# Political Science 6341: Maximum Likelihood Estimation

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Office hours:

M 10:00-11:00

W 12:00-2:00

and by appointment

## Pedagogical Goals

The purpose of this course is to introduce students to the method of maximum likelihood analysis. The course will expose students to the mathematical properties underlying maximum likelihood estimation as well as practical aspects of using maximum likelihood estimation to generate and communicate results of analysis.

## Course Requirements:

Students are responsible for all the material in the readings and discussed in lectures. The only required text for the course is Ward and Ahlquist *Maximum Likelihood for Social Science: Strategies for Analysis*. All other assigned readings are either uploaded to the class's Canvas site or available through the library website (`https://library.unt.edu/`). It is *extremely* important that you attend class having completed the reading. I do not expect that you will understand all of the reading before you come to class, but if your first exposure to the week's material is in class, you will almost certainly do poorly. The grade for this course will be determined by five problem sets (30%), a midterm exam (20%), a reseach paper (25%), and a final exam (25%).

All assignments and exams should be uploaded to the class Canvas site as pdf documents. You can use LaTeX, Word, or any other preferred word processing package, but you must convert the document to pdf before submitting. One purpose of this course is to teach you how to communicate your findings to your audience. Accordingly, when presenting results, you should include properly formatted tables and figures. Pasting the raw output from your analysis is NOT acceptable. Additionally, you should also submit all of the computer code you used to generate your analysis. The code should be written so that anyone can effortlessly and without error reproduce your results.

The research paper should be a fully-formed paper (aiming to be suitable for publication), with a literature review, theory, research design, and results. Early in the semester, you should start thinking about a reseach question whose examination can be best undertaken using the methods from this class. You will also need to develop a research design and identify data that permits a reasonable statistical test of your hypothesis using these methods. As with the other assignments, you will need to submit all information, including all recodes from the original dataset, that is necessary for replicating your work.

The midterm and final exams will be take-home exams where you will have a 24-hour period to complete and submit the exam. These exams will have a combination of questions that require students to display their understanding of the theoretical concepts and ability to apply these concepts.

## Recommended Materials

1. Harvard Government Department [Math Prefresher]. This site covers some fundamental mathematical functions that will better help you understand the foundations of maximum likelihood estimation.

2. King, Gary. 1989. *Unifying Political Methodology*. Cambridge University Press.

3. Maddala. G.S. 1983. *Limited-dependent Variables and Qualitative Variables in Econometrics*. Cambridge University Press.

4. McCullagh, P. and J.A. Nelder. 1983. *Generalized Linear Models*. Chapman & Hall/CRC.

5. Ward and Ahlquist. `http://www.maxlikebook.com/` provides R code that the authors use in their book. You don't need to use R for this course, but their site provides a useful resource if you decide at some point that you need R for some analysis.

**Academic Integrity**

According to UNT Policy 06.003, Student Academic Integrity, academic dishonesty occurs when students engage in behaviors including, but not limited to cheating, fabrication, facilitating academic dishonesty, forgery, plagiarism, and sabotage. A finding of academic dishonesty may result in a range of academic penalties or sanctions ranging from admonition to expulsion from the University. Students should review the policy, which may be located at Academic Integrity Policy Faculty are required to submit reports of violations of academic dishonesty even in instances that do not result in sanctions. There will be no deviation from this policy.

All work turned in for this course must be your own original work. Such actions as plagiarizing by using a source without giving it appropriate credit, or using material written by somebody else or by generative AI/chatbots like ChatGPT and presenting it as your own, represent violations of academic integrity. According to the UNT Academic Integrity Policy (UNT Policy 6.003), any form of "unauthorized assistance" constitutes cheating. As a result, use of any artificial intelligence is not authorized for completion of assignments or exams in this course, unless specifically authorized by the instructor.

**Disabilities Accommodation**

The University of North Texas makes reasonable academic accommodation for students with disabilities. Students seeking accommodation must first register with the Office of Disability Accommodation (ODA) to verify their eligibility. If a disability is verified, the ODA will provide you with an accommodation letter to be delivered to faculty to begin a private discussion regarding your specific needs in a course. You may request accommodations at any time, however, ODA notices of accommodation should be provided as early as possible in the semester to avoid any delay in implementation. Note that students must obtain a new letter of accommodation for every semester and must meet with each faculty member prior to implementation in each class. For additional information see the Office of Disability Accommodation website at UNT Disability Accomodation.

**Emergency Notification & Procedures**

UNT uses a system called Eagle Alert to quickly notify you with critical information in the event of an emergency (i.e., severe weather, campus closing, and health and public safety emergencies like chemical spills, fires, or violence). In the event of a university closure, please refer to Canvas for contingency plans for covering course materials.

1. Introduction to Maximum Likelihood (Aug. 23)

   This class will introduce the basic framework for maximum likelihood analysis and the goals for the semester.

   - Ward and Ahlquist. Ch. 1

2. Theory and Properties of MLE (Aug. 30)

This class will introduce the properties of MLE, with reference and comparison to students' understanding of the properties from OLS.

