paper EAH, SEM models

2021-01-07

Contents

1 Data

```
data=read.csv2("DATA/DATA-papier-EAH-entrepot/data-paper-EAH.csv",header=T)
```

```
data=data[,c("app1","app2","app3",
                 "eah1","eah2","eah3","eah4","eah5","eah6",
                 "ic1","ic2","ic3","ic4","ic5",
                 "fr1","fr2","fr3",
                 "restr.w1","restr.w2","restr.w3","restr.w4",
                        "restr.w5","restr.w6","restr.w7","restr.w8",
                 "restr.h1","restr.h2","restr.h3","restr.h4",
                 "zbmi")]
```

2 SEM models

```
require(lavaan)
```

```
## Loading required package: lavaan
```

```
## Warning: package 'lavaan' was built under R version 3.6.3
```

```
## This is lavaan 0.6-7
```

```
## lavaan is BETA software! Please report any bugs.
```

2.1 restriction for weight

2.1.1 EAH to restr.w (model 1a)

```
items=c("app1","app2","app3",
"eah1","eah3","eah5","eah6",
"ic1","ic2","ic3","ic4","ic5",
"restr.w1","restr.w2","restr.w3","restr.w6","restr.w8",
"restr.h2","restr.h3","restr.h4",
"fr1","fr2","fr3")
```

```
mod1='
# latent variables
app=~app1+app2+app3
eah=~eah1+eah3+eah5+eah6
ic=~ic1+ic2+ic3+ic4+ic5
restr.w=~restr.w1+restr.w2+restr.w3+restr.w6+restr.w8
fr=~fr1+fr2+fr3
# hyp
zbmi~eah+app
eah~ic+fr
restr.w~app+eah+zbmi
'
sem1=sem(mod1,data=data,ordered=items)
summary(sem1,standardize=T,fit.measures=T)
```

```
## lavaan 0.6-7 ended normally after 38 iterations
##
##   Estimator                                         DWLS
##   Optimization method                           NLMINB
##   Number of free parameters                        118
##
##                                                   Used       Total
##   Number of observations                           541         621
##
## Model Test User Model:
##                                              Standard      Robust
##   Test Statistic                              442.480     420.821
##   Degrees of freedom                              180         180
```

```
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.254
##   Shift parameter                                           68.043
##        simple second-order correction
##
## Model Test Baseline Model:
##
##   Test statistic                             10136.471    5838.230
##   Degrees of freedom                           210         210
##   P-value                                      0.000       0.000
##   Scaling correction factor                                  1.764
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                  0.974       0.957
##   Tucker-Lewis Index (TLI)                     0.969       0.950
##
##   Robust Comparative Fit Index (CFI)                          NA
##   Robust Tucker-Lewis Index (TLI)                             NA
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                        0.052       0.050
##   90 Percent confidence interval - lower       0.046       0.044
##   90 Percent confidence interval - upper       0.058       0.056
##   P-value RMSEA <= 0.05                        0.291       0.514
##
##   Robust RMSEA                                                NA
##   90 Percent confidence interval - lower                      NA
##   90 Percent confidence interval - upper                      NA
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                         0.077       0.077
##
## Parameter Estimates:
##
##   Standard errors                           Robust.sem
##   Information                                 Expected
##   Information saturated (h1) model        Unstructured
##
## Latent Variables:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   app =~
##     app1             1.000                               0.818    0.818
##     app2             1.134    0.042   27.054    0.000    0.927    0.927
##     app3             1.009    0.027   37.668    0.000    0.825    0.825
##   eah =~
##     eah1             1.000                               0.631    0.631
##     eah3             1.099    0.086   12.751    0.000    0.693    0.693
##     eah5             1.118    0.088   12.747    0.000    0.705    0.705
##     eah6             1.122    0.085   13.213    0.000    0.708    0.708
##   ic =~
##     ic1              1.000                               0.658    0.658
```

```
##     ic2               1.228    0.075   16.352    0.000    0.808    0.808
##     ic3               0.632    0.057   11.050    0.000    0.416    0.416
##     ic4               0.924    0.064   14.386    0.000    0.608    0.608
##     ic5               0.791    0.065   12.109    0.000    0.520    0.520
##   restr.w =~
##     restr.w1          1.000                               0.801    0.801
##     restr.w2          1.065    0.050   21.502    0.000    0.853    0.853
##     restr.w3          0.869    0.042   20.478    0.000    0.696    0.696
##     restr.w6          0.827    0.044   18.913    0.000    0.663    0.663
##     restr.w8          0.677    0.067   10.092    0.000    0.542    0.542
##   fr =~
##     fr1               1.000                               0.820    0.820
##     fr2               0.791    0.047   16.676    0.000    0.648    0.648
##     fr3               1.097    0.071   15.430    0.000    0.900    0.900
##
## Regressions:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   zbmi ~
##     eah               0.283    0.113    2.498    0.012    0.179    0.120
##     app              -0.344    0.079   -4.379    0.000   -0.281   -0.189
##   eah ~
##     ic               -0.144    0.050   -2.857    0.004   -0.150   -0.150
##     fr                0.211    0.044    4.789    0.000    0.274    0.274
##   restr.w ~
##     app              -0.015    0.048   -0.321    0.748   -0.016   -0.016
##     eah               0.009    0.074    0.120    0.905    0.007    0.007
##     zbmi              0.126    0.027    4.740    0.000    0.157    0.234
##
## Covariances:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   app ~~
##     ic                0.042    0.026    1.591    0.112    0.077    0.077
##     fr                0.066    0.036    1.804    0.071    0.098    0.098
##   ic ~~
##     fr               -0.061    0.028   -2.192    0.028   -0.113   -0.113
##
## Intercepts:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .app1              0.000                               0.000    0.000
##    .app2              0.000                               0.000    0.000
##    .app3              0.000                               0.000    0.000
##    .eah1              0.000                               0.000    0.000
##    .eah3              0.000                               0.000    0.000
##    .eah5              0.000                               0.000    0.000
##    .eah6              0.000                               0.000    0.000
##    .ic1               0.000                               0.000    0.000
##    .ic2               0.000                               0.000    0.000
##    .ic3               0.000                               0.000    0.000
##    .ic4               0.000                               0.000    0.000
##    .ic5               0.000                               0.000    0.000
##    .restr.w1          0.000                               0.000    0.000
##    .restr.w2          0.000                               0.000    0.000
##    .restr.w3          0.000                               0.000    0.000
##    .restr.w6          0.000                               0.000    0.000
```

```
##    .restr.w8          0.000                           0.000    0.000
##    .fr1               0.000                           0.000    0.000
##    .fr2               0.000                           0.000    0.000
##    .fr3               0.000                           0.000    0.000
##    .zbmi             -0.219    0.065   -3.367    0.001  -0.219   -0.148
##     app               0.000                           0.000    0.000
##    .eah               0.000                           0.000    0.000
##     ic                0.000                           0.000    0.000
##    .restr.w           0.000                           0.000    0.000
##     fr                0.000                           0.000    0.000
##
## Thresholds:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     app1|t1         -1.304    0.074  -17.526    0.000  -1.304   -1.304
##     app1|t2         -0.086    0.054   -1.589    0.112  -0.086   -0.086
##     app1|t3          0.270    0.055    4.934    0.000   0.270    0.270
##     app1|t4          1.121    0.068   16.421    0.000   1.121    1.121
##     app2|t1         -0.585    0.057  -10.194    0.000  -0.585   -0.585
##     app2|t2          0.294    0.055    5.362    0.000   0.294    0.294
##     app2|t3          0.575    0.057   10.027    0.000   0.575    0.575
##     app2|t4          1.138    0.069   16.551    0.000   1.138    1.138
##     app3|t1         -0.402    0.056   -7.239    0.000  -0.402   -0.402
##     app3|t2          0.682    0.059   11.605    0.000   0.682    0.682
##     app3|t3          1.193    0.070   16.925    0.000   1.193    1.193
##     app3|t4          1.860    0.106   17.520    0.000   1.860    1.860
##     eah1|t1         -1.765    0.099  -17.852    