Session outline

1. SEM and AMOS Basics
   - Five basic steps in SEM
2. The confirmatory approach in SEM
3. Assumptions underlying SEM
4. Superiority of SEM over MLR
5. The structural equation modeling process
6. Goodness-of-fit indices
7. A word of caution using SEM programmes

1. SEM and AMOS Basics
   - SEM = statistical modelling technique to establish (linear) relationships between variables
   - SEM = Combination of FA and PA!
   - In SEM we model relationships between latent variables (constructs that cannot be directly measured = factors \( \Rightarrow \) CFA)
   - Observed variables (indicators) conceptualise the latent variables: Each latent variable should be represented by 2 or more indicator variables.
     - E.g. Alienation: Powerlessness / Anomia (Diagram)

SEM and AMOS cont.

- SEM: Extension of MLR whereby MLR equations are fitted simultaneously.
- SEM encompasses diverse statistical techniques:
  - ANOVA/MANOVA
  - MLR
  - Path Analysis (PA): a subset of SEM but only using observed variables (i.e. no latent variables)
  - CFA (Confirmatory Factor Analysis) → Theory-based specified models are tested
  - Causal modelling with latent variables

Kline (2004) emphasises the value of testing/fitting whole models

- The emphasis on the testing of a whole model may also be a kind of antidote against the over-reliance on statistical tests of individual hypotheses
- That is, increased use of model-fitting techniques, such as SEM, can be part of the reform of data analysis methods in the behavioural and social sciences (Kline, 2004)
- Best practices in SEM also require that the researcher considers alternative models that may explain the same data equally well
SEM and AMOS cont.

**Five basic steps in SEM**

1. Model Specification
2. Model Identification (ideally over-identified)*
3. Model Estimation (ML-Method** & Assumptions)
4. Model Testing (Assessment of the fit of a 'constructed' model: Plethora of fit-indices!)
   A fit index resembles R-Square in MLR
5. Model Modification (The first model is unlikely to be the best-fitting. AMOS provides modification indices to derive alternative models with better fit)

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* Model Identification 1
- Complex topic, difficult to explain in nontechnical terms
- Identification focuses on whether or not there is a unique set of parameters consistent with the data
- Comparison: The number of data variances and covariances with the number of structural parameters.
- Number of data points: $N \times (N+1)/2$ [with $N =$ number of observed variables] is compared with the number estimatable parameters.
- In Moneta's (2008) Burnout Model there are 15 observed variables \( \Rightarrow 15 \times 16 / 2 = 120 \) Data Points.

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* Model Identification 2
- Underidentified models
  - Number of parameters to be estimated exceeds the number of covariances
  - E.g.: There is an infinite number of solutions to the equation \( 3x + 1y = 7 \) (the model contains insufficient information!)
- Just identified model:
  - One-to-one correspondence between the data and structural parameters = the number of data variances and covariances equals the number of structural parameters.
  - Hence, there is a unique solution for all parameters \( \Rightarrow \) \( df = 0 \)
  - \( 3x + 1y = 10; \) \( x + y = 4 \)
  - Because of \( df = 0 \) the model cannot be rejected and is not scientifically interesting!
- Overidentified model:
  - \( df \geq 1 \) \( \Rightarrow \) Allows rejection of the model (scientific!)

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** Maximum likelihood (ML) Method
- OLS (Ordinary Least Squares) Method:
  - Minimises the squared deviation between values of the criterion variable and those predicted by the model.
- ML (Maximum Likelihood) Method:
  - Attempts to maximise the likelihood that obtained values of the criterion variables will be correctly predicted (iterative procedure).

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2. The confirmatory approach of SEM – using one of the three:

1. Strictly confirmatory approach
   Bear in mind: An accepted model is just a not-disconfirmed model, since alternative models might fit the data better (Assessment: Fit-indices).
2. Alternative models testing approach
   Aim: Derive model with best goodness-of-fit index.
3. Model development approach
   In practice confirmatory/exploratory combination: Reject a deficient model and ‘build’ and test an alternative model (on the basis of modification indices)!

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The confirmatory approach

Theory → Model Construction → Instrument Construction → Data Collection → Model Testing → Results

Iterative Process: Theory is refined in the light of the interpretation of results. The extended theory is then tested again...
3. Assumptions underlying SEM (See also handout)

- Multivariate normal distribution of the indicators and the dependent latent variables
- Linearity: SEM based on the GLM (linear relationships between L-1 / L-L) → Diagram
- Indirect measurement (L!) → Structural model
- Multiple Indicators (Minimum: 2 I per L)
- Interval level of measurement
- Absence of complete Multicollinearity
- Sample size (as in MLR: 10-15 / N > 50 +8k)

4. Superiority of SEM over MLR

- SEM has more stringent assumptions than MLR
- But: SEM can fit models with the following characteristics:
  - Multiple dependent outcome variables are permitted
  - Mediating variables can be included in the same single model as predictors (Altern.: Baron & Kenny)
  - No assumption that predictors are measured without error
  - Multicollinearity among predictors does not hinder result interpretation

5. The structural equation modeling process

The SEM process centres around two steps:
1. Validating the measurement model though CFA (The measurement model defines relations between the observed an unobserved variables);
2. Fitting the structural model via Path Analysis (The structural model defines relations between the latent variables in a cause-and-effect manner).

6. Goodness-of-fit tests

- Goodness-of-fit indices determine if the model can be provisionally accepted or has to be rejected.
- The null-hypothesis under test is that the model fits the data → It is hoped that there will be no sign. differences between the sample covariance matrix and the reproduced model- implied covariance matrix.
- Hence, we hope not to reject the null-hypothesis
- So the researcher hopes to find a small, non-sign. chi-square model fit statistic.

There is a plethora of fit-indices:
- Chi-square [Discrepancy/CMIN]: If insignificant the model can be provisionally accepted
- Goodness-of-fit [GFI: 0-1]: Values close to .95 reflect good fit
- Root-mean-square-error of approximation [RMSEA]: Values < .05 represent a good model fit.
- See handout for in-depth account!
7. A word of caution using SEM programmes

- Numerous SEM/PA-programmes are available: LISREL, EQS, SEPATH and AMOS.
- **AMOS** (Analysis of Moment Structures) provides an easy to use graphical interface
- Prior to reading data into AMOS (from an SPSS or EXCEL-spreadsheet) the user has to ‘draw’ the model/diagram (specify the model). There is an inherent temptation ...

Caution in terms of AMOS

To beginners it may appear that all one has to do is to draw the model on the screen and let the PC do the rest. However:
- SEM requires understanding of measurement theory (how are the latent variables to be measured)
- Model specification must not be a ‘fishing expedition’ but:
- The model’s specification must rely upon:
  - Theory
  - Results of previous studies
  - Ideally on valid & reliable evidence-based theory
  - ‘Educated guesses’ that reflect the researcher’s domain knowledge and experience.

References


Optional Practical

Using the SPSS-file Path-Ingram.sav we will run a Path Analysis to test the TPB-model by conducting both:
1. A series of MLR in SPSS
2. The PA in AMOS

‘Concluding Question’

What is the core distinguishing criterion between SEM and PA?

Good luck with your Assignment 2!