ECON60302: Econometrics I

University of Notre Dame
Fall 2024-25

Instructor: Prof. Marinho Bertanha	E-mail: mbertanha@nd.edu
Lectures: Tue & Thu 8:45a-10:45a	Office Hours: Mon & Tue 1:30p-2:30p
Classroom: 201 DeBartolo	Office: 3074 Jenkins Nanovic

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Tutorials: Tue 5:30p-6:45p	Office Hours: Wed 1p-3p
Classroom: 242 DeBart	Office: 3021 Jenkins Nanovic

Course Description

This course is a PhD level class in introductory econometrics. It will cover: (i) probability theory; (ii) the fundamentals of mathematical statistics; (iii) basics of asymptotic theory; (iv) maximum likelihood; (v) method of moments; (vi) hypothesis testing and confidence intervals; and (vii) linear regression models.

Basic Textbook References

- **[Hansen I]:** B Hansen. *Probability and Statistics for Economists*. Princeton University Press, 2022a;
- **[Hansen II]:** B Hansen. *Econometrics*. Princeton University Press, 2022b.

Additional References

- George Casella and Roger Berger. *Statistical Inference*. Duxbury, Thomson Learning, 2 edition, 2002;
- Larry Wasserman. *All of statistics: a concise course in statistical inference*. Springer Science & Business Media, 2013;
- Christian Gourieroux and Alain Monfort. *Statistics and econometric models*, volume 1. Cambridge University Press, 1995;

- R Davidson and J MacKinnon. *Econometric Theory and Methods*. Oxford University Press New York, 2004;
- J Wooldridge. *Econometric Analysis of Cross Section and Panel Data*. MIT Press, second edition, 2010;
- James D Hamilton. *Time Series Analysis*. Princeton University Press, 1994.

Pre-requisites

Undergraduate level courses on multivariate calculus, probability, and statistics. Some background in linear algebra.

Evaluations

- Problem sets: there will be problems sets every two weeks, due on Thursdays by the beginning of lecture. You are allowed and encouraged to work with other students in this class, but you're required to hand-in your own solutions. For computing questions, you're expected to hand-in your own code and output. A pset without the code or output is an incomplete pset. A pset handed in on time that is complete will be given one out of three grades: check plus (100 %), check (87.5%), and check minus (77.5%).
- Quizzes: for those weeks when there is no problem set due, we will have short quizzes at the end of class on Thursdays. These are 30min, closed book, mini-exams designed to help you keep track of your progress throughout the semester. You are allowed to use one cheat sheet hand-written by you during the quizzes. The cheat sheet must be at most one page, letter size, and single sided. You are only allowed to use a cheat sheet that strictly conforms to these rules. Everybody has bad days, so I will discard your worst quiz grade when computing the average grade of quizzes.
- Final Exam: there will be a final exam during the week of finals in December, exact date to be announced. You are allowed to use one cheat sheet with the same parameters as the quiz except that it may be up to four pages long.
- Course participation: you will receive a participation grade based on your citizenship in this course. Examples of good citizenship include: coming to lectures, avoiding side conversations/texting, being focused in the classroom, handing in every assignment on time, asking/answering questions in class or during office hours. All classes are in person.

Your final grade for this course will be an average of your problem sets (30%), quizzes (30%), final exam (30%), and participation (10%).

Expectations

Students are expected to be on time and prepared for class, and to hand-in assignments when due. I will not accept late assignments. Use problems sets and quizzes to evaluate your

own progress, and please come to office hours with questions. Students who miss an assignment must have a valid, documented, and university-approved excuse before requesting a make up.

Honor Code

This course is a community built on trust; in order to create the most effective learning experience, our interactions, discussions, and course activities must remain private and free from external intrusion. As members of this course community, we have obligations to each other to preserve privacy and cultivate fearless inquiry. We are also obliged to respect the individual dignity of all and to refrain from actions that diminish others' ability to learn. Course materials (videos, assignments, problem sets, etc) are for use in this course only. You may not upload them to external sites, share with students outside of this course, or post them for public commentary without my written permission. The university strictly prohibits anyone from duplicating, downloading, or sharing live class recordings with anyone outside of this course, for any reason. Violating these principles will be handled according to the academic honor code.

