GREV 612 Statistics IV
Path Analysis/Confirmatory Factor Analysis/Structural Equation Modeling

This course is a general treatment of a class of techniques that have come to be known as structural equation modeling procedures. Structural Equation Modeling (SEM) is a general class of multivariate modeling techniques that allows the estimation of relationships between latent (unobserved) variables. It is also a regression based technique that combines both confirmatory factor analysis and path analysis. The overall goal of this course is to provide students with the conceptual aspects, statistical underpinnings, and applications of this method. It is not meant to be a tutorial on how to use a specific software. The course is intended to be very applied in the sense of how to estimate models, evaluate them, revise them, and report the results. At the same time, the course will provide a rigorous treatment of the theory underlying SEM, including discussions of causality and inference, model assumptions and consequences of their violation, and limitations.

Prerequisites:

It is expected that students have had basic and advanced statistics courses (I and II and III). Familiarity with matrix algebra is helpful. We will review matrix algebra, but the course will use matrix algebra extensively, so some level of comfort working with matrices is necessary. Understanding the basic concepts of differential and integral calculus is also helpful.

Required Book:


Possible Books to Use


The library also has one copy of each of these books in the stacks. If you do check either one out, please share with your classmates.

Readings:

For the readings listed below, I have put my personal copies on reserve at the library. Please do not damage them or remove them from the library. The supplemental readings are not on reserve. If you are interested in them you must obtain them on your own.
Software:

There are several student versions available for download on the web. MPlus which is the easiest to use but the data has to be formatted first is at www.StatModel.com. Lisrel 8.7 is available at www.ssicentral.com. EQS is available at http://www.mvsoft.com/demos.htm. Currently, AMOS is being sold by SPSS and there does not appear to be a student version. The student version of Lisrel 8.7 is on the computers in the lab in Canevin 210.

**Day 1**
Topics:
- Introduction
- Basic Concepts, Terminology
- Matrix Algebra
- Equations and Diagrams

*Readings:*
- Kline Chapter 1
- Kaplan Chapter 1
- S & L Chapters 1 & 2

*Activity*
- Matrices Activity

**Day 2**
Topics
- Cleaning Up Your Act
- Normality/Linearity/Multivariate Normality
- Discussion about using SPSS, SAS, and the SEM software

*Readings:*
- Kline Chapter 3

*Activity*
- Data Set Cleaning Activity

**Day 3**
Topics:
- Measurement Error in Observed Variables

*Readings:*
Kline Chapters 2 and 3
Crocker and Algina Chapters
Sax Chapters 8, 9 and 10.
http://www.spss.com/amos/measurement_error_application.htm
Hand out reading from Susan Embretson Book

Activity:
Psychometric Activity

Day 4
Topics:
Factor Analysis (EFA vs. CFA)
Measurement Model/CFA
How Many Indicators for a Factor
Pre- and Post Analysis Issues
Second Order CFA

Readings:
Kline Chapter 4 (specifically 4.3) and Chapter 7.
Kaplan Chapter 3
S & L Chapter 3

Day 5
Topics: Model Comparisons and Fit for CFA analyses.

Readings:
Kline Chapter 12 and 6
Kaplan Chapters 3 and 6
S & L Chapter 7

Fan 2005 Sensitivity of Fit Indexes to Misspecified Structural or Measurement Model Components: Rationale of Two-Index Strategy Revisited

Sivo 2006 The Search for "Optimal" Cutoff Properties: Fit Index Criteria in Structural Equation Modeling


Supplemental Reading

Duncan, SEM, Ch. 8, 11.


CFA Activity

Homework 1 CFA; due next class meeting.

Day 6
Topics:
- Mediation/ Traditional Path Analysis
- Pre- and Post Analysis Issues
- Power Analysis for Covariance Models

Readings:

Kline Chapter 2 (for review) and Chapter 5
Kaplan Chapter 2
S & L Chapter 3

MacKinnon et al. (2002) A comparison of methods to test mediation and other intervening variable effects. Psychological Methods, 7, 83-104


Supplemental Readings:

Kim, Kaye, & Wright: Moderating & Mediating Effects in Causal Models

Mediation Activity

Homework 2 Path Analysis: Due next class meeting.

