7 Structural Equation Modeling 4: Mean and Covariance Structure Analysis

References:

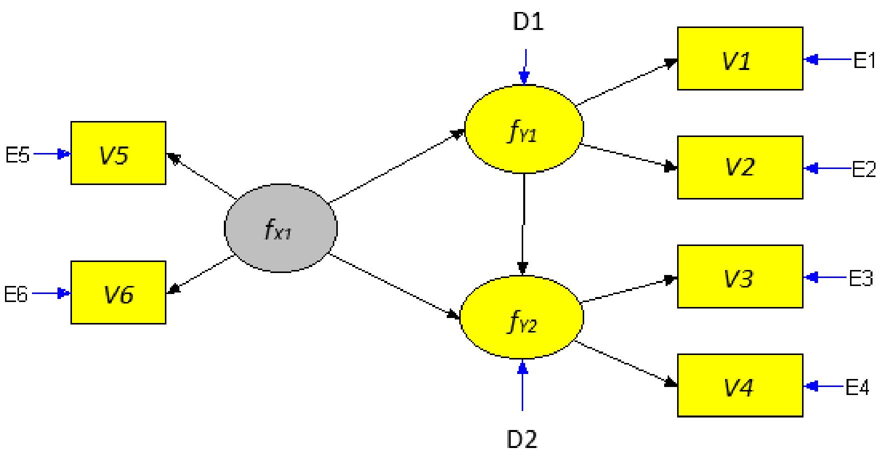
• Rosseel (2017).

7.1. Introduction

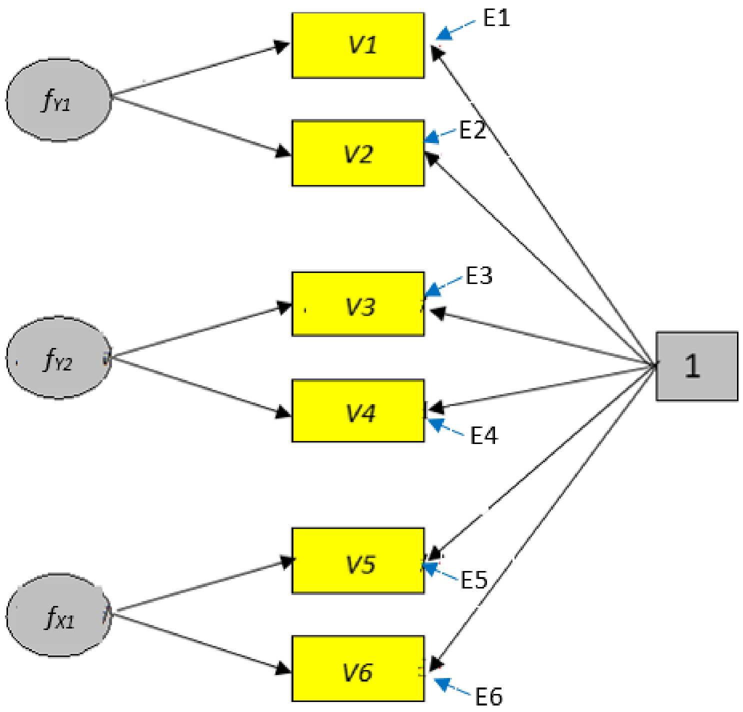
• To extend traditional SEM models by decomposing the means of the measured variables into more basic model parameters.

• Both the means, variances, covariances carry statistical information and they are analyzed simultaneously.

7.2. The General Mean and Covariance Structural Model



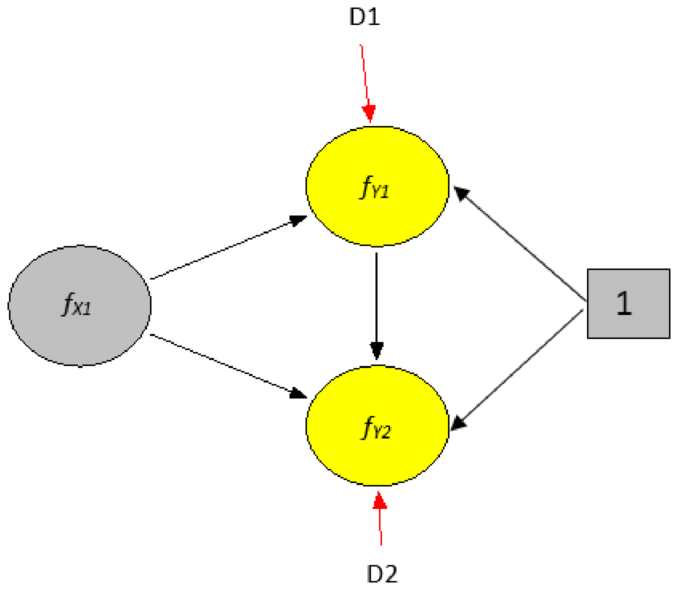
- The measurement part:



$$v = \mu + \Lambda f + e \quad (1)$$

where μ is the intercept vector of the observed variables, v.

- The structural part:



$$\begin{bmatrix} f_x \\ f_y \end{bmatrix} = \begin{bmatrix} \alpha_x \\ \alpha_y \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ \gamma & \beta \end{bmatrix} \begin{bmatrix} f_x \\ f_y \end{bmatrix} + \begin{bmatrix} f_x - E(f_x) \\ d \end{bmatrix}$$

$$f \quad = \quad \alpha \quad + \quad Bf \quad + \quad z \qquad (2)$$

where (i) α is the intercept vector of the latent variables, f, and (ii) $\alpha_x = E(f_x)$.

7.3. New Parameters Related to the Mean Structures

• In addition to the four model parameter matrices related to the covariance structure, which are, factor loading matrix (Λ), variance-covariance matrix of e (Θ), structural coefficient matrix among the factors (B), variance-covariance matrix of f_x and d (Ψ), we have two new parameter vectors:

(1) μ, which is a $p \times 1$ vector of intercepts of the observed variables, v

(2) α, which is a $k \times 1$ vector of intercepts of the latent variables, f

7.4. Connecting Means and Intercepts

• From Equation (2),

$$(I-B)f = \alpha + z$$
$$f = (I-B)^{-1}\alpha + (I-B)^{-1}z \qquad (3)$$

where $(I-B)^{-1} = \begin{bmatrix} I & 0 \\ (I-\beta)^{-1}\gamma & (I-\beta)^{-1} \end{bmatrix}$.

