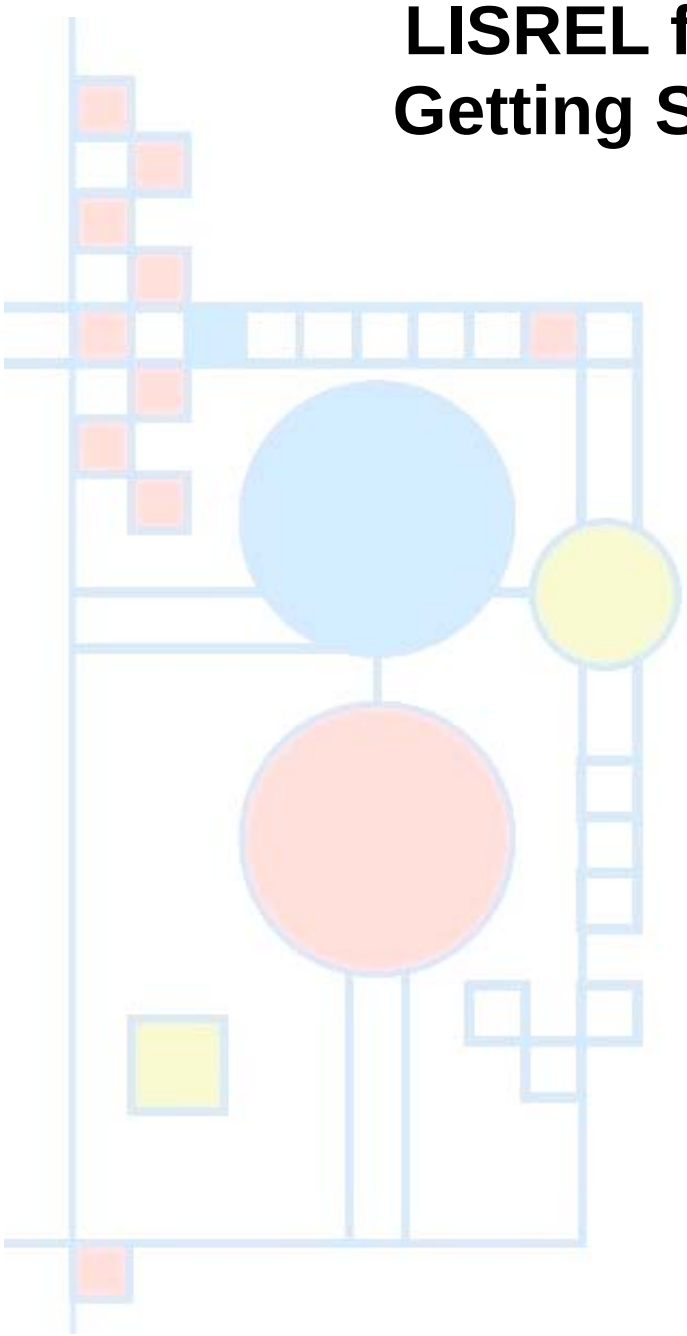

LISREL for Windows: Getting Started Guide

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SSI SCIENTIFIC SOFTWARE INTERNATIONAL

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LISREL® for Windows: Getting Started Guide

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Contents

1. Introduction

LISREL for Windows (Jöreskog & Sörbom 2006) is a Windows application for Structural Equation Modeling, Multilevel Structural Equation Modeling, Multilevel Linear and Nonlinear Modeling, Formal Inference-based Recursive Modeling, and Generalized Linear Modeling. This application consists of a 32-bit Windows application LISWIN32 that interfaces with the 32-bit applications LISREL, PRELIS, MULTILEV, CATFIRM, CONFIRM, SURVEYGLIM, and MAPGLIM.

PRELIS is a 32-bit application for manipulating data, transforming data, generating data, computing moment matrices, computing asymptotic covariance matrices, performing regression analyses, performing exploratory factor analyses of ordinal and continuous variables, etc.

The 32-bit application LISREL is intended for Standard and Multilevel Structural Equation Modeling. The Full Information Maximum Likelihood (FIML) method for missing data is also available for both Standard and Multilevel Structural Equation Modeling.

MULTILEV fits multilevel linear and nonlinear models to raw data while CATFIRM and CONFIRM allow Formal Inference-based Recursive Modeling for raw categorical and continuous data respectively. SURVEYGLIM fits Generalized LInear Models (GLIMs) to data from simple random and complex survey designs while MAPGLIM fits GLIMs to multilevel data.

LISREL for Windows imports external data in formats such as SPSS, SAS, STATA, Statistica, Microsoft Excel, SYSTAT, BMDP, etc. as a PRELIS System File (PSF).

This document is intended as a tutorial to familiarize new users of LISREL for Windows with the features of the application. Section 2 describes the various files used and generated by LISREL for Windows. A step-by-step procedure to fit a measurement model to an SPSS data set with LISREL for Windows is described in Section 3. A procedure to fit a structural equation model with latent variables is outlined in Section 4. The Robust Maximum Likelihood (RML) and Weighted Least Squares (WLS) methods of LISREL for Windows are illustrated in Sections 5 and 6 respectively. A Multilevel Confirmatory Factor Analysis model is fitted to a longitudinal data set in Section 7. Section 8 illustrates how LISREL for Windows can be used to compute latent variable scores and observational residuals. In addition, the exporting of the latent variable scores and the observational residuals as an SPSS data file is illustrated. An illustrative example of using latent variable scores is provided in section 9. Section 10 illustrates the use of the multiple group analysis feature of LISREL for Windows to assess the cross validation of a measurement model for retail experience. A logistic regression analysis of the public's perception of their influence on government is demonstrated in the section 11. Sections 12 and 13 illustrate a censored regression analysis and a latent growth curve analysis respectively. In Section 14, a Bernoulli-Probit model is fitted to a complex survey data set.

2. Files

LISREL for Windows uses a PRELIS System File (PSF) to store raw data.

A structural equation model can be specified by means of a path diagram, a SIMPLIS project file, a LISREL project file, a SIMPLIS syntax file or a LISREL syntax file. LISREL for Windows uses a graphics file with the default extension PTH to capture a path diagram. The extensions SPJ and LPJ are used for SIMPLIS and LISREL project files respectively. SIMPLIS and LISREL syntax files are text files with the default extensions SPL and LS8 respectively. These five file types can access the data from the PSF. If a user has prepared any of these files, then LISREL for Windows can be used to fit the specified model to the data specified in the corresponding PSF.

Path diagram, SIMPLIS project and LISREL project files are described in Du Toit & Du Toit (2001). SIMPLIS syntax files are described in Jöreskog & Sörbom (1999c) and in http://www.ssicentral.com/lisrel/techdocs/SIMPLISSyntax.pdf#pagemode=bookmarks while the LISREL syntax files are outlined in Jöreskog & Sörbom (1999b) and in http://www.ssicentral.com/lisrel/techdocs/LISRELSyntax.pdf#pagemode=bookmarks.

Whenever PRELIS processes a PSF interactively, a PRELIS syntax file with the same file name as the PSF is created. A PRELIS syntax file is a text file with default extension PR2. PRELIS syntax files are described in Jöreskog & Sörbom (1999a) and in http://www.ssicentral.com/lisrel/techdocs/IPUG.pdf.

MULTILEV, SURVEYGLIM, MAPGLIM, CATFIRM, and CONFIRM syntax files are also text files with default extension PR2. MULTILEV syntax files are described in Jöreskog et al. (2001) and in http://www.ssicentral.com/lisrel/techdocs/MLUG.pdf while CATFIRM and CONFIRM syntax files are described in Du Toit & Du Toit (2001).

SURVEYGLIM and MAPGLIM syntax files are described in http://www.ssicentral.com/lisrel/techdocs/SGUG.pdf#pagemode=bookmarks and in the LISREL for Windows help file respectively.

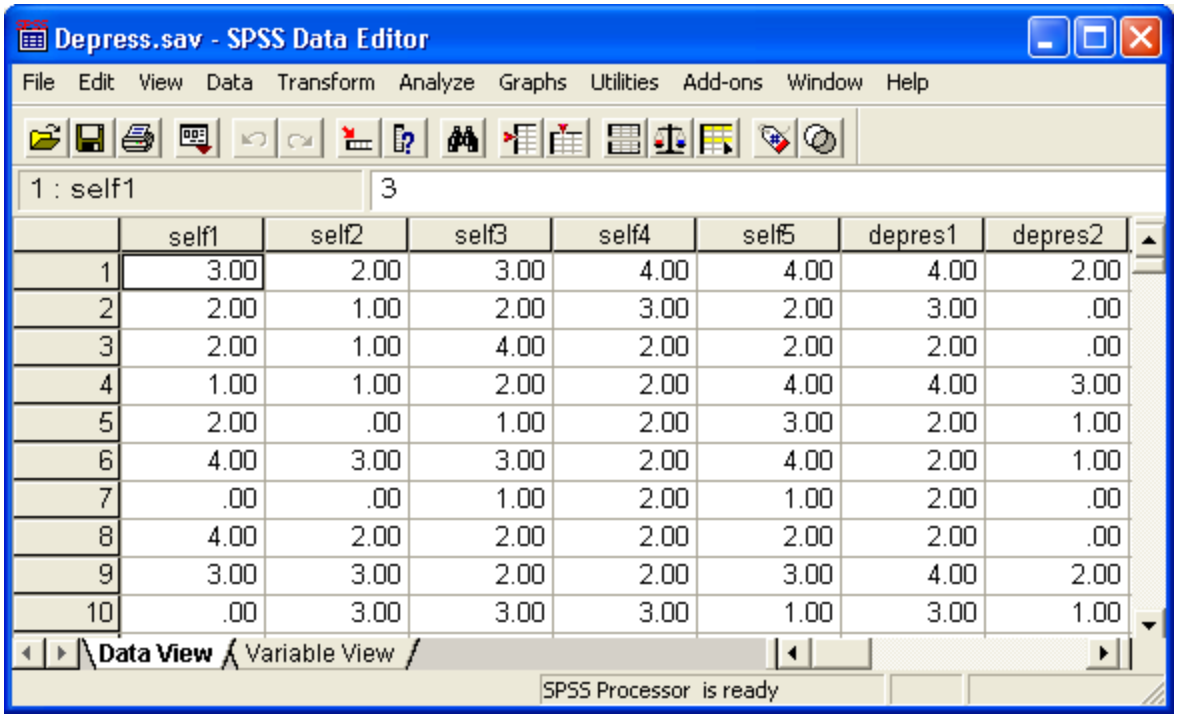
LISREL for Windows starts up by opening a main window with three menus. The ***File*** menu can then be used to open existing or new PSFs and PTH files in ***PSF*** and ***PTH*** windows respectively. It can also be used to open new or existing LISREL and SIMPLIS project files in LISREL and SIMPLIS project (LPJ and SPJ) windows. Text editor windows are used to display new or existing syntax files and output files. PTH, PSF, LPJ, SPJ, and text editor windows have window-specific menus.

3. Fitting a measurement model to SPSS data

LISREL for Windows can be used to fit measurement models to data. In this section, we illustrate this feature by fitting a measurement model to an SPSS data set using a path diagram and a SIMPLIS syntax file.

The data

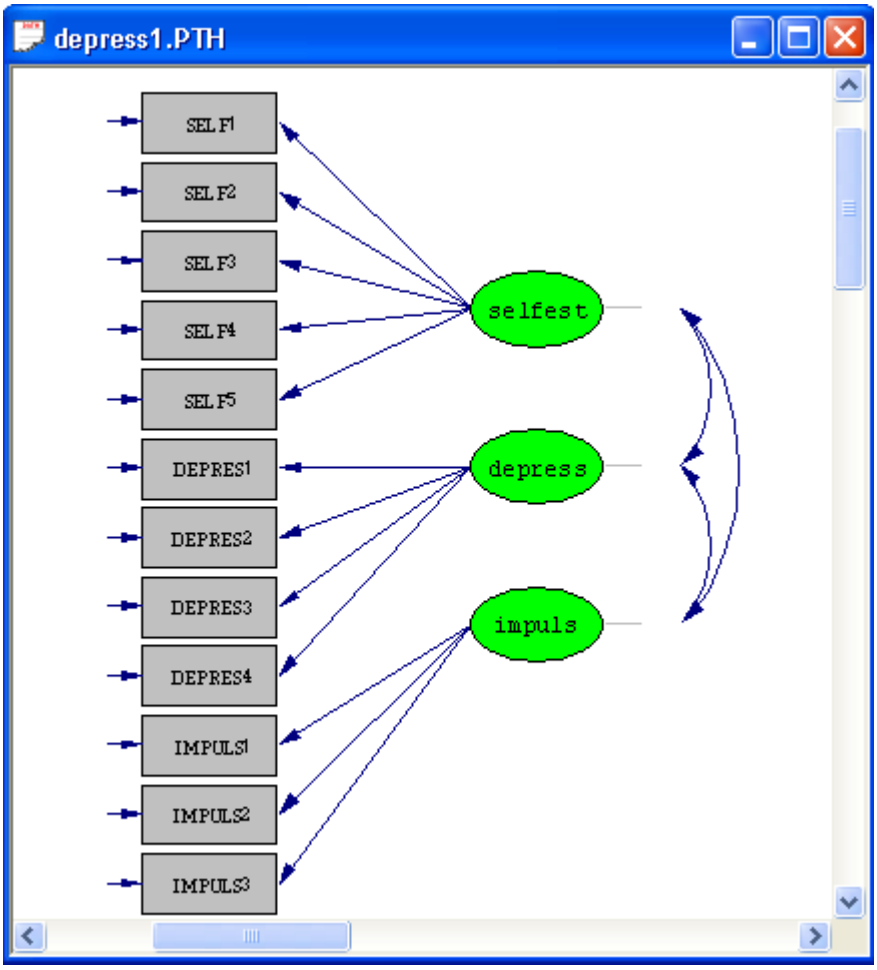
The SPSS for Windows data file ***Depress.sav*** in the ***TUTORIAL*** subfolder contains 204 observations of 12 indicators of three latent variables. More specifically, the first 5 indicators (SELF1 to SELF5) are indicators of the latent variable *Self-esteem*, DEPRES1 to DEPRES4 are indicators of the latent variable *Depressiveness* and IMPULS1 to IMPULS3 are indicators of the latent variable *Impulsiveness*. The first portion of the SPSS data file is shown in the following SPSS data editor window.



	self1	self2	self3	self4	self5	depres1	depres2
1	3.00	2.00	3.00	4.00	4.00	4.00	2.00
2	2.00	1.00	2.00	3.00	2.00	3.00	.00
3	2.00	1.00	4.00	2.00	2.00	2.00	.00
4	1.00	1.00	2.00	2.00	4.00	4.00	3.00
5	2.00	.00	1.00	2.00	3.00	2.00	1.00
6	4.00	3.00	3.00	2.00	4.00	2.00	1.00
7	.00	.00	1.00	2.00	1.00	2.00	.00
8	4.00	2.00	2.00	2.00	2.00	2.00	.00
9	3.00	3.00	2.00	2.00	3.00	4.00	2.00
10	.00	3.00	3.00	3.00	1.00	3.00	1.00

The model

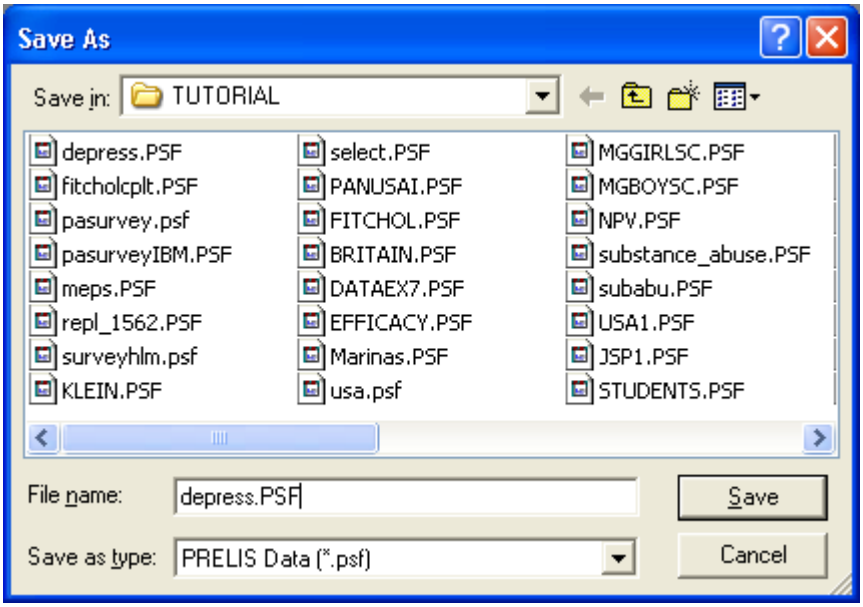
The theoretical measurement model is a CFA model that specifies that the 12 indicators are indeed indicators of the latent variables *Self-esteem*, *Depressiveness*, and *Impulsiveness*. A path diagram of this model is shown below.



Fitting the model to the data

Using a path diagram

- Use the ***Import Data*** option from the ***File*** menu of the main window of LISREL for Windows to load the ***Open*** dialog box.
- Select the ***SPSS data file (*.sav)*** option from the ***Files of type*** drop-down list box.
- Browse for the file ***Depress.sav*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to load the ***Save As*** dialog box.
- Enter the name ***depress.PSF*** in the ***File name*** string field to produce the following dialog box.

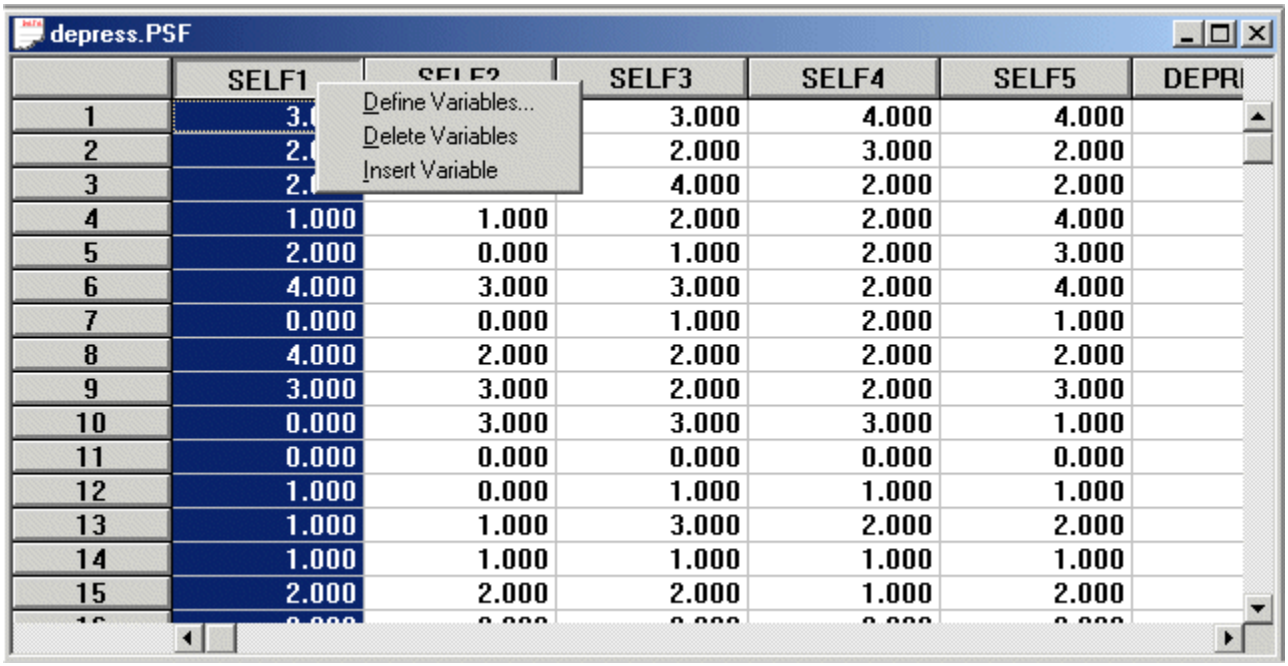


➢ Click on the ***Save*** button to open the following ***PSF*** window.

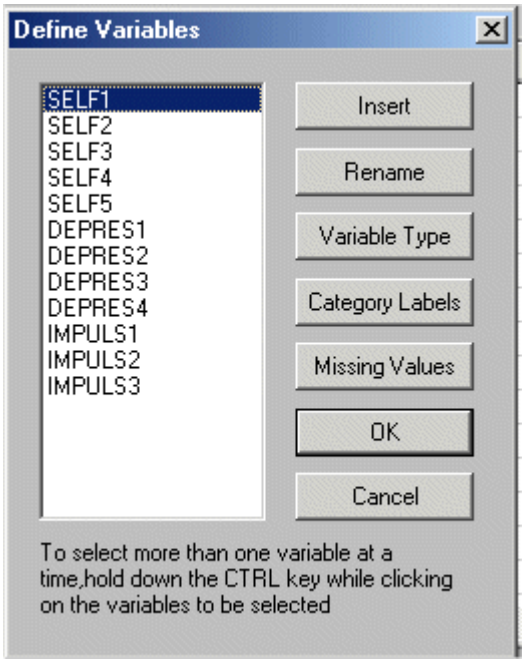
depress.PSF

	SELF1	SELF2	SELF3	SELF4	SELF5	DEPR
1	3.000	2.000	3.000	4.000	4.000	
2	2.000	1.000	2.000	3.000	2.000	
3	2.000	1.000	4.000	2.000	2.000	
4	1.000	1.000	2.000	2.000	4.000	
5	2.000	0.000	1.000	2.000	3.000	
6	4.000	3.000	3.000	2.000	4.000	
7	0.000	0.000	1.000	2.000	1.000	
8	4.000	2.000	2.000	2.000	2.000	
9	3.000	3.000	2.000	2.000	3.000	
10	0.000	3.000	3.000	3.000	1.000	
11	0.000	0.000	0.000	0.000	0.000	
12	1.000	0.000	1.000	1.000	1.000	
13	1.000	1.000	3.000	2.000	2.000	
14	1.000	1.000	1.000	1.000	1.000	
15	2.000	2.000	2.000	1.000	2.000	

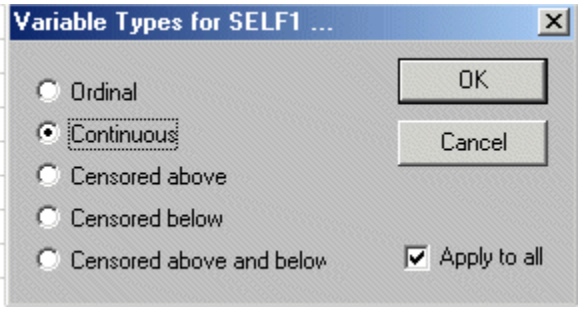
➢ Click on the variable label ***SELF1*** to highlight the entire column.
➢ Right-click to open the variable menu as shown in the following ***PSF*** window.



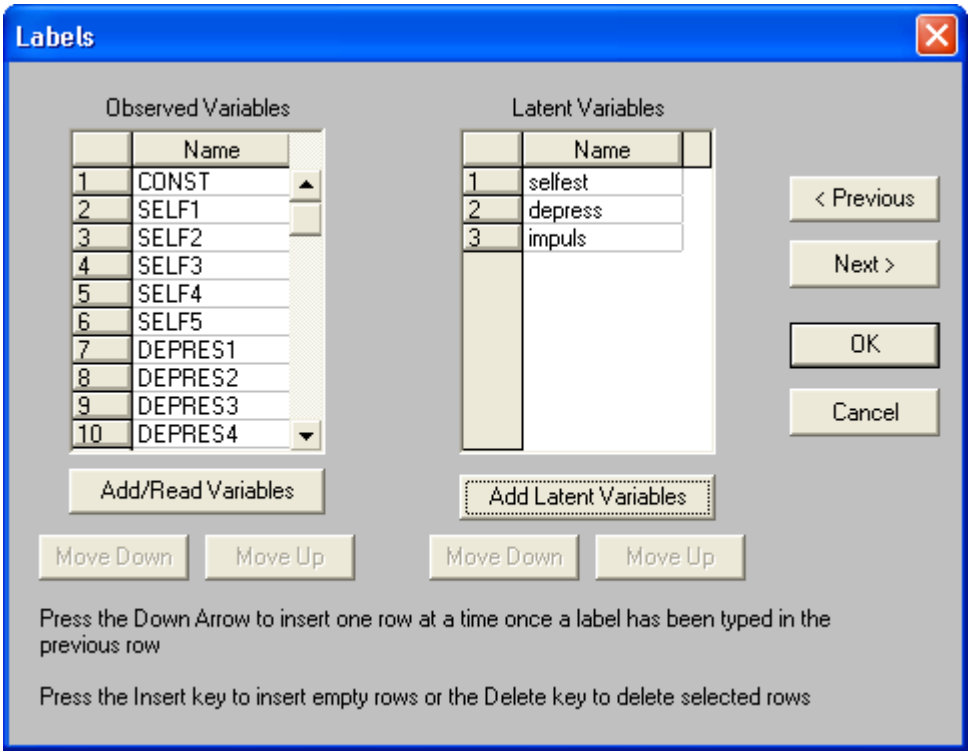
- Select the ***Define Variables*** option to load the ***Define Variables*** dialog box.
- Select the label ***SELF1*** to produce the following ***Define Variables*** dialog box.



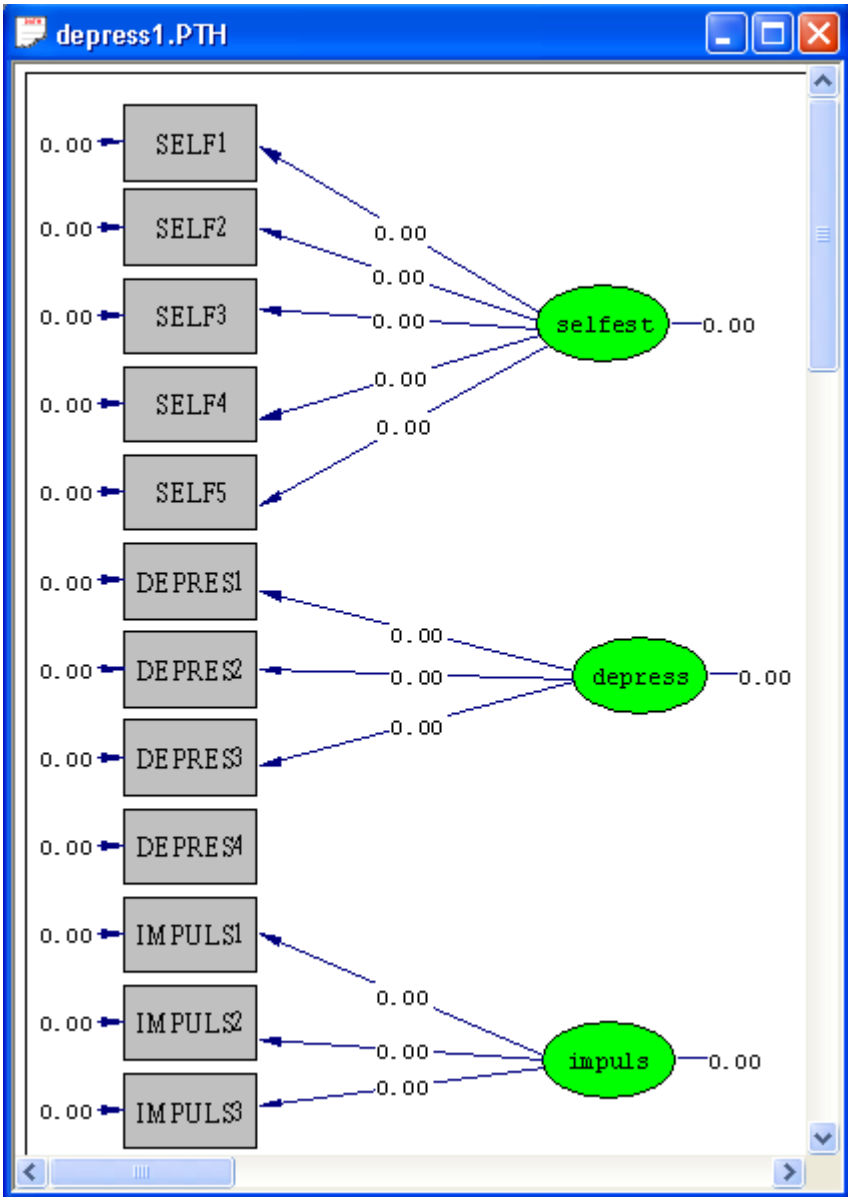
- Click on the ***Variable Type*** button to load the ***Variable Types for SELF1…*** dialog box.
- Select the ***Continuous*** radio button.
- Check the ***Apply to all*** checkbox to produce the ***Variable Types for SELF1…*** dialog box below.



