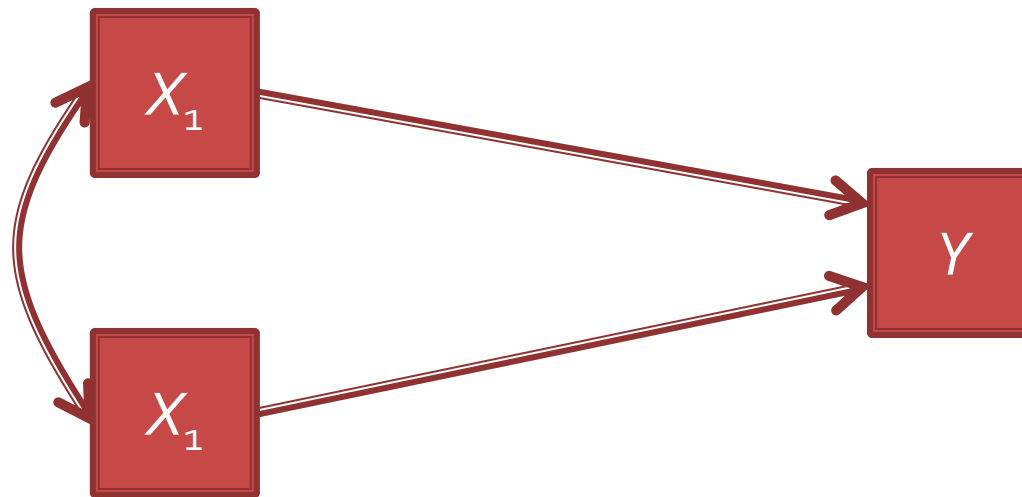


Sunthud Pornprasertmanit
Lab 3: Structural Equation Modeling

Structural Model and Report Your Results

Multiple Regression

- Investigate the effect of independent variable on dependent variable

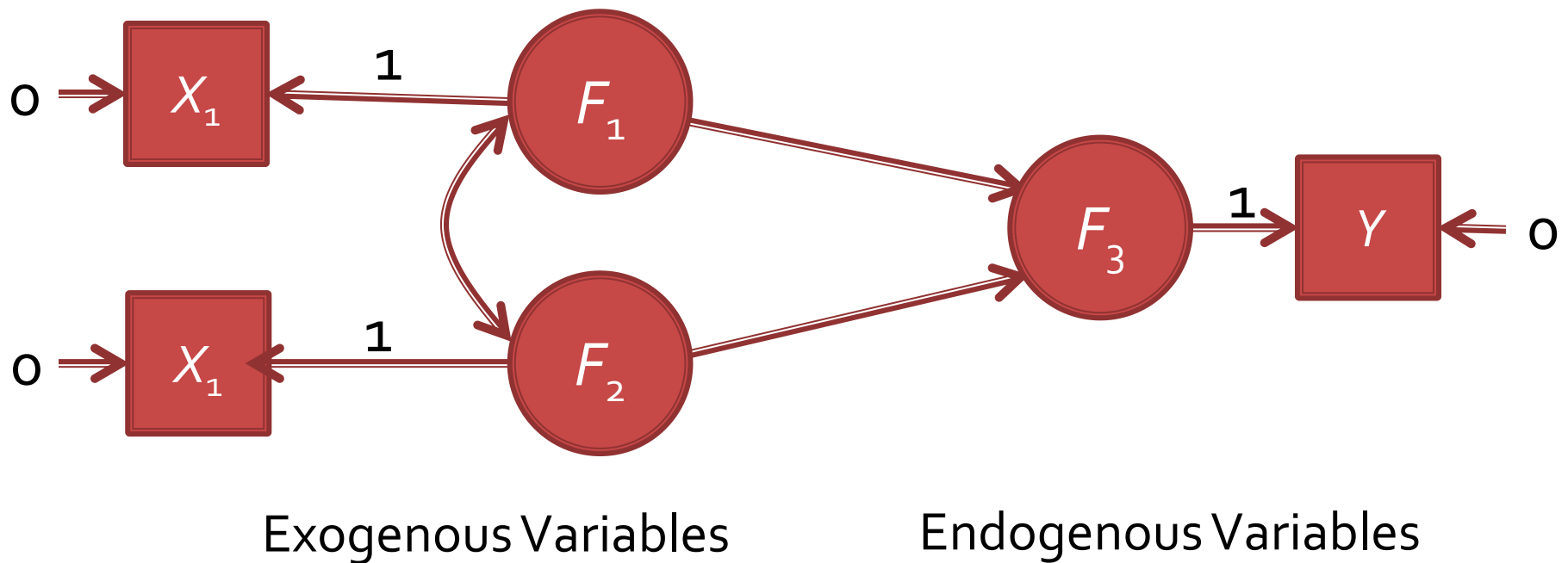


Exogenous Variables

Endogenous Variables

Multiple Regression

- Investigate the effect of independent variable on dependent variable



Multiple Regression

- LISREL

MO NY=3 NE=3 PS=SY, FI BE=FU, FI

LY=FU, FI TE=SY, FI

FR BE (3, 1) BE (3, 2)

FR PS (1, 1) PS (2, 2) PS (3, 3) PS (2, 1)

ST 1 LY (1, 1) LY (2, 2) LY (3, 3)

From

$$BE = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ * & * & 0 \end{bmatrix} \quad \text{To} \quad PS = \begin{bmatrix} * & & \\ * & * & \\ 0 & 0 & * \end{bmatrix}$$

Multiple Regression

- LISREL

MO NY=3 NE=3 PS=SY, FI BE=FU, FI

LY=FU, FI TE=SY, FI

FR BE (3, 1) BE (3, 2)