• The means of f are

$$E(f) = (I-B)^{-1}\alpha \qquad (4)$$

such that

$$E(f_x) = \alpha_x \qquad (4.1)$$

$$E(f_y) = (I-\beta)^{-1}(\gamma\alpha_x + \alpha_y) \qquad (4.2)$$

- Substituting Equation (3) into Equation (1), we have

$$v = \mu + \Lambda[(I - B)^{-1}\alpha + (I - B)^{-1}z] + e$$

and

$$E(v) = \mu + \Lambda(I - B)^{-1}\alpha \tag{5}$$

7.5. Identification Issues due to Mean Structure

- The parameters cannot be identified without additional parameter constraints.

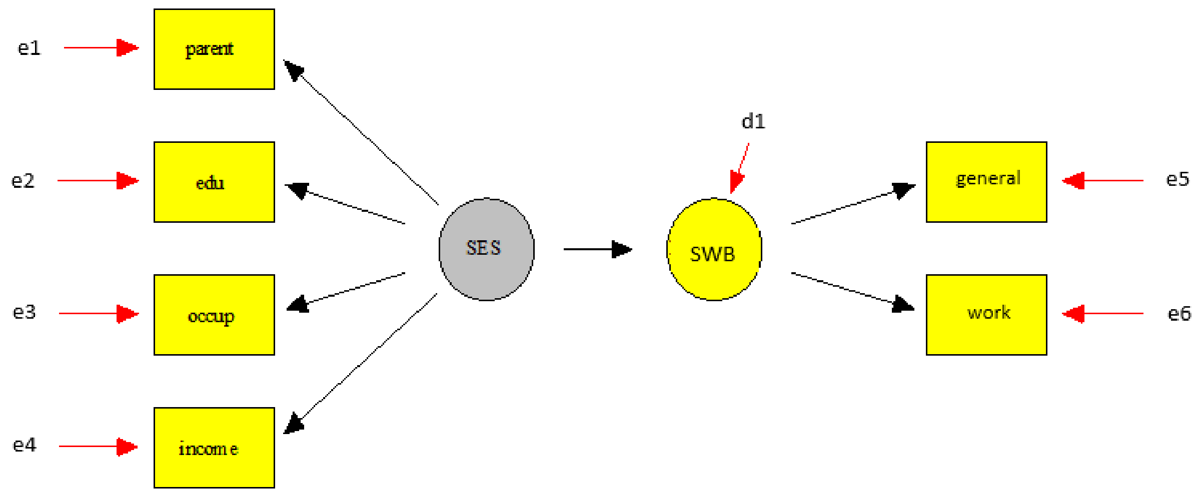
- On one hand, we have p more data points from the observed means. On the other hand, we have $(p + k)$ more parameters which are the intercepts of both the observed and latent variables.

- If we fix the latent intercepts to 0 (i.e., $\alpha = 0$), the fit will be identical to the model without the mean structure.

- In practice, models with mean structures are meaningful only when some more constraints are specified.

- Typical situations where we would include the means are (1) multiple group SEM and (2) latent growth curve modeling

7.6. Example 1. Effect of SES on SWB: A Comparison between USA and China



• SES = socioeconomic status, which was measured by *parent* (parent educational background), *edu* (self education level), *occup* (occupation), and *income*

• SWB = subjective well being, which was measured by *general* (general life satisfaction) and *work* (work satisfaction)

- Group 1: USA ($N = 200$, filename = *usa.dat*)

parent	1.00					
edu	.48	1.00				
occup	.22	.34	1.00			
income	.27	.22	.39	1.00		
general	.23	.22	.20	.12	1.00	
work	.27	.30	.23	.16	.64	1.00
SD	1.36	1.20	1.19	3.24	3.90	2.72
MEAN	3.84	3.29	2.60	6.44	20.42	10.07

- Group 2: China ($N = 220$, filename = *china.dat*)

parent	1.00					
edu	.44	1.00				
occup	.22	.20	1.00			
income	.30	.18	.38	1.00		
general	.27	.27	.21	.08	1.00	
work	.27	.12	.25	.20	.66	1.00
SD	1.33	1.28	1.08	2.65	3.76	2.68
MEAN	3.52	3.08	2.09	5.36	19.67	9.56

Questions:

