

LISREL output files for structural equation models

Contents

1. Introduction.....	1
2. The data	1
3. The model.....	2
4. Fitting the structural model to the data.....	2
5. The results.....	4

1. Introduction

In practice, the variables of interest are often latent (unobservable) variables, such as intelligence, job satisfaction, organizational commitment, socio-economic status, ambition, alienation, verbal ability, etc. These latent variables are modeled by specifying a measurement model and a structural model. The measurement model specifies the relationships between the observed indicators and the latent variables while the structural model specifies the relationships amongst the latent variables. However, it is also possible and often desired to include observed variables as part of the structural model.

LISREL (Jöreskog & Sörbom 2006) implements the Maximum Likelihood (ML), Robust Maximum Likelihood (RML), Generalized Least Squares (GLS), Un-weighted Least Squares (ULS), Weighted Least Squares (WLS), Diagonally Weighted Least Squares (DWLS) and Full Information Maximum Likelihood (FIML) methods to fit structural equation models to data. More information on these methods is provided in Jöreskog & Sörbom (1999) and Du Toit & Du Toit (2001).

In this note, the ML method of LISREL is used to fit a structural equation model to the values of a sample of school children on 10 observed variables. The data set is described in the next section. The structural equation model is described in section 3. In section 4, the structural equation model is fitted to the data by means of the ML method. The LISREL output file is reviewed in section 5.

2. The data

The data are the values on ten observed variables of 194 freshman students at a high school in Bainbridge, Georgia. These variables are described below.

- AVG_SES – A Socio-Economic Index score – Indicator of Socio-Economic Status (SES).
- AVGP_AGE – Average age of parents – Indicator of SES.
- AVGP_EDU – Average education level of parents – Indicator of SES.
- CAF – Attitude towards father – Indicator of attitude about home (HOME_ATT).
- CAM – Attitude towards mother – Indicator of HOME_ATT.
- S_SE_H – Attitude about house or apartment – Indicator of HOME_ATT.
- GPA – Grade Point Average.

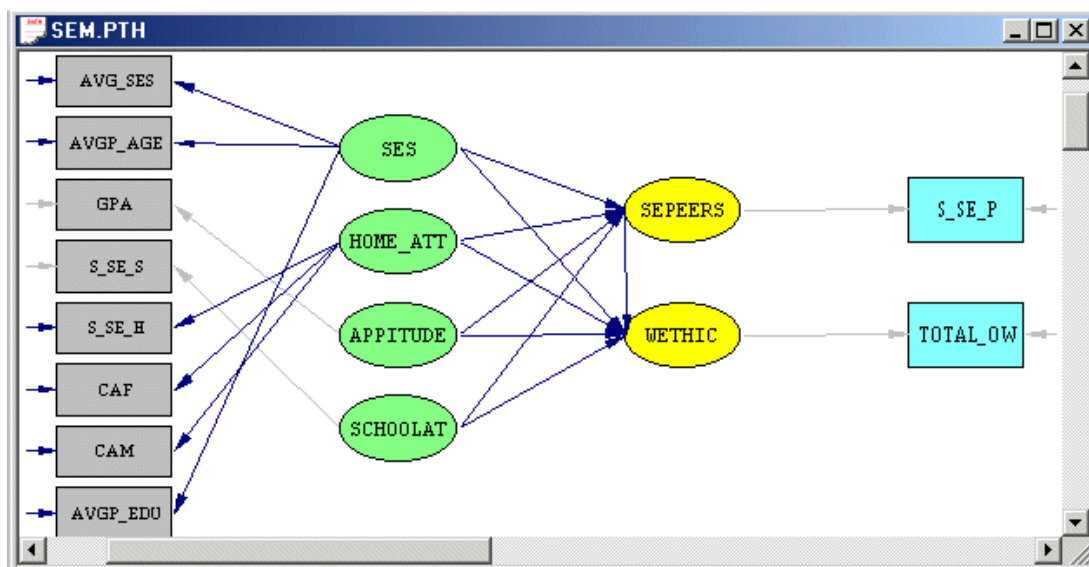
- S_SE_S – Attitude about school score.
- S_SE_P – Self-Esteem around peers score.
- TOTAL_OW – Work Ethics score.

