Psych 770 – Latent Variable Modeling

Fall 2021
Wednesday 2:30 – 5:15

Dr. Irwin D. Waldman
Office: PAIS Building, Room 475
Phone: 727-7430; EMAIL: psyiw@emory.edu
Office Hours: Virtually, by appointment

Required Texts (Plus selected articles and chapters listed below):
1) Loehlin, J.C. & Beaujean, A. A. (2016). Latent Variable Modeling (5th ed.). Hillsdale, NJ: Erlbaum (**LVM**).
Supplementary Text (I'll be listing some supplementary texts that emphasize Mplus, but below is one on lavaan):
1) Beaujean, A. A. (2015). Latent Variable Modeling Using R: A Step-by-Step Guide. New York, NY: Routledge (**Rlavaan**).

A note on statistical software: We will use Mplus to conduct analyses, but time permitting we will also try to examine how to use lavaan in R when possible. Mplus has the advantages of being a very popular LVM program that is very flexible and has a large literature supporting it. Unfortunately, the full version is very expensive. lavaan is a free program in R and thus represents the direction in which statistical programming is moving in the future. It has a bit of a steep learning curve (at least for me!) especially regarding data access and management in R, cannot perform certain analyses that are often required, cannot handle nested data, and is newer and thus has a bit less literature supporting it at present. This all being said, note that in this course we will focus on learning the fundamentals and concepts underlying Latent Variable Modeling, as well as on how to implement relevant analyses in Mplus. But it is not a cookbook, "how to" course, such as one would get in a 3- or 5-day Workshop.

Content: In this course we will examine various aspects of latent variable modeling using the Mplus (and perhaps lavaan programs) as a statistical framework for addressing substantive issues in psychometrics and measurement, and causal modeling / path analysis. The course will include a mix of theoretical, conceptual, and "hands-on" approaches both in general and centered around these specific substantive applications.

We will begin by quickly reviewing simple and multiple regression, and then -- after a consideration of the nature of causality embodied in structural equation models -- examine the basic statistical concepts and methods necessary for the analysis of various latent variable models. These concepts will include path diagrams and tracing rules, model specification and identification, solving a set of simultaneous equations, and estimation methods such as least squares and maximum likelihood and their extensions. We then will proceed to the application of structural equation modeling to causal modeling and path analysis with manifest and latent variables. Next, we will explore the use of latent variable models via confirmatory and exploratory factor analysis for: 1) testing psychometric hypotheses regarding the equivalence of multiple measures of constructs, 2) testing hypotheses regarding the underlying structure of a single measure within a population, and 3) testing hypotheses regarding the underlying structure of a measure across groups (i.e., measurement and structural invariance). We also will investigate Item Response Theory (IRT) as a complementary method for exploring issues in measurement and construct validity and will contrast it with CFA and classical measurement theory. We then will have **one or more** sessions on structural relations among variables, including models for testing mediation and moderation. We will then proceed to have a session or so exploring the use of Monte Carlo Simulations for investigating latent variable models and their properties. We will end the course with 1 or 2 sessions on advanced issues in latent variable models that will include the treatment of non-normally distributed data, the handling of missing and nested data, sample size and power, and applications to psychiatric classification. Please note that the syllabus is somewhat fluid, in that some topics may take a bit longer to cover than anticipated, and some articles may be added, some may be dropped, and some may be replaced through the course of the semester.

The primary goals for the course are to furnish students with an adequate conceptual and working understanding of latent variable modeling, such that they will be competent users of these techniques in their own research and effective critics of the application of these techniques in others' research.

Assignments: There will be **five** assignments spread throughout the semester integrating statistical analyses on computer with concepts learned in class. Analyses will be done either by hand or using the Mplus or lavaan analysis packages. With the exception of Assignment 1, which will be due one week after it is distributed, assignments will be due 2 weeks after they are distributed. There will be no exceptions to this and no extensions given; students will be penalized one grade for every week that their assignment is late. Assignments will be graded in a categorical fashion using the following scheme: 5=Excellent; 4=Very good; 3=Good; 2=OK; 1=Marginal. Each of the 4 or 5 assignments will count 15% or 20% toward the final grade. Student presentations of final projects and class participation will count for the remaining 20% or 25% of the final grade.

