Terry College of Business
*Department of Management*
UNIVERSITY OF GEORGIA

# Structural Equation Modeling

MGMT9610
Fall Semester 2021

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**Class**

Days: Wednesday
Time: 9:00 to 11:45 a.m.
Location: Benson Hall C400 (*please note that you cannot get to the 4th floor of Benson from either the first or second floors of Benson. Rather you must go into Amos Hall – the one in the middle – and walk up to the 4th floor or take the elevator, and walk back into Benson Hall.*).

**Professor**

Name: Bob Vandenberg
Office: Benson Hall C200A
Phone: 706-542-1294
E-mail: rvandenb@uga.edu

Office hours: If you need to see me for any reason, please email me a few alternative days and times, and I will select the one that fits my schedule the best. Or approach me after class to set up a time.

## Course Materials

**Required Textbook:** Kline, R. B. (2016). Principles and Practice of Structural Equation Modeling (4th Ed.). New York: Guilford Publications. 978-1-4625-2334-4

**Optional Textbooks**: *Beaujean, A.A. (2014). Latent Variable Modeling Using R: A Step-by-Step Guide. New York: Routledge.

*Finch, W.H., & French, B.F. (2015). Latent Variable Modeling With R. New York: Routledge.

Bollen, K. A. (1989). Structural Equations With Latent Variables. New York: Wiley-Interscience Publications.

Hancock, G.R. & Mueller, R.O. (2013). Structural Equation Modeling: A Second

Course (2nd Ed.). Charlotte, NC: Information Age Publishing.

*Lance, C.E., & Vandenberg, R.J. (2009). Statistical and Methodological Myths and Urban Legends: Received Doctrine, Verity, and Fable in the Organizational and Social Sciences. New York: Routledge.

*Lance, C.E. & Vandenberg, R.J. (2015). More Statistical and Methodological Myths and Urban Legends. New York, NY: Routledge

*Highly recommended!

**Software:** We will be using the R package, lavaan, through the RStudio interface for the whole semester. Please make sure to first install the latest version of R. You install the free version of RStudio after the R installation. There are a number of commercially available SEM packages available to you such as Mplus, LISREL, EQS, and AMOS. You are welcome to use these, BUT I will neither help you learn those packages nor assist you with any syntax errors. The *one possible exception* to this is Mplus given that I've used it for nearly 22 years. *Possible exception* means that I will not assist you during classtime, and will only do so if you make an appointment with me and have a very specific question. If you need to cite lavaan in any manuscripts that you are submitting for review, please use the following citation: Yves Rosseel (2012). lavaan: An R Package for Structural Equation Modeling. Journal of Statistical Software, 48(2), 1-36. URL http://www.jstatsoft.org/v48/i02/.

This citation was good as of 7/26/2021, but you should google it to make sure a newer citation isn't available.

## Course Objectives

*This course provides a foundation in structural equation modeling methods and techniques. The course progresses from measurement models, including the application of confirmatory factor analysis, to testing actual structural models with single and multiple indicator variables. Emphasis is placed on students actually using the tools.* Underlying this purpose is my sincere hope to demystify SEM. That is, SEM is largely a "glorified" regression procedure, and in that vein, if you have a good grasp of multiple regression, you already have an understanding of some of the basics underlying SEM. Unlike ordinary regression, though, SEM: (a) doesn't assume that measurement error is zero; and (b) can simultaneously estimate parameters representing the whole model rather than just pieces of the model. By the time you complete this course, you will be able to:

- Test and evaluate simple and complex measurement models
- Test and evaluate simple and complex structural equation models
- Understand the importance of model fit and the values used to evaluate it
- Be proficient in your use of your selected SEM software package

## Course Requirements

*Examinations*. There are two mandatory examinations. The midterm exam will be given on October 6th during normal class time and the end-term exam on December 1ST during normal class time. Each examination is worth 30% of your final grade, and thus, collectively account for 60% of your final grade. The exams are all essay and all material covered during a given period is fair game.

