POLSCI 599
Statistical Methods in Political Research I

Fall 2023

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This is the first course of the Political Science graduate methods sequence to provide students with the foundations in statistics that will be required in the subsequent courses of the sequence. Topics covered include probability spaces, random variables, expected values and moments, sampling distributions, hypothesis testing and confidence intervals, limit theorems, and the maximum likelihood estimation. The course prerequisites are calculus and linear algebra equivalent to the Political Science Math Camp, and proficiency in the statistical programming language R or concurrent enrollment in POLSCI 514. Also, students are strongly encouraged to enroll concurrently in POLSCI 598. A previous background in statistics is useful but not required.

1 Contact Information

	Yuki Shiraito (Instructor)	Adam Rauh (GSI)	Maya Khuzam (grader)
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2 Logistics

- Lectures: Tuesday and Thursday, 4:00PM–5:20PM, 6000 South Thayer Building
- Sections: Thursday, 6:00PM–7:00PM, 2325 Mason Hall
- Yuki's office hours:
  - Stop by anytime at the ISR office
- Adam's office hours:
  - Thursday, 11:00AM–1:00PM, 7722 Haven Hall
  - Or by appointment

3 Questions and Announcements

In addition to sections and office hours, please use the *Piazza Discussion Board* when asking questions about lectures, problem sets, and other course materials. This allows all students to benefit

from the discussion and to help each other understand the materials. Both students and instructors are encouraged to participate in discussions and answer any questions that are posted.

To join the POLSCI 599 `Piazza` site, click on "Piazza" from the modules in the `Canvas` course site. You will then be prompted to create your account and confirm enrollment. Once you create your account, the `Piazza` course page can also be accessed by logging in from `https://piazza.com` or its mobile apps. In addition, all class announcements will be made through `Piazza`. `Canvas` will still be used for hosting all class materials.

4 Prerequisites

There are two prerequisites for this course:

- Materials covered in the University of Michigan Political Science Math Camp.
- Statistical programming in **R** at the level of the following textbook of POLSCI 514. If you are not proficient in **R** and LaTeX, you are strongly encouraged to take POLSCI 514 concurrently in Fall 2021.

  Kosuke Imai. *Quantitative Social Science: An Introduction*. Princeton University Press, Princeton, 2017.

In addition, the following is recommended but not required:

- Concurrent enrollment in POLSCI 598: Basic real analysis and calculus.

5 Course Requirements

The final grades are based on the following items:

- **Participation** (10%): The level of engagement in exercise sessions, sections, and `Piazza` discussions.
- **Problem Sets** (60%): Total six problem sets will be given approximately every other week throughout the semester. Each problem set will equally contribute to the final grade and contain analytical questions. In addition, approximately every other week, the problem sets include data analysis questions.

  The following instructions will apply to all problem sets:

  - *Collaboration policy.* Collaboration on the problem sets is encouraged, because it provides opportunities for learning from each other. However, to facilitate individual learning, you should try all problem set questions before working together with other students and you must write your answers by yourself. Copying any part of someone else's answers is considered as academic misconduct (see below for the University's academic misconduct policy).
  - *Submission policy.* Hand in your answers individually through `Canvas`. All answers must be typed via LaTeX, which is covered in POLSCI 514 at the beginning of the semester. You can use the problem set template available at `http://jenpan.com/resources/`. The **R** source code should also be included in your answers whenever you use **R**. Please ensure your code adheres to the Google's **R** Style Guide rules available at `https://google.github.io/styleguide/Rguide.xml`.

- **Take-home Midterm and Final Exams** (30%): The take-home open-book midterm and final exams will be given on October 13 and December 8, respectively. You have one week to complete each exam. The exam consists of both analytical and data analysis questions. Except that *no collaboration is allowed for the exams*, the above submission policy also applies.

- **Incomplete Policy**: No incompletes will be given.

6 Course Policies

- **COVID-19:** The course follows the University of Michigan's COVID-19 Policies & Guidelines at `https://healthresponse.umich.edu/policies-guidance/`.

