Appendix A) Example 1: Testing equality of factor loadings in CFA (fixed-effects analysis)

Contents

Installing the metaSEM package

- R can be downloaded at http://www.r-project.org/.
- We only need to install the metaSEM-package once.

```
install.packages("metaSEM")
```

Read in the data and load metaSEM package

```
library(metaSEM)
```

```
## Warning: package 'metaSEM' was built under R version 3.3.3
```

```
## Warning: package 'OpenMx' was built under R version 3.3.3
```

```
## Load the functions to facilitate analysis
source("http://www.suzannejak.nl/subgroup.functions.R")

# The data "Norton13" are available after loading the metaSEM package
# display correlation matrices for first and last study
round(Norton13$data[[1]], 2)
```

```
##       x1   x2   x3   x4   x5   x6   x7   x8   x9  x10  x11  x12  x13  x14
## x1  1.00 0.32 0.47 0.34 0.54 0.46 0.42 0.28 0.54 0.20 0.35 0.35 0.46 0.29
## x2  0.32 1.00 0.25 0.48 0.32 0.41 0.41 0.33 0.35 0.35 0.18 0.37 0.29 0.38
## x3  0.47 0.25 1.00 0.37 0.56 0.39 0.35 0.28 0.38 0.20 0.30 0.36 0.48 0.28
## x4  0.34 0.48 0.37 1.00 0.33 0.52 0.46 0.28 0.33 0.27 0.19 0.41 0.31 0.40
## x5  0.54 0.32 0.56 0.33 1.00 0.42 0.35 0.27 0.45 0.22 0.28 0.35 0.46 0.27
## x6  0.46 0.41 0.39 0.52 0.42 1.00 0.55 0.38 0.39 0.33 0.29 0.42 0.36 0.43
## x7  0.42 0.41 0.35 0.46 0.35 0.55 1.00 0.37 0.39 0.32 0.32 0.34 0.33 0.44
## x8  0.28 0.33 0.28 0.28 0.27 0.38 0.37 1.00 0.32 0.30 0.25 0.29 0.27 0.27
## x9  0.54 0.35 0.38 0.33 0.45 0.39 0.39 0.32 1.00 0.24 0.37 0.35 0.47 0.33
## x10 0.20 0.35 0.20 0.27 0.22 0.33 0.32 0.30 0.24 1.00 0.12 0.26 0.28 0.29
```

```
## x11 0.35 0.18 0.30 0.19 0.28 0.29 0.32 0.25 0.37 0.12 1.00 0.31 0.34 0.20
## x12 0.35 0.37 0.36 0.41 0.35 0.42 0.34 0.29 0.35 0.26 0.31 1.00 0.32 0.32
## x13 0.46 0.29 0.48 0.31 0.46 0.36 0.33 0.27 0.47 0.28 0.34 0.32 1.00 0.25
## x14 0.29 0.38 0.28 0.40 0.27 0.43 0.44 0.27 0.33 0.29 0.20 0.32 0.25 1.00
```

```
round(Norton13$data[[28]], 2)
```

```
##       x1   x2   x3   x4   x5   x6   x7   x8   x9  x10  x11  x12  x13  x14
## x1  1.00 0.10 0.22 0.06 0.21 0.15 0.06 0.25 0.18 0.26 0.11 0.08 0.19 0.06
## x2  0.10 1.00 0.18 0.28 0.22 0.26 0.22 0.24 0.22 0.10 0.19 0.33 0.16 0.19
## x3  0.22 0.18 1.00 0.13 0.34 0.26 0.18 0.29 0.40 0.11 0.23 0.17 0.44 0.14
## x4  0.06 0.28 0.13 1.00 0.20 0.31 0.28 0.15 0.17 0.04 0.13 0.32 0.13 0.20
## x5  0.21 0.22 0.34 0.20 1.00 0.30 0.21 0.30 0.37 0.19 0.23 0.18 0.34 0.16
## x6  0.15 0.26 0.26 0.31 0.30 1.00 0.32 0.30 0.32 0.14 0.21 0.25 0.27 0.20
## x7  0.06 0.22 0.18 0.28 0.21 0.32 1.00 0.18 0.26 0.05 0.19 0.20 0.16 0.27
## x8  0.25 0.24 0.29 0.15 0.30 0.30 0.18 1.00 0.36 0.15 0.20 0.22 0.37 0.11
## x9  0.18 0.22 0.40 0.17 0.37 0.32 0.26 0.36 1.00 0.12 0.26 0.21 0.52 0.10
## x10 0.26 0.10 0.11 0.04 0.19 0.14 0.05 0.15 0.12 1.00 0.09 0.06 0.10 0.03
## x11 0.11 0.19 0.23 0.13 0.23 0.21 0.19 0.20 0.26 0.09 1.00 0.15 0.29 0.15
## x12 0.08 0.33 0.17 0.32 0.18 0.25 0.20 0.22 0.21 0.06 0.15 1.00 0.18 0.23
## x13 0.19 0.16 0.44 0.13 0.34 0.27 0.16 0.37 0.52 0.10 0.29 0.18 1.00 0.12
## x14 0.06 0.19 0.14 0.20 0.16 0.20 0.27 0.11 0.10 0.03 0.15 0.23 0.12 1.00
```

```
# Display sample sizes
Norton13$n
```

```
##  [1]  512  195 5857  892  140  534  387 1028  357 3221  547  298  106  484
## [15]  801  177  521 1511  763  153  256  131  154  144  167  294 1474  716
```

```
# Display population type
Norton13$population
```

```
##  [1] "cancer"            "community"         "community"
##  [4] "cardiovascular"    "brain"             "cardiovascular"
##  [7] "parkinsons"        "community"         "community"
## [10] "community"         "community"         "motorneuro"
## [13] "caregivers"        "elderlyinpatient"  "cardiovascular"
## [16] "parkinsons"        "elderlyoutpatient" "generalpractice"
## [19] "cancer"            "community"         "community"
## [22] "eatingdisorder"    "flambowel"         "respiratory"
## [25] "cardiovascular"    "brain"             "cancer"
## [28] "hivaids"
```

