

FITTING STRUCTURAL EQUATION MODELS TO COMPLETE CONTINUOUS DATA

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 8.7 for Windows (Jöreskog & Sörbom 2004) 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 and RML methods of LISREL 8.7 for Windows are 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 RML method is then used in section 5 to fit the model to the data.

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.

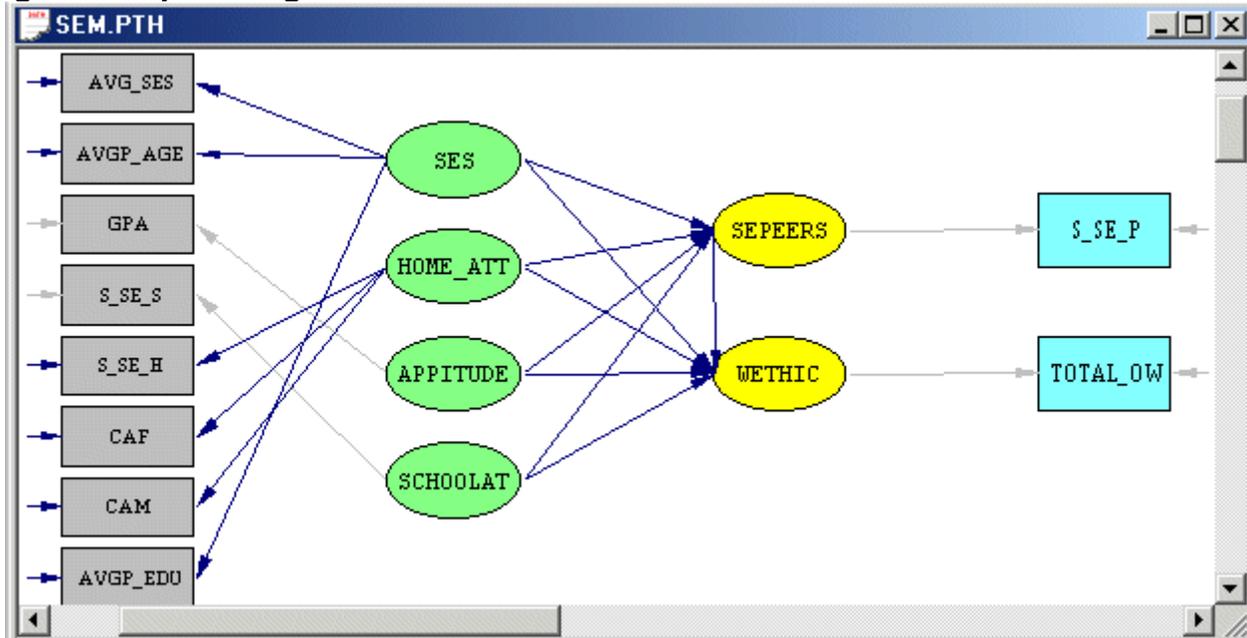
The raw data are listed in the PRELIS System File (PSF) **STUDENTS.PSF** in the **WORKSHOP** subfolder of the LISREL 8.7 for Windows installation folder. The first couple of lines of this file are shown in the following PSF window.

	AVG_SES	AVGP_AGE	GPA	S_SE_S	S_SE_H	S_SE_P	CAF
1	35.550	40.500	85.000	20.000	25.000	22.000	15.
2	34.620	41.500	75.000	26.000	21.000	29.000	12.
3	30.125	50.500	85.000	24.000	25.000	23.000	19.
4	35.370	37.000	95.000	23.000	26.000	26.000	5.
5	22.400	43.500	75.000	20.000	24.000	23.000	24.
6	15.960	29.500	85.000	24.000	26.000	25.000	7.
7	22.745	49.000	95.000	24.000	25.000	31.000	56.
8	37.315	47.000	75.000	24.000	24.500	17.000	7.
9	22.695	37.000	85.000	27.000	30.000	24.000	50.
10	22.540	42.500	85.000	26.000	27.000	27.000	6.
11	23.500	30.500	75.000	24.000	29.000	26.000	50.
12	23.280	29.000	85.000	27.000	27.500	22.000	0.
13	23.430	35.500	85.000	25.000	21.000	26.000	6.
14	30.915	32.500	85.000	25.000	25.000	24.000	36.
15	49.200	45.000	85.000	34.000	25.000	32.000	14.

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.

