LATENT GROWTH CURVES

1. Introduction

In practice, many multivariate data sets are repeated measurements over time. For these data sets, the researcher is often interested in modeling the growth that occurs over time. In this regard, linear and nonlinear latent growth curves may be used if the researcher is interested in modeling the growth parameters such as, for example, the intercept and the slope of the linear latent growth curve. Duncan et al (1999) provides a comprehensive treatment of latent growth curve analysis.

LISREL 8.8 for Windows (Jöreskog & Sörbom 2006) may be used to fit linear and nonlinear latent growth curves to repeated measurements over time. Traditional statistical methods such as Maximum Likelihood (ML), Robust Maximum Likelihood (RML), Weighted Least Squares (WLS), Diagonally Weighted Least Squares (DWLS), Generalized Least Squares (GLS) and Un-weighted Least Squares (ULS) are available for complete repeated measurements over time while the Full Information Maximum Likelihood (FIML) method is available for repeated measurements over time with missing values.

In this note, LISREL 8.8 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 quarters. This data set is described in the next section. The model is described in Section 3. Thereafter, the model is fitted to the data. In Section 5, the model is first adjusted based on the sample means for the four quarters. Thereafter, the resulting modification indices are used to modify the model further.

2. 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 quarters. At the end of each quarter, 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.

Figure: lgc.psf data table

	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.

3. The Model

We consider the four quarterly participation scores and four quarterly cancer acceptance scores obtained for the sample of 374 cancer patients. A linear latent growth curve is modeled for the four quarterly 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 cancer Participation and Acceptance is shown in Figure 1.

Figure 1: A path diagram for a LGC model for Participation and Acceptance
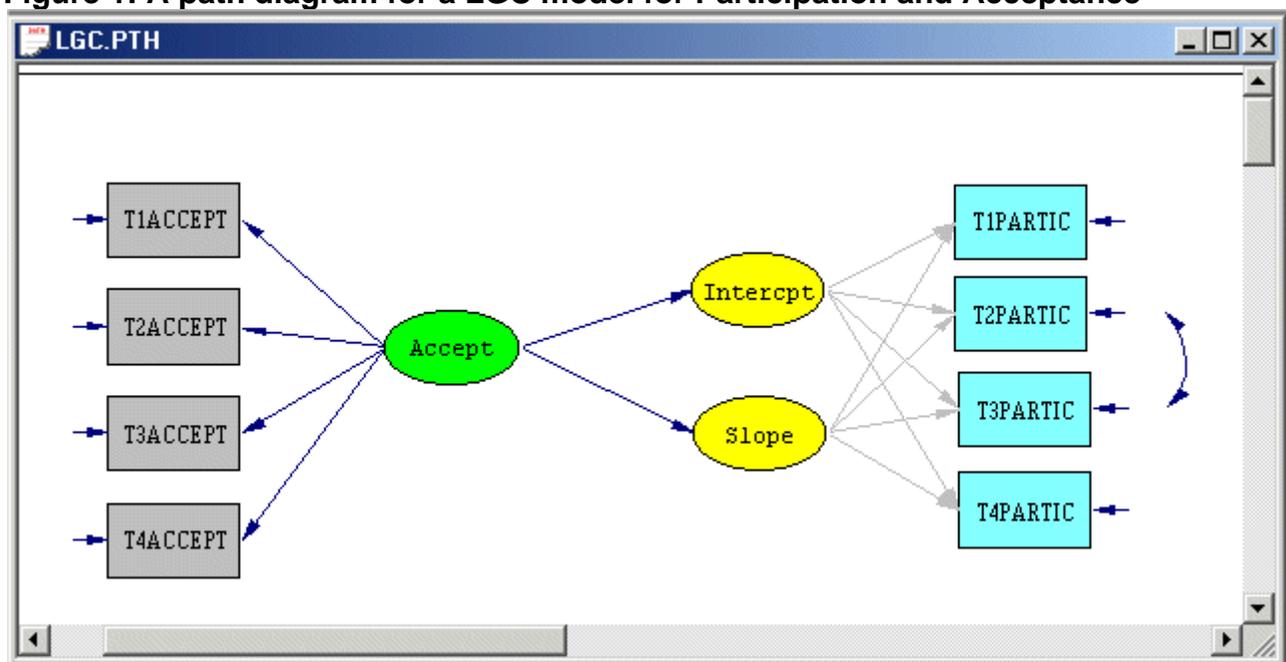
4. The Analysis