Stage 1 analysis overall

```
# Running Stage 1 model and getting the summary takes +- 4 minutes
# depending on the speed of the computer.
Stage1.fit <- tssem1(Norton13$data, Norton13$n, method = "FEM")

summary(Stage1.fit)
```

```
##
## Call:
## tssem1FEM(my.df = my.df, n = n, cor.analysis = cor.analysis,
##     model.name = model.name, cluster = cluster, suppressWarnings = suppressWarnings,
```

```
##     silent = silent, run = run)
##
## Coefficients:
##           Estimate Std.Error z value  Pr(>|z|)
## S[1,2]   0.2872562 0.0062783  45.754 < 2.2e-16 ***
## S[1,3]   0.4779457 0.0052775  90.563 < 2.2e-16 ***
## S[1,4]   0.2942195 0.0062702  46.924 < 2.2e-16 ***
## S[1,5]   0.5479844 0.0047795 114.652 < 2.2e-16 ***
## S[1,6]   0.4037913 0.0057153  70.651 < 2.2e-16 ***
## S[1,7]   0.4197591 0.0056460  74.346 < 2.2e-16 ***
## S[1,8]   0.3493033 0.0059797  58.415 < 2.2e-16 ***
## S[1,9]   0.4205464 0.0056525  74.400 < 2.2e-16 ***
## S[1,10]  0.2320663 0.0064397  36.037 < 2.2e-16 ***
## S[1,11]  0.3312777 0.0060567  54.696 < 2.2e-16 ***
## S[1,12]  0.3032258 0.0062286  48.682 < 2.2e-16 ***
## S[1,13]  0.4922356 0.0051759  95.101 < 2.2e-16 ***
## S[1,14]  0.2351585 0.0064527  36.443 < 2.2e-16 ***
## S[2,3]   0.2440967 0.0064108  38.076 < 2.2e-16 ***
## S[2,4]   0.4158277 0.0057368  72.485 < 2.2e-16 ***
## S[2,5]   0.2981942 0.0062236  47.914 < 2.2e-16 ***
## S[2,6]   0.3813135 0.0058807  64.841 < 2.2e-16 ***
## S[2,7]   0.3392150 0.0060480  56.087 < 2.2e-16 ***
## S[2,8]   0.3576063 0.0059812  59.788 < 2.2e-16 ***
## S[2,9]   0.2485478 0.0063932  38.877 < 2.2e-16 ***
## S[2,10]  0.2520684 0.0064090  39.331 < 2.2e-16 ***
## S[2,11]  0.1805794 0.0065770  27.456 < 2.2e-16 ***
## S[2,12]  0.4699760 0.0053861  87.257 < 2.2e-16 ***
## S[2,13]  0.2614969 0.0063440  41.220 < 2.2e-16 ***
## S[2,14]  0.2785518 0.0063039  44.188 < 2.2e-16 ***
## S[3,4]   0.2764715 0.0063167  43.768 < 2.2e-16 ***
## S[3,5]   0.5248801 0.0049404 106.243 < 2.2e-16 ***
## S[3,6]   0.3560833 0.0059476  59.870 < 2.2e-16 ***
## S[3,7]   0.3567240 0.0059576  59.877 < 2.2e-16 ***
## S[3,8]   0.3014191 0.0061775  48.793 < 2.2e-16 ***
## S[3,9]   0.4581006 0.0054013  84.813 < 2.2e-16 ***
## S[3,10]  0.2146078 0.0064896  33.069 < 2.2e-16 ***
## S[3,11]  0.2943873 0.0062060  47.436 < 2.2e-16 ***
## S[3,12]  0.2740730 0.0063104  43.432 < 2.2e-16 ***
## S[3,13]  0.5433384 0.0048034 113.116 < 2.2e-16 ***
## S[3,14]  0.2170381 0.0065027  33.377 < 2.2e-16 ***
## S[4,5]   0.3155640 0.0061711  51.136 < 2.2e-16 ***
## S[4,6]   0.4508253 0.0055068  81.866 < 2.2e-16 ***
## S[4,7]   0.3614794 0.0059693  60.556 < 2.2e-16 ***
## S[4,8]   0.2523243 0.0064086  39.373 < 2.2e-16 ***
## S[4,9]   0.2711399 0.0063281  42.847 < 2.2e-16 ***
## S[4,10]  0.2551643 0.0063845  39.966 < 2.2e-16 ***
## S[4,11]  0.1817370 0.0065754  27.639 < 2.2e-16 ***
## S[4,12]  0.4619026 0.0054256  85.134 < 2.2e-16 ***
## S[4,13]  0.2823885 0.0062823  44.950 < 2.2e-16 ***
## S[4,14]  0.3097494 0.0061964  49.989 < 2.2e-16 ***
## S[5,6]   0.4349818 0.0055348  78.590 < 2.2e-16 ***
## S[5,7]   0.4135316 0.0056696  72.938 < 2.2e-16 ***
## S[5,8]   0.3386347 0.0060161  56.288 < 2.2e-16 ***
## S[5,9]   0.4234941 0.0056095  75.496 < 2.2e-16 ***
```

```
## S[5,10]  0.2506663 0.0063751  39.320 < 2.2e-16 ***
## S[5,11]  0.3342963 0.0060380  55.366 < 2.2e-16 ***
## S[5,12]  0.3211812 0.0061239  52.447 < 2.2e-16 ***
## S[5,13]  0.5018116 0.0050865  98.656 < 2.2e-16 ***
## S[5,14]  0.2498873 0.0064041  39.020 < 2.2e-16 ***
## S[6,7]   0.4032644 0.0057397  70.259 < 2.2e-16 ***
## S[6,8]   0.3307815 0.0060646  54.543 < 2.2e-16 ***
## S[6,9]   0.3069402 0.0061806  49.662 < 2.2e-16 ***
## S[6,10]  0.3026122 0.0061992  48.815 < 2.2e-16 ***
## S[6,11]  0.2224804 0.0064533  34.475 < 2.2e-16 ***
## S[6,12]  0.4250593 0.0056353  75.428 < 2.2e-16 ***
## S[6,13]  0.3589573 0.0059236  60.598 < 2.2e-16 ***
## S[6,14]  0.3125969 0.0061608  50.739 < 2.2e-16 ***
## S[7,8]   0.2848582 0.0062551  45.540 < 2.2e-16 ***
## S[7,9]   0.3491117 0.0059919  58.264 < 2.2e-16 ***
## S[7,10]  0.2237876 0.0064850  34.508 < 2.2e-16 ***
## S[7,11]  0.3230571 0.0060943  53.010 < 2.2e-16 ***
## S[7,12]  0.3575366 0.0059697  59.892 < 2.2e-16 ***
## S[7,13]  0.3611724 0.0059246  60.961 < 2.2e-16 ***
## S[7,14]  0.3399497 0.0060422  56.262 < 2.2e-16 ***
## S[8,9]   0.2698996 0.0063134  42.750 < 2.2e-16 ***
## S[8,10]  0.2618181 0.0063298  41.363 < 2.2e-16 ***
## S[8,11]  0.2301360 0.0064345  35.766 < 2.2e-16 ***
## S[8,12]  0.3233790 0.0061104  52.922 < 2.2e-16 ***
## S[8,13]  0.3349906 0.0060363  55.496 < 2.2e-16 ***
## S[8,14]  0.1940613 0.0065487  29.633 < 2.2e-16 ***
## S[9,10]  0.1819058 0.0065767  27.659 < 2.2e-16 ***
## S[9,11]  0.2796407 0.0062729  44.579 < 2.2e-16 ***
## S[9,12]  0.2776067 0.0062990  44.071 < 2.2e-16 ***
## S[9,13]  0.4987823 0.0051459  96.928 < 2.2e-16 ***
## S[9,14]  0.2169761 0.0065006  33.378 < 2.2e-16 ***
## S[10,11] 0.1685948 0.0065922  25.575 < 2.2e-16 ***
## S[10,12] 0.3266226 0.0061104  53.454 < 2.2e-16 ***
## S[10,13] 0.2231204 0.0064540  34.571 < 2.2e-16 ***
## S[10,14] 0.2072736 0.0065434  31.677 < 2.2e-16 ***
## S[11,12] 0.1883964 0.0065500  28.763 < 2.2e-16 ***
## S[11,13] 0.3692218 0.0058707  62.892 < 2.2e-16 ***
## S[11,14] 0.2115262 0.0064998  32.544 < 2.2e-16 ***
## S[12,13] 0.2850655 0.0062590  45.545 < 2.2e-16 ***
## S[12,14] 0.3319761 0.0060933  54.482 < 2.2e-16 ***
## S[13,14] 0.2455148 0.0064050  38.332 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Goodness-of-fit indices:
##                                       Value
## Sample size                       21820.0000
## Chi-square of target model        10400.0403
## DF of target model                 2457.0000
## p value of target model               0.0000
## Chi-square of independence model  98426.0902
## DF of independence model           2548.0000
## RMSEA                                 0.0644
## RMSEA lower 95% CI                    0.0632
```

```
## RMSEA upper 95% CI                    0.0657
## SRMR                                  0.0980
## TLI                                   0.9141
## CFI                                   0.9172
## AIC                                5486.0403
## BIC                              -14146.8203
## OpenMx status1: 0 ("0" or "1": The optimization is considered fine.
## Other values may indicate problems.)
```

