POLS XXXX-XXX: Maximum Likelihood Estimation
Spring 20XX | XX:XX XM—XX:XX XM | XXX XXX

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Overview, Objectives, and Outcomes

This course is split into two components. The first discusses the principles of maximum likelihood estimation (MLE); the second applies those principles to a variety of statistical models. Specifically, this course is designed to train you to recognize when alternative estimation strategies can provide higher quality estimates and inferences than the ordinary least squares regression model.

Learning outcomes: by the end of the course, you should be able to identify the statistical experiment that generated a variety of data, estimate a model to provide inferences regarding that data, and defend those inferences according to a variety of statistical tests.

Prerequisites

We will start assuming that you have a solid grounding in basic matrix mathematics, basic calculus, the properties of the OLS model (and its assumptions), and familiarity estimating these models in your choice of statistical program.

Required Materials

There are three required textbooks (you should already own a copy of Greene's *Econometric Analysis*):

- Long, J. Scott. 1997. *Regression Models for Categorical and Limited Dependent Variables*. Thousand Oaks, CA: Sage.
- King, Gary. 1998. *Unifying Political Methodology: The Likelihood Theory of Statistical Inference*. Ann Arbor: University of Michigan Press.
- Forbes, Catherine, Merran Evans, Nicholas Hastings, and Brian Peacock. 2010. *Statistical Distributions (Fourth Edition)*. New York: Wiley. (Referred to in this syllabus as "F/E/H/P.")

Unlike some substantive books, these will become reference materials that will inform your practice of MLE throughout your research career. I highly suggest that you buy a personal copy of each of these books rather than use a library copy.

If you'd like a more technical (but very accessible) treatment of MLE, I recommend Pawitan, Yudi. 2013. *In All Likelihood: Statistical Modeling and Inference Using Likelihood*. Oxford: Oxford University Press. A great, compact reader is Eliason, Scott R. 1993. *Maximum Likelihood Estimation: Logic and Practice*. Newbury Park: Sage. I will not require you to buy either of these books, though I do consider them a great investment.

We will also read political science applications of the models covered here. They will all be available from JSTOR; if not, they will be distributed electronically.

Your homework assignments will be due in both R *and* Stata. You should have access to these programs, if not your own copies on your personal computer.

Assignments

First, a word on collaboration in graduate-level methods classes: I highly encourage you to work together on all homework assignments. You're encouraged to collaborate to find solutions to coding problems and to adapt the code we discuss in class to the homework problem. What is prohibited, however, is sharing *written* answers. When I ask you application questions, or ask you to interpret a model and/or inferences from a model, you must work alone and in your own words.

This also extends to midterm and final examinations. These are take-home exams. You can consult any textbook materials, online materials, or class notes that you like. You can even consult other students. The goal of this course is to learn MLE and be able to use it in your research: a goal often best achieved through collaboration. At the end of the day, however, you must write your own answers. Your explanations of MLE and interpretations of the models estimated must be in your own words. Sharing written work undermines your own understanding of MLE (which is bad considering that you are training to be a practitioner of MLE!) and constitutes plagiarism. When in doubt, just ask me.

With that said, the course is divided into the following components:

Homework	15%
Midterm examination	25%
Final examination	35%
Final paper	25%

In order, those components are ...

Homework: these are weekly exercises. I will give you a dataset and code to run in both Stata and R (most weeks) to estimate a model illustrative of that week's MLE concepts. I will ask a few short questions regarding the code and the models estimated. You should turn in your output (such as a Stata log file or R output) and your answers to the questions.

Midterm examination: a typed examination that will include the principles of MLE and a specific application. It will be assigned Week 8: assigned on the Monday of Week 8 and due on the Friday of Week 8. We will not have class that week.

Final examination: a typed examination that will include the principles of MLE and a specific application. It will be assigned Week 15: assigned on the Monday of Week 15 and due on the Friday of Week 15. We will not have class that week.

Final paper: a publishable-quality paper that applies MLE to a research question of your choosing. I am open to this paper being used in a substantive class as well. It is due on XXX. You must meet with me by Week 10 to discuss your proposed research question.

If you fear you will miss any of the deadlines outlined above, please meet with me as soon as possible. If you feel like you are falling behind at any point, please meet with me as soon as possible. I try to make myself as available as possible for graduate-level methods classes.

Now some material that the university requires I provide. [*Statements on cheating, disabilities, inclusion, etc.*]

Course Outline

Week 1: Statistics, Probability, and Inference: Matrix Algebra, R, and Stata

- Long, Chapter 1.
- King, Chapters 1 and 2.
- F/E/H/P, Chapter 33 (Normal).

Week 2: Statistics, Probability, and Inference: The Method of MLE and Its Peers

- F/E/H/P, Chapters 1-6.
- King, Chapter 3.

Week 3: A Familiar Friend: OLS and a Closed-Form MLE Solution (The Normal Model)

- Long, Chapters 1 and 2.
- F/E/H/P, Chapter 33 (Normal).