Days 7-8
Topics:
- Latent (Covariance) Structure Models:SEM/
- Covariance Algebra
- Power Analysis for Covariance Models
- Identification

Readings:
- Kline Chapters 8 and 11
- S&L Chapters 4, 5, and 10
Kaplan Chapter 5


Supplemental Readings:
Kline: pp. 108-111, 155-170, 248-251
Bollen: pp. 238-254
Jöreskog, Karl G., and Sörbom, Dag, L8, Chs. 1and 2
Loehlin, LVM, Ch. 2 (pp. 37-57).
Bollen, SELV, pp. 10-20, Ch. 4 (104-123), (238-254) Ch. 8 (pp. 319-369).
Hoyle, CIA, Ch. 2, 3.

Day 9 - 10
Topics:
Estimation Algorithms
http://www.princeton.edu/~slynch/maxlike.pdf
http://www.princeton.edu/~slynch/altest.pdf
Goodness of Fit
Identification
Misspecification and respecification AKA Modification and Residual Analysis
Missing Data Issues

Readings:

Klein has Fit indices mainly in 133-145 Algorithms in various spots along with other topics so you will have to look in the index and find them.
S & L Chapters 3, and 5-7
Kaplan 5, 6 and 9.5

Goodness of Fit
See Earlier articles first (Sivo, Fan…..)

Supplemental Readings for Fit


Modifications

Missing Data


Ried, D. (2007) Missing data on CDC depression scale


http://www.princeton.edu/~slynch/missingdata.pdf

http://www.spss.com/amos/missing_values_application.htm

Supplemental Readings

Kline: pp. 276-278

Bollen: pp. 256-289
Bollen: pp. 296-305
Bollen, SELV, Ch. 8 (pp. 369-376).

**Homework 3 SEM; due next class meeting.**

**Day 11**

**Topics:**

**Writing SEM and CFA Method and Result Sections**


**Results Section Critique Activity**

**Advanced Topics (Depending on time)**

Topics:

MIMIC Models
Non-recursive
**Nested Models**
Non-normal data
Categorical Data
Growth Modeling

Readings:
Klein Chapters 10, 11, and 13
S & L Chapter 10
Kaplan Chapters 7 and 8


Day 12
Presentation of Individual Projects
Presentation of In-Depth Topic Review

Course Requirements:

Homework
There will be three homework assignments worth 25 points each. The first assignment concerns confirmatory factor analysis, the second, path analysis, and the third structural equation modeling.

Project
There will be one structural equation modeling project. You will have to obtain data for this project. There will also be a presentation to the class on the project. The project is worth 100 points and the presentation is worth 25 points.

In-Depth Review of an SEM Topic
For the final course requirement, you are required to take one topic within SEM and do an in-depth review of that topic. You will also present a summary of your review to the class. The review is worth 75 points and the presentation is worth 25 points.

Final Exam
The last day of class there will be a 100 point test on the material from the class.

Each homework and project will be graded with a rubric that will award points for correct information included. Those points will be summed and then compared to the grading scale below.

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<tr>
<th>Letter Grade</th>
<th>Approx Percent</th>
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<td>A</td>
<td>93-100</td>
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Please note that this course will work as a seminar and test of the materials and activities for future courses. Therefore, you will also find websites and articles and provide a critique of them, i.e., information is correct, updated and practical for graduate students.