Stage 2 analysis overall

- Specify the A-matrix with factor loadings, the S-matrix with variances and covariances, and the F-matrix in selecting observed variables. See Cheung (2015) or McArdle & McDonald (1984) for an explanation of the A, S and F matrices in the RAM formulation.

```
varnames <- paste("x", 1:14, sep="")
factornames <- c("Dist","Anx","Dep")

# Vector to indicate whether variable is observed (1) or latent (0)
F <- create.Fmatrix(c(1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0,0), name="F", as.mxMatrix=FALSE)

dimnames(F) <- list(varnames,c(varnames,factornames))

## Display F
F
```

```
##     x1 x2 x3 x4 x5 x6 x7 x8 x9 x10 x11 x12 x13 x14 Dist Anx Dep
## x1   1  0  0  0  0  0  0  0  0   0   0   0   0   0    0   0   0
## x2   0  1  0  0  0  0  0  0  0   0   0   0   0   0    0   0   0
## x3   0  0  1  0  0  0  0  0  0   0   0   0   0   0    0   0   0
## x4   0  0  0  1  0  0  0  0  0   0   0   0   0   0    0   0   0
## x5   0  0  0  0  1  0  0  0  0   0   0   0   0   0    0   0   0
## x6   0  0  0  0  0  1  0  0  0   0   0   0   0   0    0   0   0
## x7   0  0  0  0  0  0  1  0  0   0   0   0   0   0    0   0   0
## x8   0  0  0  0  0  0  0  1  0   0   0   0   0   0    0   0   0
## x9   0  0  0  0  0  0  0  0  1   0   0   0   0   0    0   0   0
## x10  0  0  0  0  0  0  0  0  0   1   0   0   0   0    0   0   0
## x11  0  0  0  0  0  0  0  0  0   0   1   0   0   0    0   0   0
## x12  0  0  0  0  0  0  0  0  0   0   0   1   0   0    0   0   0
## x13  0  0  0  0  0  0  0  0  0   0   0   0   1   0    0   0   0
## x14  0  0  0  0  0  0  0  0  0   0   0   0   0   1    0   0   0
```

```
# matrix with factor loadings, later included in matrix A
lambda <-matrix(
        c("0.1*L1_1","0.1*L1_2","0",
          "0.1*L2_1","0","0.1*L2_3",
          "0.1*L3_1","0.1*L3_2","0",
          "0.1*L4_1","0","0.1*L4_3",
          "0.1*L5_1","0.1*L5_2","0",
          "0.1*L6_1","0","0.1*L6_3",
          "0.1*L7_1","0.1*L7_2","0",
          "0.1*L8_1","0","0.1*L8_3",
          "0.1*L9_1","0.1*L9_2","0",
          "0.1*L10_1","0","0.1*L10_3",
```

```
          "0.1*L11_1","0.1*L11_2","0",
          "0.1*L12_1","0","0.1*L12_3",
          "0.1*L13_1","0.1*L13_2","0",
          "0.1*L14_1","0","0.1*L14_3"),
            nrow=14, ncol=3, byrow = TRUE)

A <- rbind(cbind(matrix(0,ncol=14,nrow=14),lambda),
           matrix(0, nrow=3, ncol=17))

dimnames(A) <- list(c(varnames,factornames),c(varnames,factornames))

## Display A
A
```

```
##      x1  x2  x3  x4  x5  x6  x7  x8  x9  x10 x11 x12 x13 x14 Dist
## x1   "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0.1*L1_1"
## x2   "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0.1*L2_1"
## x3   "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0.1*L3_1"
## x4   "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0.1*L4_1"
## x5   "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0.1*L5_1"
## x6   "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0.1*L6_1"
## x7   "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0.1*L7_1"
## x8   "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0.1*L8_1"
## x9   "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0.1*L9_1"
## x10  "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0.1*L10_1"
## x11  "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0.1*L11_1"
## x12  "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0.1*L12_1"
## x13  "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0.1*L13_1"
## x14  "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0.1*L14_1"
## Dist "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0"
## Anx  "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0"
## Dep  "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0"
##      Anx         Dep
## x1   "0.1*L1_2"  "0"
## x2   "0"         "0.1*L2_3"
## x3   "0.1*L3_2"  "0"
## x4   "0"         "0.1*L4_3"
## x5   "0.1*L5_2"  "0"
## x6   "0"         "0.1*L6_3"
## x7   "0.1*L7_2"  "0"
## x8   "0"         "0.1*L8_3"
## x9   "0.1*L9_2"  "0"
## x10  "0"         "0.1*L10_3"
## x11  "0.1*L11_2" "0"
## x12  "0"         "0.1*L12_3"
## x13  "0.1*L13_2" "0"
## x14  "0"         "0.1*L14_3"
## Dist "0"         "0"
## Anx  "0"         "0"
## Dep  "0"         "0"
```

```
## Convert to OpenMx-matrices
A <- as.mxMatrix(A)
```

```r
# Matrix with residual variances
psi <- matrix(0, nrow = 14, ncol = 14)
diag(psi) <- paste("0.1*","e",1:14,sep="")

# Matrix with factor variances and covariances
phi <- matrix(c(1,0,0,
                0,1,0,
                0,0,1),
              nrow = 3, ncol = 3)

# Psi and phi are combined in matrix S
S <- bdiagMat(list(psi, phi))

dimnames(S) <- list(c(varnames,factornames),c(varnames,factornames))

## Display S
S
```

```
##      x1       x2       x3       x4       x5       x6       x7
## x1   "0.1*e1" "0"      "0"      "0"      "0"      "0"      "0"
## x2   "0"      "0.1*e2" "0"      "0"      "0"      "0"      "0"
## x3   "0"      "0"      "0.1*e3" "0"      "0"      "0"      "0"
## x4   "0"      "0"      "0"      "0.1*e4" "0"      "0"      "0"
## x5   "0"      "0"      "0"      "0"      "0.1*e5" "0"      "0"
## x6   "0"      "0"      "0"      "0"      "0"      "0.1*e6" "0"
## x7   "0"      "0"      "0"      "0"      "0"      "0"      "0.1*e7"
## x8   "0"      "0"      "0"      "0"      "0"      "0"      "0"
## x9   "0"      "0"      "0"      "0"      "0"      "0"      "0"
## x10  "0"      "0"      "0"      "0"      "0"      "0"      "0"
## x11  "0"      "0"      "0"      "0"      "0"      "0"      "0"
## x12  "0"      "0"      "0"      "0"      "0"      "0"      "0"
## x13  "0"      "0"      "0"      "0"      "0"      "0"      "0"
## x14  "0"      "0"      "0"      "0"      "0"      "0"      "0"
## Dist "0"      "0"      "0"      "0"      "0"      "0"      "0"
## Anx  "0"      "0"      "0"      "0"      "0"      "0"      "0"
## Dep  "0"      "0"      "0"      "0"      "0"      "0"      "0"
##      x8       x9       x10       x11       x12       x13       x14
## x1   "0"      "0"      "0"       "0"       "0"       "0"       "0"
## x2   "0"      "0"      "0"       "0"       "0"       "0"       "0"
## x3   "0"      "0"      "0"       "0"       "0"       "0"       "0"
## x4   "0"      "0"      "0"       "0"       "0"       "0"       "0"
## x5   "0"      "0"      "0"       "0"       "0"       "0"       "0"
## x6   "0"      "0"      "0"       "0"       "0"       "0"       "0"
## x7   "0"      "0"      "0"       "0"       "0"       "0"       "0"
## x8   "0.1*e8" "0"      "0"       "0"       "0"       "0"       "0"
## x9   "0"      "0.1*e9" "0"       "0"       "0"       "0"       "0"
## x10  "0"      "0"      "0.1*e10" "0"       "0"       "0"       "0"
## x11  "0"      "0"      "0"       "0.1*e11" "0"       "0"       "0"
## x12  "0"      "0"      "0"       "0"       "0.1*e12" "0"       "0"
## x13  "0"      "0"      "0"       "0"       "0"       "0.1*e13" "0"
## x14  "0"      "0"      "0"       "0"       "0"       "0"       "0.1*e14"
## Dist "0"      "0"      "0"       "0"       "0"       "0"       "0"
## Anx  "0"      "0"      "0"       "0"       "0"       "0"       "0"
## Dep  "0"      "0"      "0"       "0"       "0"       "0"       "0"
```

```
##      Dist Anx Dep
## x1   "0"  "0" "0"
## x2   "0"  "0" "0"
## x3   "0"  "0" "0"
## x4   "0"  "0" "0"
## x5   "0"  "0" "0"
## x6   "0"  "0" "0"
## x7   "0"  "0" "0"
## x8   "0"  "0" "0"
## x9   "0"  "0" "0"
## x10  "0"  "0" "0"
## x11  "0"  "0" "0"
## x12  "0"  "0" "0"
## x13  "0"  "0" "0"
## x14  "0"  "0" "0"
## Dist "1"  "0" "0"
## Anx  "0"  "1" "0"
## Dep  "0"  "0" "1"
```

```
## Convert to OpenMx-matrices
S <- as.mxMatrix(S)
```

