

Applied Causal Machine Learning

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Course Description

This course is designed for students aspiring to work at the intersection of economics, data science, and technology, particularly those interested in leveraging machine learning (ML) and newly developed causal machine learning models for addressing real-world economic challenges. The focus will be on providing students with the skills necessary to conduct edge-of-knowledge economic research, interpret results, and apply this knowledge to academic and industry questions. This course will be primarily in Python.

Course Objectives

1. Learn Causal Machine Learning:

- Understand causal ML methods and how they differ from predictive models.
- Apply these tools to real economic questions.

2. Develop Data and Coding Skills:

- Gain hands-on experience in Python for data manipulation, analysis, and visualization.
- Use coding and ML tools to carry out independent research.

3. Conduct Independent Research:

- Design and execute a research project from start to finish with emphasis on identification strategies and causality.
- Write a comprehensive paper that applies causal ML to address an economic problem.

4. Apply to Real-World Issues:

- Participate in the Real-World Impact Challenge to connect your research with current economic debates.

Readings and Office Hours

Please check Quercus for office hours time and location. We will use multiple textbooks and journal articles. Details and the required readings will be posted on Quercus weekly.

How to Succeed in This Course

To succeed in this course, it is important to adopt a different approach to learning. Here are some key things to keep in mind:

1. Make sure to work on your project consistently, *ideally every day*. You should code everyday and write everyday! Double fun!
2. *Plan to spend at least half of your time researching and seeking help to understand the various topics and tools you need for your specific research question.* This may involve googling errors, reading documentation, and seeking assistance from the course instructors. Keep in mind that your research may differ from that of other students in your class, and you may need to learn to use additional packages depending on your chosen research question and methodologies.
3. *You will use Google and GPT a lot.* Think of this course as a piano class; most of your learning happens when you practice at home, yet you need the instructor to guide you, teach the important core content, and refine your skills.
4. Remember that the projects, the readings, and the notebooks will be the primary sources of learning in this course, in addition to the in-class lectures. *ECO1465 is a research course that aims to teach you not just the subject matter, but also the crucial skill of how to learn new topics on your own.* This will become more evident as you work through the project.
5. *It is normal to feel overwhelmed when working on a research paper, as it can be a complex and challenging process.* Your ideas may not always pan out as planned, and it's important to be prepared for this inherent uncertainty in research. However, you don't have to go through this process alone. Our team is here to provide support and guidance, and we encourage you to take advantage of all the resources we offer. As you work on your paper, it's important to plan ahead and stay organized. Make sure to check in with your TAs during the designated office hours for additional help and support. We will discuss this in more detail later.

Grading

Item	Weight	Due Dates	Time
Project Reports and/or Weekly assignments	18%	almost weekly	Fri. 7 PM
Quiz 1	10%	Oct 8	Wed. 1 PM
Term Project	20%	Oct 17	Fri. 7 PM
Quiz 2 (cumulative)	10%	Nov 19	Wed. 1 PM
Final Project	25%	Nov 28	Fri. 7 PM
Contribution and Class Engagement	17%	weekly	
Real-World Impact Challenge	5% (bonus marks)		

Project Reports

Students are required to submit a brief written update each week summarizing their project progress. Updates should include key achievements from the week and plans for the upcoming week. A reporting template, including the required sections, will be provided. In addition, students should regularly update their Git repository with the most recent version of their code.

Weekly reports are intended to help you stay on track with your term project. However, the term and final project should not simply be a compilation of these reports. The expectation is a complete paper prepared in the style and structure of a journal article. While groundbreaking novelty is not required, the presentation and organization should follow academic publishing standards.

To meet deadlines successfully and enjoying your other courses, it is strongly recommended that you develop a consistent writing routine, ideally writing every day. Please note: The lowest weekly report grade will be dropped. Consider using this allowance only in cases of illness, technical issues, or other unforeseen circumstances.

Term Project and the Final Project

Students will develop a research paper that builds on an existing published study. While the project will begin with a foundational paper and may use its data, the goal is *not replication*. Instead, students are expected to make a clear and original contribution, this might involve extending the analysis, testing additional hypotheses, or exploring a related research question.

The contribution does not need to be groundbreaking. Instead, it should show that you have engaged carefully with the literature, used sound methods, and extended the original work in a meaningful way. The main goal is to apply your research skills, practice

academic writing, and produce a paper that follows the structure and style of a journal article.

To support your progress, the paper will be developed incrementally through weekly report submissions and a term project. These reports (mentioned in the previous section) will serve as scaffolding and will be incorporated into your final paper. Resources and examples will be provided throughout the term to guide you.

