

# PSCI 7155: Maximum Likelihood

University of Colorado Boulder

Fall 2024

**Time:** Friday, 9:00-11:30AM  
**Location:** KTCH 1B31  
  
**Instructor:** Dr. Andrew Q. Philips  
**Office:** KTCH 131  
**Email:** andrew.philips@colorado.edu  
**Office hours:** Wednesday, 10:00AM-12:00PM (or by appointment)

**COURSE DESCRIPTION:** Models utilizing maximum likelihood (ML) estimation are ubiquitous in political science. This course is designed to introduce you to a variety of ML estimators that you are likely to encounter in your research. We will start with a simple overview of probability models and show why we might need such an estimation technique. After discussing likelihood theory, we then move to more “novel” types of outcomes, such as linear models with censoring and truncation, binary choice models, count models, and duration models. Much of the class will be spent on learning how to interpret these models and implement them in a statistical program.

By the end of this course you should be able to:

- Understand what is going on “under the hood” when estimating maximum likelihood models.
- Identifying which parametric model best fits your research question and the underlying data-generating process.
- Be able to interpret a variety of ML models and present your results using predictions, substantive interpretations, marginal effects, simulations, etc.
- Apply what you have learned to your own research.

**PREREQUISITES:** This an graduate level course; students should have a background in at least introductory (and preferably) advanced regression statistics (i.e., Data I and Data II). Students from other graduate programs must check with me before signing up for this course.

**SOFTWARE:** We will use both R and Stata in this course, the former slightly more so. Those unfamiliar with either program may want to purchase or borrow some of the suggested textbooks below, although there are copious amounts of information available for free online (also see Philips’ “brief introductions” in the course Dropbox). Please have R (<https://cran.r-project.org/>), RStudio (<https://www.rstudio.com>) and a copy of Stata installed on your computer before the first class session.

**GRADES:** Course grades will be based on the following. Participation and homework assignments are worth 20% of the final grade. The colleague critique is worth 15%. About halfway through the semester, a take-home mid-term exam will be given that is worth 25% of the final grade. An original research paper will comprise 40% of the final grade. Note that there are no opportunities for extra credit, nor is there a final exam.

Participation/Homework	20%
Colleague Critique	15%
Midterm Exam	25%
Original Research Paper	40%

The following scale will be used to turn numerical grades into letter ones. Note that I will round up a letter should your grade fall on the number (but on or above 0.5) between two letters (e.g., 89.5 up to 90 rounds up to an A-).

#### Grade Scale

A	95-100
A-	90-94
B+	87-89
B	84-86
B-	80-83
C+	77-79
C	74-76
C-	70-73
D+	67-69
D	64-66
D-	60-63
F	0-59

**PARTICIPATION:** Participation is an integral component of graduate courses. Students are expected to come to every class *having already read the assigned readings for that day*, and should be prepared to discuss them. Graduate-level courses only are successful when all participate actively in the discussion.

**HOMEWORK:** Most weeks we will have a lab portion. For homework, students will turn in a log file of the weekly lab in Stata or R, being sure to note any places where they had issues or did not understand the code/command.

**MIDTERM EXAM:** About halfway through the semester there will be a mid-term exam. There are two portions to this. This will be a take-home exam with a mix of theoretical questions as well as several applied questions where you will need to use R/Stata or interpret output. Although you may consult help files, slides and your notes, *you cannot consult with other graduate students*. This will be considered a form of cheating.

**ORIGINAL RESEARCH PAPER:** By the end of the class, students should have a solo-authored research article-length working paper that is either: a.) a purely methodological paper (less common), or b.) an applied research paper that utilizes at least one of the maximum likelihood models discussed in the course. Since one semester is a short time in which to write such a paper, it is crucial to get some semblance of a research topic early in the semester. I encourage students to meet with me early on to discuss potential topics. Half-way through the semester, there will be a mandatory “check-in” to ensure all students have a feasible research topic. *I am very open to this paper being submitted for credit in another course, a substantial re-write from a previous semester, or a current coauthored working paper, but this needs to be cleared by me (and by the other professor if applicable)*. Note that the most important part of the research paper for the purposes of this class is the theory, hypotheses, research design, and presentation and interpretation of the results. Students are strongly encouraged to write the paper using  $\LaTeX$ .