Week 4: Optimization and Hypothesis Testing: Methods and a Peek Under the Hood

- *Reading to be assigned.* This is fairly technical, so we're going to be looking a lot at code. I will probably scan and distribute Pawitan Chapters 7-9 and Eliason Chapter 3.
- Instead, you should prepare to do a lot of coding, particularly in `R` this week.

Week 5: Extensions of the Normal Model: The Heteroskedastic and Autocorrelated General Linear Models

- King, Chapter 4.
- Franklin, Charles. 1991. "Eschewing Obfuscation? Campaigns and the Perception of Senate Incumbents." *American Political Science Review* 85 (4): 1193-1214.

Week 6: Binary Dependent Variables: Logit and Probit (and the Challenge of Inferences)

- King, Chapter 5.
- Long, Chapter 3.

- F/E/H/P, Chapter 7 (Bernoulli).
- F/E/H/P, Chapter 28 (Logistic).
- Rainey, Carlisle. "Compression and Conditional Effects: A Product Term is Essential When Using Logistic Regression to Test for Interaction." *Political Science Research and Methods. Forthcoming.*

Week 7: Multiple Discrete Choices: Ordered Logit and Probit, Multinomial Logit and Probit

- Long, Chapters 5 - 6.
- F/E/H/P, Chapter 30 (Multinomial).
- F/E/H/P, Chapter 31 (Multivariate Normal).
- Alvarez, R. Michael and Jonathan Nagler. 1995. "Economics, Issues and the Perot Candidacy: Voter Choice in the 1992 Presidential Election." *American Journal of Political Science* 39 (3): 714-744.
- 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* 40(1): 231-260.

Week 8: No Class (Midterm Examination)

Week 9: Continuous Distributions with Truncation: Gamma, Exponential, Weibull, Log Normal, Beta, and Truncated Normal Distributions

- F/E/H/P, Chapter 22 (Gamma).
- F/E/H/P, Chapter 17-18 (Exponential and Family).
- F/E/H/P, Chapter 46 (Weibull).
- F/E/H/P, Chapter 29 (Log-Normal).
- F/E/H/P, Chapter 8 (Beta).
- Brehm, John and Scott Gates. 1993. "Donut Shops and Speed Traps: Evaluating Models of Supervision on Police Behavior." *American Journal of Political Science* 37 (2): 555-581. (Beta example).
- Paolino, Philip. 2010. "Maximum Likelihood Estimation of Models with Beta-Distributed Dependent Variables." *Political Analysis* 9(4): 325-346. (Beta example).
- King, Gary, James E. Alt, Nancy E. Burns, and Michael Laver. 1990. "A Unified Model of Cabinet Dissolution in Parliamentary Democracies." *American Journal of Political Science* 34(3): 846-871. (Gamma example).
- Farrell, Henry and Daniel W. Drezner. 2008. "The Power and Politics of Blogs." *Public Choice* 134: 15-30. (Log-Normal example).

Week 10: Censoring and Truncation

- Long, Chapter 7.
- King, Chapter 9.
- Heckman, James J. 1979. "Sample Selection Bias as a Specification Error." *Econometrica* 47 (1): 153-161.

- Tobin, James. 1958. "Estimation of Relationships for Limited Dependent Variables." *Econometrica* 26 (1): 24-36.
- Dubin, Jeffrey A. and Douglas Rivers. 1989/1990. "Selection Bias in Linear Regression, Logit, and Probit Models." *Sociological Methods and Research* 18(2-3): 360-390.

Week 11/12: Integer Data: Poisson, Negative Binomial, and Generalized Count Models

- Long, Chapter 8.
- King, Chapter 5.
- F/E/H/P, Chapter 35 (Poisson).
- F/E/H/P, Chapter 32 (Negative-Binomial).
- F/E/H/P, Chapter 9 (Binomial).
- Zorn, Christopher J. W. 1998. "An Analytic and Empirical Examination of Zero-Inflated and Hurdle Poisson Specifications." *Sociological Methods & Research* 26 (3): 368-400.
- King, Gary. 1989. "Variance Specification in Event Count Models: From Restrictive Assumptions to a Generalized Estimator." *American Journal of Political Science* 33 (3): 762784.
- Mullahy, John. 1986. "Specification and Testing of Some Modified Count Data Models." *Journal of Econometrics* 33: 341365.

Week 12/13: Duration Models

- Long, Chapter 9.
- Review the distributions from Week 9.
- 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* 41 (4): 1414-1461
- Box-Steffensmeier, Janet M. and Christopher J. W. Zorn. 2001. "Duration Models and Proportional Hazard Models in Political Science." *American Journal of Political Science* 45 (4): 972-988.

Week 14: Innovating MLE Approaches and Original Research on MLE

- Efron, Bradley and Gail Gong. 1983. "A Leisurely Look at the Bootstrap, the Jackknife, and Cross-Validation." *The American Statistician* 37(1): 36-48.
- McCaskey, Kelly and Carlisle Rainey. "Estimating Logit Models with Small Samples." *Working paper.*
- Jordan, Soren and Clayton McLaughlin Webb. "Identifying and Treating Separation in Binary Response Models." *Working paper.*

Week 15: No Class (Final Examination)