Econometric Theory
Rome Masters in Economics (RoME)
Winter 2025

Syllabus

Instructor

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Website: http://www.eief.it/eief/index.php/people/faculty-az?id=174.
Office hours: Wednesday 3:00–4:15 pm, or by appointment.

Classes

Tuesday 9:00-10:30 am (LUISS), Wednesday 5:00–6:30 pm (EIEF), and Thursday 2:45–4:15 pm (EIEF), for six weeks from January 21 to February 27, 2025. Thursday classes will be devoted to the discussion of the assigned homework.

Goals

This course is a rigorous introduction to the theory of econometrics. By the end of the course the students will be able to critically evaluate the credibility of the main empirical strategies adopted in applied work. The course consists of two parts. The first part (Weeks 1–4) provides a thorough understanding of the workhorses of empirical research in economics, namely the linear regression model and the ordinary least squares estimator, and of the problems that arise when the assumptions of the linear model are violated. The second part (Weeks 5–6) introduces students to the instrumental variables (IV) method and its extension, the generalized method of moments (GMM). Under a number of conditions, these methods offer a solution to the endogeneity problem which arises when the covariates in a regression model cannot be regarded as uncorrelated with the regressors. It also discusses other approaches to the endogeneity problem, namely intent-to-treat analysis, and regression discontinuity and difference-in-differences designs.

Pre-requisites

Basic elements of calculus, matrix algebra, probability, and statistics.

Homework

Every week I assign a homework that students are asked to solve and then discuss in the Thursday class. Spending a significant amount of time each week on the assigned homework is essential to learning the material covered. Homework must be returned on the dates indicated below. There is no credit for late homework.

Homework due dates:

- Problem set 1: January 23, by 12 (noon).
- Problem set 2: January 30, by 12 (noon).

- Problem set 3: February 6, by 12 (noon).
- Problem set 4: February 13, by 12 (noon).
- Problem set 5: February 20, by 12 (noon).
- Problem set 6: February 27, by 12 (noon).

Final exam

The final exam will cover all the material presented in the course and will last 3 hours. Its date will be finalized at the beginning of the module.

Grades

Grading will depend for 40 percent on the homework, 40 percent on the final exam, and 20 percent on class participation.

Course outline

- Week 1: Regression models. Introduction to the course. Basic concepts: conditional means and conditional variances, potential outcomes and causal effects, choosing a regression model, best linear predictors, relations between conditional means and best linear predictors. The classical linear model: elements, interpretations, and properties. .
- Week 2: Least squares. The ordinary least squares (OLS) problem and its solution, fitted values and residuals, goodness of fit, constrained OLS. Algebraic properties of OLS: partitioned regression and the Frisch-Waugh-Lovell theorem, adding/dropping variables, adding/dropping observations Sampling properties of OLS under ideal conditions. The Gauss-Markov theorem. Violations of the ideal conditions. Generalized least squares (GLS), Aitken theorem, weighted least squares, and feasible GLS. The classical Gaussian linear model: maximum-likelihood estimation, Cramér-Rao bounds, classical confidence sets.
- Week 3: Asymptotic properties of least squares. Asymptotic properties of OLS: consistency and asymptotic normality. Applying the asymptotic results: estimates of statistical precision, asymptotically-valid confidence intervals. Resampling methods: the jackknife and the bootstrap. Asymptotic properties of GLS and feasible GLS. Inconsistency of OLS.
- Week 4: Hypothesis testing and model selection. The classical t- and F-tests: exact and asymptotic properties. Likelihood-based tests. Specification tests. Covariate selection: R^2 and adjusted R^2, the C_p criterion, cross-validation. Pre-testing vs. honesty.
- Week 5: IV, GMM and 2SLS. The instrumental variables (IV) method: just- and over-identified models, the Wald estimator, the general class of IV estimators. The generalized method of moments (GMM). Sampling properties of IV estimators: consistency, asymptotic normality, and asymptotic efficiency. Hypothesis testing: Wald tests, tests of overidentifying restrictions, difference tests. Two stage least squares (2SLS): GLS and control function interpretations, asymptotic properties. Too many instruments and weak instruments.

- Week 6: Estimation of treatment effects. Estimating treatment effects: OLS, IV and local average treatment effects. Examples of applications. Intent-to-treat analysis. Regression discontinuity designs. Difference-in-differences designs.

References

The main references for this course are:

- Hansen B.E. (2022) *Econometrics*. Princeton University Press: Princeton (NJ). The relevant part of this book consists of Chapters 2–13.
- Magnus J. R. (2021). *Introduction to the Theory of Econometrics* (6th printing). VU University Press: Amsterdam.

Additional references include:

- Angrist J.D., and Pischke J.-S. (2009). *Mostly Harmless Econometrics: An Empiricists's Companion*, Princeton University Press: Princeton (NJ).
- Angrist J.D., and Pischke J.-S. (2015). *Mastering 'Metrics: The Path from Cause to Effects*, Princeton University Press: Princeton (NJ).
- Aronow P. M., and Miller B. T. (2019). *Foundations of Agnostic Statistics*, Cambridge University Press: Cambridge (UK).
- Hansen B.E. (2022) *Probability and Statistics for Economists*. Princeton University Press: Princeton (NJ).
- Linton O. (2017). *Probability, Statistics and Econometrics*, Academic Press: London.
- Magnus J. R., and Telg S. (2022). *Mastering Econometrics: Exercises and Solutions*. VU University Press: Amsterdam.
- Stock J.H., and Watson M.W. (2020) *Introduction to Econometrics* (4th ed.), Pearson: Hoboken (NJ).

Suggestions for further reading will be provided in class.