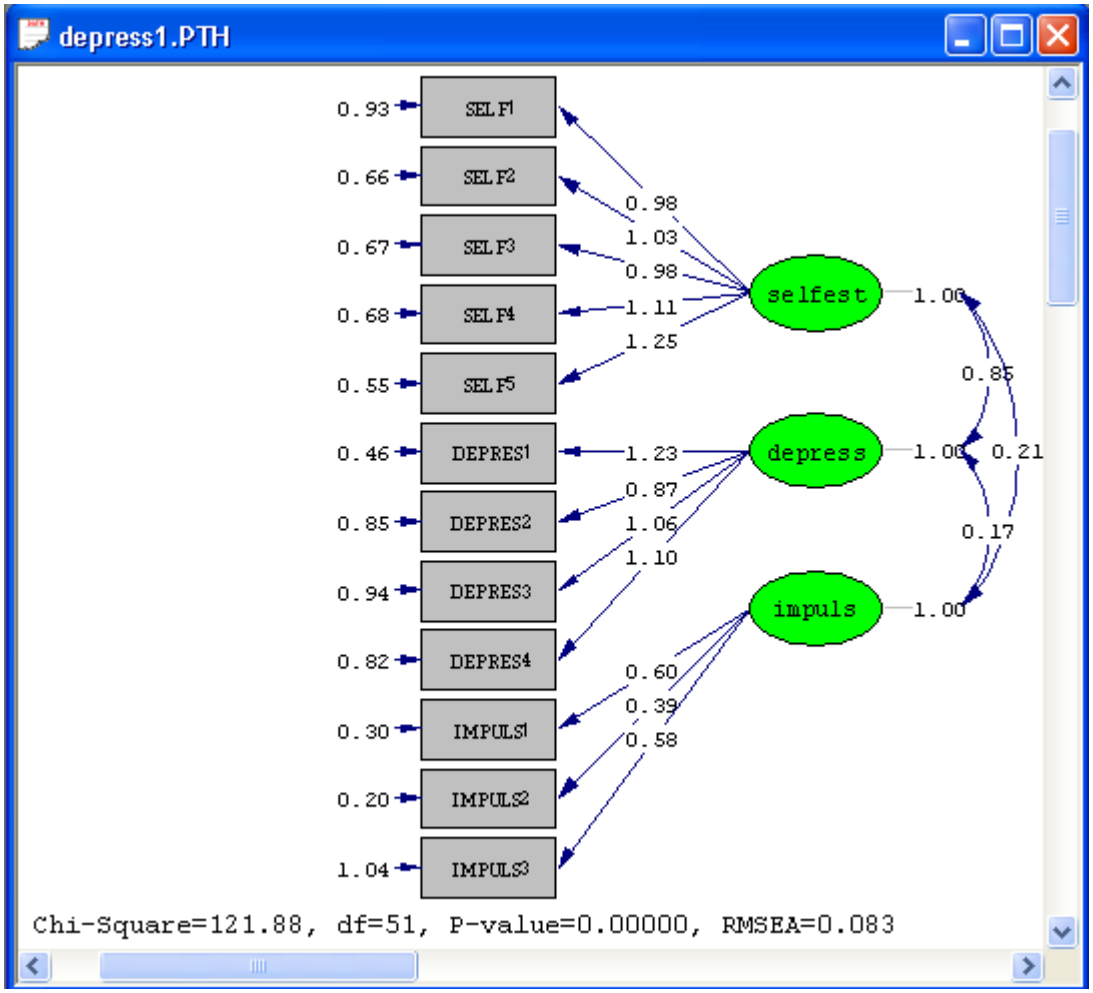
- Click on the ***OK*** button to reload the ***Variable Types*** dialog box.
- Click on the ***OK*** button to return to the ***PSF*** window.
- Save your changes to the PSF by using the ***Save*** option on the ***File*** menu.
- Select the ***New*** option on the ***File*** menu to load the ***New*** dialog box.
- Select the ***Path Diagram*** option in the ***New*** list box.
- Click on the ***OK*** button to load the ***Save As*** dialog box.
- Enter the name ***depress1.PTH*** in the ***File name*** string field.
- Click on the ***Save*** button to open the empty ***PTH*** window for ***depress1.PTH***.
- Select the ***Variables*** option on the ***Setup*** menu to load the ***Labels*** dialog box.
- Click on the ***Add/Read Variables*** button to load the ***Add/Read Variables*** dialog box.
- Select the ***PRELIS System File*** option from the drop-down list box.
- Click on the ***Browse*** button to load the ***Browse*** dialog box.
- Browse for the file ***depress.PSF*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to return to the ***Add/Read Variables*** dialog box.
- Click on the ***OK*** button to return to the ***Labels*** dialog box.
- Click on the ***Add Latent Variables*** button to load the ***Add Variables*** dialog box.
- Enter the label ***selfest*** in the string field.
- Click on the ***OK*** button to return to the ***Labels*** dialog box.
- Click on the ***Add Latent Variables*** button to load the ***Add Variables*** dialog box.
- Enter the label ***depress*** in the string field.
- Click on the ***OK*** button to return to the ***Labels*** dialog box.
- Click on the ***Add Latent Variables*** button to load the ***Add Variables*** dialog box.
- Enter the label ***impuls*** in the string field.
- Click on the ***OK*** button to produce the following ***Labels*** dialog box.



- Click on the ***OK*** button to return to the ***PTH*** window for ***depress1.PTH***.
- Click, drag and drop the observed variable labels one at a time into the empty ***PTH*** window.
- Click, drag and drop the latent variable labels one at a time into the empty ***PTH*** window.
- Click on the ***Arrow*** button on the drawing toolbar.
- Click and drag 5 paths from ***selfest*** to ***SELF1***, ***SELF2***, ***SELF3***, ***SELF4***, and ***SELF5***.
- Click and drag 4 paths from ***depress*** to ***DEPRES1***, ***DEPRES2***, ***DEPRES3***, and ***DEPRES4***.
- Click and drag 3 paths from ***impuls*** to ***IMPULS1***, ***IMPULS2***, and ***IMPULS3*** to produce the following ***PTH*** window.



- Click on the ***Build SIMPLIS Syntax*** option on the ***Setup*** menu to open the ***SPJ*** window for ***depress1.SPJ***.
- Click on the ***Run LISREL*** button to produce the following ***PTH*** window.

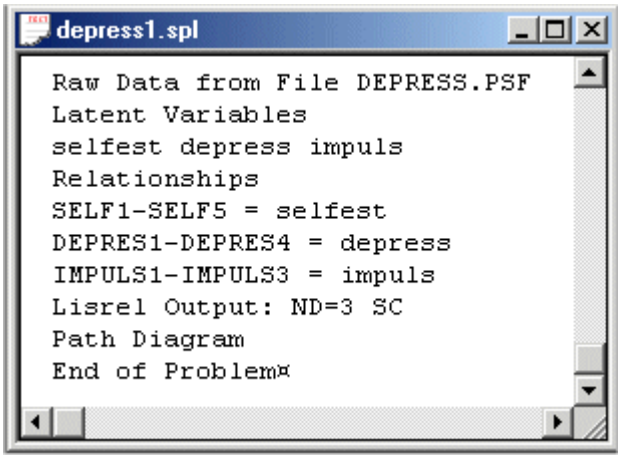


The requested results are listed in the text editor window for ***depress1.OUT***.

Submitting the SIMPLIS syntax file

A SIMPLIS syntax file may also be used to generate the previous ***PTH*** window. The corresponding SIMPLIS syntax file ***depress1.spl***, which is located in the ***TUTORIAL*** subfolder, is submitted as follows.

- Select the ***Open*** option on the ***File*** menu to load the ***Open*** dialog box.
- Browse for the file ***depress1.spl*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the following text editor window.



Line 1 specifies the raw data source.
Lines 2 and 3 specify labels for the latent variables of the model.
Lines 4 to 7 specify the measurement model for the latent variables *Self-esteem*, *Depressiveness* and *Impulsiveness*.
Line 8 requests that the results in the output file should be given in terms of the LISREL model for the structural equation model (LISREL Output). It also requests that the results should be written to three decimal places (ND=3) and that the completely standardized solution should be written to the output file (SC).
Line 9 requests a path diagram of the model.
Line 10 indicates that no more SIMPLIS commands are to be processed.

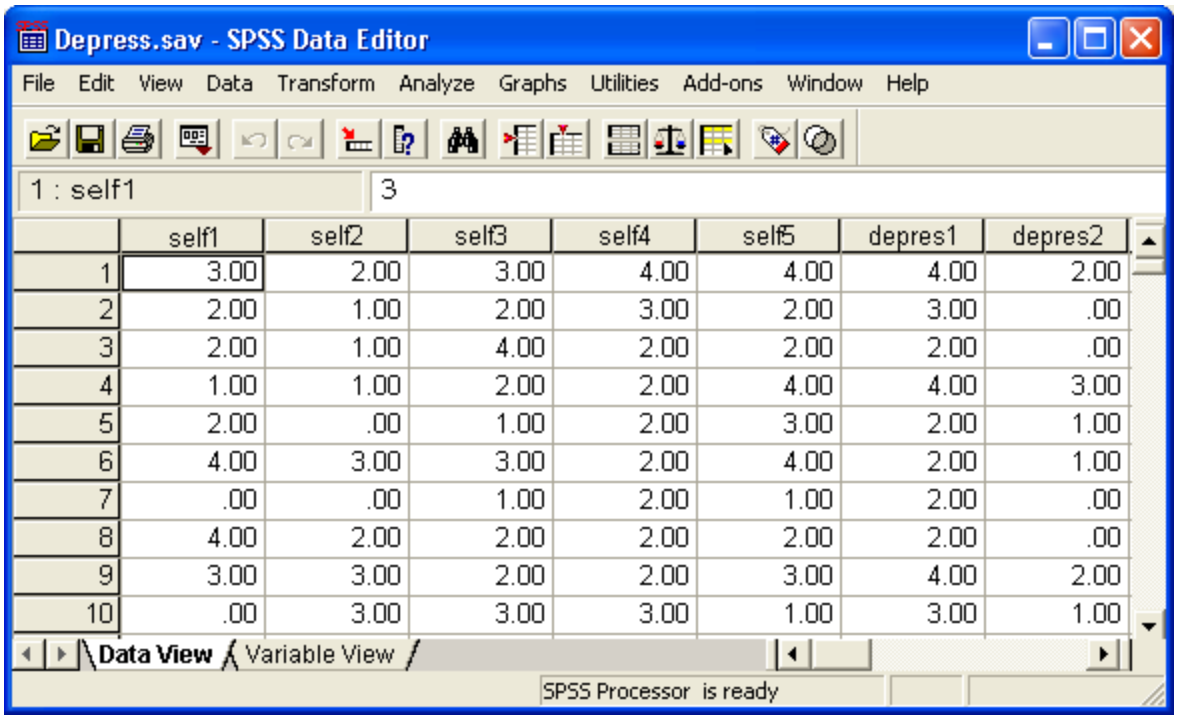
- Click on the ***Run LISREL*** button to produce the ***PTH*** window on the previous page.

4. Fitting a structural equation model to SPSS data

In this section, we demonstrate how to use LISREL for Windows to fit a structural equation model to SPSS data.

The data

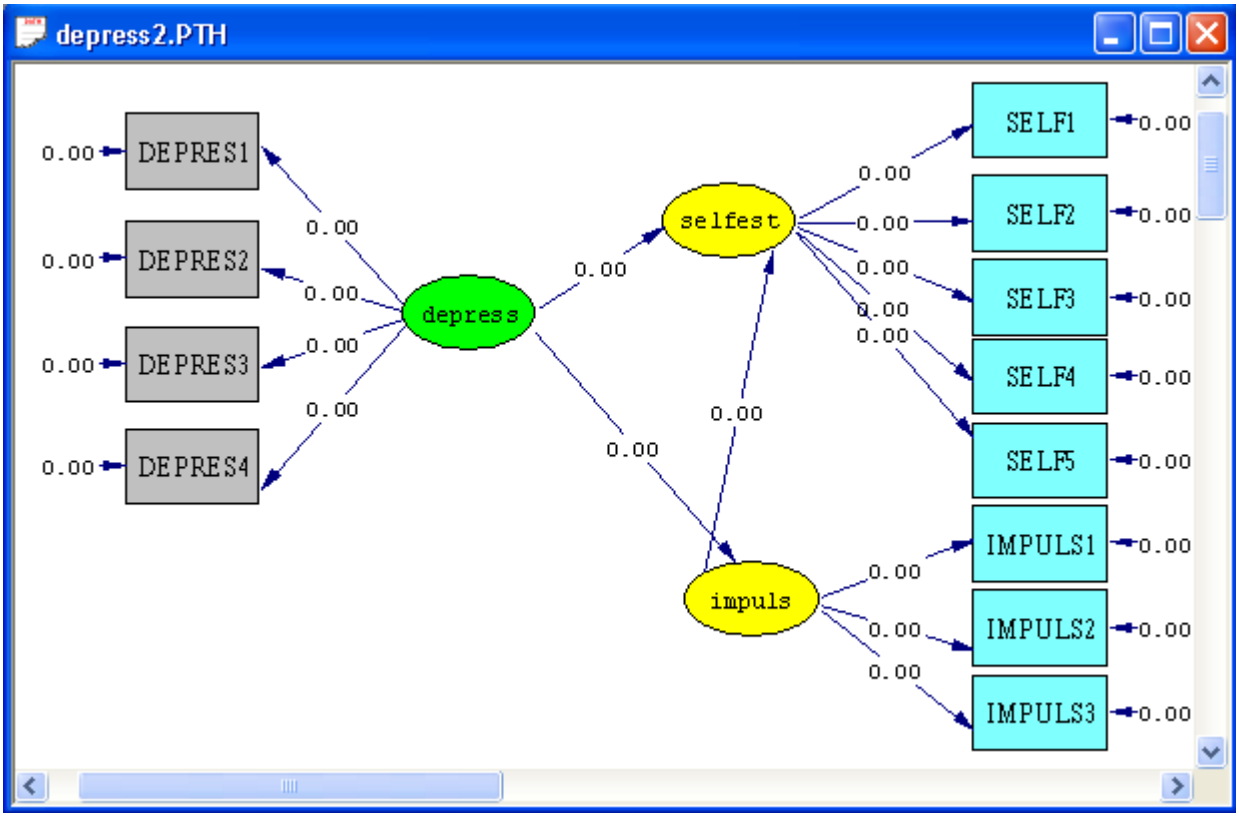
The SPSS for Windows data file ***Depress.sav*** in the ***TUTORIAL*** subfolder contains 204 observations of 12 indicators of three latent variables. More specifically, the first 5 indicators (SELF1 to SELF5) are indicators of the latent variable *Self-esteem*, DEPRES1 to DEPRES4 are indicators of the latent variable *Depressiveness* and IMPULS1 to IMPULS3 are indicators of the latent variable *Impulsiveness*. The first portion of the SPSS data file is shown in the following SPSS data editor window.



	self1	self2	self3	self4	self5	depres1	depres2
1	3.00	2.00	3.00	4.00	4.00	4.00	2.00
2	2.00	1.00	2.00	3.00	2.00	3.00	.00
3	2.00	1.00	4.00	2.00	2.00	2.00	.00
4	1.00	1.00	2.00	2.00	4.00	4.00	3.00
5	2.00	.00	1.00	2.00	3.00	2.00	1.00
6	4.00	3.00	3.00	2.00	4.00	2.00	1.00
7	.00	.00	1.00	2.00	1.00	2.00	.00
8	4.00	2.00	2.00	2.00	2.00	2.00	.00
9	3.00	3.00	2.00	2.00	3.00	4.00	2.00
10	.00	3.00	3.00	3.00	1.00	3.00	1.00

The model

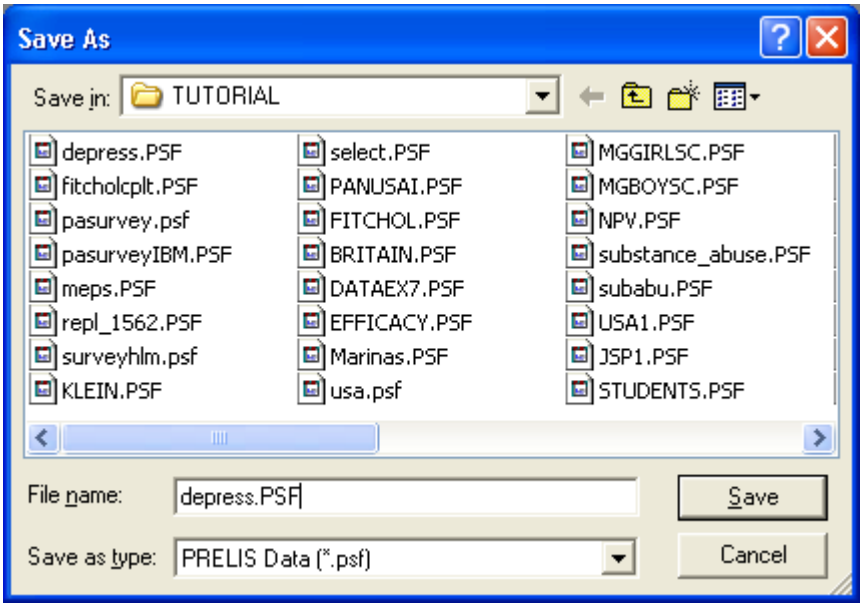
The structural equation model suggests that the latent variables *Depressiveness* and *Impulsiveness* are correlated antecedents of the latent variable *Self-esteem*. A path diagram of this model follows.



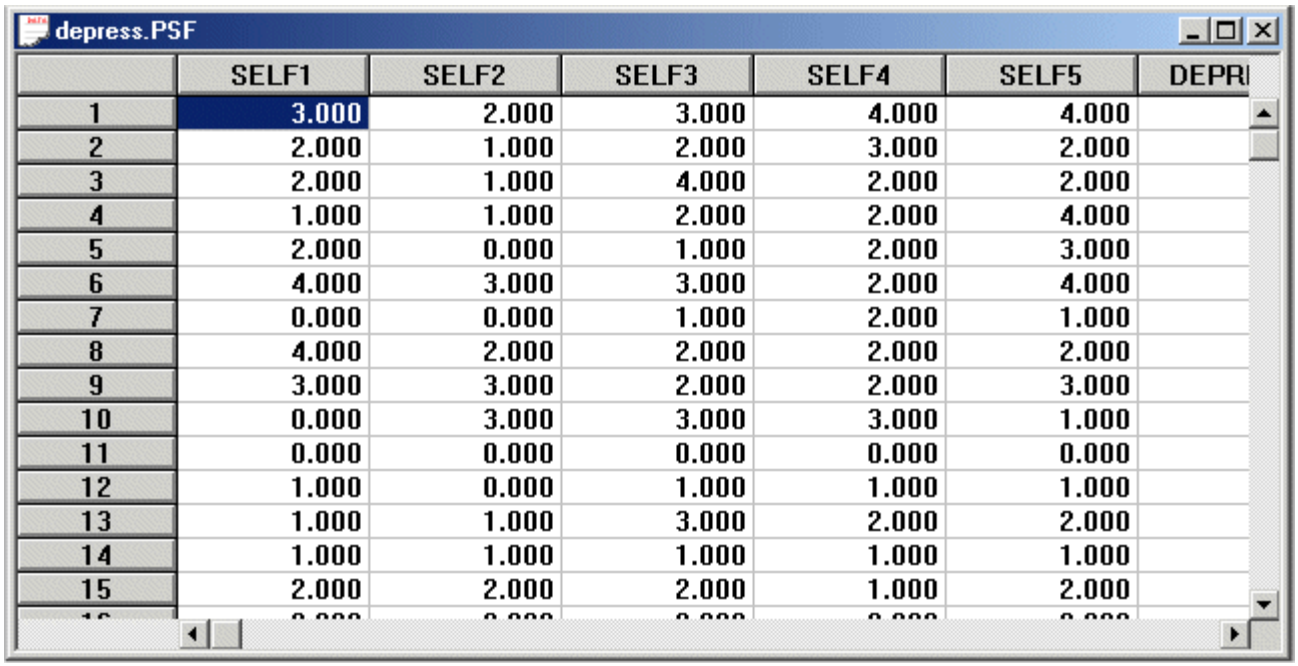
Fitting the model to the data

Using a path diagram

- Use the ***Import Data*** option from the ***File*** menu of the main window of LISREL for Windows to load the ***Open*** dialog box.
- Select ***SPSS data file (*.sav)*** from the ***Files of type*** drop-down list box.
- Browse for the file ***Depress.sav*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to load the ***Save As*** dialog box.
- Enter the name ***depress.PSF*** in the ***File name*** string field to produce the following dialog box.

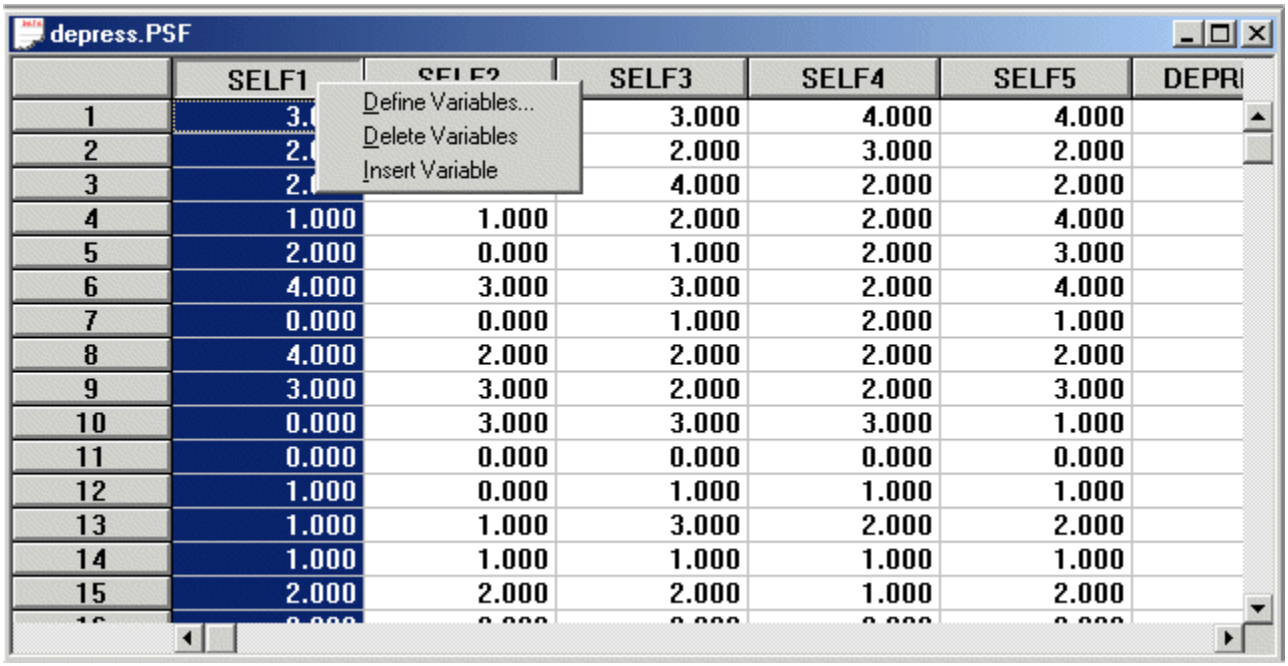


- Click on the ***Save*** button to open the following ***PSF*** window.

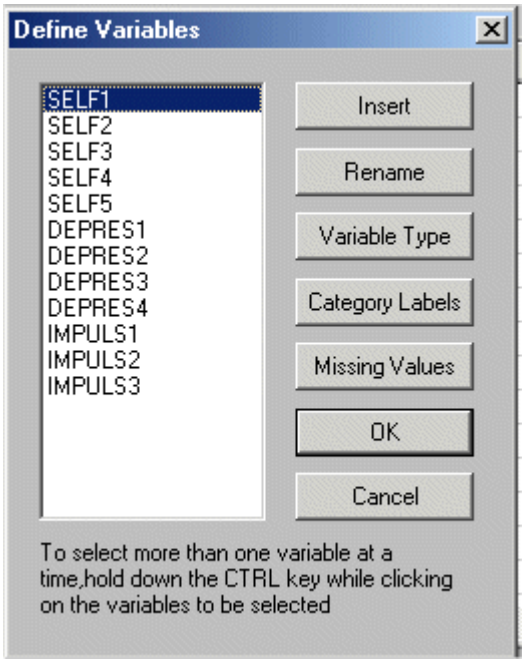


	SELF1	SELF2	SELF3	SELF4	SELF5	DEPR
1	3.000	2.000	3.000	4.000	4.000	
2	2.000	1.000	2.000	3.000	2.000	
3	2.000	1.000	4.000	2.000	2.000	
4	1.000	1.000	2.000	2.000	4.000	
5	2.000	0.000	1.000	2.000	3.000	
6	4.000	3.000	3.000	2.000	4.000	
7	0.000	0.000	1.000	2.000	1.000	
8	4.000	2.000	2.000	2.000	2.000	
9	3.000	3.000	2.000	2.000	3.000	
10	0.000	3.000	3.000	3.000	1.000	
11	0.000	0.000	0.000	0.000	0.000	
12	1.000	0.000	1.000	1.000	1.000	
13	1.000	1.000	3.000	2.000	2.000	
14	1.000	1.000	1.000	1.000	1.000	
15	2.000	2.000	2.000	1.000	2.000	

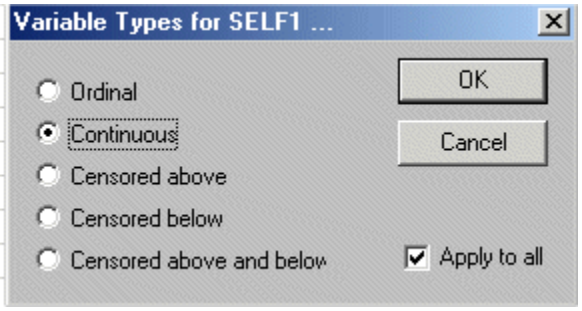
- Click on the variable label ***SELF1*** to highlight the entire column.
- Right-click to open the variable menu as shown in the following ***PSF*** window.



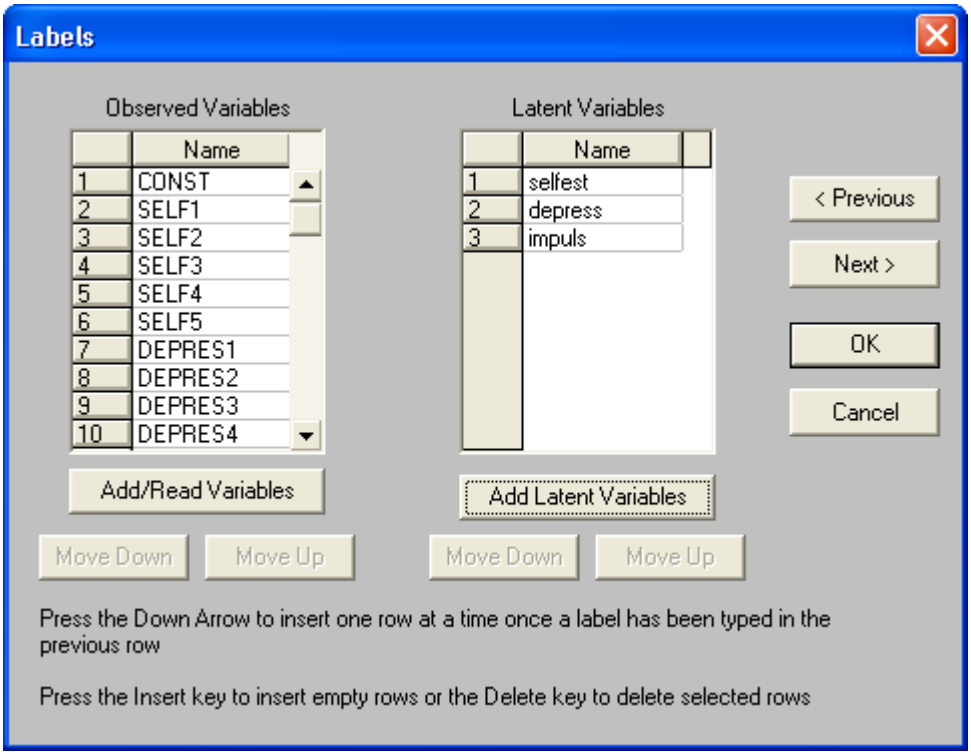
- Select the ***Define Variables*** option to load the ***Define Variables*** dialog box.
- Select the label ***SELF1*** to produce the following ***Define Variables*** dialog box.