- Fitting the Stage 2 model on the pooled correlation matrix from the fixed effects Stage 1 analysis

```
# Run the Stage 2 model
Stage2.fit <- tssem2(Stage1.fit, Amatrix=A, Smatrix=S, Fmatrix=F)
summary(Stage2.fit)
```

```
##
## Call:
## wls(Cov = coef.tssem1FEM(tssem1.obj), asyCov = vcov.tssem1FEM(tssem1.obj),
##     n = sum(tssem1.obj$n), Amatrix = Amatrix, Smatrix = Smatrix,
##     Fmatrix = Fmatrix, diag.constraints = diag.constraints, cor.analysis = tssem1.obj$cor.analysis,
##     intervals.type = intervals.type, mx.algebras = mx.algebras,
##     model.name = model.name, suppressWarnings = suppressWarnings,
##     silent = silent, run = run)
##
## 95% confidence intervals: z statistic approximation
## Coefficients:
##         Estimate  Std.Error     lbound     ubound  z value  Pr(>|z|)
## L1_2   0.1948645  0.0120544  0.1712384  0.2184907  16.1654 < 2.2e-16 ***
## L1_1   0.6908226  0.0052869  0.6804604  0.7011848 130.6660 < 2.2e-16 ***
## L10_3  0.2734161  0.0093812  0.2550292  0.2918029  29.1451 < 2.2e-16 ***
## L10_1  0.3681739  0.0069935  0.3544670  0.3818808  52.6454 < 2.2e-16 ***
## L11_2  0.1232817  0.0130608  0.0976830  0.1488804   9.4391 < 2.2e-16 ***
## L11_1  0.4758235  0.0066663  0.4627578  0.4888893  71.3773 < 2.2e-16 ***
## L12_3  0.5309869  0.0080716  0.5151668  0.5468069  65.7845 < 2.2e-16 ***
## L12_1  0.4961878  0.0064181  0.4836085  0.5087670  77.3105 < 2.2e-16 ***
## L13_2  0.4453823  0.0123412  0.4211941  0.4695706  36.0891 < 2.2e-16 ***
## L13_1  0.6297955  0.0074524  0.6151889  0.6444020  84.5086 < 2.2e-16 ***
## L14_3  0.2283365  0.0091553  0.2103925  0.2462806  24.9404 < 2.2e-16 ***
## L14_1  0.4298049  0.0066454  0.4167802  0.4428296  64.6774 < 2.2e-16 ***
## L2_3   0.4668391  0.0086681  0.4498500  0.4838281  53.8574 < 2.2e-16 ***
## L2_1   0.4703079  0.0066858  0.4572039  0.4834119  70.3438 < 2.2e-16 ***
## L3_2   0.4016487  0.0119408  0.3782452  0.4250522  33.6367 < 2.2e-16 ***
## L3_1   0.6103118  0.0071871  0.5962254  0.6243982  84.9182 < 2.2e-16 ***
```

```
## L4_3   0.4366264  0.0088328  0.4193145  0.4539383  49.4326 < 2.2e-16 ***
## L4_1   0.4974585  0.0065743  0.4845732  0.5103438  75.6677 < 2.2e-16 ***
## L5_2   0.2336598  0.0116626  0.2108014  0.2565181  20.0349 < 2.2e-16 ***
## L5_1   0.7055020  0.0053041  0.6951062  0.7158978 133.0116 < 2.2e-16 ***
## L6_3   0.2947796  0.0094084  0.2763396  0.3132197  31.3317 < 2.2e-16 ***
## L6_1   0.6147348  0.0060054  0.6029644  0.6265051 102.3638 < 2.2e-16 ***
## L7_2  -0.1257873  0.0188987 -0.1628282 -0.0887464  -6.6559 2.817e-11 ***
## L7_1   0.7110237  0.0061459  0.6989780  0.7230694 115.6911 < 2.2e-16 ***
## L8_3   0.2089462  0.0099407  0.1894628  0.2284296  21.0193 < 2.2e-16 ***
## L8_1   0.5037025  0.0065171  0.4909291  0.5164758  77.2889 < 2.2e-16 ***
## L9_2   0.3344300  0.0118479  0.3112085  0.3576514  28.2269 < 2.2e-16 ***
## L9_1   0.5569339  0.0071287  0.5429619  0.5709058  78.1260 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Goodness-of-fit indices:
##                                                Value
## Sample size                                21820.0000
## Chi-square of target model                  2103.0799
## DF of target model                            63.0000
## p value of target model                        0.0000
## Number of constraints imposed on "Smatrix"     0.0000
## DF manually adjusted                           0.0000
## Chi-square of independence model           43649.6173
## DF of independence model                      91.0000
## RMSEA                                          0.0385
## RMSEA lower 95% CI                             0.0371
## RMSEA upper 95% CI                             0.0399
## SRMR                                           0.0328
## TLI                                            0.9323
## CFI                                            0.9532
## AIC                                         1977.0799
## BIC                                         1473.6733
## OpenMx status1: 0 ("0" or "1": The optimization is considered fine.
## Other values indicate problems.)
```