*Homework*. There are numerous homework assignments throughout the semester accounting for the remaining 40% of your total grade. I need some flexibility on your part in this respect. In as much as I would like to know what this homework is exactly going to be, I can't do so. The intent, though, is to get you to conduct the analyses yourselves. I will provide the data.

**Class Attendance**

You are Ph.D. students and as such, I am not going to take attendance.

**Academic Honesty Policy and Dealing With Infractions**

As a University of Georgia student, you have agreed to abide by the University's academic honesty policy, "A Culture of Honesty," and the Student Honor Code. Specifically, you made the following oath. *"I will be academically honest in all of my academic work and will not tolerate academic dishonesty of others."* A Culture of Honesty, the University's policy and procedures for handling cases of suspected dishonesty, can be found at www.uga.edu/ovpi. Lack of knowledge of the academic honesty policy is not a reasonable explanation for a violation. Academic dishonesty will not be tolerated. We take personal offense to anyone who plagiarizes, cheats or is dishonest in any way in the course. If any dishonesty occurs in this class, the offender will receive an automatic failing grade on the assignment, will be dismissed from the course with an F, and will be reported to the Office of the Vice President for Instruction to the Coordinator for Academic Honesty, accordingly. In short, don't cheat—it's not worth it.

**Disabilities and Accommodations**

Students with disabilities who require reasonable accommodation in order to participate in course activities or meet course requirements should contact me, the instructor by an appointment. If you plan to request accommodations for a disability, please register with the Disability Resource Center (http://drc.uga.edu), The University of Georgia, 114 Clark Howell Hall, Athens, GA 30602-3338.

**Mental Health and Wellness Resources**

If you or someone you know needs assistance, you are encouraged to contact Student Care and Outreach in the Division of Student Affairs at 706-542-7774 or visit https://sco.uga.edu. They will help you navigate any difficult circumstances you may be facing by connecting you with the appropriate resources or services.
UGA has several resources for a student seeking mental health services (https://www.uhs.uga.edu/bewelluga/bewelluga) or crisis support (https://www.uhs.uga.edu/info/emergencies).

If you need help managing stress anxiety, relationships, etc., please visit BeWellUGA (https://www.uhs.uga.edu/bewelluga/bewelluga) for a list of FREE workshops, classes, mentoring, and health coaching led by licensed clinicians and health educators in the University Health Center.
Additional resources can be accessed through the UGA App.

## Diversity, Equity, and Inclusion

The Terry College is committed to promoting diversity, equity, inclusion, and belonging among its students, faculty, and staff. This class welcomes the open exchange of ideas and values freedom of thought and expression. This class provides a professional environment that recognizes the inherent worth of every person. It aims to foster dignity, understanding, and mutual respect among all individuals in the class.

## Schedule of Events

*The course syllabus is a general plan for the course; deviations announced to the class by the instructor may be necessary.* Specifically, the following schedule is subject to change at the discretion of the professor, department, college and university, and it will change – I can guarantee it.

For the following, "K" means the Kline text. Note that Chapters 5 and 8 are not assigned to read during the semester. However, you may want to consult them.

**8/18 – Course and Regression Overview**

Text:

K: Chapters 2 and 3

Readings:

James, L.R., Mulaik, S.A., & Brett, J.M. (1982). Causal analysis: Assumptions, models and data. Beverly Hills, CA: Sage. (pages 13-59).

Edwards, J.R. (2008). To prosper, organizational psychology should . . . overcome methodological barriers to progress. Journal of Organizational Behavior, 29, 469-491.

Aguinis, H., & Vandenberg, R.J. (2014). An ounce of prevention is worth a pound of cure: Improving research quality before data collection. Annual Review of Organizational Psychology and Organizational Behavior, 1, 569-595.