Note that all assignments must be submitted electronically, no paper will be accepted.

Grading will be as follows:

A: Average grade on assignments close to 5
A-: Average grade on assignments close to 4
B+: Average grade on assignments close to 3.5
B: Average grade on assignments close to 3
B-: Average grade on assignments $\leq$ 2.5

Software: We will use a copy of the program Mplus located on Dr. Rohan Palmer's server; details on how to access it will be provided. To get started trying out the program if you so desire, you can also download a student trial copy from http://www.statmodel.com. You can also use R and lavaan (if you so desire). Mplus may also be available on the computers in PAIS 361, and through certain faculty members' labs (though this may not be the best moment to hang out in a lab on campus). Special student pricing is available for Mplus. Information is available at the same website.

Course Outline (Note that some readings may be added or deleted on a weekly basis)

8/25&9/1. Week 1&2 — Organizational meeting / Introductions, with student research interests; review syllabus, brief description of *Mplus* & lavaan?
Review of estimation and testing in simple and multiple regression analysis

Reading: Review appropriate chapters in Cohen, Cohen, West, & Aiken, Applied Multiple Regression / Correlation Analysis for the Behavioral Sciences; review class notes from Multiple Regression class and other materials I suggested in my email.
Tversky, A. & Kahneman, D. (1971). Belief in the law of small numbers. *Psychological Bulletin, 76,* 105-110.
Cohen, J. (1990). Things I've learned (So far). American Psychologist, 45, 1304-1312.

9/8 Week 3 — Causality in structural equation modeling / Introduction to path analysis and structural equation modeling (SEM); MPlus example

Reading: Einhorn, H.J. & Hogarth, R.M. (1986). Judging probable cause. Psychological Bulletin, 99, 3-19.
Meehl, P.E. (1973). High school yearbooks: A reply to Schwarz. In Psychodiagnosis: Selected Papers, 174-181.
Platt, J.R. (1964). Strong inference. Science, 146, 347-353.
Loehlin, J.C. & Busjean, A. (2016). **LVM** Ch. 1 Path models in factor, path, & structural analysis.

9/15 Week 4 — Path analysis and SEM (Cntd.) / Getting Started with *Mplus* and lavaan / Introduction to the *MPlus* & lavaan software;

Reading: Hayduk, L.A. (1987). Ch.5 Estimating structural coefficients with maximum likelihood estimation. Structural equation modeling with LISREL: Essentials and advances. Baltimore, MD: Johns Hopkins University Press.
Loehlin, J.C. & Busjean, A. (2016). **LVM** Ch. 2 Fitting path models.
Rlavaan. Ch 1. Introduction to R, and Ch. 2. path models and analysis. ??
Assignment 1 distributed: Path Tracing Rules

9/22 Week 5 — Introduction to Confirmatory Factor Analysis (CFA)

Reading: Cole, D.A. (1987). Utility of confirmatory factor analysis in test validation research. *Journal of Consulting and Clinical Psychology*, *55*, 584-59.
Likely replace with Greg Smith 2006 paper *Psychological Assessment* paper
Loehlin, J.C. & Busjean, A. (2016). **LVM** Ch. 3 Varieties of path and structural models -I
Rlavaan. Ch 3. Basic latent variable models
Assignment 1 due; Assignment 2 distributed: CFA by hand

9/29 Week 6 — The measurement model: Confirmatory Factor Analysis (continued)

Reading: Steven P. Reise (2012) The Rediscovery of Bifactor Measurement Models, Multivariate Behavioral Research, 47, 667-696. [replace with Rodriguez Bifactor paper]
Flora, D.B. & Curran, P.J. (2004). An empirical evaluation of alternative methods of estimation for confirmatory factor analysis with ordinal data. Psychological Methods, 9, 466-491.
Wirth, R. J. & Edwards, Michael C. (2007). Item factor analysis: Current approaches and future directions. *Psychological Methods*, *12*, 58-79.
Rlavaan. Ch. 6. models with dichotomous indicator variables..

