# Assessing Multiple Imputation to Test Measurement Invariance with Ordinal Items

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## INTRODUCTION

- In confirmatory factor analysis (CFA), mean and variance adjusted weighted least square estimation (WLSMV) is suggested to handle ordinal data.
- There are studies on multiple imputation (MI) method in structural equation modeling (Enders & Mansolf, 2018; Lee & Shi, 2021; Liu & Sriutaisuk, 2020)
- However, none of the previous studies conducted in a factorial invariance setting.
- Thus, this study aims to examine the use of MI with WLSMV estimation in factorial invariance test with ordinal items.

## METHODS

We extended Enders and Mansolf's (2018) simulation design to a factorial invariance test.

**Population Model:**

- Two-group three-factor model
- Three indicators per factor
- Factor loadings: range from .65 to .75
- Items: 5-point ordinal items
- Factor correlation: .60
- Distribution of items: Symmetric
- Magnitude of non-invariance: 0.0

**Type of Missing Data and Missing Data Model**: Missing at random (MAR)

**Conditions:**

- Missing rate: 10%, 20%, 40%
- Sample size: 100, 500 per group

**Analytic Procedures:**

1. Data generation by R ver. 4.3.0 (R Core Team, 2022) and lavaan (Rosseel, 2012)
2. Multiple imputation process by Blimp software ver. 3.1.4 (Keller & Enders, 2022)
3. The imputation-based RMSEA, CFI, TLI were calculated in each measurement invariance step using semTools package ver. 0.5.6 (Jorgensen et al., 2022) in R

## Main findings

- The tables below presented the proportion of the CFI, TLI, and RMSEA that indicate invariance by sample size, missing data rate, and the number of imputations based on symmetric distribution condition.
  - The cutoff values were .005 (ΔCFI, ΔTLI) and .01 (ΔRMSEA) for a small sample size, and .01 (ΔCFI, ΔTLI) and .015 (ΔRMSEA) for a big sample size (Chen, 2007; Cheung & Rensvold, 2002)

### CFI (Comparative Fit Index)

| *N* | Missing Rate | Tested Model | Complete Data | MI (*m* = 20) | MI (*m* = 100) |
|---|---|---|---|---|---|
| **100** | 10% | loading invariance | 80.7 | 88.3 | 82.2 |
| | | Intercept invariance | 83.3 | 80.4 | 80.0 |
| | 20% | loading invariance | 78.5 | 78.0 | 80.8 |
| | | Intercept invariance | 82.2 | 81.9 | 82.2 |
| **500** | 10% | loading invariance | 100 | 99.9 | 99.9 |
| | | Intercept invariance | 100 | 99.7 | 99.7 |
| | 20% | loading invariance | 100 | 99.1 | 99.9 |
| | | Intercept invariance | 99.9 | 98.4 | 99.4 |
| | 40% | loading invariance | 100 | 86.9 | 96.6 |
| | | Intercept invariance | 100 | 91.9 | 99.0 |

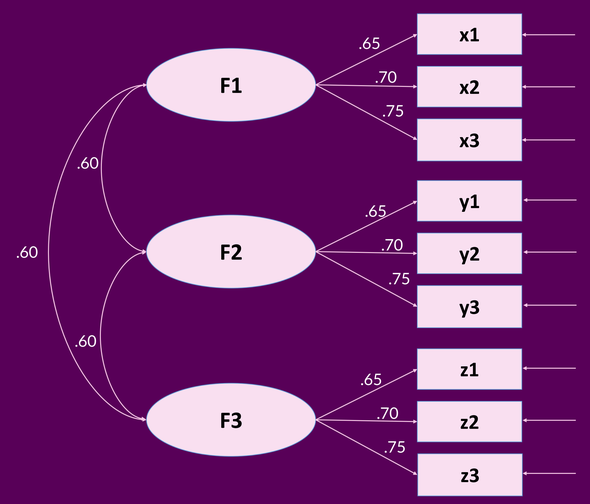
### TLI (Tucker Lewis Index)

| *N* | Missing Rate | Tested Model | Complete Data | MI (*m* = 20) | MI (*m* = 100) |
|---|---|---|---|---|---|
| **100** | 10% | loading invariance | 68.6 | 66.6 | 69.1 |
| | | Intercept invariance | 78.6 | 70.4 | 72.4 |
| | 20% | loading invariance | 65.4 | 63.3 | 69.5 |
| | | Intercept invariance | 77.4 | 68.6 | 74.1 |
| **500** | 10% | loading invariance | 99.9 | 99.0 | 99.5 |
| | | Intercept invariance | 99.9 | 99.2 | 99.6 |
| | 20% | loading invariance | 99.8 | 94.9 | 98.6 |
| | | Intercept invariance | 100 | 96.2 | 99.1 |
| | 40% | loading invariance | 99.8 | 72.4 | 90.8 |
| | | Intercept invariance | 100 | 86.0 | 98.0 |

### RMSEA (Root Mean Square Error of Approximation)

| *N* | Missing Rate | Tested Model | Complete Data | MI (*m* = 20) | MI (*m* = 100) |
|---|---|---|---|---|---|
| **100** | 10% | loading invariance | 80.1 | 85.5 | 84.7 |
| | | Intercept invariance | 87.9 | 88.3 | 87.2 |
| | 20% | loading invariance | 80.3 | 83.1 | 85.1 |
| | | Intercept invariance | 89.1 | 90.2 | 90.6 |
| **500** | 10% | loading invariance | 97.8 | 98.0 | 98.1 |
| | | Intercept invariance | 98.7 | 98.0 | 98.9 |
| | 20% | loading invariance | 97.8 | 96.9 | 98.9 |
| | | Intercept invariance | 97.8 | 98.0 | 98.5 |
| | 40% | loading invariance | 97.5 | 91.8 | 97.8 |
| | | Intercept invariance | 97.7 | 96.8 | 99.6 |

### Model




## CONVERGENCE RATE

| *N* | Missing rate | MI (*m*=20) | MI (*m*=100) |
|---|---|---|---|
| 100 | 10% | 97.0 | 97.0 |
| | 20% | 88.9 | 88.1 |
| | 40% | 3.8 | 2.5 |
| 500 | 10% | 99.9 | 99.9 |
| | 20% | 99.9 | 99.9 |
| | 40% | 99.9 | 99.9 |

## DICUSSIONS

- This study examined the performance of the fit indices (TLI, CFI, RMSEA) with multiply imputed data using WLSMV in the factorial invariance test with ordinal items.
- The most often used cutoffs of fit indices in the factor invariance test (Chen 2007; Cheung & Rensvold 2002) are too restrictive for a small sample size and too liberal for some conditions in big sample size.

## LIMITATIONS

- Small sample size (*N*=100) and high missing rate (40%) condition was excluded from the analysis because of the low convergence rate.

## FUTURE DIRECTIONS

- Analyses with asymmetric conditions and different magnitudes of non-invariance conditions
- Recommendation of new cutoff values of fit indices in factor invariance test.

## REFERENCES