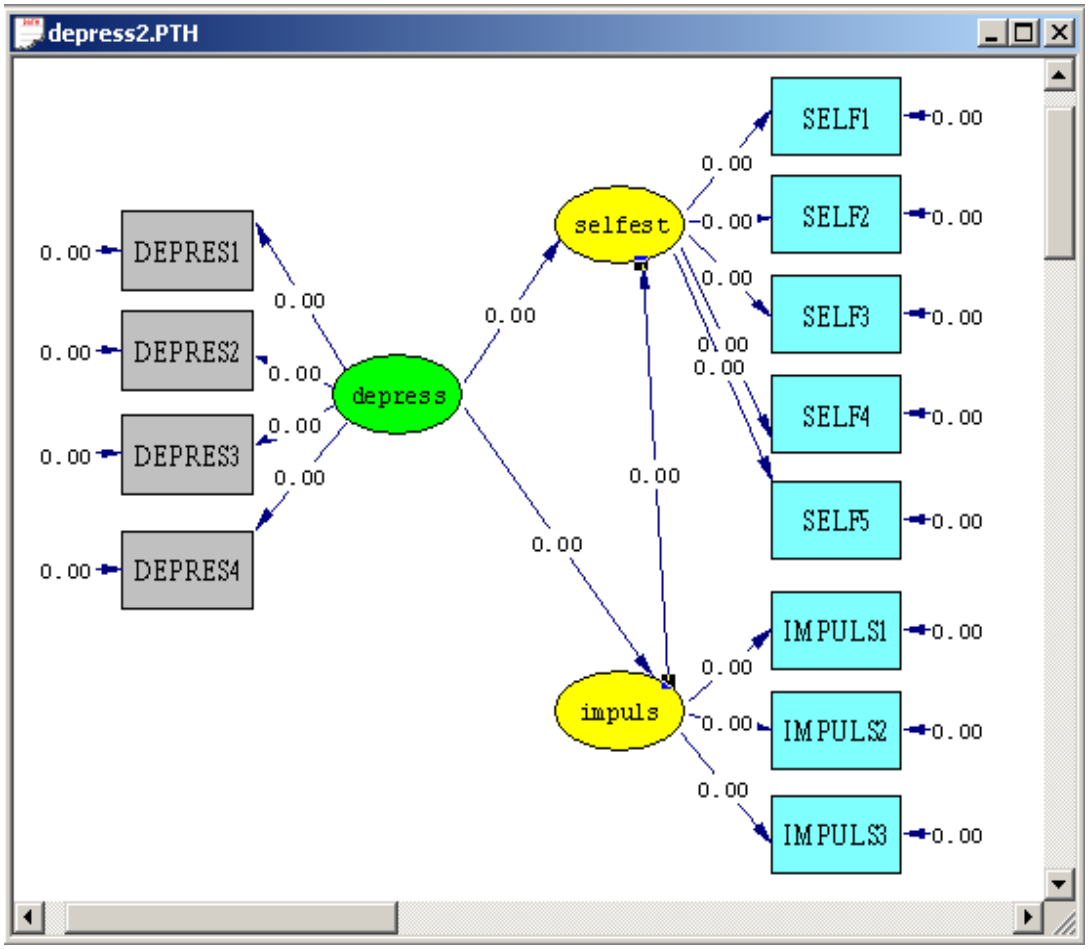
- Click on the ***Variable Type*** button to load the ***Variable Types for SELF1…*** dialog box.
- Select the ***Continuous*** radio button.
- Check the ***Apply to all*** checkbox to produce the ***Variable Types for SELF1…*** dialog box below.



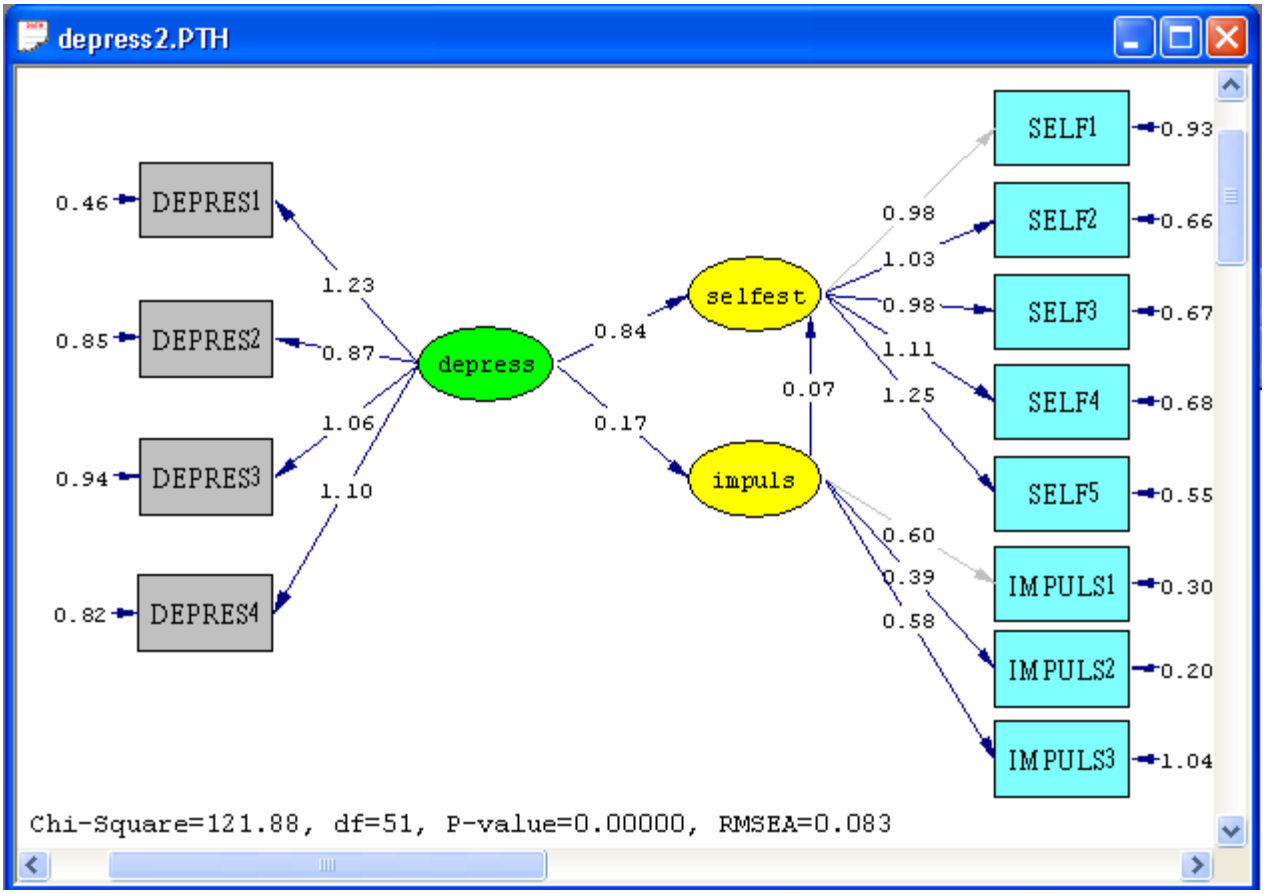
- Click on the ***OK*** button to reload the ***Variable Types*** dialog box.
- Click on the ***OK*** button to return to the ***PSF*** window.
- Save your changes to the PSF by using the ***Save*** option on the ***File*** menu.
- Select the ***New*** option on the ***File*** menu to load the ***New*** dialog box.
- Select the ***Path Diagram*** option in the ***New*** list box.
- Click on the ***OK*** button to load the ***Save As*** dialog box.
- Enter the name ***depress2.PTH*** in the ***File name*** string field.
- Click on the ***Save*** button to open the empty ***PTH*** window for ***depress1.PTH***.
- Select the ***Variables*** option on the ***Setup*** menu to load the ***Labels*** dialog box.
- Click on the ***Add/Read Variables*** button to load the ***Add/Read Variables*** dialog box.
- Select the ***PRELIS System File*** option from the drop-down list box.
- Click on the ***Browse*** button to load the ***Browse*** dialog box.
- Browse for the file ***depress.PSF*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to return to the ***Add/Read Variables*** dialog box.
- Click on the ***OK*** button to return to the ***Labels*** dialog box.
- Click on the ***Add Latent Variables*** button to load the ***Add Variables*** dialog box.
- Enter the label ***selfest*** in the string field.
- Click on the ***OK*** button to return to the ***Labels*** dialog box.
- Click on the ***Add Latent Variables*** button to load the ***Add Variables*** dialog box.
- Enter the label ***depress*** in the string field.
- Click on the ***OK*** button to return to the ***Labels*** dialog box.
- Click on the ***Add Latent Variables*** button to load the ***Add Variables*** dialog box.
- Enter the label ***impuls*** in the string field.
- Click on the ***OK*** button to produce the following ***Labels*** dialog box.



- Click on the ***OK*** button to return to the ***PTH*** window for ***depress1.PTH***.
- Check the ***Y*** check boxes for ***SELF1***, ***SELF2***, ***SELF3***, ***SELF4***, ***SELF5***, ***IMPULS1***, ***IMPULS2***, and ***IMPULS3***.
- Check the ***Eta*** check boxes for ***impuls*** and ***selfest***.
- Click, drag and drop the observed variable labels one at a time into the empty ***PTH*** window.
- Click, drag and drop the latent variable labels one at a time into the empty ***PTH*** window.
- Click on the ***Arrow*** button on the drawing toolbar.
- Click and drag 5 paths from ***selfest*** to ***SELF1***, ***SELF2***, ***SELF3***, ***SELF4***, and ***SELF5***.
- Click and drag 4 paths from ***depress*** to ***DEPRES1***, ***DEPRES2***, ***DEPRES3***, and ***DEPRES4***.
- Click and drag 3 paths from ***impuls*** to ***IMPULS1***, ***IMPULS2***, and ***IMPULS3***.
- Click and drag 2 paths from ***depress*** and ***impuls*** to ***selfest***.
- Click and drag a path from ***impuls*** to ***depress*** to produce the following ***PTH*** window.



- Click on the ***Build SIMPLIS Syntax*** option on the ***Setup*** menu to open the ***SPJ*** window for ***depress2.SPJ***.
- Click on the ***Run LISREL*** button to produce the following ***PTH*** window.

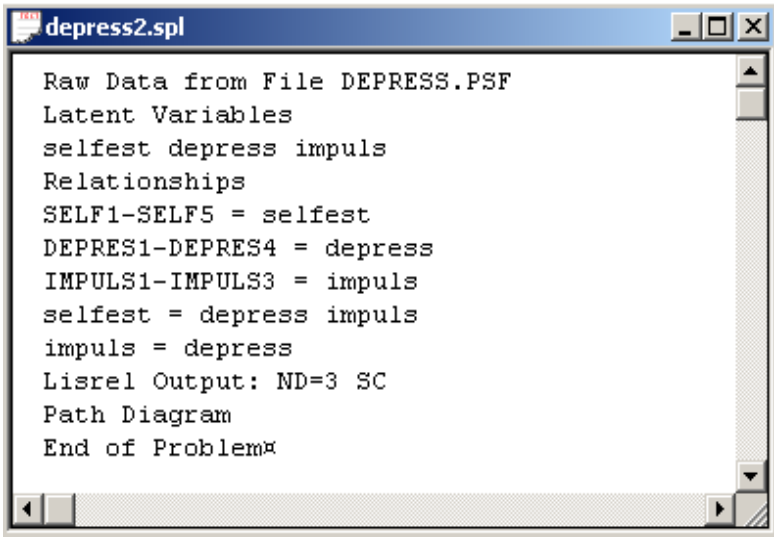


The requested results are listed in the text editor window for ***depress2.OUT***.

Submitting the SIMPLIS syntax file

A SIMPLIS syntax file may also be used to generate the previous ***PTH*** window. The corresponding SIMPLIS syntax file ***depress2.spl***, which is located in the ***TUTORIAL*** subfolder, is submitted as follows.

- Select the ***Open*** option on the ***File*** menu to load the ***Open*** dialog box.
- Browse for the file ***depress2.spl*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the following text editor window.



Line 1 specifies the raw data source.
Lines 2 and 3 specify labels for the latent variables of the model.
Lines 4 to 9 specify the structural equation model for the latent variables *Self-esteem*, *Depressiveness* and *Impulsiveness*.
Line 10 requests that the results in the output file should be given in terms of the LISREL model for the structural equation model (LISREL Output). It also requests that the results should be written to three decimal places (ND=3) and that the completely standardized solution should be written to the output file (SC).
Line 11 requests a path diagram of the model.
Line 12 indicates that no more SIMPLIS commands are to be processed.

- Click on the ***Run LISREL*** button to produce the path diagram on the previous page.

5. Robust maximum likelihood

Browne (1987) formulated a Robust Maximum Likelihood (RML) method for factor analysis and related models. Satorra & Bentler (1988) extended this method by providing a correct Chi-square test statistic. This method is available in LISREL for Windows and the associated formulae are provided in Jöreskog et al (2001). To implement this method, the user needs to compute the Asymptotic Covariance Matrix (ACM) of the sample variances and covariances. In this section, we illustrate how to fit a structural equation model to data by using the RML method.

The data

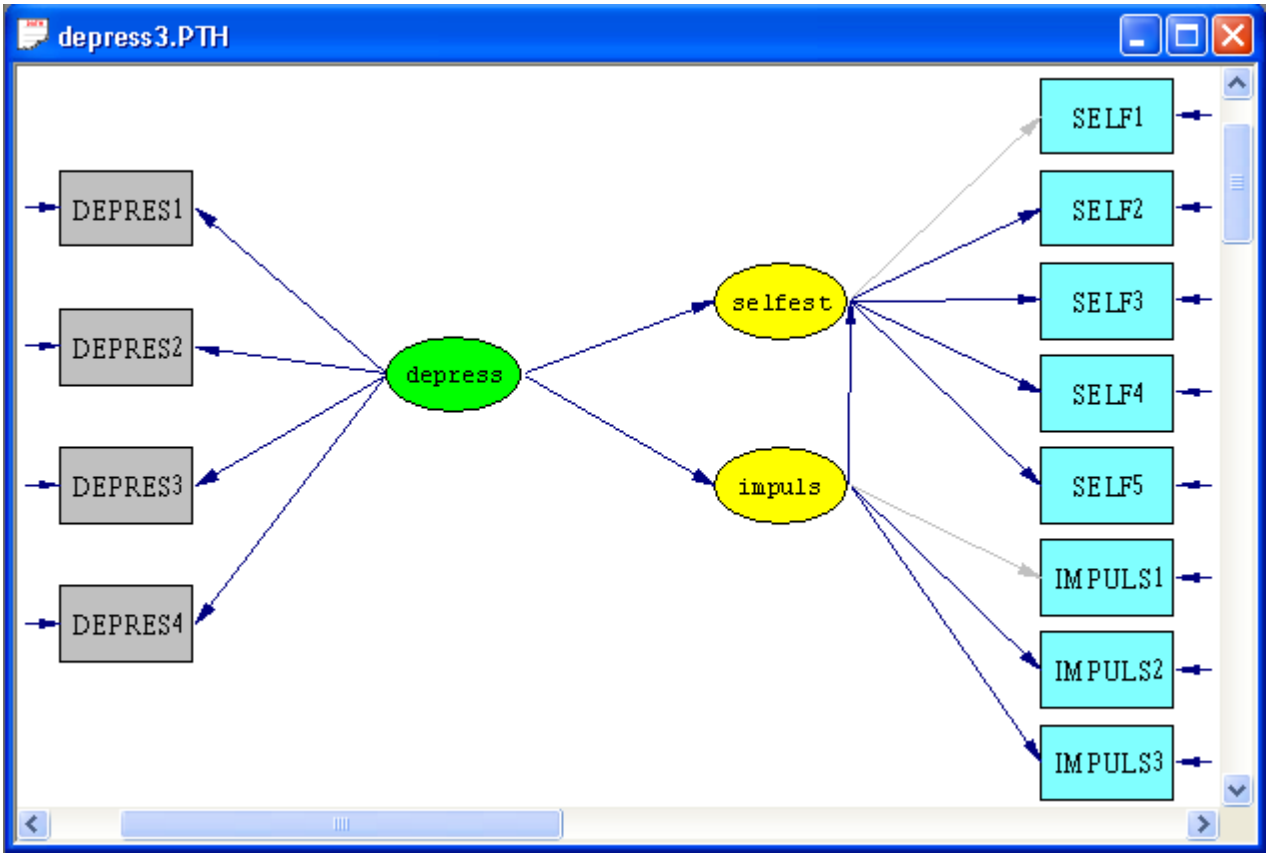
The data file ***depress.PSF*** in the ***TUTORIAL*** subfolder contains 204 observations of 12 indicators of three latent variables. More specifically, the first 5 indicators (SELF1 to SELF5) are indicators of the latent variable *Self-esteem*, DEPRES1 to DEPRES4 are indicators of the latent variable *Depressiveness* and IMPULS1 to IMPULS3 are indicators of the latent variable *Impulsiveness*. The first portion of the data file is shown in the following ***PSF*** window.

depress.PSF

	SELF1	SELF2	SELF3	SELF4	SELF5	DEPR
1	3.000	2.000	3.000	4.000	4.000	
2	2.000	1.000	2.000	3.000	2.000	
3	2.000	1.000	4.000	2.000	2.000	
4	1.000	1.000	2.000	2.000	4.000	
5	2.000	0.000	1.000	2.000	3.000	
6	4.000	3.000	3.000	2.000	4.000	
7	0.000	0.000	1.000	2.000	1.000	
8	4.000	2.000	2.000	2.000	2.000	
9	3.000	3.000	2.000	2.000	3.000	
10	0.000	3.000	3.000	3.000	1.000	
11	0.000	0.000	0.000	0.000	0.000	
12	1.000	0.000	1.000	1.000	1.000	
13	1.000	1.000	3.000	2.000	2.000	
14	1.000	1.000	1.000	1.000	1.000	
15	2.000	2.000	2.000	1.000	2.000	

The model

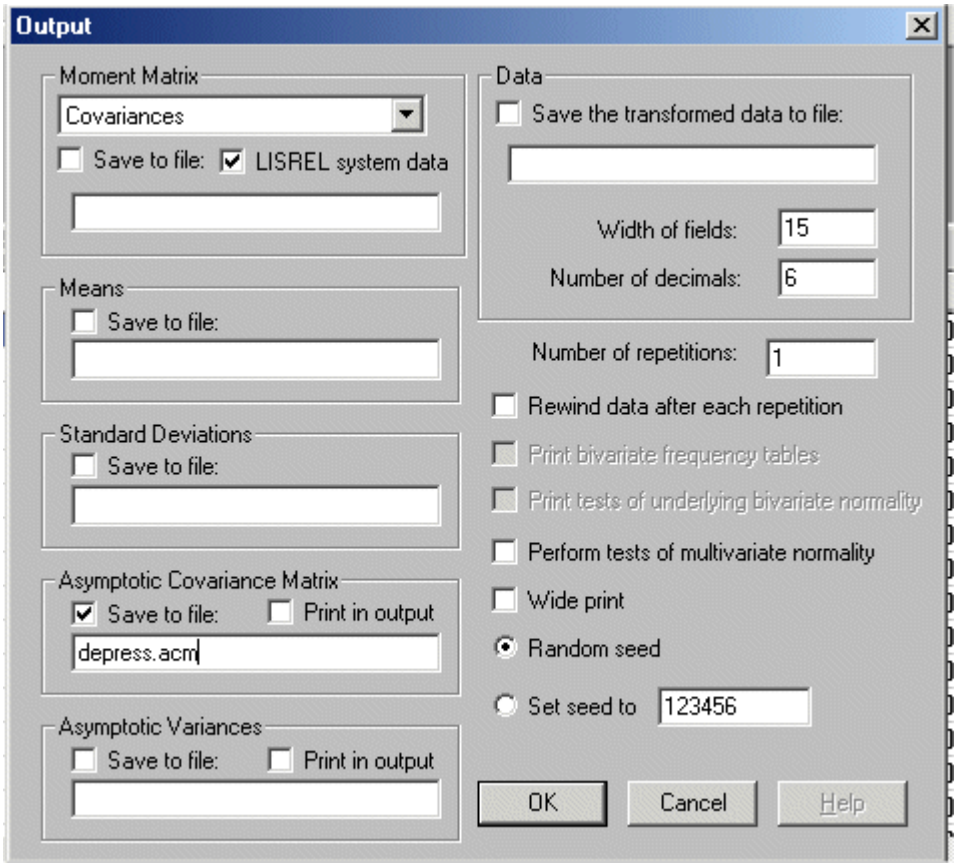
The structural equation model suggests that the latent variables *Depressiveness* and *Impulsiveness* are antecedents of the latent variable *Self-esteem* and that *Depressiveness* determines *Impulsiveness*. A path diagram of this model follows.



Fitting the model to the data

Generating the ACM file

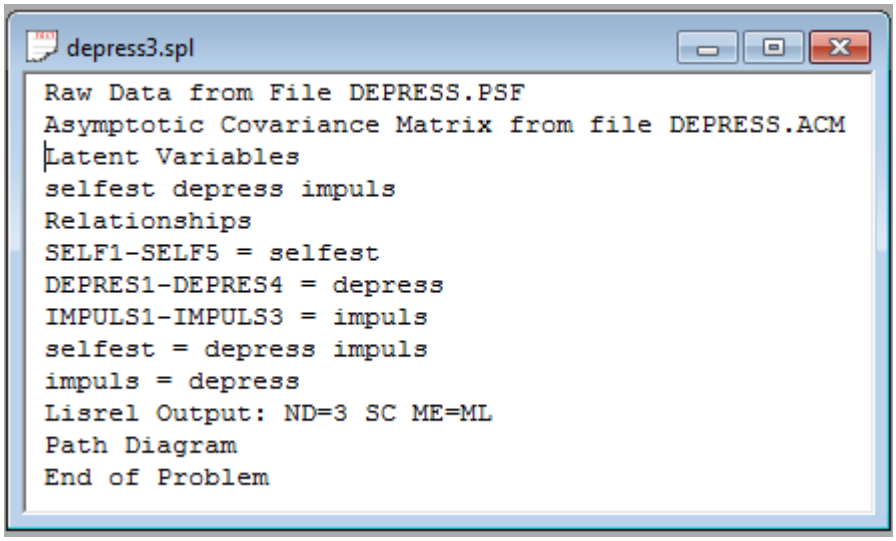
- Select the ***Open*** option from the ***File*** menu to load the ***Open*** dialog box.
- Select the ***PRELIS Data (*.psf)*** option from the ***Files of type*** drop-down list box.
- Browse for the file ***depress.PSF*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the ***PSF*** window for ***depress.PSF***.
- Select the ***Output Options*** option from the ***Statistics*** menu to load the ***Output*** dialog box.
- Check the ***LISREL system data*** check box in the ***Moment Matrix*** section.
- Check the ***Save to File*** check box in the ***Asymptotic Covariance Matrix*** section.
- Enter the name ***depress.acm*** in the string field in the ***Asymptotic Covariance Matrix*** section to produce the following ***Output*** dialog box.



- Click on the ***OK*** button to run PRELIS to generate the text editor window containing the output file ***Depress.out***. This action causes PRELIS to generate the estimated asymptotic covariance matrix file ***depress.acm*** that will be needed to implement the RML method.

Submitting the SIMPLIS syntax file

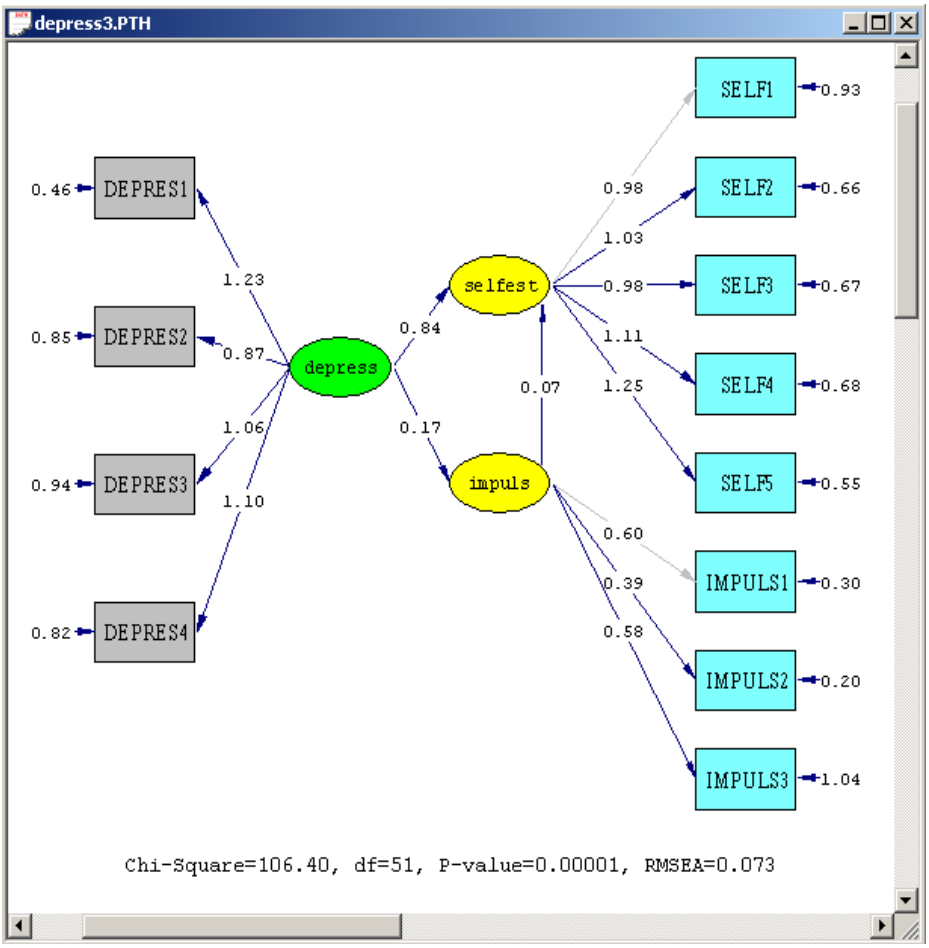
- Select the ***Open*** option on the ***File*** menu to load the ***Open*** dialog box.
- Browse for the file ***Depress3.spl*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the following text editor window.



Line 1 specifies the summary data source.

Lines 2 and 3 specify labels for the latent variables of the model.
Lines 4 to 9 specify the structural equation model for the latent variables *Self-esteem*, *Depressiveness* and *Impulsiveness*.
Line 10 requests that the results in the output file should be given in terms of the LISREL model for the structural equation model (LISREL Output). It also requests that the results should be written to three decimal places (ND=3), that the completely standardized solution should be written to the output file (SC), and that the maximum likelihood method should be used (ME=ML).
Line 11 requests a path diagram of the model.
Line 12 indicates that no more SIMPLIS commands are to be processed.

- Click on the ***Run LISREL*** button to produce the following ***PTH*** window.



The requested results are displayed in the text editor window for ***Depress3.OUT***.

6. Weighted least squares

Browne (1982, 1984) formulated an Asymptotically Distribution Free (ADF) method for covariance structures. This method is implemented in LISREL for Windows as Weighted Least Squares (WLS) and extended to correlation structures. To implement this method, the user needs to compute the Asymptotic Covariance Matrix (ACM) of the sample variances and covariances or sample correlations. Next, we demonstrate how to use the WLS method of LISREL for Windows to fit a structural equation model to data on depression.

