Factor Models: Evaluation and Improvement

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Factor analytic models use a variance covariance matrix to estimate underlying factors through the equation $\Sigma = \Lambda\Phi\Lambda' + \Psi$. In order to provide estimates for Λ, Φ, and Ψ some of the parameters need to be restricted and at least k^2 restrictions are required to provide a unique estimate (Joreskog, 1969). The most common specified models place restrictions on Φ or place restrictions on Λ.

The estimation of the specified models, which make restrictions on Λ or Φ, were compared and evaluated. Several different Λ and Φ conditions were used to assess whether the specified models can reproduce these target Λ and Φ conditions. The estimation results indicated that when the Λ and Φ conditions matched the restrictions imposed by the specified models, the models performed well in reproducing the target values. However, when the conditions didn't match the imposed restrictions the specified models performed poorly. In practice a researcher must assume "a priori" knowledge of the restrictions to be imposed on Λ and Φ, and hence, won't really know if the estimation results are correct or not.

Several measures of fit (fit statistics) are commonly used to assess factor analytic models, and were evaluated using a simulation. The simulation results indicated in general that fit statistics have no consistent relationship with the estimation quality of the specified models. In particular, the fit statistics couldn't identify when the estimated correlation between the factors was incorrect.

In an attempt to provide better estimation of factor analytic models, a new model was developed which places no restrictions on Λ or Φ. This was accomplished by expanding Λ by a set of known constants which then could be appropriately restricted, thus satisfying Joreskog's requirement. The estimation based on this model performed better than the other methods considered and appears to be capable of estimating Λ and Φ of any possible form.

References

Joreskog, K. G. (1969). A general approach to confirmatory maximum likelihood factor analysis. *Psychometrika*, *34*(2), 183-202.