Homework:

Complete "Your Turn" regression assignments from the booklet – Due 8-24 by 5pm

**8-25 – SEM Overview – Basic Principles**

Text:

K: Chapters 1 and 6, and 4 (Data Preparation)

Readings:

Guide to Social Science Data Preparation and Archiving: Best Practices Throughout the Data Life Cycle (2005). ICPSR, Institute for Social Research, The University of Michigan.

Anderson, J.C., & Gerbing, D.W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. Psychological Bulletin, 103, 411-423.

Williams, L.J., Vandenberg, R.J., & Edwards, J.R. (2009). Structural equation modeling in management research: A guide for improved analysis. The Academy of Management Annals, 3, 543-604.

McDonald, R., & Ho, M.-H. R. (2002). Principles and practice in reporting structural equation analyses. Psychological Methods, 7, 64-82.

Rigdon, E.E. (1994). Calculating degrees of freedom for a structural equation model. Structural Equation Modeling, 1, 274-278.

Cortina, J.M., Green, J.P., Keeler, K.R., & Vandenberg, R.J. (2017). Degrees of freedom in SEM: Are we testing the models that we claim to test? Organizational Research Methods, 20, 350-378.

Rönkkö, M., & Evermann, J. (2013). A critical examination of common beliefs about partial least squares path modeling. Organizational Research Methods, 16, 425-448.

Homework:

Select 3 recently published articles from one of your top journals that used SEM. Using the Cortina et al. (2017) article as a guide, calculate the degrees of freedom from the information in the article. Do your calculations agree with the degrees of freedom reported by the 3 sets of authors? Dues 8-31 by 5pm.

**9-1 – SEM Overview – Model Fit**

Text:

K: Chapter 12

Readings:

Tanaka, J.S. (1993). Multifaceted conceptions of fit in structural equation models. In K.A. Bollen & J.S. Long (Eds.), Testing Structural Equation Models (pages 10-39). Newbury Park, CA: Sage.

Hu, L.T., & Bentler, P. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural Equation Modeling, 6, 1-55.

Williams, L.J., & O'Boyle, Jr., E. (2011). The myth of global fit indices and alternatives for assessing latent variable relations. Organizational Research Methods, 14, 350-369.

O'Boyle, E. H., Jr., & Williams, L.J. (2011). Decomposing model fit: Measurement vs. theory in organizational research using latent variables. Journal of Applied Psychology, 96, 1-12.

How to Evaluate Models – PDF from Unknow Authors

Homework:

Develop an Excel spreadsheet that will execute at least 10 fit indices. Also, using the 3 articles from last week's assignment calculate whether the structural path model adds anything above that of the measurement model per the O'Boyle and Williams articles. Due 9-7 by 5pm.

**9-8 – Measurement Models: Exploratory and Confirmatory Factor Analysis**

Text:

K: Chapters 9 and 13, and 11

Readings:

Bandalos, D.L., & Boehm-Kaufman, M.R. (2009). Four common misconceptions in exploratory factor analysis. In C.E. Lance & R.J. Vandenberg (eds.), Statistical and Methodological Myths and Urban Legends: Received Doctrine, Verity, and Fable in the Organizational and Social Sciences (pp. 61-88). New York, NY: Routledge.

Lance, C.E., & Vandenberg, R.J. (2001). Confirmatory factor analysis. In F. Drasgow & N. Schmitt (Eds.), Measuring and Analyzing Behavior in Organizations: Advances in Measurement and Data Analysis (pp. 221-256, Volume in the Organizational Frontier Series). San Francisco: Jossey-Bass.

Hurley, A.E., Scandura, T.A., Schriesheim C.A., Brannick, M.T., Seers, A., Vandenberg, R.J., & Williams, L.J. (1997). Exploratory and confirmatory factor analysis: Guidelines, issues, and alternatives. Journal of Organizational Behavior. 18, 667-683.