Students are expected to not engage in or tolerate academic dishonesty. This also includes, but it is not limited to, copying solutions (which includes computer code and output) from instructors or students inside or outside our course community, in the current or past semesters. Students are not allowed to use artificial intelligence to obtain answers or computer code to the assignments. Please familiarize yourself with the University's code of honor at **honorcode.nd.edu**.

Helpful Resources

1. MATLAB and STATA are installed on OIT Lab computers on campus and student licenses may be available at special rates, contact OIT (**oit.nd.edu**) for more info.
2. You can access a computer lab remotely from your computer. Please go to this **link** to get started.
3. You may also connect your computer to a CRC server and use MATLAB/STATA remotely. The first step is to visit **crc.nd.edu** and request a CRC account. Learning how to use the servers on campus will serve you well in a variety of research areas during grad school. This is particularly helpful to run jobs that take a long time to run in your computer.
4. If you would like to install STATA in your own computer, the cheapest possible license is a 6-month student license currently at $48. For details visit **www.stata.com**, click on purchase, order Stata, choose US as your country, student, new purchase, 6-month.
5. Besides the examples given in the course, your primary source of help with STATA/MATLAB is the web. If you need extra help with programming, please contact the TA.

Topics and References

Topic 1: Types of data

a. Cross-sectional data

b. Time series data
c. Panel data
d. Clustered data
e. Spatial
f. Observational vs. experimental data

Topic 2: Probability theory review

a. Outcomes, events, and sample spaces
b. Probability measures
c. Conditional probability
d. Independence
e. Bayes Theorem
f. Random variables
g. Cumulative distribution functions
h. Probability mass functions and probability density functions
i. Quantile functions
j. Univariate change of variables
k. Expected values
l. Higher-order moments
m. Famous discrete & continuous distributions
n. Useful inequalities
o. Moment generating functions, cumulant generating functions, and characteristic functions
Text: Chapters 1, 2, 3 of Hansen I
Optional text: Chapters 1, 2, 3 of Casella & Berger

Topic 3: Multivariate probability theory

a. Joint, marginal, and conditional distributions
b. Conditional expectations and conditional variances
c. Correlation and covariance
d. Law of iterated expectations and law of total variance
e. Multivariate change of variables
Text: Chapters 4, 5 of Hansen I
Optional text: Chapter 4 of Casella & Berger

Topic 4: Dependent random variables

a. Serial dependence and autocorrelation
b. Autocovariance functions
c. Moving average (MA) processes
d. Autoregressive (AR) processes
e. Autoregressive moving average (ARMA) processes

f. Vector autoregressive (VAR) processes
g. Ergodicity
Text: Chapters 1-3 and 10 of Hamilton
Optional text: Chapter 22 of Wasserman

Topic 5: Sampling

a. Parametric vs. semi-parametric vs. non-parametric models
b. Frequentist versus Bayesian thought experiment
c. Sampling distributions
   - Exact finite sampling distributions
   - Bias of an estimator
d. Bias-variance trade-off
Text: Chapter 6 Hansen I
Optional text: Chapter 5 of Casella & Berger

Topic 6: Convergence of random variables

a. Deterministic convergence of sequences
b. Deterministic convergence of functions
c. Convergence in distribution
d. Convergence in probability
e. Convergence almost surely
f. Consistency and asymptotic normality of an estimator
g. Continuous mapping theorem & Slutsky's theorem
h. Delta method
i. Stochastic orders of magnitude

Text: Chapters 7, 8, 9 of Hansen I
Optional text: Chapter 5 of Casella & Berger
Optional text: Chapter 5 of Wasserman