0.000  -1.765   -1.765
##     eah1|t2         -0.694    0.059  -11.770    0.000  -0.694   -0.694
##     eah1|t3          0.198    0.054    3.649    0.000   0.198    0.198
##     eah1|t4          1.304    0.074   17.526    0.000   1.304    1.304
##     eah3|t1         -1.112    0.068  -16.355    0.000  -1.112   -1.112
##     eah3|t2         -0.510    0.057   -9.018    0.000  -0.510   -0.510
##     eah3|t3          0.165    0.054    3.048    0.002   0.165    0.165
##     eah3|t4          0.969    0.064   15.084    0.000   0.969    0.969
##     eah5|t1         -0.863    0.062  -13.939    0.000  -0.863   -0.863
##     eah5|t2          0.918    0.063   14.557    0.000   0.918    0.918
##     eah6|t1         -1.046    0.066  -15.808    0.000  -1.046   -1.046
##     eah6|t2          1.014    0.065   15.523    0.000   1.014    1.014
##     ic1|t1          -1.664    0.092  -18.064    0.000  -1.664   -1.664
##     ic1|t2          -0.748    0.060  -12.504    0.000  -0.748   -0.748
##     ic1|t3          -0.284    0.055   -5.191    0.000  -0.284   -0.284
##     ic1|t4          -0.025    0.054   -0.472    0.637  -0.025   -0.025
##     ic1|t5           0.463    0.056    8.257    0.000   0.463    0.463
##     ic1|t6           1.611    0.089   18.116    0.000   1.611    1.611
##     ic2|t1          -2.086    0.128  -16.297    0.000  -2.086   -2.086
##     ic2|t2          -1.372    0.077  -17.792    0.000  -1.372   -1.372
##     ic2|t3          -0.863    0.062  -13.939    0.000  -0.863   -0.863
##     ic2|t4          -0.602    0.058  -10.445    0.000  -0.602   -0.602
##     ic2|t5           0.072    0.054    1.331    0.183   0.072    0.072
##     ic2|t6           1.315    0.075   17.574    0.000   1.315    1.315
##     ic3|t1          -1.611    0.089  -18.116    0.000  -1.611   -1.611
##     ic3|t2          -0.817    0.061  -13.388    0.000  -0.817   -0.817
##     ic3|t3          -0.289    0.055   -5.276    0.000  -0.289   -0.289
##     ic3|t4          -0.002    0.054   -0.043    0.966  -0.002   -0.002
##     ic3|t5           0.255    0.055    4.677    0.000   0.255    0.255
```

```
##     ic3|t6            1.112    0.068   16.355    0.000    1.112    1.112
##     ic4|t1           -2.356    0.166  -14.232    0.000   -2.356   -2.356
##     ic4|t2           -2.129    0.133  -16.007    0.000   -2.129   -2.129
##     ic4|t3           -1.945    0.114  -17.127    0.000   -1.945   -1.945
##     ic4|t4           -1.502    0.083  -18.083    0.000   -1.502   -1.502
##     ic4|t5           -0.890    0.062  -14.250    0.000   -0.890   -0.890
##     ic4|t6            0.357    0.055    6.472    0.000    0.357    0.357
##     ic5|t1           -2.011    0.120  -16.767    0.000   -2.011   -2.011
##     ic5|t2           -1.517    0.084  -18.099    0.000   -1.517   -1.517
##     ic5|t3           -1.212    0.071  -17.043    0.000   -1.212   -1.212
##     ic5|t4           -0.897    0.063  -14.327    0.000   -0.897   -0.897
##     ic5|t5           -0.510    0.057   -9.018    0.000   -0.510   -0.510
##     ic5|t6            0.526    0.057    9.271    0.000    0.526    0.526
##     restr.w1|t1      -0.114    0.053   -2.124    0.034   -0.114   -0.114
##     restr.w1|t2       0.637    0.059   10.846    0.000    0.637    0.637
##     restr.w1|t3       1.433    0.081   17.655    0.000    1.433    1.433
##     restr.w1|t4       2.019    0.124   16.304    0.000    2.019    2.019
##     restr.w2|t1       0.173    0.054    3.202    0.001    0.173    0.173
##     restr.w2|t2       0.962    0.065   14.833    0.000    0.962    0.962
##     restr.w2|t3       1.599    0.090   17.714    0.000    1.599    1.599
##     restr.w2|t4       2.199    0.146   15.022    0.000    2.199    2.199
##     restr.w3|t1       0.057    0.054    1.062    0.288    0.057    0.057
##     restr.w3|t2       1.022    0.066   15.427    0.000    1.022    1.022
##     restr.w3|t3       1.492    0.084   17.804    0.000    1.492    1.492
##     restr.w3|t4       2.413    0.180   13.374    0.000    2.413    2.413
##     restr.w6|t1      -0.095    0.054   -1.746    0.081   -0.095   -0.095
##     restr.w6|t2       0.659    0.059   11.116    0.000    0.659    0.659
##     restr.w6|t3       1.292    0.075   17.161    0.000    1.292    1.292
##     restr.w6|t4       1.922    0.114   16.916    0.000    1.922    1.922
##     restr.w8|t1       1.483    0.083   17.843    0.000    1.483    1.483
##     restr.w8|t2       2.110    0.133   15.837    0.000    2.110    2.110
##     restr.w8|t3       2.521    0.202   12.498    0.000    2.521    2.521
##     restr.w8|t4       2.884    0.313    9.222    0.000    2.884    2.884
##     fr1|t1            0.053    0.054    0.988    0.323    0.053    0.053
##     fr1|t2            0.925    0.063   14.633    0.000    0.925    0.925
##     fr1|t3            1.945    0.114   17.127    0.000    1.945    1.945
##     fr1|t4            2.356    0.166   14.232    0.000    2.356    2.356
##     fr2|t1            0.156    0.054    2.877    0.004    0.156    0.156
##     fr2|t2            0.876    0.062   14.095    0.000    0.876    0.876
##     fr2|t3            1.531    0.085   18.111    0.000    1.531    1.531
##     fr2|t4            2.129    0.133   16.007    0.000    2.129    2.129
##     fr3|t1            0.246    0.055    4.506    0.000    0.246    0.246
##     fr3|t2            0.947    0.064   14.860    0.000    0.947    0.947
##     fr3|t3            1.860    0.106   17.520    0.000    1.860    1.860
##     fr3|t4            2.540    0.202   12.601    0.000    2.540    2.540
##
## Variances:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .app1             0.331                              0.331    0.331
##    .app2             0.140                              0.140    0.140
##    .app3             0.320                              0.320    0.320
##    .eah1             0.602                              0.602    0.602
##    .eah3             0.520                              0.520    0.520
##    .eah5             0.503                              0.503    0.503
```

```
##    .eah6              0.499                                  0.499    0.499
##    .ic1               0.567                                  0.567    0.567
##    .ic2               0.347                                  0.347    0.347
##    .ic3               0.827                                  0.827    0.827
##    .ic4               0.630                                  0.630    0.630
##    .ic5               0.729                                  0.729    0.729
##    .restr.w1          0.359                                  0.359    0.359
##    .restr.w2          0.272                                  0.272    0.272
##    .restr.w3          0.516                                  0.516    0.516
##    .restr.w6          0.561                                  0.561    0.561
##    .restr.w8          0.706                                  0.706    0.706
##    .fr1               0.328                                  0.328    0.328
##    .fr2               0.580                                  0.580    0.580
##    .fr3               0.191                                  0.191    0.191
##    .zbmi              2.097    0.115   18.279    0.000       2.097    0.950
##     app               0.669    0.032   20.825    0.000       1.000    1.000
##    .eah               0.355    0.042    8.501    0.000       0.893    0.893
##     ic                0.433    0.038   11.290    0.000       1.000    1.000
##    .restr.w           0.605    0.038   15.827    0.000       0.943    0.943
##     fr                0.672    0.053   12.793    0.000       1.000    1.000
##
## Scales y*:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     app1             1.000                                1.000    1.000
##     app2             1.000                                1.000    1.000
##     app3             1.000                                1.000    1.000
##     eah1             1.000                                1.000    1.000
##     eah3             1.000                                1.000    1.000
##     eah5             1.000                                1.000    1.000
##     eah6             1.000                                1.000    1.000
##     ic1              1.000                                1.000    1.000
##     ic2              1.000                                1.000    1.000
##     ic3              1.000                                1.000    1.000
##     ic4              1.000                                1.000    1.000
##     ic5              1.000                                1.000    1.000
##     restr.w1         1.000                                1.000    1.000
##     restr.w2         1.000                                1.000    1.000
##     restr.w3         1.000                                1.000    1.000
##     restr.w6         1.000                                1.000    1.000
##     restr.w8         1.000                                1.000    1.000
##     fr1              1.000                                1.000    1.000
##     fr2              1.000                                1.000    1.000
##     fr3              1.000                                1.000    1.000
```