Subgroup analysis

- We group the sample characteristics into patients versus non-patients. The variable is stored in `Norton13$group`.

```
# Display the populations grouped into patients vs. non-patients
Norton13$group
```

```
##  [1] "patients"     "non-patients" "non-patients" "patients"
##  [5] "patients"     "patients"     "patients"     "non-patients"
##  [9] "non-patients" "non-patients" "non-patients" "patients"
## [13] "non-patients" "patients"     "patients"     "patients"
## [17] "non-patients" "patients"     "patients"     "non-patients"
## [21] "non-patients" "patients"     "patients"     "patients"
## [25] "patients"     "patients"     "patients"     "patients"
```

```r
# Stage 1 per subgroup
Stage1_subgroup.fit <- tssem1(Norton13$data, Norton13$n, method = "FEM",
                              cluster = Norton13$group)

summary(Stage1_subgroup.fit)
```

```
## $`non-patients`
##
## Call:
## tssem1FEM(my.df = data.cluster[[i]], n = n.cluster[[i]], cor.analysis = cor.analysis,
##     model.name = model.name, suppressWarnings = suppressWarnings)
##
## Coefficients:
##           Estimate Std.Error z value  Pr(>|z|)
## S[1,2]   0.2220173 0.0086258  25.739 < 2.2e-16 ***
## S[1,3]   0.4407463 0.0072996  60.379 < 2.2e-16 ***
## S[1,4]   0.2100095 0.0086853  24.180 < 2.2e-16 ***
## S[1,5]   0.5165091 0.0066316  77.886 < 2.2e-16 ***
## S[1,6]   0.3505683 0.0079437  44.132 < 2.2e-16 ***
## S[1,7]   0.3777573 0.0077656  48.645 < 2.2e-16 ***
## S[1,8]   0.3296029 0.0080757  40.814 < 2.2e-16 ***
## S[1,9]   0.3586008 0.0078914  45.442 < 2.2e-16 ***
## S[1,10]  0.1694992 0.0087919  19.279 < 2.2e-16 ***
## S[1,11]  0.2997345 0.0082525  36.321 < 2.2e-16 ***
## S[1,12]  0.2099230 0.0086942  24.145 < 2.2e-16 ***
## S[1,13]  0.4677028 0.0070713  66.141 < 2.2e-16 ***
## S[1,14]  0.1637217 0.0088025  18.599 < 2.2e-16 ***
## S[2,3]   0.1743831 0.0087798  19.862 < 2.2e-16 ***
## S[2,4]   0.2933167 0.0082848  35.404 < 2.2e-16 ***
## S[2,5]   0.2281905 0.0085787  26.600 < 2.2e-16 ***
## S[2,6]   0.2897715 0.0083376  34.755 < 2.2e-16 ***
## S[2,7]   0.2736889 0.0083785  32.666 < 2.2e-16 ***
## S[2,8]   0.2953601 0.0083579  35.339 < 2.2e-16 ***
## S[2,9]   0.1869329 0.0087350  21.401 < 2.2e-16 ***
## S[2,10]  0.1736110 0.0088040  19.720 < 2.2e-16 ***
## S[2,11]  0.1375212 0.0088853  15.477 < 2.2e-16 ***
## S[2,12]  0.3709394 0.0078741  47.109 < 2.2e-16 ***
## S[2,13]  0.2117454 0.0086399  24.508 < 2.2e-16 ***
## S[2,14]  0.2034295 0.0086792  23.439 < 2.2e-16 ***
## S[3,4]   0.1858420 0.0087579  21.220 < 2.2e-16 ***
## S[3,5]   0.4688025 0.0070601  66.401 < 2.2e-16 ***
## S[3,6]   0.2900422 0.0082918  34.979 < 2.2e-16 ***
## S[3,7]   0.2995115 0.0082359  36.367 < 2.2e-16 ***
## S[3,8]   0.2773558 0.0083477  33.226 < 2.2e-16 ***
## S[3,9]   0.3976453 0.0076316  52.105 < 2.2e-16 ***
## S[3,10]  0.1652478 0.0087958  18.787 < 2.2e-16 ***
## S[3,11]  0.2654278 0.0084287  31.491 < 2.2e-16 ***
## S[3,12]  0.1919247 0.0087336  21.976 < 2.2e-16 ***
## S[3,13]  0.4970984 0.0068113  72.982 < 2.2e-16 ***
## S[3,14]  0.1386767 0.0088727  15.630 < 2.2e-16 ***
## S[4,5]   0.2237835 0.0086032  26.012 < 2.2e-16 ***
## S[4,6]   0.3453652 0.0079974  43.185 < 2.2e-16 ***
## S[4,7]   0.2687415 0.0083999  31.993 < 2.2e-16 ***
## S[4,8]   0.1722034 0.0088057  19.556 < 2.2e-16 ***
```

```
## S[4,9]   0.1898956 0.0087361  21.737 < 2.2e-16 ***
## S[4,10]  0.1924205 0.0087174  22.073 < 2.2e-16 ***
## S[4,11]  0.1359811 0.0088824  15.309 < 2.2e-16 ***
## S[4,12]  0.3626970 0.0078857  45.995 < 2.2e-16 ***
## S[4,13]  0.2135505 0.0086409  24.714 < 2.2e-16 ***
## S[4,14]  0.2243665 0.0085951  26.104 < 2.2e-16 ***
## S[5,6]   0.3716337 0.0077952  47.675 < 2.2e-16 ***
## S[5,7]   0.3606988 0.0078679  45.845 < 2.2e-16 ***
## S[5,8]   0.3153680 0.0081455  38.717 < 2.2e-16 ***
## S[5,9]   0.3548343 0.0079137  44.838 < 2.2e-16 ***
## S[5,10]  0.1908061 0.0087141  21.896 < 2.2e-16 ***
## S[5,11]  0.2955045 0.0082640  35.758 < 2.2e-16 ***
## S[5,12]  0.2436664 0.0085182  28.605 < 2.2e-16 ***
## S[5,13]  0.4646134 0.0070882  65.547 < 2.2e-16 ***
## S[5,14]  0.1758031 0.0087614  20.066 < 2.2e-16 ***
## S[6,7]   0.3218613 0.0081190  39.643 < 2.2e-16 ***
## S[6,8]   0.2909700 0.0082992  35.060 < 2.2e-16 ***
## S[6,9]   0.2426067 0.0085254  28.457 < 2.2e-16 ***
## S[6,10]  0.2365428 0.0085459  27.679 < 2.2e-16 ***
## S[6,11]  0.1867349 0.0087475  21.347 < 2.2e-16 ***
## S[6,12]  0.3214027 0.0081555  39.409 < 2.2e-16 ***
## S[6,13]  0.3132638 0.0081627  38.378 < 2.2e-16 ***
## S[6,14]  0.2375736 0.0085382  27.825 < 2.2e-16 ***
## S[7,8]   0.2494964 0.0084897  29.388 < 2.2e-16 ***
## S[7,9]   0.2901629 0.0082875  35.012 < 2.2e-16 ***
## S[7,10]  0.1685117 0.0088018  19.145 < 2.2e-16 ***
## S[7,11]  0.2961935 0.0082745  35.796 < 2.2e-16 ***
## S[7,12]  0.2816218 0.0083427  33.757 < 2.2e-16 ***
## S[7,13]  0.3276580 0.0080769  40.567 < 2.2e-16 ***
## S[7,14]  0.2722196 0.0083766  32.498 < 2.2e-16 ***
## S[8,9]   0.2311406 0.0085639  26.990 < 2.2e-16 ***
## S[8,10]  0.2266162 0.0085908  26.379 < 2.2e-16 ***
## S[8,11]  0.2069342 0.0086855  23.825 < 2.2e-16 ***
## S[8,12]  0.2582103 0.0084839  30.435 < 2.2e-16 ***
## S[8,13]  0.3114517 0.0081690  38.126 < 2.2e-16 ***
## S[8,14]  0.1358378 0.0088790  15.299 < 2.2e-16 ***
## S[9,10]  0.1283768 0.0089020  14.421 < 2.2e-16 ***
## S[9,11]  0.2434707 0.0085210  28.573 < 2.2e-16 ***
## S[9,12]  0.2018857 0.0086884  23.236 < 2.2e-16 ***
## S[9,13]  0.4575573 0.0071814  63.714 < 2.2e-16 ***
## S[9,14]  0.1480130 0.0088508  16.723 < 2.2e-16 ***
## S[10,11] 0.1476318 0.0088549  16.672 < 2.2e-16 ***
## S[10,12] 0.2545461 0.0084793  30.020 < 2.2e-16 ***
## S[10,13] 0.1792081 0.0087532  20.474 < 2.2e-16 ***
## S[10,14] 0.1326150 0.0088914  14.915 < 2.2e-16 ***
## S[11,12] 0.1433666 0.0088704  16.162 < 2.2e-16 ***
## S[11,13] 0.3613415 0.0078950  45.768 < 2.2e-16 ***
## S[11,14] 0.1650808 0.0088019  18.755 < 2.2e-16 ***
## S[12,13] 0.2116532 0.0086452  24.482 < 2.2e-16 ***
## S[12,14] 0.2543880 0.0084738  30.021 < 2.2e-16 ***
## S[13,14] 0.1773619 0.0087583  20.251 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Goodness-of-fit indices:
##                                       Value
## Sample size                       12241.0000
## Chi-square of target model         3254.6011
## DF of target model                  819.0000
## p value of target model               0.0000
## Chi-square of independence model  41966.5699
## DF of independence model            910.0000
## RMSEA                                 0.0493
## RMSEA lower 95% CI                    0.0475
## RMSEA upper 95% CI                    0.0511
## SRMR                                  0.0623
## TLI                                   0.9341
## CFI                                   0.9407
## AIC                                1616.6011
## BIC                               -4454.2743
## OpenMx status1: 0 ("0" or "1": The optimization is considered fine.