Topic 7: Maximum likelihood

a. Basic idea and examples
b. Identification (parameteric)
c. Score Function and Fisher Information
d. Cramer-Rao lower bound
e. Consistency and asymptotic normality
f. Maximum likelihood of miss-specified models

g. Basics of non-linear optimization

Texts: Chapters 10 & 12 of Hansen I
Optional text: Chapters 7 and 22 of Gourieroux & Monfort
Optional text: Chapter 7 of Casella & Berger
Optional text: Chapter 9 of Wasserman

Topic 8: Method of Moments

a. Classical method of moments
b. Analogy principle and method of moments
c. Estimating a univariate mean
    - i.i.d. data
    - dependent data
d. Estimating a vector mean
    - panel data
    - vector time series data
e. Identification (reduced form moments)
f. Estimating higher-order moments
g. Estimating functions of moments
h. Estimating covariance matrices

Texts: Chapter 11 of Hansen I
Optional: Chapter 9 of Hansen I and Chapter 6 of Hansen II
Optional text: Chapter 6 and 10.5 of Hamilton

Topic 9: Hypothesis testing

a. Fundamental concepts of hypothesis testing
    - One-sided and two-sided hypothesis tests
    - Likelihood ratio test
    - Power functions
    - Neyman-Pearson lemma
b. P-values
c. Asymptotic hypothesis testing
    - likelihood ratio test
    - Wald test
    - Lagrange multiplier test
d. Multiple-testing
    - Family wise error rates

- False discovery rates

Text: Chapter 13 of Hansen I
Optional text: Selected parts of Chapters 8 and 9 of Casella & Berger
Optional text: Chapter 6 of Wasserman

Topic 10: Confidence Intervals & Confidence Sets

a. Fundamental concepts of confidence intervals & confidence sets
   - Coverage probabilities
b. Asymptotic confidence sets

Text: Chapter 14 of Hansen I
Optional text: Selected parts of Chapters 8 and 9 of Casella & Berger
Optional text: Chapter 6 of Wasserman

Topic 11: Linear regression with normally distributed errors

a. Simple linear regression
b. Finite-sample properties
c. Classical hypothesis tests in the linear regression model

Text: Chapter 5 of Hansen II

Topic 12: Regression

a. Linear projection
b. Multiple regression
   - dummy variables
   - categorical variables
c. The algebra of least squares
d. Asymptotic theory of least squares
   - Consistency and asymptotic normality
   - Covariance matrix estimation

Text: Chapters 2-4 and 7 of Hansen II

Topic 13: Time series regression (time permitting)

a. Spurious regression
b. Asymptotic theory of least squares
   - Consistency and asymptotic normality
   - Covariance matrix estimation

Text: Chapter 14 of Hansen II

Course Calendar

Week	Dates	Notes
1	27-Aug	lecture 9am - 12pm B066 JNH
	29-Aug	no class, no O.H.
2	3-Sep	no class, no O.H.
	5-Sep	lecture 9am - 12pm B066 JNH
3	10-Sep	lecture 9am - 12pm B066 JNH
	12-Sep	lecture 9am - 12pm B066 JNH Quiz 1
4	17-Sep	
	19-Sep	Pset 1
5	24-Sep	
	26-Sep	Quiz 2
6	1-Oct	lecture 10am-12pm B066 JNH
	3-Oct	no class, no O.H. Pset 2
7	8-Oct	lecture 10am-12pm B066 JNH
	10-Oct	Quiz 3
8	15-Oct	lecture 10am-12pm B066 JNH
	17-Oct	Pset 3

Week	Dates	Notes
	22-Oct	Fall Break
	24-Oct	no class, no O.H.
9	29-Oct	
	31-Oct	Quiz4
10	5-Nov	
	7-Nov	Pset4
11	12-Nov	
	14-Nov	Quiz5
12	19-Nov	
	21-Nov	Pset5
13	26-Nov	
	28-Nov	Thanksgiving no class, no O.H.
14	3-Dec	no class, no O.H.
	5-Dec	Quiz6
15	10-Dec	
	12-Dec	Pset6
Finals	TBA	