Assignment 2

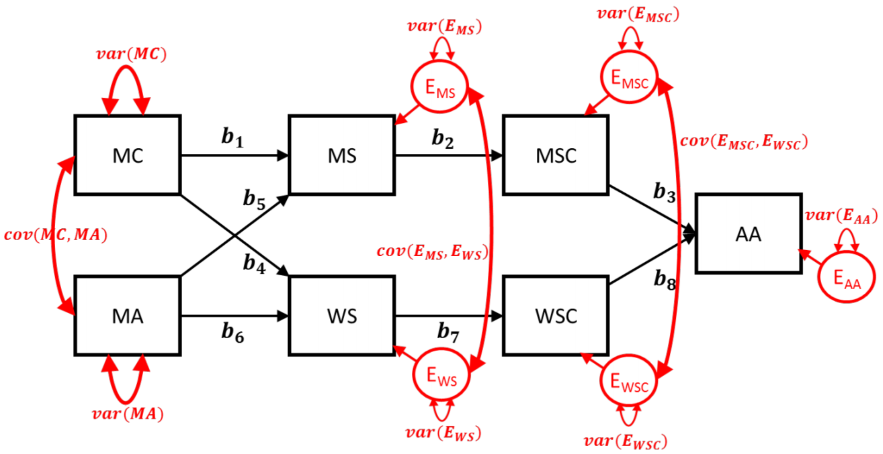
SEM 2: Structural Equation Modeling

Please hand in a `.pdf` file containing your report and a `.R` containing your codes or screenshots of every Jasp analysis. The deadline of this assignment is Wednesday May 24 11:00.

Assignment

Part 1

Last week you analyzed the following SEM model:

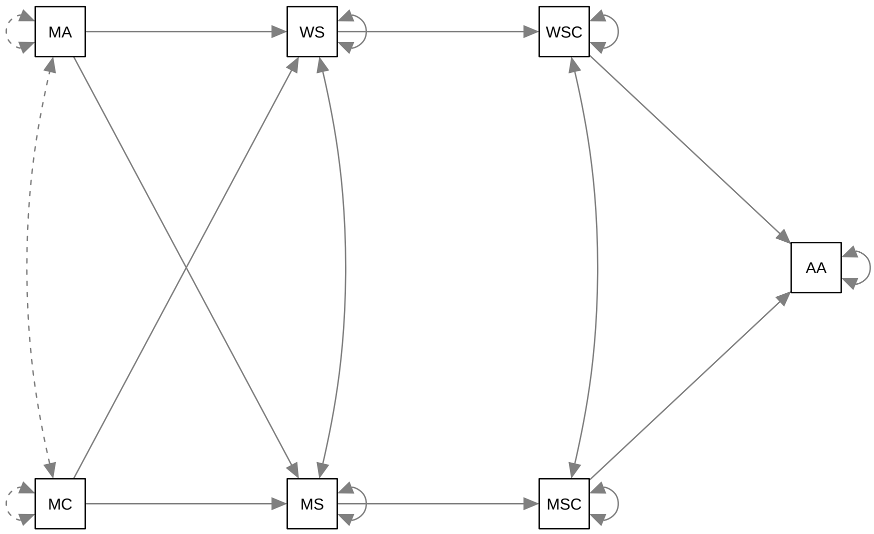


This model could be fitted in Lavaan using the following codes:

```r
library("lavaan")

# Correlation matrix:
Cor <- getCov('
              1
              .16 1
              .61 .23 1
              -.46 -.16 -.06 1
              .34 .03 .50 .06 1
              -.17 -.14 .09 .49 .45 1
              .18 .08 .28 -.07 .37 .11 1')

# Standard deviations:
SD <- c(1.22, 1.74, 1.38, 1.42, 1.78, 1.93, 1.87)

# Covariances:
Cov <- cor2cov(Cor, SD)

# Names:
colnames(Cov) <- rownames(Cov) <- c("MC","MA","MS","WS","MSC","WSC","AA")

# Model:
Model <- '
AA ~ MSC + WSC
MSC ~ MS
WSC ~ WS
MS ~ MC + MA
WS ~ MC + MA
MS ~~ WS
```

```
MSC ~~ WSC
'

# Fit:
fit <- sem(Model, sample.cov = Cov, sample.nobs = 105, fixed.x = TRUE)
fit
```

```
library("semPlot")
semPaths(fit, style = "RAM", layout = "tree2", rotation = 2)
```

