Econ 220B
Linear and Nonlinear Econometric Methods

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Course Description

The primary goal of this course is to give a rigorous introduction to linear and nonlinear econometric methods. The course contains four parts. In the first part, we discuss the **potential outcomes framework** and several important treatment effect estimands (causal parameters) which are of central importance in empirical research. In the second part, we introduce **linear regression**, which can be viewed as a natural extension to the difference-in-means estimator. Large-sample statistical properties of linear regression, such as consistency and asymptotic normality, will be studied in detail. We will also discuss topics such as partitioned regression and heteroskedasticity-robust standard errors.

Although linear regression can accommodate additional covariates, its linear structure can still be too rigid. The third part of the course will cover two important extensions: using **regression adjustment** and **inverse probability weighting** to estimate the average treatment effect, and using **two stage least squares** to estimate the local average treatment effect. Although these procedures build on linear regression, they (or further generalizations thereof) are no longer linear estimators, meaning that they cannot be written as a linear function of some dependent/outcome variable. Taking one step further, the last part of the course will cover the theory of **(generalized) method of moments**, which provides a unified treatment of statistical estimation and inference for a large class of nonlinear problems.

The course will be taught at an advanced level. It is designed for students who want to understand and use sophisticated empirical techniques in their research. Students are assumed to be familiar with linear algebra, probability theory, and mathematical statistics (non-measure theoretic).

Prerequisite: Econ 220A.

Team

Instructor:	Xinwei Ma (x1ma@ucsd.edu)
Class Website:	Canvas
Lectures:	Monday/Wednesday, 3:30–4:50pm @ SSB 107
Office hours:	Monday, 5:00–6:00pm, or by appointment @ SDSC 176E
TA:	Chen Lin (chl029@ucsd.edu)
Office hours:	To be announced
Discussion sessions:	To be announced

Lecture Notes

My lecture notes are available on Canvas. You should at least skim through the relevant sections before coming to lecture.

Textbook and Main References

Abadie, Alberto, and Matias D. Cattaneo (2018): "Econometric Methods for Program Evaluation," *Annual Review of Economics*, 10, 465-503.

Imbens, Guido W., and Jeffrey M. Wooldridge (2009): "Recent Developments in the Econometrics of Program Evaluation," *Journal of Economic Literature*, 47, 5-86

Newey, Whitney K. and Daniel L. McFadden (1994): "Large Sample Estimation and Hypothesis Testing," in Handbook of Econometrics, Volume 4. Amsterdam: North-Holland 2111-2245.

Wooldridge, Jeffrey M. (2007): *Econometric Analysis of Cross Section and Panel Data* (second edition). Cambridge: MIT Press.

Additional References

Cameron, A. Colin, and Pravin K. Trivedi (2005): *Microeconometrics: Methods and Applications*. New York: Cambridge University Press.

Casella, George, and Roger L. Berger (2002): *Statistical Inference* (second edition). Pacific Grove: Wadsworth Group.

Hansen, Bruce E. (2022): *Econometrics*. Princeton: Princeton University Press.

Hayashi, Fumio (2001): *Econometrics*. Princeton: Princeton University Press.

Imbens, Guido W., and Donald B. Rubin (2015): *Causal Inference in Statistics, Social, and Biomedical Sciences*. New York: Cambridge University Press.

Morgan, Stephen L., and Christopher Winship (2015): *Counterfactuals and Causal Inference: Methods and Principles for Social Research* (second edition). New York: Cambridge University Press.

Ruud, Paul A. (2000): *An Introduction to Classical Econometric Theory*. New York: Oxford University Press.

van der Vaart, Ada W. (2000): *Asymptotic Statistics*. New York: Cambridge University Press.

Assessment

The final grade will depend on one **midterm exam (40%, February 9, 3:30–5:30pm @ SSB 107)**, and one **final exam (60%, March 18, 7:00–10:00pm @ to be announced)**. Except for rare cases, such as medical emergencies, no makeup exam will be given.

The exams will be closed book.

Schedule

The following is a tentative schedule of this course, and is likely to change depending on our pace through the quarter. I reserve the right to modify this schedule, and add/replace some topics as needed.

Part 1 & 2

- The potential outcomes framework
  Three treatment effect estimands (ATE, ATT and ATU)
  Estimation using the sample mean
  Estimation based on moment conditions

- Linear regression
  - Linear causal effect and the zero conditional mean assumption
  - The best linear prediction interpretation
  - Large-sample properties: consistency, asymptotic normality, and the delta method
  - Partitioned regression
  - Standard errors and heteroskedasticity

Part 3

- The selection-on-observables assumption and related methods
  - The fundamental problem of causal inference
  - The basic idea behind identification: imputing counterfactuals
  - Regression adjustment
  - Inverse probability weighting
  - Propensity score estimation: binary response models
- Instrumental variables
  - The two stage least squares
  - What does the two stage least squares estimate? The local average treatment effect
  - Asymptotic analysis with weak instruments
  - Controlling for additional covariates (if time permits)

Part 4

- The (generalized) method of moments
  - Some examples
  - Consistency and the role of uniform law of large numbers
  - Asymptotic normality
  - Standard errors and statistical inference
  - Two-step estimators revisited
  - The generalized method of moments: how to choose the weighting matrix

Other

Disability. If you believe that you have a disability and desire accommodation, please

(1) Register with the Office for Students with Disabilities (link).

(2) Contact econosd@ucsd.edu (cc x1ma@ucsd.edu in the email) with the Authorization for Accommodations (AFA) letter from OSD for accommodations such as extra exam time.

Academic Integrity. Students who violate UCSD's academic integrity (link) policy will earn a failing grade for the course. In addition, the Council of Deans of Student Affairs will impose a disciplinary penalty.