FR PS (1, 1) PS (2, 2) PS (3, 3) PS (2, 1)

ST 1 LY (1, 1) LY (2, 2) LY (3, 3)

$$\begin{array}{c} \text{Latent} \\ LY = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \text{Indicator} \end{array} \quad \begin{array}{c} TE = \begin{bmatrix} 0 & & \\ 0 & 0 & \\ 0 & 0 & 0 \end{bmatrix} \end{array}$$

Multiple Regression

- MPLUS

Y ON X1 X2

! X1 WITH X2 ! Uncomment to treat X as random

- MPLUS has two approaches to deal with exogenous variable: Fixed X or Random X.
 - **Fixed X.** Cannot have missing data. Nonnormal X is fine.
 - **Random X.** Can have missing data but need to be normal distribution.

Multiple Regression

- **lavaan**

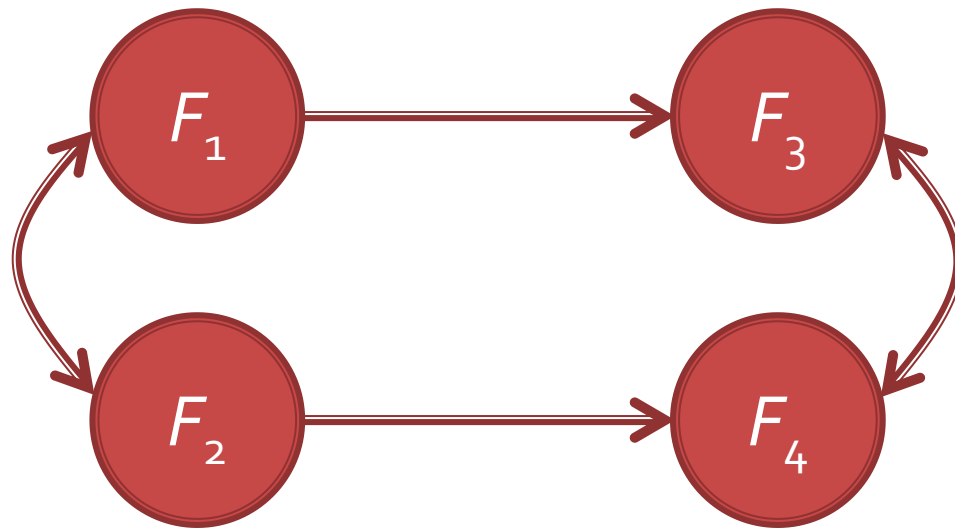
```
Script <- "Y ~ X1 + X2"
```

```
Model <- sem(Script, data=data,  
fixed.x=TRUE)
```

- The **sem** function is used
- Like Mplus, **fixed.x** can be specified.
- In LISREL and EQS, X is always treated as random.