1. How well does the proposed model fit the data in each group?

2. Is the measurement model the same for both groups?

3. Are the two groups different in their mean SES values?

4. Are the two groups different in their mean SWB values?

5. Is the effect of SES on SWB the same for both groups?

filename: *china.R* (R script)

```
# Example 1. Effect of SES on SWB: A comparison between USA and China

# set work directory
setwd("c:/users/wchan/google drive/stat6108/data")

# load the lavaan package
library(lavaan)
library(semPlot)

# data preparation

# group 1: USA
usa.corr <- "
1.00
 .48  1.00
 .22   .34  1.00
 .27   .22   .39  1.00
 .23   .22   .20   .12  1.00
 .27   .30   .23   .16   .64   1.00"
usa.sd <- c(1.36, 1.20, 1.19, 3.24, 3.90, 2.72)
usa.mean <- c(3.84, 3.29, 2.60,  6.44, 20.42, 10.07)

# group 2: China
china.corr <- "
1.00
 .44  1.00
 .22   .20  1.00
 .30   .18   .38  1.00
 .27   .27   .21   .08  1.00
 .27   .12   .25   .20   .66  1.00"
china.sd <- c(1.33, 1.28, 1.08, 2.65, 3.76, 2.68)
china.mean <- c(3.52, 3.08, 2.09, 5.36, 19.67, 9.56)
```

```
# assgin variable labels
varname <- c("parent", "edu", "occup", "income", "general", "work")
usa.cov <- getCov(usa.corr, sds=usa.sd, names=varname)
china.cov <- getCov(china.corr, sds=china.sd, names=varname)
names(usa.mean) <- names(china.mean) <- varname

# specify Model 1 (configural invariance)
model1 <- "
# measurement model
SES =~ 1*parent + edu + occup + income
SWB =~ 1*general + work
# error variance
parent ~~ parent
edu ~~ edu
occup ~~ occup
income ~~ income
general ~~ general
work ~~ work
# structural paths
SWB ~ SES
# factor and disturbance variance
SES ~~ SES
SWB ~~ SWB
# intercepts
parent + edu + occup + income + general + work ~ 1
"

# Fit Model 1 to data
fit1 <-lavaan(model1, sample.cov=list(USA=usa.cov, China=china.cov), sample.mean=list(USA=usa.mean,
China=china.mean), sample.nobs=c(200, 220))
```

```
# specify Model 2 (strong measurement invariance)
model2 <- "
# measurement model
SES =~ parent + edu + occup + income
SWB =~ general + work
# structural paths
SWB ~ c(ga1,ga2)*SES
# means/intercepts of latent variables
SES ~ c(al_x1,al_x2)*1
SWB ~ c(al_y1,al_y2)*1
# constraint the intercepts of the factors in China
al_x2 == 0
al_y2 == 0
# Define new parameters
# difference of gamma_11 between USA and China
gamma_d := ga2-ga1
# mean of SWB in USA
mean_SWB_USA := ga1*al_x1+al_y1
"

# Fit Model 2 to data
fit2 <-lavaan(model2, sample.cov=list(USA=usa.cov, China=china.cov), sample.mean=list(USA=usa.mean,
China=china.mean), sample.nobs=c(200, 220), auto.var=TRUE, auto.fix.first=TRUE, meanstructure=TRUE,
int.ov.free=TRUE, group.equal=c("loadings","intercepts"))
```

```
# specify Model 3 (using LR test to compare the effect of SES on SWB)
model3 <- "
# measurement model
SES =~ parent + edu + occup + income
SWB =~ general + work
# structural paths
SWB ~ c(ga,ga)*SES
# means/intercepts of latent variables
SES ~ c(al_x1,al_x2)*1
SWB ~ c(al_y1,al_y2)*1
# constraint the intercepts of the factors in China
al_x2 == 0
al_y2 == 0
# mean of SWB in USA
mean_SWB_USA := ga*al_x1+al_y1
"

# Fit Model 3 to data
fit3 <-lavaan(model3, sample.cov=list(USA=usa.cov, China=china.cov), sample.mean=list(USA=usa.mean,
China=china.mean), sample.nobs=c(200, 220), auto.var=TRUE, auto.fix.first=TRUE, meanstructure=TRUE,
int.ov.free=TRUE, group.equal=c("loadings","intercepts"))

# save the output
sink("china.out", split=TRUE)
writeLines("\n Example 1. Effect of SES on SWB: A comparison between USA and China\n")
writeLines("\n Output for Model 1 (Configural Invariance)\n")
inspect(fit1)
summary(fit1, fit.measures=TRUE, standardized=TRUE)
writeLines("\n Output for Model 2 (Strong Factorial Invariance)\n")
inspect(fit2)
summary(fit2, fit.measures=TRUE, standardized=TRUE)
writeLines("\n Output for Model 3 (using LR test to compare the effect of SES on SWB)\n")
summary(fit3, fit.measures=TRUE, standardized=TRUE)
writeLines("\n Model Comparisons\n")
lavTestLRT(fit1, fit2, fit3)
sink()
```

```
# output path diagrams
semPaths(fit1,"path","est",layout="tree2")
semPaths(fit2,"path","est",style="lisrel",layout="spring")
```

filename: *china.out* (output file)

```
 Example 1. Effect of SES on SWB: A comparison between USA and China

 Output for Model 1 (Configural Invariance)

$USA
$USA$lambda
        SES SWB
parent    0   0
edu       1   0
occup     2   0
income    3   0
general   0   0
work      0   4

$USA$theta
        parent edu occup income generl work
parent   5
edu      0      6
occup    0      0   7
income   0      0   0     8
general  0      0   0     0      9
work     0      0   0     0      0     10

$USA$psi
    SES SWB
SES 12
SWB  0  13

$USA$beta
    SES SWB
SES   0   0
SWB  11   0
```

```
$USA$nu
        intrcp
parent      14
edu         15
occup       16
income      17
general     18
work        19

$USA$alpha
    intrcp
SES      0
SWB      0


$China
$China$lambda
        SES SWB
parent    0   0
edu      20   0
occup    21   0
income   22   0
general   0   0
work      0  23

$China$theta
        parent edu occup income generl work
