Econ 5280 Applied Econometrics (4 Credits)

Department of Economics, HKUST

Fall 2024

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Course Description

This course provides an introduction to a toolkit of cutting-edge econometric methods for causal inference. Reasonably rigorous mathematical treatment will be given. Implementation (using R) and applications of the methods will be covered.

Prerequisites. ISOM 2500, MATH 2411, MATH 3423 or equivalent. A brief review on matrix algebra and statistical inference will be provided, but basic knowledge of them is needed.

AOL Learning Goal, CLIOs and Mapped PILOs

AASCSB Assurance of Learning (AOL, Goal 2; see Canvas (`http://canvas.ust.hk`) for detailed rubrics):

- Graduates will be able to command the key problem-solving skills for their discipline.
  - Objective 1: Use state-of-the-art technology, methods, and support systems to conduct advanced analyses.
  - Objective 2: Identify the best approach, tools, and data sources to analyze a given business problem.

Related Program Intended Learning Outcomes (PILOs):

- 6. Evaluate the implications of empirical data analysis using an understanding of theories and tools from empirical data analysis.
- 7. Explain and apply econometric principles.
- 9. Construct proper econometric models and use relevant software to conduct empirical analysis on given data.

- 10. Make predictions on economic and business outcomes based on results from empirical analysis.

Course Intended Learning Outcomes (CLIOs) and Mapped Learning Objectives and PILOs:

- Understand the potential outcome framework for causal inference and its relationship with econometric models. (Learning Goal 2.2; PILOs 6, 7, 9 & 10).
- Possess a reasonably solid theoretical foundation in various econometrics and related machine learning methods. (Learning Goal 2.1 & 2.2; PILOs 6, 7, 9 & 10).
- Use software to analyze a given economic data set and interpret the results. (Learning Goal 2.1; PILOs 9).

Course Materials and Websites

- **Lecture notes**. Lecture notes are the main learning resources of this course.
  - Lecture notes in pdf will be posted on Canvas. All lecture notes with R code are Binder-enabled: You can run the R code on any device including your mobile phones or tablets with Internet conenction without installing R.
  - Lecture notes in ipynb and data will be available on **GitHub** (https://github.com/junlong-feng/econ5280).
- **References**. The course does not have a required textbook. Below is a list of useful references. You don't have to purchase any of them.
  - Hansen, Bruce. *Econometrics*, Princeton.
  - Stock, James and Mark Waston. *Introduction to Econometrics*, Pearson.
  - Angrist, Joshua and Jörn-Steffen Pischke. *Mostly Harmless Econometrics: An Empiricist's Companion*, Princeton.
  - Hanck, Christoph *et.al. Econometrics with R*, https://www.econometrics-with-r.org/.

Software and Generative AI

- R, free and open-source, will be taught and used. To get started, you will need to sequentially install the following two:
  1. R: https://www.r-project.org/.
  2. RStudio (changing name to Posit): https://rstudio.com/. You have to install R first. RStudio is only an interface making it easier for you to interact with R.
     - Alternative IDEs such as Visual Studio are also welcome.

  - You don't have to install R or RStudio to run the code in the lecture notes. Click the binder button 

whenever it shows up, and you can run/modify code online. It may take long for the first time.
  - You do have to install R for homework.

- You may use other software/languages (Python, Stata, MATLAB, Julia, etc., with Python highly recommended), but they will not be taught in class.
- **GPT and other generative AI**. You can use them freely for this course, including homework. Subject to change depending on the university's general policies. **If you use them for your homework questions, you are required to give them credit properly by stating how they helped you with the questions.**
  - You can access a bunch of AI tools, including GPT-4o, Gemini and llama, via https://chatgpt.ust.hk/.
  - These tools, at the moment, are not very reliable when solving math problems. Don't always trust them.
  - None of such tools is allowed in the exam.

Assessment

The course requirements include three problem sets (50%), roughly equally spaced over the span of the semester, and a final exam (50%). More details will be announced later. **Under the new departmental policy, attendance is going to be checked; missing more than 15% of the lectures will negatively impact your grade.**

Problem Sets

The problem sets evaluate your ability to use the tools and to comprehend and recall the theoretical knowledge discussed in the lecture (PILOs 6, 7, 9, & 10).

Final Exam

The final exam assesses your ability to use the techniques covered in the course to analyze new econometric problems (Learning Goal 2.1; PILOs 6, 7, 9 & 10) and to form the best empirical strategies to address economic problems (Learning Goal 2.2; PILOs 6, 7, 9 & 10).

Rubrics for Final Grade

- Excellent Performance (A range): Demonstrates a deep understanding of the econometric tools covered in the course. Exhibits exceptional skills in utilizing the taught techniques to solve related econometric problems. Excels in the problems sets and exam with effective class participation.
- Good Performance (B range): Shows a solid grasp of the econometric tools and techniques covered in the course. Demonstrates good skills in utilizing them to solve related econometric problems. Performs well in the problems sets and exam with class participation.
- Marginal Performance (B-, C+, C): Has basic knowledge of the econometric tools and techniques covered in the course. Shows limited skills in utilizing them. Acceptable performance in the problems sets and exam with limited class participation.

- Fail: Demonstrates insufficient understanding of the econometric tools and techniques covered in the course. Lacks skills in utilizing them. Unsuccessful in the problem sets and exams. Little to no class participation.

Academic Integrity

You are expected to adhere to the university's academic integrity policy. You are expected to uphold HKUST's Academic Honor Code and to maintain the highest standards of academic integrity. The University has zero tolerance of academic misconduct. Please refer to Academic Integrity | HKUST - Academic Registry for the University's definition of plagiarism and ways to avoid cheating and plagiarism.

Course Outline (Tentative)

September.

- Preliminaries: Review of matrix algebra, probability, statistical inference, and in particular, linear regression.

September - October.

- The potential outcome framework.
- Causal inference with experimental data.
  - Average treatment effect (ATE) and regression adjustment.
- Causal inference with observational data.
  - Inverse propensity score weighting (IPW).
  - Doubly robust learning.
- Causal inference for heterogeneity.
  - Conditional average treatment effect (CATE).
  - Causal tree/forest.
  - **Optional**. Sharp regression discontinuity design.

October - November.

- Endogeneity.
  - Local average treatment effect (LATE) and instrumental variable.
  - **Optional**. Fuzzy Regression discontinuity design.
  - Deep learning, neural networks, and DeepIV.
- **Optional**. Causal inference in panel data.
  - Diff-in-diff, event study, matrix completion and low-rank matrix recovery, etc.