Latent Variable Regression

- Correction of Measurement Error → Unbiased Estimates and More Power
- Flexible for Multiple Dependent Variables / Mediation Analysis



Latent Variable Regression

■ LISREL

MO NY=12 NE=4 PS=SY,FI BE=FU,FI LY=FU,FI
TE=DI,FR

FR BE (3,1) BE (4,2)

ST 1 PS (1,1) PS (2,2) PS (3,3) PS (4,4)

FR PS (1,2) PS (3,4)

FR LY (1,1) LY (2,1) LY (3,1)

FR LY (4,2) LY (5,2) LY (6,2)

FR LY (7,3) LY (8,3) LY (9,3)

FR LY (10,4) LY (11,4) LY (12,4)

Latent Variable Regression

- LISREL

$$BE = \begin{bmatrix} 0 & 0 & 0 & 0 \\ * & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & * & 0 \end{bmatrix}$$

$$PS = \begin{bmatrix} 1 & & & \\ * & 1 & & \\ 0 & 0 & 1 & \\ 0 & 0 & * & 1 \end{bmatrix}$$

(The details on LY and TE are skipped)

Latent Variable Regression

- Mplus

```
F1 BY V1 V2 V3;
```

```
F2 BY V4 V5 V6;
```

```
F3 BY V7 V8 V9;
```

```
F4 BY V10 V11 V12;
```

```
F3 ON F1;
```

```
F4 ON F2;
```

```
F1 WITH F2;
```

```
F3 WITH F4;
```

Latent Variable Regression

■ Lavaan

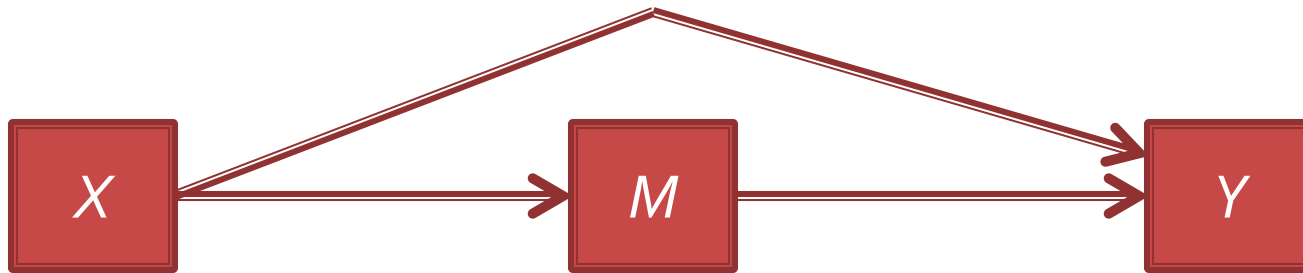
```
Script <- "  
F1 =~ V1 + V2 + V3  
F2 =~ V4 + V5 + V6  
F3 =~ V7 + V8 + V9  
F4 =~ V10 + V11 + V12  
F3 ~ F1  
F4 ~ F2  
F1 ~~ NA*F2  
F3 ~~ NA*F4  
"
```

Mediation vs Moderation

- Mediation = Why? How?
 - Why does studying SEM make you happy?
 - Studying SEM → Intellectual Discovery → Happy
- Moderation = When?
 - When does studying SEM make you happy?
 - Studying SEM → Happy only at the beginning of the semester

