# PSCI 7155: Maximum Likelihood

University of Colorado Boulder

Fall 2017

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| **Time:** | Wednesday, 3:30-6:00 |
| **Location:** | HLMS 196 |
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| **Instructor:** | Dr. Andrew Q. Philips |
| **Office:** | KTCH 144 |
| **Email:** | andrew.philips@colorado.edu |
| **Office hours:** | Thursday 12:00-1:45 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. 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 data, 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. The last two weeks are special topics that we will decide on during the first weeks of class, and may cover topics such as bounded and compositional data, interpreting linear and non-linear interactions, and imputing missing data. These last topics will be chosen based on time constraints and class interests.

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, simulations, etc.

- Apply what you have learned to your 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).

**SOFTWARE:** We will use R in this course. Although familiarity with R is not necessary, it is a plus. Those unfamiliar with this program may want to purchase or borrow the suggested textbooks that cover working with R, although there are copious amounts of information available for free online. Please download both R (https://cran.r-project.org/) and RStudio (https://www.rstudio.com/) before the first class session.

**GRADES:** Course grades will be based on the following. Participation is worth 15% of the final grade. An in-class presentation of the student's original research paper is worth 10%, as is the colleague critique. About halfway through the semester, a mid-term exam will be given that is worth 20% of the final grade. Last, the original research paper will comprise 45% of the final grade. Note that there are no opportunities for extra credit, nor is there a final exam.

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| Participation | 15% |
| In-Class Presentation | 10% |
| Colleague Critique | 10% |
| Midterm Exam | 20% |
| Original Research Paper | 45% |

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

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|:---:|:---|
| 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.

**MIDTERM EXAM:** About halfway through the semester there will be a mid-term exam. There are two portions to this. First is an in-class, open book exam, where you are free to consult your notes, readings, etc. The second part is a take-home applied exam which you should use R or other programs to produce your answer. Although you may consult help files, notes, and the internet for the second portion of the midterm, *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 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 an 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 open to this paper being submitted for credit in another course, or a substantial re-write from a previous semester, but this needs to be cleared by me (and by the other professor). 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 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.

**IN-CLASS PRESENTATIONS:** Instead of a final exam, students will give in-class presentations on their research papers. This will be held after the colleague critiques are due, so students will have some time to make changes as necessary. These are conference-length (i.e., about 12-15 minutes) presentations.

**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 appears on the slide. Attendance is mandatory, with the exception of university-excused absences. If you need to miss a class, you should—if possible—let me know in advance so that we can make arrangements.

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.

- 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.

- King, Gary. 1998. *Unifying political methodology: The likelihood theory of statistical inference*. University of Michigan 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. In the schedule below there are additional texts in the "suggested readings".

- 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.

- Monogan, James E. 2015. *Political analysis using R*. Springer.

- Philips, Andrew Q. 2016. "LaTeX: A brief introduction". Available here.

- 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:**

## Week 1: Introduction to Probability Models

Required Readings:

- King Chapters 1 and 2
- Eliason Chapter 1 (pp. 1-18)
- Long Chapter 1

Suggested Readings:

- Burns, Patrick. 2011. *The R Inferno*. Available at: http://www.burns-stat.com/documents/books/the-r-inferno/.
- Philips, Andrew Q. 2017. "R: A brief introduction"

## Week 2: Estimation: Looking Under the Hood

Properties of ML models,

Required Readings:

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

## Week 3: Generalized Linear Model

Required Readings:

- King Chapter 4
- Eliason Chapter 2

## Week 4: Censoring and Truncation, Selection Models and More

Required Readings:

- Eliason Chapter 5
- Reed, William, and David H. Clark. 2000. "War initiators and war winners: The consequences of linking theories of democratic war success." *Journal of Conflict Resolution* 44(3): 378–395.

Suggested Readings:

- White, Halbert. 1980. "A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity." *Econometrica: Journal of the Econometric Society*: 817-838.
- Tobin, James. 1958. "Estimation of relationships for limited dependent variables." *Econometrica: Journal of the Econometric Society*: 24-36.
- Sigelman, Lee and Langche Zeng. 2000. "Analyzing censored and sample-selected data with Tobit and Heckit models." *Political Analysis* 8(2): 167-182.

## Week 5: Binary Choice Models

Logit and probit Required Readings:

- Long Chapter 3
- King Chapter 5

## Week 6: Binary Choice Models Continued

### Heteroskedastic probit and interpretation

Required Readings:

- 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.
- 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.

## Week 7: Ordered and Multinomial Choice Models

### Ordered and multinomial logit and probit

Required Readings:

- Long Chapters 5 and 6
- Eliason Chapter 4
- 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 transision." *American Political Science Review* 98(3):437-452
- 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.

Suggested Readings:

- Imai, Kosuke and David A. van Dyk. 2005. "A Bayesian analysis of the multinomial probit model using marginal data augmentation." *Journal of Econometrics* 124(2): 311-334.
- 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.

## Week 8: Midterm Exam

Part I (in class)
Part II (take-home) **Due by 11:59pm on Friday, October 20**

## Week 9: Event Count Models

### Poisson, negative binomial, dealing with overdispersion and zero-inflation

Required Readings:

- Long Chapter 8
- King, Gary. 1989. "Event count models for international relations: Generalizations and applications." *International Studies Quarterly* 33(2): 123–147.
- 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.

Suggested Readings:

- Cameron, Adrian Colin and Pravin K. Trivedi. 2013. *Regression analysis of count data*. Second Edition. Cambridge University Press.