2.1.2 restr.w to EAH (model 1b)

```
mod1='
# latent variables
app=~app1+app2+app3
eah=~eah1+eah3+eah5+eah6
ic=~ic1+ic2+ic3+ic4+ic5
restr.w=~restr.w1+restr.w2+restr.w3+restr.w6+restr.w8
```

```
fr=~fr1+fr2+fr3
# hyp
zbmi~eah+app
eah~ic+fr
restr.w~app+zbmi
eah~restr.w
'
sem1=sem(mod1,data=data,ordered=items)
summary(sem1,standardize=T,fit.measures=T)
```

```
## lavaan 0.6-7 ended normally after 41 iterations
##
##   Estimator                                         DWLS
##   Optimization method                           NLMINB
##   Number of free parameters                        118
##
##                                                   Used       Total
##   Number of observations                           541         621
##
## Model Test User Model:
##                                              Standard      Robust
##   Test Statistic                              428.802     406.546
##   Degrees of freedom                              180         180
##   P-value (Chi-square)                          0.000       0.000
##   Scaling correction factor                                 1.270
##   Shift parameter                                          69.037
##         simple second-order correction
##
## Model Test Baseline Model:
##
##   Test statistic                            10136.471    5838.230
##   Degrees of freedom                              210         210
##   P-value                                       0.000       0.000
##   Scaling correction factor                                 1.764
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                   0.975       0.960
##   Tucker-Lewis Index (TLI)                      0.971       0.953
##
##   Robust Comparative Fit Index (CFI)                           NA
##   Robust Tucker-Lewis Index (TLI)                              NA
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                         0.051       0.048
##   90 Percent confidence interval - lower        0.044       0.042
##   90 Percent confidence interval - upper        0.057       0.055
##   P-value RMSEA <= 0.05                         0.427       0.667
##
##   Robust RMSEA                                                 NA
##   90 Percent confidence interval - lower                       NA
##   90 Percent confidence interval - upper                       NA
```

```
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.075       0.075
##
## Parameter Estimates:
##
##   Standard errors                             Robust.sem
##   Information                                   Expected
##   Information saturated (h1) model          Unstructured
##
## Latent Variables:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   app =~
##     app1             1.000                               0.817    0.817
##     app2             1.135    0.042   27.107    0.000    0.928    0.928
##     app3             1.009    0.027   37.659    0.000    0.824    0.824
##   eah =~
##     eah1             1.000                               0.631    0.631
##     eah3             1.077    0.085   12.732    0.000    0.680    0.680
##     eah5             1.116    0.087   12.836    0.000    0.705    0.705
##     eah6             1.130    0.085   13.345    0.000    0.713    0.713
##   ic =~
##     ic1              1.000                               0.658    0.658
##     ic2              1.228    0.075   16.358    0.000    0.807    0.807
##     ic3              0.634    0.057   11.070    0.000    0.417    0.417
##     ic4              0.925    0.064   14.401    0.000    0.608    0.608
##     ic5              0.791    0.065   12.105    0.000    0.520    0.520
##   restr.w =~
##     restr.w1         1.000                               0.799    0.799
##     restr.w2         1.072    0.050   21.436    0.000    0.856    0.856
##     restr.w3         0.865    0.043   20.291    0.000    0.691    0.691
##     restr.w6         0.828    0.044   18.795    0.000    0.661    0.661
##     restr.w8         0.694    0.067   10.321    0.000    0.554    0.554
##   fr =~
##     fr1              1.000                               0.819    0.819
##     fr2              0.793    0.047   16.722    0.000    0.650    0.650
##     fr3              1.099    0.071   15.444    0.000    0.900    0.900
##
## Regressions:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   zbmi ~
##     eah              0.475    0.131    3.636    0.000    0.300    0.205
##     app             -0.354    0.079   -4.506    0.000   -0.290   -0.198
##   eah ~
##     ic              -0.149    0.051   -2.929    0.003   -0.155   -0.155
##     fr               0.216    0.044    4.892    0.000    0.281    0.281
##   restr.w ~
##     app              0.013    0.049    0.275    0.783    0.014    0.014
##     zbmi             0.166    0.031    5.312    0.000    0.208    0.305
##   eah ~
##     restr.w         -0.094    0.050   -1.871    0.061   -0.119   -0.119
##
## Covariances:
```

```
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   app ~~
##     ic                0.041    0.026    1.567    0.117    0.076    0.076
##     fr                0.067    0.036    1.846    0.065    0.101    0.101
##   ic ~~
##     fr               -0.061    0.028   -2.194    0.028   -0.113   -0.113
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .app1              0.000                              0.000    0.000
##    .app2              0.000                              0.000    0.000
##    .app3              0.000                              0.000    0.000
##    .eah1              0.000                              0.000    0.000
##    .eah3              0.000                              0.000    0.000
##    .eah5              0.000                              0.000    0.000
##    .eah6              0.000                              0.000    0.000
##    .ic1               0.000                              0.000    0.000
##    .ic2               0.000                              0.000    0.000
##    .ic3               0.000                              0.000    0.000
##    .ic4               0.000                              0.000    0.000
##    .ic5               0.000                              0.000    0.000
##    .restr.w1          0.000                              0.000    0.000
##    .restr.w2          0.000                              0.000    0.000
##    .restr.w3          0.000                              0.000    0.000
##    .restr.w6          0.000                              0.000    0.000
##    .restr.w8          0.000                              0.000    0.000
##    .fr1               0.000                              0.000    0.000
##    .fr2               0.000                              0.000    0.000
##    .fr3               0.000                              0.000    0.000
##    .zbmi             -0.221    0.066   -3.368    0.001   -0.221   -0.151
##     app               0.000                              0.000    0.000
##    .eah               0.000                              0.000    0.000
##     ic                0.000                              0.000    0.000
##    .restr.w           0.000                              0.000    0.000
##     fr                0.000                              0.000    0.000
##
## Thresholds:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     app1|t1          -1.304    0.074  -17.526    0.000   -1.304   -1.304
##     app1|t2          -0.086    0.054   -1.589    0.112   -0.086   -0.086
##     app1|t3           0.270    0.055    4.934    0.000    0.270    0.270
##     app1|t4           1.121    0.068   16.421    0.000    1.121    1.121
##     app2|t1          -0.585    0.057  -10.194    0.000   -0.585   -0.585
##     app2|t2           0.294    0.055    5.362    0.000    0.294    0.294
##     app2|t3           0.575    0.057   10.027    0.000    0.575    0.575
##     app2|t4           1.138    0.069   16.551    0.000    1.138    1.138
##     app3|t1          -0.402    0.056   -7.239    0.000   -0.402   -0.402
##     app3|t2           0.682    0.059   11.605    0.000    0.682    0.682
##     app3|t3           1.193    0.070   16.925    0.000    1.193    1.193
##     app3|t4           1.860    0.106   17.520    0.000    1.860    1.860
##     eah1|t1          -1.761    0.099  -17.800    0.000   -1.761   -1.761
##     eah1|t2          -0.690    0.059  -11.715    0.000   -0.690   -0.690
##     eah1|t3           0.202    0.054    3.713    0.000    0.202    0.202
##     eah1|t4           1.307    0.074   17.603    0.000    1.307    1.307
```

```