➤ Use the *New* option on the *File* menu of the root 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.

```
LGC.spl                                        _ □ ×

Raw Data from File LGC.PSF
Latent Variables: Intercpt Slope Accept
Relationships:
T1PARTIC = 1*Intercpt 1*Slope
T2PARTIC = 1*Intercpt 2*Slope
T3PARTIC = CONST 1*Intercpt 3*Slope
T4PARTIC = CONST 1*Intercpt 4*Slope
Let the Errors of T2PARTIC and T3PARTIC Correlate
T1ACCEPT T2ACCEPT T3ACCEPT T4ACCEPT = Accept
Slope = CONST Accept
Intercpt = CONST Accept
Let the Errors of Intercpt and Slope Correlate
LISREL Output: ND=3 SC MI
Path Diagram
End of Problem*
```

Line 1 specifies the raw data source.
Line 2 specifies labels for the latent variables of the model.
Lines 4-8 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 over time.
Lines 10-12 specify the structural 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.

Chi-Square=47.63, df=22, P-value=0.00121, RMSEA=0.056
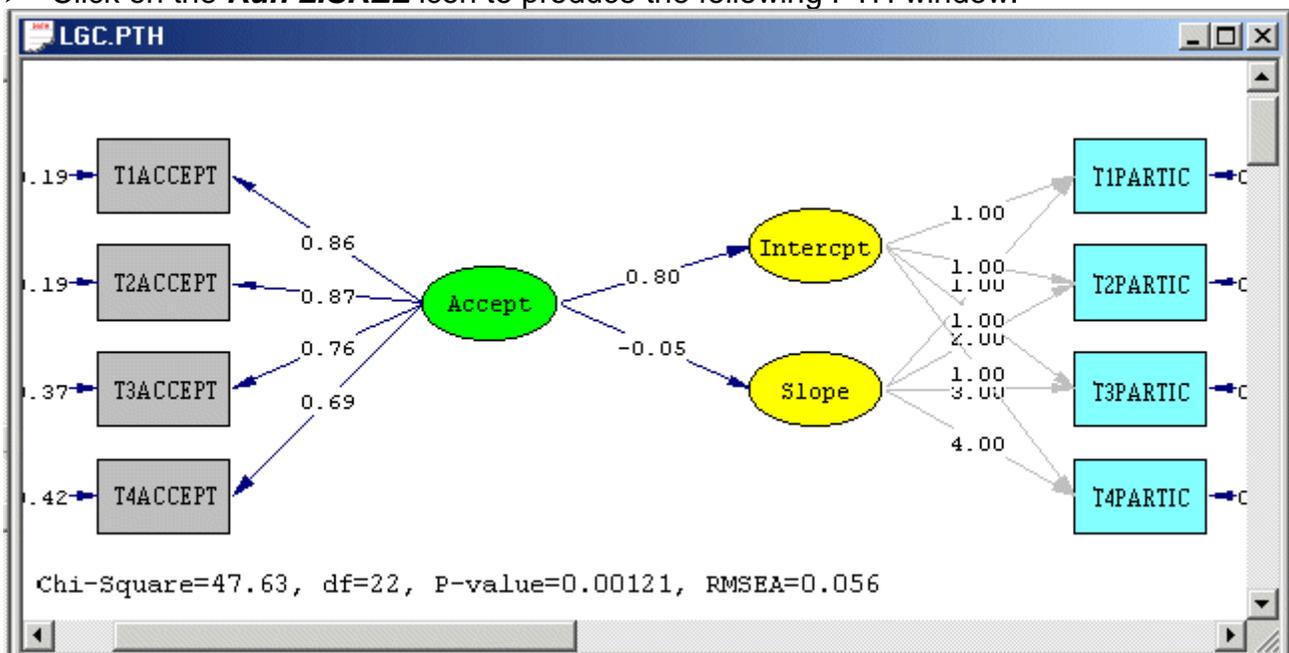
5. Adjusting the Model

