Multilevel Models II: Advanced Topics

John Poe, University of Kentucky
Office TBA
Office Hours TBA
jdpo223@g.uky.edu

TA: Chris Schwarz, New York University
Office TBA
Office Hours TBA
cschwarz@nyu.edu

TA: George Williford, University of Georgia
Office TBA
Office Hours TBA
williford@uga.edu

Course Description

This course is designed to extend the basic multilevel skills that participants receive from an introductory applied class to more sophisticated and complex models like nonlinear and non-hierarchical mixed effects models.

In the first week, we will review the basics of multilevel models, discuss models with non-hierarchical structures, and compare likelihood and Bayesian multilevel models. In the second week, we discuss generalized linear mixed models for non-linear outcomes. In the third week, we discuss models focused on group-level endogeneity or omitted variable bias. In the final week, we focus on mixed effects models for causal inference with observational data.

The course is at about the same technical level of other Track III courses, such as Maximum Likelihood Estimation II: Advanced Topics. Prior exposure to maximum likelihood or basic categorical models as well as some previous background in either multilevel or longitudinal modeling is a prerequisite. Ideally, students will have had courses like the Maximum Likelihood Estimation I and Multilevel Models I classes at ICPSR prior to attending. The primary goal of the course will be to allow students to use advanced models and to understand how and when more sophisticated techniques will provide practical benefits.
Readings

There is no required book for purchase. Required and (some) recommended readings from book chapters and articles will be provided in the class shared drive. You are expected to read material that is marked as required. Recommended readings are designed to give you further knowledge on any given topic at a later date. Below is a set of recommended books that will cover many of these advanced topics. You should probably buy at least some of these books for your library. I recommend Hox (2017) and/or Snijders and Bosker (2011) for basic references. For advanced references, the three handbooks of multilevel modeling: De Leeuw, Meijer, and Goldstein (2008) Hox and Roberts (2011) and Scott, Simonoff, and Marx (2013) are all terrific. For broader (accessible) theories of how multilevel models fit into broader statistics, I strongly recommend Skrondal and Rabe-Hesketh (2004) and Hodges (2013).

Software Books


Recommended Multilevel Books (Introductory/Intermediate):


Recommended Multilevel Books (Advanced/Specialized):

Software
This class is designed to be somewhat agnostic to the kind of software that you want to use. Different people in different fields have different preferences and I'm not going to tell you what you should use for your own work. However, this is an advanced topics class and I guarantee you that some topics are not practical in your preferred software. If you want to be able to do everything that this course covers, you'll need to be flexible about the tools that you use. The instructor and TAs can provide practical help with R & Stata. I've assigned some readings on specialized R packages mainly because they are useful for teaching concepts. Similar packages in Stata (or SAS & SPSS) tend to be canned as part of the program and thus in the main documentation files.

Homework
The homework assignments are designed to help you think through complex conceptual problems as well as helping you gain some practical experience implementing the techniques in the class. You'll be given notes on code to do these exercises in both R and Stata. While homework is not required of any student, doing these assignments while you can ask the instructional staff questions will be easier than trying to do them after the course. The homework assignments are due (for any participant who chooses to do them) on the first three Fridays of the course since we will discuss them in class the following week. You are strongly encouraged to do them if you want to get the most out of this class.

Paper
Any student interested in a grade will need to turn in the analytical portion of a seminar paper using advanced methods covered in this course. If you have some other advanced multilevel model that is not covered in this course but is required for your analysis you will need to consult with me about it in person. However, even if you plan to use a model covered in this course you should feel strongly encouraged to speak to me about it in person as well. Ideally, this is a paper that you have worked on previously where you want to build up the methods section but a new topic is fine. Do not try to do a project for which you do not currently possess data unless you plan to simulate data. If you plan to get a grade, please submit the following milestones to me (by email) by the deadlines below.