Vandenberg, R.J., & Grelle, D. (2009). Alternative model specifications in structural equation modeling: Facts, fictions, and truth. In C.E. Lance & R.J. Vandenberg (eds.), Statistical and Methodological Myths and Urban Legends: Received Doctrine, Verity, and Fable in the Organizational and Social Sciences (pp. 167-193). New York, NY: Routledge.

Landis, R.S., Edwards, B.D., & Cortina, J.M. (2009). On the practice of allowing correlated residuals among indicators in structural equation modeling. In C.E. Lance & R.J. Vandenberg (eds.), Statistical and Methodological Myths and Urban Legends: Received Doctrine, Verity, and Fable in the Organizational and Social Sciences (pp. 193-218). New York, NY: Routledge.

Crede, M., & Harms, P. (2019). Questionable research practices when using confirmatory factor analysis. Journal of Managerial Psychology, 34(1), 18-30.

Homework:

Complete "Your Turn" assignments from the booklet: Due 9-14 by 5p.m.

**9-15 Measurement Models – Measurement Equivalence/Invariance**

Text:

K: Chapter 16

Readings:

Vandenberg, R.J., & Lance, C.E. (2000). A Review and synthesis of the measurement invariance literature: Suggestions, practices and recommendations for organizational research. Organizational Research Methods, 3, 4-70.

Ployhart, R.E., & Oswald, F.L. (2004). Applications of mean and covariance structure analysis: Integrating correlational and experimental approaches. Organizational Research Methods, 7, 27-65.

Schmitt, N., & Kuljanin, G. (2008). Measurement invariance: Review of practice and implications. Human Resources Management Review, 18, 210-222.

Vandenberg, R.J., & Morelli, N.A. (2016). A contemporary update on testing for measurement invariance and equivalence. In J.P. Meyer (Ed.), The Handbook of Employee Commitment (pp.449-461). Cheltenham, UK: Edward Elgar.

Homework:

Complete "Your Turn" assignments from the booklet: Due 9-21 by 5p.m.

**9-22 Models with Structural Path and Measurement Components**

Text:

K: Chapters 10 and 14

Readings:

Millsap, R.E. (2001). Structural equation modeling: A user's guide. In F. Drasgow & N. Schmitt (Eds.), Measuring and Analyzing Behavior in Organizations: Advances in Measurement and Data Analysis (pp. 257-301, Volume in the Organizational Frontier Series). San Francisco: Jossey-Bass.

Rigdon, E.E. (1994). Demonstrating the effects of unmodeled random measurement error. Structural Equation Modeling, 1, 375-380.

Marsh, H.W., Morin, A.J.S., Parker, P.D., & Kaur, G. (2014). Exploratory structural equation modeling: An integration of the best features of exploratory and confirmatory factor analysis. Annual Review of Clinical Psychology, 10, 85-110.

Homework:

Complete "Your Turn" assignments from the booklet: Due 9-28 by 5p.m.

**9-29 – Nonrecursive Structural Models: Actually a Lesson in Model Idenfication**

Text:

K: Chapter 7; See also Chapter 6 section starting on p. 135

Readings:

Edwards, J.R. (2001). Multidimensional constructs in organizational behavior research: An integrative analytical framework. Organizational Research Methods, 4, 144-192.

Edwards, J.R., & Bagozzi, R.P. (2000). On the nature and direction of relationships between constructs and measures. Psychological Methods, 5, 155-174.

Rigdon, E.E. (1995). A necessary and sufficient identification rule for structural models estimated in practice. Multivariate Behavioral Research, 30, 359-383.

Vandenberg, R.J., & Lance, C.E. (1992). Examining the causal order of job satisfaction and organizational commitment. Journal of Management, 18, 153-167.

In-class exercise:

Using Figure 5, page 370 from Rigdon (1995) apply the rules of identification to all 8 cases. You may work in teams of 2 or 3 for this. I will give you 15 minutes to do it.