**COLLEAGUE CRITIQUE:** After all research papers are due, I will assign each student to read and critique *two* of their fellow students’ papers. Students should treat this just as they would an invitation to peer review a manuscript. Theory, research design, data, methods, etc,... should be critiqued.

**ATTENDANCE AND LATE POLICY:** Attendance is a key component of succeeding in graduate school. I provide slides for each class, but we will have a much more comprehensive discussion than what ap-

pears on the slide. Attendance is mandatory.

Assignments are due on the day listed in the syllabus. Late assignments will not be accepted.

**REQUIRED TEXTS:** The following texts are required for the course. Any additional readings will be made available to you on the first day of class or as needed.

- King, Gary. 1998. *Unifying political methodology: The likelihood theory of statistical inference*. University of Michigan Press.
- Ward, Michael D. and John S. Ahlquist. 2018. *Maximum likelihood for social science*. Cambridge University Press.

Note that it is expected to read the week's required readings before coming to class.

**RECOMMENDED TEXTS:** The following texts are not required, but may be helpful to some. I'm happy to talk more with you if you are interested in a particular topic. In the schedule below there are additional texts in the "suggested readings".

- Long, J. Scott. 1997. *Regression models for categorical and limited dependent variables*. Thousand Oaks, CA: Sage.
- Eliason, Scott R. 1993. *Maximum likelihood estimation: Logic and practice*. Thousand Oaks, CA: Sage.
- Box-Steffensmeier, Janet M., and Bradford S. Jones. 2004. *Event history modeling: A guide for social scientists*. Cambridge University Press.
- Cameron, Adrian Colin and Pravin K. Trivedi. 2013. *Regression analysis of count data*. Second Edition. Cambridge University Press.
- Cameron, Adrian Colin, and Pravin K. Trivedi. 2009. *Microeconometrics using Stata Volume 5*. College Station, TX: Stata Press.
- Gelman, Andrew, and Jennifer Hill. *Data analysis using regression and multilevel/hierarchical models*. Cambridge University Press, 2006.
- Hosmer, D., Stanley Lemeshow, and Susanne May. 2008. *Applied survival analysis: Regression modeling of time to event data*. Second Edition. New York: Wiley.
- Long, J. Scott and Jeremy Freese. 2014. *Regression models for categorical dependent variables using Stata*. Third Edition. Stata Press.
- Neumayer, Eric and Thomas Plumper. 2017. *Robustness tests for quantitative research*. Cambridge University Press.
- Forbes, Catherine, Merran Evans, Nicholas Hastings, and Brian Peacock. 2010. *Statistical distributions*. Fourth Edition. Wiley.
- Greene, William. 2011. *Econometric analysis*. 7th Edition. Upper Saddle River, NJ: Prentice-Hall.

## **TENTATIVE SCHEDULE:**

### **Topic 1: Introduction to Probability Models**

Required Readings:

- King Chapters 1 and 2
- Ward and Ahlquist Chapter 1

Suggested Readings:

- Eliason Chapter 1 (pp. 1-18)
- Long Chapter 1
- Burns, Patrick. 2011. *The R Inferno*.
- Philips, Andrew Q. 2024. "R: A brief introduction"
- Philips, Andrew Q. 2024. "Stata: A brief introduction"
- Philips, Andrew Q. 2024. "L<sup>A</sup>T<sub>E</sub>X: A brief introduction"

### **Topic 2: Estimation: Looking Under the Hood**

Properties of ML models

Required Readings:

- King Chapter 3
- Ward and Ahlquist Chapter 2 and 4

Suggested Readings:

- Eliason Chapters 1 (pp. 18-21), and 3

### **Topic 3: Generalized Linear Model**

Required Readings:

- King Chapter 4
- Ward and Ahlquist Chapter 7
- Neuhaus, J. and McCulloch, C., 2011. "Generalized linear models." *Wiley Interdisciplinary Reviews: Computational Statistics* 3(5): 407-413.

