

### Illustration of Scaled Chi-square Difference Computation

To illustrate the scaled chi-square difference test, a weighted test for robust estimates when data are continuous non-normal (MLM or MLR in Mplus and lavaan), I used the values from handout "Examples of Estimates with non-normal data" from the lavaan output as the baseline model and the model below as the nested model and the Excel sheet created by Bryant and Satorra (2013). Note that my constraint of two factor correlations to be equal is not particularly theoretically driven and might not occur often in practice. Results here indicate that the difference is not significant, scaled  $\Delta\chi^2(1) = .930$ ,  $p = .335$ .

```
> #retest model with two factor covariances constrained
> model2 = '
+   hostile =~ neg6 + neg26 + neg30 + neg35
+   badadv =~ neg11 + neg12 + neg13 + neg14
+   demands =~ neg16 + neg17 + neg19 + neg20
+
+   hostile ~~ psyl*badadv
+   hostile ~~ demands
+   badadv ~~ psyl*demands
+ '
> fit2 = sem(model2, data = nonnorm1, estimator="mlm")
> summary(fit2, fit.measures=TRUE, rsquare=TRUE, standardized=TRUE)
```

|                                    |          |         |
|------------------------------------|----------|---------|
| Number of observations             | 194      |         |
| Estimator                          | ML       | Robust  |
| Minimum Function Test Statistic    | 133.059  | 82.061  |
| Degrees of freedom                 | 52       | 52      |
| P-value (Chi-square)               | 0.000    | 0.005   |
| Scaling correction factor          |          | 1.621   |
| for the Satorra-Bentler correction |          |         |
| Model test baseline model:         |          |         |
| Minimum Function Test Statistic    | 1287.035 | 586.734 |
| Degrees of freedom                 | 66       | 66      |
| P-value                            | 0.000    | 0.000   |

The Mplus specification for constraining the two factor covariances to be equal is below.

```
hostile with badadv (1);
hostile with demands;
badadv with demands (1);
```

| Satorra-Bentler (2001) Scaled Difference Chi-Square Test for LISREL 9, EQS, or Mplus  |                |              | Baseline (less restrictive) model = <b>more</b> estimated parameters (SMALLER df)                      |             |
|---|----------------|--------------|--|-------------|
| <small>(see first sheet for scaled difference test for LISREL 8)</small>  |                |              | Nested (more restrictive) comparison model = <b>fewer</b> estimated parameters (LARGER df)             |             |
| <b>Example data below are from the "Examples of Estimates with Non-normal Data" handout and "Illustration of scaled chi-square difference computation" handout (Newsom)</b> |                |              |  |             |
|   | Baseline Model | Nested Model |  |             |
| Min Fit ML chi-square (T1)  | 132.168        | 133.059      | Note: you enter the green font fields the rest are computed. Answer is in the yellow highlighted area. |             |
| ML scaled chi-square value (T3)   | 80.888         | 82.061       |  |             |
| df  | 51             | 52           |  |             |
| c: scale correction factor (T1/T3)  | 1.634          | 1.621        |  |             |
| c*df  | 83.334         | 84.292       |  |             |
| c*df difference   |                |              |  | 0.958       |
| m (difference in dfs)   |                |              |  | 1           |
| scaling factor for difference test (c-d)  |                |              |  | 0.958       |
| Min fit ML difference   |                |              |  | 0.891       |
| Scaled chi-square difference  |                |              |  | 0.9301      |
| df for scaled chi-square difference test  |                |              |  | 1           |
|   |                | p value      |  | 0.334836941 |

**Bryant, F. B., & Satorra, A. (2012). Principles and practice of scaled difference chi-square testing. *Structural Equation Modeling, 19*(3), 372-398.**

**Satorra, A., & Bentler, P. M. (2001). A scaled difference chi-square test statistic for moment structure analysis. *Psychometrika, 66*, 507-514.**

**INSTRUCTIONS:**

- Enter T1 (row 5), T3 (row 6), & df (row 7) for both Baseline and Nested Comparison models in table above.
- Report final result of scaled chi-square difference test in terms of scaled difference chi-square value (row 14), df (row 15), & p value (row 16) for scaled difference test.

Citation for the use of this macro file: **Bryant, F. B., & Satorra, A. (2013). EXCEL macro file for conducting scaled difference chi-square tests via LISREL 8, LISREL 9, EQS, and Mplus. Available from the authors.**