## Other values may indicate problems.)
##
## $patients
##
## Call:
## tssem1FEM(my.df = data.cluster[[i]], n = n.cluster[[i]], cor.analysis = cor.analysis,
##     model.name = model.name, suppressWarnings = suppressWarnings)
##
## Coefficients:
##           Estimate Std.Error z value  Pr(>|z|)
## S[1,2]   0.3589723 0.0090193  39.800 < 2.2e-16 ***
## S[1,3]   0.5202306 0.0075783  68.648 < 2.2e-16 ***
## S[1,4]   0.3856090 0.0088310  43.665 < 2.2e-16 ***
## S[1,5]   0.5832701 0.0068495  85.155 < 2.2e-16 ***
## S[1,6]   0.4618187 0.0081332  56.782 < 2.2e-16 ***
## S[1,7]   0.4665827 0.0081602  57.178 < 2.2e-16 ***
## S[1,8]   0.3718755 0.0088889  41.836 < 2.2e-16 ***
## S[1,9]   0.4908596 0.0079383  61.834 < 2.2e-16 ***
## S[1,10]  0.3034491 0.0093250  32.541 < 2.2e-16 ***
## S[1,11]  0.3681541 0.0088825  41.447 < 2.2e-16 ***
## S[1,12]  0.4026261 0.0086585  46.501 < 2.2e-16 ***
## S[1,13]  0.5198201 0.0075796  68.582 < 2.2e-16 ***
## S[1,14]  0.3165073 0.0093053  34.014 < 2.2e-16 ***
## S[2,3]   0.3196375 0.0092403  34.592 < 2.2e-16 ***
## S[2,4]   0.5447111 0.0073941  73.669 < 2.2e-16 ***
## S[2,5]   0.3740101 0.0088909  42.067 < 2.2e-16 ***
## S[2,6]   0.4771459 0.0080192  59.500 < 2.2e-16 ***
## S[2,7]   0.4100153 0.0086015  47.668 < 2.2e-16 ***
## S[2,8]   0.4252404 0.0084386  50.392 < 2.2e-16 ***
## S[2,9]   0.3163333 0.0092658  34.140 < 2.2e-16 ***
## S[2,10]  0.3391362 0.0091410  37.100 < 2.2e-16 ***
## S[2,11]  0.2297085 0.0097239  23.623 < 2.2e-16 ***
## S[2,12]  0.5719582 0.0070028  81.675 < 2.2e-16 ***
## S[2,13]  0.3163669 0.0092726  34.118 < 2.2e-16 ***
## S[2,14]  0.3618762 0.0089753  40.319 < 2.2e-16 ***
## S[3,4]   0.3729933 0.0088725  42.039 < 2.2e-16 ***
## S[3,5]   0.5863183 0.0067616  86.713 < 2.2e-16 ***
```

```
## S[3,6]   0.4267440 0.0084048  50.774 < 2.2e-16 ***
## S[3,7]   0.4199386 0.0085177  49.302 < 2.2e-16 ***
## S[3,8]   0.3289947 0.0091700  35.877 < 2.2e-16 ***
## S[3,9]   0.5255864 0.0074814  70.253 < 2.2e-16 ***
## S[3,10]  0.2711370 0.0095317  28.446 < 2.2e-16 ***
## S[3,11]  0.3282190 0.0091465  35.885 < 2.2e-16 ***
## S[3,12]  0.3606703 0.0089408  40.340 < 2.2e-16 ***
## S[3,13]  0.5947078 0.0066647  89.233 < 2.2e-16 ***
## S[3,14]  0.3052447 0.0093482  32.653 < 2.2e-16 ***
## S[4,5]   0.4135132 0.0085893  48.143 < 2.2e-16 ***
## S[4,6]   0.5603158 0.0071704  78.143 < 2.2e-16 ***
## S[4,7]   0.4604963 0.0081892  56.232 < 2.2e-16 ***
## S[4,8]   0.3400941 0.0091401  37.209 < 2.2e-16 ***
## S[4,9]   0.3588626 0.0089749  39.985 < 2.2e-16 ***
## S[4,10]  0.3251665 0.0092416  35.185 < 2.2e-16 ***
## S[4,11]  0.2336865 0.0097131  24.059 < 2.2e-16 ***
## S[4,12]  0.5639916 0.0071035  79.397 < 2.2e-16 ***
## S[4,13]  0.3569135 0.0090077  39.623 < 2.2e-16 ***
## S[4,14]  0.4038049 0.0086808  46.517 < 2.2e-16 ***
## S[5,6]   0.5028304 0.0077182  65.148 < 2.2e-16 ***
## S[5,7]   0.4714855 0.0080790  58.359 < 2.2e-16 ***
## S[5,8]   0.3650442 0.0089123  40.960 < 2.2e-16 ***
## S[5,9]   0.4996655 0.0077594  64.395 < 2.2e-16 ***
## S[5,10]  0.3181843 0.0092323  34.464 < 2.2e-16 ***
## S[5,11]  0.3791192 0.0087901  43.130 < 2.2e-16 ***
## S[5,12]  0.4029169 0.0086361  46.655 < 2.2e-16 ***
## S[5,13]  0.5426677 0.0072555  74.793 < 2.2e-16 ***
## S[5,14]  0.3330228 0.0091950  36.218 < 2.2e-16 ***
## S[6,7]   0.4900095 0.0078806  62.179 < 2.2e-16 ***
## S[6,8]   0.3745472 0.0088442  42.349 < 2.2e-16 ***
## S[6,9]   0.3768991 0.0088464  42.605 < 2.2e-16 ***
## S[6,10]  0.3758098 0.0088571  42.431 < 2.2e-16 ***
## S[6,11]  0.2626837 0.0095295  27.565 < 2.2e-16 ***
## S[6,12]  0.5306689 0.0074317  71.406 < 2.2e-16 ***
## S[6,13]  0.4083603 0.0085581  47.716 < 2.2e-16 ***
## S[6,14]  0.3946581 0.0087074  45.325 < 2.2e-16 ***
## S[7,8]   0.3247738 0.0092160  35.240 < 2.2e-16 ***
## S[7,9]   0.4147547 0.0085513  48.502 < 2.2e-16 ***
## S[7,10]  0.2867122 0.0094851  30.228 < 2.2e-16 ***
## S[7,11]  0.3541806 0.0089886  39.403 < 2.2e-16 ***
## S[7,12]  0.4378547 0.0083650  52.344 < 2.2e-16 ***
## S[7,13]  0.3983398 0.0086882  45.848 < 2.2e-16 ***
## S[7,14]  0.4159087 0.0085505  48.642 < 2.2e-16 ***
## S[8,9]   0.3144775 0.0092945  33.835 < 2.2e-16 ***
## S[8,10]  0.3027494 0.0093216  32.478 < 2.2e-16 ***
## S[8,11]  0.2577935 0.0095641  26.954 < 2.2e-16 ***
## S[8,12]  0.3936819 0.0086816  45.346 < 2.2e-16 ***
## S[8,13]  0.3618757 0.0089466  40.449 < 2.2e-16 ***
## S[8,14]  0.2611649 0.0095786  27.265 < 2.2e-16 ***
## S[9,10]  0.2432445 0.0096624  25.174 < 2.2e-16 ***
## S[9,11]  0.3224117 0.0092202  34.968 < 2.2e-16 ***
## S[9,12]  0.3589313 0.0089746  39.994 < 2.2e-16 ***
## S[9,13]  0.5452400 0.0072996  74.695 < 2.2e-16 ***
## S[9,14]  0.2956801 0.0094100  31.422 < 2.2e-16 ***
```

```
## S[10,11] 0.1938563 0.0098597  19.662 < 2.2e-16 ***
## S[10,12] 0.4056047 0.0086327  46.985 < 2.2e-16 ***
## S[10,13] 0.2733783 0.0094930  28.798 < 2.2e-16 ***
## S[10,14] 0.2941425 0.0094520  31.120 < 2.2e-16 ***
## S[11,12] 0.2383152 0.0096595  24.672 < 2.2e-16 ***
## S[11,13] 0.3787195 0.0087818  43.126 < 2.2e-16 ***
## S[11,14] 0.2665800 0.0095576  27.892 < 2.2e-16 ***
## S[12,13] 0.3632599 0.0089228  40.711 < 2.2e-16 ***
## S[12,14] 0.4169592 0.0085546  48.741 < 2.2e-16 ***
## S[13,14] 0.3226122 0.0092317  34.946 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Goodness-of-fit indices:
##                                       Value
## Sample size                        9579.0000
## Chi-square of target model         5756.8400
## DF of target model                 1547.0000
## p value of target model               0.0000
## Chi-square of independence model  56459.5203
## DF of independence model           1638.0000
## RMSEA                                 0.0715
## RMSEA lower 95% CI                    0.0696
## RMSEA upper 95% CI                    0.0736
## SRMR                                  0.1112
## TLI                                   0.9187
## CFI                                   0.9232
## AIC                                2662.8400
## BIC                               -8425.0171
## OpenMx status1: 0 ("0" or "1": The optimization is considered fine.
## Other values may indicate problems.)
```