The data

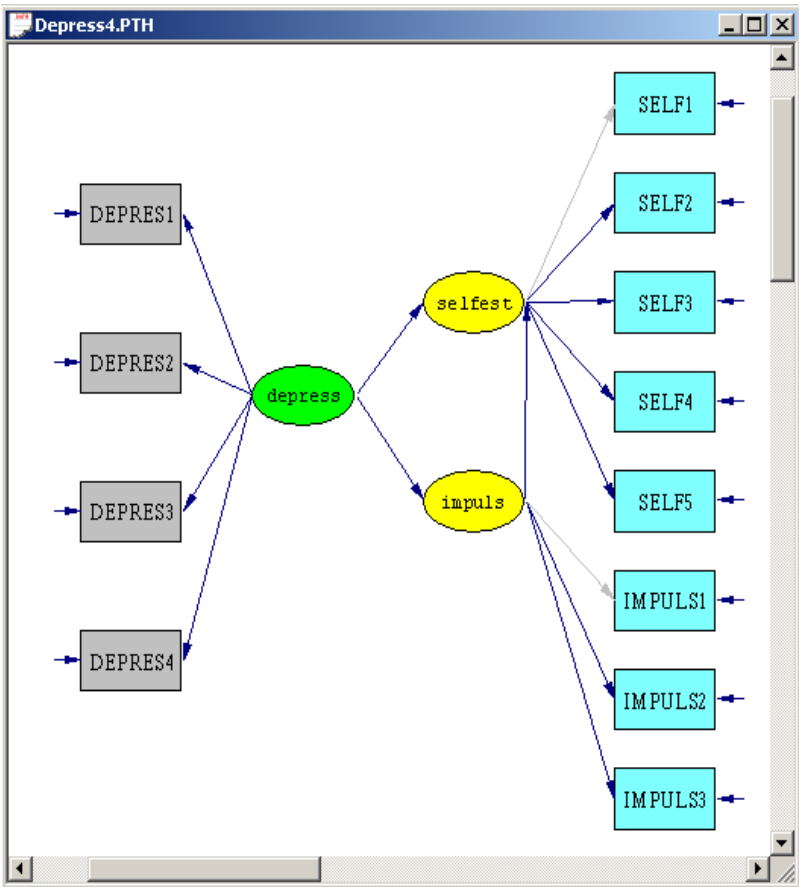
The data file ***depress.PSF*** in the ***TUTORIAL*** subfolder contains 204 observations of 12 indicators of three latent variables. More specifically, the first 5 indicators (SELF1 to SELF5) are indicators of the latent variable *Self-esteem*, DEPRES1 to DEPRES4 are indicators of the latent variable *Depressiveness* and IMPULS1 to IMPULS3 are indicators of the latent variable *Impulsiveness*. The first portion of the data file is shown in the following ***PSF*** window.

depress.PSF

	SELF1	SELF2	SELF3	SELF4	SELF5	DEPR
1	3.000	2.000	3.000	4.000	4.000	
2	2.000	1.000	2.000	3.000	2.000	
3	2.000	1.000	4.000	2.000	2.000	
4	1.000	1.000	2.000	2.000	4.000	
5	2.000	0.000	1.000	2.000	3.000	
6	4.000	3.000	3.000	2.000	4.000	
7	0.000	0.000	1.000	2.000	1.000	
8	4.000	2.000	2.000	2.000	2.000	
9	3.000	3.000	2.000	2.000	3.000	
10	0.000	3.000	3.000	3.000	1.000	
11	0.000	0.000	0.000	0.000	0.000	
12	1.000	0.000	1.000	1.000	1.000	
13	1.000	1.000	3.000	2.000	2.000	
14	1.000	1.000	1.000	1.000	1.000	
15	2.000	2.000	2.000	1.000	2.000	

The model

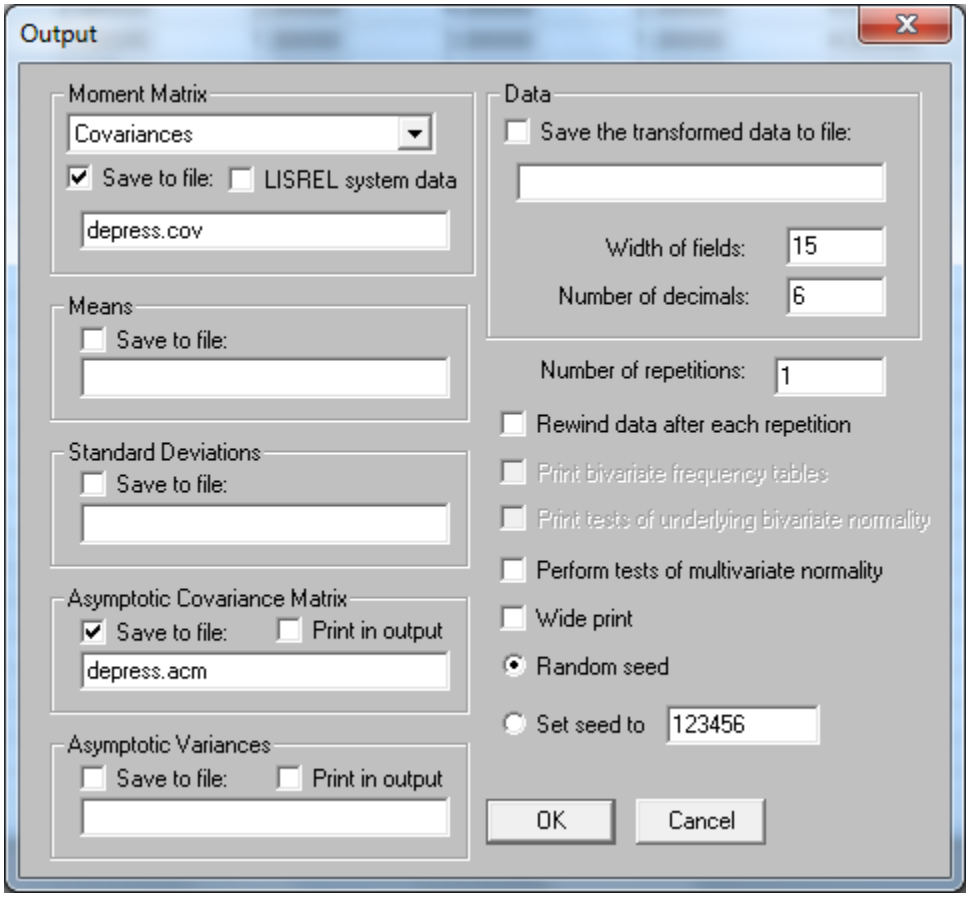
The structural equation model suggests that the latent variables *Depressiveness* and *Impulsiveness* are correlated antecedents of the latent variable *Self-esteem*. A path diagram of this model follows.



Fitting the model to the data

Generating the matrix files

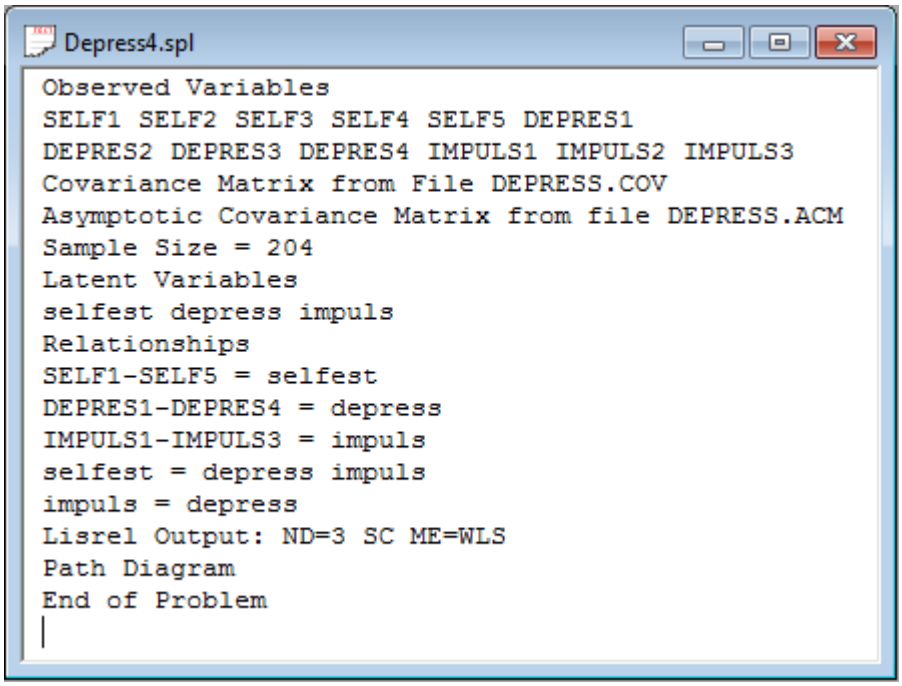
- Select the ***Open*** option from the ***File*** menu to load the ***Open*** dialog box.
- Select the ***PRELIS Data (*.psf)*** option from the ***Files of type*** drop-down list box.
- Browse for the file ***depress.PSF*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the ***PSF*** window for ***depress.PSF***.
- Select the ***Output Options*** option from the ***Statistics*** menu to load the ***Output*** dialog box.
- Check the ***Save to File*** check box in the ***Moment Matrix*** section.
- Enter the name ***depress.cov*** in the string field in the ***Moment Matrix*** section.
- Check the ***Save to File*** check box in the ***Asymptotic Covariance Matrix*** section.
- Enter the name ***depress.acm*** in the string field in the ***Asymptotic Covariance Matrix*** section to produce the following ***Output*** dialog box.



- Click on the ***OK*** button to run PRELIS to generate the text editor window containing the output file ***Depress.out***. This action causes PRELIS to generate the sample covariance matrix ***depress.cov*** and the estimated asymptotic covariance matrix file ***depress.acm*** that will be needed to implement the WLS method.

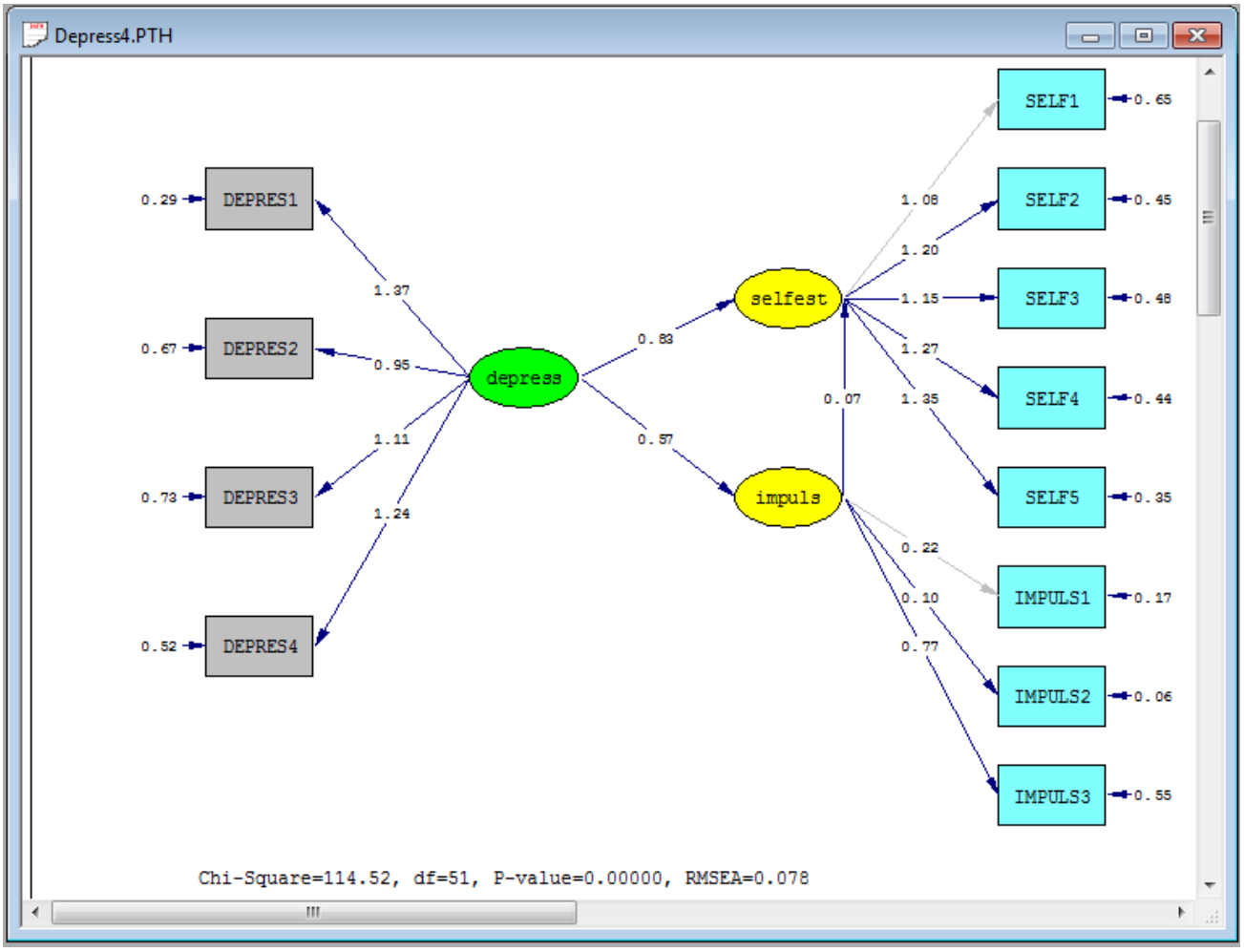
Submitting the SIMPLIS syntax file

- Select the ***Open*** option on the ***File*** menu to load the ***Open*** dialog box.
- Browse for the file ***Depress4.spl*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the following text editor window.



Lines 1-3 specify the names of the observed variables of the model.
Line 4 specifies the sample covariance matrix file to be used.
Line 5 specifies the estimated asymptotic covariance matrix file to be used.
Line 6 specifies the number of observations.
Lines 7 and 8 specify labels for the latent variables of the model.
Lines 9 to 14 specify the structural equation model for the latent variables *Self-esteem*, *Depressiveness* and *Impulsiveness*.
Line 15 requests that the results in the output file should be given in terms of the LISREL model for the structural equation model (LISREL Output). It also requests that the results should be written to three decimal places (ND=3), that the completely standardized solution should be written to the output file (SC), and that the weighted least squares method should be used (ME=WLS).
Line 16 requests a path diagram of the model.
Line 17 indicates that no more SIMPLIS commands are to be processed.

➢ Click on the ***Run LISREL*** button to produce the following ***PTH*** window.



The requested results are displayed in the text editor window for ***Depress4.OUT***.

7. Multilevel confirmatory factor analysis

The multilevel SEM module of LISREL for Windows (Jöreskog & Sörbom 2006) allows the user to fit latent variable models to two-level hierarchical multivariate data sets by using Full Information Maximum Likelihood (FIML) estimation. Complete data sets or data sets with missing values can both be analyzed. More details on this multilevel SEM module are available in Du Toit & Du Toit (2001). In this section, we illustrate how to implement this module to fit a two-factor Confirmatory Factor Analysis (CFA) model to a 2-level data set.

The data

The data set forms part of the data library of the Multilevel Project at the University of London, and emanates from the Junior School Project (Mortimore et al, 1988). Mathematics and language tests were administered in three consecutive years to more than 1000 students from 50 primary schools, which were randomly selected from primary schools maintained by the Inner London Education Authority. The data are provided in the file ***JSP1.PSF*** which is located in the ***TUTORIAL*** subfolder of LISREL for Windows. The first portion of this file is shown in the following ***PSF*** window.

JSP1.PSF

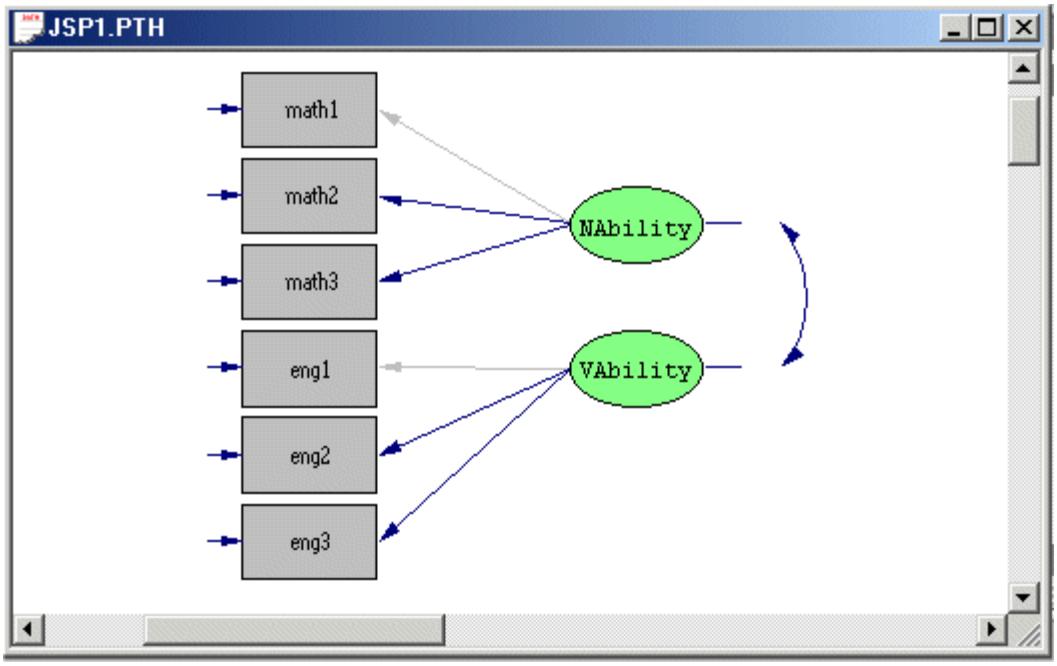
	school	gender	math1	math2	math3	eng1	eng2
1	1.000	0.000	23.000	24.000	23.000	72.000	80.
2	1.000	1.000	14.000	11.000	-9.000	7.000	17.
3	1.000	1.000	36.000	32.000	39.000	88.000	89.
4	1.000	1.000	24.000	26.000	32.000	12.000	25.
5	1.000	0.000	22.000	23.000	-9.000	67.000	78.
6	1.000	0.000	19.000	23.000	11.000	52.000	76.
7	1.000	1.000	22.000	22.000	26.000	37.000	68.
8	1.000	0.000	18.000	29.000	28.000	57.000	86.
9	1.000	1.000	30.000	31.000	-9.000	42.000	59.
10	1.000	0.000	29.000	29.000	-9.000	46.000	79.
11	1.000	0.000	31.000	28.000	32.000	69.000	84.
12	1.000	0.000	18.000	26.000	-9.000	54.000	74.
13	1.000	0.000	23.000	-9.000	27.000	63.000	-9.
14	1.000	0.000	39.000	35.000	36.000	83.000	88.
15	1.000	0.000	24.000	30.000	33.000	37.000	44.

Note that the –9.000 entries represent missing values.

The models

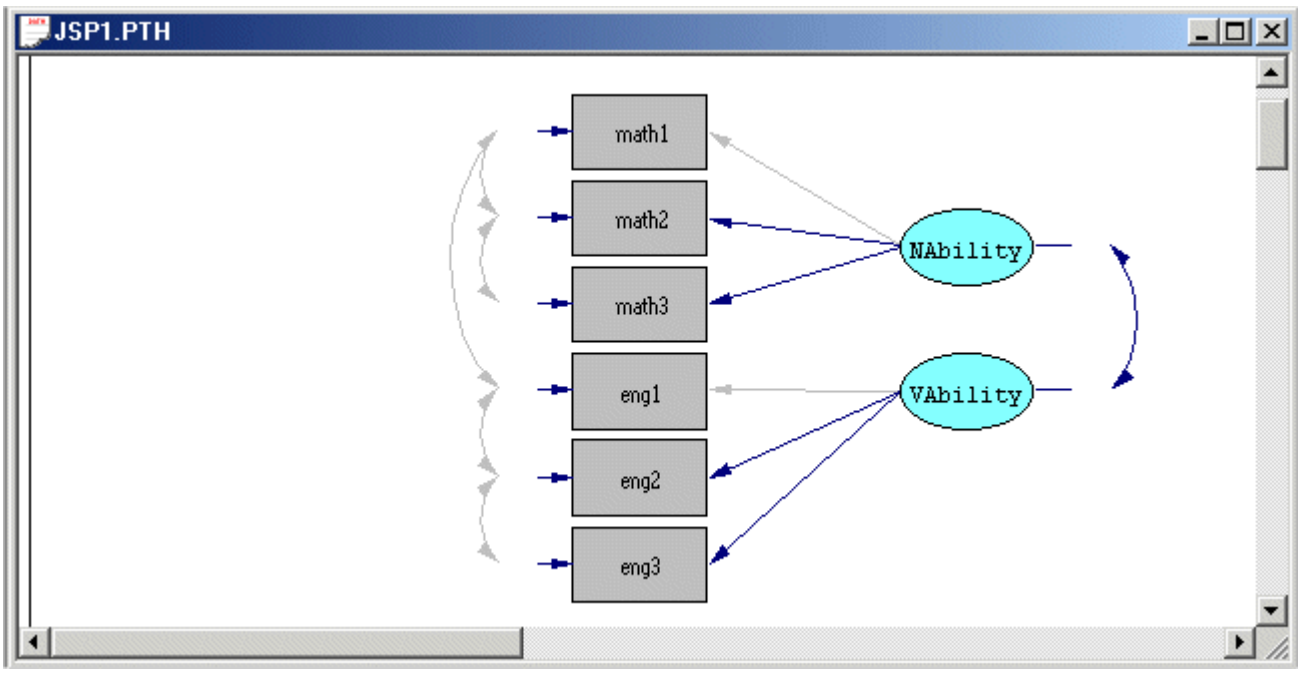
The between schools model

We consider Mathematics and Language tests, which were administered in three consecutive years to more than 1000 students from 50 primary schools. The three Mathematics scores are regarded as indicators of the latent variable ***Numerical Ability*** while the three English scores are regarded as indicators of the latent variable ***Verbal Ability***. A path diagram for the between schools model for Numerical and Verbal Ability is shown below.



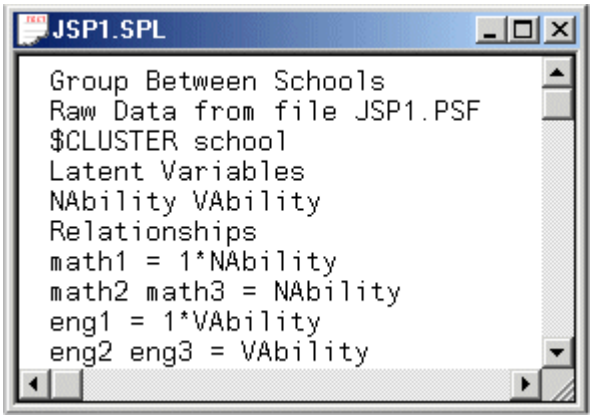
The within schools model

We consider Mathematics and Language tests, which were administered in three consecutive years to more than 1000 students from 50 primary schools. The three Mathematics scores are regarded as indicators of the latent variable ***Numerical Ability*** while the three English scores are regarded as indicators of the latent variable ***Verbal Ability***. In addition, it is assumed that the successive measurement errors for the Mathematics and English scores are correlated within schools. It is also hypothesized that the initial errors for the Mathematics and English scores are correlated within schools. A path diagram for the within schools model for Numerical and Verbal Ability is shown below.



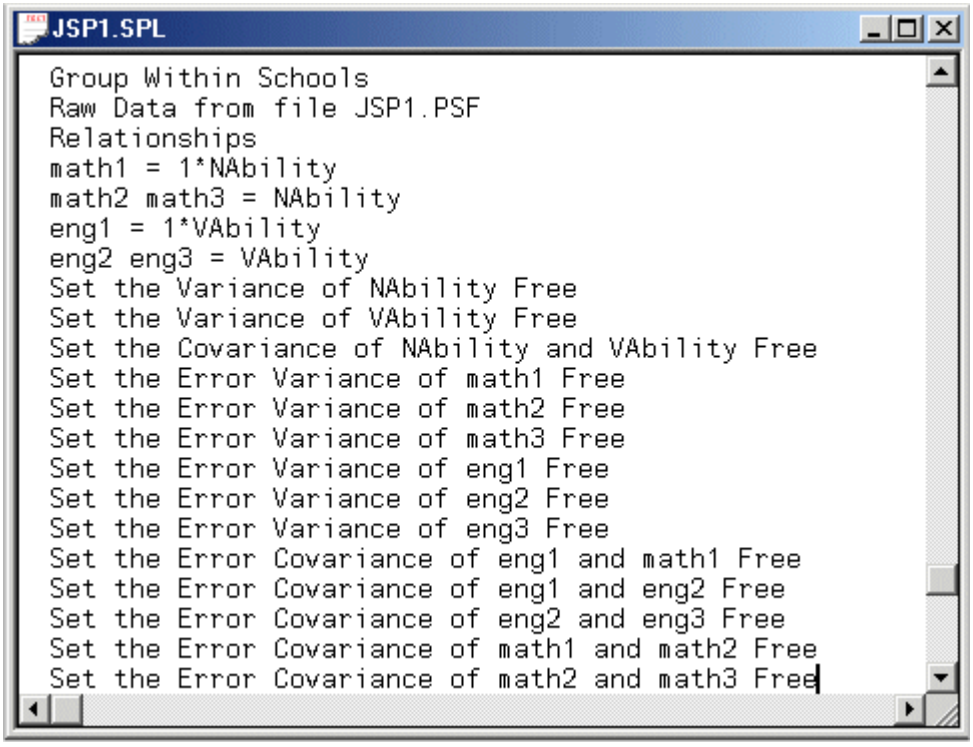
Fitting the between and within schools models

- Use the ***New*** option on the ***File*** menu of the main window to load the ***New*** dialog box.
- Select the ***Syntax Only*** option from the list box on the ***New*** dialog box to open the ***SYNTAX1*** text editor window.
- Enter the following commands into the ***SYNTAX1*** text editor window.



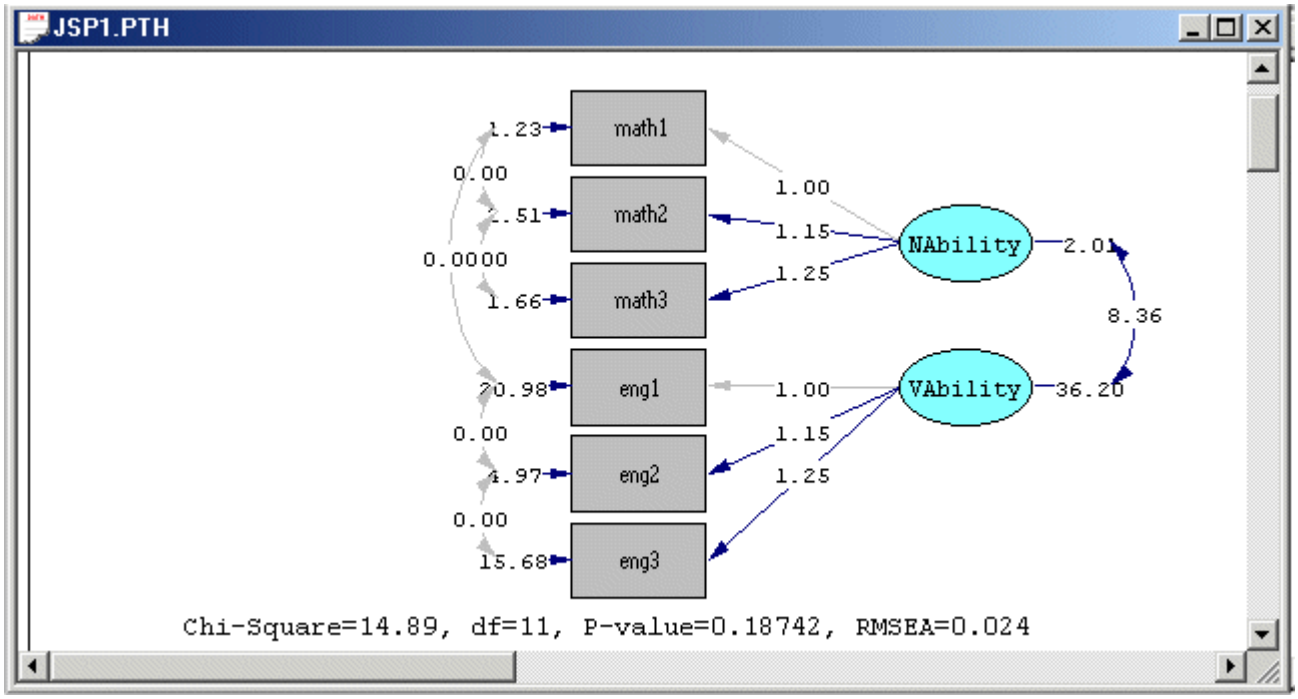
Line 1 specifies that the model that follows is the ***between schools model***.
Line 2 specifies the raw data source.
Line 3 specifies the cluster variable. This specification invokes the multilevel SEM method of LISREL for Windows.
Lines 4-5 specify labels for the latent variables of the model.
Lines 6-10 specify the between schools model.

- Add the following commands into the ***SYNTAX1*** text editor window.



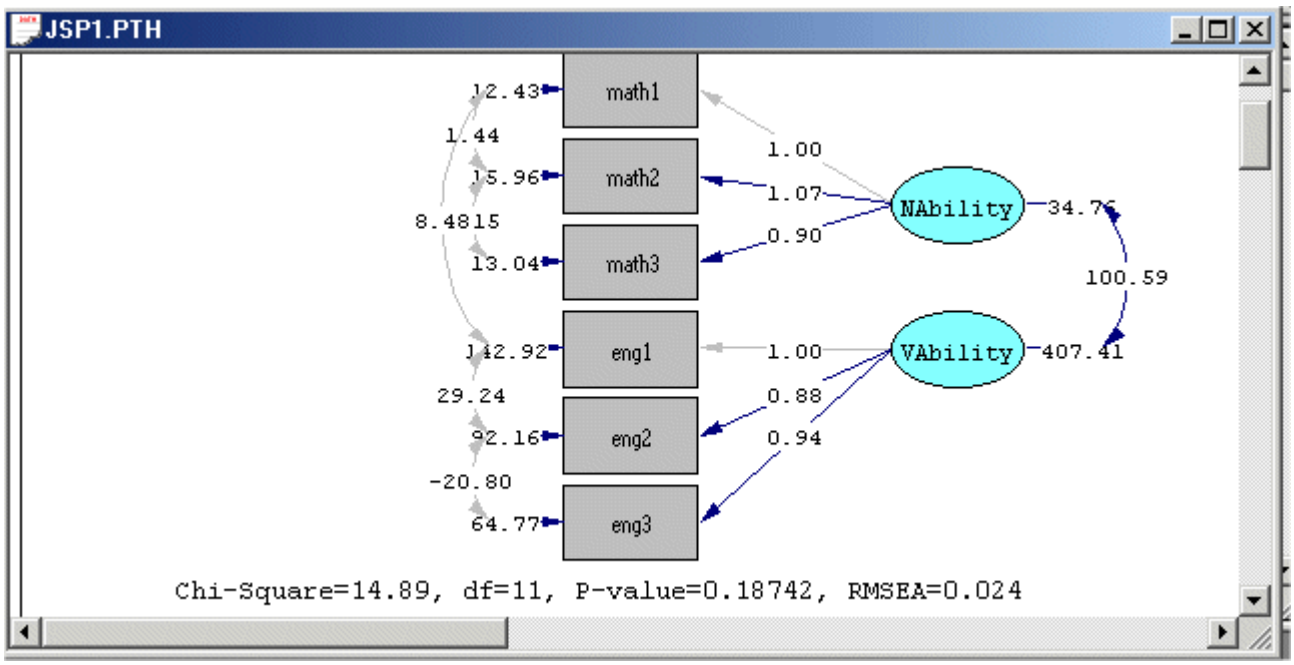
Line 1 specifies that the model that follows is the ***within schools model***.
Line 2 specifies the raw data source.
Lines 3-21 specify the within schools model.
Line 17 specifies that the measurement errors for the initial Mathematics and English scores be correlated.
Lines 18-21 specify that the measurement errors for the consecutive Mathematics and English scores be correlated.