parent  24
edu      0     25
occup    0      0  26
income   0      0   0    27
general  0      0   0     0     28
work     0      0   0     0      0     29
```

```
$China$psi
    SES SWB
SES 31
SWB  0  32

$China$beta
    SES SWB
SES   0   0
SWB  30   0

$China$nu
        intrcp
parent      33
edu         34
occup       35
income      36
general     37
work        38

$China$alpha
    intrcp
SES      0
SWB      0


lavaan 0.6-3 ended normally after 110 iterations

  Optimization method                           NLMINB
  Number of free parameters                         38

  Number of observations per group
  USA                                              200
  China                                            220

  Estimator                                         ML
  Model Fit Test Statistic                      57.468
```

```
  Degrees of freedom                                    16
  P-value (Chi-square)                               0.000

Chi-square for each group:

  USA                                               19.900
  China                                             37.568

Model test baseline model:

  Minimum Function Test Statistic                  534.875
  Degrees of freedom                                    30
  P-value                                            0.000

User model versus baseline model:

  Comparative Fit Index (CFI)                        0.918
  Tucker-Lewis Index (TLI)                           0.846

Loglikelihood and Information Criteria:

  Loglikelihood user model (H0)                  -5027.831
  Loglikelihood unrestricted model (H1)          -4999.097

  Number of free parameters                             38
  Akaike (AIC)                                   10131.661
  Bayesian (BIC)                                 10285.191
  Sample-size adjusted Bayesian (BIC)            10164.605

Root Mean Square Error of Approximation:

  RMSEA                                              0.111
  90 Percent Confidence Interval          0.081  0.143
  P-value RMSEA <= 0.05                              0.001
```

```
Standardized Root Mean Square Residual:

  SRMR                                           0.049

Parameter Estimates:

  Information                                 Expected
  Information saturated (h1) model          Structured
  Standard Errors                             Standard


Group 1 [USA]:

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  SES =~
    parent            1.000                               0.852    0.628
    edu               0.974    0.167    5.837    0.000    0.830    0.694
    occup             0.694    0.136    5.084    0.000    0.591    0.498
    income            1.625    0.358    4.545    0.000    1.385    0.429
  SWB =~
    general           1.000                               2.773    0.713
    work              0.879    0.173    5.082    0.000    2.436    0.898

Regressions:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  SWB ~
    SES               1.557    0.417    3.738    0.000    0.479    0.479

Intercepts:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
   .parent            3.840    0.096   40.031    0.000    3.840    2.831
   .edu               3.290    0.085   38.870    0.000    3.290    2.749
   .occup             2.600    0.084   30.976    0.000    2.600    2.190
   .income            6.440    0.229   28.180    0.000    6.440    1.993
   .general          20.420    0.275   74.233    0.000   20.420    5.249
```

```
   .work             10.070    0.192   52.488    0.000   10.070    3.711
    SES               0.000                               0.000    0.000
   .SWB               0.000                               0.000    0.000

Variances:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
   .parent            1.114    0.159    7.025    0.000    1.114    0.605
   .edu               0.743    0.127    5.860    0.000    0.743    0.519
   .occup             1.059    0.124    8.556    0.000    1.059    0.752
   .income            8.527    0.944    9.028    0.000    8.527    0.816
   .general           7.447    1.598    4.660    0.000    7.447    0.492
   .work              1.425    1.101    1.294    0.196    1.425    0.194
    SES               0.726    0.185    3.928    0.000    1.000    1.000
   .SWB               5.925    1.430    4.142    0.000    0.771    0.771


Group 2 [China]:

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  SES =~
    parent            1.000                               0.909    0.685
    edu               0.785    0.148    5.306    0.000    0.714    0.559
    occup             0.517    0.112    4.607    0.000    0.470    0.436
    income            1.319    0.279    4.733    0.000    1.199    0.454
  SWB =~
    general           1.000                               3.117    0.831
    work              0.681    0.122    5.602    0.000    2.124    0.794

Regressions:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  SWB ~
    SES               1.637    0.383    4.276    0.000    0.477    0.477
```

