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. Master Econometrics and Machine Learning Techniques:

- Understand causal methods in traditional econometrics.
- Learn about classic predictive machine learning models.
- Explore and apply advanced causal machine learning models recently introduced.

2. Develop Practical Data Analysis Skills:

- Gain hands-on experience in machine learning, causal ML, coding, and data analysis to address complex economic questions.
- Achieve proficiency in Python for data manipulation, analysis, and visualization.

3. Enhance Critical Thinking and Research Abilities:

- Practice critical thinking skills to interpret causal outcomes and derive specific, actionable policy implications.
- Conduct independent research and write a comprehensive economics paper using the methods and tools learned in the course.

4. Collaborate and Communicate Effectively:

- Work collaboratively on projects to simulate real-world economic research environments.
- Develop the ability to communicate complex economic and machine learning concepts clearly in written and verbal forms.

5. Apply Knowledge to Real-World Scenarios:

• Engage in the Real-World Impact Challenge, using your research to address pressing economic issues and influence real-world decisions.

Email Policy

Before emailing us, check the syllabus and Quercus announcements. If your question is about coding, first try Google, then post on our discussion board, and only email as a last resort. Always use your U of T email and include $\hat{a}ECO2425\hat{a}$ in the subject line.

Email is mainly for private communications. Please use office hours or talk to us after class and office hours sessions for content-focused questions.

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.*
- 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 and notebook exercises will be the primary sources of learning in this course, in addition to the in-class lectures. *ECO2425 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 first 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.

Readings and Office Hours

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

Grading

Item	Weight	Due Dates	Time
Project Reports and/or Weekly assignments	18%	almost weekly	Fri. 7 PM
Test 1	11%	Oct 9	Wed. 1 PM
Term Project	20%	Oct 18	Fri. 7 PM
Test 2	11%	Nov 20	Wed. 1 PM
Final Project	20%	Nov 29	Fri. 7 PM
Participation and Class Engagement	15%	weekly	
Final Presentation	5%	TBA	
Real-World Impact Challenge	5% (bonus marks)		

Project Reports

Students must submit weekly written updates on their project progress, detailing achievements and future plans. We will provide a structure for these reports and what must be included. In addition students should update their Git with their updated code. These updates are essential for ongoing assessment. We need to see the updates you talk about matches your coding progress on Git.

* We will drop the lowest weekly reports mark. Wisely reserve these options for unforeseen technical difficulties, illness, or other incidents.

Participation

To succeed in this course, it is important to be an active and engaged participant. Your participation grade will be based on your attendance and involvement during Think Tank Hours, discussions on the online platform, and any live or in-person lectures. 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.

We will keep track of your participation in the course each week through your attendance at Think Tank Hours, your activity on the discussion board, and any live or in-person lectures. To ensure that you receive credit for participation, you must attend class and Think Tank Hours and actively participate in discussions on the online platform by asking and answering questions. Answering questions is worth more than asking questions. The weight distribution will be 4% class attendance, 7% Think Tank Hours attendance, and 4% discussion platform participation. For the Piazza share, two helpful answers and one question per week get full marks.



Think Tank Hours:

Think Tank Hours are dedicated sessions designed to create a collaborative environment where students can work together, share ideas, and support each other in their research projects. These sessions are an opportunity to brainstorm, troubleshoot, and refine your work with the guidance of your TA and the collective knowledge of your peers. Please read the Think Tank Hours guidelines provided on the course page. Students present their work each week as part of these hours.

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 itâs 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 Registrarâs 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 <u>one week in advance of the due date</u>. 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 text 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 will 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.

Last Words

Every beginning is tough, but remember, everything is hard before it is easy. By the end of this course, you will create an state of the art paper that could change your career and life. Stay focused, work hard, and know that your efforts will pay off in amazing ways!

I look forward to working with you all.