Regression analysis with meta-analytic data

Juan Francisco Martin Rodriguez (modified by Mike Cheung)

April 01, 2022

Regression analysis: https://openmx.ssri.psu.edu/node/4801

```
library(metaSEM)
library(readr)

regression_model <- read_delim("Regression.csv",
                               ";", escape_double = FALSE,
                               col_types = cols(Type_training =
                                                    col_factor(levels = c("SP", "MP", "IM"))),
                               na = "NA", trim_ws = TRUE)
# View(regression_model)

## Regression between both ES: MEP --> strength
# 1. remove the missing values (these models cannot work with MV) and exclude
# the 3 first columns
RM_new <- regression_model[-8,4:9]

## A: asymmetric paths for regression coefficients
## and factor loadings
A <- matrix(c(0, "0.1*beta1_2", 0, 0,
              0, 0, 0, 0,
              1, 0, 0, 0,
              0, 1, 0, 0),
            ncol=4, nrow=4, byrow=TRUE)

dimnames(A) <- list(c("f_strength","f_MEP",
                      "y_strength","y_MEP"),
                    c("f_strength","f_MEP",
                      "y_strength","y_MEP"))
A
```

```
##            f_strength f_MEP         y_strength y_MEP
## f_strength "0"        "0.1*beta1_2" "0"        "0"
## f_MEP      "0"        "0"           "0"        "0"
## y_strength "1"        "0"           "0"        "0"
## y_MEP      "0"        "1"           "0"        "0"
```

```
## Convert it into OpenMx matrix
A <- as.mxMatrix(A)
```

```r
# S: symmetric covariances and variances
S <- mxMatrix(type="Symm", nrow=4, ncol=4, byrow=TRUE,
              free=c(TRUE,
                     FALSE,TRUE,
                     FALSE,FALSE,FALSE,
                     FALSE,FALSE,FALSE,FALSE),
              values=c(0.1,
                       0,0.1,
                       0,0,0,
                       0,0,0,0),
              labels=c("tau2_1_1",
                       NA,"tau2_2_2",
                       NA,NA,"data.v_strength",
                       NA,NA,"data.Cov_strength_MEP","data.v_MEP"),
              name = "S")

## F: select observed variables
F <- matrix(c(0, 0, 1, 0,
              0, 0, 0, 1), nrow = 2, ncol = 4, byrow = TRUE)
dimnames(F) <- list(c("y_strength","y_MEP"),
                    c("f_strength","f_MEP","y_strength",
                      "y_MEP"))
F
```

```
##            f_strength f_MEP y_strength y_MEP
## y_strength          0     0          1     0
## y_MEP               0     0          0     1
```

```r
F <-as.mxMatrix(F)

## M: intercepts or means (only intercepts of the latent are estimated
## the intercepts of the observed variables are set to 0)
M <- matrix(c("0*beta1_0","0*beta2_0",0,0), nrow=1, ncol=4, byrow = TRUE)
dimnames(M)[[2]] <- c("f_strength","f_MEP",
                      "y_strength","y_MEP")
M
```

```
##      f_strength  f_MEP       y_strength y_MEP
## [1,] "0*beta1_0" "0*beta2_0" "0"        "0"
```

```r
M <- as.mxMatrix(M)

## Formula for R2
R2 <- mxAlgebra(beta1_2^2*tau2_2_2/(beta1_2^2*tau2_2_2 + tau2_1_1),
                name="R2")

## Build the model
reg <- mxModel("Regression",
               mxData(observed=as.data.frame(RM_new), type="raw"),
               A, S, F, M, R2, mxCI("R2"),
               mxExpectationRAM(A="A", S="S",
                                F="F", M="M",
```

```
                                dimnames = c("f_strength","f_MEP",
                                             "y_strength","y_MEP")),
                mxFitFunctionML())

## Run the analysis
reg.fit <- mxRun(reg, intervals=TRUE, silent=TRUE)
summary(reg.fit)
```

```