➢ Select the *Close all* option on the *Windows* menu to close all open windows.
➢ Select the *Open* option on the *File* menu of the root 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* in the *WORKSHOP* subfolder of the LISREL 8.8 for Windows installation folder.
➢ Click on the file *LGC.PSF* to enter it into the *File name:* string field.
➢ Click on the *Open* push 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* push button to run PRELIS27.EXE to produce the means shown in the following output window.
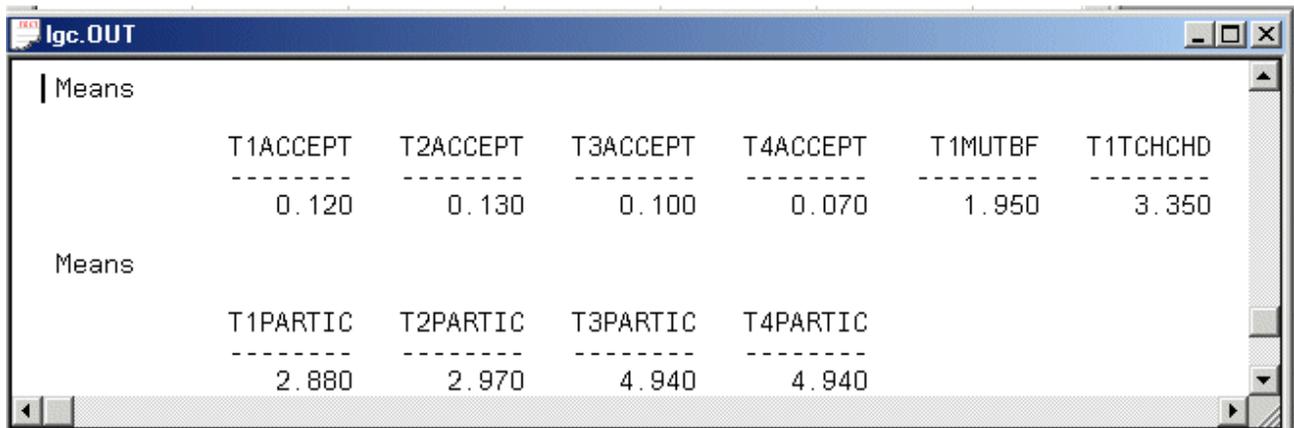
```
lgc.OUT                                                                    _ □ ×

  Means

            T1ACCEPT   T2ACCEPT   T3ACCEPT   T4ACCEPT    T1MUTBF   T1TCHCHD
            --------   --------   --------   --------   --------   --------
               0.120      0.130      0.100      0.070      1.950      3.350

  Means

            T1PARTIC   T2PARTIC   T3PARTIC   T4PARTIC
            --------   --------   --------   --------
               2.880      2.970      4.940      4.940
```

The results above indicate that the mean participation scores for quarters 3 and 4 are identical up to 3 decimal places. Consequently, it appears that no significant growth occurred from quarter 3 to quarter 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 *Close all* option on the *Windows* menu to close all open windows.
➢ Select the *Open* option on the *File* menu of the root window to load the *Open* dialog box.
➢ Browse to locate the file *LGC.SPL* in the *WORKSHOP* subfolder of the LISREL 8.8 for Windows installation folder.
➢ Click on the file *LGC.SPL* to enter it into the *File name:* string field.
➢ Click on the *Open* push 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* push button to produce the following text editor window.

```
LGC1.spl                                          _ □ X
Raw Data from File LGC.PSF
Latent Variables: Intercpt Slope Accept
Relationships:
T1PARTIC = 1*Intercpt 1*Slope
T2PARTIC = 1*Intercpt 2*Slope
T3PARTIC = CONST 1*Intercpt 3*Slope
T4PARTIC = CONST 1*Intercpt 3*Slope
Let the Errors of T2PARTIC and T3PARTIC Correlate
T1ACCEPT T2ACCEPT T3ACCEPT T4ACCEPT = Accept
Slope = CONST Accept
Intercpt = CONST Accept
Let the Errors of Intercpt and Slope Correlate
LISREL Output: ND=3 SC MI
Path Diagram
End of Problem*
```