##     eah3|t1          -1.108    0.068  -16.282    0.000   -1.108   -1.108
##     eah3|t2          -0.506    0.057   -8.924    0.000   -0.506   -0.506
##     eah3|t3           0.169    0.054    3.110    0.002    0.169    0.169
##     eah3|t4           0.972    0.064   15.127    0.000    0.972    0.972
##     eah5|t1          -0.859    0.062  -13.854    0.000   -0.859   -0.859
##     eah5|t2           0.922    0.063   14.656    0.000    0.922    0.922
##     eah6|t1          -1.042    0.066  -15.682    0.000   -1.042   -1.042
##     eah6|t2           1.018    0.065   15.631    0.000    1.018    1.018
##     ic1|t1           -1.664    0.092  -18.064    0.000   -1.664   -1.664
##     ic1|t2           -0.748    0.060  -12.504    0.000   -0.748   -0.748
##     ic1|t3           -0.284    0.055   -5.191    0.000   -0.284   -0.284
##     ic1|t4           -0.025    0.054   -0.472    0.637   -0.025   -0.025
##     ic1|t5            0.463    0.056    8.257    0.000    0.463    0.463
##     ic1|t6            1.611    0.089   18.116    0.000    1.611    1.611
##     ic2|t1           -2.086    0.128  -16.297    0.000   -2.086   -2.086
##     ic2|t2           -1.372    0.077  -17.792    0.000   -1.372   -1.372
##     ic2|t3           -0.863    0.062  -13.939    0.000   -0.863   -0.863
##     ic2|t4           -0.602    0.058  -10.445    0.000   -0.602   -0.602
##     ic2|t5            0.072    0.054    1.331    0.183    0.072    0.072
##     ic2|t6            1.315    0.075   17.574    0.000    1.315    1.315
##     ic3|t1           -1.611    0.089  -18.116    0.000   -1.611   -1.611
##     ic3|t2           -0.817    0.061  -13.388    0.000   -0.817   -0.817
##     ic3|t3           -0.289    0.055   -5.276    0.000   -0.289   -0.289
##     ic3|t4           -0.002    0.054   -0.043    0.966   -0.002   -0.002
##     ic3|t5            0.255    0.055    4.677    0.000    0.255    0.255
##     ic3|t6            1.112    0.068   16.355    0.000    1.112    1.112
##     ic4|t1           -2.356    0.166  -14.232    0.000   -2.356   -2.356
##     ic4|t2           -2.129    0.133  -16.007    0.000   -2.129   -2.129
##     ic4|t3           -1.945    0.114  -17.127    0.000   -1.945   -1.945
##     ic4|t4           -1.502    0.083  -18.083    0.000   -1.502   -1.502
##     ic4|t5           -0.890    0.062  -14.250    0.000   -0.890   -0.890
##     ic4|t6            0.357    0.055    6.472    0.000    0.357    0.357
##     ic5|t1           -2.011    0.120  -16.767    0.000   -2.011   -2.011
##     ic5|t2           -1.517    0.084  -18.099    0.000   -1.517   -1.517
##     ic5|t3           -1.212    0.071  -17.043    0.000   -1.212   -1.212
##     ic5|t4           -0.897    0.063  -14.327    0.000   -0.897   -0.897
##     ic5|t5           -0.510    0.057   -9.018    0.000   -0.510   -0.510
##     ic5|t6            0.526    0.057    9.271    0.000    0.526    0.526
##     restr.w1|t1      -0.122    0.054   -2.280    0.023   -0.122   -0.122
##     restr.w1|t2       0.628    0.059   10.624    0.000    0.628    0.628
##     restr.w1|t3       1.424    0.082   17.448    0.000    1.424    1.424
##     restr.w1|t4       2.010    0.124   16.187    0.000    2.010    2.010
##     restr.w2|t1       0.164    0.055    3.005    0.003    0.164    0.164
##     restr.w2|t2       0.952    0.065   14.599    0.000    0.952    0.952
##     restr.w2|t3       1.589    0.091   17.548    0.000    1.589    1.589
##     restr.w2|t4       2.189    0.146   14.943    0.000    2.189    2.189
##     restr.w3|t1       0.050    0.054    0.919    0.358    0.050    0.050
##     restr.w3|t2       1.014    0.067   15.232    0.000    1.014    1.014
##     restr.w3|t3       1.485    0.084   17.636    0.000    1.485    1.485
##     restr.w3|t4       2.406    0.181   13.321    0.000    2.406    2.406
##     restr.w6|t1      -0.102    0.055   -1.870    0.062   -0.102   -0.102
##     restr.w6|t2       0.652    0.060   10.913    0.000    0.652    0.652
##     restr.w6|t3       1.285    0.076   16.964    0.000    1.285    1.285
##     restr.w6|t4       1.915    0.114   16.812    0.000    1.915    1.915
```

```
##     restr.w8|t1       1.477    0.084   17.673    0.000    1.477    1.477
##     restr.w8|t2       2.103    0.134   15.731    0.000    2.103    2.103
##     restr.w8|t3       2.515    0.202   12.444    0.000    2.515    2.515
##     restr.w8|t4       2.878    0.313    9.199    0.000    2.878    2.878
##     fr1|t1            0.053    0.054    0.988    0.323    0.053    0.053
##     fr1|t2            0.925    0.063   14.633    0.000    0.925    0.925
##     fr1|t3            1.945    0.114   17.127    0.000    1.945    1.945
##     fr1|t4            2.356    0.166   14.232    0.000    2.356    2.356
##     fr2|t1            0.156    0.054    2.877    0.004    0.156    0.156
##     fr2|t2            0.876    0.062   14.095    0.000    0.876    0.876
##     fr2|t3            1.531    0.085   18.111    0.000    1.531    1.531
##     fr2|t4            2.129    0.133   16.007    0.000    2.129    2.129
##     fr3|t1            0.246    0.055    4.506    0.000    0.246    0.246
##     fr3|t2            0.947    0.064   14.860    0.000    0.947    0.947
##     fr3|t3            1.860    0.106   17.520    0.000    1.860    1.860
##     fr3|t4            2.540    0.202   12.601    0.000    2.540    2.540
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .app1              0.332                               0.332    0.332
##    .app2              0.139                               0.139    0.139
##    .app3              0.320                               0.320    0.320
##    .eah1              0.602                               0.602    0.602
##    .eah3              0.538                               0.538    0.538
##    .eah5              0.503                               0.503    0.503
##    .eah6              0.491                               0.491    0.491
##    .ic1               0.567                               0.567    0.567
##    .ic2               0.348                               0.348    0.348
##    .ic3               0.826                               0.826    0.826
##    .ic4               0.630                               0.630    0.630
##    .ic5               0.729                               0.729    0.729
##    .restr.w1          0.362                               0.362    0.362
##    .restr.w2          0.267                               0.267    0.267
##    .restr.w3          0.523                               0.523    0.523
##    .restr.w6          0.563                               0.563    0.563
##    .restr.w8          0.693                               0.693    0.693
##    .fr1               0.329                               0.329    0.329
##    .fr2               0.578                               0.578    0.578
##    .fr3               0.190                               0.190    0.190
##    .zbmi              2.001    0.118   16.888    0.000    2.001    0.934
##     app               0.668    0.032   20.843    0.000    1.000    1.000
##    .eah               0.354    0.042    8.500    0.000    0.888    0.888
##     ic                0.433    0.038   11.290    0.000    1.000    1.000
##    .restr.w           0.588    0.039   15.156    0.000    0.922    0.922
##     fr                0.671    0.053   12.781    0.000    1.000    1.000
##
## Scales y*:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     app1              1.000                               1.000    1.000
##     app2              1.000                               1.000    1.000
##     app3              1.000                               1.000    1.000
##     eah1              1.000                               1.000    1.000
##     eah3              1.000                               1.000    1.000
##     eah5              1.000                               1.000    1.000
```

```
##     eah6              1.000                                1.000    1.000
##     ic1               1.000                                1.000    1.000
##     ic2               1.000                                1.000    1.000
##     ic3               1.000                                1.000    1.000
##     ic4               1.000                                1.000    1.000
##     ic5               1.000                                1.000    1.000
##     restr.w1          1.000                                1.000    1.000
##     restr.w2          1.000                                1.000    1.000
##     restr.w3          1.000                                1.000    1.000
##     restr.w6          1.000                                1.000    1.000
##     restr.w8          1.000                                1.000    1.000
##     fr1               1.000                                1.000    1.000
##     fr2               1.000                                1.000    1.000
##     fr3               1.000                                1.000    1.000
```