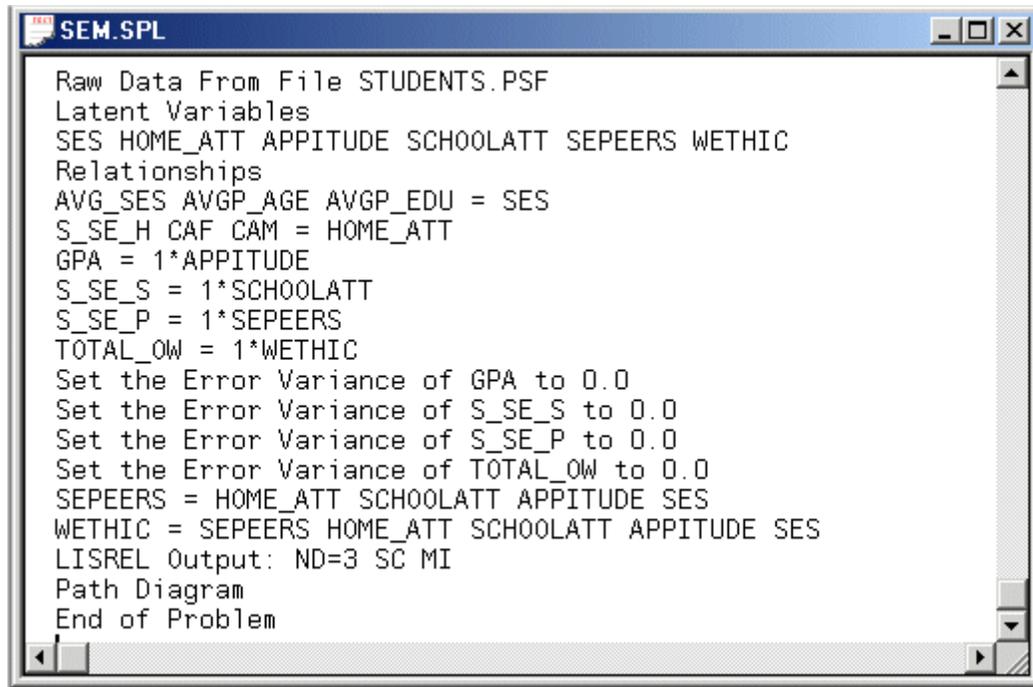
Figure 1: A path diagram for a model for Work Ethics of Freshmen



4. The ML Method

- Use the **Open** option on the **File** menu to load the **Open** dialog box.
- Browse for the **WORKSHOP** folder of the LISREL 8.7 for Windows installation folder.
- Select the file **SEM.SPL**.