The raw data are listed in the PLISREL System File **STUDENTS.LSF** in the **SIMPLIS Examples** folder. The first couple of lines of this file are shown in the following LSF window.

	AVG_SES	AVGP_AG	GPA	S_SE_S	S_SE_H	S_SE_P	CAF	CAM
1	35.55	40.50	85.00	20.00	25.00	22.00	15.33	14.00
2	34.62	41.50	75.00	26.00	21.00	29.00	12.00	2.00
3	30.13	50.50	85.00	24.00	25.00	23.00	19.33	21.33
4	35.37	37.00	95.00	23.00	26.00	26.00	5.33	0.00
5	22.40	43.50	75.00	20.00	24.00	23.00	24.67	34.00
6	15.96	29.50	85.00	24.00	26.00	25.00	7.33	0.00
7	22.75	49.00	95.00	24.00	25.00	31.00	56.67	4.00
8	37.31	47.00	75.00	24.00	24.50	17.00	7.33	50.00
9	22.70	37.00	85.00	27.00	30.00	24.00	50.00	34.00
10	22.54	42.50	85.00	26.00	27.00	27.00	6.67	4.67
11	23.50	30.50	75.00	24.00	29.00	26.00	50.00	50.00
12	23.28	29.00	85.00	27.00	27.50	22.00	0.00	4.17
13	23.43	35.50	85.00	25.00	21.00	26.00	6.00	6.67
14	30.91	32.50	85.00	25.00	25.00	24.00	36.67	42.00
15	49.20	45.00	85.00	34.00	25.00	32.00	14.67	7.33
16	34.09	40.50	85.00	26.00	26.00	25.00	26.67	38.67
17	32.48	44.00	95.00	26.00	26.00	26.00	4.67	8.00

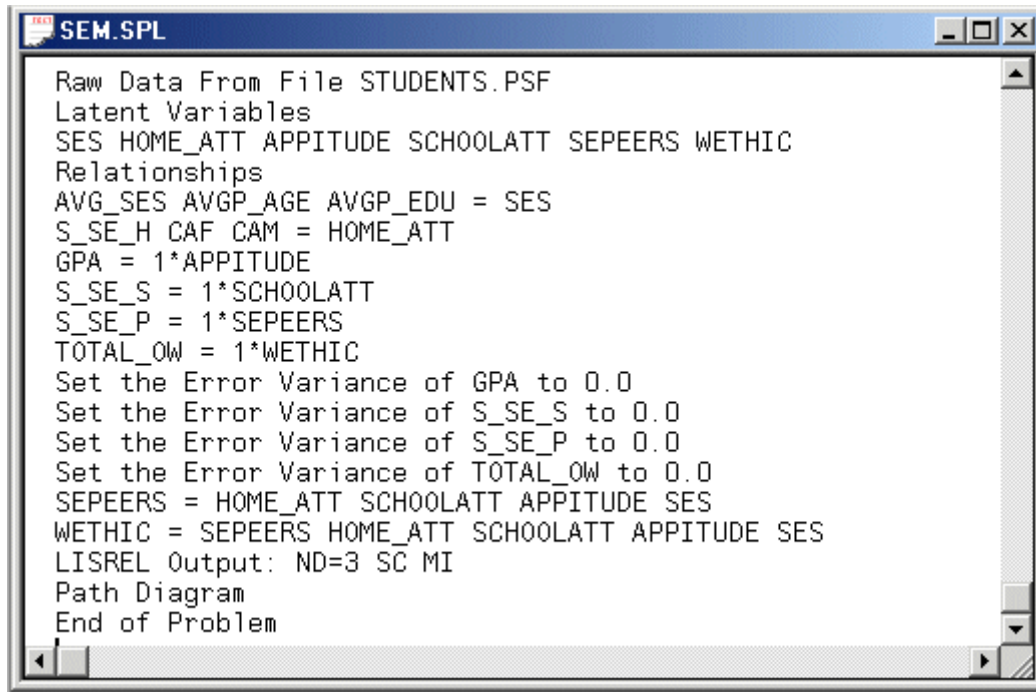
3. The model

We consider a model that suggests that a student’s Socio-Economic Status and Attitudes about Home and School are antecedents of his/her Self-Esteem around Peers and that a student’s Socio-Economic Status, Attitudes about Home and School and Self-Esteem around Peers are antecedents of his/her Work Ethics. A path diagram of the corresponding structural equation model is shown in Figure 1.



