ECPR Summer School in Methods and Techniques
Course Description Form

Course title

B10. Introduction to Structural Equation Modelling

Instructor details

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Short Bio

Dr. Jochen Mayerl is researcher and lecturer in Social Sciences at University of Stuttgart, Germany, where he has taught various research and analysis methods since 2001. He finished his doctoral thesis in "Cognitive foundations of social behavior: theoretical and statistical analysis of attitude-behavior relations" in 2008. In winter term 2011/2012, he was substitute professor at University of Kassel, Germany. His main research interests in methodology are new developments and applications in structural equation modelling, response effects in surveys, response latency measurement in computer assisted surveys and ego-centered network analysis. He has published in the field of methodology as well as sociological theory (attitude-behaviour research, bounded rationality, framing) and substantial research (e.g. donation behaviour, environmental concern, ethnocentrism, political attitudes).

Short outline

The course gives an introduction to theory and practice of Structural Equation Modelling (SEM) with computer software AMOS. It is shows how theoretical latent constructs (e.g. social and political attitudes, values, and intentions) can be operationalised and how their causal relationships can be tested.
The first part of the course introduces the specification of Confirmatory Factor Analysis (CFA) as a special case of SEM. Measurement models with single or multiple indicators of latent variables are estimated and tested. Different modelling specifications will be introduced including multiple group analysis (e.g. to test measurement equivalence across different social groups or countries). The second part of the course deals with specification and test of causal structural equation models (e.g. MIMIC models (Multiple Indicators and Multiple Causes), assessment of models, mediation and moderation, feedback loops).

Long outline

Structural Equation Modelling (SEM) is a powerful tool to analyse latent variable models that are common in social sciences, e.g. the analysis of personality factors, social and political attitudes, social values, and behavioural intentions. SEM combines factor analysis and path analysis by simultaneously estimating causal relations between latent constructs and relations of latent constructs and its corresponding manifest indicators in the measurement models. Additionally, SEM allows the estimation and control for random and systematic measurement errors. Thus, SEM methodology allows an adequate modelling and empirical testing of measurement models and complex theoretical assumptions.

The course introduces to theory and practice of SEM using the software AMOS. Basic modelling techniques of SEM are explained and applied by exercises using free access social science data. Additionally, participants have the possibility and are encouraged to use their own data for analyses. Exercises allow the application and transfer of SEM methodology to own research interests.

The first part (week 1) of the course introduces to principles of Structural Equation Modelling. It is shown how Confirmatory Factor Analysis (CFA) can be specified and estimated, i.e. how latent constructs (e.g. attitudes, values, behavioural intentions) can be operationalised by multiple manifest indicators and how these measurement models can be tested empirically. The first week includes the following topics:

- On first day, a general introduction to advantages, possibilities, and applications of SEM and its relations to Principal Component Analysis (PCA), regression analysis and path analysis are shown and discussed. Basic concepts like manifest and latent variables, measurement model and structural model, formative and reflective indicators, and relation of modelling and theory are introduced.

- Day 2 introduces to basic principles of SEM (e.g. causality and theory testing, notation, assumptions, formalisation, estimation procedures, model specification, model identification). It is shown how a Confirmatory Factor Analysis (CFA) can be estimated to operationalise latent constructs specifying measurement models with manifest indicators (including one-indicator and multiple-indicator models). Data and modelling ideas of participants for their own projects will be discussed.

- Day 3 deals with the question of how to identify "good" CFA models, i.e. the interpretation of fit indices. It is shown how to specify, estimate, assess and re-specify a CFA model step-by-step (model modification). Preconditions like normality and outlier identification will be evaluated. The specification of higher order constructs to measure multidimensional latent constructs is demonstrated. Further, it is shown how to deal with systematic measurement errors (e.g. error correlations and specification of method factors).

- Multiple group analysis is a very important and a powerful tool for comparative social science. On day 4, it is shown how multiple group models can be specified, estimated and evaluated to test for measurement equivalence of different groups (e.g. within and between social groups, sub-populations, countries). Further, validity and reliability estimates in CFA are introduced.

- On day 5, multiple group models are extended to the specification of a CFA with meanstructure, i.e. with latent means and intercepts. This allows the estimation and comparison of latent means between different groups and countries. Possible problems of models with meanstructure will be discussed.

In the second part of the course (week 2), full SEM is introduced to specify and estimate causal relations between latent constructs and thus to test theoretical hypotheses. Additionally, advanced techniques of SEM and special problems will be illustrated and discussed.

- Day 6 deals with the specification of full causal structural equation models. Alternative modelling strategies and equivalent causal models will be shown and discussed. Further, it is illustrated how to specify, estimate and interpret MIMIC models ("Multiple Indicators and Multiple Causes").

- On day 7, decomposition of causal effects, model modification and interpretation of parameters will be introduced. It will be shown how to estimate direct, indirect and total effects and how to estimate their standard errors and significance (models with intervening latent variables). Thus, it is demonstrated how to test for mediation effects. Further, it is illustrated how to specify and estimate non-recursive models (models with feedback loops) and how to handle special problems of these models.

- Full SEM is extended to multiple group comparison to test for moderator effects (and combined moderator-mediator models) on day 8. Interaction models are introduced as an alternative to multiple group analysis. Additionally, full SEM will be extended to full SEM with meanstructure, i.e. with latent means and intercepts.

- On day 9, special topics of SEM will be discussed. This includes the logic and specification of SEM with categorical indicators and non-normal data (e.g. bootstrapping), strategies how to deal with missing values and how to specify non-linear effects.