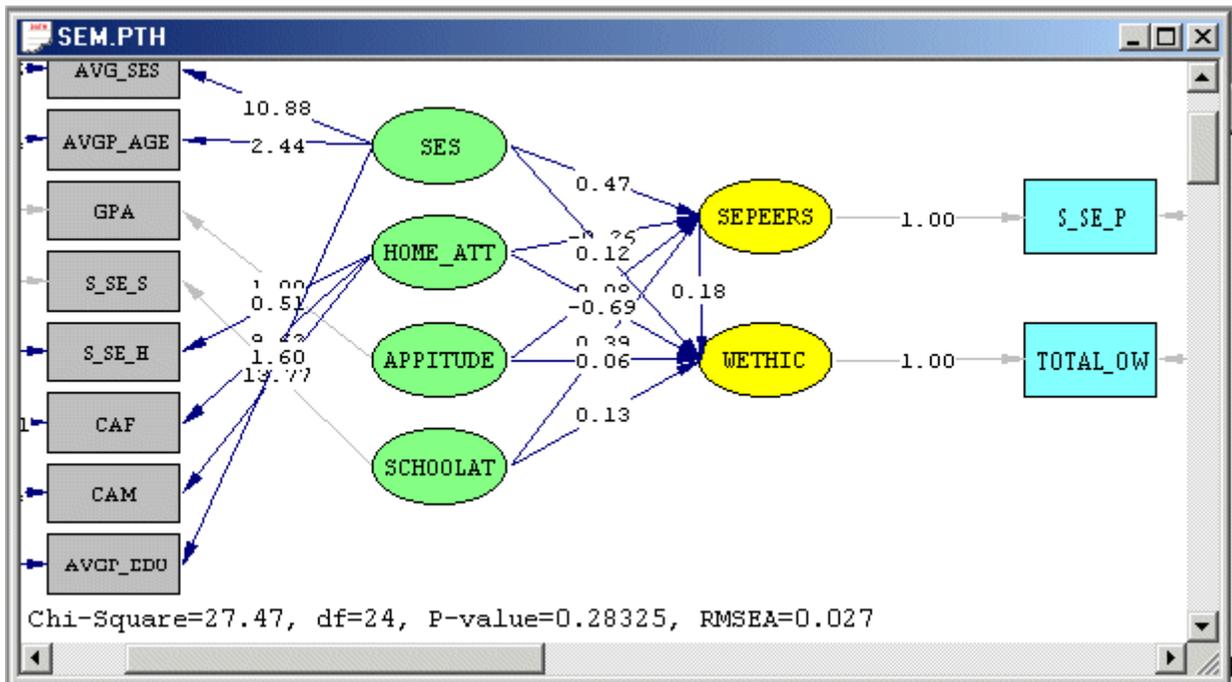
- Click on the **Open** push button to open the following text editor window for **SEM.SPL**.



```
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 RML Method

Generating the Data System File (DSF)

- Select the **Close all** option on the **Windows** menu to close all open windows.
- Use the **Open** option on the **File** menu to load the **Open** dialog box.
- Browse for the **WORKSHOP** folder of the LISREL 8.7 for Windows installation folder.
- Select the **PRELIS Data (*.psf)** option from the **Files of type** dropdown list box.
- Select the file **STUDENTS.PSF**.
- Click on the **Open** push button to open the PSF window for **STUDENTS.PSF**.
- Select the **Output Options** option on the **Statistics** menu to load the **Output** dialog box.
- Check the **Save to File** checkbox in the **Asymptotic Covariance Matrix** section.
- Enter the name **STUDENTS.ACM** in the string field in the **Asymptotic Covariance Matrix** section.
- Click on the **OK** push button to run PRELIS27.EXE to generate the text editor window containing the output file **STUDENTS.OUT**.

The RML Method

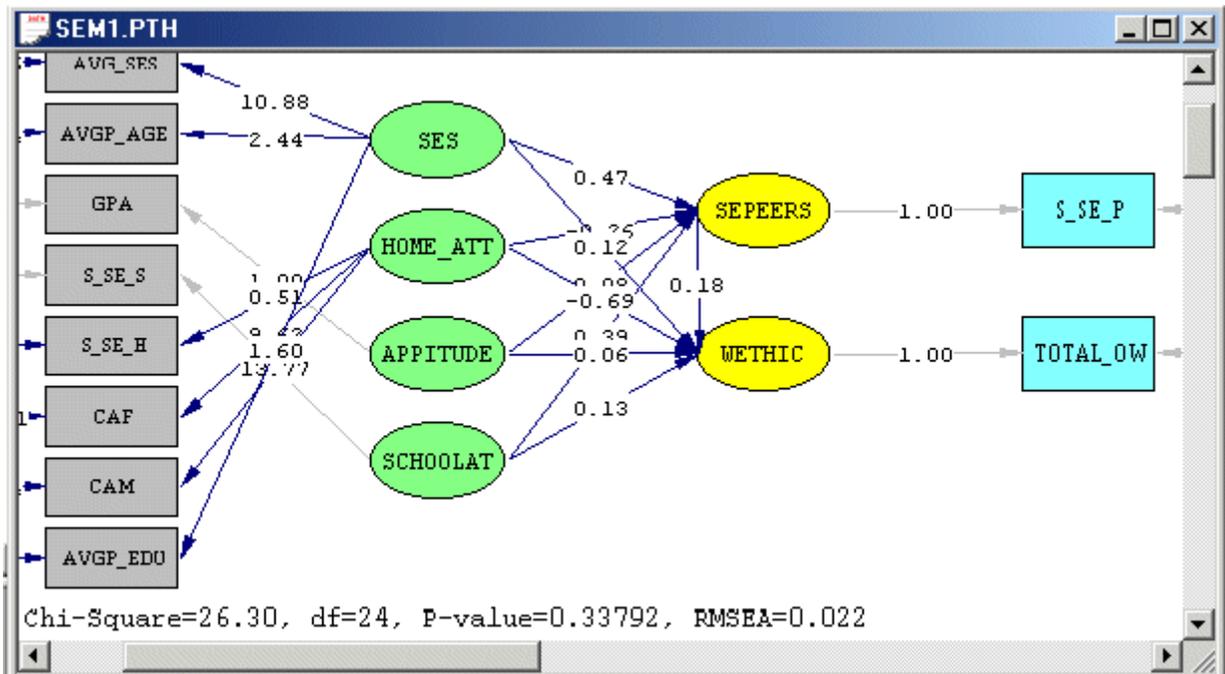
- Select the **Close all** option on the **Windows** menu to close all open windows.
- Use the **Open** option on the **File** menu to load the **Open** dialog box.
- Browse for the **WORKSHOP** folder of the LISREL 8.7 for Windows installation folder.
- Select the file **SEM.SPL**.
- Click on the **Open** push button to open the text editor window for **SEM.SPL**.
- Replace the first line **Raw Data From File STUDENTS.PSF** by **System File From File STUDENTS.DSF**.
- Use the **Save As** option on the **File** menu of the text editor window to load the **Save As** dialog box.
- Enter the name **SEM1.SPL** in the **File name** string field.
- Click on the **Save** push button to produce the following text editor window for **SEM1.SPL**.

