Stats Camp for Economists and Econometricians
Rice University
Summer 2021

Logistics

Instructor: Qinyou Hu, qh8@rice.edu
Schedule: May 24 - July 16, 2021
Time: 20 lectures covered over roughly 8 weeks
Office Hours: Via Zoom, By appointment
Location: Canvas Platform, https://canvas.rice.edu

Course Outline

In this course, we will equip students with the essential tools and knowledge in statistics that are essential to modern econometric theory. As probability theory lies in the very foundation of statistics, we will build the probability tools we need along the way. In this sense, this course is designed to be self-contained. The students are expected to not only understand the tools but also be able to have a firm understanding of the mathematical mechanisms behind them, in order to prepare for future econometrics training and research.

There are four modules covered over twenty lectures of approximately two hours each. There is one problem set for each module and one quiz for each lecture. We will ask questions to be answered during the online lectures to measure your attendance. There will be an exam at the end of the course. Assignment of course grades will be based on attendance (10%), quizzes (20%), homeworks (20%) and the exam (50%).

I. Probability Theory (lecture 1-4)

Introduction:

\footnote{This material adapted from past years’ materials from Mehreen Gul and Amir Kazempour.}
- Why study statistics?
- Statistics and econometrics.

Axiomatic Probability Theory:
- Basic Set Theory (intersection, union, complement, DeMorgan’s Law)
- Sigma Algebra
- Sample Space and Events
- Axioms of Probability Measures
- Probability and its Properties
- Conditional Probability
- Independence
- Bayes rule


II. Random Variables (lecture 5-10)

Random Variables and Distributions:
- Random Variables (RV) and Induced Probability.
- Cumulative Distribution Function (CDF).
- Probability Mass Function (PMF) and Probability Density Function (PDF)
- Transformations.
- Probability Integral Transformations.
- Moments of Distribution (Mean and Variance among others)
- Moment Generating Functions (MGF)
- Transformations of Random Variables: an MGF Approach
- Convergence in Distribution


Common Families of RV’s:
- Bernoulli.
- Binomial.
- Poisson.
- Relationship Between Binomial and Poisson.
- Uniform.
- Normal.
- Cauchy
- Gamma Function and Gamma Distribution.
- Chi-squared.
- Exponential.
- Log-normal.


III. Multivariate Random Variables (lecture 11-14)

Multivariate Random Variables:
- Joint and Marginal PMF.
- Conditional PMF.
- Independence of RVs.
- Example: Sum of Independent Poisson RVs.
- Continuous Multiple RVs
- Conditional PDF.
- Conditional Expectations.
- Independence of RVs revisited.
- Sum of Independent Normal RVs
- Jacobian Transformations of Multivariate Random Variables
- Law of Iterated Expectations.
- Law of Total Variance.
- Covariance.
- Bivariate Normal and its Properties
Useful Inequalities:
- Markov, Chebyshev, Jensen, Minkowski, Liapounov, Holder, Cauchy-Schwarz, with proofs.


IV. Large Sample Theory (lecture 15-20)

Random Sampling:
- Sample Mean.
- Sample Variance.
- Sample Covariance.
- Distributions Derived from Normal: Chi-squared, t and F.

Limit Theorems in Probability:
- Modes of Convergence (Almost sure, Probability and Distribution).
- Examples (convergence in probability does not imply almost sure convergence).
- Weak Law of Large Numbers (WLLN) for Uncorrelated Random Variables (proof with Chebyshev’s inequality) and i.i.d Random Variables (proof).
- Central Limit theorem (CLT).
- Proof of CLT using MGF when second moment exists.

Delta Method
Stochastic $o$ and $O$ symbols