Supplementary: Rhemtulla, M., Brosseau-Liard, P. É., & Savalei, V. (2012). When can categorical variables be treated as continuous? A comparison of robust continuous and categorical SEM estimation methods under suboptimal conditions. *Psychological Methods, 17(3),* 354–373. doi:10.1037/a0029315

10/6 Week 7 — The measurement model: Confirmatory Factor Analysis (continued) / Exploratory Factor Analysis (EFA) and ESEM

Readings:
Loehlin, J.C. & Busjean, A. (2016). **LVM** Ch. 5 Exploratory Factor Analysis – The Basics, 141-170, and Ch. 6 Exploratory Factor Analysis – Elaborations, 180-192 Only.
Marsh, H. W., Muthén, B., Asparouhov. T., Lüdtke, O., Robitzsch, A., Morin, A.J.S., & Trautwein, U. (2009). Exploratory Structural Equation Modeling, Integrating CFA and EFA: Application to Students' Evaluations of University Teaching. *Structural Equation Modeling*, *16*,
Preacher, Kristopher J., Zhang, Guangjian, Kim, Cheongtag, & Mels, Gerhard. (2013). Choosing the Optimal Number of Factors in Exploratory Factor Analysis: A Model Selection Perspective. Multivariate Behavioral Research, 48, 28-56.

Supplementary:
Lykken, D.T. (1971). Multiple factor analysis and personality research. Journal of Experimental Research in Personality, 5, 161-170. ???

(**Assignment 2 due; Assignment 3 distributed: CFA by computer**)

10/13 Week 8 — Exploratory Factor Analysis (EFA) and ESEM (continued) / Item Response Theory (IRT)

Reading:
Embretson, S. E. (2000). The new rules of measurement. In Embretson, S. E. & Reise, S.P. (Eds.), *Item Response Theory in Psychological Research*, New York: Routledge.
Reise, S. P., & Waller, N. G. (2009). Item response theory and clinical measurement. Annual Review of Clinical Psychology, 5, 27-48.
Reise, S. P., & Widaman, K. F. (1999). Assessing the fit of measurement models at the individual level: A comparison of item response theory and covariance structure approaches. Psychological Methods, 4, 3-21.

Supplementary:
Reise, S.P., Widaman, K.F., & Pugh, R.H. (1993). Confirmatory factor analysis and item response theory: Two approaches for exploring measurement invariance. Psychological Bulletin, 114, 552-566.
Liu, Y., Magnus, B., Quinn, H., and Thissen, D. (in press). Multidimensional item response theory. In Hughes, D., Irwing, P., and Booth, T., editors, Handbook of Psychometric Testing. Wiley-Blackwell.

10/20 Week 9 — Exploratory Factor Analysis (EFA) and ESEM (continued) / Item Response Theory (IRT)

Reading:
Embretson, S. E. (2000). The new rules of measurement. In Embretson, S. E. & Reise, S.P. (Eds.), *Item Response Theory in Psychological Research*, New York: Routledge.
Reise, S. P., & Waller, N. G. (2009). Item response theory and clinical measurement. Annual Review of Clinical Psychology, 5, 27-48.
Reise, S. P., & Widaman, K. F. (1999). Assessing the fit of measurement models at the individual level: A comparison of item response theory and covariance structure approaches. Psychological Methods, 4, 3-21.

Supplementary:
Reise, S.P., Widaman, K.F., & Pugh, R.H. (1993). Confirmatory factor analysis and item response theory: Two approaches for exploring measurement invariance. Psychological Bulletin, 114, 552-566.
Liu, Y., Magnus, B., Quinn, H., and Thissen, D. (in press). Multidimensional item response theory. In Hughes, D., Irwing, P., and Booth, T., editors, Handbook of Psychometric Testing. Wiley-Blackwell.