```

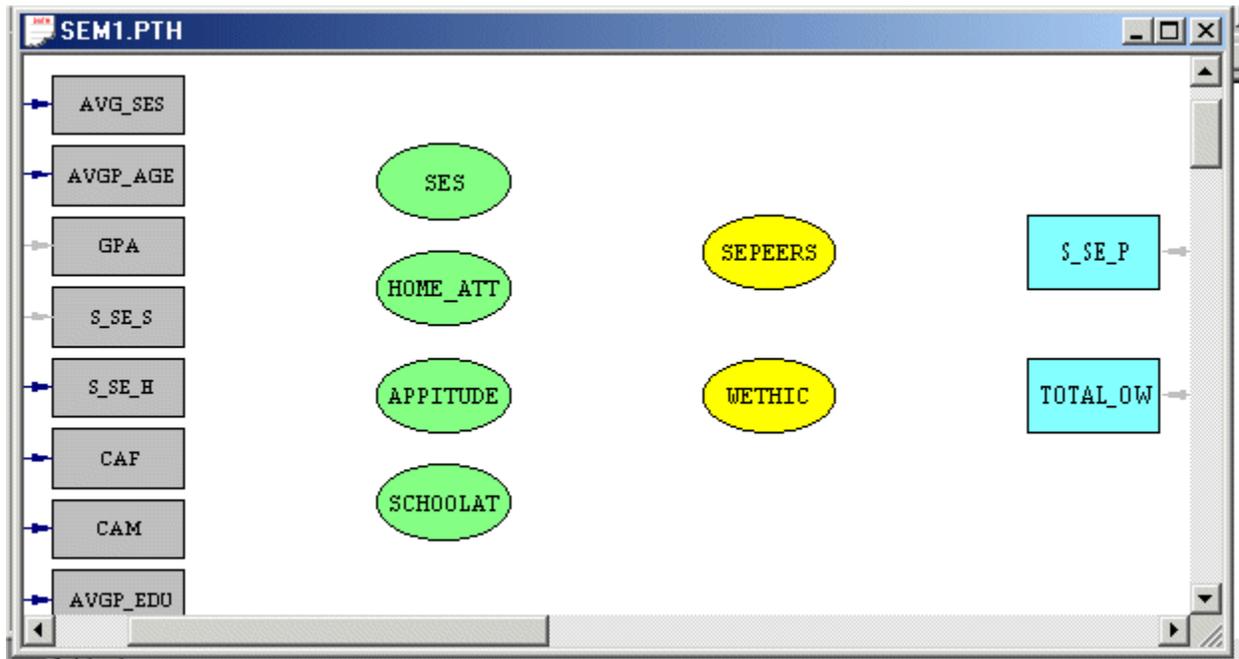
SEM1.SPL
System File From File STUDENTS.DSF
Latent Variables
SES HOME_ATT APPITUDE SCHOOLATT SEPEERS WETHIC
Relationships
AVG_SES AVGP_AGE AVGP_EDU = SES
S_SE_H CAF CAM = HOME_ATT
GPA = 1*APPITUDE
S_SE_S = 1*SCHOOLATT
S_SE_P = 1*SEPEERS
TOTAL_OW = 1*WETHIC
Set the Error Variance of GPA to 0.0
Set the 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

```

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



- Select the **Modification Indices** option from the **Estimates** dropdown list box to open the following PTH window.



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

References

- Du Toit, M. & Du Toit, S.H.C. (2001).
Interactive LISREL: User's Guide.
 Lincolnwood, IL: Scientific Software International, Inc.
- Jöreskog, K.G. & Sörbom, D. (1999).
LISREL 8: User's Reference Guide.
 Lincolnwood, IL: Scientific Software International, Inc.
- Jöreskog, K.G. & Sörbom, D. (2004).
LISREL 8.7 for Windows [Computer Software].
 Lincolnwood, IL: Scientific Software International, Inc.