2.2 restriction for health

2.2.1 EAH to restr.h (model 2a)

```
mod1='
# latent variables
app=~app1+app2+app3
eah=~eah1+eah3+eah5+eah6
ic=~ic1+ic2+ic3+ic4+ic5
restr.h=~restr.h2+restr.h3+restr.h4
fr=~fr1+fr2+fr3
# hyp
zbmi~eah+app
eah~ic+fr
restr.h~app+eah+zbmi
'
sem1=sem(mod1,data=data,ordered=items)
summary(sem1,standardize=T,fit.measures=T)
```

```
## lavaan 0.6-7 ended normally after 40 iterations
##
##   Estimator                                         DWLS
##   Optimization method                           NLMINB
##   Number of free parameters                        108
##
##                                                   Used       Total
##   Number of observations                           541         621
##
## Model Test User Model:
##                                               Standard      Robust
##   Test Statistic                               269.610     292.956
##   Degrees of freedom                               143         143
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.096
##   Shift parameter                                           47.051
##        simple second-order correction
##
```

```
## Model Test Baseline Model:
##
##   Test statistic                                9203.339    5466.797
##   Degrees of freedom                                171         171
##   P-value                                         0.000       0.000
##   Scaling correction factor                                   1.706
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                     0.986       0.972
##   Tucker-Lewis Index (TLI)                        0.983       0.966
##
##   Robust Comparative Fit Index (CFI)                             NA
##   Robust Tucker-Lewis Index (TLI)                                NA
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                           0.040       0.044
##   90 Percent confidence interval - lower          0.033       0.037
##   90 Percent confidence interval - upper          0.048       0.051
##   P-value RMSEA <= 0.05                           0.984       0.911
##
##   Robust RMSEA                                                   NA
##   90 Percent confidence interval - lower                         NA
##   90 Percent confidence interval - upper                         NA
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                            0.055       0.055
##
## Parameter Estimates:
##
##   Standard errors                             Robust.sem
##   Information                                   Expected
##   Information saturated (h1) model        Unstructured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   app =~
##     app1              1.000                               0.818    0.818
##     app2              1.133    0.041   27.321    0.000    0.927    0.927
##     app3              1.006    0.027   37.676    0.000    0.823    0.823
##   eah =~
##     eah1              1.000                               0.591    0.591
##     eah3              1.215    0.093   13.025    0.000    0.718    0.718
##     eah5              1.130    0.092   12.286    0.000    0.668    0.668
##     eah6              1.191    0.094   12.710    0.000    0.704    0.704
##   ic =~
##     ic1               1.000                               0.657    0.657
##     ic2               1.230    0.076   16.248    0.000    0.809    0.809
##     ic3               0.646    0.058   11.087    0.000    0.425    0.425
##     ic4               0.922    0.064   14.358    0.000    0.606    0.606
##     ic5               0.779    0.066   11.760    0.000    0.512    0.512
##   restr.h =~
```

```
##     restr.h2          1.000                              0.754    0.754
##     restr.h3          0.664    0.060   11.031    0.000    0.500    0.500
##     restr.h4          1.150    0.085   13.503    0.000    0.867    0.867
##   fr =~
##     fr1               1.000                              0.813    0.813
##     fr2               0.820    0.050   16.537    0.000    0.667    0.667
##     fr3               1.108    0.074   15.027    0.000    0.900    0.900
##
## Regressions:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   zbmi ~
##     eah               0.316    0.122    2.593    0.010    0.187    0.126
##     app              -0.345    0.078   -4.400    0.000   -0.282   -0.190
##   eah ~
##     ic               -0.157    0.047   -3.306    0.001   -0.174   -0.174
##     fr                0.235    0.042    5.530    0.000    0.323    0.323
##   restr.h ~
##     app               0.062    0.044    1.429    0.153    0.068    0.068
##     eah               0.708    0.082    8.635    0.000    0.555    0.555
##     zbmi              0.032    0.022    1.472    0.141    0.042    0.063
##
## Covariances:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   app ~~
##     ic                0.039    0.026    1.507    0.132    0.073    0.073
##     fr                0.072    0.036    2.003    0.045    0.108    0.108
##   ic ~~
##     fr               -0.061    0.027   -2.221    0.026   -0.114   -0.114
##
## Intercepts:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .app1              0.000                              0.000    0.000
##    .app2              0.000                              0.000    0.000
##    .app3              0.000                              0.000    0.000
##    .eah1              0.000                              0.000    0.000
##    .eah3              0.000                              0.000    0.000
##    .eah5              0.000                              0.000    0.000
##    .eah6              0.000                              0.000    0.000
##    .ic1               0.000                              0.000    0.000
##    .ic2               0.000                              0.000    0.000
##    .ic3               0.000                              0.000    0.000
##    .ic4               0.000                              0.000    0.000
##    .ic5               0.000                              0.000    0.000
##    .restr.h2          0.000                              0.000    0.000
##    .restr.h3          0.000                              0.000    0.000
##    .restr.h4          0.000                              0.000    0.000
##    .fr1               0.000                              0.000    0.000
##    .fr2               0.000                              0.000    0.000
##    .fr3               0.000                              0.000    0.000
##    .zbmi             -0.219    0.065   -3.367    0.001   -0.219   -0.148
##     app               0.000                              0.000    0.000
##    .eah               0.000                              0.000    0.000
##     ic                0.000                              0.000    0.000
##    .restr.h           0.000                              0.000    0.000
```

```
##     fr                0.000                           0.000    0.000
##
## Thresholds:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     app1|t1          -1.304    0.074  -17.526    0.000   -1.304   -1.304
##     app1|t2          -0.086    0.054   -1.589    0.112   -0.086   -0.086
##     app1|t3           0.270    0.055    4.934    0.000    0.270    0.270
##     app1|t4           1.121    0.068   16.421    0.000    1.121    1.121
##     app2|t1          -0.585    0.057  -10.194    0.000   -0.585   -0.585
##     app2|t2           0.294    0.055    5.362    0.000    0.294    0.294
##     app2|t3           0.575    0.057   10.027    0.000    0.575    0.575
##     app2|t4           1.138    0.069   16.551    0.000    1.138    1.138
##     app3|t1          -0.402    0.056   -7.239    0.000   -0.402   -0.402
##     app3|t2           0.682    0.059   11.605    0.000    0.682    0.682
##     app3|t3           1.193    0.070   16.925    0.000    1.193    1.193
##     app3|t4           1.860    0.106   17.520    0.000    1.860    1.860
##     eah1|t1          -1.765    0.099  -17.852    0.000   -1.765   -1.765
##     eah1|t2          -0.694    0.059  -11.770    0.000   -0.694   -0.694
##     eah1|t3           0.198    0.054    3.649    0.000    0.198    0.198
##     eah1|t4           1.304    0.074   17.526    0.000    1.304    1.304
##     eah3|t1          -1.112    0.068  -16.355    0.000   -1.112   -1.112
##     eah3|t2          -0.510    0.057   -9.018    0.000   -0.510   -0.510
##     eah3|t3           0.165    0.054    3.048    0.002    0.165    0.165
##     eah3|t4           0.969    0.064   15.084    0.000    0.969    0.969
##     eah5|t1          -0.863    0.062  -13.939    0.000   -0.863   -0.863
##     eah5|t2           0.918    0.063   14.557    0.000    0.918    0.918
##     eah6|t1          -1.046    0.066  -15.808    0.000   -1.046   -1.046
##     eah6|t2           1.014    0.065   15.523    0.000    1.014    1.014
##     ic1|t1           -1.664    0.092  -18.064    0.000   -1.664   -1.664
##     ic1|t2           -0.748    0.060  -12.504    0.000   -0.748   -0.748
##     ic1|t3           -0.284    0.055   -5.191    0.000   -0.284   -0.284
##     ic1|t4           -0.025    0.054   -0.472    0.637   -0.025   -0.025
##     ic1|t5            0.463    0.056    8.257    0.000    0.463    0.463
##     ic1|t6            1.611    0.089   18.116    0.000    1.611    1.611
##     ic2|t1           -2.086    0.128  -16.297    0.000   -2.086   -2.086
##     ic2|t2           -1.372    0.077  -17.792    0.000   -1.372   -1.372
##     ic2|t3           -0.863    0.062  -13.939    0.000   -0.863   -0.863
##     ic2|t4           -0.602    0.058  -10.445    0.000   -0.602   -0.602
##     ic2|t5            0.072    0.054    1.331    0.183    0.072    0.072
##     ic2|t6            1.315    0.075   17.574    0.000    1.315    1.315
##     ic3|t1           -1.611    0.089  -18.116    0.000   -1.611   -1.611
##     ic3|t2           -0.817    0.061  -13.388    0.000   -0.817   -0.817
##     ic3|t3           -0.289    0.055   -5.276    0.000   -0.289   -0.289
##     ic3|t4           -0.002    0.054   -0.043    0.966   -0.002   -0.002
##     ic3|t5            0.255    0.055    4.677    0.000    0.255    0.255
##     ic3|t6            1.112    0.068   16.355    0.000    1.112    1.112
##     ic4|t1           -2.356    0.166  -14.232    0.000   -2.356   -2.356
##     ic4|t2           -2.129    0.133  -16.007    0.000   -2.129   -2.129
##     ic4|t3           -1.945    0.114  -17.127    0.000   -1.945   -1.945
##     ic4|t4           -1.502    0.083  -18.083    0.000   -1.502   -1.502
##     ic4|t5           -0.890    0.062  -14.250    0.000   -0.890   -0.890
##     ic4|t6            0.357    0.055    6.472    0.000    0.357    0.357
##     ic5|t1           -2.011    0.120  -16.767    0.000   -2.011   -2.011
##     ic5|t2           -1.517    0.084  -18.099    0.000   -1.517   -1.517
```

```
##     ic5|t3          -1.212    0.071  -17.043    0.000   -1.212   -1.212
##     ic5|t4          -0.897    0.063  -14.327    0.000   -0.897   -0.897
##     ic5|t5          -0.510    0.057   -9.018    0.000   -0.510   -0.510
##     ic5|t6           0.526    0.057    9.271    0.000    0.526    0.526
##     restr.h2|t1     -1.229    0.072  -17.182    0.000   -1.229   -1.229
##     restr.h2|t2     -0.522    0.057   -9.214    0.000   -0.522   -0.522
##     restr.h2|t3     -0.139    0.054   -2.565    0.010   -0.139   -0.139
##     restr.h2|t4      0.932    0.064   14.614    0.000    0.932    0.932
##     restr.h3|t1     -1.246    0.072  -17.254    0.000   -1.246   -1.246
##     restr.h3|t2     -0.132    0.054   -2.443    0.015   -0.132   -0.132
##     restr.h3|t3      0.592    0.058   10.280    0.000    0.592    0.592
##     restr.h3|t4      1.623    0.090   18.076    0.000    1.623    1.623
##     restr.h4|t1     -1.046    0.066  -15.805    0.000   -1.046   -1.046
##     restr.h4|t2     -0.235    0.055   -4.304    0.000   -0.235   -0.235
##     restr.h4|t3      0.008    0.054    0.151    0.880    0.008    0.008
##     restr.h4|t4      0.848    0.062   13.739    0.000    0.848    0.848
##     fr1|t1           0.053    0.054    0.988    0.323    0.053    0.053
##     fr1|t2           0.925    0.063   14.633    0.000    0.925    0.925
##     fr1|t3           1.945    0.114   17.127    0.000    1.945    1.945
##     fr1|t4           2.356    0.166   14.232    0.000    2.356    2.356
##     fr2|t1           0.156    0.054    2.877    0.004    0.156    0.156
##     fr2|t2           0.876    0.062   14.095    0.000    0.876    0.876
##     fr2|t3           1.531    0.085   18.111    0.000    1.531    1.531
##     fr2|t4           2.129    0.133   16.007    0.000    2.129    2.129
##     fr3|t1           0.246    0.055    4.506    0.000    0.246    0.246
##     fr3|t2           0.947    0.064   14.860    0.000    0.947    0.947
##     fr3|t3           1.860    0.106   17.520    0.000    1.860    1.860
##     fr3|t4           2.540    0.202   12.601    0.000    2.540    2.540
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .app1              0.330                               0.330    0.330
##    .app2              0.140                               0.140    0.140
##    .app3              0.322                               0.322    0.322
##    .eah1              0.650                               0.650    0.650
##    .eah3              0.484                               0.484    0.484
##    .eah5              0.554                               0.554    0.554
##    .eah6              0.504                               0.504    0.504
##    .ic1               0.568                               0.568    0.568
##    .ic2               0.346                               0.346    0.346
##    .ic3               0.819                               0.819    0.819
##    .ic4               0.632                               0.632    0.632
##    .ic5               0.737                               0.737    0.737
##    .restr.h2          0.431                               0.431    0.431
##    .restr.h3          0.750                               0.750    0.750
##    .restr.h4          0.248                               0.248    0.248
##    .fr1               0.340                               0.340    0.340
##    .fr2               0.556                               0.556    0.556
##    .fr3               0.190                               0.190    0.190
##    .zbmi              2.095    0.115   18.255    0.000    2.095    0.949
##     app               0.670    0.032   20.979    0.000    1.000    1.000
##    .eah               0.298    0.037    8.048    0.000    0.853    0.853
##     ic                0.432    0.039   11.187    0.000    1.000    1.000
##    .restr.h           0.384    0.043    8.906    0.000    0.675    0.675
```

```
##     fr                0.660    0.053   12.358    0.000    1.000    1.000
##
## Scales y*:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     app1              1.000                               1.000    1.000
##     app2              1.000                               1.000    1.000
##     app3              1.000                               1.000    1.000
##     eah1              1.000                               1.000    1.000
##     eah3              1.000                               1.000    1.000
##     eah5              1.000                               1.000    1.000
##     eah6              1.000                               1.000    1.000
##     ic1               1.000                               1.000    1.000
##     ic2               1.000                               1.000    1.000
##     ic3               1.000                               1.000    1.000
##     ic4               1.000                               1.000    1.000
##     ic5               1.000                               1.000    1.000
##     restr.h2          1.000                               1.000    1.000
##     restr.h3          1.000                               1.000    1.000
##     restr.h4          1.000                               1.000    1.000
##     fr1               1.000                               1.000    1.000
##     fr2               1.000                               1.000    1.000
##     fr3               1.000                               1.000    1.000
```