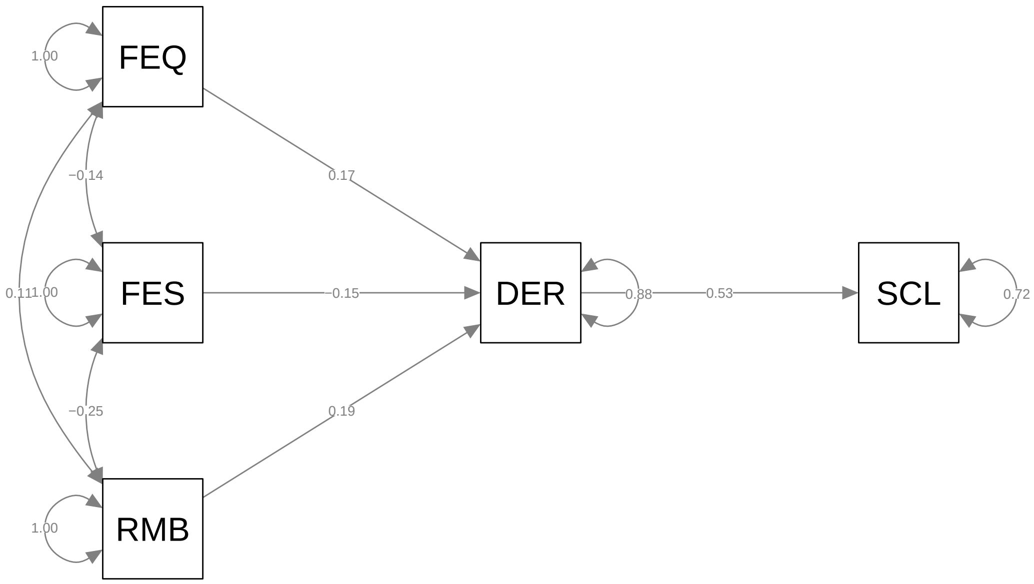


Question 1 (4 points) Think of an equivalent model and fit the model on the same dataset (tip: Lavaan automatically adds covariances between dependent variables which you might need to remove). Argue why you think the models should be equivalent. Compare the χ^2 and degrees of freedom of both models, are they the same?

Given the following SEM analysis (original article on blackboard):

```
library("semPlot")
library("lavaan")
suveg.r <- c(
'1.00
-0.25 1.00
 0.11 -0.14 1.00
 0.25 -0.22 0.21 1.00
```

```
0.18 -0.15 0.19 0.53 1.00')

suveg.r <- getCov(suveg.r, names = c("RMBI", "FES", "FEQN", "DERS", "SCL90ANX"))
sd.suveg <- c(0.33, 0.62, 1.00, 0.54, 0.47)
suveg <- cor2cov(R = suveg.r, sds = sd.suveg)

mod1 <- '

ENTER MODEL HERE

'

fit1 <- sem(mod1, sample.cov = suveg, sample.nobs = 676, fixed.x = FALSE)
semPaths(fit1,"mod","std", layout = "tree2", rotation = 2,
         sizeMan = 10, curve = 2)
```



Question 2 (2 points) Fill in the model to replicate the above analysis

Question 3 (3 points) Given the above path diagram, which of these statements are true?

- FES $\perp\!\!\!\perp$ SCL
- FES $\perp\!\!\!\perp$ SCL | DER
- RMB $\perp\!\!\!\perp$ FEQ | DER

We can obtain the implied variances and covariances using:

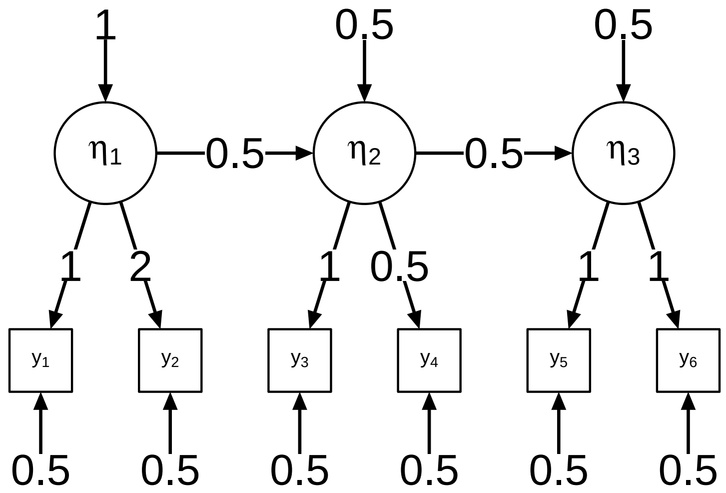
```
lavInspect(fit1, "sigma")

##            DERS   SCL90A RMBI   FES    FEQN
## DERS        0.291
## SCL90ANX    0.134  0.221
## RMBI        0.044  0.021  0.109
## FES        -0.074 -0.034 -0.051  0.384
```

```
## FEQN      0.113  0.052  0.036 -0.087  0.999
```

Question 4 (2 points) Using the Schur complement and the *model implied* variances and covariances, compute the partial correlation between FES and SCL given DER. Round your result to 4 digits. ■

Question 5 (2 points) Can the arrow DER $\rightarrow$ SCL be changed into DER $\leftarrow$ SCL? Why (not)? ■

Consider the following SEM diagram:



$$\boldsymbol{\Lambda} = \begin{bmatrix} 1 & 0 & 0 \\ 2 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0.5 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \end{bmatrix}, \boldsymbol{\Psi} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0.5 & 0 \\ 0 & 0 & 0.5 \end{bmatrix}, \boldsymbol{B} = \begin{bmatrix} 0 & 0 & 0 \\ 0.5 & 0 & 0 \\ 0 & 0.5 & 0 \end{bmatrix}$$

And $\boldsymbol{\Theta}$ is a diagonal matrix with 0.5 on all diagonal elements. We assume all variables are centered, meaning they have an expected value of 0:

$$\mathbb{E}(y_1) = \mathbb{E}(y_2) = \mathbb{E}(y_3) = \mathbb{E}(y_4) = \mathbb{E}(y_5) = \mathbb{E}(y_6) = \mathbb{E}(\eta_1) = \mathbb{E}(\eta_2) = \mathbb{E}(\eta_3) = 0$$

This means that without knowing anything, our best prediction on a persons score on any of these variable would be 0. This makes use of the fact that the expected values of all residuals are always zero as well:

$$\mathbb{E}(\varepsilon_1) = \mathbb{E}(\varepsilon_2) = \mathbb{E}(\varepsilon_3) = \mathbb{E}(\varepsilon_4) = \mathbb{E}(\varepsilon_5) = \mathbb{E}(\varepsilon_6) = \mathbb{E}(\zeta_1) = \mathbb{E}(\zeta_2) = \mathbb{E}(\zeta_3) = 0$$

Question 6 (4 points) Compute the following expectations (tip: to compute these, derive structural equations in terms of exogenous variables and replace all unknown exogenous variables with their expectation):

- $\mathbb{E}(y_1|\text{Do}(\eta_1 = 1))$
- $\mathbb{E}(y_1|\text{Do}(y_2 = 1))$
- $\mathbb{E}(\eta_3|\text{Do}(\eta_1 = 1))$
- $\mathbb{E}(\eta_1|\text{Do}(\eta_3 = 1))$

■

Question 7 (4 points) Are the following statements true or false (you do not have to compute these expectations)?

- $\mathbb{E}(y_1|\text{Do}(y_2 = 1)) = \mathbb{E}(y_1|\text{See}(y_2 = 1))$
- $\mathbb{E}(\eta_2|\text{Do}(\eta_1 = 1)) = \mathbb{E}(\eta_2|\text{See}(\eta_1 = 1))$

- $\mathbb{E}(y_6|\text{Do}(\eta_1 = 3)) = \mathbb{E}(y_6)$
- $\mathbb{E}(\eta_2|\text{Do}(\eta_1 = -3)) > \mathbb{E}(\eta_2)$

References

te Nijenhuis, J., Tolboom, E., Resing, W., & Bleichrodt, N. (2004). Does cultural background influence the intellectual performance of children from immigrant groups? *European Journal of Psychological Assessment*, *20*(1), 10–26.

Wicherts, J. M., & Dolan, C. V. (2010). Measurement invariance in confirmatory factor analysis: An illustration using iq test performance of minorities. *Educational Measurement: Issues and Practice*, *29*(3), 39–47.