## Summary of Regression
##
## free parameters:
##      name matrix      row        col  Estimate Std.Error A
## 1  beta1_2      A f_strength      f_MEP 0.5143001 0.1166106
## 2 tau2_1_1      S        1          1 0.1432816 0.1115068
## 3 tau2_2_2      S        2          2 1.7727245 0.6569429
## 4  beta1_0      M        1 f_strength 0.6069641 0.1596404
## 5  beta2_0      M        1      f_MEP 1.0435207 0.3048190
##
## confidence intervals:
##                      lbound   estimate     ubound note
## Regression.R2[1,1] 0.3186566 0.7659468 0.9862779
##
## Model Statistics:
##                | Parameters | Degrees of Freedom | Fit (-2lnL units)
##        Model:            5                   39             123.2064
##    Saturated:            5                   39                   NA
## Independence:            4                   40                   NA
## Number of observations/statistics: 22/44
##
## Information Criteria:
##       | df Penalty | Parameters Penalty | Sample-Size Adjusted
## AIC:      45.206414             133.2064                 136.9564
## BIC:       2.655758             138.6616                 123.2064
## CFI: NA
## TLI: 1   (also known as NNFI)
## RMSEA:  0  [95% CI (NA, NA)]
## Prob(RMSEA <= 0.05): NA
## To get additional fit indices, see help(mxRefModels)
## timestamp: 2022-04-01 11:38:05
## Wall clock time: 0.136869 secs
## optimizer:  SLSQP
## OpenMx version number: 2.20.6
## Need help?  See help(mxSummary)
```

```
reg.fit@output$status[[1]]
```

```
## [1] 0
```

An alternative approach with the developmental version at https: //github.com/mikewlcheung/metasem

```
model <- "## Latent effect sizes
          f_strength =~ 1*y_strength
          f_MEP =~ 1*y_MEP

          ## Regression coefficient
          f_strength ~ beta1_2*f_MEP

          ## Mean and intercept
          f_strength ~ beta1_0*1
          f_MEP ~ beta2_0*1

          ## Latent variances
          f_strength ~~ tau2_1_1*f_strength
          f_MEP ~~ tau2_2_2*f_MEP

          ## Known sampling variances and covariance
          y_strength ~~ data.v_strength*y_strength
          y_MEP ~~ data.v_MEP*y_MEP
          y_strength ~~ data.Cov_strength_MEP*y_MEP

          ## Define an R2
          R2 := beta1_2^2*tau2_2_2/(beta1_2^2*tau2_2_2 + tau2_1_1)
"

plot(model, layout="tree")
```
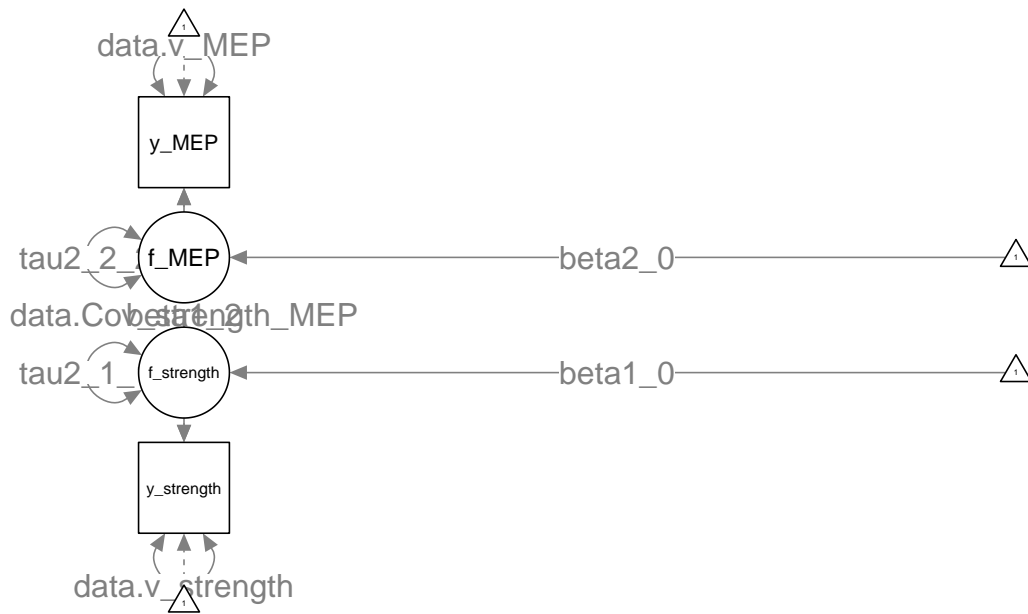
```
RAM <- lavaan2RAM(model, obs.variables = c("y_strength", "y_MEP"), std.lv=FALSE)

mx.fit <- create.mxModel("Regressoin", RAM=RAM, data=as.data.frame(RM_new),
                         intervals.type="LB")
summary(mx.fit)
```

```
## Summary of Regressoin
##
## free parameters:
##        name  matrix        row        col  Estimate Std.Error A
## 1  beta1_2 Amatrix f_strength      f_MEP 0.5143001 0.1166106
## 2 tau2_1_1 Smatrix f_strength f_strength 0.1432816 0.1115068
## 3 tau2_2_2 Smatrix      f_MEP      f_MEP 1.7727243 0.6569429
## 4  beta1_0 Mmatrix          1 f_strength 0.6069641 0.1596404
## 5  beta2_0 Mmatrix          1      f_MEP 1.0435208 0.3048189
##
## confidence intervals:
##                      lbound   estimate    ubound note
## beta1_2           0.289792684 0.5143001 0.7709697
## tau2_1_1          0.007250631 0.1432816 0.5182668
## tau2_2_2          0.872768675 1.7727243 3.8024010
## beta1_0           0.284552909 0.6069641 0.9506220
## beta2_0           0.431701676 1.0435208 1.6889816
## Regressoin.R2[1,1] 0.318656620 0.7659468 0.9862779
##
```

```