2.2.2 restr.h to EAH (model 2b)

```
mod1='
# latent variables
app=~app1+app2+app3
eah=~eah1+eah3+eah5+eah6
ic=~ic1+ic2+ic3+ic4+ic5
restr.h=~restr.h2+restr.h3+restr.h4
fr=~fr1+fr2+fr3
# hyp
zbmi~eah+app
eah~ic+fr
restr.h~app+zbmi
eah~restr.h
'
sem1=sem(mod1,data=data,ordered=items)
summary(sem1,standardize=T,fit.measures=T)
```

```
## lavaan 0.6-7 ended normally after 42 iterations
##
##   Estimator                                         DWLS
##   Optimization method                           NLMINB
##   Number of free parameters                        108
##
##                                                   Used       Total
##   Number of observations                           541         621
##
## Model Test User Model:
##                                              Standard      Robust
```

```
##   Test Statistic                                409.086     412.961
##   Degrees of freedom                                143         143
##   P-value (Chi-square)                            0.000       0.000
##   Scaling correction factor                                   1.119
##   Shift parameter                                            47.463
##        simple second-order correction
##
## Model Test Baseline Model:
##
##   Test statistic                               9203.339    5466.797
##   Degrees of freedom                                171         171
##   P-value                                         0.000       0.000
##   Scaling correction factor                                   1.706
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                     0.971       0.949
##   Tucker-Lewis Index (TLI)                        0.965       0.939
##
##   Robust Comparative Fit Index (CFI)                             NA
##   Robust Tucker-Lewis Index (TLI)                                NA
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                           0.059       0.059
##   90 Percent confidence interval - lower          0.052       0.053
##   90 Percent confidence interval - upper          0.065       0.066
##   P-value RMSEA <= 0.05                           0.016       0.012
##
##   Robust RMSEA                                                   NA
##   90 Percent confidence interval - lower                         NA
##   90 Percent confidence interval - upper                         NA
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                            0.068       0.068
##
## Parameter Estimates:
##
##   Standard errors                             Robust.sem
##   Information                                   Expected
##   Information saturated (h1) model          Unstructured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   app =~
##     app1              1.000                               0.817    0.817
##     app2              1.136    0.042   27.241    0.000    0.928    0.928
##     app3              1.007    0.027   37.621    0.000    0.823    0.823
##   eah =~
##     eah1              1.000                               0.606    0.606
##     eah3              1.216    0.094   12.936    0.000    0.737    0.737
##     eah5              1.119    0.091   12.244    0.000    0.678    0.678
##     eah6              1.188    0.092   12.955    0.000    0.720    0.720
```

```
##   ic =~
##     ic1               1.000                               0.659    0.659
##     ic2               1.228    0.075   16.366    0.000    0.809    0.809
##     ic3               0.631    0.057   11.034    0.000    0.416    0.416
##     ic4               0.921    0.064   14.366    0.000    0.607    0.607
##     ic5               0.789    0.065   12.093    0.000    0.520    0.520
##   restr.h =~
##     restr.h2          1.000                               0.771    0.771
##     restr.h3          0.654    0.059   11.114    0.000    0.505    0.505
##     restr.h4          1.103    0.081   13.536    0.000    0.850    0.850
##   fr =~
##     fr1               1.000                               0.820    0.820
##     fr2               0.790    0.048   16.570    0.000    0.647    0.647
##     fr3               1.100    0.071   15.389    0.000    0.901    0.901
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   zbmi ~
##     eah               0.253    0.137    1.855    0.064    0.153    0.103
##     app              -0.347    0.078   -4.438    0.000   -0.283   -0.191
##   eah ~
##     ic               -0.137    0.048   -2.848    0.004   -0.149   -0.149
##     fr                0.191    0.042    4.549    0.000    0.258    0.258
##   restr.h ~
##     app               0.039    0.049    0.797    0.425    0.041    0.041
##     zbmi              0.038    0.028    1.372    0.170    0.050    0.074
##   eah ~
##     restr.h           0.391    0.049    8.016    0.000    0.497    0.497
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   app ~~
##     ic                0.039    0.026    1.487    0.137    0.072    0.072
##     fr                0.076    0.035    2.152    0.031    0.113    0.113
##   ic ~~
##     fr               -0.061    0.028   -2.196    0.028   -0.113   -0.113
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .app1              0.000                               0.000    0.000
##    .app2              0.000                               0.000    0.000
##    .app3              0.000                               0.000    0.000
##    .eah1              0.000                               0.000    0.000
##    .eah3              0.000                               0.000    0.000
##    .eah5              0.000                               0.000    0.000
##    .eah6              0.000                               0.000    0.000
##    .ic1               0.000                               0.000    0.000
##    .ic2               0.000                               0.000    0.000
##    .ic3               0.000                               0.000    0.000
##    .ic4               0.000                               0.000    0.000
##    .ic5               0.000                               0.000    0.000
##    .restr.h2          0.000                               0.000    0.000
##    .restr.h3          0.000                               0.000    0.000
##    .restr.h4          0.000                               0.000    0.000
```

```
##    .fr1               0.000                               0.000    0.000
##    .fr2               0.000                               0.000    0.000
##    .fr3               0.000                               0.000    0.000
##    .zbmi             -0.219    0.065   -3.367    0.001   -0.219   -0.147
##     app               0.000                               0.000    0.000
##    .eah               0.000                               0.000    0.000
##     ic                0.000                               0.000    0.000
##    .restr.h           0.000                               0.000    0.000
##     fr                0.000                               0.000    0.000
##
## Thresholds:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     app1|t1          -1.304    0.074  -17.526    0.000   -1.304   -1.304
##     app1|t2          -0.086    0.054   -1.589    0.112   -0.086   -0.086
##     app1|t3           0.270    0.055    4.934    0.000    0.270    0.270
##     app1|t4           1.121    0.068   16.421    0.000    1.121    1.121
##     app2|t1          -0.585    0.057  -10.194    0.000   -0.585   -0.585
##     app2|t2           0.294    0.055    5.362    0.000    0.294    0.294
##     app2|t3           0.575    0.057   10.027    0.000    0.575    0.575
##     app2|t4           1.138    0.069   16.551    0.000    1.138    1.138
##     app3|t1          -0.402    0.056   -7.239    0.000   -0.402   -0.402
##     app3|t2           0.682    0.059   11.605    0.000    0.682    0.682
##     app3|t3           1.193    0.070   16.925    0.000    1.193    1.193
##     app3|t4           1.860    0.106   17.520    0.000    1.860    1.860
##     eah1|t1          -1.768    0.099  -17.925    0.000   -1.768   -1.768
##     eah1|t2          -0.697    0.059  -11.860    0.000   -0.697   -0.697
##     eah1|t3           0.195    0.054    3.583    