

# Measurement and Latent Trait Models

## L32 539

CLASS MEETING  
Friday  
11:00 AM - 1:00 PM  
Seigle Hall 205

OFFICE HOURS  
Tuesday: 9:00 AM - 11:00 AM  
and by appointment  
Seigle Hall 243

### Instructor Information

Jacob M. Montgomery, Ph.D.  
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### Course Description

This class is an advanced quantitative methods course in which we will derive, fit, and analyze latent variable models commonly used in social science research. The ultimate goal is to give students the requisite skills and knowledge to apply these models in their own research. The course will focus on building foundational skills needed to engage contemporary measurement models and estimation techniques. In addition, the course will survey prominent and promising models in the political science, statistics, and psychology literatures.

### Prerequisites

Students are expected to have previously taken a graduate level course in linear models and maximum likelihood. Students should also be comfortable with the basic elements of matrix algebra. It is desirable (although not required) that students also have some background in the Bayesian approach to statistical inference.

### Learning objectives

By the end of this course, you will be able to:

- Validate a proposed measure;
- Explain the difference between prominent approaches to estimating latent traits;
- Fit factor models for categorical and continuous latent traits; using continuous, dichotomous, polytomous, and mixed indicators;
- Research and explain more advanced measurement models in the literature; and,
- Estimate and present a measurement model **of theoretical interest**.

## **Plan of the course**

The basic outline of the course is divided into three components. We will begin by exploring basic concepts in theories of measurement validity. In this initial period, we will also review some needed concepts from matrix algebra and statistical inference. The bulk of the course will be spent analyzing and applying latent trait and latent class models using different types of observed indicators including continuous, dichotomous, and categorical data. During this period, students will also present overviews of more advanced methods in the literature. In the final unit, students will present the results of their own empirical analysis to the class.

## **Textbooks**

In addition to assigned readings that will be posted on Blackboard, the following books are required and can be purchased at the bookstore.

David Bartholomew, Martin Knott, and Iriini Moustaki. 2011 *Latent Variable Models and Factor Analysis: A Unified Approach, 3rd edition*. John Wiley and Sons, Ltd.

David A. Harvill. 1997. *Matrix Algebra From a Statistician's Perspective*. Springer.

Timothy A Brown. 2006. *Confirmatory Factor Analysis for Applied Research*. Guilford Press.

## **Academic Honesty**

Cheating and plagiarism will not be tolerated. All students are expected to adhere to high standards of academic integrity. In this class especially, that means that all work presented as original must, in fact, be original, and the ideas and contributions of others must always be appropriately acknowledged. Quotations must, of course, be acknowledged, but so must summaries, paraphrases, and the ideas of others. If you have any doubts or questions about documentation requirements, **please ask me**. Don't guess.

## **Religious observances**

Some students may wish to take part in religious observances that occur during this academic term. If you have a religious observance that conflicts with your participation in the course, please meet with me before the end of the second week of the term to discuss appropriate accommodations.

## **Students with disabilities**

Students with disabilities enrolled in this course who may need disability-related classroom accommodations are encouraged to make an appointment to see me before the end of the second week of the term.

### **Late assignments – don't do it**

Late assignments will not be accepted and no incompletes will be given for assignments or the course. Exceptions will be granted only under truly extraordinary circumstances at the request of your Director of Graduate Studies. This means that *you need to plan ahead*. When in doubt, turn your assignment in early. Late assignments will not be allowed due to delayed flights, midterms in other classes, etc.

### **Requirements and Evaluation**

Grading in this class will be based on the components described below.

#### **Take home exam – 20%**

There will be a take home exam due at the end of the class.

#### **Final poster – 30%**

In consultation with me, students will choose a research project on which to apply an advanced measurement model presented or discussed in class. Preliminary research plans including a topic and summary statistics of the dataset will be due after Spring Break. First drafts of the poster are due to me two weeks before the scheduled date of the poster session.

#### **In-class presentations – 20%**

During the semester, students will be asked to research and explain more advanced measurement models. These models will be chosen in consultation with me, and don't show up in my office two days before the presentations are due. Presentations should be approximately 30-45 minutes, and must include at least one application of the method from the political science literature. Outstanding presentations will include fitted results from your own analysis along with practical advice for students seeking to fit the model.

#### **Problem sets – 30%**

There will be a problem set due for every class period through 4/5.

#### **Grading scale**

The course is graded on the 10 point scale below. There will be no exceptions. Don't ask.

Score	Grade	Score	Grade	Score	Grade	Score	Grade
≥94	A	≥83	B	≥ 73	C	≥63	D
≥90	A-	≥80	B-	≥ 70	C-	≥60	D-
≥87	B+	≥77	C+	≥ 67	D+	<60	Fail

## Teaching Assistants

There is one graduate teaching assistant who is available to help with problem sets.

*Constanza F. Schibber*

Email: [cfiguero@wustl.edu](mailto:cfiguero@wustl.edu)

Office Hours: Wednesday from 11:00 AM - 1:00 PM

Office: Seigle 256

## Software

The class has no official statistical package, and students may use any statistical software that allows them to complete the homework. I will focus on teaching the R statistical package (<http://www.r-project.org/>), JAGS (<http://mcmc-jags.sourceforge.net/>), and MPlus (<http://www.statmodel.com/>). The latter is quite expensive and I will not require you purchase it. But if you are not confident in your own programming skills in the other programs, MPlus is going to make this class a lot easier.

Flexibility and self-motivation will be required by students. We will try to provide some guidance, but there is no way to figure out how to fit models other than to fit them.

