Examples of Estimates for Non-normal Data

Mplus Example with Satorra-Bentler Scaled χ^2 and Robust Standard Errors

(excerpts from output)

```
INPUT INSTRUCTIONS
    title:  CFA of three negative exchanges factors;
    data:  file=c:\jason\mplus\semclass\nonnorm1.dat;
                format=12f1.0;
                listwise=on;
    variable:  names = neg6 neg26 neg30 neg35
        neg11 neg12 neg13 neg14
        neg16 neg17 neg19 neg20;
    usevariables=neg6 neg26 neg30 neg35
        neg11 neg12 neg13 neg14
        neg16 neg17 neg19 neg20;
    analysis:  type=general; estimator=mlm;
!MLM is used to request Satorra & Bentler (1988; 1994)
! robust standard errors and scaled chi-square;
    model: hostile by neg6-neg35;
           badadv by neg11-neg14;
           demands by neg16-neg20;
    output: stdyx;
INPUT READING TERMINATED NORMALLY
SUMMARY OF ANALYSIS
Number of groups                                                 1
Number of observations                                         194
Number of dependent variables                                   12
Number of independent variables                                  0
Number of continuous latent variables                            3

Estimator                                                      MLM
Information matrix                                        EXPECTED
Maximum number of iterations                                 1000
Convergence criterion                                   0.500D-04
Maximum number of steepest descent iterations                  20
THE MODEL ESTIMATION TERMINATED NORMALLY
MODEL FIT INFORMATION
Number of Free Parameters                       39
Loglikelihood
          H0 Value                      -2102.720
          H1 Value                      -2036.636
Information Criteria
          Akaike (AIC)                   4283.440
          Bayesian (BIC)                 4410.886
          Sample-Size Adjusted BIC       4287.342
            (n* = (n + 2) / 24)
Chi-Square Test of Model Fit
          Value                             90.344*
          Degrees of Freedom                    51
          P-Value                           0.0006
          Scaling Correction Factor          1.463
            for MLM
*   The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used
    for chi-square difference testing in the regular way.  MLM, MLR and WLSM
    chi-square difference testing is described on the Mplus website.  MLMV, WLSMV,
    and ULSMV difference testing is done using the DIFFTEST option.
RMSEA (Root Mean Square Error Of Approximation)
          Estimate                           0.063
          90 Percent C.I.                    0.041  0.084
          Probability RMSEA <= .05           0.151
CFI/TLI
          CFI                                0.951
          TLI                                0.937
Chi-Square Test of Model Fit for the Baseline Model
          Value                            870.347
          Degrees of Freedom                    66
          P-Value                           0.0000
SRMR (Standardized Root Mean Square Residual)
          Value                              0.051
WRMR (Weighted Root Mean Square Residual)
          Value                              0.757

MODEL RESULTS
                                                    Two-Tailed
                  Estimate       S.E.  Est./S.E.    P-Value
 HOSTILE  BY
    NEG6              1.000      0.000    999.000    999.000
    NEG26             1.406      0.165      8.531      0.000
```

```
    NEG30              1.252      0.149      8.423      0.000
    NEG35              1.172      0.121      9.681      0.000
 BADADV   BY
    NEG11              1.000      0.000    999.000    999.000
    NEG12              1.036      0.155      6.668      0.000
    NEG13              1.369      0.155      8.856      0.000
    NEG14              1.490      0.151      9.857      0.000
 DEMANDS  BY
    NEG16              1.000      0.000    999.000    999.000
    NEG17              1.037      0.103     10.080      0.000
    NEG19              0.966      0.177      5.446      0.000
    NEG20              0.934      0.151      6.186      0.000
 BADADV   WITH
    HOSTILE            0.174      0.042      4.118      0.000
 DEMANDS  WITH
    HOSTILE            0.215      0.068      3.157      0.002
    BADADV             0.200      0.045      4.464      0.000
```