- **Student Sexual Misconduct Policy:** Title IX prohibits sex discrimination to include sexual misconduct: harassment, domestic and dating violence, sexual assault, and stalking. If you or someone you know has been harassed or assaulted, you can receive confidential support and academic advocacy at the Sexual Assault Prevention and Awareness Center (SAPAC). SAPAC can be contacted on their 24-hour crisis line, 734–936–3333 and online at sapac.umich.edu. Alleged violations can be reported non-confidentially to the Office for Institutional Equity (OIE) at institutional.equity@umich.edu. Reports to law enforcement can be made to University of Michigan Police Department at 734–763–3434.[1]

- **Accommodations for Students with Disabilities:** If you think you need an accommodation for a disability, please let me know at your earliest convenience. Some aspects of this course, the assignments, the in-class activities, and the way the course is usually taught may be modified to facilitate your participation and progress. As soon as you make me aware of your needs, we can work with the Services for Students with Disabilities (SSD) office to help us determine appropriate academic accommodations. SSD (734–763–3000; `http://ssd.umich.edu`) typically recommends accommodations through a Verified Individualized Services and Accommodations (VISA) form. Any information you provide is private and confidential and will be treated as such.[2]

- **Religious-Academic Conflicts:** While the university does not observe religious holidays, it is the policy of the University of Michigan to make every reasonable effort to allow members of the university community to observe their religious holidays without academic penalty. Absensce from classes or examinations for religious reasons does not relieve students from responsibility for any part of the course work required during the period ob absence. Students who expect to miss classes as a consequence of their religious observance shall be provided with a reasonable alternative opportunity to make-up missed academic work. It is the obligation of students to provide faculty with reasonable notice of the dates on which they will be absent. When the absence coincides with an exam or other assignment due date, the options to make up that missed work may be limited and will be determined by the instructor within the boundaries of the respective class.[3]

- **Academic Misconduct:** The University of Michigan community functions best when its members treat one another with honesty, fairness, respect, and trust. The college promotes the assumption of personal responsibility and integrity, and prohibits all forms of academic

[1] This statement is taken from: `https://sapac.umich.edu/article/faculty-resources-sample-syllabus-language`.
[2] This statement is taken from: `https://ssd.umich.edu/article/syllabus-statement`.
[3] This statement is taken from: *Handbook for Faculty and Instructional Staff 2018*, p. 17.

dishonesty and misconduct. All cases of academic misconduct will be referred to the Office of the Assistant Dean for Undergraduate Education. Being found responsible for academic misconduct will usually result in a grade sanction, in addition to any sanction from the college. For more information, including examples of behaviors that are considered academic misconduct and potential sanctions, please see `https://lsa.umich.edu/lsa/academics/academic-integrity.html`.[4]

- **Student Mental Health and Wellbeing:** The University of Michigan is committed to advancing the mental health and wellbeing of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. For help, contact *Counseling and Psychological Services (CAPS)* at (734) 764-8312 and `https://caps.umich.edu/` during and after hours, on weekends and holidays, or through its counselors physically located in schools on both North and Central Campus. You may also consult *University Health Service (UHS)* at (734) 764-8320 and `https://www.uhs.umich.edu/mentalhealthsvcs`, or for alcohol or drug concerns, see `https://www.uhs.umich.edu/aodresources`. For a listing of other mental health resources available on and off campus, visit: `http://umich.edu/~health`.[5]

- **Use of Generative AI:** In principle you may submit AI-generated code, or code that is based on or derived from AI-generated code, as long as this use is properly documented in the comments: you need to include the prompt and the significant parts of the response. AI tools may help you avoid syntax errors, but there is no guarantee that the generated code is correct. It is your responsibility to identify errors in program logic through comprehensive, documented testing. Moreover, generated code, even if syntactically correct, may have significant scope for improvement, in particular regarding separation of concerns and avoiding repetitions. The submission itself should meet our standards of attribution and validation.[6]

7 Textbooks

There is no single textbook for this course. However, you are likely to find it useful in this course and for the future to keep the following textbooks in your bookshelf (henceforth, they are referred by the authors' initials).

The course materials are based mainly on the following two books:

Joseph K. Blitzstein and Jessica Hwang. *Introduction to Probability*. Chapman and Hall/CRC, 2nd edition, 2019.

Morris H. DeGroot and Mark J. Schervish. *Probability and Statistics*. Pearson Education, Boston, 4th edition, 2012.