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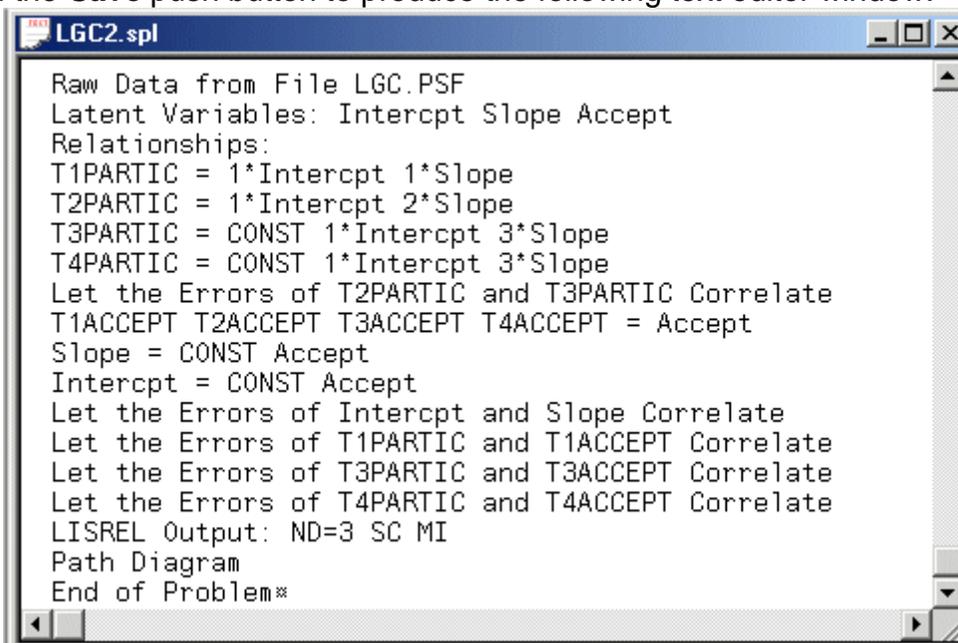

Chi-Square=45.94, df=22, P-value=0.00201, RMSEA=0.054
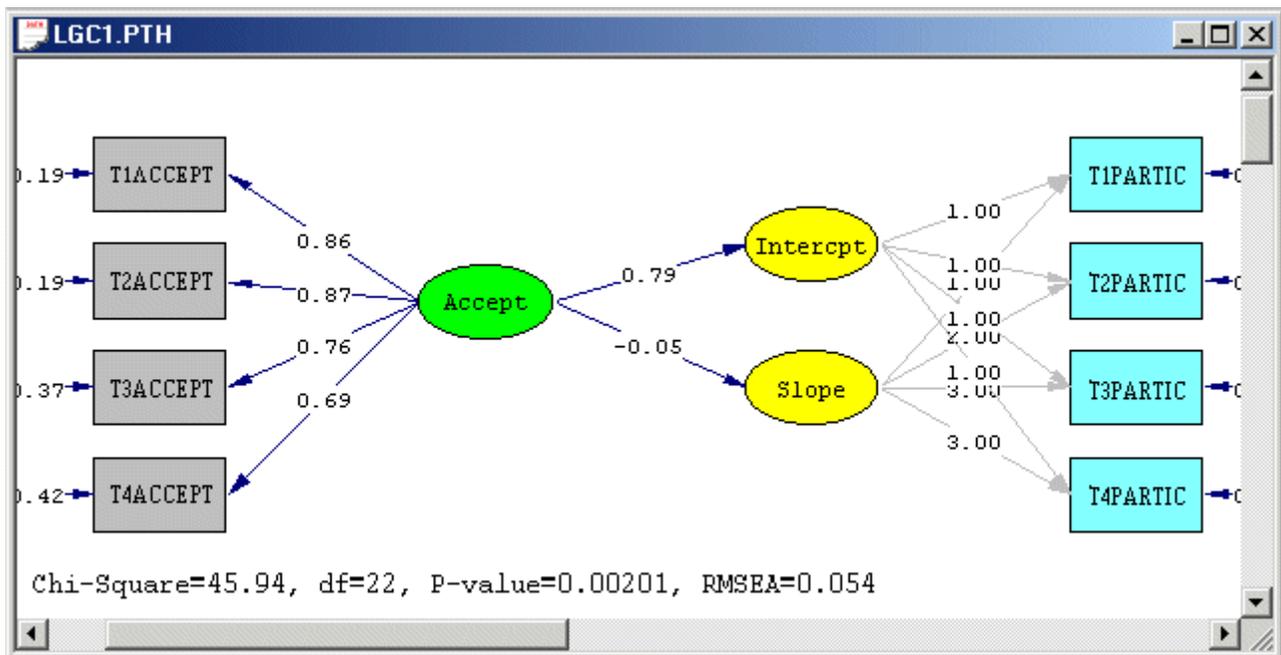
➢ Close the **PTH** window for **LGC1.PTH**.
➢ Browse down the text editor window for **LGC1.OUT** to locate the **Modification Indices for THETA-DELTA-EPS** as shown in the following text editor window.
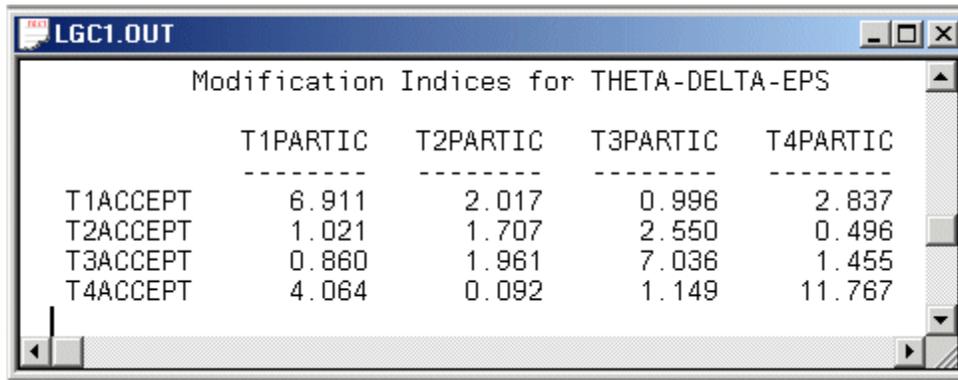
```
LGC1.OUT                                          _ □ X
          Modification Indices for THETA-DELTA-EPS

              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 quarters 1, 3, and 4. These correlated measurement errors may be incorporated in the model in Figure 1 as follows.

➢ Select the **Close all** option on the **Windows** menu to close all open windows.
➢ Select the **Open** option on the **File** menu of the root window to load the **Open** dialog box.
➢ Browse to locate the file **LGC1.SPL** in the **WORKSHOP** subfolder of the LISREL 8.8 for Windows installation folder.
➢ Click on the file **LGC1.SPL** to enter it into the **File name:** string field.
➢ Click on the **Open** push 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** push button to produce the following text editor window.