- Use the ***Save As*** option on the ***File*** menu to save the SIMPLIS syntax file as ***JSP1.SPL***.
- Click on the ***Run LISREL*** icon to produce the following ***PTH*** window.



The results above are those for the between schools model.

- Select the ***Group Within Schools*** option from the ***Groups*** dropdown list box on the ***PTH*** window to display the following ***PTH*** window.



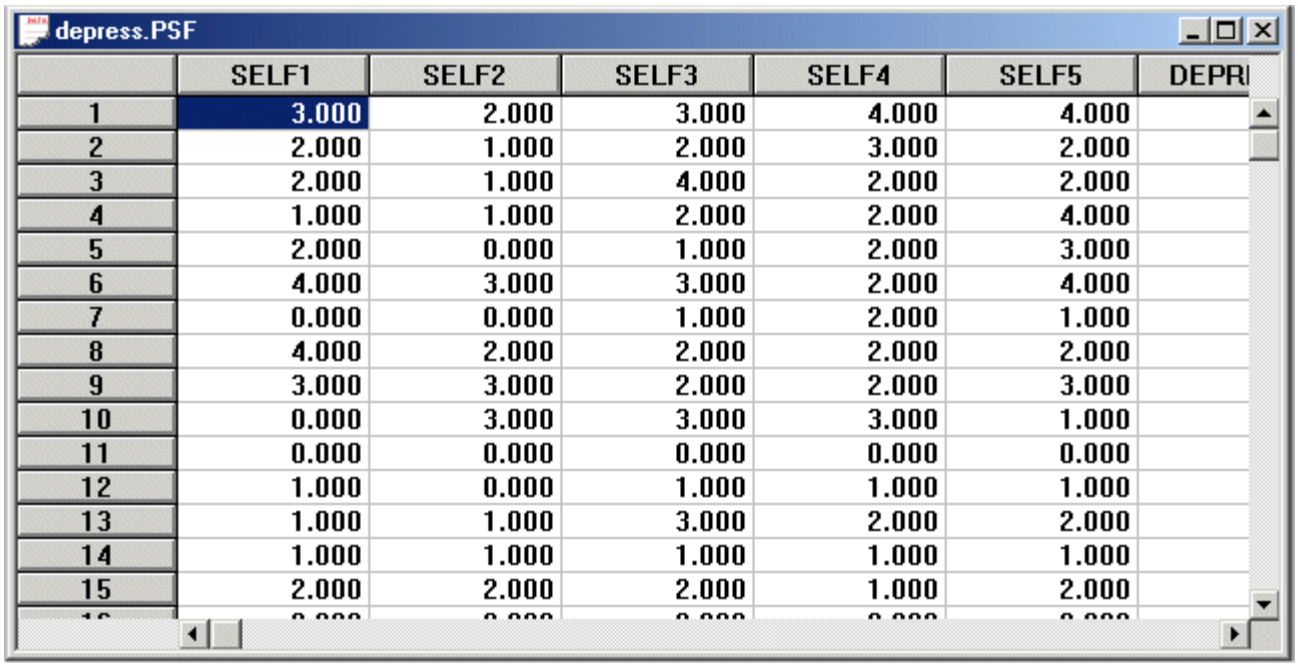
The results above are those for the within schools model.

8. Latent variable scores and observational residuals

LISREL for Windows can compute latent variable scores for the latent variables of a structural equation model with latent variables. The statistical theory and methods for these scores are provided by Jöreskog (2000). In addition, LISREL for Windows can also compute observational residuals for structural equation models. These residuals are based on the methods in Bollen & Arminger (1991) and are described in Jöreskog, Sörbom & Wallentin (2006). In this section, we use LISREL for Windows to obtain latent variable scores as well as observational residuals for depression data.

The data

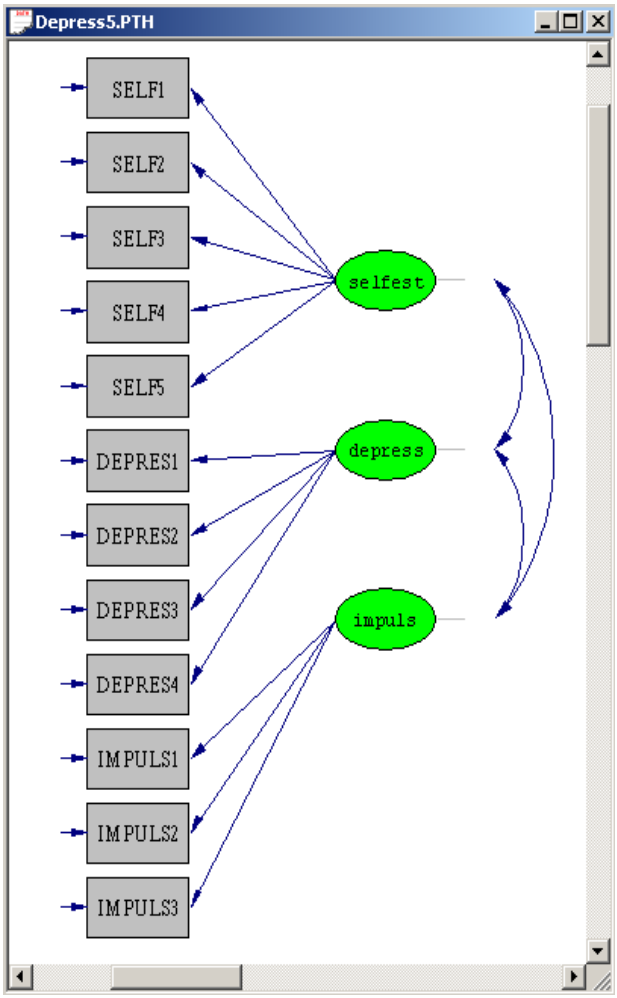
The data file ***depress.PSF*** in the ***TUTORIAL*** subfolder contains 204 observations of 12 indicators of three latent variables. More specifically, the first 5 indicators (SELF1 to SELF5) are indicators of the latent variable *Self-esteem*, DEPRES1 to DEPRES4 are indicators of the latent variable *Depressiveness* and IMPULS1 to IMPULS3 are indicators of the latent variable *Impulsiveness*. The first portion of the data file is shown in the following ***PSF*** window.



	SELF1	SELF2	SELF3	SELF4	SELF5	DEPR
1	3.000	2.000	3.000	4.000	4.000	
2	2.000	1.000	2.000	3.000	2.000	
3	2.000	1.000	4.000	2.000	2.000	
4	1.000	1.000	2.000	2.000	4.000	
5	2.000	0.000	1.000	2.000	3.000	
6	4.000	3.000	3.000	2.000	4.000	
7	0.000	0.000	1.000	2.000	1.000	
8	4.000	2.000	2.000	2.000	2.000	
9	3.000	3.000	2.000	2.000	3.000	
10	0.000	3.000	3.000	3.000	1.000	
11	0.000	0.000	0.000	0.000	0.000	
12	1.000	0.000	1.000	1.000	1.000	
13	1.000	1.000	3.000	2.000	2.000	
14	1.000	1.000	1.000	1.000	1.000	
15	2.000	2.000	2.000	1.000	2.000	

The model

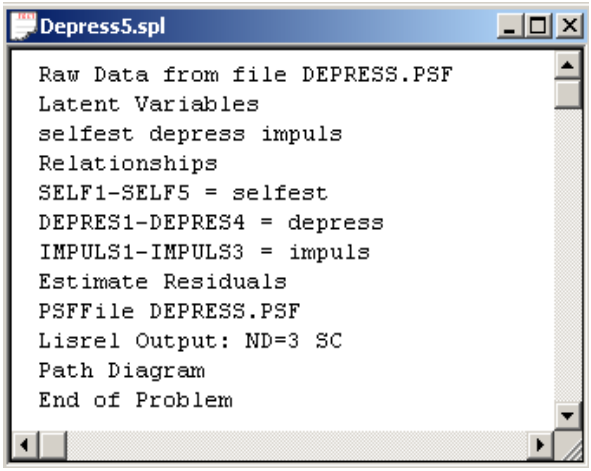
The theoretical measurement model specifies that the 12 indicators are indeed indicators of the latent variables *Self-esteem*, *Depressiveness* and *Impulsiveness*. A path diagram of this model is shown below.



Computing latent variable scores and observational residuals

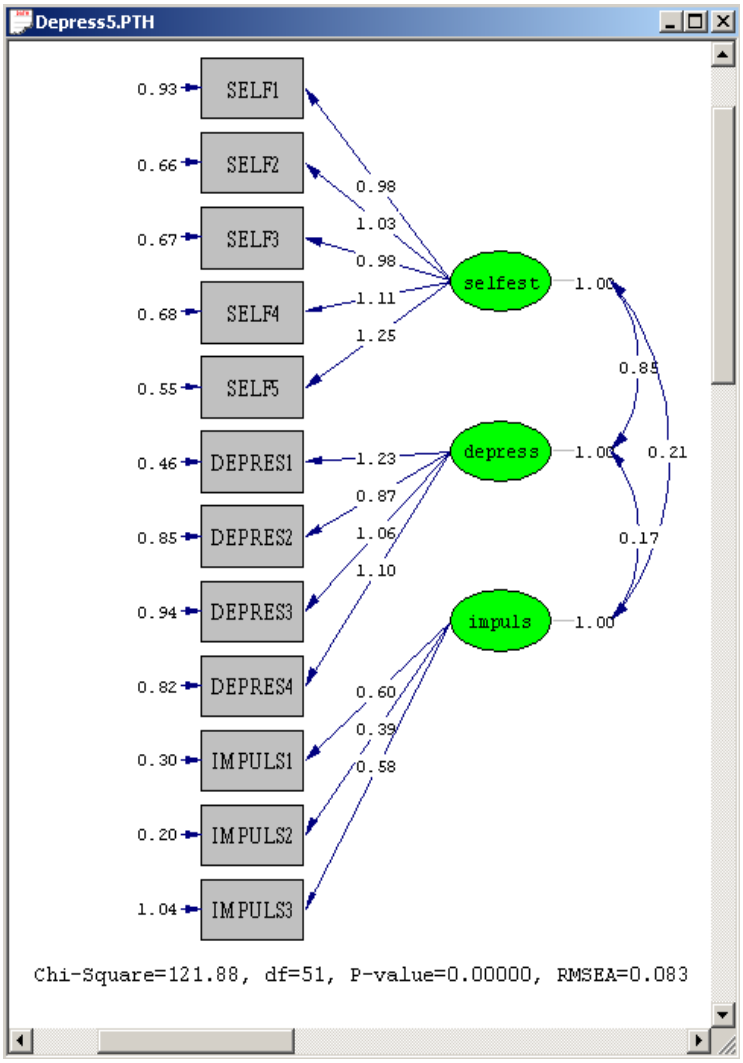
Submitting the SIMPLIS syntax file

- Select the ***Open*** option on the ***File*** menu to load the ***Open*** dialog box.
- Browse for the file ***depress5.spl*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the following text editor window.



Line 1 specifies the raw data source.
Lines 2 and 3 specify labels for the latent variables of the model.
Lines 4 to 7 are used to specify the measurement model for the latent variables *Self-esteem*, *Depressiveness* and *Impulsiveness*.
Lines 8 and 9 instruct LISREL for Windows to append the observational residuals and the latent variable scores as columns of the file ***depress.PSF*** and write the resulting file to ***depressnew.psf***.
Line 10 requests that the results in the output file should be given in terms of the LISREL model for the structural equation model (LISREL Output). It also requests that the results should be written to three decimal places (ND=3) and that the completely standardized solution should be written to the output file (SC).
Line 11 requests a path diagram of the model.
Line 12 indicates that no more SIMPLIS commands are to be processed.

- Click on the ***Run LISREL*** button  to produce the following ***PTH*** window.



The latent variable scores and the observational residuals are the final columns of the file ***depressnew.psf***. We access this file as follows.

- Select the ***Open*** option from the ***File*** menu to load the ***Open*** dialog box.

- Select the ***PRELIS Data (*.psf)*** option from the ***Files of type*** drop-down list box.
- Browse for the file ***depressnew.psf*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the following ***PSF*** window.

DEPRESSnew.psf

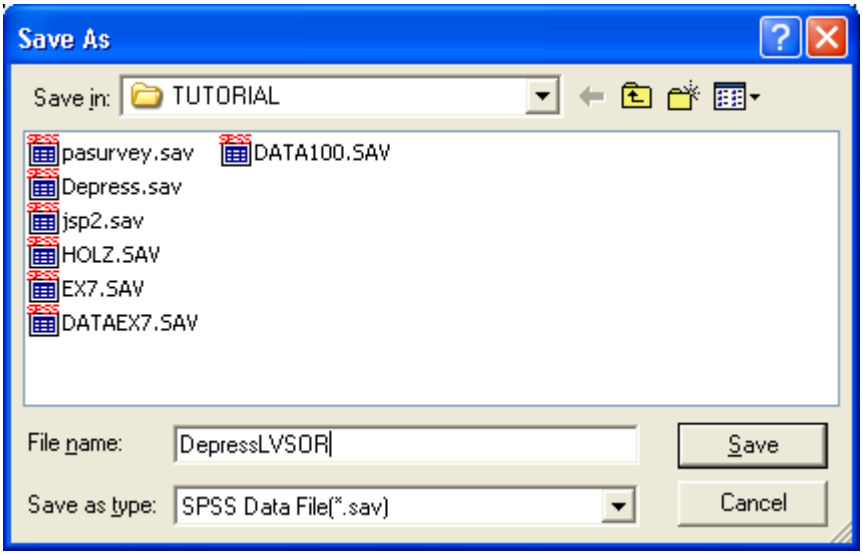
	selfest	depress	impuls	R_SELF1	R_SELF2	R_SELF3	R_SELF4
1	1.127	0.960	-0.551	-0.006	-0.878	0.067	0.529
2	0.003	-0.251	1.468	0.100	-0.719	0.173	0.776
3	0.201	0.470	-0.584	-0.094	-0.922	1.979	-0.443
4	0.376	1.500	-0.580	-1.267	-1.104	-0.194	-0.638
5	-0.143	0.538	0.502	0.244	-1.568	-0.683	-0.062
6	1.023	0.583	0.046	1.097	0.230	0.170	-1.355
7	-0.917	-0.444	-0.423	-0.995	-0.771	0.078	0.796
8	0.273	0.481	-0.582	1.835	0.003	-0.092	-0.523
9	0.657	1.421	-0.569	0.456	0.607	-0.470	-0.950
10	0.150	0.903	-0.587	-2.045	1.130	1.029	0.613
11	-1.745	-1.635	-0.452	-0.180	0.083	-0.107	-0.285
12	-1.074	-1.240	-0.628	0.160	-0.608	0.234	-0.029
13	-0.129	-0.202	-0.595	-0.770	-0.582	1.304	-0.077
14	-0.864	-0.767	-0.621	-0.047	0.175	0.026	-0.262
15	-0.236	-0.671	-0.598	0.335	0.528	0.409	-0.959

The final twelve columns contain the observational residuals for the measurement model while the three preceding columns contain the latent variable scores for the latent variables *Self-esteem*, *Depressiveness* and *Impulsiveness*.

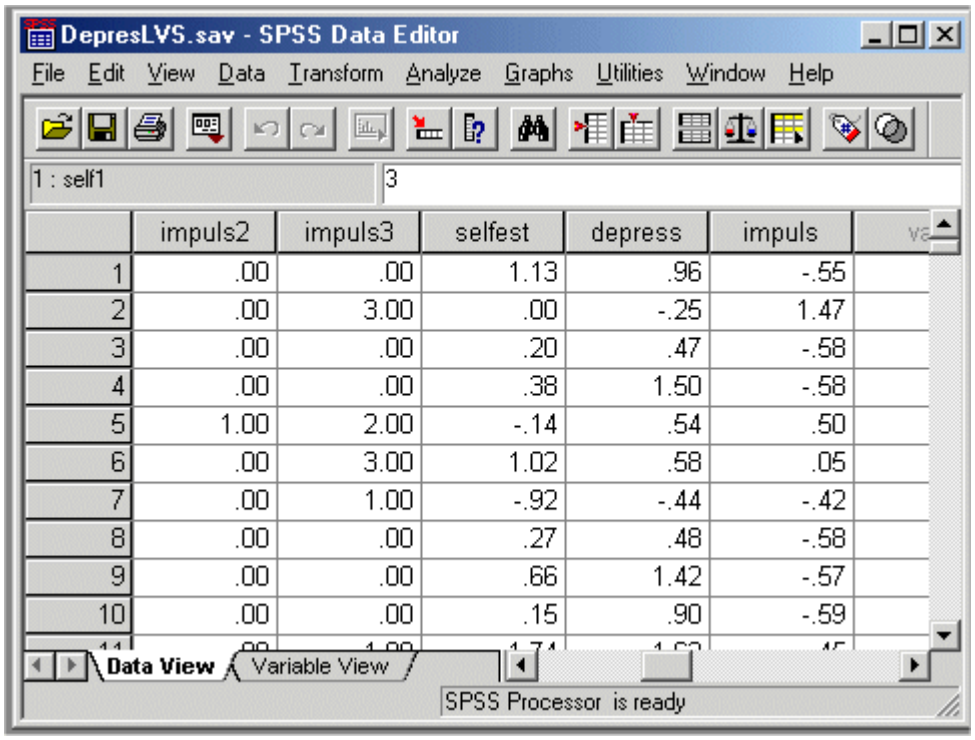
Exporting the latent variable scores and observational residuals

The latent variable scores and observational residuals can also be exported as an SPSS data (****.sav***), a Microsoft Excel (****.xls***), a comma-separated (****.csv***) or a tab-delimited (****.txt***) file. This is extremely useful if external analyses of the latent variable scores and observational residuals are required. The following procedure may be used to export the file ***depressnew.psf*** as the SPSS data file ***DepresLVSOR.sav***.

- Select the ***Open*** option from the ***File*** menu to load the ***Open*** dialog box.
- Select the ***PRELIS Data (*.psf)*** option from the ***Files of type*** drop-down list box.
- Browse for the file ***depressnew.psf*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the ***PSF*** window for ***depressnew.PSF***.
- Use the ***Export Data*** option on the ***File*** menu to load the ***Save As*** dialog box.
- Select the ***SPSS Data File (*.sav)*** option from ***Save as type*** dropdown list box.
- Enter the name ***DepresLVSOR*** in the file name string field to produce the following ***Save As*** dialog box.



- Click on the ***Save*** button to create ***DepresLVSOR.sav***.
- A portion of the resulting SPSS data file ***DepresLVSOR.sav*** is shown in the following SPSS Data Editor window.



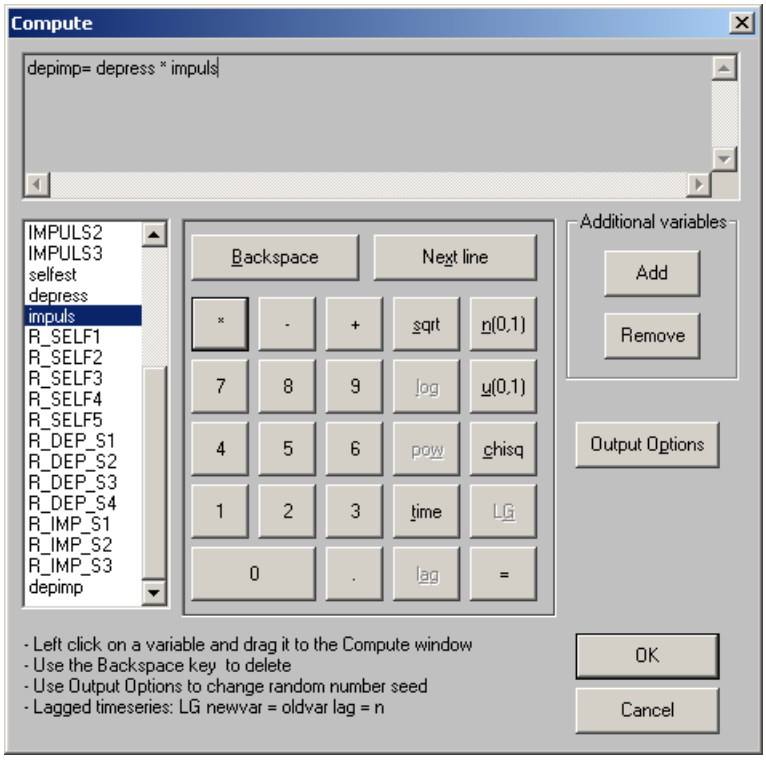
	impuls2	impuls3	selfest	depress	impuls
1	.00	.00	1.13	.96	-.55
2	.00	3.00	.00	-.25	1.47
3	.00	.00	.20	.47	-.58
4	.00	.00	.38	1.50	-.58
5	1.00	2.00	-.14	.54	.50
6	.00	3.00	1.02	.58	.05
7	.00	1.00	-.92	-.44	-.42
8	.00	.00	.27	.48	-.58
9	.00	.00	.66	1.42	-.57
10	.00	.00	.15	.90	-.59

9. Using latent variable scores

Latent variable scores for the latent variables *Self-esteem*, *Depressiveness* and *Impulsiveness* were computed from the file ***depress.psf*** and written to the file ***depressnew.psf*** in section 8. The following step-by-step procedure may be used to fit a regression model with an interaction term to these latent variable scores.

Computing the values of the interaction variable

- Select the ***Open*** option from the ***File*** menu to load the ***Open*** dialog box.
- Select the ***PRELIS Data (*.psf)*** option from the ***Files of type*** drop-down list box.
- Browse for the file ***depressnew.PSF*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the ***PSF*** window for ***depressnew.PSF***.
- Use the ***Compute*** option from the ***Transformation*** menu to load the ***Compute*** dialog box.
- Click on the ***Add*** button to load the ***Add Variables*** dialog box.
- Enter the name ***depimp*** for the interaction between the latent variables scores of the latent variables *Depressiveness* and *Impulsiveness* in the string box.
- Click on the ***OK*** button to return to the ***Compute*** dialog box.
- Click and drag the variable name ***depimp*** to the top left of the string box.
- Click on the **=** key on the keypad to add an "=" sign to the string box.
- Click and drag the variable name ***depress*** to the top right of the string box.
- Click on the ***** key on the keypad to insert the symbol "*" for multiplication in the string box.
- Click and drag the variable name ***impuls*** to the top right of the string box to produce the following ***Compute*** dialog box.



- Click on the ***OK*** button to run PRELIS to produce the following ***PSF*** window.

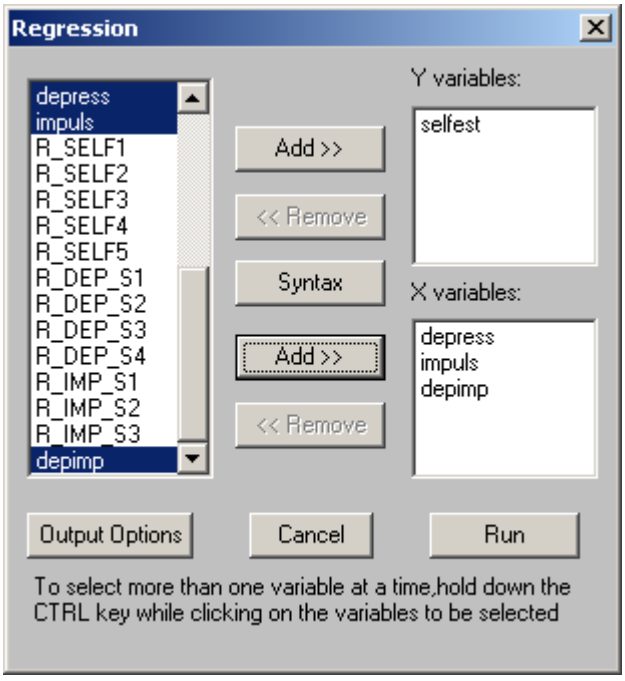
DEPRESSnew.psf

	R_DEP_S1	R_DEP_S2	R_DEP_S3	R_DEP_S4	R_IMP_S1	R_IMP_S2	R_IMP_S3	depimp
1	0.758	0.126	-2.982	0.905	-0.015	0.020	-0.681	-0.529
2	1.251	-0.814	-1.693	-0.763	0.766	-0.772	1.151	-0.369
3	-0.638	-1.446	1.539	1.444	0.005	0.033	-0.662	-0.275
4	0.092	0.653	0.443	0.312	0.002	0.031	-0.665	-0.869
5	-0.722	-0.505	1.466	1.369	-0.651	0.607	0.710	0.270
6	-0.778	-0.544	0.419	1.320	-0.376	-0.214	1.973	0.027
7	0.488	-0.646	0.511	-0.551	-0.092	-0.030	0.245	0.188
8	-0.652	-1.455	1.527	1.432	0.003	0.032	-0.664	-0.280
9	0.189	-0.278	0.527	0.398	-0.004	0.027	-0.671	-0.809
10	-0.172	-0.824	1.078	0.968	0.006	0.034	-0.661	-0.530
	-0.043	0.396	-0.221	-0.242	-0.075	-0.019	0.261	0.738

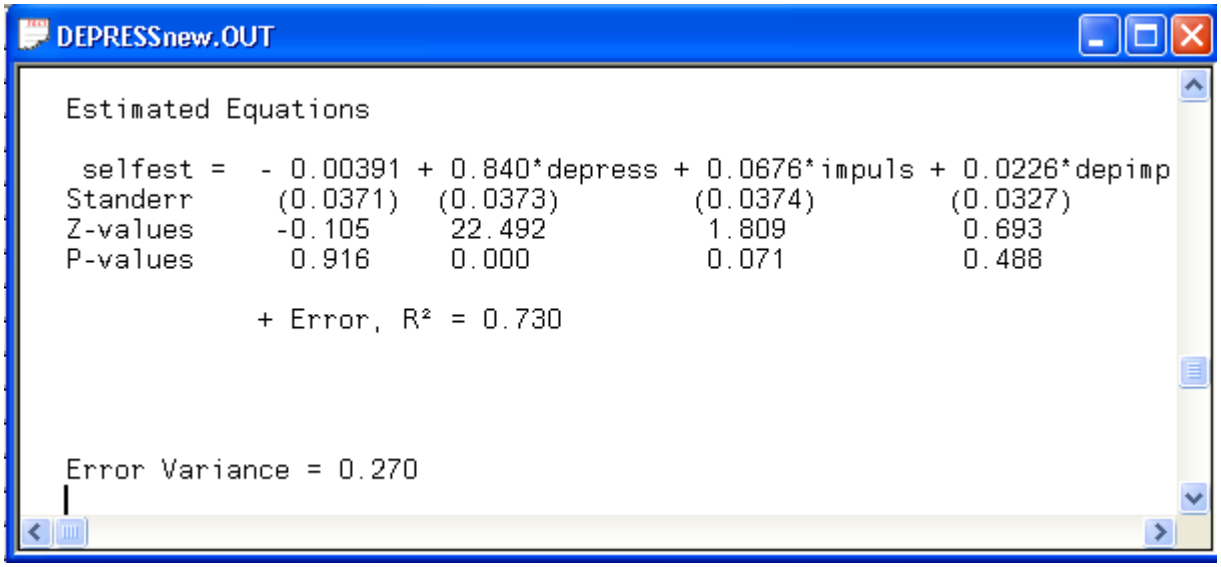
The final column of the ***PSF*** window above contains the interaction scores.

Performing the regression analysis

- Select the ***Regressions*** option from the ***Statistics*** menu to load the ***Regression*** dialog box.
- Highlight the variable name ***selfest*** and click on the Y-variables ***Add*** button.
- Highlight the variable names ***depress***, ***impuls***, and ***depimp*** and click on the X-variables ***Add*** button to generate the following ***Regression*** dialog box.



- Click on the ***Run*** button to run PRELIS to produce the text editor window for ***depressnew.OUT***. A portion of this output file is shown in the following text editor window.

