**Description**: This workshop is designed to (re)introduce you to basic hierarchical linear modeling from the perspectives of psychometrics (multilevel modeling), econometrics (correlated random effects modeling), and statistics (mixed effects modeling). We will then move beyond basic fixed and random effects modeling to more advanced topics for complex data structures and non-linear outcomes. Finally, we will walk through some of the conceptual and practical differences between standard (likelihood-based) multilevel modeling and Bayesian hierarchical modeling.

This workshop is not intended to be overly mathematical. It is designed to give you practical intuition behind complex model structure, diagnostics, and interpretation. By the end of the workshop you should (eventually) be able to do the following:

- Figure out how to set up basic and complex multilevel models in robust ways
- Interpret the right diagnostics to understand if you need more or less complicated models
- Understand the practical benefits of standard and Bayesian multilevel models
- Understand computational tradeoffs in speed, accuracy, the ability to produce any estimates at all (without changing software)
- Translate multilevel modeling papers written from an econometrics, psychometrics, and statistics perspective into a common language
Day 1: Thinking Through Multilevel Models

Morning 1: Overview and Basics of Clustered Data Problems

- Basic Assumptions and the Problems of Correlated Data
  - Standard Error Problems
  - Cluster Confounding
  - Heterogeneous Effects Across Groups
- The Semantics of Fixed, Random, and Mixed Effects Models Across Fields

Suggested Reading

Morning 2: Multilevel Models

- Fixed and Random Effects
- Hierarchical Linear Modeling
- Group-Mean and Grand-Mean Centering in 2 or More Levels
- Random Coefficients Models

Suggested Readings

Afternoon 1: Some Implications of Badly Structured Data

- The Hausman Test & the Mundlak Test
- Too Few Groups
- Small Groups
- Correlated Groups
- Large Numbers of Levels
- Badly Modeled Subpopulations

Suggested Readings

Afternoon 2: Fit, Diagnostics, and Being Properly Paranoid about your Model

- The Intraclass Correlation Coefficient
- Wald tests, P values, & LR Tests
- Outlier Diagnostics
- Residual and Random Effect Diagnostics

Suggested Readings

  - Oliveresampler: Bootstrap Methods for Nested Linear Mixed-Effects Model

Day 2: Complex Structures

Morning 1: Multilevel Network Models

- Egocentric Network Models
- Actor-Partner Models
- Cross-Classified and Multiple Membership Models
- Whole Network Models

Suggested Readings


**Morning 2: Multilevel Spatial Models**
- Spatial Correlation at Different Levels
- Spatially Correlated Random Effects Modeling
- Spatial Random Coefficients

**Suggested Readings**

**Afternoon 1: Panel Data and Multilevel Modeling**
- Fixed, Random and Mixed Effects Models
- Pattern Covariance Structures
- Lags

**Suggested Readings**
Afternoon 2: Repeated or Rolling Cross-Sections

- Fixed, Random, and Mixed Effects Models
- Growth Curve Models
- (Basic) Cointegration Problems

Suggested Readings


Day 3: Generalized Linear Mixed Models

Morning 1: Likelihood, Simulated Likelihood, and Bayesian-flavored Multilevel Models

- Generalized Linear Mixed Models
- Optimization vs. Approximation vs. Simulation
- Link functions, priors, and distributional assumptions

Suggested Reading


Morning 2: How Random Effects Are Estimated

- Linear Models
  - Maximum Likelihood (MLE)
  - Restricted Maximum Likelihood (REML)
- Non-Linear Models
  - Linearization
  - Laplace Approximation
  - Marginal Quasi Likelihood (MQL)/Penalized Quasi Likelihood (PQL)
  - Quadrature & Adaptive Quadrature
  - MCMC and Quasi-MCMC
  - Expectation Maximization (EM) and Variational Bayes

Suggested Readings


Train, Kenneth E. 2009. Discrete choice methods with simulation: Cambridge university press. Ch. 8-10

Rabe-Hesketh, Sophia, and Anders Skrondal. 2012. "Multilevel and Longitudinal Modeling Using Stata." Ch. 10


Afternoon 1: Multilevel Binary Outcomes
- LPM, Probit, Logit, Clog-log, and Generalized Linear Mixed Models
- The Incidental Parameters Problem, Random Effects Misspecification, and other Nightmares
- What Likelihood, Simulated Likelihood, and Bayesian Variations Do Differently

Suggested Readings
- Rabe-Hesketh, Sophia, and Anders Skrondal. 2012. "Multilevel and Longitudinal Modeling Using Stata." Ch. 10
- Beck, Nathaniel. 2015. Estimating grouped data models with a binary dependent variable and fixed effects: What are the issues? Paper read at annual meeting of the Society for Political Methodology, July.