**Supplementary texts:**


In-depth Topic Ideas

PATH ANALYSIS, PATH MODELS
SAMPLE SIZE ISSUES
CORRELATION VS. COVARIANCE MATRICES
MISSING DATA, MISSING DATA IMPUTATION, MISSING DATA ESTIMATION
LATENT CLASS ANALYSIS
QUALITATIVE VARIABLES
CROSS-LAGGED PANEL MODELS, LONGITUDINAL MODELS, LONGITUDINAL ANALYSIS GENERAL (see also latent growth curve models)
SIMPLEX MODELS
LATENT GROWTH CURVE MODELS (LGC)
LATENT STATE-TRAIT MODELS, LATENT TRAIT-STATE MODELS
POWER, POWER ANALYSIS
SOFTWARE
ALPHA INFLATION
EXAMPLES OF SECOND-ORDER FACTOR MODELS (HIEARCHICAL FACTOR MODELS)
COEFFICIENT ALPHA
ADF, AGLS, and WLS ESTIMATION METHODS
NONNORMALITY, DISTRIBUTIONAL ASSUMPTIONS, CATEGORICAL DATA
ASSUMPTIONS, MULTICOLLINEARITY, NONCONSTANT VARIANCE, HETEROSCEDASTICITY, OUTLIERS
POLYCHORIC CORRELATIONS, TETRACHORIC CORRELATIONS, POLYSERIAL CORRELATIONS, and NONNORMALITY
MTMM (MULTI-TRAIT MULTI-METHOD MATRIX)
VALIDITY
STANDARDIZED SOLUTIONS
SAMPLE WEIGHTING, COMPLEX SURVEY DESIGNS, SAMPLING ADJUSTMENTS
REGRESSION DIAGNOSTICS
REVERSED ITEMS, SCALING, ACQUIESCENCE, RESPONSE BIAS, SOCIAL DESIRABILITY, METHODS FACTORS

ITEM PARCELLING, ITEM PARCELS

META-ANALYSIS

IRT, FULL-INFORMATION ML FACTOR ANALYSIS, DIF

SUPPRESSION EFFECTS, SUPPRESSOR VARIABLES

CORRELATED ERRORS, CORRELATED UNIQUENESS

FACTOR SCORES

HIERARCHICAL LINEAR MODELING (HLM) and MULTILEVEL MODELS

DYADIC DATA, SOCIAL RELATIONS MODELS

EXPLORATORY DATA ANALYSIS

NONRECURSIVE MODELS, RECIPROCAL PATHS, RECIPROCAL CAUSES, FEEDBACK LOOPS

EFFECTS OF MEASUREMENT ERROR

EXTENSION ANALYSIS

MEDIATION, INDIRECT EFFECTS (with sem)

INTERACTIONS, MODERATOR, MODERATION, LATENT MODERATORS (SEM)
(see also: NONLINEAR sem and 2SLS)

NONLINEAR, QUADRATIC, CURVILINEAR, POLYNOMIAL
(see also moderation)

TWO-STAGE LEAST SQUARES, 2SLS, TLS
(see also moderation)

CONFIRMATORY FACTOR ANALYSIS (CFA)

EXPLORATORY FACTOR ANALYSIS, EFA
(see also comparing exploratory factor analysis and confirmatory factor analysis)

COMPARING EXPLORATORY FACTOR ANALYSIS (EFA) AND CONFIRMATORY FACTOR ANALYSIS (CFA)

CAUSAL INDICATORS
(FORMATIVE INDICATORS, FORMATIVE VS. REFLECTIVE INDICATORS, COMPOSITES, PRINCIPAL COMPONENTS)

COMPARING CORRELATIONS, COMPARING CORRELATION MATRICES

INTERRATER RELIABILITY
FIT INDICES (FIT INDEXES)
(see also noncentrality parameter)

POST HOC MODEL MODIFICATION, MODIFICATION INDICES

NONCENTRALITY PARAMETER, NCP, DELTA, D
TWO-STEP APPROACH TO SEM, FOUR-STEP DEBATE

BOOTSTRAPPING

CAUSALITY AND SEM, CAUSAL INference, CAUΣATION

BAYESIAN INFORMATION CRITERIA (BIC)

PLS (PARTIAL LEAST SQUARES)

TIME SERIES

FACTOR ANALYSIS WITH DICHOTOMOUS DATA

MULTIGROUP SEM, STACKED MODELS, CROSS-GROUP ANALYSIS, MEASUREMENT INVARIANCE, FACTORIAL INVARIANCE

STRUCTURAL MEANS, MEAN STRUCTURES, LATENT MEANS

PARSIMONY

HEYWOOD CASES, NEGATIVE ERROR VARIANCES, NONPOSITIVE DEFINITE MATRIX, IDENTIFICATION

RASCH MODELS