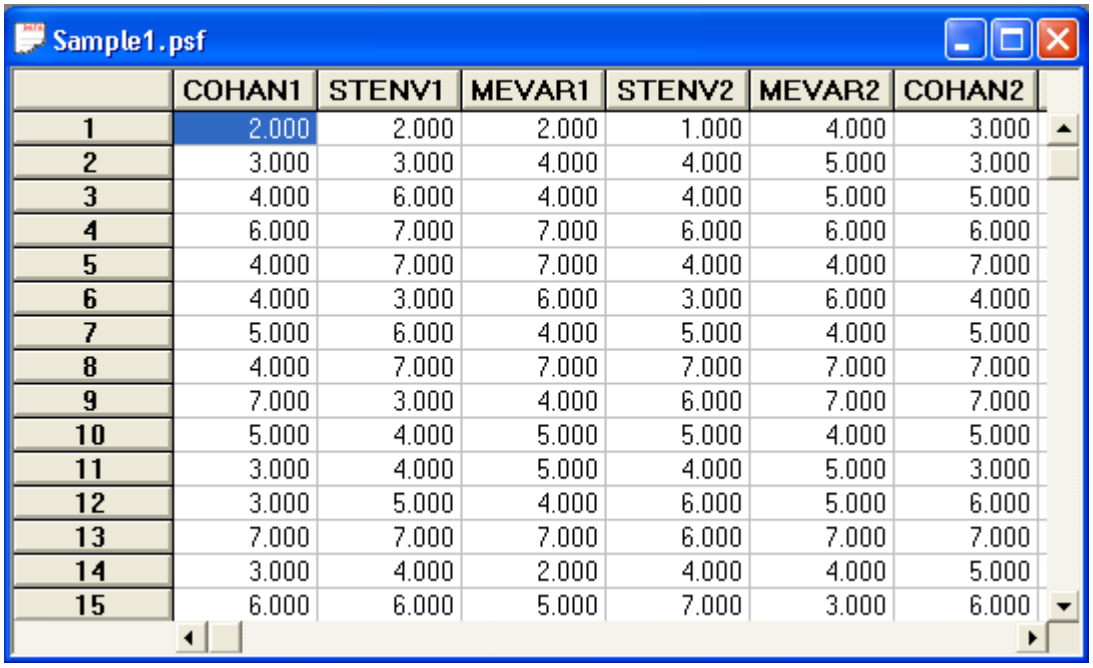

DEPRESSnew.OUT
Estimated Equations
selfest = - 0.00391 + 0.840*depress + 0.0676*impuls + 0.0226*depimp
Standerr (0.0371) (0.0373) (0.0374) (0.0327)
Z-values -0.105 22.492 1.809 0.693
P-values 0.916 0.000 0.071 0.488
+ Error, R² = 0.730
Error Variance = 0.270

10. Cross validation

The cross validation of a structural equation model refers to the ability of the model to be invariant across two or more random samples from the same population. In this section, we demonstrate how LISREL for Windows can be used to assess the cross validation of a measurement model.

The data

Boshoff & Terblanche (2003) consider the cross validation of a measurement model for retail experience. A variation of this measurement model will be used to illustrate how the multiple group feature of LISREL for Windows may be used to assess the cross validation of a structural equation model. This measurement model specifies COHAN1 to COHAN3 to be indicators of Complaint HANdling (COHAN), STENV1 to STENV5 to be indicators of STore ENVironment (STENV) and MEVAR1 to MEVAR4 to be indicators of MErchandise VARiety (MEVAR). Data on these 11 indicators for two samples of South African consumers are provided in the files SAMPLE1.PSF and SAMPLE2.PSF in the TUTORIAL subfolder. The first portions of these data files are shown in the following two PSF windows.


Sample1.psf

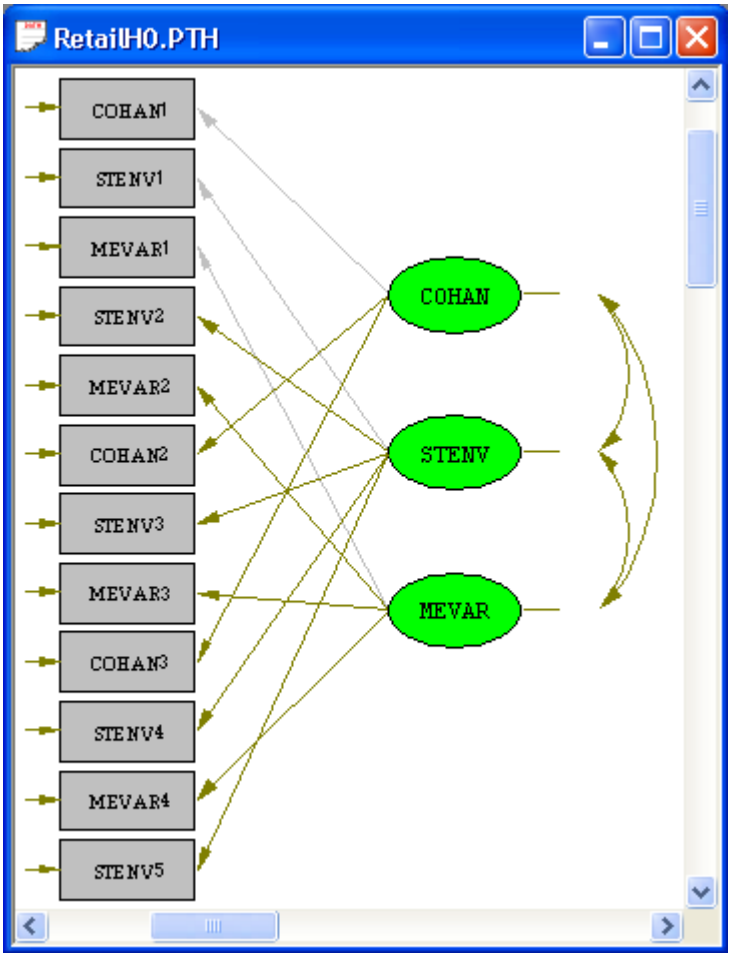
	COHAN1	STENV1	MEVAR1	STENV2	MEVAR2	COHAN2
1	2.000	2.000	2.000	1.000	4.000	3.000
2	3.000	3.000	4.000	4.000	5.000	3.000
3	4.000	6.000	4.000	4.000	5.000	5.000
4	6.000	7.000	7.000	6.000	6.000	6.000
5	4.000	7.000	7.000	4.000	4.000	7.000
6	4.000	3.000	6.000	3.000	6.000	4.000
7	5.000	6.000	4.000	5.000	4.000	5.000
8	4.000	7.000	7.000	7.000	7.000	7.000
9	7.000	3.000	4.000	6.000	7.000	7.000
10	5.000	4.000	5.000	5.000	4.000	5.000
11	3.000	4.000	5.000	4.000	5.000	3.000
12	3.000	5.000	4.000	6.000	5.000	6.000
13	7.000	7.000	7.000	6.000	7.000	7.000
14	3.000	4.000	2.000	4.000	4.000	5.000
15	6.000	6.000	5.000	7.000	3.000	6.000

Sample2.psf

	COHAN1	STENV1	MEVAR1	STENV2	MEVAR2	COHAN2
1	3.000	4.000	4.000	3.000	4.000	4.000
2	5.000	3.000	6.000	6.000	5.000	2.000
3	6.000	6.000	5.000	5.000	5.000	6.000
4	5.000	7.000	7.000	5.000	7.000	7.000
5	6.000	7.000	6.000	7.000	7.000	7.000
6	3.000	4.000	6.000	3.000	6.000	2.000
7	1.000	4.000	4.000	4.000	4.000	1.000
8	6.000	4.000	5.000	4.000	5.000	6.000
9	4.000	3.000	6.000	4.000	6.000	4.000
10	3.000	5.000	6.000	4.000	6.000	6.000
11	7.000	6.000	6.000	7.000	5.000	6.000
12	7.000	7.000	7.000	7.000	7.000	7.000
13	7.000	7.000	7.000	7.000	4.000	7.000
14	6.000	7.000	6.000	5.000	7.000	6.000
15	3.000	3.000	7.000	2.000	7.000	3.000

The model

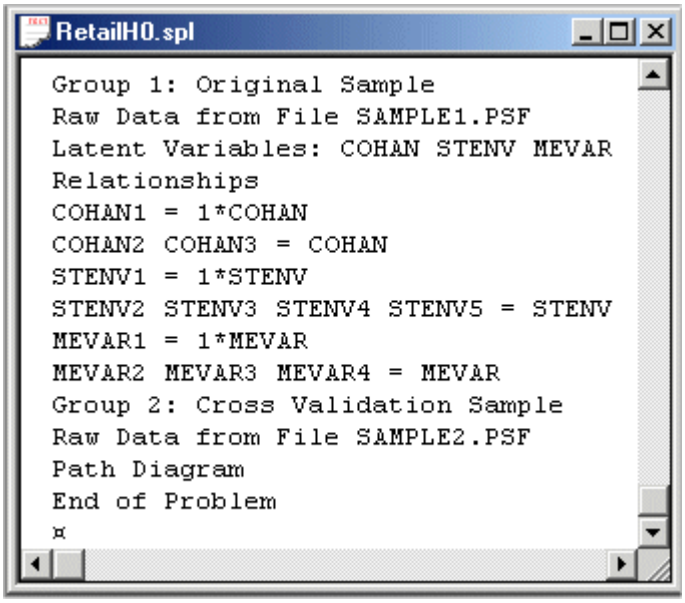
The measurement model specifies COHAN1 to COHAN3 to be indicators of *Complaint HANdling (COHAN)*, STENV1 to STENV5 to be indicators of *STore ENVironment (STENV)*, and MEVAR1 to MEVAR4 to be indicators of *MErchandise VARiety (MEVAR)*. This model is depicted in the following path diagram.



The analysis

The following step-by-step procedure may be used to assess the cross-validation of the measurement model for retail experience across the two samples.

- Use the ***Open*** option on the ***File*** menu to load the ***Open*** dialog box.
- Browse for the SIMPLIS syntax file ***RetailH0.spl*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the following text editor window.

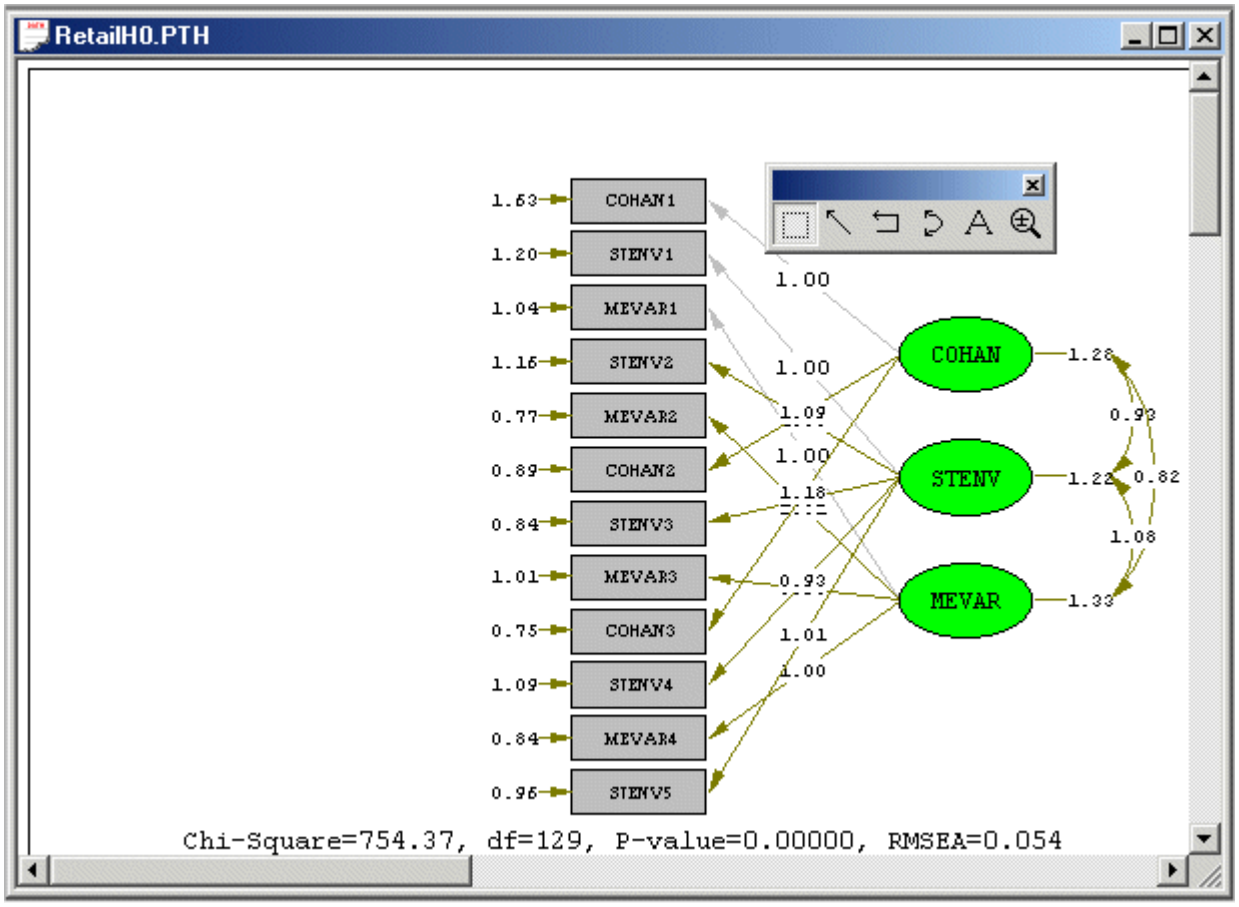


The SIMPLIS syntax file above specifies the measurement models under the null hypothesis. This null hypothesis states that the measurement model parameters (factor loadings, factor variances, factor covariances and measurement error variances) are identical (invariant) across the two samples.

The first line identifies the first sample as the first group.
The second line provides the raw data source for the first sample.
Line 3 provides labels for the 3 latent variables.
Lines 4-10 specify the measurement model for the first sample.
Line 11 identifies the second sample as the second group.
Line 12 provides the raw data source for the second sample.
Line 13 requests a path diagram in the form of a ***PTH*** file.
Line 14 indicates the end of the SIMPLIS commands to be processed.

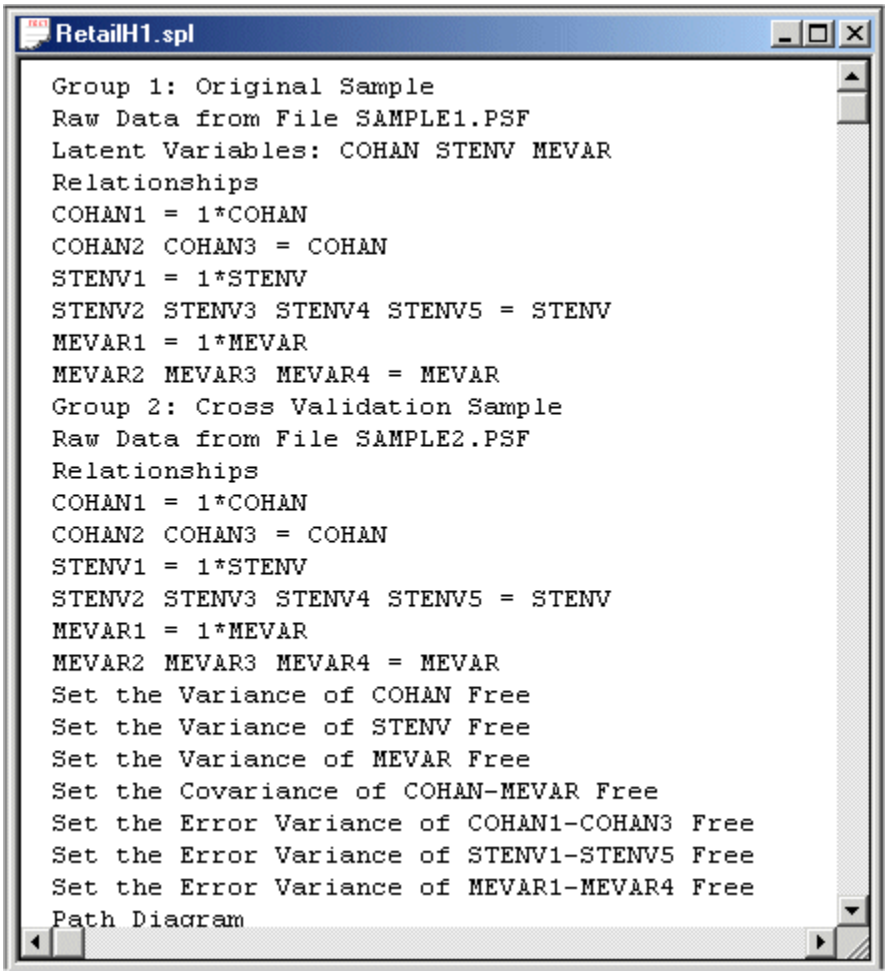
Since no ***Relationships*** paragraph is used for the second sample, all parameters are assumed to be equal across the two samples.

- Click on the ***Run LISREL*** button  to produce the following ***PTH*** window.



The alternative hypothesis states that at least two parameters of the measurement model are not identical across the two samples. The measurement models for the two samples under this alternative hypothesis are specified in the SIMPLIS syntax file ***RetailH1.spl***.

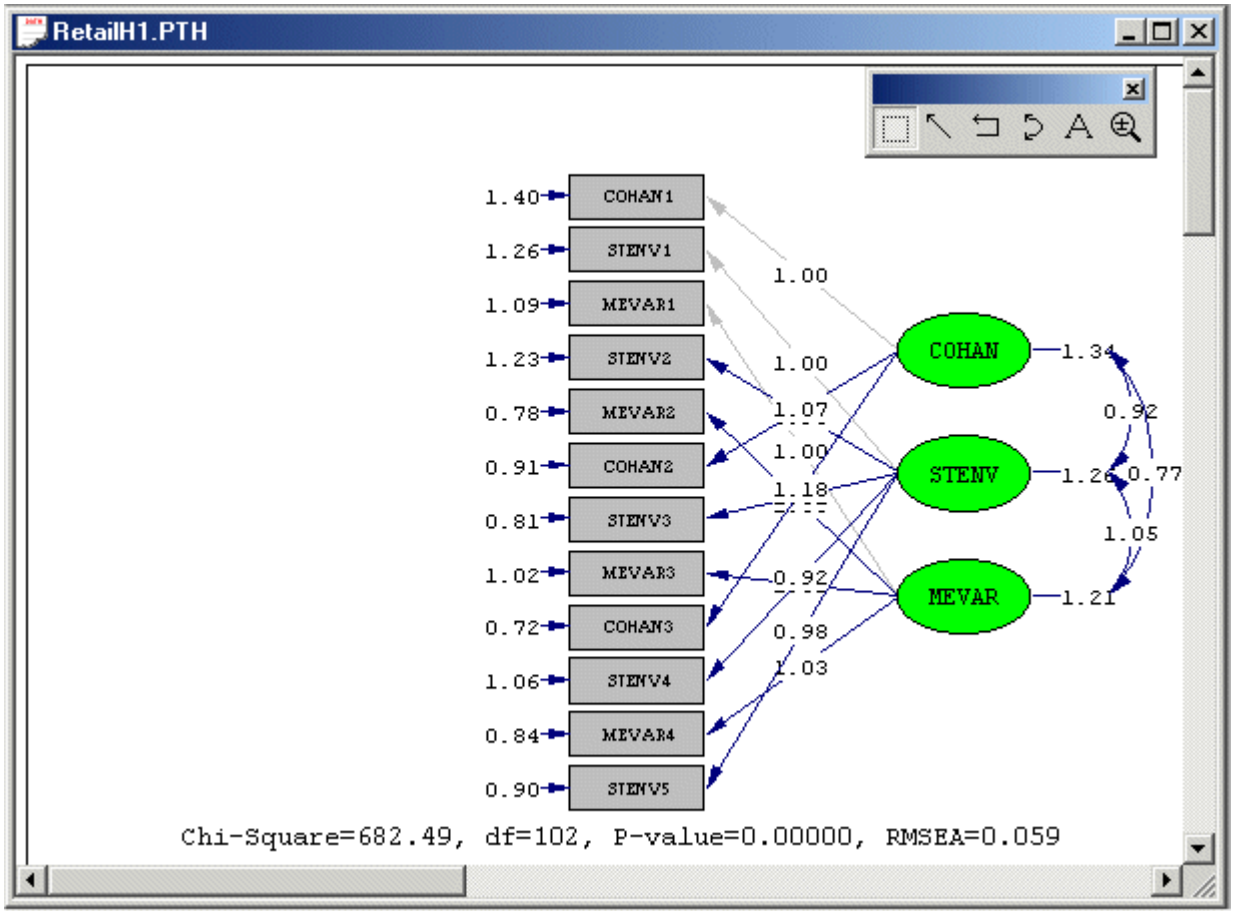
- Use the ***Open*** option on the ***File*** menu to load the ***Open*** dialog box.
- Browse for the SIMPLIS syntax file ***RetailH1.spl*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the following text editor window.



The first line identifies the first sample as the first group.
The second line provides the raw data source for the first sample.
Line 3 provides labels for the 3 latent variables.
Lines 4-10 specify the measurement model for the first sample.
Line 11 identifies the second sample as the second group.
Line 12 provides the raw data source for the second sample.
Lines 13-26 specify the measurement model for the second sample.
Line 27 requests a path diagram in the form of a PTH file.
Line 28 indicates the end of the SIMPLIS syntax commands to be processed.

Note that the ***Set*** commands for the second sample are required to ensure that the factor variances, factor covariances and measurement error variances are different across the two samples. Otherwise, these parameters are assumed to be equal across the two samples.

- Click on the ***Run LISREL*** button  to produce the following ***PTH*** window.



A Chi-square difference test is used to assess the cross validation of the measurement model. In other words, a Chi-square difference test is used to test the null and alternative hypotheses. The test statistic value for the Chi-square difference test is merely the difference between the goodness-of-fit Chi-square test statistic values of the measurement models under the null and the alternative hypotheses. The associated degrees of freedom are merely the difference between the degrees of freedom of the measurement models under the null and the alternative hypotheses. The Chi-square difference test results for the measurement model for retail experience are summarized in the MS-Excel workbook ***Retail.xls***. The contents of this file are shown below.

Retail.xls

	A	B	C	D	E	F	G
1		MINIMUM FIT FUNCTION CHI-SQUARE			NORMAL-THEORY WLS CHI-SQUARE		
2	HYPOTHESIS	CHISQ	DF	P-VALUE	CHISQ	DF	P-VALUE
3	EQUAL	741.92	129	8.47538E-87	754.37	129	4.81E-89
4	UNEQUAL	665.8	102	1.33781E-83	682.49	102	1.09137E-86
5	DIFFERENCE	76.12	27	1.44194E-06	71.88	27	6.02468E-06

Sheet1 Sheet2 Sheet3

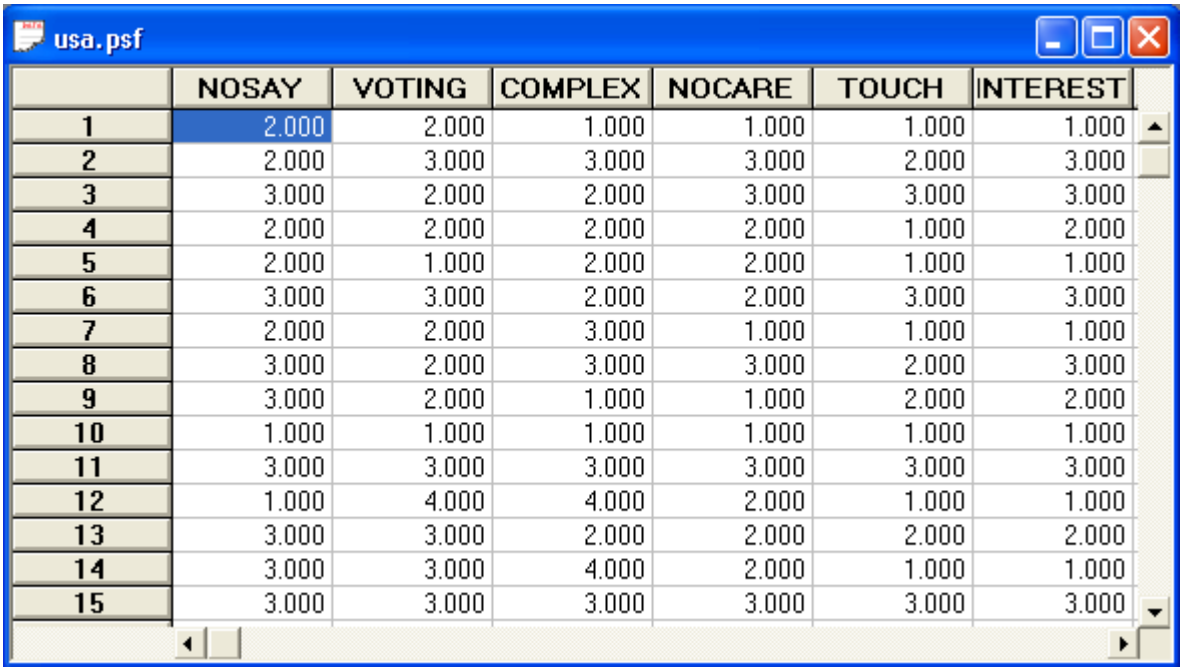
The small P-values suggest that there is sufficient evidence that the null hypothesis is rejected. In other words, the cross validation of the measurement model for retail experience is not supported by the data of the two samples.

11. Logistic regression analysis

LISREL for Windows can also be used to perform a logistic regression analysis. In this section, we illustrate this feature by fitting a logistic regression model to political data.

The data

Barnes & Kaase (1979) conducted a cross-national survey to obtain information on conventional and unconventional forms of political participation in industrial societies. This survey is known as the Political Action Survey. This survey included several attitude and perception statements to which the respondents had to respond to as one of agree strongly, agree, disagree, disagree strongly, don't know or no answer. The perception of an individual's influence on government was assessed by using the statement "People like me have no say in what the government does." The responses (NOSAY) of a sample of 1076 United States respondents, along with their gender (NOSAY), education level (EDUCAT) and age (AGE), are listed in the file USA.PSF in the TUTORIAL subfolder. The first portion of this data file is shown in the following PSF window.


usa.psf

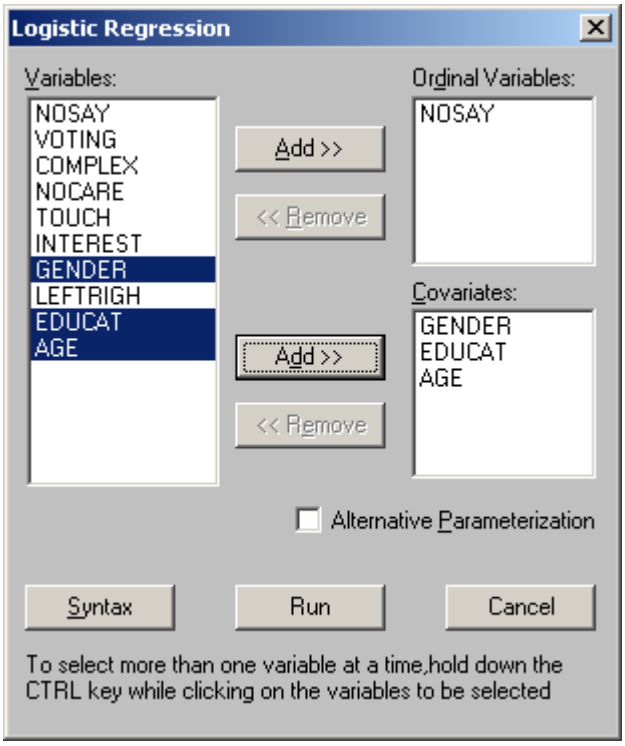
	NOSAY	VOTING	COMPLEX	NOCARE	TOUCH	INTEREST
1	2.000	2.000	1.000	1.000	1.000	1.000
2	2.000	3.000	3.000	3.000	2.000	3.000
3	3.000	2.000	2.000	3.000	3.000	3.000
4	2.000	2.000	2.000	2.000	1.000	2.000
5	2.000	1.000	2.000	2.000	1.000	1.000
6	3.000	3.000	2.000	2.000	3.000	3.000
7	2.000	2.000	3.000	1.000	1.000	1.000
8	3.000	2.000	3.000	3.000	2.000	3.000
9	3.000	2.000	1.000	1.000	2.000	2.000
10	1.000	1.000	1.000	1.000	1.000	1.000
11	3.000	3.000	3.000	3.000	3.000	3.000
12	1.000	4.000	4.000	2.000	1.000	1.000
13	3.000	3.000	2.000	2.000	2.000	2.000
14	3.000	3.000	4.000	2.000	1.000	1.000
15	3.000	3.000	3.000	3.000	3.000	3.000

The analysis

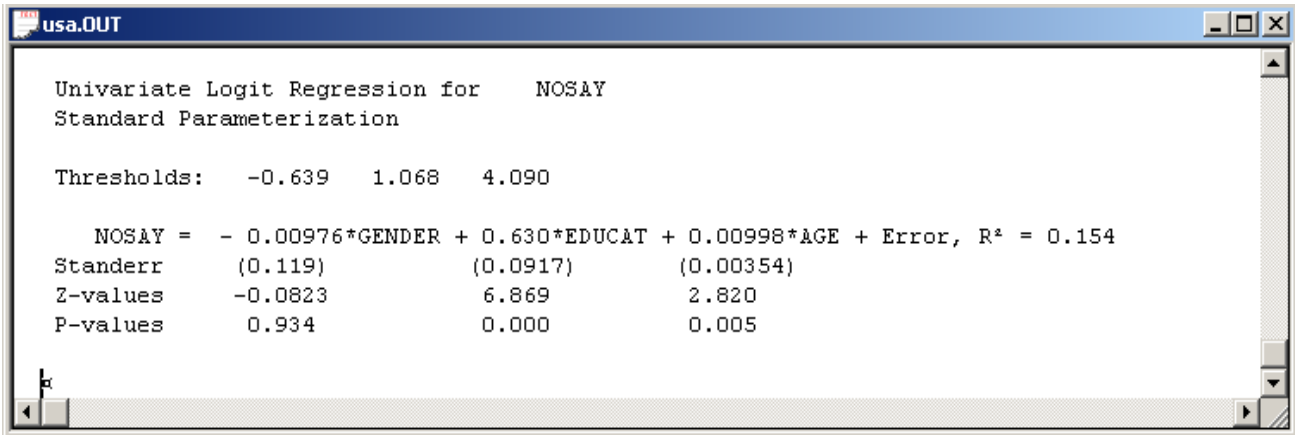
The following step-by-step procedure may be used to perform a logistic regression analysis on ***NOSAY*** with gender, education level, and age as covariates with LISREL for Windows.

