

Using a Parametric Bootstrap Approach for Nested Model Comparisons in Structural Equation Modeling

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Outline

- Introduction
- Trivial Misspecification
- Research Questions
- Parametric Bootstrap Approach
- Simulation
- Result and Discussion

Introduction

- Model evaluation
- Chi-square
- Practical fit Indices
 - Can a single cutoff be applied to any models with any sample sizes and with any types of data?

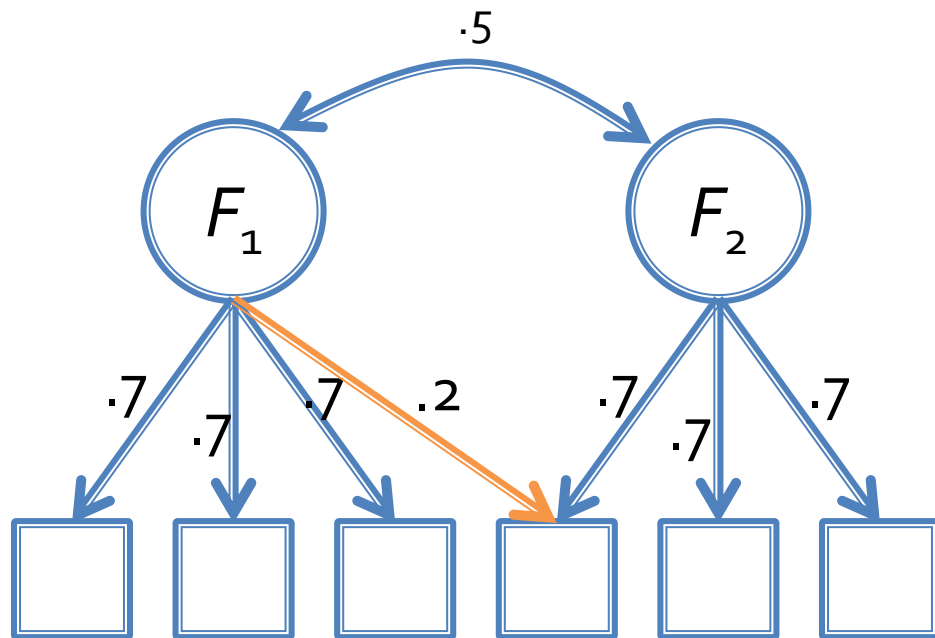
Introduction

- Nested Model Comparison
- Chi-square difference test
- Change in fit indices (e.g., ΔCFI)
 - Results of simulation study → Golden rules
 - Creative applications to nongeneralizable situations

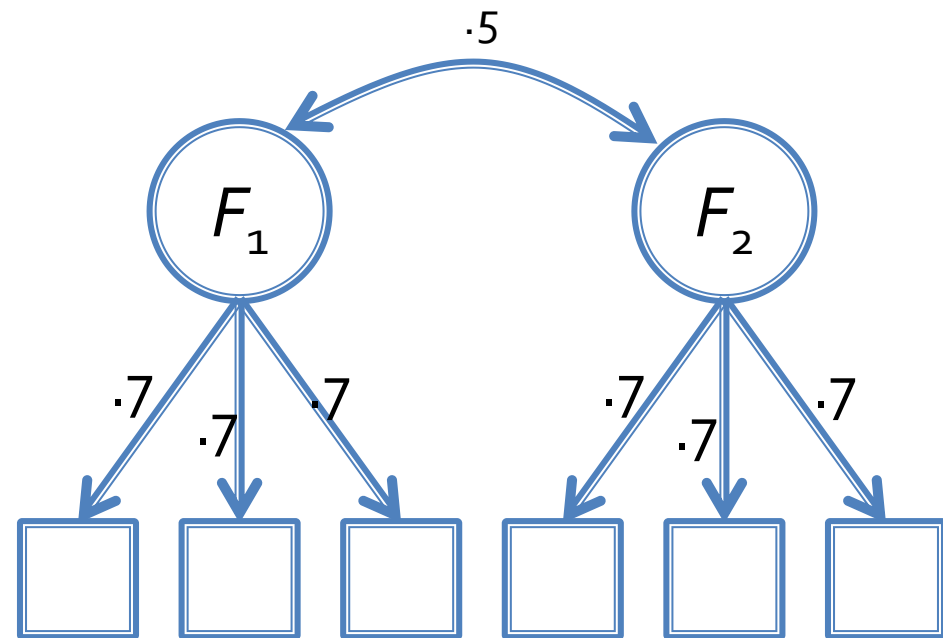
Trivial Misspecification

- Hypothesized model approximates the underlying mechanism.

