A Problem of Multi-group Analysis in Structural Equation Modeling:
Arguments around Testing Scalar Invariance

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There have been different opinions about the requirement of scalar invariance as the prerequisite of testing factor mean difference across groups in multi-group analyses. Although it is more often suggested to test factor mean differences after scalar invariance is ascertained, there have been questions about the necessity of testing scalar invariance before testing factor mean invariance. Vandenberg and Lance (2000) argued that a judgment of whether to test scalar invariance or not should be made in consideration of research contexts. To investigate this issue, we conducted simulation studies on three cases of relationships between intercepts and factor scores in the equation of mean structure across groups: difference of response intervals, difference of thresholds, and difference of response sets such as leniency or severity. Based on a simple model of one factor and one observed variable, we compared results from X-ANOVA (analysis of variance on observed variable) and F-ANOVA (analysis of variance on factor scores) to determine whether testing scalar invariance is necessary before factor mean difference is tested across groups in each of the three cases.

Method

Design. We conducted simulation studies of 4x3 randomized factorial design for each of the three cases. Factor 1 was sample size with four levels: 50, 100, 200, 400. Factor 2 was mean difference with three levels: small, medium, large. Mean differences were manipulated for measured variable X in cases 1 and 3, and for factor F in case 2. Cell size was 100.

Procedure. The parameters for each simulation are given in Table 1.

<table>
<thead>
<tr>
<th>Simulation</th>
<th>$\bar{F}_1 = \bar{F}_2$</th>
<th>$\bar{X}_1 = \bar{X}_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 .28</td>
<td>0 .28</td>
</tr>
<tr>
<td>2</td>
<td>0 .50</td>
<td>0 .50</td>
</tr>
<tr>
<td>3</td>
<td>0 .80</td>
<td>0 .80</td>
</tr>
</tbody>
</table>

Table 1. Parameters for Each Simulation

Results and Discussion

There are three findings. First, when response intervals were different and intercepts were different across groups, both F-ANOVA and X-ANOVA were significant in the same direction. In this case, X-ANOVA will be enough to infer factor mean difference once the scalar invariance is obtained, which is a required step. Second, when response thresholds were different and intercepts were different across groups, F-ANOVA was significant despite that X-ANOVA was not significant. Third, when response sets were expected and intercepts were different across groups, F-ANOVA was not significant despite that X-ANOVA was significant. In the latter two cases, testing factor mean difference is required even when scalar invariance does not hold across groups. So testing scalar invariance is not required in these two cases. The results provide qualifications to the propositions of Davison and Sharma (1988) in regards to X-ANOVA and F-ANOVA.

Reference