4. Fitting the structural model to the data

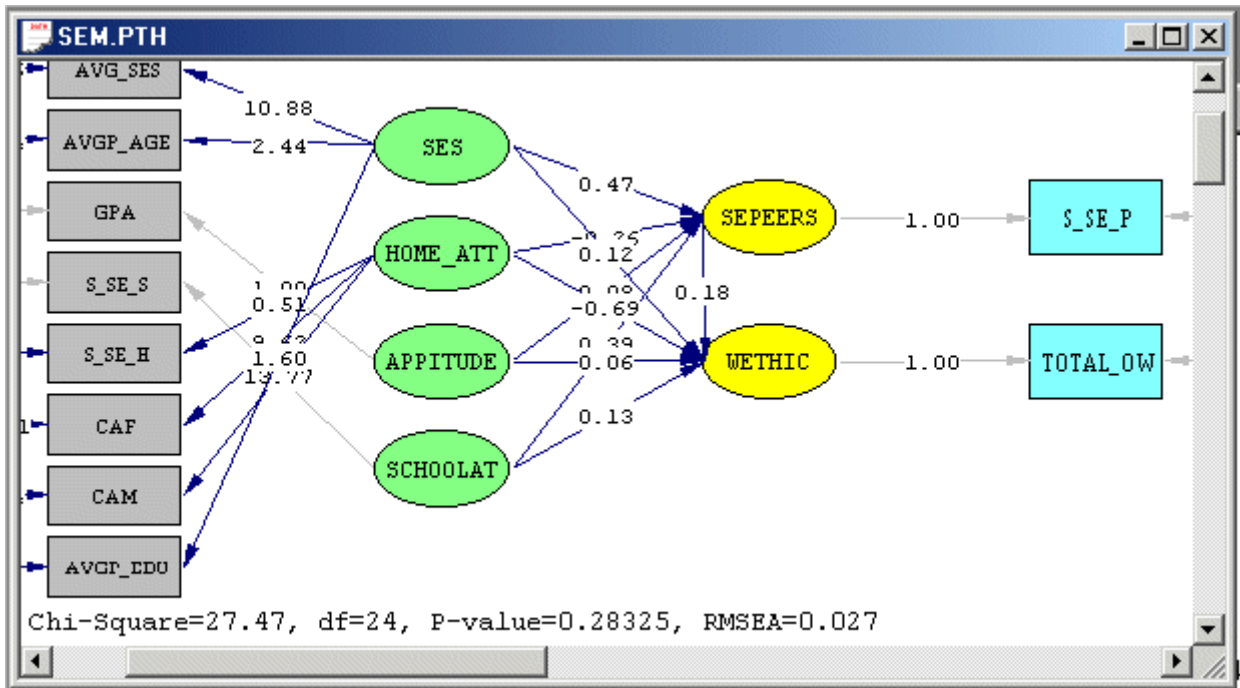
Use the **Open** option on the **File** menu to load the **Open** dialog box. Select the file **SEM.SPL** by clicking on it. Click on the **Open** button to open the following text editor window for **SEM.SPL**.



```
SEM.SPL
Raw Data From File STUDENTS.PSF
Latent Variables
SES HOME_ATT APPITUDE SCHOOLATT SEPEERS WETHIC
Relationships
AVG_SES AVGP_AGE AVGP_EDU = SES
S_SE_H CAF CAM = HOME_ATT
GPA = 1*APPITUDE
S_SE_S = 1*SCHOOLATT
S_SE_P = 1*SEPEERS
TOTAL_OW = 1*WETHIC
Set the Error Variance of GPA to 0.0
Set the Error Variance of S_SE_S to 0.0
Set the Error Variance of S_SE_P to 0.0
Set the Error Variance of TOTAL_OW to 0.0
SEPEERS = HOME_ATT SCHOOLATT APPITUDE SES
WETHIC = SEPEERS HOME_ATT SCHOOLATT APPITUDE SES
LISREL Output: ND=3 SC MI
Path Diagram
End of Problem
```

- Line 1 specifies the source for the raw data.
- Lines 2-3 specify labels for the latent variables of the model. Note that the labels APPITUDE, SCHOOLATT, SEPEERS and WETHIC are used for phantom latent variables that are used to represent the observed variables of the structural model.
- Lines 5-6 specify the measurement model for the latent variables SES and HOME_ATT.
- Lines 7-14 specify the phantom latent variables for GPA, S_SE_S, S_SE_P and TOTAL_OW.
- Lines 15-16 specify the structural model.
- Line 17 requests the results in the terms of the LISREL model for the model in Figure 1.
- Line 18 requests a path diagram (PTH) file.
- Line 19 indicates the end of the SIMPLIS commands to be processed.