The starting point of an existing paper is intended to give structure, not to limit creativity. You will have room to explore your own ideas within a well-defined framework. This approach is designed to help you focus your efforts while still producing original research.

Contribution and Class Engagement

To succeed in this course, it is important to be an active and engaged participant. Your contribution grade will be based on your attendance and *involvement* during class, TA office hours, and discussions on the online platform. As this is a project-based course, you and your classmates will encounter various challenges and questions. One way to boost your participation grade is by helping your peers by answering their questions and asking your own questions on the online platform.

For the 17% contribution grade, the breakdown is:

- 6% Class contribution: active participation in activities such as one-minute presentations, coding exercises, and tech-assistant roles.
- 6% Weekly check-ins: meet with the professor or TAs each week to discuss research progress.
- 5% Discussion platform: post at least two helpful answers and one question per week on Piazza.

Real-World Impact Challenge: Transforming Data into Economic Insights

In this course, you will have the chance to make a real difference by participating in the Real-World Impact Challenge. Your task will be to choose a pressing economic issue or policy question and use machine learning to analyze data and find innovative solutions. Whether it's predicting market trends, understanding consumer behavior, or assessing the impact of economic policies, your work will go beyond theory and contribute to actual economic discussions.

Up to 5 bonus points will be awarded to one or two papers that demonstrate a significant real-world impact. To qualify, your research should show clear potential to influence economic policies, address pressing economic issues, or provide insights that could lead to meaningful change. This is your chance to go beyond theoretical knowledge and showcase how your work can make a real difference.

Projects and Presentations Late Submission Policy

Late Project submissions will be **penalized by day**. There is a **20% penalty** for each calendar day of late submission. For instance, if the project is due at 7:00 PM of a Friday, all the late submissions until Saturday 7:00 PM will incur a 20% point late penalty. There is no grace period. No submissions will be accepted five calendar days after the deadline.

If the Office of the Registrar supports an extension, there may be a delay in their response. In such cases, please submit your project as soon as possible and do not wait for their approval of extension. Please note that, even with the Registrar's support, extensions cannot typically exceed one week.

Ongoing Learning Disability or Accommodation Requirement

If you have an ongoing disability issue or you need accommodation, please register with Accessibility Services (AS) (accessibility.utoronto.ca) at the beginning of the academic year. After AS processes your request, we will coordinate to provide the required accommodations for you. If you need accessibility related extensions, you should ask your advisor to send us the request at least one week in advance of the due date. We will then coordinate to provide the required accommodations for you.

Academic Integrity

The University of Toronto is deeply committed to the free and open exchange of ideas, and to the values of independent inquiry. As such, academic integrity is also fundamental to the University's intellectual life. Please visit academicintegrity.utoronto.ca for smart strategies and information on academic integrity processes and procedures at the University of Toronto. You can review the Code of Behaviour on Academic Matters in its entirety [here](#).

Common forms of academic misconduct with code references include:

- Copy pasting text or code from Chat GPT and other AI.
- Possession or use of unauthorized aids (B.I.1.b). Impersonation (B.I.1.c). Plagiarism (B.I.1.d) (plagiarism is a serious instance of academic misconduct, and university policy explicitly stipulates that ignorance of what constitutes plagiarism is not an acceptable defense.). Submission of work for which credit has previously been obtained (B.I.1.e). Submission of work containing purported statement(s) of fact or reference(s) to concocted sources (B.I.1.f). Assisting another student in committing an offence (B.II.1.a).

Usage of ChatGPT and AI

We will use ChatGPT and AI in different forms in this course. However, copying full text with no intellectual contribution directly from GPT into your projects is not accepted as your work and will receive a penalty of up to 100% of your grade and in some cases may be reported. You may use ChatGPT to generate code snippets or outline ideas,

but you must significantly modify and provide your own analysis and code. If you are unsure about how your use of AI aligns with academic integrity, please reach out to us for clarification before submitting your work.

The most important part of your projects is the economic intuition that you add to your results and your analysis, and this part is one of the components that must not be generated by AI. I will explain how students can use GPT during the semester in this course. I will announce the details during the semester and according to the status of AI at that time.

Closing Note

Every beginning feels challenging, but remember: everything is hard before it is easy. By the end of this course, you will have written a state-of-the-art paper with the potential to shape your career and open new doors. Stay focused, work steadily, and trust that your efforts will bring meaningful rewards.

I look forward to working with you all!