Mediation

PARTIAL MEDIATION



FULL MEDIATION

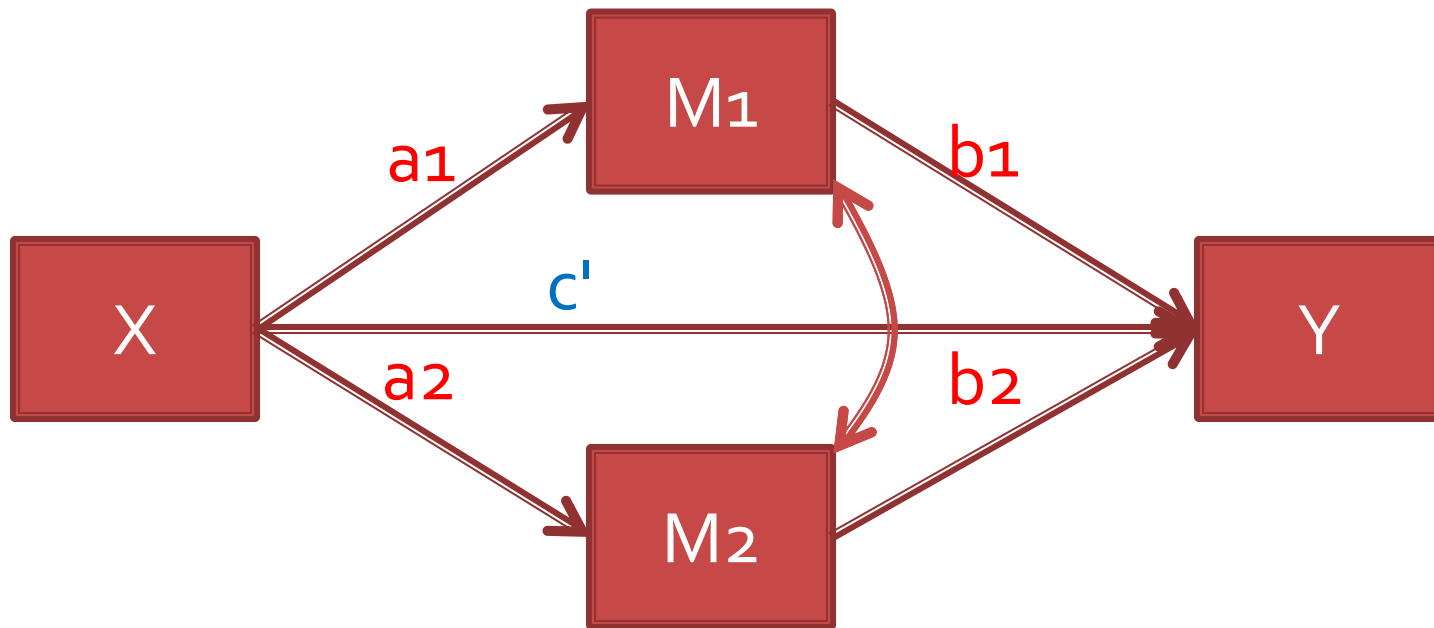


Significance Testing in Mediation

- Baron & Kenny (Thumbs down)
- Sobel Test and co. (Thumbs down)
- Wald Test in SEM (Okay)
- Monte Carlo Approach (Okay)
- Bootstrap Procedure (Great)
 - Parametric
 - Symmetric (Thumbs down)
 - Percentile
 - Bias-corrected

Wald Test

- Example



Total Effect = Direct Effect + Indirect Effect

$$\text{Total Effect} = c' + (a_1 * b_1 + a_2 * b_2)$$

Wald Test

■ LISREL

MO NY=4 NE=4 PS=SY,FI BE=FU,FI LY=FU,FI
TE=SY,FI AP=2

FR BE(2,1) BE(3,1) BE(4,1) BE(4,2) BE(4,3)

FR PS(1,1) PS(2,2) PS(3,3) PS(4,4) PS(3,2)

ST 1 LY(1,1) LY(2,2) LY(3,3) LY(4,4)

CO PA(1) = BE(2,1) * BE(4,2)

CO PA(2) = BE(3,1) * BE(4,3)

Wald Test

- Mplus

```
Y ON X
```

```
    M1 (b1)
```

```
    M2 (b2);
```

```
M1 ON X (a1);
```

```
M2 ON X (a2);
```

```
MODEL CONSTRAINTS:
```

```
new(ind1 ind2);
```

```
ind1 = a1 * b1;
```

```
ind2 = a2 * b2;
```