0.000    0.195    0.195
##     eah1|t4           1.301    0.074   17.471    0.000    1.301    1.301
##     eah3|t1          -1.116    0.068  -16.419    0.000   -1.116   -1.116
##     eah3|t2          -0.514    0.057   -9.074    0.000   -0.514   -0.514
##     eah3|t3           0.161    0.054    2.973    0.003    0.161    0.161
##     eah3|t4           0.965    0.064   15.024    0.000    0.965    0.965
##     eah5|t1          -0.867    0.062  -13.993    0.000   -0.867   -0.867
##     eah5|t2           0.914    0.063   14.512    0.000    0.914    0.914
##     eah6|t1          -1.050    0.066  -15.856    0.000   -1.050   -1.050
##     eah6|t2           1.010    0.065   15.451    0.000    1.010    1.010
##     ic1|t1           -1.664    0.092  -18.064    0.000   -1.664   -1.664
##     ic1|t2           -0.748    0.060  -12.504    0.000   -0.748   -0.748
##     ic1|t3           -0.284    0.055   -5.191    0.000   -0.284   -0.284
##     ic1|t4           -0.025    0.054   -0.472    0.637   -0.025   -0.025
##     ic1|t5            0.463    0.056    8.257    0.000    0.463    0.463
##     ic1|t6            1.611    0.089   18.116    0.000    1.611    1.611
##     ic2|t1           -2.086    0.128  -16.297    0.000   -2.086   -2.086
##     ic2|t2           -1.372    0.077  -17.792    0.000   -1.372   -1.372
##     ic2|t3           -0.863    0.062  -13.939    0.000   -0.863   -0.863
##     ic2|t4           -0.602    0.058  -10.445    0.000   -0.602   -0.602
##     ic2|t5            0.072    0.054    1.331    0.183    0.072    0.072
##     ic2|t6            1.315    0.075   17.574    0.000    1.315    1.315
##     ic3|t1           -1.611    0.089  -18.116    0.000   -1.611   -1.611
##     ic3|t2           -0.817    0.061  -13.388    0.000   -0.817   -0.817
##     ic3|t3           -0.289    0.055   -5.276    0.000   -0.289   -0.289
##     ic3|t4           -0.002    0.054   -0.043    0.966   -0.002   -0.002
##     ic3|t5            0.255    0.055    4.677    0.000    0.255    0.255
##     ic3|t6            1.112    0.068   16.355    0.000    1.112    1.112
```

```
##     ic4|t1           -2.356    0.166  -14.232    0.000   -2.356   -2.356
##     ic4|t2           -2.129    0.133  -16.007    0.000   -2.129   -2.129
##     ic4|t3           -1.945    0.114  -17.127    0.000   -1.945   -1.945
##     ic4|t4           -1.502    0.083  -18.083    0.000   -1.502   -1.502
##     ic4|t5           -0.890    0.062  -14.250    0.000   -0.890   -0.890
##     ic4|t6            0.357    0.055    6.472    0.000    0.357    0.357
##     ic5|t1           -2.011    0.120  -16.767    0.000   -2.011   -2.011
##     ic5|t2           -1.517    0.084  -18.099    0.000   -1.517   -1.517
##     ic5|t3           -1.212    0.071  -17.043    0.000   -1.212   -1.212
##     ic5|t4           -0.897    0.063  -14.327    0.000   -0.897   -0.897
##     ic5|t5           -0.510    0.057   -9.018    0.000   -0.510   -0.510
##     ic5|t6            0.526    0.057    9.271    0.000    0.526    0.526
##     restr.h2|t1      -1.230    0.072  -17.192    0.000   -1.230   -1.230
##     restr.h2|t2      -0.524    0.057   -9.229    0.000   -0.524   -0.524
##     restr.h2|t3      -0.141    0.055   -2.584    0.010   -0.141   -0.141
##     restr.h2|t4       0.931    0.064   14.544    0.000    0.931    0.931
##     restr.h3|t1      -1.247    0.072  -17.253    0.000   -1.247   -1.247
##     restr.h3|t2      -0.133    0.054   -2.457    0.014   -0.133   -0.133
##     restr.h3|t3       0.591    0.058   10.252    0.000    0.591    0.591
##     restr.h3|t4       1.623    0.090   18.066    0.000    1.623    1.623
##     restr.h4|t1      -1.047    0.066  -15.791    0.000   -1.047   -1.047
##     restr.h4|t2      -0.236    0.055   -4.319    0.000   -0.236   -0.236
##     restr.h4|t3       0.007    0.054    0.127    0.899    0.007    0.007
##     restr.h4|t4       0.847    0.062   13.675    0.000    0.847    0.847
##     fr1|t1            0.053    0.054    0.988    0.323    0.053    0.053
##     fr1|t2            0.925    0.063   14.633    0.000    0.925    0.925
##     fr1|t3            1.945    0.114   17.127    0.000    1.945    1.945
##     fr1|t4            2.356    0.166   14.232    0.000    2.356    2.356
##     fr2|t1            0.156    0.054    2.877    0.004    0.156    0.156
##     fr2|t2            0.876    0.062   14.095    0.000    0.876    0.876
##     fr2|t3            1.531    0.085   18.111    0.000    1.531    1.531
##     fr2|t4            2.129    0.133   16.007    0.000    2.129    2.129
##     fr3|t1            0.246    0.055    4.506    0.000    0.246    0.246
##     fr3|t2            0.947    0.064   14.860    0.000    0.947    0.947
##     fr3|t3            1.860    0.106   17.520    0.000    1.860    1.860
##     fr3|t4            2.540    0.202   12.601    0.000    2.540    2.540
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .app1              0.332                               0.332    0.332
##    .app2              0.138                               0.138    0.138
##    .app3              0.322                               0.322    0.322
##    .eah1              0.633                               0.633    0.633
##    .eah3              0.457                               0.457    0.457
##    .eah5              0.540                               0.540    0.540
##    .eah6              0.482                               0.482    0.482
##    .ic1               0.566                               0.566    0.566
##    .ic2               0.346                               0.346    0.346
##    .ic3               0.827                               0.827    0.827
##    .ic4               0.632                               0.632    0.632
##    .ic5               0.730                               0.730    0.730
##    .restr.h2          0.406                               0.406    0.406
##    .restr.h3          0.745                               0.745    0.745
##    .restr.h4          0.277                               0.277    0.277
```

```
##    .fr1               0.328                                  0.328    0.328
##    .fr2               0.581                                  0.581    0.581
##    .fr3               0.187                                  0.187    0.187
##    .zbmi              2.082    0.115   18.109    0.000       2.082    0.947
##     app               0.668    0.032   20.910    0.000       1.000    1.000
##    .eah               0.238    0.036    6.607    0.000       0.649    0.649
##     ic                0.434    0.038   11.297    0.000       1.000    1.000
##    .restr.h           0.586    0.053   10.963    0.000       0.986    0.986
##     fr                0.672    0.053   12.765    0.000       1.000    1.000
##
## Scales y*:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     app1             1.000                                1.000    1.000
##     app2             1.000                                1.000    1.000
##     app3             1.000                                1.000    1.000
##     eah1             1.000                                1.000    1.000
##     eah3             1.000                                1.000    1.000
##     eah5             1.000                                1.000    1.000
##     eah6             1.000                                1.000    1.000
##     ic1              1.000                                1.000    1.000
##     ic2              1.000                                1.000    1.000
##     ic3              1.000                                1.000    1.000
##     ic4              1.000                                1.000    1.000
##     ic5              1.000                                1.000    1.000
##     restr.h2         1.000                                1.000    1.000
##     restr.h3         1.000                                1.000    1.000
##     restr.h4         1.000                                1.000    1.000
##     fr1              1.000                                1.000    1.000
##     fr2              1.000                                1.000    1.000
##     fr3              1.000                                1.000    1.000
```