It is recommended to read relevant chapters (indicated in Section 9) for your preview and review of the class materials.

If you would like to study more advanced materials, read:

[4]This statement is taken from: *Handbook for Faculty and Instructional Staff 2018*, p. 16.
[5]This statement is taken from: *Handbook for Faculty and Instructional Staff 2018*, p. 16.
[6]Boris Steipe (2023) "Syllabus Resources." The Sentient Syllabus Project `http://sentientsyllabus.org`.

Larry Wasserman. *All of Statistics: A Concise Course in Statistical Inference*. Springer Texts in Statistics. Springer, New York, 2004.

George Casella and Roger L Berger. *Statistical Inference*. Duxbury, Pacific Grove, 2nd edition, 2002.

If time permits, the course covers the basics of statistical causal inference. Standard references on causal inference for social scientists are:

Donald B. Rubin and Guido W. Imbens. *Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction*. Cambridge University Press, New York, 2015.

Joshua D. Angrist and Jörn-Steffen Pischke. *Mostly Harmless Econometrics: An Empiricist's Companion*. Princeton University Press, Princeton, 2009.

DS, CB, and **AP** are requested to be reserved in the Shapiro Undergraduate Library. The other textbooks are available online at the University of Michigan Library website.

8 Important Dates of Course and Assignment Schedule

August 29 On-demand video lecture to introduce the course and methods sequence

August 31 Lecture and section canceled

September 7 Problem Set 1 issued; Adam's section will be rescheduled

September 14 Problem Set 1 due

September 21 Problem Set 2 issued

September 28 Problem Set 2 due

October 5 Problem Set 3 issued

October 10 Problem Set 3 due

October 13 Midterm Exam issued

October 19 Midterm Exam due

October 19 Problem Set 4 issued

October 26 Problem Set 4 due

November 2 Problem Set 5 issued

November 9 Problem Set 5 due

November 16 Problem Set 6 issued; Lecture canceled

November 21 Lecture canceled

November 30 Problem Set 6 due

December 8 Final Exam issued

December 14 Final Exam due

9 Course Outline

Each section of the course is followed by the list of supplementary readings. Additional optional readings may be provided in lectures. Note that sections do not divide the course evenly. The plan is subject to change, depending on how students are keeping up with the course materials.

Probability

- **Week 1 (Sept. 5 and 7)**
  - Topics
    1. Probability space
    2. Countable sample space
    3. Counting: multiplication rule, sampling with and without replacement, permutations, and combinations
    4. Uncountable sample space
    5. Independence of events
  - Recommended review readings
    - Blitzstein and Hwang (2019, Ch. 1)
    - DeGroot and Schervish (2012, Ch. 1)
  - Problem Set 1 (Sept. 7–14)

- **Weeks 2 (Sept. 12 and 14)**
  - Topics
    1. Mutual and pairwise independence
    2. Conditional probability
    3. Conditional probability and independence
    4. Bayes' rule and Bayes' theorem
  - Recommended review readings
    - Blitzstein and Hwang (2019, Ch. 2)
    - DeGroot and Schervish (2012, Ch. 2)

Random Variables

- **Week 3 (Sept. 19 and 21)**
  - Topics
    1. Random variable
    2. Distribution
    3. Cumulative distribution function
    4. Discrete random variable and probability function
    5. Bernoulli distribution
    6. Binomial distribution

  - Recommended review readings
    * Blitzstein and Hwang (2019, Sections 3.1–3.6)
    * DeGroot and Schervish (2012, Section 3.1 and pp. 107–111)
  - Problem Set 2 (Sept. 21–28)

- **Week 4 (Sept. 26 and 28)**
  - Topics
    1. Continuous random variable and probability density function
    2. Uniform distribution
    3. Functions of random variables
    4. Inverse-CDF method
    5. Multivariate random variables and joint distribution
    6. Joint probability function
    7. Multinomial distribution
  - Recommended review readings
    * Blitzstein and Hwang (2019, Sections 3.7, Ch. 5, and 7.1)
    * DeGroot and Schervish (2012, Sections 3.2–4, 3.8 and 5.2)