True Model



Approximate Model

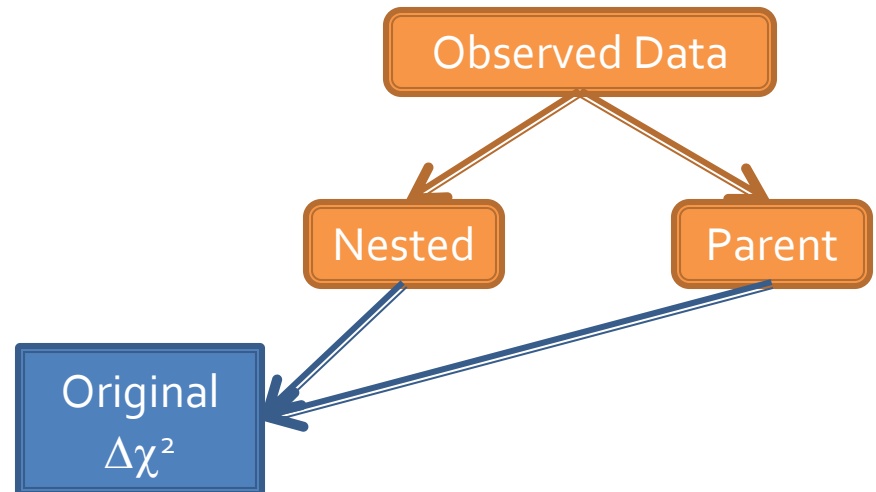


Research Questions

- How can the cutoff be tailored for each hypothesized model?
- How can the golden rule be avoided?
- How can the cutoff be accounted for trivial misspecification? → Test of approximate fit

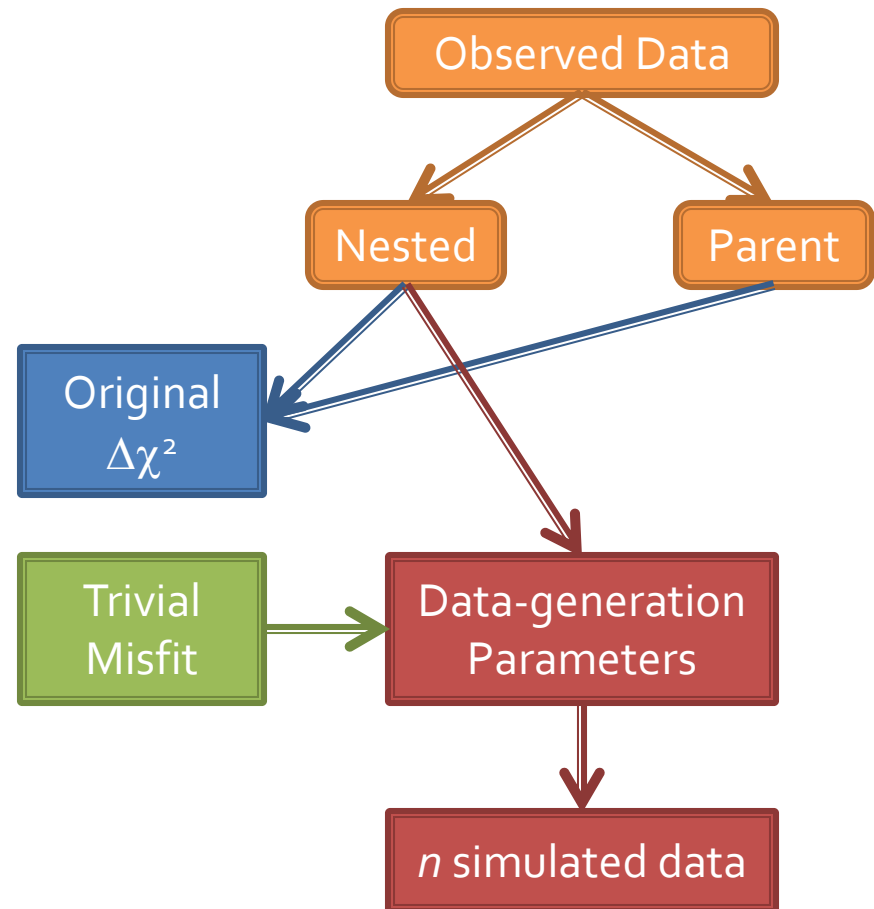
Parametric Bootstrap

- Fit the nested and parent models to the observed data
- Save the **difference** in a fit index