Homework:

Complete "Your Turn" assignments from the booklet: Due 10-5 by 5p.m.

**10-6 Midterm Examination**

****ALL OF THE MATERIAL FROM AUGUST 18TH TO SEPTEMBER 29TH IS FAIR GAME. IT WILL BE ALL ESSAY AND YOU WILL HAVE THE FULL 3 HOURS TO COMPLETE****

**10-13 and 10-20 Longitudinal Data Analysis: Latent Change and Latent Growth Models**

Text:

K: Chapter 15

Readings:

Grim, K., Zhang, Z., Hamagami, F., & Mazzocco, M. (2013). Modeling Nonlinear Change via Latent Change and Latent Acceleration Frameworks: Examining Velocity and Acceleration of Growth Trajectories. Multivariate Behavioral Research, 48, 117-143.

Chen, G., Ployhart, R., Thomas, H.C., & Bliese, P.D. (2011). The power of momentum: A new model of dynamic relationships between job satisfaction change and turnover intention. Academy of Mangement Journal, 54, 159-182.

Ployhart, R., & Vandenberg, R.J. (2010). Longitudinal research: The theory design and analysis of change. Journal of Management, 36, 94-120.

McArdle, J.J., & Hamagami, F. (2001). Latent difference score structural models for linear dynamic analyses with incomplete longitudinal data. In L.M. Collins & A.G. Sayer (eds.), New Methods for the Analysis of Change (pp. 137-176). American Psychological Association: Washington, D.C.

Huang, G., Zhao, H.H., Niu, X., Jackson, S.J., & Lee, C. (2013). Reducing job insecurity and increasing performance ratings: Does impression management matter? Journal of Applied Psychology, 98, 852-862.

Chan, D. (1998). The conceptualization and analysis of change over time: An integrative approach incorporating longitudinal mean and covariance structures analysis (LMACS) and multiple indicator latent growth modeling (MLGM). Organizational Research Methods, 1, 421-483.

Bentein, K., Vandenberg, R., Vandenberghe, C., & Stinglhamber, F. (2005). The role of change in the relationship between commitment and turnover: A latent growth modeling approach. Journal of Applied Psychology, 90, 468-482.

Homework:

Complete "Your Turn" assignments from the booklet as we cover them: First set due 10-12 by 5p.m. Second set due 10-26 by 5p.m.

**10-27 and 11-3 – Multi-Level Analyses: Observed and Latent Variable Approaches**

Text:

K: Chapter 17 (p. 444 to end)

Readings:

Kozlowski, S. W. J., & Klein, K. J. (2000). A multilevel approach to theory and research in organizations: Contextual, temporal, and emergent processes. In K. J. Klein & S. W. J. Kozlowski Eds., Multilevel theory, research and methods in organizations: Foundations, extensions, and new directions (pp. 3-90). San Francisco: Jossey-Bass.

Bliese, P.D. (2000). Within group agreement, non-independence, and reliability: Implications for data aggregation and analysis. In K. J. Klein & S. W. J. Kozlowski Eds., Multilevel theory, research and methods in organizations: Foundations, extensions, and new directions (pp. 349-381). San Francisco: Jossey-Bass.

Chan, D. (1998). Functional relations among constructs in the same content domain at different levels of analysis: A typology of composition models. Journal of Applied Psychology, 83, 234-246.

LoPilato, A.C., & Vandenberg, R.J. (2015). The not so direct cross-level direct effect. In C.E. Lance & R.J. Vandenberg (Eds.), More Statistical and Methodological Myths and Urban Legends (pp. 292-310). New York, NY: Routledge.

Bliese, P. D., Maltarich, M. A., & Hendricks, J. L. (2018). Back to basics with mixed-effects models: Nine take-away points. Journal of Business and Psychology, 33(1), 1-23.

González-Romá, V., & Hernádez, A. (2017). Multilevel modeling: Research-based lessons for substantive researchers. Annual Review of Organizational Psychology and Organizational Behavior, 4, 183-201.