Intercepts:

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
.parent	3.520	0.089	39.345	0.000	3.520	2.653
.edu	3.080	0.086	35.772	0.000	3.080	2.412
.occup	2.090	0.073	28.769	0.000	2.090	1.940
.income	5.360	0.178	30.069	0.000	5.360	2.027
.general	19.670	0.253	77.771	0.000	19.670	5.243
.work	9.560	0.180	53.030	0.000	9.560	3.575
SES	0.000				0.000	0.000
.SWB	0.000				0.000	0.000

Variances:

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
.parent	0.935	0.162	5.762	0.000	0.935	0.531
.edu	1.121	0.141	7.975	0.000	1.121	0.688
.occup	0.940	0.102	9.243	0.000	0.940	0.810
.income	5.552	0.610	9.109	0.000	5.552	0.794
.general	4.359	1.688	2.582	0.010	4.359	0.310
.work	2.638	0.800	3.296	0.001	2.638	0.369
SES	0.826	0.197	4.204	0.000	1.000	1.000
.SWB	7.501	1.747	4.294	0.000	0.772	0.772

Output for Model 2 (Strong Factorial Invariance)

```
Note: model contains equality constraints:

   lhs op rhs
1   27 ==   0
2   28 ==   0
3    1 ==  22
4    2 ==  23
5    3 ==  24
6    4 ==  25
7   16 ==  37
8   17 ==  38
9   18 ==  39
10  19 ==  40
11  20 ==  41
12  21 ==  42

$USA
$USA$lambda
        SES SWB
parent    0   0
edu       1   0
occup     2   0
income    3   0
general   0   0
work      0   4

$USA$theta
        parent edu occup income generl work
parent   8
edu      0      9
occup    0      0  10
income   0      0   0    11
general  0      0   0     0     12
work     0      0   0     0      0     13
```

```
$USA$psi
    SES SWB
SES 14
SWB  0  15

$USA$beta
    SES SWB
SES   0   0
SWB   5   0

$USA$nu
        intrcp
parent      16
edu         17
occup       18
income      19
general     20
work        21

$USA$alpha
    intrcp
SES      6
SWB      7


$China
$China$lambda
        SES SWB
parent    0   0
edu      22   0
occup    23   0
income   24   0
general   0   0
work      0  25
```

```
$China$theta
        parent edu occup income generl work
parent  29
edu      0     30
occup    0      0  31
income   0      0   0    32
general  0      0   0     0     33
work     0      0   0     0      0     34

$China$psi
    SES SWB
SES 35
SWB  0  36

$China$beta
    SES SWB
SES   0   0
SWB  26   0

$China$nu
        intrcp
parent      37
edu         38
occup       39
income      40
general     41
work        42

$China$alpha
    intrcp
SES     27
SWB     28

lavaan 0.6-3 ended normally after 98 iterations

  Optimization method                           NLMINB
```

```
  Number of free parameters                         42
  Number of equality constraints                    12

  Number of observations per group
  USA                                              200
  China                                            220

  Estimator                                         ML
  Model Fit Test Statistic                      70.912
  Degrees of freedom                                24
  P-value (Chi-square)                           0.000

Chi-square for each group:

  USA                                           26.546
  China                                         44.365

Model test baseline model:

  Minimum Function Test Statistic              534.875
  Degrees of freedom                                30
  P-value                                        0.000

User model versus baseline model:

  Comparative Fit Index (CFI)                    0.907
  Tucker-Lewis Index (TLI)                       0.884

Loglikelihood and Information Criteria:

  Loglikelihood user model (H0)              -5034.552
  Loglikelihood unrestricted model (H1)      -4999.097

  Number of free parameters                         30
  Akaike (AIC)                               10129.105
  Bayesian (BIC)                             10250.312
```

```
  Sample-size adjusted Bayesian (BIC)        10155.113

Root Mean Square Error of Approximation:

  RMSEA                                          0.096
  90 Percent Confidence Interval          0.071  0.123
  P-value RMSEA <= 0.05                          0.002

Standardized Root Mean Square Residual:

  SRMR                                           0.057

Parameter Estimates:

  Information                                 Expected
  Information saturated (h1) model          Structured
  Standard Errors                             Standard

Group 1 [USA]:

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  SES =~
    parent            1.000                               0.861    0.631
    edu     (.p2.)    0.861    0.108    7.950    0.000    0.742    0.631
    occup   (.p3.)    0.743    0.098    7.602    0.000    0.640    0.532
    income  (.p4.)    1.783    0.245    7.263    0.000    1.536    0.471
  SWB =~
    general           1.000                               2.954    0.754
    work    (.p6.)    0.779    0.097    8.000    0.000    2.300    0.851

Regressions:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  SWB ~
    SES      (ga1)    1.686    0.375    4.498    0.000    0.492    0.492
```

```
Intercepts:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
    SES    (al_x1)    0.428    0.104    4.107    0.000    0.497    0.497
   .SWB    (al_y1)   -0.033    0.336   -0.097    0.923   -0.011   -0.011
   .parent  (.18.)    3.469    0.080   43.553    0.000    3.469    2.540
   .edu     (.19.)    2.990    0.074   40.363    0.000    2.990    2.543
   .occup   (.20.)    2.173    0.065   33.310    0.000    2.173    1.805
   .income  (.21.)    5.475    0.161   34.036    0.000    5.475    1.678
   .generl  (.22.)   19.696    0.239   82.424    0.000   19.696    5.029
   .work    (.23.)    9.547    0.177   54.018    0.000    9.547    3.534

Variances:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
   .parent            1.123    0.153    7.353    0.000    1.123    0.602
   .edu               0.832    0.114    7.321    0.000    0.832    0.602
   .occup             1.040    0.123    8.468    0.000    1.040    0.717
   .income            8.291    0.929    8.924    0.000    8.291    0.779
   .general           6.617    1.322    5.006    0.000    6.617    0.431
   .work              2.007    0.723    2.778    0.005    2.007    0.275
    SES               0.742    0.155    4.794    0.000    1.000    1.000
   .SWB               6.615    1.310    5.048    0.000    0.758    0.758

Group 2 [China]:

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  SES =~
    parent            1.000                               0.771    0.591
    edu     (.p2.)    0.861    0.108    7.950    0.000    0.664    0.518
    occup   (.p3.)    0.743    0.098    7.602    0.000    0.573    0.523
    income  (.p4.)    1.783    0.245    7.263    0.000    1.374    0.516
  SWB =~
    general           1.000                               2.912    0.779
    work    (.p6.)    0.779    0.097    8.000    0.000    2.268    0.845

Regressions:
```

```
                      Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  SWB ~
    SES        (ga2)     1.820    0.409    4.445    0.000    0.482    0.482

Intercepts:
                      Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
    SES     (al_x2)      0.000                               0.000    0.000
   .SWB     (al_y2)      0.000                               0.000    0.000
   .parent  (.18.)       3.469    0.080   43.553    0.000    3.469    2.660
   .edu     (.19.)       2.990    0.074   40.363    0.000    2.990    2.331
   .occup   (.20.)       2.173    0.065   33.310    0.000    2.173    1.984
   .income  (.21.)       5.475    0.161   34.036    0.000    5.475    2.057
   .generl  (.22.)      19.696    0.239   82.424    0.000   19.696    5.273
   .work    (.23.)       9.547    0.177   54.018    0.000    9.547    3.559

Variances:
                      Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
   .parent               1.106    0.139    7.933    0.000    1.106    0.651
   .edu                  1.204    0.137    8.802    0.000    1.204    0.732
   .occup                0.871    0.100    8.714    0.000    0.871    0.726
   .income               5.197    0.594    8.748    0.000    5.197    0.733
   .general              5.477    1.213    4.515    0.000    5.477    0.392
   .work                 2.053    0.692    2.965    0.003    2.053    0.285
    SES                  0.594    0.126    4.705    0.000    1.000    1.000
   .SWB                  6.510    1.251    5.203    0.000    0.768    0.768

Defined Parameters:
                      Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
    gamma_d              0.133    0.487    0.274    0.784   -0.010   -0.010
    mean_SWB_USA         0.689    0.325    2.117    0.034    0.233    0.233

Constraints:
                                               |Slack|
    al_x2 - 0                                    0.000
    al_y2 - 0                                    0.000
```

