University of Waterloo is situated on the Haldimand Tract, the land promised to the Six Nations that includes six miles on each side of the Grand River.