Suggested Readings:

- Eliason Chapter 2

### **Topic 4: Censoring and Truncation, Selection Models and More**

Required Readings:

- Sigelman, Lee and Langche Zeng. 2000. "Analyzing censored and sample-selected data with Tobit and Heckit models." *Political Analysis* 8(2): 167-182.
- Hug, S., 2003. "Selection bias in comparative research: The case of incomplete data sets." *Political Analysis* 11(3): 255-274.
- Plumper, Thomas, Christina J. Schneider and Vera E. Troeger. 2005. "The politics of EU Eastern enlargement: Evidence from a Heckman selection model." *British Journal of Political Science* 36: 17-38.

Suggested Readings:

- Vance, Colin and Nolan Ritter. 2014. "Is peace a missing value or a zero? On selection models in political science." *Journal of Peace Research* 51(4): 528-540.
- Bushway, Shawn, Brian D. Johnson and Lee Ann Slocum. 2007. "Is the magic still there? The use of the Heckman two-step correction for selection bias in criminology." *Journal of Quantitative Criminology* 23:151-178.
- Eliason Chapter 5
- Heckman, James. 1979. "Sample selection bias as a specification error." *Econometrica: Journal of the Econometric Society*: 47(1): 153-161.
- Tobin, James. 1958. "Estimation of relationships for limited dependent variables." *Econometrica: Journal of the Econometric Society*: 24-36.

## Topic 5: Binary Choice Models

### Logit and probit

Required Readings:

- King Chapter 5
- Ward and Ahlquist Chapter 3 (pp. 43-54)
- Flores-Macias, Gustavo A. and Sarah E. Kreps. 2013. "Political parties at war: A study of American war finance, 1789-2010." *American Political Science Review* 107(4): 833-848.

Suggested Readings:

- Long Chapter 3

## Topic 6: Binary Choice Models Continued

### Heteroskedastic probit, binary choice interpretation, and more

Required Readings:

- Ward and Ahlquist Chapter 3 (pp. 54-78)
- Alvarez, R. Michael and John Brehm. 1995. "American ambivalence towards abortion policy: Development of a heteroscedastic probit model of competing values". *American Journal of Political Science* 39(4): 1055-1082.
- Ai, Chunrong, and Edward C. Norton. 2003. "Interaction terms in logit and probit models". *Economics Letters* 80:123-129.
- Mood, Carina. 2010. "Logistic regression: Why we cannot do what we think we can do, and what we can do about it." *European Sociological Review* 26:67-82.

Suggested Readings:

- Greenhill, Brian, Michael D. Ward, and Audrey Sacks. 2011. "The separation plot: A new visual method for evaluating the fit of binary models." *American Journal of Political Science* 55(4): 991-1002.
- Nagler, Jonathan. 1994. "Scobit: An alternative estimator to logit and probit." *American Journal of Political Science* 38(1):230-255.
- Yatchew, Adonis and Zvi Griliches. 1985. "Specification error in probit models." *The Review of Economics and Statistics* 67(1):134-139.
- Rainey, Carlisle and Kelly McCaskey. 2021. "Estimating logit models with small samples." *Political Science Research and Methods* 9: 549-564.