Output for Model 3 (using LR test to compare the effect of SES on SWB)

```
lavaan 0.6-3 ended normally after 93 iterations

  Optimization method                           NLMINB
  Number of free parameters                         42
  Number of equality constraints                    13

  Number of observations per group
  USA                                              200
  China                                            220

  Estimator                                         ML
  Model Fit Test Statistic                      70.986
  Degrees of freedom                                25
  P-value (Chi-square)                           0.000

Chi-square for each group:

  USA                                           26.587
  China                                         44.399

Model test baseline model:

  Minimum Function Test Statistic              534.875
  Degrees of freedom                                30
  P-value                                        0.000

User model versus baseline model:

  Comparative Fit Index (CFI)                    0.909
  Tucker-Lewis Index (TLI)                       0.891

Loglikelihood and Information Criteria:

  Loglikelihood user model (H0)              -5034.590
```

```
  Loglikelihood unrestricted model (H1)      -4999.097

  Number of free parameters                         29
  Akaike (AIC)                               10127.179
  Bayesian (BIC)                             10244.347
  Sample-size adjusted Bayesian (BIC)        10152.321

Root Mean Square Error of Approximation:

  RMSEA                                          0.094
  90 Percent Confidence Interval          0.068  0.120
  P-value RMSEA <= 0.05                          0.003

Standardized Root Mean Square Residual:

  SRMR                                           0.057

Parameter Estimates:

  Information                                 Expected
  Information saturated (h1) model          Structured
  Standard Errors                             Standard


Group 1 [USA]:

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  SES =~
    parent            1.000                               0.858    0.629
    edu     (.p2.)    0.862    0.108    7.955    0.000    0.739    0.629
    occup   (.p3.)    0.742    0.098    7.597    0.000    0.637    0.529
    income  (.p4.)    1.781    0.245    7.265    0.000    1.529    0.469
  SWB =~
    general           1.000                               2.966    0.755
    work    (.p6.)    0.780    0.098    7.981    0.000    2.314    0.854
```

```
Regressions:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  SWB ~
    SES       (ga)    1.744    0.307    5.686    0.000    0.505    0.505

Intercepts:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
    SES    (al_x1)    0.428    0.104    4.106    0.000    0.498    0.498
   .SWB    (al_y1)   -0.058    0.323   -0.180    0.857   -0.020   -0.020
   .parent  (.18.)    3.469    0.080   43.473    0.000    3.469    2.543
   .edu     (.19.)    2.990    0.074   40.292    0.000    2.990    2.545
   .occup   (.20.)    2.173    0.065   33.270    0.000    2.173    1.807
   .income  (.21.)    5.475    0.161   34.000    0.000    5.475    1.679
   .generl  (.22.)   19.697    0.238   82.713    0.000   19.697    5.014
   .work    (.23.)    9.547    0.176   54.188    0.000    9.547    3.521

Variances:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
   .parent            1.125    0.152    7.394    0.000    1.125    0.604
   .edu               0.834    0.113    7.360    0.000    0.834    0.604
   .occup             1.041    0.123    8.494    0.000    1.041    0.720
   .income            8.302    0.929    8.941    0.000    8.302    0.780