- Select the ***Open*** option on the ***File*** menu to access the ***Open*** dialog box**.**
- Select the ***PRELIS Data (*.psf)*** option from the ***Files of type*** drop-down list box.
- Browse for the file ***USA.psf*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the ***PSF*** window for ***USA.psf***.
- Select the ***Logistic Regressions…*** option on the ***Statistics*** menu of the ***PSF*** window to access the ***Logistic Regression*** dialog box.
- Click on the label ***NOSAY*** in the ***Variables:*** list box to highlight it.

- Click on the ***Add >>*** button of the ***Ordinal Variables:*** list box.
- Select the labels ***GENDER***, ***EDUCAT*** and ***AGE*** in the ***Variables:*** list box.
- Click on the ***Add >>*** button of the ***Covariates:*** list box to produce the following dialog box.



- Click on the ***Run*** button to open the following text editor window.



12. Censored regression analysis

LISREL for Windows can be used to perform a censored regression analysis. In this section, we illustrate this feature by fitting a censored regression model to water data.

The data

In a study about the determinants of Tributyltin (TBT) and Dibutyltin (DBT) levels of the lakes in California, Gonzalez et al. (1987) measured the pH level (***pH***) and water temperature in degrees Celcius (***WTEMP***), along with the TBT (***TBT***) and DBT (***DBT***) concentrations, for 22 replicate water samples from 10 marinas on 6 lakes in California during August 1987. The resulting data are shown in the following ***PSF*** window.

Marinas.PSF

	pH	WTEMP	TBT	DBT
1	7.100	22.000	0.000	0.000
2	7.100	22.000	0.000	0.000
3	8.500	21.000	0.000	0.000
4	8.500	21.000	17.000	0.000
5	8.400	25.000	0.000	0.000
6	8.400	25.000	0.000	0.000
7	7.100	25.000	17.000	0.000
8	7.100	25.000	0.000	0.000
9	7.900	22.000	34.000	0.000
10	7.900	22.000	20.000	0.000
11	8.500	22.000	17.000	0.000
12	8.500	22.000	17.000	0.000
13	8.900	19.000	1220.000	690.000
14	8.900	19.000	950.000	390.000
15	8.500	19.000	660.000	180.000
16	8.500	19.000	1000.000	370.000
17	6.700	15.000	63.000	0.000
18	6.700	15.000	93.000	0.000
19	7.000	15.000	46.000	0.000
20	7.000	15.000	78.000	0.000
21	7.100	20.000	17.000	0.000
22	7.100	20.000	0.000	0.000

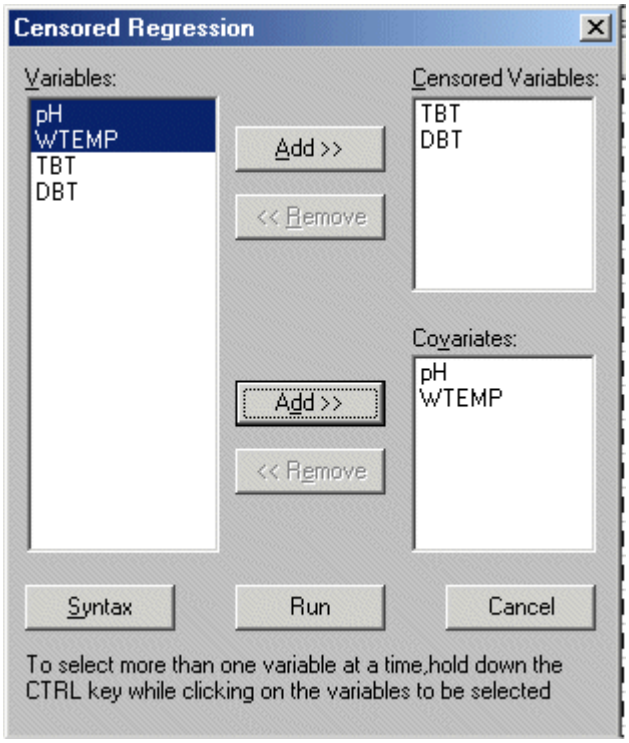
Note that the TBT and the DBT concentration values are censored. In both cases, the censoring is below by zero.

The analysis

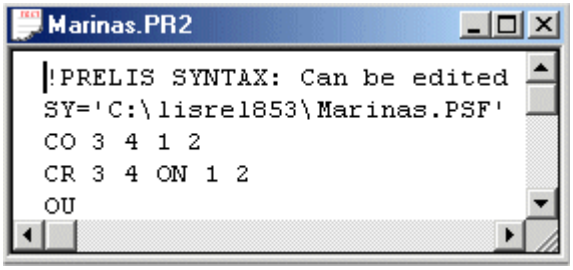
The following step-by-step procedure may be used to perform censored regression analyses on ***TBT*** and ***DBT*** with pH level and water temperature as covariates with LISREL for Windows.

- Select the ***Open*** option on the ***File*** menu to access the ***Open*** dialog box**.**
- Select the ***PRELIS Data (*.psf)*** from the ***Files of type*** drop-down list box.
- Browse for the file ***Marinas.psf*** in the ***TUTORIAL*** subfolder and select it.

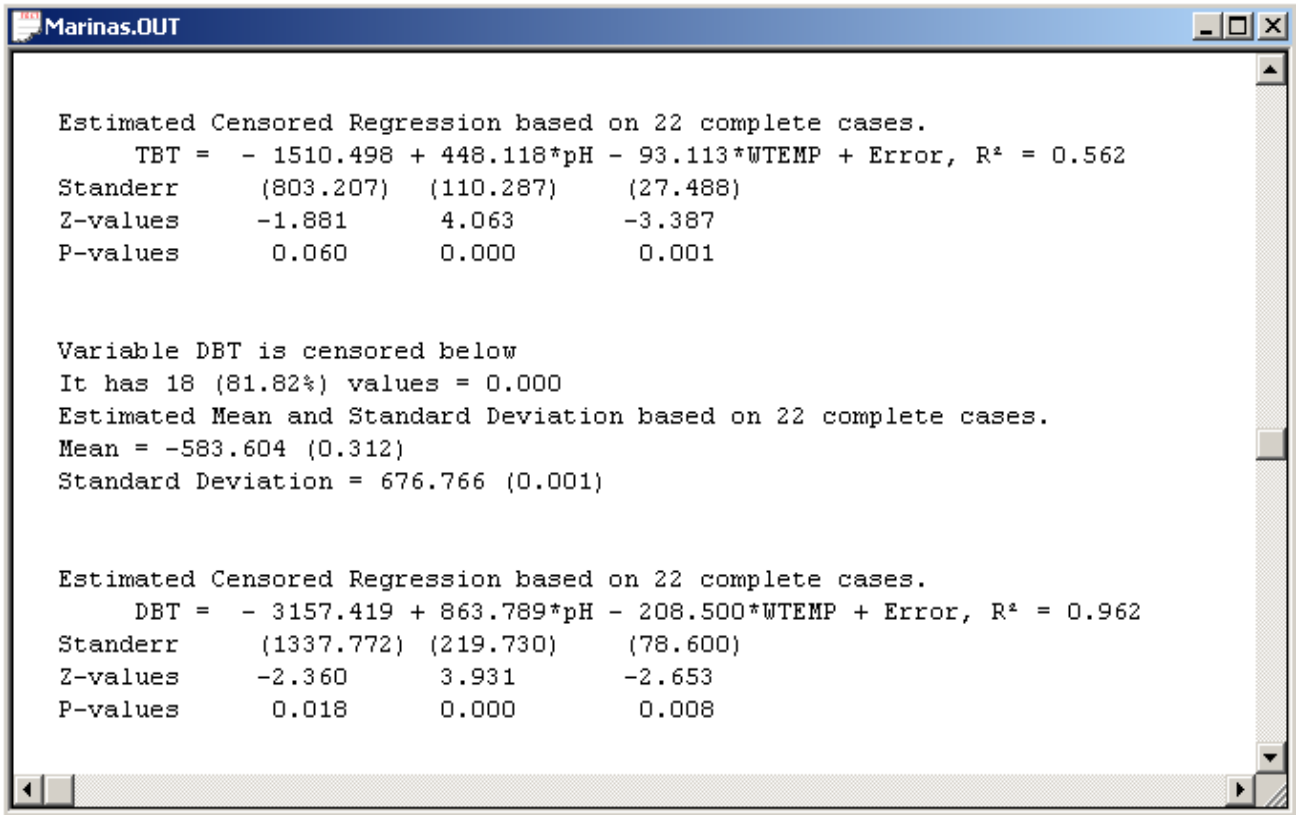
- Click on the ***Open*** button to open the ***PSF*** window for ***Marinas.psf***.
- Select the ***Censored Regressions…*** option on the ***Statistics*** menu of the ***PSF*** window to access the ***Censored Regression*** dialog box.
- Select the labels ***TBT*** and ***DBT*** in the ***Variables:*** list box.
- Click on the ***Add >>*** button of the ***Censored variables:*** list box.
- Select the labels ***pH*** and ***WTEMP*** in the ***Variables:*** list box.
- Click on the ***Add >>*** button of the ***Covariates:*** list box to produce the following dialog box.



- Click on the ***Syntax*** button to open the following text editor window.



- Click on the ***Run PRELIS*** button  to produce the following text editor window.


Marinas.OUT
Estimated Censored Regression based on 22 complete cases.
TBT = - 1510.498 + 448.118*pH - 93.113*WTEMP + Error, R² = 0.562
Standerr (803.207) (110.287) (27.488)
Z-values -1.881 4.063 -3.387
P-values 0.060 0.000 0.001
Variable DBT is censored below
It has 18 (81.82%) values = 0.000
Estimated Mean and Standard Deviation based on 22 complete cases.
Mean = -583.604 (0.312)
Standard Deviation = 676.766 (0.001)
Estimated Censored Regression based on 22 complete cases.
DBT = - 3157.419 + 863.789*pH - 208.500*WTEMP + Error, R² = 0.962
Standerr (1337.772) (219.730) (78.600)
Z-values -2.360 3.931 -2.653
P-values 0.018 0.000 0.008

13. Latent growth curves

LISREL for Windows (Jöreskog & Sörbom 2006) may be used to fit linear and nonlinear latent growth curves to repeated measurements over time. Traditional estimation methods such as Maximum Likelihood (ML), Robust Maximum Likelihood (RML), Weighted Least Squares (WLS), Diagonally Weighted Least Squares (DWLS), Generalized Least Squares (GLS) and Unweighted Least Squares (ULS) are available for complete repeated measurements over time while Full Information Maximum Likelihood (FIML) estimation is available for repeated measurements over time with missing values.

In this section, LISREL for Windows is used to fit a linear Latent Growth Curve (LGC) model with an explanatory latent variable to a data set consisting of repeated measurements over four separate months.

The data

The data set to be considered emanates from a longitudinal study on the growth of the participation of cancer patients in cancer treatment programs. A sample of 374 cancer patients was monitored over a period of four months. At the end of each month, a participation score was computed for each patient. These four scores are labeled as T1PARTIC, T2PARTIC, T3PARTIC and T4PARTIC respectively. In addition, a cancer acceptance score was computed for each patient. The four corresponding scores are labeled as T1ACCEPT, T2ACCEPT, T3ACCEPT and T4ACCEPT respectively. A small portion of the data set is shown in the following PSF window for LGC.PSF which is located in the TUTORIAL subfolder.

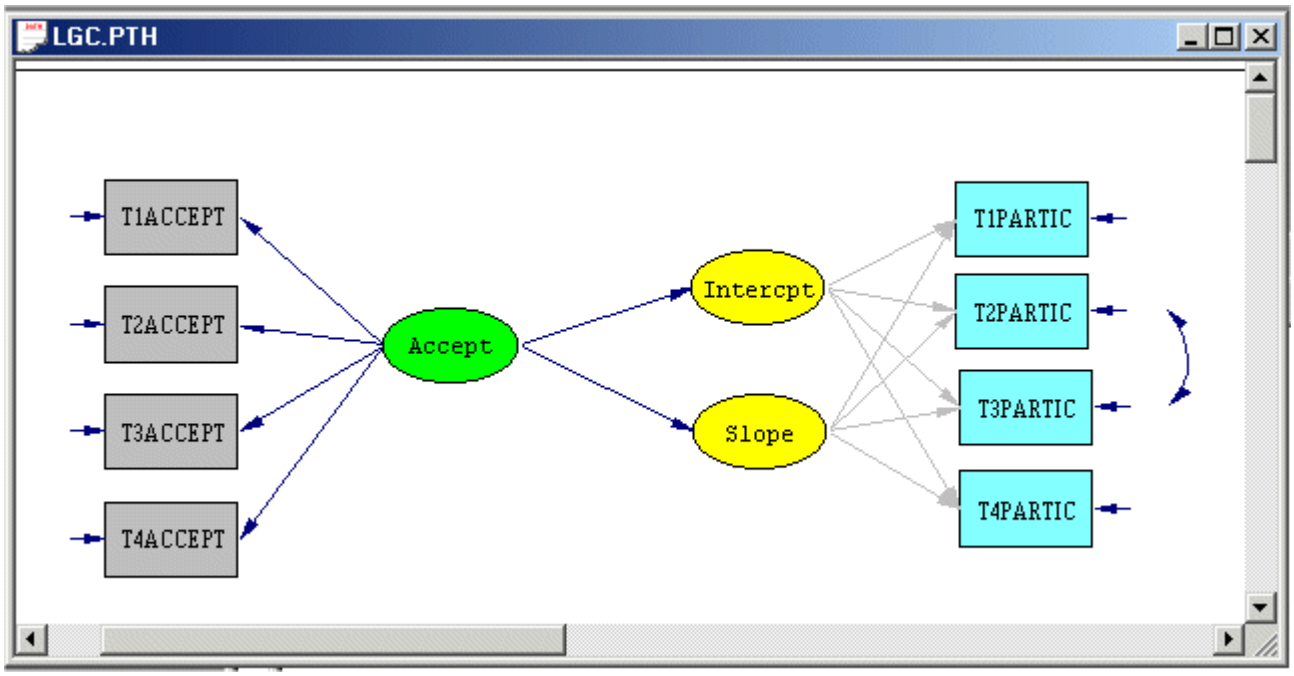
lgc.psf

	T1ACCEPT	T2ACCEPT	T3ACCEPT	T4ACCEPT	T1MUTBF	T1TCHCHD	T1PART
1	-0.006	-0.072	0.919	-0.046	2.692	3.696	3.
2	0.695	0.210	0.509	-0.723	2.759	2.892	3.
3	-0.245	-0.322	-1.110	-0.632	1.430	3.337	3.
4	0.001	0.739	0.557	-0.231	1.933	2.706	2.
5	0.628	0.841	-0.442	0.918	3.723	3.361	2.
6	-0.315	0.323	0.630	0.049	0.634	2.520	2.
7	-1.368	-1.009	-1.001	-1.373	0.080	3.641	1.
8	-0.618	-1.074	0.324	-1.191	1.307	3.115	2.
9	0.966	0.152	-0.091	0.410	2.861	4.093	3.
10	0.598	0.082	1.359	0.763	1.233	4.052	2.
11	-0.177	0.196	0.969	0.324	1.301	1.758	2.
12	2.087	1.372	1.163	1.728	3.899	4.367	2.
13	0.766	1.497	1.214	1.514	3.009	3.910	4.
14	1.456	1.420	0.381	-0.085	-0.631	4.358	4.
15	-0.329	0.132	-0.445	0.091	3.525	2.267	3.

The model

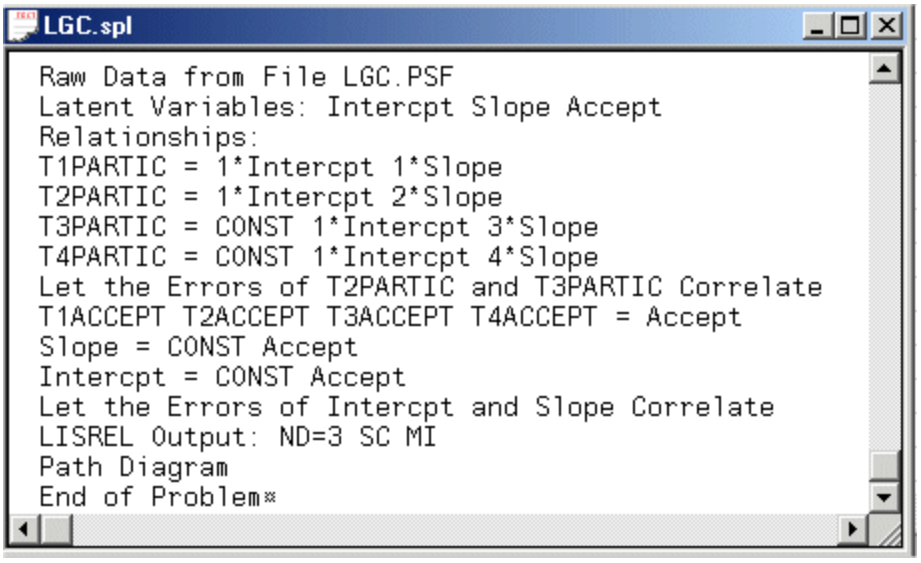
We consider the four annual participation scores and four annual cancer acceptance scores obtained for the sample of 374 cancer patients. A linear latent growth curve is modeled for the four annual participation scores. In addition, cancer acceptance level is

modeled as an explanatory effect for the intercept and slope of the latent growth curve. A path diagram for the corresponding LGC model for Participation and Acceptance Level is shown in the following path diagram.



Fitting the model to the data

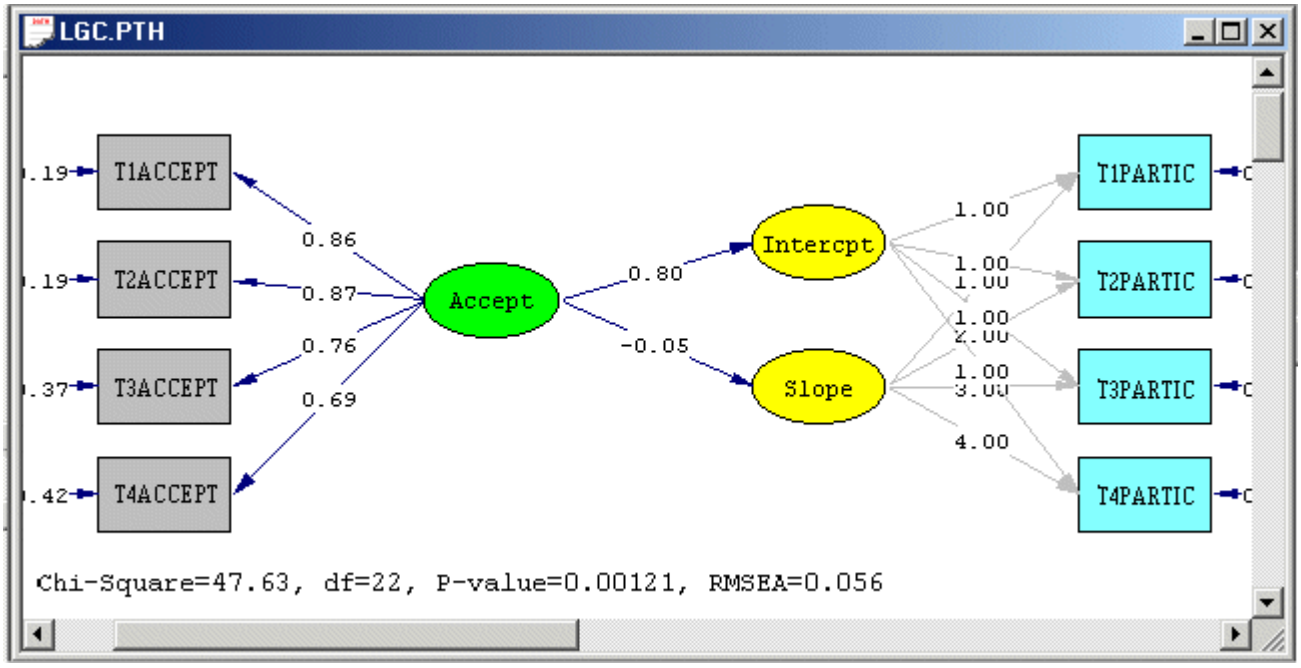
- Use the ***New*** option on the ***File*** menu of the main window to load the ***New*** dialog box.
- Select the ***Syntax Only*** option from the list box on the ***New*** dialog box to open the ***SYNTAX1*** text editor window.
- Enter the following commands into the ***SYNTAX1*** text editor window.



Line 1 specifies the raw data source.
Line 2 specifies labels for the latent variables of the model.
Lines 3-8 specify the linear latent growth curve model for the 4 participation scores.

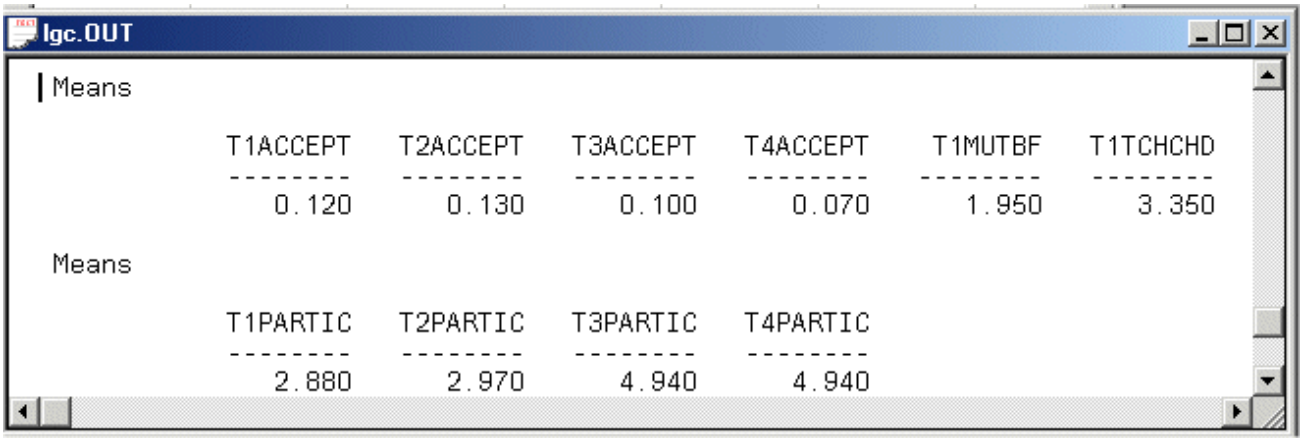
Line 9 specifies the 4 acceptance scores as indicators of the latent variable cancer acceptance level.
Lines 10-12 specify the model for the intercept and slope of the latent growth curve.
Line 13 requests the results in the terms of the LISREL model for the model in Figure 1.
Line 14 requests a path diagram (PTH) file.
Line 15 indicates the end of the SIMPLIS commands to be processed.

- Use the ***Save As*** option on the ***File*** menu to save the SIMPLIS syntax file as ***LGC.spl***.
- Click on the ***Run LISREL*** icon to produce the following ***PTH*** window.



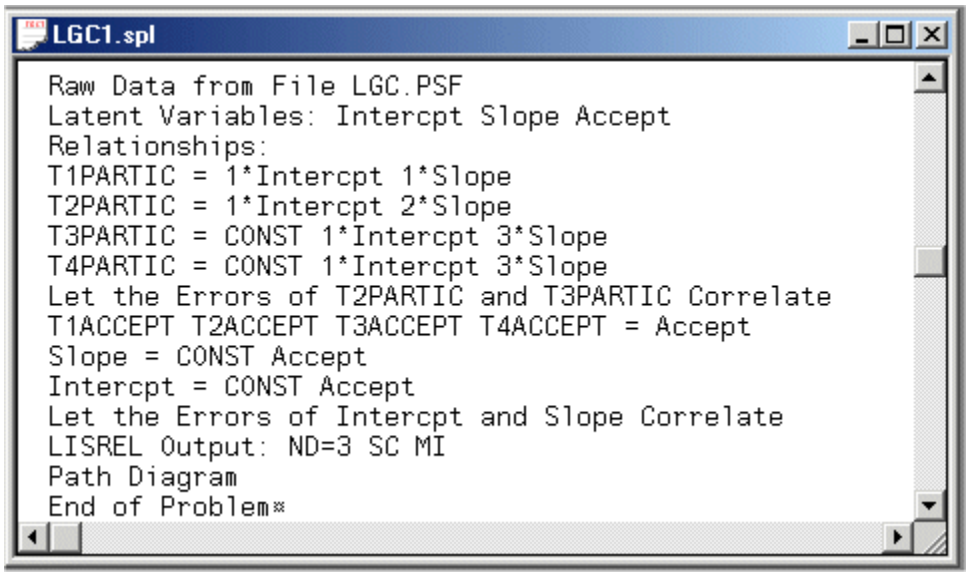
Adjusting the Model

- Select the ***Open*** option on the ***File*** menu of the main window to load the ***Open*** dialog box.
- Select the ***Prelis Data (*.psf)*** option from the ***Files of type:*** dropdown list box.
- Browse to locate the file ***LGC.PSF***.
- Click on the file ***LGC.PSF*** to enter it into the ***File name:*** string field.
- Click on the ***Open*** button to open the ***PSF*** window for ***LGC.PSF***.
- Select the ***Output Options*** option on the ***Statistics*** menu of the ***PSF*** window to load the ***Output*** dialog box.
- Click on the ***OK*** button to run PRELIS to produce the means shown in the following text editor window.

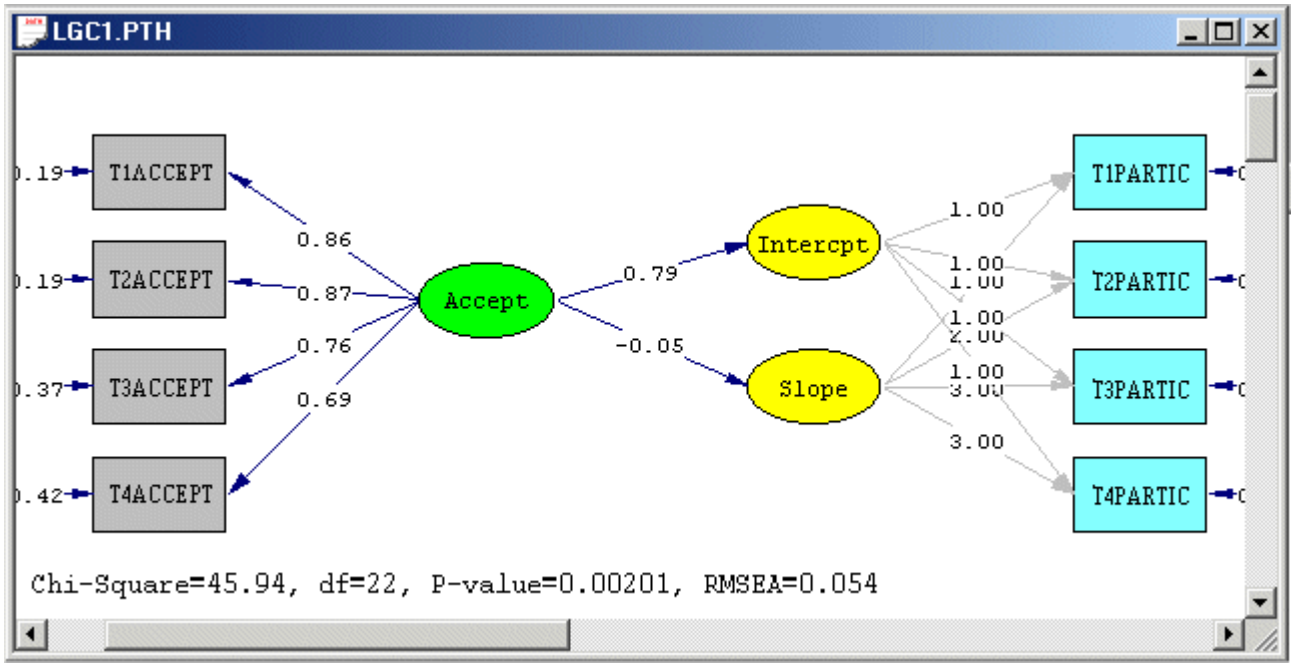


The results above indicate that the mean participation scores for months 3 and 4 are identical up to 3 decimal places. Consequently, it appears that no significant growth occurred from month 3 to month 4. This implies that it may be sensible to incorporate this result in the linear latent growth curve model for the 4 participation scores. This result may be incorporated as follows.