## MIDTERM EXAM (TAKE-HOME, DUE BY 11:59PM ON OCTOBER 10)

### Topic 7: Ordered and Multinomial Choice Models

Ordered and multinomial logit and probit

Required Readings:

- Ward and Ahlquist Chapter 8 and 9
- Bélanger, Éric and Nadeau, Richard. 2005. "Political trust and the vote in multiparty elections: The Canadian case." *European Journal of Political Research* 44(1): 121-146.
- Rudolph, Thomas J. 2003. "Who's Responsible for the Economy? The Formation and Consequences of Responsibility Attributions." *American Journal of Political Science* 47(4): 698-713.
- Cook, Scott J., John Niehaus and Samantha Zuhlke. 2018. "A warning on separation in multinomial logistic models." *Research and Politics* 1-5.
- Dow, Jay K. and Endersby, James W. 2004. "Multinomial probit and multinomial logit: A comparison of choice models for voting research." *Electoral Studies* 23: 107-122.
- Paolino, Philip. 2020. "Predicted probabilities and inference with multinomial logit." *Political Analysis* 29: 416-421.

Suggested Readings:

- Whitten, Guy D. and Harvey D. Palmer. 1996. "Heightening comparativists' concern for model choice: Voting behavior in Great Britain and the Netherlands". *American Journal of Political Science*: 231-260.
- Alvarez, R.M. and J. Nagler. 1995. "Economics, issues and the Perot candidacy: Voter choice in the 1992 presidential election". *American Journal of Political Science*: 714-744.
- Long Chapters 5 and 6
- Eliason Chapter 4
- Cheng, Simon and J. Scott Long. 2007. "Testing for IIA in the multinomial logit model." *Sociological Methods & Research* 35(4): 583-600.
- Alvarez, R. Michael, and Jonathan Nagler. 1998. "When politics and models collide: Estimating models of multiparty elections." *American Journal of Political Science* 42(1): 55-96.
- Duch, Raymond M. and Harvey D. Palmer. 2004. "It's not whether you win or lose, but how you play the game: Self-interest, social justice, and mass attitudes toward market transition." *American Political Science Review* 98(3):437-452

### Topic 8: Event Count Models

Poisson, negative binomial, overdispersion and zero-inflation

Required Readings:

- Ward and Ahlquist Chapter 10
- King, Gary. 1989. "Event count models for international relations: Generalizations and applications." *International Studies Quarterly* 33(2): 123-147.

Suggested Readings:

- King, Gary. 1988. "Statistical models for political science event counts: Bias in conventional procedures and evidence for the exponential poisson regression model". *American Journal of Political Science* 32:838-63.
- Long Chapter 8
- Cameron, Adrian Colin and Pravin K. Trivedi. 2013. *Regression analysis of count data*. Second Edition. Cambridge University Press.

## Topic 9: Event Count Models Continued

### Required Readings:

- Wilson, Matthew C., and James A. Piazza. 2013. "Autocracies and terrorism: Conditioning effects of authoritarian regime type on terrorist attacks." *American Journal of Political Science* 57(4): 941-955.
- Ruggeri, Andrea, Theodora-Ismene Gizelis, and Han Dorussen. 2013. "Managing mistrust: An analysis of cooperation with UN peacekeeping in Africa." *Journal of Conflict Resolution* 57(3):387-409.

## Topic 10: Duration Models

### Required Readings:

- Box-Steffensmeier, Janet M., and Bradford S. Jones. 1997. "Time is of the essence: Event history models in political science." *American Journal of Political Science*: 1414-1461.
- Berliner, Daniel. 2014. "The political origins of transparency." *The Journal of Politics* 76(2): 479-491.
- Bueno de Mesquita, Bruce, and Randolph M. Siverson. 1995. "War and the survival of political leaders: A comparative study of regime types and political accountability." *American Political Science Review* 89(2):841-55.

### Suggested Readings:

- Berry, Frances Stokes, and William Berry. 1990. "State lottery adoptions as policy innovations: An event history analysis." *American Political Science Review* 84(2): 395-415.
- Box-Steffensmeier, Janet M., and Bradford S. Jones. 2004. *Event history modeling: A guide for social scientists*. Cambridge University Press.
- Hosmer, D., Stanley Lemeshow, and Susanne May. 2008. *Applied survival analysis: Regression modeling of time to event data*. Second Edition. New York: Wiley.