Mplus: Same Model without Robust Statistics

(excerpts from output)

```
INPUT INSTRUCTIONS
    title:  CFA of three negative exchanges factors;
    data:  file=c:\jason\mplus\semclass\nonnorm1.dat;
                format=12f1.0;
              listwise=on;
    variable:  names = neg6 neg26 neg30 neg35
        neg11 neg12 neg13 neg14
        neg16 neg17 neg19 neg20;
    usevariables=neg6 neg26 neg30 neg35
        neg11 neg12 neg13 neg14
        neg16 neg17 neg19 neg20;
    analysis:  type=general; estimator=ml;
    model=nomeanstructure; information=expected;  (statements used to request standard ML)
    model: hostile by neg6-neg35;
           badadv by neg11-neg14;
           demands by neg16-neg20;
    output: standardized;
Estimator                                                       ML
MODEL FIT INFORMATION
Chi-Square Test of Model Fit
          Value                            132.168
          Degrees of Freedom                    51
          P-Value                           0.0000
RMSEA (Root Mean Square Error Of Approximation)
          Estimate                           0.091
          90 Percent C.I.                    0.072  0.110
          Probability RMSEA <= .05           0.000
CFI/TLI
          CFI                                0.934
          TLI                                0.914
Chi-Square Test of Model Fit for the Baseline Model
          Value                           1287.035
          Degrees of Freedom                    66
          P-Value                           0.0000
SRMR (Standardized Root Mean Square Residual)
          Value                              0.055
MODEL RESULTS
                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value
 HOSTILE  BY
    NEG6               1.000      0.000    999.000    999.000
    NEG26              1.406      0.139     10.089      0.000
    NEG30              1.252      0.132      9.512      0.000
    NEG35              1.172      0.134      8.714      0.000
 BADADV   BY
    NEG11              1.000      0.000    999.000    999.000
    NEG12              1.036      0.103     10.040      0.000
    NEG13              1.369      0.128     10.683      0.000
    NEG14              1.490      0.137     10.902      0.000
 DEMANDS  BY
    NEG16              1.000      0.000    999.000    999.000
    NEG17              1.037      0.105      9.854      0.000
    NEG19              0.966      0.134      7.231      0.000
    NEG20              0.934      0.112      8.340      0.000
 BADADV   WITH
    HOSTILE            0.174      0.030      5.850      0.000
 DEMANDS  WITH
    HOSTILE            0.215      0.036      6.002      0.000
```

```
    BADADV             0.200      0.033      5.993      0.000
```

Bootstrap Approach

```
MUTHEN & MUTHEN
02/25/2015  10:49 AM
INPUT INSTRUCTIONS
    title:  CFA of three negative exchanges factors;
    data:  file=c:\jason\mplus\semclass\nonnorm1.dat;
                format=12f1.0;
                listwise=on;
    variable:  names = neg6 neg26 neg30 neg35
        neg11 neg12 neg13 neg14
        neg16 neg17 neg19 neg20;
    usevariables=neg6 neg26 neg30 neg35
        neg11 neg12 neg13 neg14
        neg16 neg17 neg19 neg20;
    analysis:  type=general; estimator=ml;
      bootstrap=1000(residual);
!residual option gives Bollen-Stine bootstrap corrected chi-square;
    model: hostile by neg6-neg35;
           badadv by neg11-neg14;
           demands by neg16-neg20;
    output: stdyx cinterval(bcbootstrap);
!bcbootstrap option gives bias-corrected bootstrap estimates
! for nonsymmetric sampling distribution;
```