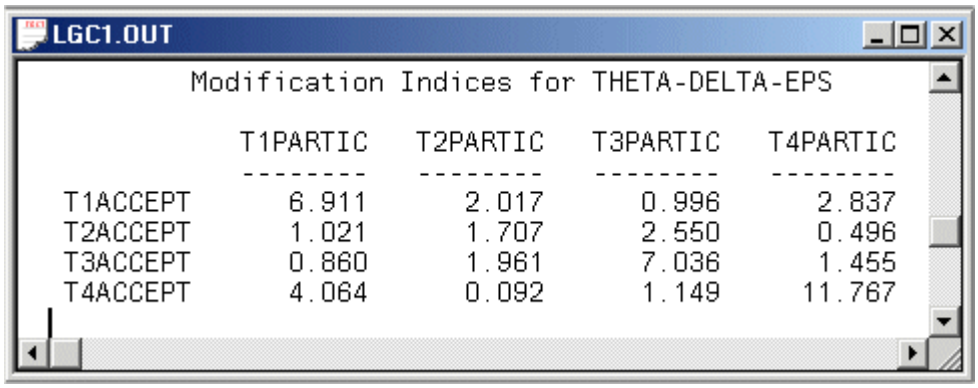
- Select the ***Open*** option on the ***File*** menu of the main window to load the ***Open*** dialog box.
- Browse for the file ***LGC.SPL*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the text editor window for ***LGC.SPL***.
- Change the coefficient of the latent variable ***Slope*** from "4" to "3" for the fourth participation score.
- Select the ***Save As*** option on the ***File*** menu of the text editor window to load the ***Save As*** dialog box.
- Enter the name ***LGC1.SPL*** in the ***File name:*** string field.
- Click on the ***Save*** button to produce the following text editor window.



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



- Close the ***PTH*** window for ***LGC1.PTH***.
- Browse down the text editor window for ***LGC1.OUT*** to locate the ***Modification Indices for THETA-DELTA-EPS*** as shown in the following text editor window.

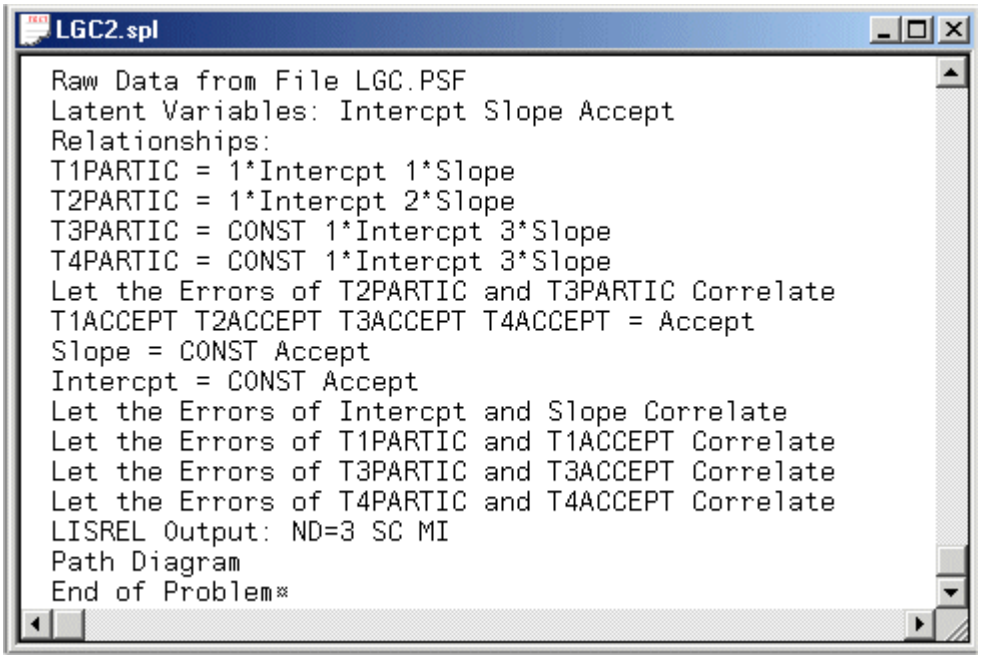


	T1PARTIC	T2PARTIC	T3PARTIC	T4PARTIC
T1ACCEPT	6.911	2.017	0.996	2.837
T2ACCEPT	1.021	1.707	2.550	0.496
T3ACCEPT	0.860	1.961	7.036	1.455
T4ACCEPT	4.064	0.092	1.149	11.767

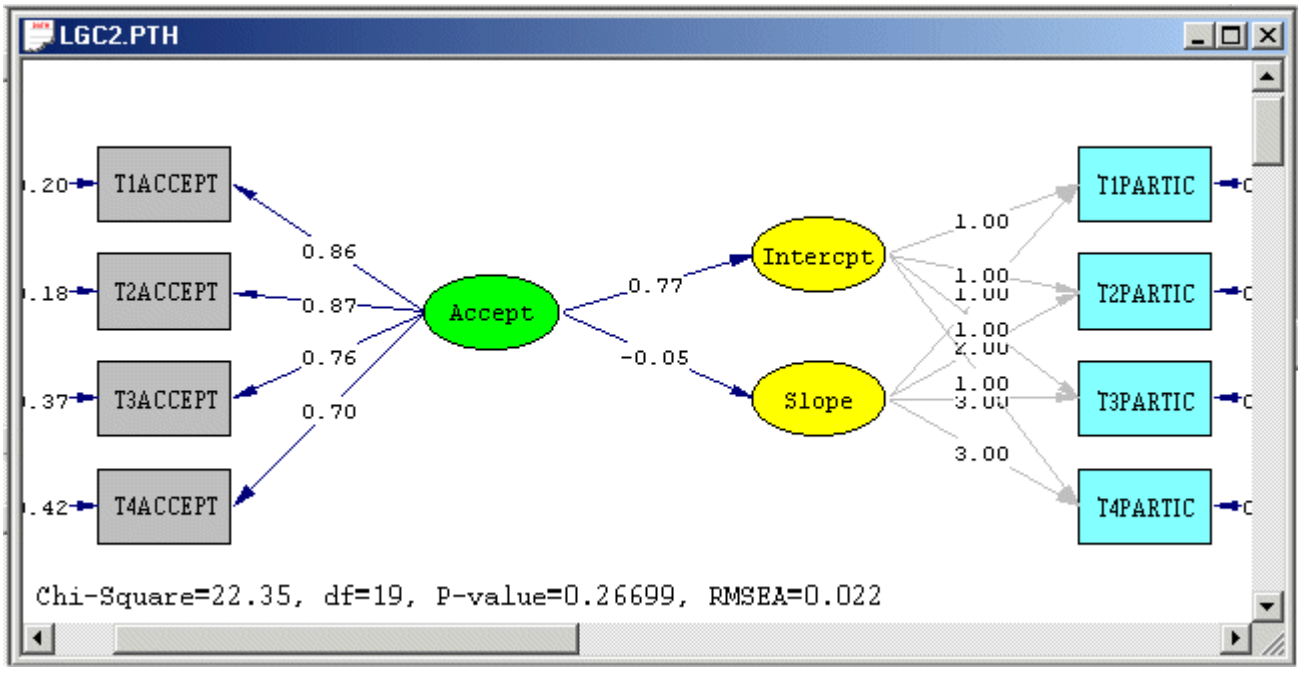
We note that the largest modification indices are those for the measurement error covariances between the participation and acceptance indicators at months 1, 2 and 4. These correlated measurement errors may be incorporated in the model in Figure 1 as follows.

- Select the ***Open*** option on the ***File*** menu of the main window to load the ***Open*** dialog box.
- Browse for the file ***LGC1.SPL*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the text editor window for ***LGC1.SPL***.
- Insert the following lines
  Let the Errors of T1PARTIC and T1ACCEPT Correlate
  Let the Errors of T3PARTIC and T3ACCEPT Correlate
  Let the Errors of T4PARTIC and T4ACCEPT Correlate
  just before the ***LISREL Output*** command.
- Select the ***Save As*** option on the ***File*** menu of the text editor window to load the ***Save As*** dialog box.

- Enter the name ***LGC2.SPL*** in the ***File name:*** string field.
- Click on the ***Save*** button to produce the following text editor window.



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



14. Generalized linear models

LISREL for Windows (Jöreskog & Sörbom 2006) includes the 32-bit application SURVEYGLIM, which implements the methods in Agresti (2002) and Binder (1983), to fit Generalized Linear Models (GLIMs) to complex and random survey data. In this section, the GLIM module of LISREL for Windows is used to fit a Bernoulli-Probit model to a data set emanating from a complex survey.

The Data

The data set forms part of the data library of the Alcohol and Drug Services Study (ADSS). The ADSS was a national study of substance abuse treatment facilities and clients. Background data and data on the substance abuse of a sample of 1752 clients were obtained. The sample was stratified by census region (CENREG) and within each stratum a sample was obtained for each of three facility treatment types (FACTYPE) within each of the four census regions. More information on the ADSS and the data are available at http://webapp.icpsr.umich.edu/cocoon/SAMHDA-DISPLAY/03088.xml

The specific data set is contained in the file ***substance_abuse.PSF*** which is located in the ***TUTORIAL*** subfolder. The first portion of this file is shown in the following ***PSF*** window.

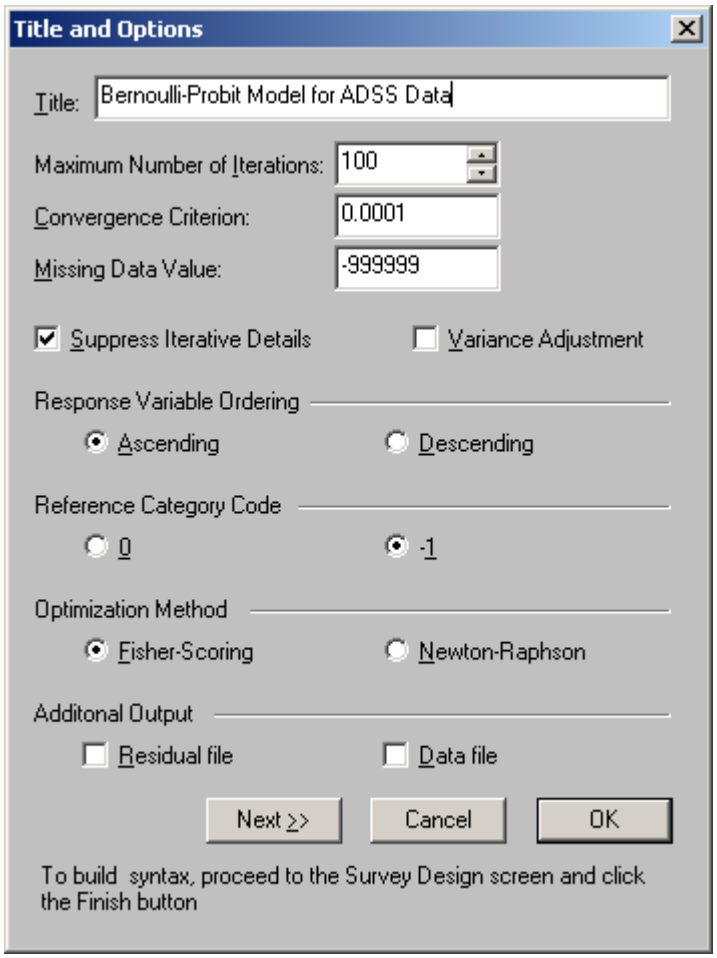
substance_abuse.PSF

	CENREG	FACTYPE	A2TWA0	depr	alceu	cntdiag	numte	gender	race_d
1	4.00	4.00	47.00	0.00	1.00	0.00	0.00	1.00	1.00
2	4.00	4.00	47.00	1.00	1.00	0.00	0.00	1.00	1.00
3	4.00	4.00	47.00	1.00	1.00	0.00	0.00	0.00	1.00
4	4.00	4.00	47.00	0.00	1.00	0.00	0.00	1.00	1.00
5	4.00	4.00	47.00	0.00	1.00	0.00	1.00	1.00	1.00
6	4.00	4.00	47.00	0.00	1.00	0.00	0.00	1.00	1.00
7	4.00	4.00	47.00	0.00	1.00	0.00	0.00	1.00	1.00
8	4.00	4.00	60.10	1.00	1.00	2.00	1.00	1.00	0.00
9	4.00	4.00	60.10	1.00	1.00	1.00	1.00	0.00	1.00
10	4.00	4.00	60.10	1.00	1.00	3.00	1.00	1.00	0.00
11	4.00	4.00	60.10	1.00	1.00	3.00	7.00	1.00	1.00
12	4.00	4.00	60.10	1.00	1.00	3.00	1.00	1.00	1.00
13	4.00	4.00	60.10	1.00	1.00	2.00	1.00	1.00	1.00
14	4.00	4.00	60.10	1.00	1.00	3.00	0.00	0.00	1.00
15	4.00	4.00	60.10	1.00	1.00	3.00	3.00	0.00	1.00
16	4.00	4.00	12.60	1.00	1.00	3.00	1.00	1.00	1.00
17	4.00	2.00	114.10	1.00	1.00	2.00	10.00	1.00	1.00
18	4.00	2.00	114.10	0.00	1.00	2.00	0.00	1.00	1.00
19	4.00	2.00	114.10	1.00	1.00	1.00	1.00	1.00	1.00
20	4.00	2.00	114.10	0.00	1.00	2.00	1.00	1.00	1.00
21	4.00	2.00	114.10	0.00	1.00	2.00	1.00	1.00	1.00

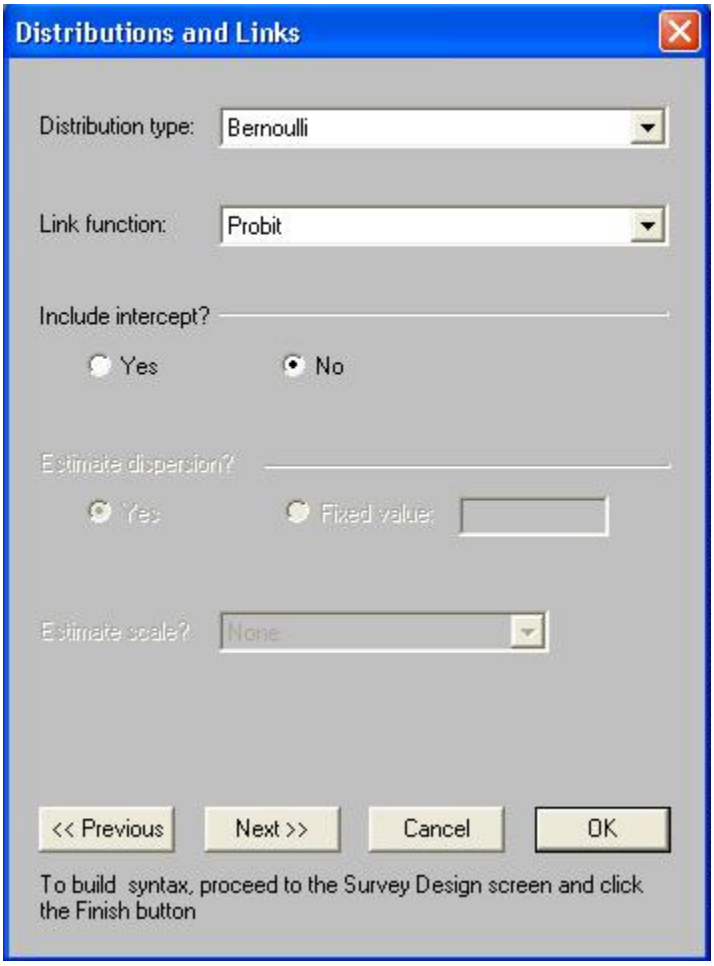
Fitting the Bernoulli-Probit model

- Use the ***Open*** option on the ***File*** menu of the main window to load the ***Open*** dialog box.
- Select the ***Prelis Data (*.psf)*** option from the ***Files of Type*** dropdown list box.
- Browse for the file ***substance_abuse.PSF*** in the ***TUTORIAL*** subfolder and select it.
- Click on the ***Open*** button to open the file ***substance_abuse.PSF*** in a ***PSF*** window.

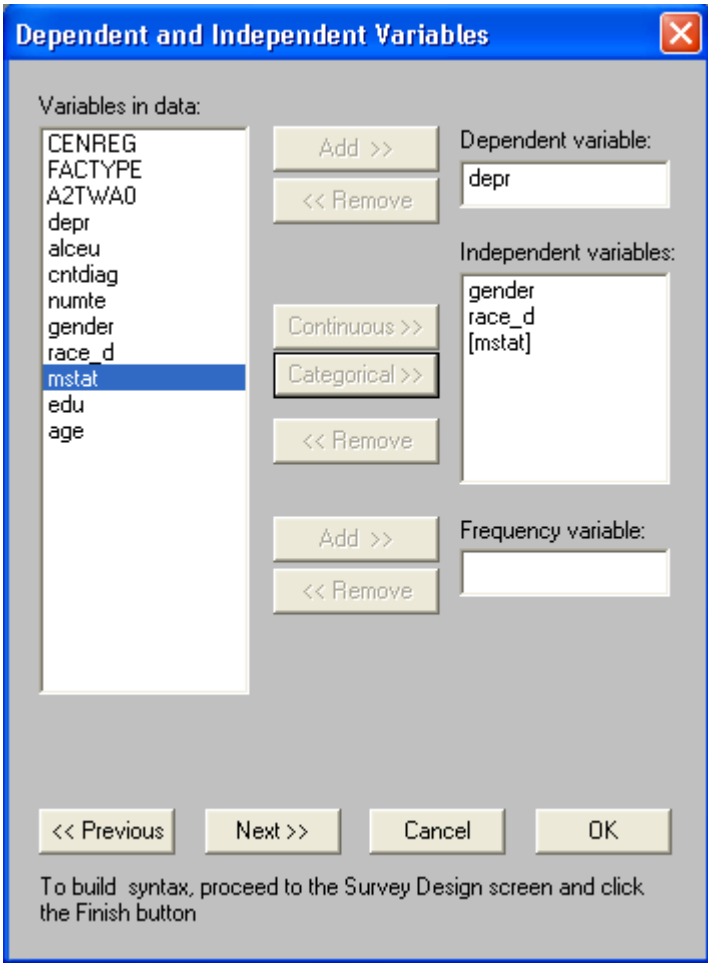
- Select the ***Title and Options*** option on the ***SurveyGLIM*** menu to load the ***Title and Options*** dialog box.
- Enter the string ***Bernoulli-Probit Model for ADSS Data*** in the ***Title*** string field.
- Check the ***Residual File*** checkbox in the ***Additional Output*** section to produce the following ***Title and Options*** dialog box.



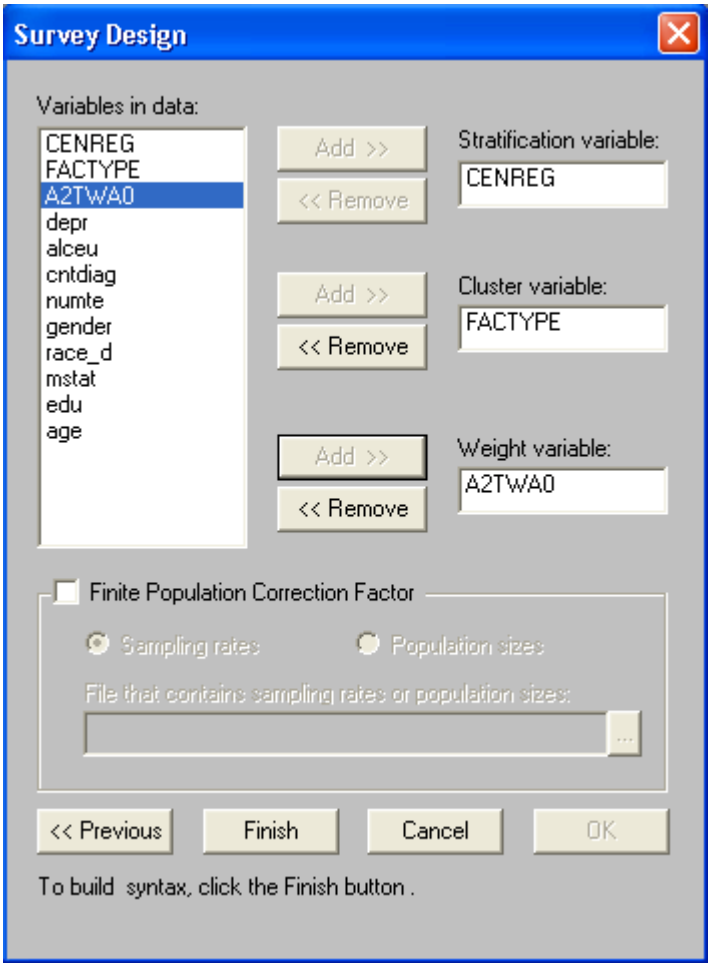
- Click on the ***Next*** button to load the ***Distributions and Links*** dialog box.
- Select the ***Bernoulli*** option from the ***Distribution type*** dropdown list box.
- Select the ***Probit*** option from ***Link function*** dropdown list box.
- Activate the ***No*** radio button in the ***Include intercept?*** section to produce the following ***Distributions and Links*** dialog box.



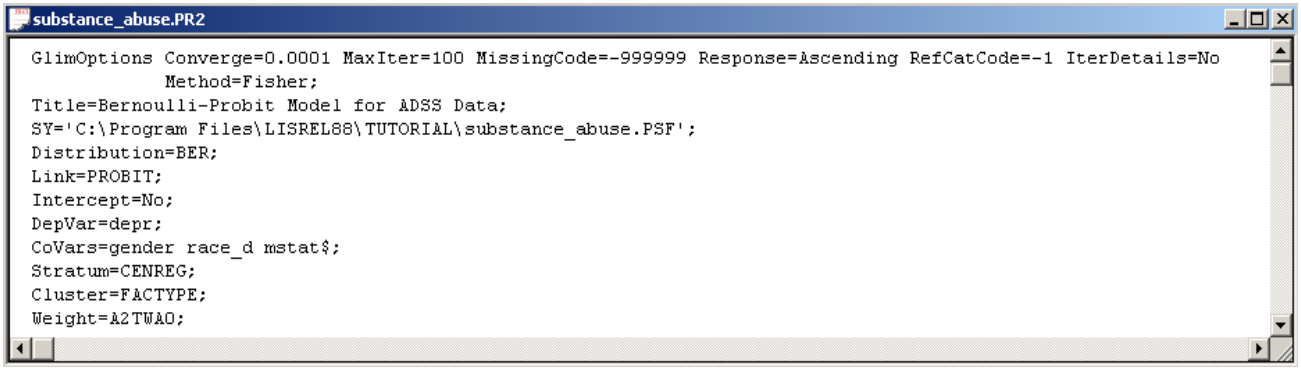
- Click on the ***Next*** button to load the ***Dependent and Independent Variables*** dialog box.
- Select the variable ***depr*** from the ***Variables in data*** list box.
- Click on the ***Add*** button of the ***Dependent variable*** section.
- Select the variables ***gender*** and ***race_d*** from the ***Variables in data*** list box.
- Click on the ***Continuous*** button of the ***Independent variable*** section.
- Select the variable ***mstat*** from the ***Variables in data*** list box.
- Click on the ***Categorical*** button of the ***Independent variable*** section to produce the following ***Dependent and Independent Variables*** dialog box.



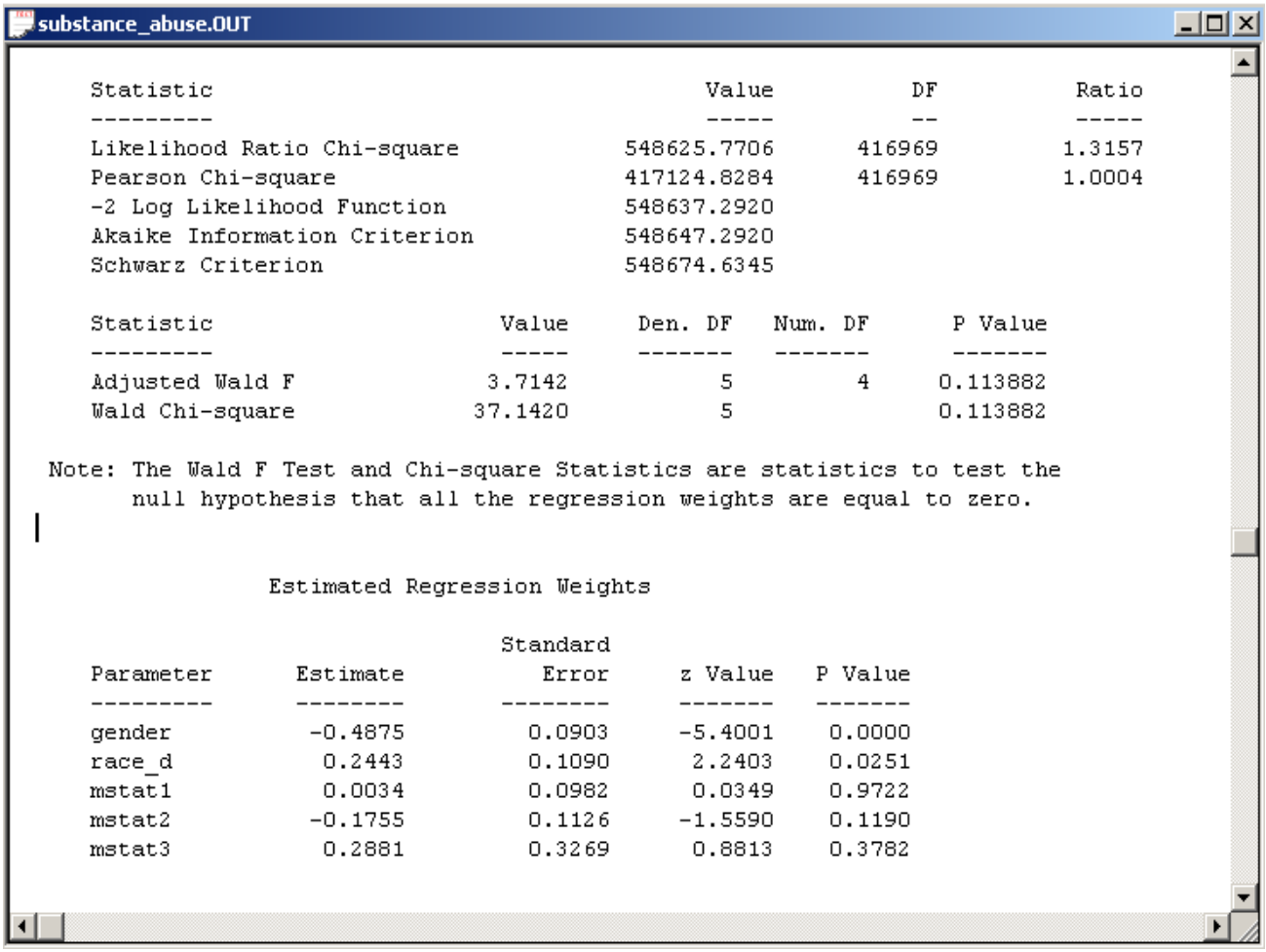
- Click on the ***Next*** button to load the ***Survey Design*** dialog box.
- Select the variable ***CENREG*** from the ***Variables in data*** list box.
- Click on the ***Add*** button of the ***Stratification variable*** section.
- Select the variable ***FACTYPE*** from the ***Variables in data*** list box.
- Click on the ***Add*** button of the ***Cluster variable*** section.
- Select the variable ***A2TWAO*** from the ***Variables in data*** list box.
- Click on the ***Add*** button of the ***Weight variable*** section to produce the following ***Survey Design*** dialog box.



- Click on the ***Finish*** button to open the following text editor window for ***substance_abuse.PR2***.



- Click on the ***Run Prelis*** toolbar icon to produce the following text editor window for ***substance_abuse.OUT***.



Statistic	Value	DF	Ratio
Likelihood Ratio Chi-square	548625.7706	416969	1.3157
Pearson Chi-square	417124.8284	416969	1.0004
-2 Log Likelihood Function	548637.2920		
Akaike Information Criterion	548647.2920		
Schwarz Criterion	548674.6345		

Statistic	Value	Den. DF	Num. DF	P Value
Adjusted Wald F	3.7142	5	4	0.113882
Wald Chi-square	37.1420	5		0.113882

Note: The Wald F Test and Chi-square Statistics are statistics to test the null hypothesis that all the regression weights are equal to zero.

Estimated Regression Weights

Parameter	Estimate	Standard Error	z Value	P Value
gender	-0.4875	0.0903	-5.4001	0.0000
race_d	0.2443	0.1090	2.2403	0.0251
mstat1	0.0034	0.0982	0.0349	0.9722
mstat2	-0.1755	0.1126	-1.5590	0.1190
mstat3	0.2881	0.3269	0.8813	0.3782

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