- Ward and Ahlquist. Ch. 2

3. Binary Choice Models (Sep. 6)

This class will provide students with a more thorough understanding of MLE through the specific application to statistical models with dichotomous dependent variables, such as logit, probit, heteroskedastic probit, and rare events logit.

- Ward and Ahlquist. Ch. 3
- Alvarez, R. Michael and John Brehm. 1995. "American Ambivalence Towards Abortion Policy: Development of a Heteroskedastic Probit Model of Competing Values." *American Journal of Political Science*. 39(4):1055-1082.
- King, Gary and Langche Zeng. 2001. "Logistic Regression in Rare Events Data." *Political Analysis*. 9(2):137-163.

4. Model Selection, Inference, Interpretation, and Presentation of MLE (Sep. 13)

This class will focus upon model selection and the interpretation and presentation of MLE results, with the emphasis upon providing results from binary choice models.

- Ward and Ahlquist. Ch. 5 & 6
- Problem Set #1 due

5. Nominal Choice Models (Sep. 20)

This class will extend the framework for binary choice models into models with dependent variables that multiple categorical responses, such as multinomial logit, multinomial probit, conditional logit, and nested logit.

- Ward and Ahlquist. Ch. 9
- 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.
- Dow, Jay and James Endersby. 2004. "Multinomial Probit and Multinomial Logit: A Comparison of Choice Models for Voting Research." *Electoral Studies*. 23(1):107-122.
- Paolino, Philip. 2021. "Predicted Probabilities and Inference with Multinomial Logit." *Political Analysis*. 29(3):416-421.
- (Recommended) McFadden. 1973. "Conditional Logit Analysis of Qualitative Choice Behavior." (Canvas)

6. Binomial Regression Models (Sep. 27)

This class will extend the framework for binary choice models into models with dependent variables that reflect outcomes of a discrete number of multiple trials, such as binomial and beta-binomial models.

- King, Ch. 5.5-5.6 (Canvas).
- Palmquist, Bradley. 1999. "Analysis of Proportions Data" (Canvas)
- Problem Set #2 due

7. Midterm Exam (Oct. 4). Exam is due at 2:00 pm on Oct. 5.

8. Implementing MLE and Generalized Linear Models (Oct. 11)

   This class will examine the process by which MLE estimates are obtained and the challenges that can arise in models with more complicated likelihood functions and introduce the idea of generalized linear models as a basis for maximum likelihood estimation.

   - Ward and Ahlquist. Ch. 4 & 7
   - McCullough and Nelder. Ch. 2 (Canvas)

9. Ordered Categorical Models (Oct. 18)

   This class will examine MLE for models where the latent dependent variable is continuous, but the observed dependent variable is divided into a discrete number of ordered categories, such as ordered logit, ordered probit, and generalized ordered logit.

   - Ward and Ahlquist. Ch. 8
   - Williams, Richard. 2016. "Understanding and Interpreting Generalized Ordered Logit Models." *Journal of Mathematical Sociology*. 40(1):7-20. paper.
   - McCullough and Nelder, Ch. 3.5.2 (Canvas)

10. Models for Count Data (Oct. 25)

    This class will examine MLE for models where the dependent variable reflects integer number of events, bounded only from below at 0, such as Poisson regression and negative binomial regression.

    - Ward and Ahlquist. Ch. 10
    - Problem Set #3 due

11. Models for Temporal Data and Hazard Models (Nov. 1)

    - Ward and Ahlquist. Ch. 11
    - 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.
    - Box-Steffensmeier, Janet M. and Christopher J.W. Zorn. 2001. "Duration Models and Proportional Hazards in Political Science." *American Journal of Political Science*. 972-988.
    - Problem Set #4 due

12. Censored and Missing Data (Nov. 8)

    - Ward and Ahlquist. Ch. 12
    - Maddala, Ch. 6 (Canvas)
    - Sigelman, Lee and Langche Zeng. 2000. "Analysis Censured and Sample-Selected Data with Tobit and Heckit Models." *Political Analysis*. 8(2):167-182.
    - Dubin, Jeffrey A. and Douglas Rivers. 1989. "Selection Bias in Linear Regression, Logit, and Probit Models." *Sociological Research & Methods*. 18(2-3):360-390.
    - (Recommended) Heckman, James J. 1979. "Sample Selection Bias as a Specification Error." *Econometrica* 47(1):153-161.
    - Problem Set #5 due

13. Models for Proportional Data (Nov. 15)

    - Paolino, Philip. 2001. "Maximum Likelihood Estimation of Models with Beta-Distributed Dependent Variables." *Political Analysis*. 9(4):325-346.

    $\Longrightarrow$ No class Nov. 22 because of the Thanksgiving

14. Models for Correlated Data (Nov. 29)

    - Agresti, Ch. 8-10. https://mregresion.files.wordpress.com/2012/08/agresti-introduction-to-categorical-data.pdf

15. Presentations (Dec. 6)

    For this week, students will present their research papers, with time alloted after each for students' comments and questions.

16. Final Exam (Dec. 12-15). Students can choose any 24-hour period during exam week to take the final exam.