Run the Stage 2 model without equality constraints across groups

```
Stage2_free.fit <- tssem2(Stage1_subgroup.fit, Amatrix=A, Smatrix=S,
                          Fmatrix=F)

## summary of individual models
summary(Stage2_free.fit)
```

```
## $`non-patients`
##
## Call:
## wls(Cov = coef.tssem1FEM(tssem1.obj), asyCov = vcov.tssem1FEM(tssem1.obj),
##     n = sum(tssem1.obj$n), Amatrix = Amatrix, Smatrix = Smatrix,
##     Fmatrix = Fmatrix, diag.constraints = diag.constraints, cor.analysis = tssem1.obj$cor.analysis,
##     intervals.type = intervals.type, mx.algebras = mx.algebras,
##     model.name = model.name, suppressWarnings = suppressWarnings,
##     silent = silent, run = run)
##
## 95% confidence intervals: z statistic approximation
## Coefficients:
##         Estimate  Std.Error     lbound     ubound z value  Pr(>|z|)
```

```
## L1_2   0.1715826  0.0201028  0.1321818  0.2109834  8.5352 < 2.2e-16 ***
## L1_1   0.6795449  0.0081336  0.6636033  0.6954865 83.5477 < 2.2e-16 ***
## L10_3  0.2614730  0.0131783  0.2356441  0.2873020 19.8412 < 2.2e-16 ***
## L10_1  0.3002227  0.0098309  0.2809545  0.3194909 30.5386 < 2.2e-16 ***
## L11_2  0.1476701  0.0187333  0.1109534  0.1843868  7.8827 3.109e-15 ***
## L11_1  0.4508426  0.0098072  0.4316210  0.4700643 45.9708 < 2.2e-16 ***
## L12_3  0.5364586  0.0122964  0.5123580  0.5605592 43.6271 < 2.2e-16 ***
## L12_1  0.3909521  0.0094156  0.3724978  0.4094064 41.5216 < 2.2e-16 ***
## L13_2  0.4687870  0.0181713  0.4331718  0.5044022 25.7981 < 2.2e-16 ***
## L13_1  0.6082485  0.0109895  0.5867096  0.6297875 55.3484 < 2.2e-16 ***
## L14_3  0.2205599  0.0125849  0.1958940  0.2452259 17.5257 < 2.2e-16 ***
## L14_1  0.3311279  0.0096145  0.3122839  0.3499720 34.4405 < 2.2e-16 ***
## L2_3   0.4048730  0.0128381  0.3797108  0.4300352 31.5369 < 2.2e-16 ***
## L2_1   0.3896491  0.0097030  0.3706317  0.4086665 40.1578 < 2.2e-16 ***
## L3_2   0.3755776  0.0186577  0.3390092  0.4121460 20.1299 < 2.2e-16 ***
## L3_1   0.5670218  0.0107009  0.5460484  0.5879952 52.9882 < 2.2e-16 ***
## L4_3   0.4156639  0.0127112  0.3907505  0.4405773 32.7007 < 2.2e-16 ***
## L4_1   0.3763794  0.0095582  0.3576458  0.3951130 39.3778 < 2.2e-16 ***
## L5_2   0.1925092  0.0201037  0.1531066  0.2319118  9.5758 < 2.2e-16 ***
## L5_1   0.6810790  0.0083458  0.6647215  0.6974364 81.6075 < 2.2e-16 ***
## L6_3   0.2826901  0.0131246  0.2569663  0.3084139 21.5389 < 2.2e-16 ***
## L6_1   0.5444671  0.0087224  0.5273715  0.5615628 62.4215 < 2.2e-16 ***
## L7_2  -0.0852377  0.0239342 -0.1321477 -0.0383276 -3.5613  0.000369 ***
## L7_1   0.6505043  0.0092935  0.6322893  0.6687193 69.9953 < 2.2e-16 ***
## L8_3   0.1829404  0.0144487  0.1546215  0.2112594 12.6614 < 2.2e-16 ***
## L8_1   0.4919707  0.0091960  0.4739469  0.5099944 53.4986 < 2.2e-16 ***
## L9_2   0.3516532  0.0163449  0.3196177  0.3836887 21.5145 < 2.2e-16 ***
## L9_1   0.4870084  0.0105672  0.4662970  0.5077198 46.0867 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Goodness-of-fit indices:
##                                                Value
## Sample size                                12241.0000
## Chi-square of target model                  1211.2217
## DF of target model                            63.0000
## p value of target model                        0.0000
## Number of constraints imposed on "Smatrix"     0.0000
## DF manually adjusted                           0.0000
## Chi-square of independence model           18989.1897
## DF of independence model                      91.0000
## RMSEA                                          0.0386
## RMSEA lower 95% CI                             0.0367
## RMSEA upper 95% CI                             0.0405
## SRMR                                           0.0323
## TLI                                            0.9122
## CFI                                            0.9392
## AIC                                         1085.2217
## BIC                                          618.2313
## OpenMx status1: 0 ("0" or "1": The optimization is considered fine.
## Other values indicate problems.)
##
## $patients
##
```

```
## Call:
## wls(Cov = coef.tssem1FEM(tssem1.obj), asyCov = vcov.tssem1FEM(tssem1.obj),
##     n = sum(tssem1.obj$n), Amatrix = Amatrix, Smatrix = Smatrix,
##     Fmatrix = Fmatrix, diag.constraints = diag.constraints, cor.analysis = tssem1.obj$cor.analysis,
##     intervals.type = intervals.type, mx.algebras = mx.algebras,
##     model.name = model.name, suppressWarnings = suppressWarnings,
##     silent = silent, run = run)
##
## 95% confidence intervals: z statistic approximation
## Coefficients:
##         Estimate  Std.Error     lbound     ubound  z value  Pr(>|z|)
## L1_2   0.2049160  0.0160262  0.1735052  0.2363269  12.7863 < 2.2e-16 ***
## L1_1   0.7139223  0.0071901  0.6998299  0.7280147  99.2922 < 2.2e-16 ***
## L10_3  0.2727295  0.0140086  0.2452731  0.3001859  19.4687 < 2.2e-16 ***
## L10_1  0.4465401  0.0099487  0.4270410  0.4660392  44.8843 < 2.2e-16 ***
## L11_2  0.1169962  0.0180851  0.0815500  0.1524424   6.4692 9.853e-11 ***
## L11_1  0.5012266  0.0093372  0.4829261  0.5195271  53.6808 < 2.2e-16 ***
## L12_3  0.5082226  0.0115837  0.4855190  0.5309261  43.8740 < 2.2e-16 ***
## L12_1  0.5997854  0.0087217  0.5826913  0.6168796  68.7696 < 2.2e-16 ***
## L13_2  0.4417949  0.0159060  0.4106197  0.4729701  27.7753 < 2.2e-16 ***
## L13_1  0.6498168  0.0099153  0.6303832  0.6692503  65.5370 < 2.2e-16 ***
## L14_3  0.2166640  0.0139770  0.1892696  0.2440584  15.5015 < 2.2e-16 ***
## L14_1  0.5329670  0.0091095  0.5151128  0.5508212  58.5070 < 2.2e-16 ***
## L2_3   0.5222720  0.0114771  0.4997773  0.5447667  45.5056 < 2.2e-16 ***
## L2_1   0.5510004  0.0089942  0.5333722  0.5686286  61.2620 < 2.2e-16 ***
## L3_2   0.4224822  0.0166444  0.3898598  0.4551047  25.3828 < 2.2e-16 ***
## L3_1   0.6570845  0.0098457  0.6377874  0.6763817  66.7385 < 2.2e-16 ***
## L4_3   0.4403558  0.0128758  0.4151196  0.4655920  34.2002 < 2.2e-16 ***
## L4_1   0.6166029  0.0088179  0.5993201  0.6338857  69.9262 < 2.2e-16 ***
## L5_2   0.2609957  0.0154058  0.2308009  0.2911905  16.9414 < 2.2e-16 ***
## L5_1   0.7388379  0.0071609  0.7248028  0.7528730 103.1770 < 2.2e-16 ***
## L6_3   0.2898737  0.0141323  0.2621750  0.3175724  20.5115 < 2.2e-16 ***
## L6_1   0.6912294  0.0081337  0.6752877  0.7071712  84.9834 < 2.2e-16 ***
## L7_2  -0.1309077  0.0265126 -0.1828713 -0.0789440  -4.9376 7.910e-07 ***
## L7_1   0.7611647  0.0078909  0.7456989  0.7766305  96.4615 < 2.2e-16 ***
## L8_3   0.2431788  0.0134933  0.2167324  0.2696253  18.0221 < 2.2e-16 ***
## L8_1   0.5222198  0.0091827  0.5042221  0.5402176  56.8701 < 2.2e-16 ***
## L9_2   0.3321911  0.0167115  0.2994371  0.3649450  19.8780 < 2.2e-16 ***
## L9_1   0.6219521  0.0094745  0.6033825  0.6405217  65.6450 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Goodness-of-fit indices:
##                                                Value
## Sample size                                 9579.0000
## Chi-square of target model                  1037.4946
## DF of target model                            63.0000
## p value of target model                        0.0000
## Number of constraints imposed on "Smatrix"     0.0000
## DF manually adjusted                           0.0000
## Chi-square of independence model           28032.2019
## DF of independence model                      91.0000
## RMSEA                                          0.0402
## RMSEA lower 95% CI                             0.0381
```

```
## RMSEA upper 95% CI                                  0.0424
## SRMR                                                0.0374
## TLI                                                 0.9496
## CFI                                                 0.9651
## AIC                                               911.4946
## BIC                                               459.9529
## OpenMx status1: 0 ("0" or "1": The optimization is considered fine.
## Other values indicate problems.)
```

```
## summary of combined model
subgroup.summary(Stage2_free.fit)
```

```
## # # # # # # # # # # # # # # # # # # #
##  Output for subgroup MASEM analysis
## # # # # # # # # # # # # # # # # # # #
##
##  Total sample size: 21820
##  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
##  Fit indices of the free model:
##
##           Statistic  Free_m1
##                  df  126.000
##         Chi-square 2248.716
##                   p    0.000
##               RMSEA    0.039
##  RMSEA lower 95% CI    0.038
##  RMSEA upper 95% CI    0.041
##                 CFI    0.955
##                 TLI    0.935
##                 AIC 2416.716
##                 BIC 3087.925
##                SRMR    0.035
## - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
##
##  No constrained model provided
##
##  # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # #
```