   .general           6.637    1.323    5.018    0.000    6.637    0.430
   .work              1.995    0.725    2.752    0.006    1.995    0.271
    SES               0.737    0.152    4.839    0.000    1.000    1.000
   .SWB               6.555    1.295    5.061    0.000    0.745    0.745


Group 2 [China]:

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  SES =~
    parent            1.000                               0.775    0.594
    edu     (.p2.)    0.862    0.108    7.955    0.000    0.668    0.520
```

```
    occup   (.p3.)    0.742    0.098    7.597    0.000    0.575    0.525
    income  (.p4.)    1.781    0.245    7.265    0.000    1.381    0.518
  SWB =~
    general           1.000                               2.895    0.777
    work    (.p6.)    0.780    0.098    7.981    0.000    2.259    0.845

Regressions:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  SWB ~
    SES       (ga)    1.744    0.307    5.686    0.000    0.467    0.467

Intercepts:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
    SES    (al_x2)    0.000       NA                      0.000    0.000
   .SWB    (al_y2)    0.000                               0.000    0.000
   .parent  (.18.)    3.469    0.080   43.473    0.000    3.469    2.658
   .edu     (.19.)    2.990    0.074   40.292    0.000    2.990    2.330
   .occup   (.20.)    2.173    0.065   33.270    0.000    2.173    1.982
   .income  (.21.)    5.475    0.161   34.000    0.000    5.475    2.056
   .generl  (.22.)   19.697    0.238   82.713    0.000   19.697    5.287
   .work    (.23.)    9.547    0.176   54.188    0.000    9.547    3.571

Variances:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
   .parent            1.103    0.139    7.921    0.000    1.103    0.647
   .edu               1.201    0.137    8.792    0.000    1.201    0.729
   .occup             0.871    0.100    8.709    0.000    0.871    0.725
   .income            5.187    0.594    8.734    0.000    5.187    0.731
   .general           5.495    1.214    4.528    0.000    5.495    0.396
   .work              2.042    0.695    2.940    0.003    2.042    0.286
    SES               0.601    0.125    4.793    0.000    1.000    1.000
   .SWB               6.556    1.234    5.315    0.000    0.782    0.782

Defined Parameters:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
    mean_SWB_USA      0.688    0.325    2.115    0.034    0.232    0.232
```

```
Constraints:
                                               |Slack|
    al_x2 - 0                                    0.000
    al_y2 - 0                                    0.000


 Model Comparisons

Chi Square Difference Test

     Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
fit1 16 10132 10285 57.468
fit2 24 10129 10250 70.912    13.4435       8    0.09747 .
fit3 25 10127 10244 70.986     0.0746       1    0.78471
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

• Model Goodness-of-fit:

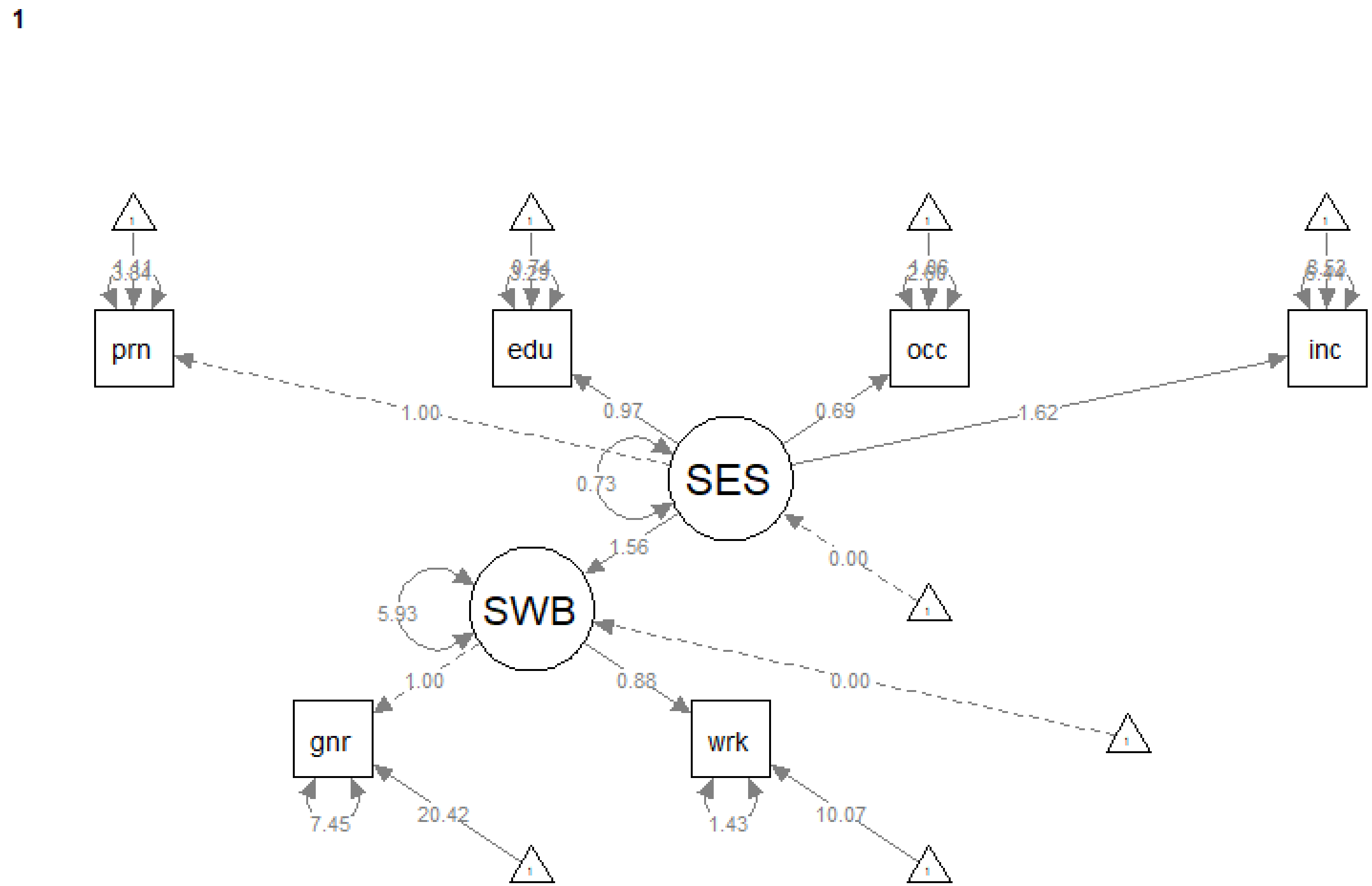
Model	χ^2_1	χ^2_2	χ^2 (*df*)	*p*	*NNFI*	*CFI*	*RMSEA*	*SRMR*	$\Delta\chi^2$	Δdf	*p*
1	19.900	37.568	57.468 (16)	.000	0.846	0.918	0.111	0.049			
2	26.546	44.365	70.912 (24)	.000	0.884	0.907	0.096	0.057	13.444	8	.097
3	26.587	44.399	70.986 (25)	.000	0.891	0.909	0.094	0.057	0.074	1	.785

• Parameter estimates:

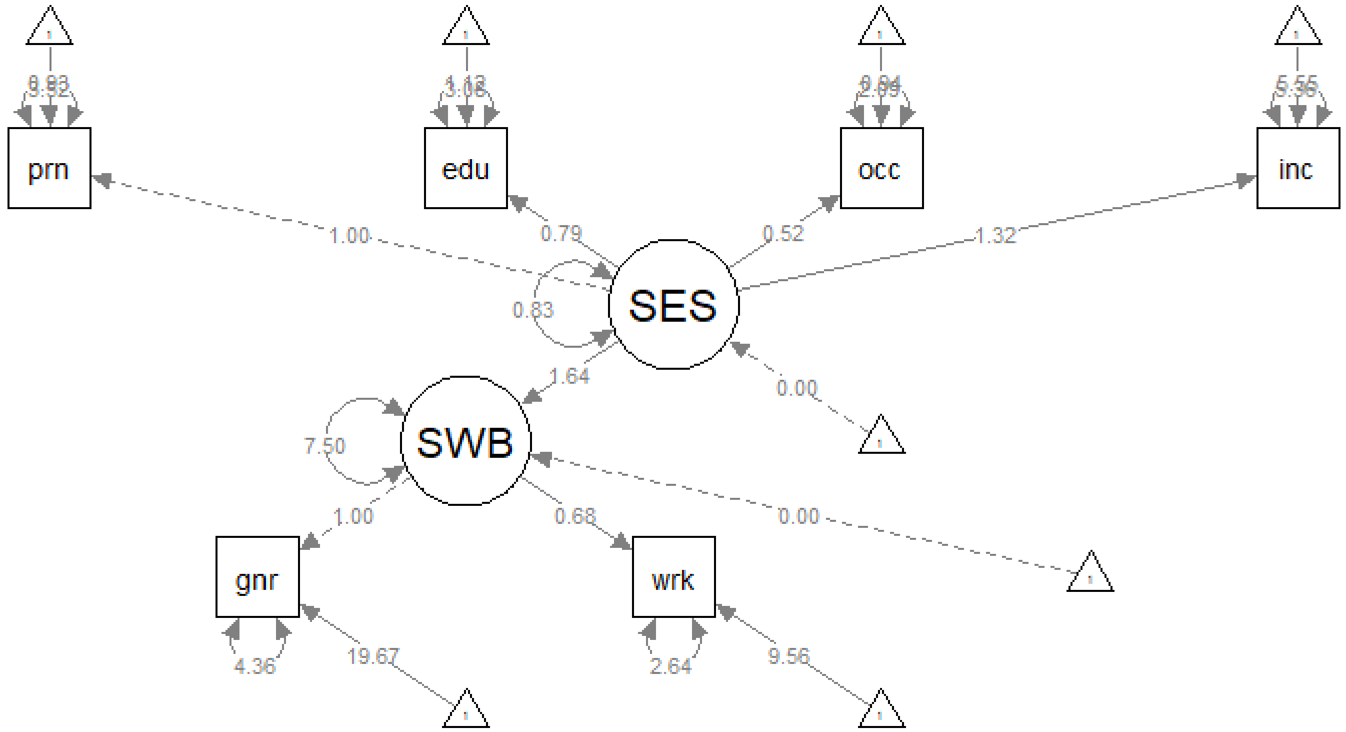
		Model 2		Model 3		
Effects	Parameters	USA	China	USA		China
mean of SES	$\widehat{\alpha}_x$	0.428*	0	0.428*		0
intercept of SWB	$\widehat{\alpha}_y$	-0.033	0	-0.058		0
mean of SWB	$(I\text{-}\widehat{\beta})^{-1}(\widehat{\gamma}\widehat{\alpha}_x+\widehat{\alpha}_y)$	0.689*	0	0.688*		0
effect of SES on SWB	$\widehat{\gamma}$	1.686*	1.820*	1.744*	=	1.744*

7.7. Output Path Diagrams