Click on the **Run LISREL** icon on the main toolbar to produce the following PTH window.



5. The results

The results are written to the output file, **SEM.OUT**, which consists of several sections. In this section, we will review some selections of this output file. The sample covariance matrix is shown in the following text editor window.

SEM.OUT

Covariance Matrix

	S_SE_P	TOTAL_OW	AVG_SE_S	AVGP_AGE	GPA	S_SE_S
S_SE_P	9.613					
TOTAL_OW	2.897	5.027				
AVG_SE_S	8.340	4.705	132.480			
AVGP_AGE	1.844	1.567	27.102	28.909		
GPA	6.332	5.971	24.044	5.975	48.673	
S_SE_S	2.677	1.573	2.664	0.067	2.155	5.948
S_SE_H	0.180	0.379	2.980	0.554	-0.176	0.798
CAF	-9.747	-10.936	-36.128	-10.853	-31.584	-4.747
CAM	-6.920	-13.259	-4.794	-4.004	-24.378	-4.070
AVGP_EDU	1.174	0.938	17.369	3.448	4.490	0.258

	S_SE_H	CAF	CAM	AVGP_EDU
S_SE_H	5.058			
CAF	5.734	397.145		
CAM	7.932	128.724	276.820	
AVGP_EDU	0.503	-3.931	0.221	4.232

The parameter specifications of the LISREL model in Figure 1 are shown in the following two text editor windows.

LAMBDA-X				
	SES	HOME_ATT	APPITUDE	SCHOOLAT
	-----	-----	-----	-----
AVG_SES	1	0	0	0
AVGP_AGE	2	0	0	0
GPA	0	0	0	0
S_SE_S	0	0	0	0
S_SE_H	0	3	0	0
CAF	0	4	0	0
CAM	0	5	0	0
AVGP_EDU	6	0	0	0

BETA	
SEPEERS	WETHIC
-----	-----
SEPEERS	0
WETHIC	7

GAMMA				
	SES	HOME_ATT	APPITUDE	SCHOOLAT
	-----	-----	-----	-----
SEPEERS	8	9	10	11
WETHIC	12	13	14	15

PHI				
	SES	HOME_ATT	APPITUDE	SCHOOLAT
	-----	-----	-----	-----
SES	0			
HOME_ATT	16	0		
APPITUDE	17	18	19	
SCHOOLAT	20	21	22	23

PSI	
SEPEERS	WETHIC
-----	-----
24	25

THETA-DELTA					
AVG_SES	AVGP_AGE	GPA	S_SE_S	S_SE_H	CAF
-----	-----	-----	-----	-----	-----
26	27	0	0	28	29

CAM	AVGP_EDU
-----	-----
30	31

These parameter specifications indicate that the free parameters of the LISREL model for the model in Figure 1 consists of 6 factor loadings, 10 regression weights, 1 correlation, 2 variances and 5 covariances and 6 measurement error variances.

The estimated factor loadings are displayed below.

SEM.OUT

LAMBDA-X				
	SES	HOME_ATT	APPITUDE	SCHOOLAT
AVG_SES	10.877 (0.816)	--	--	--
AVGP_AGE	13.336 2.442 (0.391)	--	--	--
GPA	6.244	--	1.000	--
S_SE_S	--	--	--	1.000
S_SE_H	--	0.508 (0.191)	--	--
CAF	--	2.660 9.619 (1.847)	--	--
CAM	--	5.209 13.769 (2.014)	--	--
AVGP_EDU	1.597 (0.147)	6.838	--	--
	10.883			

These results above indicate that all the factor loadings are statistically significant at a 1% level of significance. Consequently, the indicators for socio-economical status and attitude towards home seem to achieve an acceptable level of construct validity.

The estimated regression weights are displayed in the following text editor window.