Wald Test

- Lavaan

```
Script <- "  
Y ~ b1*M1 + b2*M2  
M1 ~ a1*X  
M2 ~ a2*X  
ind1 := a1*b1  
ind2 := a2*b2  
"
```

Bootstrap Procedure

- Resampling from the current sample →
Analyze data → Repeat for 1,000 times →
Find bootstrap distribution
- LISREL (See Kuant Guide #7, #9, and #10)

Bootstrap Procedure

- Mplus

```
ANALYSIS: BOOTSTRAP = 1000;
```

```
MODEL:
```

```
Y ON X
```

```
      M1 (b1)
```

```
      M2 (b2);
```

```
M1 ON X (a1);
```

```
M2 ON X (a2);
```

```
MODEL CONSTRAINTS:
```

```
new(ind1 ind2);
```

```
ind1 = a1 * b1;
```

```
ind2 = a2 * b2;
```

```
Output: STDYX CINTERVAL(BCBOOTSTRAP);
```

- The bootstrap method default is symmetric (bad idea).

Bootstrap Procedure

- Lavaan

```
Script <- "
```

```
Y ~ b1*M1 + b2*M2
```

```
M1 ~ a1*X
```

```
M2 ~ a2*X
```

```
ind1 := a1*b1
```

```
ind2 := a2*b2
```

```
"
```

```
Model <- sem(script, data=data, se="boot")
```

```
parameterEstimates(Model, boot.ci.type="bca.simple")
```

- parameterEstimates is used to find confidence interval.
- The bootstrap default is percentile method.

Real Data Example

■ Guidelines

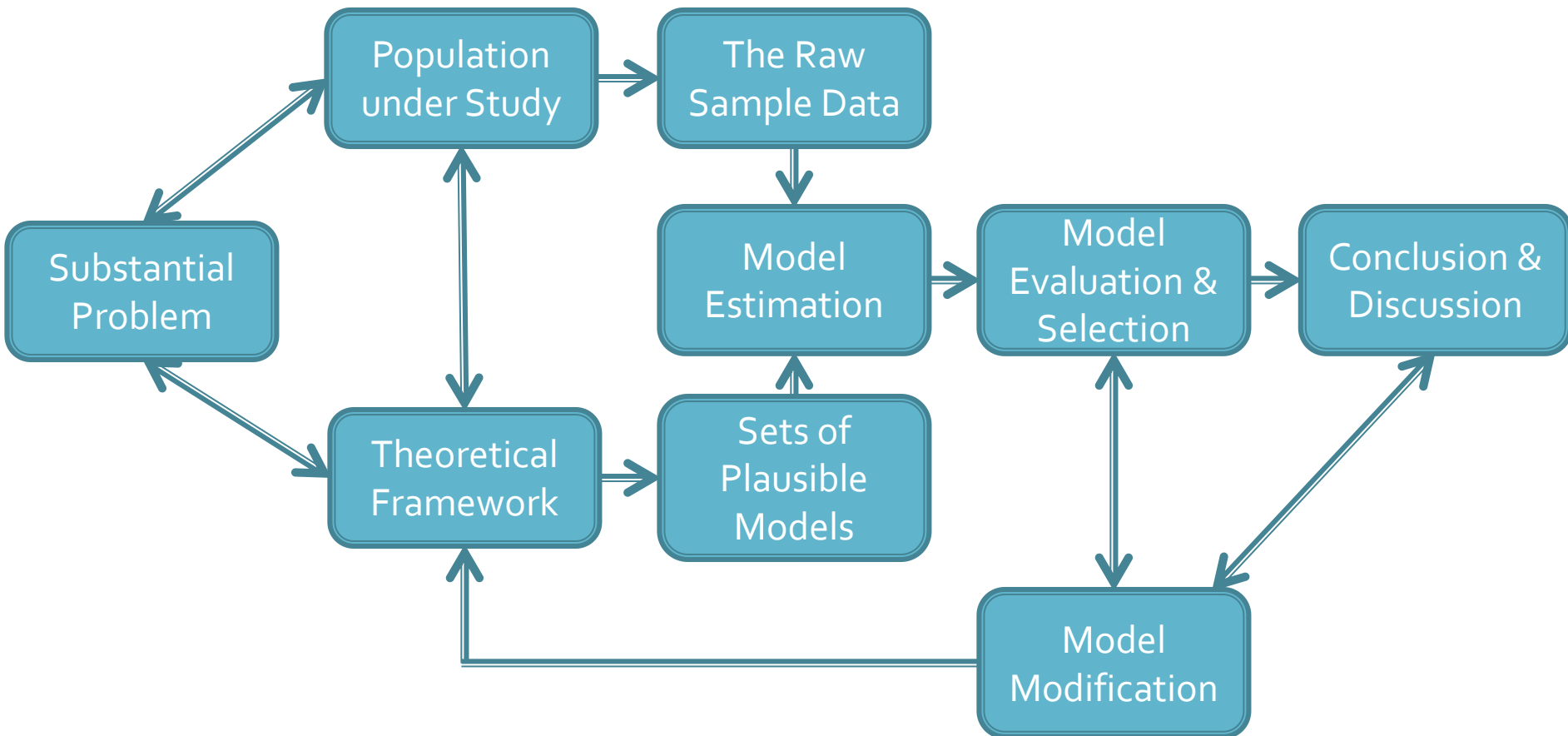
Boomsma, A. (2000). Reporting analyses of covariance structures. *Structural Equation Modeling, 7*, 461-483.