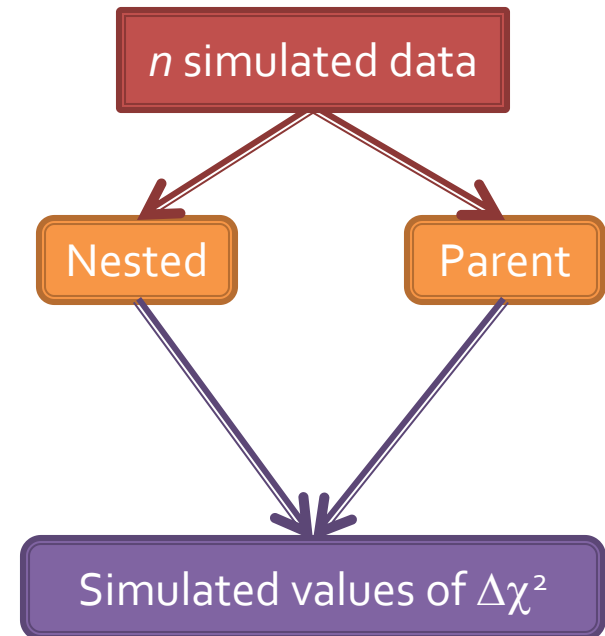
Parametric Bootstrap

- Use the parameter estimates from the nested model
- Add trivial misspecification
- Generate n datasets (e.g., 1,000)



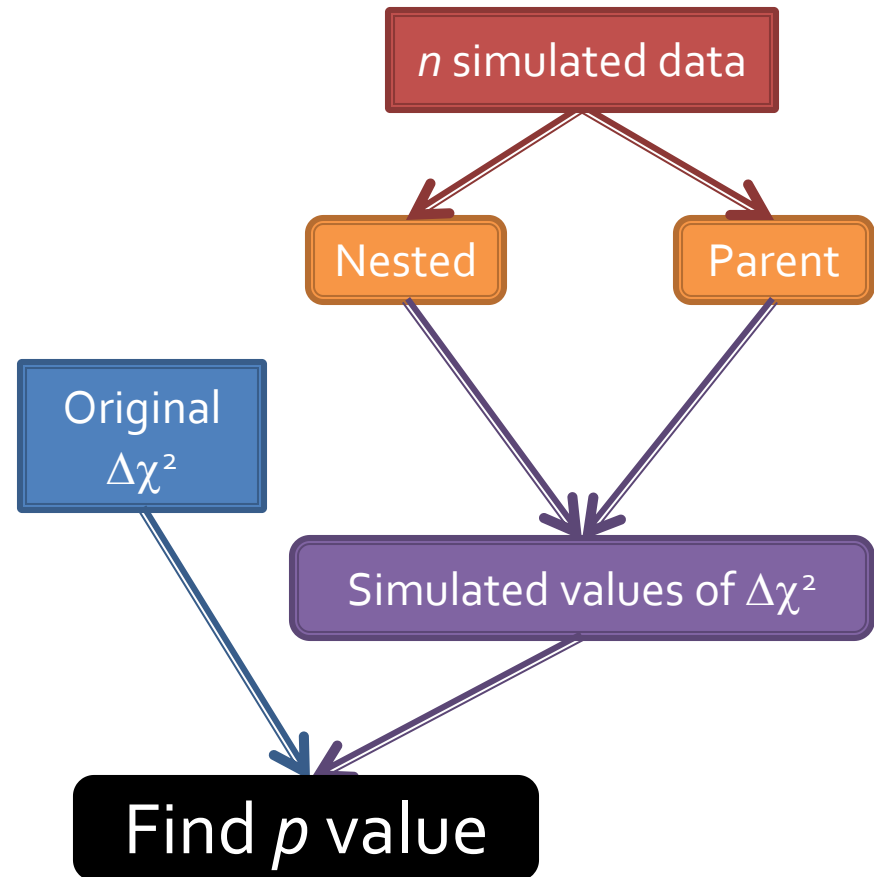
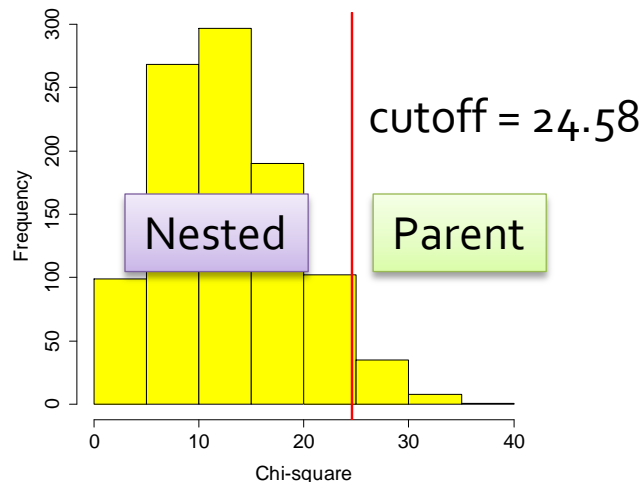
Parametric Bootstrap