```
> library(semPlot)
> semPaths(fit1,"path","est",layout="tree2")
```

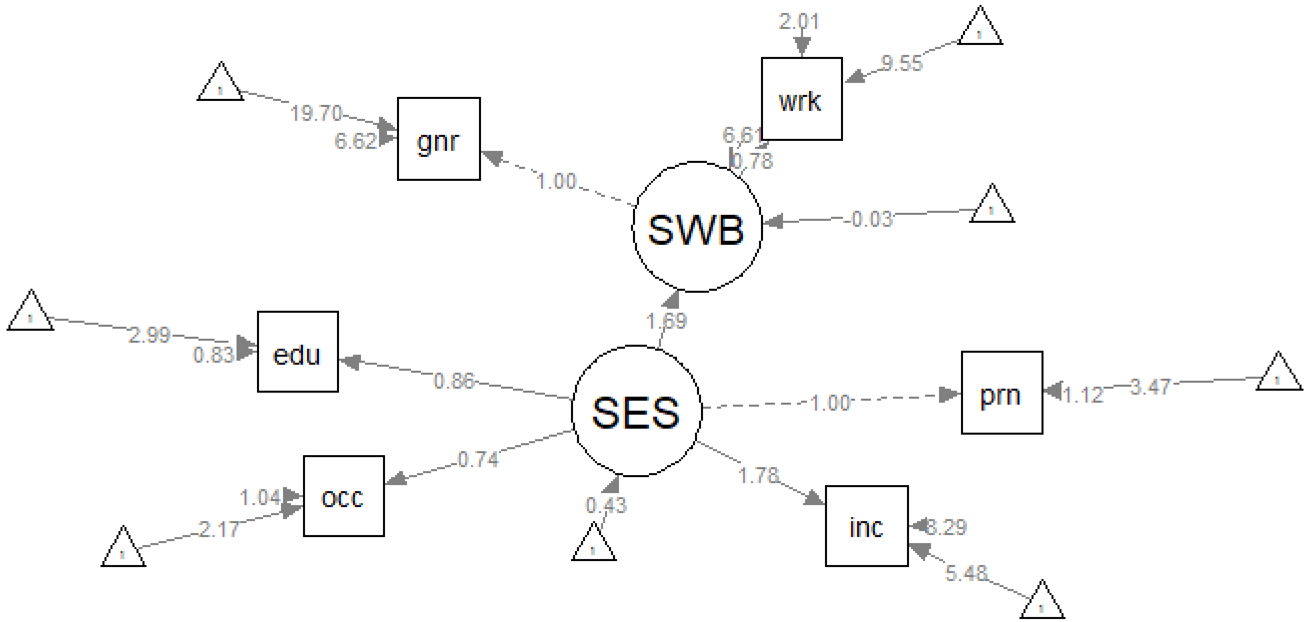


2

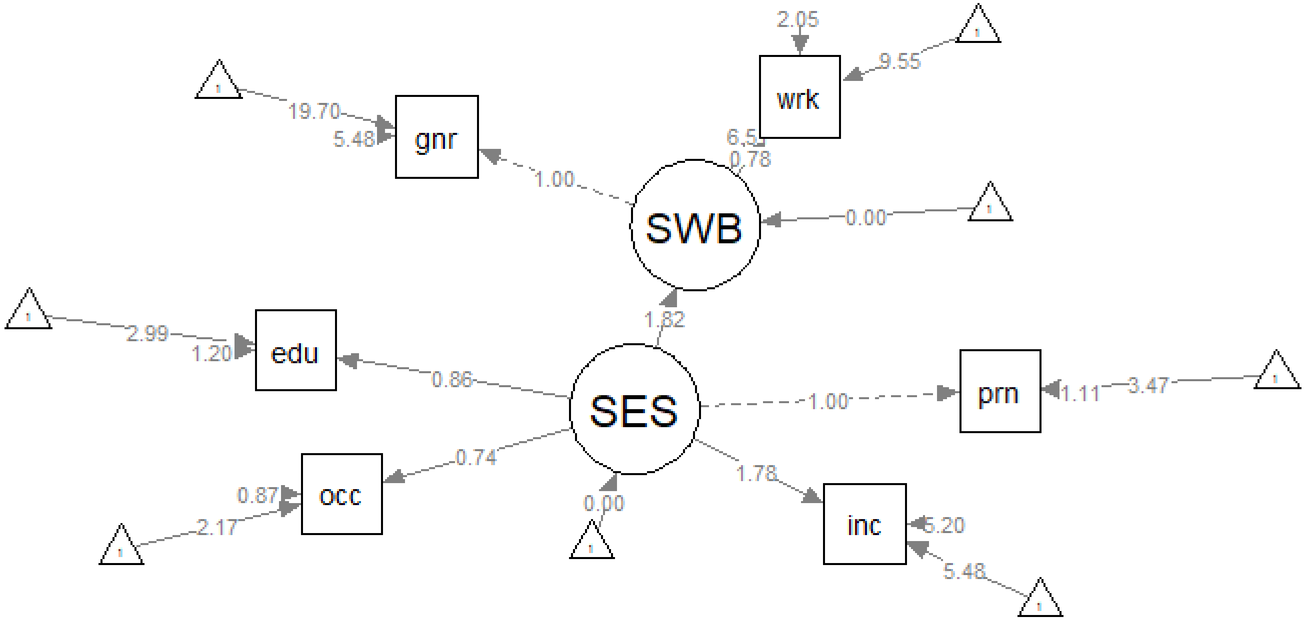

prn
edu
occ
inc
SES
SWB
gnr
wrk
1.00
0.79
0.52
1.32
0.83
1.64
0.00
7.50
1.00
0.68
0.00
4.36
19.67
2.64
9.56

```
> semPaths(fit2,"path","est",style="lisrel",layout="spring")
```

1



2



2.05
9.55
wrk
19.70
5.48
gnr
6.51
0.78
1.00
SWB
0.00
2.99
1.20
edu
1.82
0.86
SES
1.00
prn
1.11
3.47
0.74
occ
0.87
2.17
0.00
1.78
inc
5.20
5.48