## Model Statistics:
##                | Parameters | Degrees of Freedom | Fit (-2lnL units)
##         Model:           5                  39            123.2064
##     Saturated:           5                  39                  NA
## Independence:            4                  40                  NA
## Number of observations/statistics: 22/44
##
## Information Criteria:
##        | df Penalty | Parameters Penalty | Sample-Size Adjusted
## AIC:     45.206414              133.2064              136.9564
## BIC:      2.655758              138.6616              123.2064
## CFI: NA
## TLI: 1   (also known as NNFI)
## RMSEA:  0  [95% CI (NA, NA)]
## Prob(RMSEA <= 0.05): NA
## To get additional fit indices, see help(mxRefModels)
## timestamp: 2022-04-01 11:38:07
## Wall clock time: 0.1395154 secs
## optimizer:  SLSQP
## OpenMx version number: 2.20.6
## Need help?  See help(mxSummary)
```

```
sessionInfo()
```

```
## R version 4.1.3 (2022-03-10)
## Platform: x86_64-pc-linux-gnu (64-bit)
## Running under: Ubuntu 20.04.4 LTS
##
## Matrix products: default
## BLAS:   /usr/lib/x86_64-linux-gnu/blas/libblas.so.3.9.0
## LAPACK: /usr/lib/x86_64-linux-gnu/lapack/liblapack.so.3.9.0
##
## locale:
##  [1] LC_CTYPE=C.UTF-8       LC_NUMERIC=C           LC_TIME=C.UTF-8
##  [4] LC_COLLATE=C.UTF-8     LC_MONETARY=C.UTF-8    LC_MESSAGES=C.UTF-8
##  [7] LC_PAPER=C.UTF-8       LC_NAME=C              LC_ADDRESS=C
## [10] LC_TELEPHONE=C         LC_MEASUREMENT=C.UTF-8 LC_IDENTIFICATION=C
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
## [1] readr_2.1.2     metaSEM_1.2.5.9 OpenMx_2.20.6
##
## loaded via a namespace (and not attached):
##   [1] minqa_1.2.4          colorspace_2.0-2     ellipsis_0.3.2
##   [4] htmlTable_2.4.0      corpcor_1.6.10       base64enc_0.1-3
##   [7] rstudioapi_0.13      lavaan_0.6-11        bit64_4.0.5
##  [10] fansi_1.0.2          mvtnorm_1.1-3        splines_4.1.3
##  [13] mnormt_2.0.2         knitr_1.37           glasso_1.11
##  [16] Formula_1.2-4        nloptr_1.2.2.3       cluster_2.1.2
##  [19] png_0.1-7            compiler_4.1.3       backports_1.4.1
##  [22] assertthat_0.2.1     Matrix_1.4-0         fastmap_1.1.0
##  [25] cli_3.1.1            htmltools_0.5.2      tools_4.1.3
```

```
##  [28] igraph_1.2.11       coda_0.19-4          gtable_0.3.0
##  [31] glue_1.6.2          reshape2_1.4.4       dplyr_1.0.8
##  [34] Rcpp_1.0.8.3        carData_3.0-5        vctrs_0.3.8
##  [37] nlme_3.1-155        lisrelToR_0.1.4      psych_2.2.3
##  [40] xfun_0.30           stringr_1.4.0        openxlsx_4.2.5
##  [43] lme4_1.1-28         lifecycle_1.0.1      gtools_3.9.2
##  [46] XML_3.99-0.8        MASS_7.3-56          scales_1.1.1
##  [49] vroom_1.5.7         hms_1.1.1            kutils_1.70
##  [52] parallel_4.1.3      RColorBrewer_1.1-2  yaml_2.3.5
##  [55] pbapply_1.5-0       gridExtra_2.3        ggplot2_3.3.5
##  [58] rpart_4.1.16        latticeExtra_0.6-29 stringi_1.7.6
##  [61] sem_3.1-14          checkmate_2.0.0      boot_1.3-28
##  [64] zip_2.2.0           rlang_1.0.2          pkgconfig_2.0.3
##  [67] arm_1.12-2          evaluate_0.15        lattice_0.20-45
##  [70] purrr_0.3.4         htmlwidgets_1.5.4    bit_4.0.4
##  [73] tidyselect_1.1.2    plyr_1.8.6           magrittr_2.0.2
##  [76] R6_2.5.1            generics_0.1.2       Hmisc_4.6-0
##  [79] DBI_1.1.2           pillar_1.7.0         foreign_0.8-82
##  [82] rockchalk_1.8.151   survival_3.2-13      semPlot_1.1.5
##  [85] abind_1.4-5         nnet_7.3-17          tibble_3.1.6
##  [88] crayon_1.4.2        fdrtool_1.2.17       utf8_1.2.2
##  [91] ellipse_0.4.2       tmvnsim_1.0-2        tzdb_0.2.0
##  [94] rmarkdown_2.13      jpeg_0.1-9           grid_4.1.3
##  [97] qgraph_1.9.2        data.table_1.14.2    pbivnorm_0.6.0
## [100] digest_0.6.29       xtable_1.8-4         mi_1.0
## [103] RcppParallel_5.1.5  stats4_4.1.3         munsell_0.5.0
```