- On the last day, open questions will be discussed and participants present their own models. Further, advanced models will be introduced, e.g. panel models like cross-lagged autoregressive models or latent growth curve models. Additionally, best practice of how to report SEM results will be given. A final discussion deals with problems and possible traps of SEM.

5. Day-to-day schedule

[please be as precise as possible]

- Week 1

	Topic(s)	**Details [NB : incl. timing of lecture v/s lab or fieldwork etc. hours]**
Day 1	Monday Mix (90 min general introduction to the topic)	
Day 2	Basic principles of SEM; Confirmatory Factor Analysis (CFA); measurement models	1.5 hours lecture – 1.5 hours exercises
Day 3	Fit Indices; CFA: step by step; test of normality & outliers; second order measurement models; method factors	1.5 hours lecture – 1.5 hours exercises
Day 4	Multiple Group CFA: testing measurement equivalence	1.5 hours lecture – 1.5 hours exercises
Day 5	Multiple Group CFA: Latent means	1.5 hours lecture – 1.5 hours exercises

- Week 2

Day 6	Full SEM; model testing strategies; MIMIC models	1.5 hours lecture – 1.5 hours exercises
Day 7	Mediation, decomposition of causal effects: direct, indirect and total effects; feedback loops	1.5 hours lecture – 1.5 hours exercises
Day 8	Multiple group SEM and moderation, interaction effects, SEM with meanstructure	1.5 hours lecture – 1.5 hours exercises
Day 9	Special topics of SEM: categorical indicators and non-normality (incl. bootstrapping); missing value treatment; nonlinearity	1.5 hours lecture – 1.5 hours exercises
Day 10	Open questions and presentation of participant's models; Advanced techniques (e.g. cross-lagged autoregressive models, latent growth curve models); Discussion ("overfitting", how to fool yourself with SEM); How to report SEM results	1.5 hours lecture – 1.5 hours exercises

(day 11, Saturday, 9:00-12:00: Exam)

Day-to-day reading list

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- Week 1

	Readings (please read at least the compulsory reading for the scheduled day)
Day 1	Byrne 2010: chapter 1 and 2 (introduction to SEM and AMOS)
Day 2	Byrne 2010: chapter 3 (CFA); *Additional reading: Kline 2011: chapter 5 (specification), 6 (pp. 124-132, 137-150; identification) and 7 (pp. 154-160; ML estimation)*
Day 3	Byrne 2010: chapter 4 (CFA) and 5 (second order CFA) *Additional reading: Kline 2011: chapter 8 (fit indices), 9 (pp. 230-251; CFA)*
Day 4	Byrne 2010: chapter 7 (multigroup CFA) *Additional reading: Kline 2011: chapter 9 (pp. 251-262; multigroup CFA*)
Day 5	Byrne 2010: chapter 8 (multigroup CFA with meanstructure)

- Week 2

Day 6	Byrne 2010: chapter 6 (full SEM) *Additional reading: Kline 2011: chapter 10*
Day 7	Maruyama 1998: pp. 35-48 (effect decomposition); Kline 2011: pp. 160-172 (effect decomposition), pp. 132-137 (non-recursive models)
Day 8	Byrne 2010: chapter 9 (multigroup full SEM)
Day 9	Byrne 2010: chapter 12 (bootstrapping) and 13 (missing data); *Additional reading: Kline 2011: chapter 12 (interaction effects); Ping 1996 (interaction effects); Schafer/Graham 2002 (missing data)*
Day 10	Kline 2011: chapter 13 (How to fool yourself with SEM); Boomsma 2000 (reporting SEM results)

Requested prior knowledge

The summer school offers 3-day remedial courses right before the main courses and depending on their requirements, covering various topics such as SPSS, R, inferential statistics, mathematics. If there are specific capacities that you expect, please discuss your requirements with us so that remedial courses can be recommended. Also indicate textbooks for self study which cover these topics.]

Participants should understand basic principles of regression analysis and the meaning of regression results. A basic understanding of principal component analysis (explorative factor analysis) would be helpful.

Software used

IBM SPSS Amos 20.0; a trial version is available for download at:
http://www14.software.ibm.com/download/data/web/en_US/trialprograms/G556357A25118V85.html

Literature

Arbuckle, J. L., 2011: IBM SPSS Amos 20 User's Guide. Armonk, NY: IBM.

Bollen, K. A., 1989: Structural equations with latent variables. New York: John Wiley and Sons.

Boomsma, A., 2000: Reporting analyses of covariance structures. Structural Equation Modeling, 7(3), 461-483.

Brown, T. A., 2006: Confirmatory Factor Analysis for Applied Research. New York/London: Guilford.

Byrne, B. M., 2010: Structural Equation Modeling with AMOS. Basic Concepts, Applications and Programming (2nd edition). New York/London: Routledge.

Kline, R. B., 2011: Principles and Practice of Structural Equation Modeling (3rd edition). New York/London: Guilford.

Maruyama, G. M., 1998: Basics of structural equation modeling. Thousand Oaks: SAGE Publications, Inc.

Ping, R.A., 1996: Latent Variable Interaction and Quadratic Effect Estimation: A Two-Step Technique Using Structural Equation Analysis. Psachological Bulletin 119 (1): 166-175.

Schafer, J. L./Graham, J. W., 2002: Missing Data: Our View of the State of the Art. Psychological Methods 7(2): 147-177.

Schumacker, R. E./Lomax, R. G., 2004: A beginner`s guide to structural equation modeling. Mahwah: Lawrence Erlbaum Associates.

Lecture room requirement

Computer lab with IBM SPSS Amos software and projector.