SEM.OUT

BETA				
	SEPEERS	WETHIC		
SEPEERS	--	--		
WETHIC	0.177 (0.049)	--		
	3.631			
GAMMA				
	SES	HOME_ATT	APPITUDE	SCHOOLAT
SEPEERS	0.475 (0.224)	-0.257 (0.250)	0.080 (0.032)	0.391 (0.083)
	2.116	-1.030	2.488	4.728
WETHIC	0.120 (0.152)	-0.692 (0.185)	0.061 (0.023)	0.125 (0.059)
	0.792	-3.734	2.709	2.138

The results above implies that the attitudes towards home and school, GPA score and self-esteem around peers exert a statistically significant influence on work ethics if a significance level of 5% is used. In addition, it shows that attitude towards school, GPA score and socio-economic status exert a statistically significant influence on self-esteem around peers.

The estimated covariance matrix of the exogenous variables of the model in Figure 1 is listed in the following text editor window.

The screenshot shows a text editor window titled 'SEM.OUT' displaying the following covariance matrix:

	SES	HOME_ATT	APPITUDE	SCHOOLAT
SES	1.000			
HOME_ATT	-0.053 (0.089)	1.000		
APPITUDE	2.306 (0.516)	-1.922 (0.608)	48.673 (4.955)	
SCHOOLAT	0.227 (0.184)	-0.280 (0.208)	2.155 (1.235)	5.948 (0.605)
	1.235	-1.343	1.746	9.823

The results above indicate that socio-economic status is significantly correlated with GPA score, but not with attitudes towards home and school. Attitude towards home is significantly correlated with GPA score, but not with attitude towards school. Finally, attitude towards school is not significantly correlated with GPA score.

The next text editor window contains the estimated error variances and squared multiple correlations for the structural equations and the reduced form.

The screenshot shows a text editor window titled 'SEM.OUT' displaying the following information:

PSI
Note: This matrix is diagonal.

SEPEERS	WETHIC
7.557 (0.774)	3.240 (0.361)
9.758	8.980

Squared Multiple Correlations for Structural Equations

SEPEERS	WETHIC
0.214	0.355

Squared Multiple Correlations for Reduced Form

SEPEERS	WETHIC
0.214	0.308

These results indicate that socio-economic status, attitudes towards school and GPA score explains approximately 21 percent of the variation in self-esteem around peers while approximately 31 percent of the variation in work ethics is accounted for by socio-economic status, attitudes towards school and GPA score and self-esteem around peers.

THETA-DELTA

AVG_SES	AVGP_AGE	GPA	S_SE_S	S_SE_H	CAF
14.162	22.945	--	--	4.800	304.613
(11.710)	(2.429)			(0.500)	(39.381)
1.209	9.446			9.600	7.735

CAM	AVGP_EDU
87.236	1.683
(49.382)	(0.304)
1.767	5.531

Squared Multiple Correlations for X - Variables

AVG_SES	AVGP_AGE	GPA	S_SE_S	S_SE_H	CAF
0.893	0.206	1.000	1.000	0.051	0.233

CAM	AVGP_EDU
0.685	0.602

From these results, it is evident that attitude towards home explains a very small amount in the variation of the indicator S_SE_H.

The measure of fit of the model in Figure 1 are listed in the following two text editor windows.

Goodness of Fit Statistics

Degrees of Freedom = 24

Minimum Fit Function Chi-Square = 28.706 (P = 0.231)

Normal Theory Weighted Least Squares Chi-Square = 27.465 (P = 0.283)