## Week 10: 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.

## Week 11: 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.

## Week 12: 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.
- 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.
- Kiefer, Nicholas M. 1988. "Economic Duration Data and Hazard Functions." *Journal of Economic Literature* 26:646-79.

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.
- 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.

## Week 13: NO CLASS (Thanksgiving Break)

## Weeks 14 and 15: Special Topics

Weeks 14 and 15 are special topics. We may cover some/all of the following, depending on time and the interests of the class:

- Linear and Non-Linear Interactions and Interpretation
    - Rainey, Carlisle. 2016. "Compression and Conditional Effects: A Product Term Is Essential When Using Logistic Regression to Test for Interaction." *Political Science Research and Methods*: 1-19.

- Berry, William D., Jacqueline H. R. DeMeritt, and Justin Esarey. 2010. "Testing for Interaction in Binary Logit and Probit Models: Is a Product Term Essential?" *American Journal of Political Science* 54: 248-66.
- Norton, E.C., H. Want, and C. Ai. 2004. "Computing Interaction Effects and Standard Errors in Logit and Probit Models." *Stata Journal* 4(2):154-67.
- Hanmer, Michael J., and Kerem Ozan Kalkan. 2013. "Behind the curve: Clarifying the best approach to calculating predicted probabilities and marginal effects from limited dependent variable models." *American Journal of Political Science* 57(1):263-277.

- Bounded and Compositional Data

- Tomz, Michael, Joshua A. Tucker, and Jason Wittenberg. 2002. "An easy and accurate regression model for multiparty electoral data." *Political Analysis* 10(1): 66-83.
- Philips, Andrew Q., Amanda Rutherford, and Guy D. Whitten. 2016. "Dynamic pie: A strategy for modeling trade-offs in compositional variables over time". *American Journal of Political Science* 60(1):268-283.
- Lipsmeyer, Christine S., Andrew Q. Philips, Amanda Rutherford, and Guy D. Whitten. Forthcoming. "Comparing dynamic pies: A strategy for modeling compositional variables in time and space." *Political Science Research and Methods*.
- Katz, J.N. and King, G. 1999. "A statistical model for multiparty electoral data." *American Political Science Review* 93(01):15-32.

- Hierarchical Models and Random Effects

- Carter, David B. and Curtis S. Signorino. 2010. "Back to the future: Modeling time dependence in binary data." *Political Analysis* 18(3): 271-292.
- Gelman, Andrew, and Jennifer Hill. *Data analysis using regression and multilevel/hierarchical models*. Cambridge University Press, 2006.
- Arceneaux, K. and Nickerson, D.W., 2009. "Modeling certainty with clustered data: A comparison of methods." *Political Analysis* 17(2):177-190.
- Bowers, Jake and Katherine W. Drake. 2005. "EDA for HLM: Visualization when probabilistic inference fails." *Political Analysis* 13:301-326.

- Missing Data Imputation and the EM Algorithm

- Honaker, James, Gary King, and Matthew Blackwell. 2011. "Amelia II: A program for missing data." *Journal of Statistical Software* 45(7):1-47.
- Rubin, Donald B. 1976. "Inference and missing data" *Biometrika* 63(3):581-592.

- Uncertainty, Significance, Hypothesis Testing, and Presenting and Simulating Models

- Efron, Bradley. 2005. "Bayesians, frequentists, and scientists." *Journal of the American Statistical Association* 100(469):1–5.
- Gill, Jeff. 1999. "The insignificance of null hypothesis significance testing" *Political Research Quarterly* 52(3):647-674.
- Gelman, A. and Stern, H., 2006. "The difference between 'significant' and 'not significant' is not itself statistically significant". *The American Statistician* 60(4):328-331.
- King, Gary, Michael Tomz and Jason Wittenberg. 2000. "Making the most of statistical analyses: Improving interpretation and presentation" *American Journal of Political Science* 44(2):347-361.
- King, Gary. 1991. "Calculating standard errors of predicted values based on non-linear functional forms." *The Political Methodologist* 4(2):2-4.

# Week 14: Special Topics

# Week 15: Special Topics

Research papers due Wednesday, December 6 by Noon.

# Week 16: Student Presentations

Student critiques due Monday, December 11 by 11:59pm.

## STATEMENT ABOUT STUDENTS WITH DISABILITIES

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact Disability Services—either online at http://www.colorado.edu/disabilityservices/—or at the Center for Community, N200, 107 UCB.

To best accommodate students who may require alternative services, it is crucial that you contact me *early in the semester* if you need such accommodations.

## HONOR CODE, COPYRIGHT, AND PLAGARISM STATEMENTS

"*On my honor, as a University of Colorado Boulder student, I have neither given nor received unauthorized assistance*"

The CU Honor Code is intended to uphold the intellectual reputation of the university by establishing trust among individuals regarding intellectual honesty. As the website states, "The Honor Code secures an environment where academic integrity can flourish and aims to install the principles of honesty, trust, fairness, respect, and responsibility as essential features of the University of Colorado Boulder campus". Violations of intellectual honesty include plagiarism, cheating, and the unauthorized use of materials, all of which erode trust among individuals. If you have any questions about this, please see me, the Honor Code website (http://www.colorado.edu/honorcode/), or the Honor Code Office (1B70 Regent Admin Building).

The handouts and lectures used in this course are copyrighted. By "handouts," I mean all materials generated for this class, which include but are not limited to syllabi, exams, in-class materials, and review sheets. Because these are copyrighted, you do not have the right to copy them or distribute them to others outside class, unless I expressly grant permission. In addition, I do not grant permission to tape class lectures.

## 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 22, 2017