LeBreton, J.M., & Senter, J.L. (2008). Answers to 20 questions about interrater reliability and interrater agreement. Organizational Research Methods, 11, 815-852.

Aguinis, H., & Culpepper, S.A. (2015). An expanded decision-making procedure for examining cross-level interaction effect with multilevel modeling. Organizational Research Methods, 18(2), 155-176

Homework:

Complete "Your Turn" assignments from the booklet as we cover them: First set due 11-2 by 5p.m. Second set due 11-9 by 5p.m.

**11-10 and 11-17 – Latent Interaction Terms and Moderated-Mediation**

Text:

K: Chapter 17 (beginning to p. 444) and Chapter 18 (review of best practices)

Readings:

Murphy, K.R., & Russell, C.J. (2017). Mend it or end it: Redirecting the search for interactions in the organizational sciences. Organizational Research Methods, 20, 549-573.

Edwards, J.R. (2009). Seven deadly myths of testing moderation in organizational research. In C.E. Lance & R.J. Vandenberg (eds.), Statistical and Methodological Myths and Urban Legends: Received Doctrine, Verity, and Fable in the Organizational and Social Sciences (pp. 143-164). New York, NY: Routledge.

Cortina, J.M., Chen, G., & Dunlap, W.P. (2001). Testing interaction effects in LISREL: Examination and illustration of available procedures. Organizational Research Methods, 4, 324-360.

Cortina, J.M., Markell-Goldstein, H.M., Green, J.P., & Chang, Y. (2021). How are we testing interactions in latent variable models? Surging forward or fighting shy? Organizational Research Methods, 24, 26-54.

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

LeBreton, J.M., Wu, J., & Bing, M.N. (2009). The truth(s) on testing for mediation. In C.E. Lance & R.J. Vandenberg (eds.), Statistical and Methodological Myths and Urban Legends: Received Doctrine, Verity, and Fable in the Organizational and Social Sciences (pp.107-141). New York, NY: Routledge.

Edwards, J. R. & Lambert, L. S. (2007). Methods for integrating moderation and mediation: A general analytical framework using moderated path analysis. Psychological Methods, 12, 1-22.

Sardeshmukh, S.R., & Vandenberg, R.J. (2017). Integrating moderation and mediation: A structural equation modeling approach. Organizational Research Methods, 20, 721-745.

Koopman, J., Howe, M., & Hollenbeck, J.R. (2015). Pulling the Sobel test up by its bootstraps. In C.E. Lance & R.J. Vandenberg (Eds.), More Statistical and Methodological Myths and Urban Legends (pp. 224-244). New York, NY: Routledge.

Mplus Oriented Readings on Latent Interactions Because It Uses the LMS Approach

Klein, A., & Moosbruger, H. (2000). Maximum likelihood estimation of latent interaction effects with LMS method. Psychometrika, 65, 457-474.

Marsh, H.W., Wen, Z. & Hau, K-T. (2004). Structural equation models of latent interactions: Evaluation of alternative estimation strategies and indicator construction. Psychological Methods, 9, 275-300.

Maslowsky, J., Jager, J., & Hemken, D. (2015). Estimating and interpreting latent variable interactions: A tutorial for applying the latent moderated structural equation methods. International Journal of Behavioral Development, 39, 87-96.

Homework:

Complete "Your Turn" assignments from the booklet as we cover them: First set due 11-16 by 5p.m. Second set due 11-30 by 5p.m.

**11-25 through 11-27 Thanksgiving Break – No Classes. Don't eat too much!!!!**

**12-1 - End Term Examination.**

****ALL MATERIAL COVERED IN CLASS FROM OCTOBER 13TH THROUGH NOVEMBER 17TH IS FAIR GAME. IT WILL BE ALL ESSAY AND YOU WILL HAVE THE FULL 3 HOURS TO COMPLETE****