```
LGC2.spl                                          _ □ X

   Raw Data from File LGC.PSF
   Latent Variables: Intercpt Slope Accept
   Relationships:
   T1PARTIC = 1*Intercpt 1*Slope
   T2PARTIC = 1*Intercpt 2*Slope
   T3PARTIC = CONST 1*Intercpt 3*Slope
   T4PARTIC = CONST 1*Intercpt 3*Slope
   Let the Errors of T2PARTIC and T3PARTIC Correlate
   T1ACCEPT T2ACCEPT T3ACCEPT T4ACCEPT = Accept
   Slope = CONST Accept
   Intercpt = CONST Accept
   Let the Errors of Intercpt and Slope Correlate
   Let the Errors of T1PARTIC and T1ACCEPT Correlate
   Let the Errors of T3PARTIC and T3ACCEPT Correlate
   Let the Errors of T4PARTIC and T4ACCEPT Correlate
   LISREL Output: ND=3 SC MI
   Path Diagram
   End of Problem
```
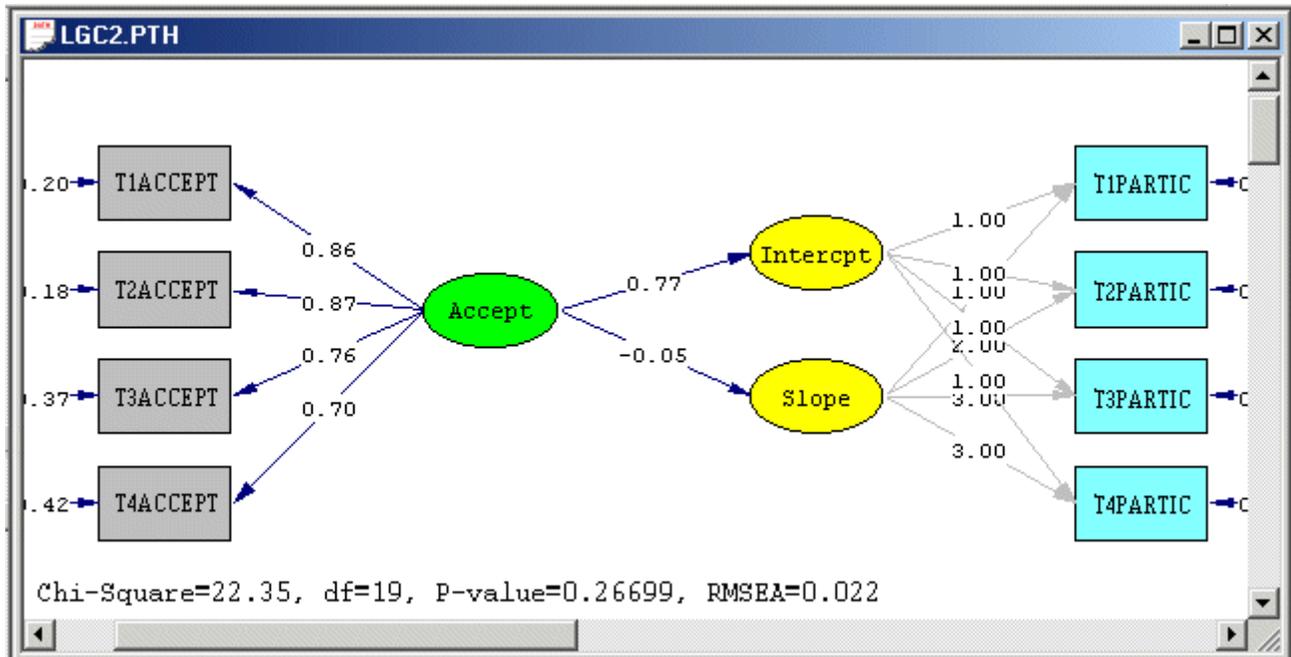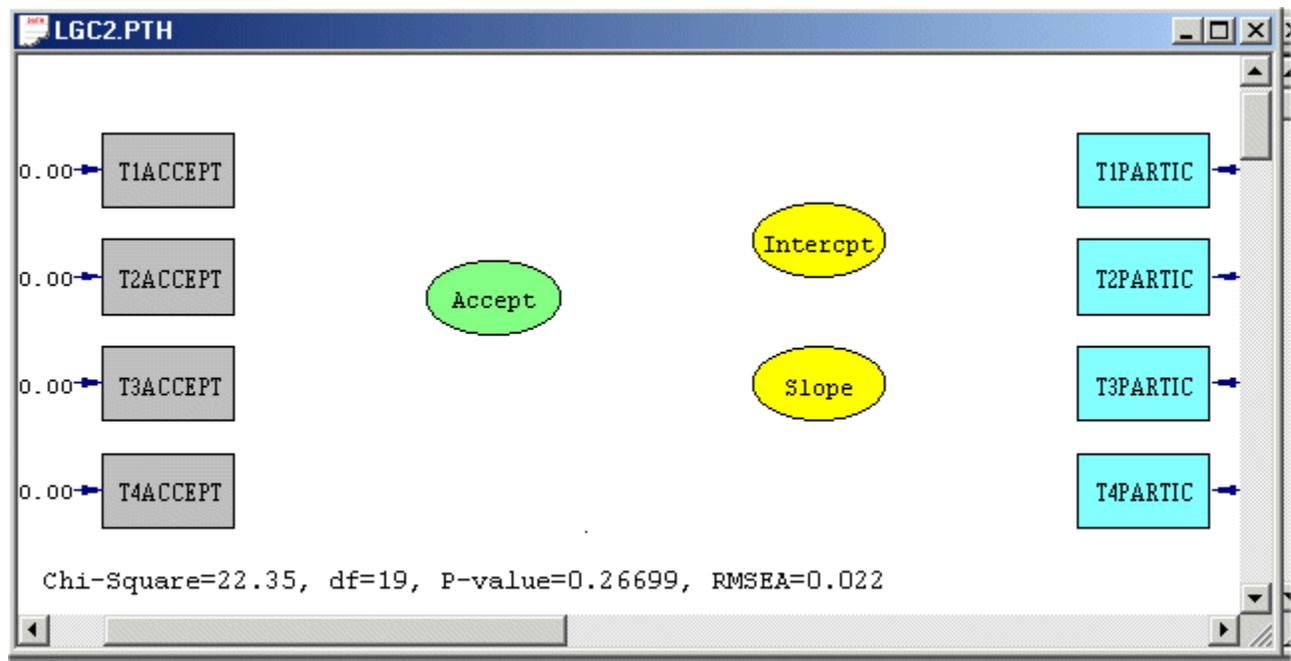
➢ Click on the **Run LISREL** icon to produce the following PTH window.

➢ 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 model.

References

Duncan, T.E., Duncan, S.C., Stycker, L.A., Fuzhong, L., & Alpert, A. (1999).
An introduction to latent variable growth curve modeling:
Concepts, issues, and applications. Mahwah, NJ: Erlbaum

Jöreskog, K. & Sörbom, D. (2006).
LISREL 8.80 for Windows [Computer Software].
Lincolnwood, IL: Scientific Software International, Inc.