(excerpts)

```
**********************************
Chi-Square Test of Model Fit
          Value                            132.168
          Degrees of Freedom                    51
          P-Value                           0.0000
          Bootstrap P-Value                 0.0170
***********************************
CONFIDENCE INTERVALS OF MODEL RESULTS
                  Lower .5%  Lower 2.5%    Lower 5%    Estimate    Upper 5%  Upper 2.5%   Upper .5%
 HOSTILE  BY
    NEG6             1.000       1.000       1.000       1.000       1.000       1.000       1.000
    NEG26            1.004       1.088       1.145       1.406       1.702       1.785       1.946
    NEG30            0.872       0.981       1.025       1.252       1.503       1.562       1.647
    NEG35            0.723       0.827       0.901       1.172       1.536       1.652       1.794
 BADADV   BY
    NEG11            1.000       1.000       1.000       1.000       1.000       1.000       1.000
    NEG12            0.636       0.773       0.806       1.036       1.252       1.297       1.367
    NEG13            1.065       1.123       1.174       1.369       1.646       1.709       1.805
    NEG14            1.096       1.221       1.260       1.490       1.855       1.921       2.024
 DEMANDS  BY
    NEG16            1.000       1.000       1.000       1.000       1.000       1.000       1.000
    NEG17            0.729       0.812       0.843       1.037       1.264       1.311       1.466
    NEG19            0.642       0.722       0.764       0.966       1.211       1.277       1.415
    NEG20            0.647       0.697       0.729       0.934       1.210       1.273       1.431
 BADADV   WITH
    HOSTILE          0.097       0.116       0.125       0.174       0.237       0.251       0.278
 DEMANDS  WITH
    HOSTILE          0.124       0.145       0.157       0.215       0.288       0.301       0.333
    BADADV           0.121       0.137       0.146       0.200       0.269       0.284       0.313
 Intercepts
    NEG6             0.450       0.490       0.509       0.588       0.683       0.699       0.727
    NEG26            0.436       0.472       0.488       0.567       0.667       0.684       0.716
    NEG30            0.520       0.548       0.560       0.639       0.734       0.753       0.781
    NEG35            0.340       0.366       0.387       0.469       0.555       0.574       0.598
    NEG11            0.333       0.358       0.368       0.454       0.533       0.549       0.579
    NEG12            0.318       0.348       0.364       0.438       0.522       0.535       0.556
    NEG13            0.702       0.734       0.757       0.851       0.949       0.976       1.025
    NEG14            0.650       0.691       0.706       0.804       0.913       0.932       0.971
    NEG16            0.353       0.394       0.414       0.500       0.597       0.611       0.654
    NEG17            0.258       0.289       0.306       0.381       0.468       0.480       0.509
    NEG19            0.832       0.874       0.895       1.000       1.103       1.124       1.169
    NEG20            0.524       0.549       0.564       0.649       0.748       0.774       0.804
 Variances
    HOSTILE          0.115       0.140       0.158       0.231       0.315       0.339       0.375
    BADADV           0.125       0.157       0.167       0.245       0.334       0.348       0.385
    DEMANDS          0.132       0.176       0.195       0.290       0.402       0.425       0.455
```

Lawrence DeCarlo's SPSS Macro for Computing Mardia's Coefficient for Multivariate Normality

http://www.columbia.edu/~ld208/

Syntax

```
INCLUDE file='C:\jason\spsswin\semclass\mardia.sps'.
mardia vars=neg6 neg26 neg30 neg35
        neg11 neg12 neg13 neg14
        neg16 neg17 neg19 neg20 /.
execute.
```

Output

```
Mardia's multivariate skew (small sample adjustment: Mardia 1974 Sankya)
        b1p    Chi(b1p)    p-value    adj-Chi    p-value
    47.8734  1547.9076      .0000  1575.5735      .0000
Mardia's multivariate kurtosis
        b2p     N(b2p)    p-value
   254.2928    32.7851      .0000
```

Note: A significant result indicates the data diverge from a multivariate normal distribution, but this test is likely to be significant when sample size is large. Significant results do not necessarily mean that the model chi-square or the standard errors will be substantially biased, and researchers need to try to gauge the magnitude of the departure from normality. N(b2p) is the normalized estimate of the multivariate kurtosis measure.

Univariate Statistics using SPSS

	N	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
neg6 Act angry or hostile	194	.59	.731	1.222	.175	1.821	.347
neg26 Behave insensitively toward you	194	.57	.774	1.332	.175	1.649	.347
neg30 Do thoughtless things	194	.64	.751	1.075	.175	1.248	.347
neg35 Make you feel inferior	194	.47	.783	1.969	.175	4.360	.347
neg11 Give you bad advice	194	.45	.683	1.401	.175	1.364	.347
neg12 Interfere or meddle with problems	194	.44	.674	1.355	.175	.927	.347
neg13 Question your decisions	194	.85	.835	.719	.175	-.122	.347
neg14 Give unwanted advice	194	.80	.889	1.021	.175	.785	.347
neg16 Not give help	194	.50	.770	1.822	.175	4.016	.347
neg17 Take advantage of you	194	.38	.690	2.111	.175	5.228	.347
neg19 Make demands or favors	194	1.00	.911	.749	.175	-.250	.347
neg20 Ask for more help than you can give	194	.65	.756	.755	.175	.602	.347
Valid N (listwise)	194						