3 SEM models, identifiability

```
require(SEMID)
```

```
## Loading required package: SEMID
```

```
## Warning: package 'SEMID' was built under R version 3.6.3
```

3.1 EAH to restr (model a) : identifiable

variables numbering 1 : IC
2 : FR
3 : EAH
4 : low app
5 : zBMI
6 : restr

```
L = t(matrix(  # single arrows (effects, directional)
 c(0, 0, 1, 0, 0, 0,
   0, 0, 1, 0, 0, 0,
   0, 0, 0, 0, 1, 1,
   0, 0, 0, 0, 1, 1,
   0, 0, 0, 0, 0, 1,
   0, 0, 0, 0, 0, 0), 6, 6))

O = t(matrix(  # double arrows (corrélations, bidirectional)
 c(0, 1, 0, 1, 0, 0,
   0, 0, 0, 1, 0, 0,
   0, 0, 0, 0, 0, 0,
   0, 0, 0, 0, 0, 0,
   0, 0, 0, 0, 0, 0,
   0, 0, 0, 0, 0, 0), 6, 6)) ; O=O+t(O)
graph = MixedGraph(L, O) # mixed graph : directional and bidirectional
```

htcID - implements the half-trek critierion of Foygel, Rina; Draisma, Jan; Drton, Mathias. Half-trek criterion for generic identifiability of linear structural equation models. Ann. Statist. 40 (2012), no. 3, 1682–1713. doi:10.1214/12-AOS1012.

```
htcID(graph, tianDecompose = F)
```

```
## Call: htcID(mixedGraph = graph, tianDecompose = F)
##
## Mixed Graph Info.
## # nodes: 6
## # dir. edges: 7
## # bi. edges: 3
##
## Generic Identifiability Summary
## # dir. edges shown gen. identifiable: 7
## # bi. edges shown gen. identifiable: 3
##
## Generically identifiable dir. edges:
## 1->3, 2->3, 3->5, 4->5, 3->6, 4->6, 5->6
##
## Generically identifiable bi. edges:
## 1<->2, 1<->4, 2<->4
```

3.2 restr to EAH (model b) : indentifiable

```
L = t(matrix(
 c(0, 0, 1, 0, 0, 0,
   0, 0, 1, 0, 0, 0,
   0, 0, 0, 0, 1, 0,
   0, 0, 0, 0, 1, 1,
   0, 0, 0, 0, 0, 1,
   0, 0, 1, 0, 0, 0), 6, 6))

O = t(matrix(
```

```
 c(0, 1, 0, 1, 0, 0,
   0, 0, 0, 1, 0, 0,
   0, 0, 0, 0, 0, 0,
   0, 0, 0, 0, 0, 0,
   0, 0, 0, 0, 0, 0,
   0, 0, 0, 0, 0, 0), 6, 6)) ; O=O+t(O)
graph = MixedGraph(L, O)
```

```
htcID(graph, tianDecompose = F)
```

```
## Call: htcID(mixedGraph = graph, tianDecompose = F)
##
## Mixed Graph Info.
## # nodes: 6
## # dir. edges: 7
## # bi. edges: 3
##
## Generic Identifiability Summary
## # dir. edges shown gen. identifiable: 7
## # bi. edges shown gen. identifiable: 3
##
## Generically identifiable dir. edges:
## 1->3, 2->3, 6->3, 3->5, 4->5, 4->6, 5->6
##
## Generically identifiable bi. edges:
## 1<->2, 1<->4, 2<->4
```

4 R and packages versions

```
sessionInfo()
```

```
## R version 3.6.1 (2019-07-05)
## Platform: x86_64-w64-mingw32/x64 (64-bit)
## Running under: Windows 10 x64 (build 19041)
##
## Matrix products: default
##
## locale:
## [1] LC_COLLATE=French_France.1252  LC_CTYPE=French_France.1252
## [3] LC_MONETARY=French_France.1252 LC_NUMERIC=C
## [5] LC_TIME=French_France.1252
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
## [1] SEMID_0.3.2  lavaan_0.6-7
##
## loaded via a namespace (and not attached):
##  [1] lattice_0.20-41   digest_0.6.27     R.methodsS3_1.8.1 grid_3.6.1
```

```
##  [5] stats4_3.6.1      magrittr_2.0.1    evaluate_0.14     rlang_0.4.9
##  [9] stringi_1.4.6     R.oo_1.24.0       Matrix_1.2-18     pbivnorm_0.6.0
## [13] rmarkdown_2.6     tools_3.6.1       stringr_1.4.0     igraph_1.2.5
## [17] xfun_0.19         yaml_2.2.1        compiler_3.6.1    pkgconfig_2.0.3
## [21] mnormt_1.5-6      htmltools_0.5.0   knitr_1.30
```