Wednesday, August 1
- The initial topic
- Hypotheses
- Descriptive statistics
- A stab at an analytical plan

Wednesday, August 8
- A full draft of the analytical plan
- Model results with interpretation (and code to generate them)
- A stab at diagnostics

Friday, August 17
- Final draft due by noon
WEEK 1: BASIC MULTILEVEL MODELS

Monday: Introduction to the Class

- Introductions and Overview of the Class
- Basic Assumptions and the Problems of Correlated Data
- The Semantics of Fixed, Random, and Mixed Effects Models Across Fields

Required Readings


Recommended Readings


Tuesday: Multilevel Models

- Standard Error Corrections
- Fixed and Random Effects
- Centering Variables and Effects
- Random Coefficients Models
- Shrinkage

Required Readings

- Mahr, Tristan. (2017) Plotting partial pooling in mixed-effects models Blog Post

Recommended Readings


**Wednesday: Cross-Classified and Multiple Membership Models**

• Multiple Membership Models
• Cross-Classified Models
• Cross-Classified Mixed Membership Models

**Required Readings**


**Recommended Readings**


**Thursday: Maximum Likelihood & Bayesian Multilevel Models**

• The Machinery of Linear Models
• Points and Distributions
• Probability Theory
• Priors and Hyperpriors

**Required Readings**


Recommended Readings


Friday: MLE and Bayes Under the Hood

• Numerical Optimizers

• Old-Style Integration

• MCMC

• EM and VB

Required Reading


Recommended Reading


WEEK 2: NONLINEAR MODELS

Monday: GLMs & How Random Effects Are Estimated

• Linear, Generalized, and Simulated Models
• Random Effects in Linear Models
• Random Effects in Nonlinear MLE
• Random Effects in Bayesian Models

Required Readings

• None Today

Recommended Readings


Tuesday: Multilevel Binary Outcomes I—Basics

• LPM, Probit, Logit, Clog-log, and Generalized Linear Mixed Models
• The Incidental Parameters Problem, Random Effects Misspecification, & other Nightmares
• What Likelihood, Simulated Likelihood, and Bayesian Variations Do Differently

Required Readings


Recommended Readings


Wednesday: Multilevel Binary Outcomes II—Latent Variables

• Empirical Bayes Predictions, Predicted Probabilities, and Marginal Effects

• Multilevel Regression and Post-stratification (MRP)

• Multilevel Item Response Theory (MIRT)

Required Readings


OR


Recommended Readings (MRP)


Recommended Readings (IRT)


Thursday: Multilevel Event History Models

- Logit
- Frailty Models
- What Likelihood, Simulated Likelihood, & Bayesian Models Do Differently

Required Readings


Recommended Readings


Friday: Multilevel Ordered and Multinomial Choice Models

- Generalizations of the Probit and Logit
- The Multiple Intercepts Problem
- Mixed Logit
Required Readings


Recommended Readings


WEEK 3: MODELING COMPLEX AND ENDOGENOUS STRUCTURES

Monday: Omitted Variables, Interactions, and Levels

• Endogeneity, Multilevel Models, and the Idea of Instrumentation
• Cluster Confounding
• Omitted Higher Level Effects
• Exchangeability Violations
• Diffusion
• Dynamics

Required Readings


Recommended Readings

Tuesday: Multilevel Repeated and Rolling Cross-Sections

- Fixed, Random and Mixed Effects Models with Time
- Temporal Autocorrelation
- Pattern Covariance Structures
- Cointegration Problems

Required Readings

- None Today

Recommended Readings


Wednesday: Multilevel Spatial Models

- Spatial Autocorrelation Within Groups
- Spatial Autocorrelation Between Groups
- Spatial Autocorrelation Across Group Boundaries
- Spatial Lag Models, Diffusion, and Joint Exposure

Required Readings

Recommended Readings

  ◦ RStudio Tutorial on spatially correlated random effects with INLA
Thursday: Multilevel Network Models

- Basic Network Structures
- Should you use a network model or a multilevel model?
- Network Autocorrelation Within Groups
- Network Autocorrelation Across Groups
- Network Lag Models

Required Readings


Recommended Readings


Friday: Modeling Complex Structures Systematically

- Space, Time, and Network Structures
- Autocorrelation
- Endogeneity
WEEK 4: MULTILEVEL CAUSAL INference

Monday: Multilevel Matching Models

• Multilevel Propensity Score Matching
• Coarsened Exact Matching

Required Readings


Recommended Readings

• Kim, J.S., & Steiner, P.M. Multilevel propensity score methods for estimating causal effects: A latent class modeling strategy. International Meeting of Psychometric Society Proceedings


• https://cran.r-project.org/web/packages/multilevelPSA/multilevelPSA.pdf


\textbf{Tuesday: Multilevel Selection Models}

• Heckman Selection Models
• Control Functions

Required Reading


Recommended Reading


\textbf{Wednesday: Heterogeneous Treatment Effects}

• Experimental Designs
• Difference in Difference
• Interactive Treatment Effects

Required Reading

Recommended Reading


Thursday: Course Review and Q&A

• Whatever participants want to discuss relating to multilevel models