## Tentative Schedule

Session #	Date	Topic
1	1/18	Introduction/Basic measurement concepts
2	1/25	Matrix algebra refresh
3	2/1	The general linear factor model
4	2/8	The normal linear factor mode
5	2 /15	Confirmatory factor analysis
6	2/22	Dimensionality, model fit, and model comparison
7	3/1	Dichotomous indicators
8	3/8	Ordered categorical indicators
–	3/11	Spring Break!
9	3/22	Latent class analysis & Mixture models
10	3/29	MTMM, multiple groups†, and MIMIC†
11	4/5	Martin & Quinn/ Computerized Adaptive Testing
–	4/11	Class Cancelled (MPSA)
12	4/19	Mixed indicator models† & LCA application † & Mixture application †
13	4/26	Poster session
	5/2	Take home exam due

† Topic will be assigned to a student for presentation

## Assigned Readings

- 1 Handbook of political methodology: Goertz, Jackman, Poole
- 2 Harville: Chapters 4, 5, 6, 8, 12, 21
- 3 BKM: Chapters 1-2
- 4 BKM: Chapter 3; Brown Chapters 1-2
- 5 Brown: Chapters 3-4; BKM Chapters 3 & 8
- 6 Brown: Chapter 5; Crespin & Rohde (2010)
- 7 BKM: Chapter 4; Clinton, Jackman, Rivers (2004)
- 8 BKM: Chapter 5; Jackman and Treier (2008)
- 9 BKM: Chapter 6;
- 10 Brown: Chapters 6 & 7
- 11 Martin & Quinn (2002); Montgomery & Cutler (Forthcoming)
- 12 Quinn (2004); Bagozzi and Mukherjee (2012); Linzer and Lewis (2011)

## Due dates

- Feb. 25 HW4
- Mar. 1 HW5
- March 8 HW6
- March 18 Poster plan. This should be a one page summary including the dataset, software, and citations to the specific model. One page will do.
- March 22 HW7
- March 29 HW8
- March 29 Presentation: Jen & Jesse (Groups); Kevin and Mi Jeong (MIMIC)
- April 19 Presentations: Patrick & Tilko (Mixed indicators); LCA (Viktoryia & Adrian); Mixture (Michael & Alicia)
- April 26 Posters due (turn in poster file along with COMMENTED replication code)
- May 2 Take home exam given at 9:00AM and collected at 5:00PM

## Extra readings for class presentations

- MIMIC models:
  - Perez (2011) *Political Analysis*
  - Muthen (1989) *Psychometrika*
  - Brown: Chapter 7
- Multiple groups
  - Layman and Carsey (2002) *AJPS*
  - Byrne and Watkins (2003) *Journal of Cross-Cultural Psychology*
  - DeSante and Smith (2012)

## Suggested research topics

More advanced topics that students may research include

- Missing data
- Cluster analysis
- Dynamic factor analysis
- Growth models
- Anchoring & Bridging
- Semi-parametric IRT
- BMA factor analysis
- Topic models
- Hierarchical IRT
- Network positions/community detection

## Bibliography

Bagozzi, Benjamin E. and Bumba Mukherjee. 2012. "A Mixture Model for Middle-category Inflation in Ordered Survey Responses." *Political Analysis*. 20(3): 369-386.

Byrne, Barbara M. and David Watkins. 2003. "The Issue Of Measurement Invariance Revisited". *Journal of Cross-Cultural Psychology* 34: 155-175.

Clinton, Joshua, Simon Jackman, and Douglas Rivers. 2004. "The Statistical Analysis of Roll Call Data." *American Political Science Review* 98(2):355-370.

Crespin, Michael and David Rohde. 2010. "Dimensions, Issues, and Bills: Appropriations Voting on the House Floor." *Journal of Politics* 72(4):976-989.

DeSantis, Christopher and Watts Smith, Candis. 2012. "New Attitudes or Old Measures? Determining the Level, Structure and Role of Racial Attitudes among the Millennial Generation." <http://www.oberlin.edu/faculty/cdesante/assets/downloads/oldmeasures.pdf>, Unpublished Manuscript.

Layman, Geoffrey, and Thomas M. Carsey. 2002. Party Polarization and Conflict Extension in the American Electorate. *American Journal of Political Science* 46(4): 786802.

Linzer, Drew A. and Jeffrey B. Lewis. 2011. "poLCA: Polytomous Variable Latent Class Analysis." *Journal of Statistical Software* 42(10): 1-29.

Martin, Andrew D. and Kevin M. Quinn. 2002. "Dynamic Ideal Point Estimation via Markov Chain Monte Carlo for the U.S. Supreme Court, 1953-1999." *Political Analysis* 10:134-153.

Montgomery, Jacob and Josh Cutler. Forthcoming. "Computerized Adaptive Testing for Public Opinion Surveys". *Political Analysis* forthcoming.

Muthn, B.. 1984. "A general structural equation model with dichotomous, ordered categorical, and continuous latent variable indicators." *Psychometrika* 49, 115-132.

Quinn, Kevin. 2004. "Bayesian Factor Analysis for Mixed Ordinal and Continuous Responses". *Political Analysis* 12:338353.

Pérez, Efrén O. 2011. "The Origins and Implications of Language Effects in Multilingual Surveys: A MIMIC Approach with Application to Latino Political Attitudes." *Political Analysis* 19(4): 434-454.

Treier, Shawn and Simon Jackman. 2008. Democracy as a Latent Variable. *American Journal of Political Science*. 52(1): 201217.