10/20 Week 9 — The measurement model: Measurement Invariance

Reading: Loehlin, J.C. & Busjean, A. (2016). **LVM** Ch. 4 Fitting models involving repeated measures or multiple groups.

Byrne, B.M., Shavelson, R.J., & Muthen, B. (1989). Testing for the equivalence of factor covariance and mean structures: The issue of partial measurement invariance. Psychological Bulletin, 105, 456-66. Too old??? Find more recent paper

Marsh, H. W., Nagengast, B., & Morin, A. J. S. (2012). Measurement invariance of Big-Five factors over the life span: ESEM tests of gender, age, plasticity, maturity, and La Dolce Vita effects. *Developmental Psychology*.

Bowen, N. K. (2014). TESTING FOR DIFFERENCES IN MEASUREMENT (CFA) MODELS USING MPLUS'S INVARIANCE SHORTCUT CODE (WLSMV) (ssw.unc.edu/sswsig/sites/.../MplusinvMay2014v2.docx)

Van de Schoot, R., Lugtig, P., Hox, J. (2012). A checklist for testing measurement invariance. *European Journal of Developmental Psychology*, 1-7.

Rlavaan. Ch. 4. Latent variable models in multiple groups.

Supplementary: Millsap, R. E., & Yun-Tein, J. (2004). Assessing factorial invariance in ordered-categorical measures. *Multivariate Behavioral Research, 39(3),* 479–515.

(Assignment 3 due; Prepare Assignment 4 Description of student projects)

10/27 Week 10 The Structural Model (I): Regression via SEM / Mediation & Moderation / Non-linearity

Readings: Loehlin, J.C. & Busjean, A. (2016). **LVM** Ch. 3 Varieties of path and structural models – II.

MacKinnon, D.P. & Fairchild, A.J. (2009). Current Directions in Mediation Analysis. *Current Directions in Psychological Science*, *18*, 16-20.

MacKinnon, D.P., Lockwood, C.M., Hoffman, J.M., West, S.C., & Sheers, V. (2002). A comparison of methods to test mediation and other intervening variable effects. *Psychological Methods*, *7*, 83-104.

Supplementary: DD Rucker, KJ Preacher, ZL Tormala, RE Petty (2011). Mediation analysis in social psychology: Current practices and new recommendations. *Social and Personality Psychology Compass*, *5*, 359-371.

Baron, R.M. & Kenny, D.A. (1986). The moderator-mediator distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*, 1173-1182.

11/3 Week 11 The Structural Model (II):Simulations / Statistical Power / Non-Normality / Missing Data

Readings: Curran, P.J., West, S.G., & Finch, J.F. (1996). The robustness of test statistics to non-normality and specification error in confirmatory factor analysis. *Psychological Methods*, *1*, 16-29.

Muthen, B. & Muthen, L. (2002). How To Use A Monte Carlo Study To Decide On Sample Size and Determine Power. Available from Mplus website.

Widaman, K.F. (2006). Missing Data: What to do with or without them. In *Monographs of the Society for Research in Child Development*, *71*, 42-64.

One or more papers on simulations, as well as *Mplus* chapter on this.

Rlavaan. Ch 7. Models with missing data, and Ch. 8. Sample size planning.

(Assignment 4 Description of student projects due)

11/10 Week 12 Continuation of Simulations / Discussion of Final Projects

11/17 Week 13 Continuation of Discussion of Final Projects

11/24	Week 14	Thanksgiving – no class
12/1	Week 15	Assignment 5 due: Student Presentations of their final projects Loehlin, J.C. (2004). **LVM** Ch.7. Issues in the application of latent variable analysis, 195-215. Borsboom, D. (2008). Psychometric Perspectives on Diagnostic Systems. *Journal of Clinical Psychology*, *64*, 1089-1108. Likely will replace with a better paper on this topic **(Assignment 5 Presentation of student projects)**