Psychology Seminar
Psych 406
Structural Equation Modeling
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Topic 4
Confirmatory Factor Analysis (CFA)

Outline/Overview

- Readings
- EFA vs. CFA
- Isolating True Score variability
- Specialized analyses=specialized software
- Estimation techniques
- Running CFA in Stata
- Postestimation – goodness of fit, residuals, modification indices
- Example – CFA of Rosenberg Self-Esteem Scale

Readings

- Pg. 11-56 in Acock book.
  - do the examples
- Stata SEM manual
  - pg. 7-15, in Intro 2
  - Intro 5,
    - single factor measurement models
    - multiple factor measurement models
    - CFA models
    - higher order CFA models

EFA vs. CFA

- EFA each indicator is associated with all factors.
  - No restrictions on loadings
- CFA determine whether the number of factors and the loadings conform based on theory
- Path models treated exogenous variables as though measured without error,
- Examine reliability and validity and if acceptable, use the scores in statistical analyses-traditional techniques do not adjust for measurement error in any way

Psychometric perspective

- Any measure we use consists of two components, traditional techniques do not separate the components.
- Observed Score = True Score + Error
- Error = noise, can obscure or attenuate the relationship between variables
- CFA allows us to estimate true score components
- Latent variables are thought to be "cleansed" of measurement error

SEM Software

- CFA and Structural Equation Modeling programs
- Commercial programs
  - LISREL - Karl Joreskog
  - M-Plus - Bengt Muthen
  - EQS - Peter Bentler
  - AMOS - Jim Arbuckle
- Free options
  - Mx - Mike Neale
  - R has a SEM package and LAVAAN

CFA diagrams/setting up in Stata

- Latent variable (factor) is large oval
- Observed variables are squares or rectangles
- Arrows point from the latent variable to the observed variables, indicates that the latent variable is responsible for the individual's level on the observed variable
- Each observed variable has an error term
- Run in Stata using the SEM builder or the SEM command (can also use GSEM command)

Setting up CFA in Stata

- Have to set the scale of the latent variable
  - first indicator for a factor used as reference indicator, unstandardized loading is set to 1.0.
  - not an issue with standardized solution
- Latents must start with a capital letter
- Estimation methods
  - Maximum Likelihood [+ VCE(robust)]
  - Asymptotic Distribution Free
  - Maximum Likelihood with Missing Values
- Typically use Maximum Likelihood

The SEM command

- For a one factor model, takes the form:

SEM (Latent-> item1 … item_n), method(ml) standardized

- Main model test is the Chi-Squared statistic
  - Test works the opposite of what you have learned
  - The Chi-Squared is test the discrepancy between the observed and model-implied covariance matrices
- Chi-Square is very sensitive to sample size
- Use fit indices to assess model fit

Post estimation

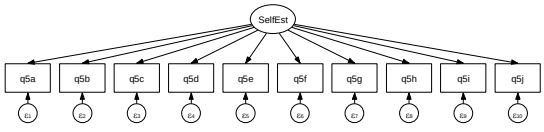
- Goodness of fit [estat gof, stats(all)]
- Residuals [estat residuals]
- Model implied covariance matrix [estat framework, fitted]
- Modification indices [estat mindices]

- After running the model, we may make modifications to improve fit, must be reasonable

Fit indices

- RMSEA (Root mean square error of approximation) –Hu and Bentler (1999) suggest <.06, Browne and Cudeck (1993) suggest <.05=good fit, between .05-.08=adequate fit and >.1=poor fit
- pclose corresponds to a test of RMSEA < .05
- AIC and BIC useful for comparing models
- CFI (comparative fit index) and TLI (Tucker-Lewis index) - incremental fit indices, want values greater than .95
- SRMR (Standardized Root Mean Square Residual) absolute measure of fit - standardized difference between the observed correlations and the predicted correlations. <.08=good fit
- CD(coefficient of determination) closer to 1=better fit

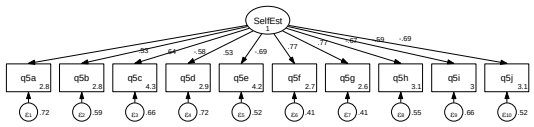
CFA of Rosenberg S.E. Scale



Estimate the model

- Typically will be interested in standardized solution
- Intercepts can be ignored
- Will then look at modification indices

CFA of Rosenberg S.E. Scale (cont.)



$\chi^2(35)=734.41$, $p > .0000$, RMSEA=.12, pclose=.000, AIC=25440.66, BIC=25596.61, CFI=.87, TLI=.83, SRMR=.06, CD=.89

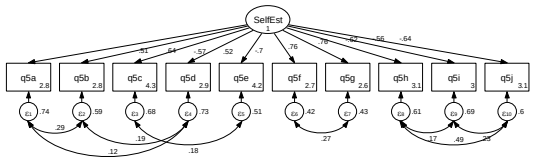
SEM Modification indices

Modification indices

	MI	df	P>MI	EPC	Standard EPC
cov(e.q5a,e.q5b)|	114.681	1	0.00	.0761988	.316855
cov(e.q5a,e.q5d)|	15.982	1	0.00	.0309309	.1153873
cov(e.q5a,e.q5h)|	29.379	1	0.00	.0543851	.1619546
cov(e.q5a,e.q5i)|	16.094	1	0.00	.0439562	.1169391
cov(e.q5a,e.q5j)|	12.978	1	0.00	.0360964	.1083898
cov(e.q5b,e.q5d)|	49.679	1	0.00	.051317	.2086486
cov(e.q5b,e.q5f)|	8.579	1	0.00	.0209402	.0957948
<11 rows omitted>					
cov(e.q5f,e.q5g)|	138.332	1	0.00	.0949114	.4241064
cov(e.q5f,e.q5h)|	24.015	1	0.00	.0496578	.1626854
cov(e.q5f,e.q5i)|	8.902	1	0.00	.032594	.0953951
cov(e.q5f,e.q5j)|	56.081	1	0.00	.0760592	.2512606
cov(e.q5g,e.q5h)|	10.550	1	0.00	.0340917	.1080806
cov(e.q5g,e.q5j)|	11.149	1	0.00	.0351283	.1122968
cov(e.q5h,e.q5i)|	18.570	1	0.00	.0627778	.1303576
cov(e.q5h,e.q5j)|	313.261	1	0.00	.2373183	.5562199
cov(e.q5i,e.q5j)|	46.065	1	0.00	.0987791	.2068269

EPC = expected parameter change

CFA of Rosenberg S.E. Scale (cont.)



$\chi^2(27)=81.88$, $p > .000$, RMSEA=.04, pclose=.97, AIC=24804.12, BIC=25001.66, CFI=.99, TLI=.98, SRMR=.02, CD=.85