Run the Stage 2 model with equality constraints across groups (per factor)

- Set factor loadings Distress equal across groups
- Give the factor loadings of Anxiety (odd items) and Depression (even items) different labels
- Give all residual variances different labels

```
Items_Anx <- c(1,3,5,7,9,11,13)
Items_Dep <- c(2,4,6,8,10,12,14)

A_pat1 <- A
A_pat1$labels[Items_Anx,16] <- paste(A$labels[Items_Anx,16],"_pat",sep="")
A_pat1$labels[Items_Dep,17] <- paste(A$labels[Items_Dep,17],"_pat",sep="")

S_pat <- S
diag(S_pat$labels)[1:14] <- paste(diag(S$labels)[1:14],"_pat",sep="")
```

- Create the models (set run=FALSE) and multigroup model with equal factor loadings of Distress factor

```r
stage2_pat <- tssem2(Stage1_subgroup.fit[[1]], Amatrix=A_pat1, Smatrix=S_pat, Fmatrix=F,
                     run=FALSE, model.name="patients")

stage2_nonpat <- tssem2(Stage1_subgroup.fit[[2]], Amatrix=A, Smatrix=S, Fmatrix=F,
                        run=FALSE, model.name="nonpatients")

stage2_constrained_distr <- mxModel(model="same_factor_loadings_Distr",
                                    stage2_nonpat, stage2_pat,
                                    mxFitFunctionMultigroup(c("patients", "nonpatients")))

Stage2_constrained_distr.fit <- mxRun(stage2_constrained_distr, intervals=FALSE)
```

```r
# get summary using subgroup.summary() function
subgroup.summary(Stage2_free.fit, Stage2_constrained_distr.fit)
```

```
## # # # # # # # # # # # # # # # # # # #
##  Output for subgroup MASEM analysis
## # # # # # # # # # # # # # # # # # # #
##
##  Total sample size: 21820
##
##  Parameter estimates of the constrained model
##
## [1] "Set 'print.est=TRUE' to print the parameter estimates of the constrained model"
##
##  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
##  Fit indices of the free model:
##
##           Statistic  Free_m1
##                  df  126.000
##         Chi-square 2248.716
##                   p    0.000
##               RMSEA    0.039
##  RMSEA lower 95% CI    0.038
##  RMSEA upper 95% CI    0.041
##                 CFI    0.955
##                 TLI    0.935
##                 AIC 2416.716
##                 BIC 3087.925
##                SRMR    0.035
## - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
##  Fit indices of the model with equality constraints:
##
##           Statistic Constrained_m2
##                  df        140.000
##         Chi-square       3116.798
##                   p          0.000
##               RMSEA          0.044
##  RMSEA lower 95% CI          0.043
##  RMSEA upper 95% CI          0.046
##                 CFI          0.936
##                 TLI          0.917
##                 AIC       3256.798
##                 BIC       3816.139
```

```
##                SRMR          0.061
## - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
##  Chi-square difference between free and constrained model:
##
##   Statistic Diff_m1_m2
##          df     14.000
##  Chi-square    868.082
##           p      0.000
##
##  # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # #
```

- Create the models (set run=FALSE) and multigroup model with equal factor loadings of Anxiety factor

```
A_pat2 <- A_pat1
A_pat2$labels[1:14,15] <- paste(A$labels[1:14,15],"_pat",sep="")
A_pat2$labels[Items_Anx,16] <- A$labels[Items_Anx,16]

# Create the models, make sure to set the argument run=FALSE

stage2_pat <- tssem2(Stage1_subgroup.fit[[1]], Amatrix=A_pat2, Smatrix=S_pat, Fmatrix=F,
                     run=FALSE, model.name="patients")

stage2_nonpat <- tssem2(Stage1_subgroup.fit[[2]], Amatrix=A, Smatrix=S, Fmatrix=F,
                        run=FALSE, model.name="nonpatients")

stage2_constrained_anx <- mxModel(model="same_factor_loadings_Anx",
                                  stage2_nonpat, stage2_pat,
                                  mxFitFunctionMultigroup(c("patients", "nonpatients")))

Stage2_constrained_anx.fit <- mxRun(stage2_constrained_anx, intervals=FALSE)
```

```
subgroup.summary(Stage2_free.fit, Stage2_constrained_anx.fit)
```

```
## # # # # # # # # # # # # # # # # # #
##  Output for subgroup MASEM analysis
## # # # # # # # # # # # # # # # # # #
##
##  Total sample size: 21820
##
##  Parameter estimates of the constrained model
##
## [1] "Set 'print.est=TRUE' to print the parameter estimates of the constrained model"
##
##  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
##  Fit indices of the free model:
##
##           Statistic  Free_m1
##                  df  126.000
##         Chi-square 2248.716
##                   p    0.000
##               RMSEA    0.039
##  RMSEA lower 95% CI    0.038
##  RMSEA upper 95% CI    0.041
##                 CFI    0.955
##                 TLI    0.935
```

```
##                 AIC 2416.716
##                 BIC 3087.925
##                SRMR    0.035
## - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
##  Fit indices of the model with equality constraints:
##
##           Statistic Constrained_m2
##                  df        133.000
##          Chi-square       2265.627
##                   p          0.000
##               RMSEA          0.038
##  RMSEA lower 95% CI          0.037
##  RMSEA upper 95% CI          0.040
##                 CFI          0.954
##                 TLI          0.938
##                 AIC       2419.627
##                 BIC       3034.902
##                SRMR          0.036
## - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
##  Chi-square difference between free and constrained model:
##
##   Statistic Diff_m1_m2
##          df      7.000
##  Chi-square     16.911
##           p      0.018
##
##  # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # #
```

- Create the models (set run=FALSE) and multigroup model with equal factor loadings of Depression factor

```
#  factor loadings Depression equal across groups
A_pat3 <- A_pat2
A_pat3$labels[Items_Anx,16] <- A_pat1$labels[Items_Anx,16]
A_pat3$labels[Items_Dep,17] <- A$labels[Items_Dep,17]

# Create the models, make sure to set the argument run=FALSE

stage2_pat <- tssem2(Stage1_subgroup.fit[[1]], Amatrix=A_pat3, Smatrix=S_pat, Fmatrix=F,
                     run=FALSE, model.name="patients")

stage2_nonpat <- tssem2(Stage1_subgroup.fit[[2]], Amatrix=A, Smatrix=S, Fmatrix=F,
                        run=FALSE,model.name="nonpatients")

stage2_constrained_dep <- mxModel(model="same_factor_loadings_Dep",
                                  stage2_nonpat, stage2_pat,
                                  mxFitFunctionMultigroup(c("patients", "nonpatients")))

Stage2_constrained_dep.fit <- mxRun(stage2_constrained_dep, intervals=FALSE)
```

```
subgroup.summary(Stage2_free.fit, Stage2_constrained_dep.fit)
```

```
## # # # # # # # # # # # # # # # # # # #
##  Output for subgroup MASEM analysis
## # # # # # # # # # # # # # # # # # # #
```

```
##
##  Total sample size: 21820
##
##  Parameter estimates of the constrained model
##
## [1] "Set 'print.est=TRUE' to print the parameter estimates of the constrained model"
##
##  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
##  Fit indices of the free model:
##
##           Statistic  Free_m1
##                  df  126.000
##         Chi-square 2248.716
##                   p    0.000
##               RMSEA    0.039
##  RMSEA lower 95% CI    0.038
##  RMSEA upper 95% CI    0.041
##                 CFI    0.955
##                 TLI    0.935
##                 AIC 2416.716
##                 BIC 3087.925
##                SRMR    0.035
## - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
##  Fit indices of the model with equality constraints:
##
##           Statistic Constrained_m2
##                  df        133.000
##         Chi-square       2300.159
##                   p          0.000
##               RMSEA          0.039
##  RMSEA lower 95% CI          0.037
##  RMSEA upper 95% CI          0.040
##                 CFI          0.954
##                 TLI          0.937
##                 AIC       2454.159
##                 BIC       3069.434
##                SRMR          0.037
## - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
##  Chi-square difference between free and constrained model:
##
##   Statistic Diff_m1_m2
##          df      7.000
##  Chi-square     51.443
##           p      0.000
##
##  # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # #
```