- **Week 5 (Oct. 3 and 5)**
  - Topics
    1. Joint probability density function
    2. Multivariate uniform distribution
    3. Marginal distribution
    4. Independence of random variables
    5. IID and random sample
    6. Convolution
  - Recommended review readings
    * Blitzstein and Hwang (2019, Sections 3.8–10, Ch. 5, and 7.4–7.5)
    * DeGroot and Schervish (2012, Sections 3.5, 3.9, and Ch. 5)
  - Problem Set 3 (Oct. 5–10)

- **Week 6 (Oct. 10 and 12)**
  - Topics
    1. Conditional distribution
    2. Hybrid random vector and joint p.f.-p.d.f.
    3. Uniform-Binomial Model
    4. Bayes' theorem
  - Recommended review readings
    * Blitzstein and Hwang (2019, Ch. 3, 5, and 7)
    * DeGroot and Schervish (2012, Ch. 3 and 5)

- **Week 7 (Oct. 19)**
  - Topic: study design and conditional distribution
  - Assigned Readings

Robert A Pape. The strategic logic of suicide terrorism. *American Political Science Review*, 97(3):343–361, 2003.

Scott Ashworth, Joshua D Clinton, Adam Meirowitz, and Kristopher W Ramsay. Design, inference, and the strategic logic of suicide terrorism. *American Political Science Review*, 102(2):269–273, 2008a.

Robert A Pape. Methods and findings in the study of suicide terrorism. *American Political Science Review*, 102(2):275–277, 2008.

Scott Ashworth, Joshua D Clinton, Adam Meirowitz, and Kristopher W Ramsay. Design, inference, and the strategic logic of suicide terrorism: A rejoinder. Unpublished manuscript, 2008b. URL `https://home.uchicago.edu/~sashwort/rejoinder3.pdf`.

Midterm Exam (Oct. 13–19)

Expectation and Moments

- **Week 7 (Oct. 19)**
  - Topics:
    1. Definition of expectation
    2. Existence of expectation
  - Recommended review readings
    - Blitzstein and Hwang (2019, 4.1)
    - DeGroot and Schervish (2012, pp. 207–211)
  - Problem Set 4 (Oct. 19–26)
- **Week 8 (Oct. 24 and 26)**
  - Topics:
    1. Properties of expectation
    2. Jensen's inequality
  - Recommended review readings
    - Blitzstein and Hwang (2019, 4.2–5)
    - DeGroot and Schervish (2012, pp.212–7, 4.2)
- **Week 9 (Oct. 31 and Nov. 2)**
  - Topics:
    1. Moments and variance
    2. Covariance and correlation
    3. Variance-covariance matrix
    4. Conditional expectation
  - Recommended review readings
    - Blitzstein and Hwang (2019, 4.6 and 6.1–2)
    - DeGroot and Schervish (2012, 4.3 and 4.5)

  - Problem Set 5 (Nov. 2–9)

- **Week 10 (Nov. 7 and 9)**
  - Topics:
    * Properties of conditional expectation
    * Standard Gaussian distribution
    * Linear transformation of Gaussian r.v.
    * Moment generating functions
    * Gamma distribution
  - Recommended review readings
    * Blitzstein and Hwang (2019, Ch. 9, 6.4-6)
    * DeGroot and Schervish (2012, 4.4, 4.7, 5.7, and 5.10)

- **Week 11 (Nov. 14)**
  - Topics:
    * Sample moments
    * Sample mean of Gaussian r.v.
  - Recommended review readings
    * Blitzstein and Hwang (2019, 6.3)
    * DeGroot and Schervish (2012, Ch. 8)
  - Problem Set 6 (Nov. 16–30)

Statistical Inference

- **Week 12 (Nov. 28 and 30)**
  - Topics:
    * Method of moments estimator
    * Approximate inference
    * Law of large numbers
    * Central limit theorem
  - Recommended review readings
    * Blitzstein and Hwang (2019, Ch. 10)
    * DeGroot and Schervish (2012, Ch. 6)

- **Week 13 (Dec. 5)**
  - Topics:
    * Asymptotic tests and confidence intervals
  - Recommended review readings
    * Blitzstein and Hwang (2019, Ch. 10)
    * DeGroot and Schervish (2012, Ch. 8-9)

Final Exam (Dec. 8–14)