Jackson, D. L., Gillaspay, J. A. Jr., & Purc-Stephenson. (2009). Reporting practices in confirmatory factor analysis: An overview and some recommendations. *Psychological Methods, 14*, 6-23.

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

Report Your Results

Flow chart of SEM Processes (Modified from Boomsma, 2000)



Report Your Results

- Research Questions / Hypotheses
 - Start with the goal and find the intermediate steps
 - Focus on a big picture / Focus only variables that can be used to answer your questions
 - Have alternative models / competing theories
 - Full mediation vs. partial mediation
 - Direction of effects
 - Components of a construct / Hierarchical model
 - Trends of changes
 - Stationary of an effect
 - Moderation effect

Report Your Results

- Models
 - Identifiability
 - Scaling method

Report Your Results

- Research Planning
 - Is sample size enough for absolute model fit?
 - Is sample size enough for model comparison?
 - Is sample size enough for the significance of target parameters?
 - Expect some missing values / dropouts → Find auxiliary variables
 - Sampling procedures (e.g., cluster sampling)
 - Planned missing data

Report Your Results

- Data
 - Data Screening
 - Missing Data (Missing Code, Missing Treatment)
 - Outliers (if removed, justify your reasons)
 - Multivariate Normality (Categorical / Count)
 - Sampling (Complex sampling, natural groups)
 - Report Descriptive Statistics or have it ready

Report Your Results

- Goodness of Fit
 - Two steps: Measurement Model and Path Model
 - Global Model Fit on Measurement Model
 - Always report chi-square
 - Justify your reasons on model fit decisions
 - Compare the measurement model and path models
 - Report model fits for all analyzed models

Report Your Results

- Parameter Estimates and Standard Errors
 - Check the possibility of all parameters
 - Variance < 0
 - Negative standard error
 - Correlation > 1 or < -1
 - Standardized regression can be greater than 1
 - Do the values make sense? (Signs and sizes)
 - Check for significance of all target parameter estimates.

Report Your Results

- Modification Index
 - For exploratory purpose only
 - Not only modification index but expected parameter change

Report Your Results

- Writing
 - Tell a story with sufficient supports
 - Do not forget what are your research questions
 - Include the details that are enough for your classmates to replicate your results
 - Not significant \neq No effect
 - APA style. Really help your readers (and me)!?
 - Consistency

Tips & Tricks

- Making a table quickly
- Organize your files
- Names of your variables
- Save every single draft
- Copy your final outputs into separate folders
- Always publish your papers!

Homework 3

- Due November 14 in class
- Paper drafts are preferred.
- Partial answer keys are available for checking that you are on the right track.
- Always provide your script. If scripts are redundant, only modified parts of your scripts can be provided.
- Do not provide your outputs.