Estimated Non-centrality Parameter (NCP) = 3.465

90 Percent Confidence Interval for NCP = (0.0 ; 20.647)

Minimum Fit Function Value = 0.149

Population Discrepancy Function Value (FO) = 0.0180

90 Percent Confidence Interval for FO = (0.0 ; 0.107)

Root Mean Square Error of Approximation (RMSEA) = 0.0274

90 Percent Confidence Interval for RMSEA = (0.0 ; 0.0668)

P-Value for Test of Close Fit (RMSEA < 0.05) = 0.793

Expected Cross-Validation Index (ECVI) = 0.464

90 Percent Confidence Interval for ECVI = (0.446 ; 0.553)

ECVI for Saturated Model = 0.570

ECVI for Independence Model = 2.635


```

SEM.OUT
Chi-Square for Independence Model with 45 Degrees of Freedom = 488.541
  Independence AIC = 508.541
    Model AIC = 89.465
    Saturated AIC = 110.000
  Independence CAIC = 551.220
    Model CAIC = 221.769
    Saturated CAIC = 344.732
  Normed Fit Index (NFI) = 0.941
  Non-Normed Fit Index (NNFI) = 0.980
  Parsimony Normed Fit Index (PNFI) = 0.502
  Comparative Fit Index (CFI) = 0.989
  Incremental Fit Index (IFI) = 0.990
  Relative Fit Index (RFI) = 0.890
  Critical N (CN) = 289.965
  Root Mean Square Residual (RMR) = 4.849
  Standardized RMR = 0.0542
  Goodness of Fit Index (GFI) = 0.972
  Adjusted Goodness of Fit Index (AGFI) = 0.937

```

These measures of fit indicate that the model seems to fit the data. The modification indices are displayed in the following three text editor windows.

```

SEM.OUT
Modification Indices for LAMBDA-X

```

	SES	HOME_ATT	APPITUDE	SCHOOLAT
AVG_SES	- -	0.012	2.828	0.519
AVGP_AGE	- -	0.401	0.024	0.348
GPA	- -	- -	- -	- -
S_SE_S	- -	- -	- -	- -
S_SE_H	3.612	- -	0.620	6.240
CAF	5.089	- -	3.625	0.540
CAM	1.732	- -	2.092	0.133
AVGP_EDU	- -	0.159	2.773	0.253

```

SEM.OUT
Modification Indices for THETA-DELTA-EPS

```

	S_SE_P	TOTAL_OW
AVG_SES	0.321	2.094
AVGP_AGE	0.002	0.353
GPA	- -	- -
S_SE_S	- -	- -
S_SE_H	0.613	4.737
CAF	0.225	0.045
CAM	0.587	1.994

SEM.OUT

Modification Indices for THETA-DELTA

	AVG_SES	AVGP_AGE	GPA	S_SE_S	S_SE_H	CAF
AVG_SES	--					
AVGP_AGE	2.776	--				
GPA	1.886	0.008	--			
S_SE_S	0.860	0.544	--	--		
S_SE_H	0.467	0.001	0.147	3.743	--	
CAF	1.872	0.088	0.868	0.097	0.125	--
CAM	0.077	0.051	1.082	0.260	2.692	--
AVGP_EDU	0.014	2.859	2.203	0.438	0.180	0.181

From the results above, it is evident that none of the modification indices suggests further refining of the structural equation model.

The completely standardized estimates are shown in the next two text editor windows.

SEM.OUT

Completely Standardized Solution

LAMBDA-X				
	SES	HOME_ATT	APPITUDE	SCHOOLAT
AVG_SES	0.945	--	--	--
AVGP_AGE	0.454	--	--	--
GPA	--	--	1.000	--
S_SE_S	--	--	--	1.000
S_SE_H	--	0.226	--	--
CAF	--	0.483	--	--
CAM	--	0.828	--	--
AVGP_EDU	0.776	--	--	--

BETA	
SEPEERS	WETHIC
SEPEERS	--
WETHIC	0.245

GAMMA				
	SES	HOME_ATT	APPITUDE	SCHOOLAT
SEPEERS	0.153	-0.083	0.180	0.307
WETHIC	0.054	-0.309	0.190	0.136

Correlation Matrix of ETA and KSI						
	SEPEERS	WETHIC	SES	HOME_ATT	APPITUDE	SCHOOLAT
SEPEERS	1.000					
WETHIC	0.417	1.000				
SES	0.246	0.206	1.000			
HOME_ATT	-0.176	-0.423	-0.053	1.000		
APPITUDE	0.293	0.382	0.331	-0.275	1.000	
SCHOOLAT	0.354	0.288	0.093	-0.115	0.127	1.000

PSI	
SEPEERS	WETHIC
0.786	0.645

THETA-DELTA						
AVG_SES	AVGP_AGE	GPA	S_SE_S	S_SE_H	CAF	
0.107	0.794	- -	- -	0.949	0.767	

CAM	AVGP_EDU
0.315	0.398

These results above indicate that the solution is admissible since none of the completely standardized estimates exceeds unity in absolute value.