## Topic 11: Duration Models Continued

### Required Readings:

- Box-Steffensmeier, Janet M., and Christopher JW Zorn. 2001. "Duration models and proportional hazards in political science." *American Journal of Political Science*: 972-988.
- Ward and Ahlquist Chapter 11
- Stiansen, Øyvind. 2021. "Directing Compliance? Remedial Approach and Compliance with European Court of Human Rights Judgments." *British Journal of Political Science* 51(2): 899-907.
- Kropko, Jonathan and Jeffrey J. Harden. 2017. "Beyond the hazard ratio: Generating expected durations from the Cox proportional hazards model." *British Journal of Political Science* 1-18.
- Box-Steffensmeier, Janet M., Suzanna De Boef and Kyle A. Joyce. 2007. "Event dependence and heterogeneity in duration models: The conditional frailty model." *Political Analysis* 15:237-256.

### Suggested Readings:

- Alt, James E., Gary King and Curtis S. Signorino. 2001. "Aggregation among binary, count, and duration models: Estimating the same quantities from different levels of data." *Political Analysis* 9(1):21-44.
- Park, Sunhee, and David J. Hendry. 2015. "Reassessing Schoenfeld residual tests of proportional hazards in political science event history analyses." *American Journal of Political Science* 59(4): 1072-1087.
- Beck, N, J. N. Katz and R Tucker. 1998. "Taking time seriously: Time-series-cross-section analysis with a binary dependent variable." *American Journal of Political Science* 42: 1260-1288.
- Carter, D. B. and C. S. Signorino. 2010. "Back to the future: Modeling time dependence in binary data." *Political Analysis* 18: 271-292.
- Philips, Andrew Q. 2020 "An easy way to create duration variables in binary cross-sectional time-series data." *The Stata Journal* 20(4): 916-930.

## Topic 12: Missing data and Imputation

### Required Readings:

- Ward and Ahlquist Chapter 12
- Little, Todd, Terrence Jorgensens, Kyle Lang and Whitney Moore. 2013. "On the joys of missing data." *Journal of Pediatric Psychology* 39(2): 151-162.
- Schafer, Joseph. 1999. "Multiple imputation: A primer." *Statistical Methods in Medical Research* 8: 3-15.
- White, Ian, Patrick Royston and Angela Wood. 2011. "Multiple imputation using chained equations: Issues and guidance for practice." *Statistics in Medicine* 30: 377-399.

### Suggested Readings:

- Rubin, Donald B. 1976. "Inference and missing data" *Biometrika* 63(3):581-592.
- Kropko, Jonathan, Been Goodrich, Andrew Gelman and Jennifer Hill. 2014. "Multiple imputation for continuous and categorical data: Comparing joint multivariate normal and conditional approaches." *Political Analysis* 22:497-519.
- Honaker, James, Gary King, and Matthew Blackwell. 2011. "Amelia II: A program for missing data." *Journal of Statistical Software* 45(7):1-47.

## Topic 13: Model Selection and 'Robustness'

### Required Readings:

- Ward and Ahlquist Chapter 5
- Hartman, Erin and Daniel Hidalgo. 2018. "An equivalence approach to balance and placebo tests." *American Journal of Political Science* 62(4): 1000-1013.
- Imai, Kosuke and James Lo. 2021. "Robustness of empirical evidence for the democratic peace: A nonparametric sensitivity analysis." *International Organization* 75: 901-919.
- Casper, Gretchen and Claudiu Tufis. 2003. "Correlation versus interchangeability: The limited robustness of empirical findings on democracy using highly correlated data sets." *Political Analysis* 11(2): 196-203.

### Suggested Readings:

- Neumayer, Eric and Thomas Plumper. 2017. *Robustness tests for quantitative research*. Cambridge University Press.
- Montgomery, Jacob M. and Brendan Nyhan. 2010. "Bayesian model averaging: Theoretical developments and practical applications." *Political Analysis* 18: 245-270.
- Munoz, John and Cristobal Young. 2018. "We ran 9 billion regressions: Eliminating false positives through computational model robustness." 48(1): 1-33.

