

# Econ 5280 Applied Econometrics (4 Credits)

Department of Economics, HKUST

Fall 2023

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**Instructor:** FENG, Junlong

**Email:** [jlfeng@ust.hk](mailto:jlfeng@ust.hk)

**Office:** Room 6073, LSK

**Tel:** +852-23587616

**Office Hours:** Wed 10:40 am-noon (or by appointment)

**TA:** HUANG, Jinyuqi (L1)

**Email:** [jhuangde@connect.ust.hk](mailto:jhuangde@connect.ust.hk)

ZHANG, Kaixi (L2)

[kzhangbh@connect.ust.hk](mailto:kzhangbh@connect.ust.hk)

**TA's Office Hour:** TBA

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## Course Description

This course provides an introduction to econometric methods from ordinary least squares to cutting-edge deep-learning-based techniques for causal inference. Reasonably rigorous mathematical treatment will be given. Implementation (using R) and application 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 a basic knowledge of them is needed.

## Learning Outcomes


On completion of the course, you will be expected to a) understand the potential outcome framework for causal inference and its relationship with econometric models (SILO 1 & 3), b) possess a reasonably solid theoretical foundation in econometrics and related machine learning methods (SILO 1 & 3), and c) use software to analyze a given economic data set and interpret the results (SILO 1, 2, 3, & 4).

## 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** (<http://canvas.ust.hk>). 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 connection without installing R.
  - Lecture notes in ipynb and data are 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 Watson. *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.
    - 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., though 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 GPT-4 through <https://chatgpt.ust.hk/>.
  - GPT-4, at the moment, is not very reliable when solving math problems. Don't always trust it.
  - None of such tools is allowed in the exam.

## Assessment

The course requirements include problem sets (50%) and a final exam (50%). More details will be announced later.

## Outline (Tentative)

September. Introduction. Review of matrix algebra, probability and statistical inference.

September - October.

- Framework of causal inference.
- Linear models under exogeneity: Least squares.
- Linear models under endogeneity: Instrumental variable (IV) methods and linear GMM.

October - November.

- Nonlinear models under exogeneity: Random tree, causal tree, and causal forest.
- Nonlinear models under endogeneity: Deep learning, neural networks, and DeepIV.
- Topics in panel data (optional): Matrix completion and low-rank matrix recovery, diff-in-diff, two-way fixed effects, etc.