## NO CLASS NOVEMBER 29 (Thanksgiving Break)

## Topic 14: 'Robustness' Continued and Substantive Significance

### Required Readings:

- Bernardi, Fabrizio, Lela Chakhaia and Liliya Leopold. 2017. "'Sing me a song with social significance': The (mis)use of statistical significance testing in European sociological research." *European Sociological Review* 33(1): 1-15.
- Gross, Justin. 2015. "Testing what matters (if you must test at all): A context-driven approach to substantive and statistical significance." *American Journal of Political Science* 59(3): 775-788.
- Rainey, Carlisle. 2014. "Arguing for a negligible effect." *American Journal of Political Science* 58(4): 1083-1091.

### Suggested Readings:

- Esarey, Justin and Nathan Danneman. 2015. "A quantitative method for substantive robustness assessment." *Political Science Research and Methods* 3(1): 95-111.

Research papers due by 11:59 PM on December 8

Student critiques due by 11:59 PM on December 13



## **SYLLABUS CHANGES**

I reserve the right to make changes to the syllabus during the course of the semester as needed and will make the most updated copy available to you and announce said changes during class.

**Last updated:** August 12, 2024

## **UNIVERSITY-MANDATED STATEMENTS**

### **Classroom behavior**

Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation, or political philosophy.

For more information, see the classroom behavior policy, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

### **Requirements for Infectious Disease**

Members of the CU Boulder community and visitors to campus must follow university, department, and building health and safety requirements and all applicable campus policies and public health guidelines to reduce the risk of spreading infectious diseases. If public health conditions require, the university may also invoke related requirements for student conduct and disability accommodation that will apply to this class.

If you feel ill and think you might have COVID-19 or if you have tested positive for COVID-19, please stay home and follow the guidance of the Centers for Disease Control and Prevention (CDC) for isolation and testing. If you have been in close contact with someone who has COVID-19 but do not have any symptoms and have not tested positive for COVID-19, you do not need to stay home but should follow the guidance of the CDC for masking and testing.

### **Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation**

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or [dsinfo@colorado.edu](mailto:dsinfo@colorado.edu) for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.

If you have a required medical isolation for which you require adjustment, please let me know as soon as possible.

### **Preferred student names and pronouns**

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

### **Honor code**

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the Honor Code may include but are not limited to: plagiarism (including use of paper writing services or technology [such as essay bots]), cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty.

All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution: [honor@colorado.edu](mailto:honor@colorado.edu), 303-492-5550. Students found responsible for violating the Honor Code will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Visit Honor Code for more information on the academic integrity policy.

### **Sexual misconduct, discrimination, harassment and/or related retaliation**

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits protected-class discrimination and harassment, sexual misconduct (harassment, exploitation, and assault),

intimate partner violence (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. These behaviors harm individuals and our community. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who have been subjected to misconduct can contact OIEC at 303-492-2127 or email [cureport@colorado.edu](mailto:cureport@colorado.edu). Information about university policies, reporting options, and support resources can be found on the OIEC website.

Please know that faculty and graduate instructors must inform OIEC when they are made aware of incidents related to these policies regardless of when or where something occurred. This is to ensure that individuals impacted receive outreach from OIEC about resolution options and support resources. To learn more about reporting and support for a variety of concerns, visit the Don't Ignore It page.

## **Religious accommodations**

Campus policy requires faculty to provide reasonable accommodations for students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please communicate the need for a religious accommodation in a timely manner. In this class, please let me know as soon as possible if you require an accommodation.

## **Mental Health and Wellness**

The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact Counseling and Psychiatric Services (CAPS) located in C4C or call (303) 492-2277, 24/7.

Free and unlimited telehealth is also available through Academic Live Care. The Academic Live Care site also provides information about additional wellness services on campus that are available to students.