- Fit the nested and parent models to all simulated data
- Save the **difference in a fit index** for each simulated data
- Plot the distribution of the difference



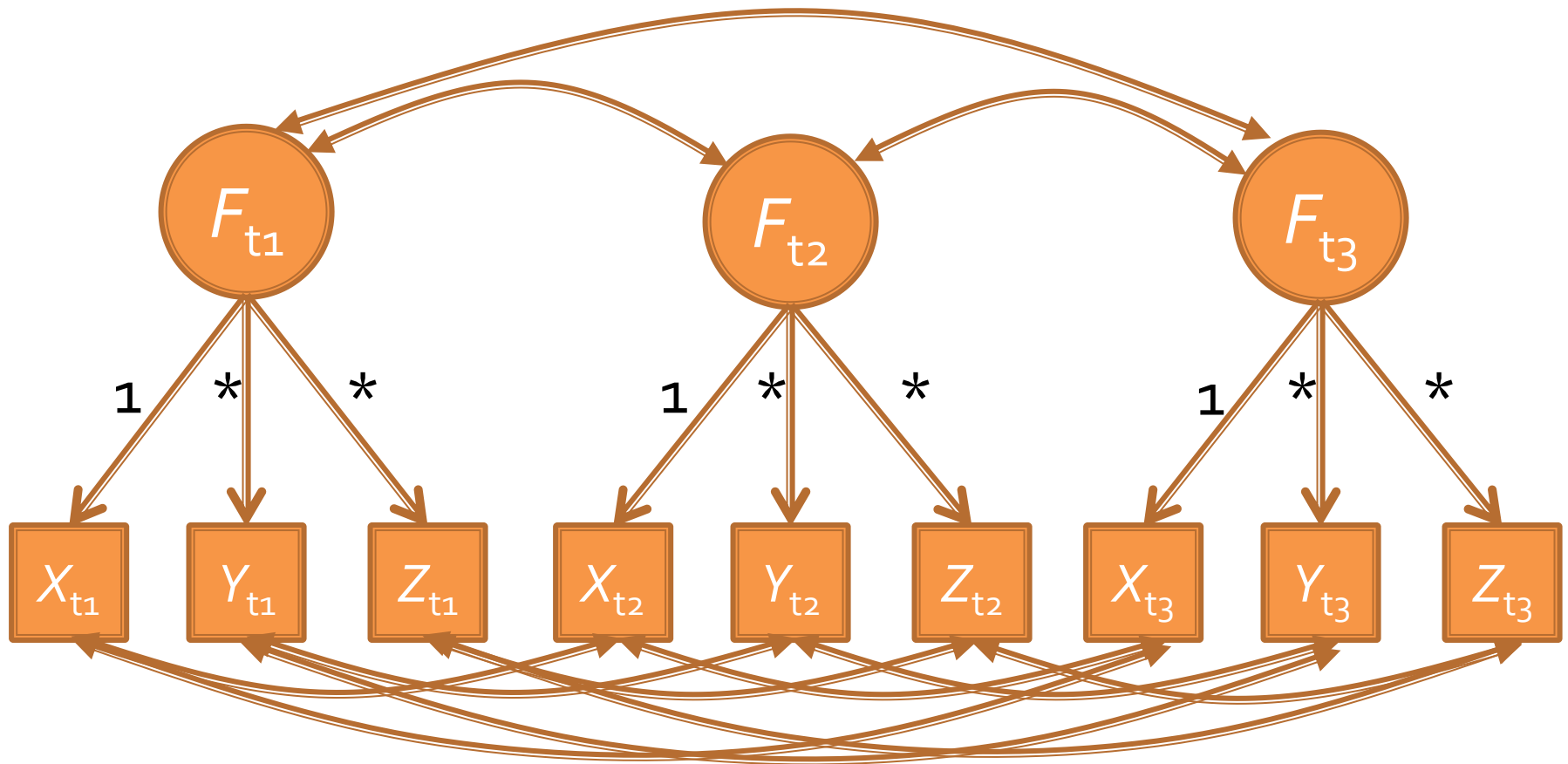
Parametric Bootstrap

- Find p value
 - $p \leq \alpha \rightarrow$ select the parent model
 - $p > \alpha \rightarrow$ select the nested model



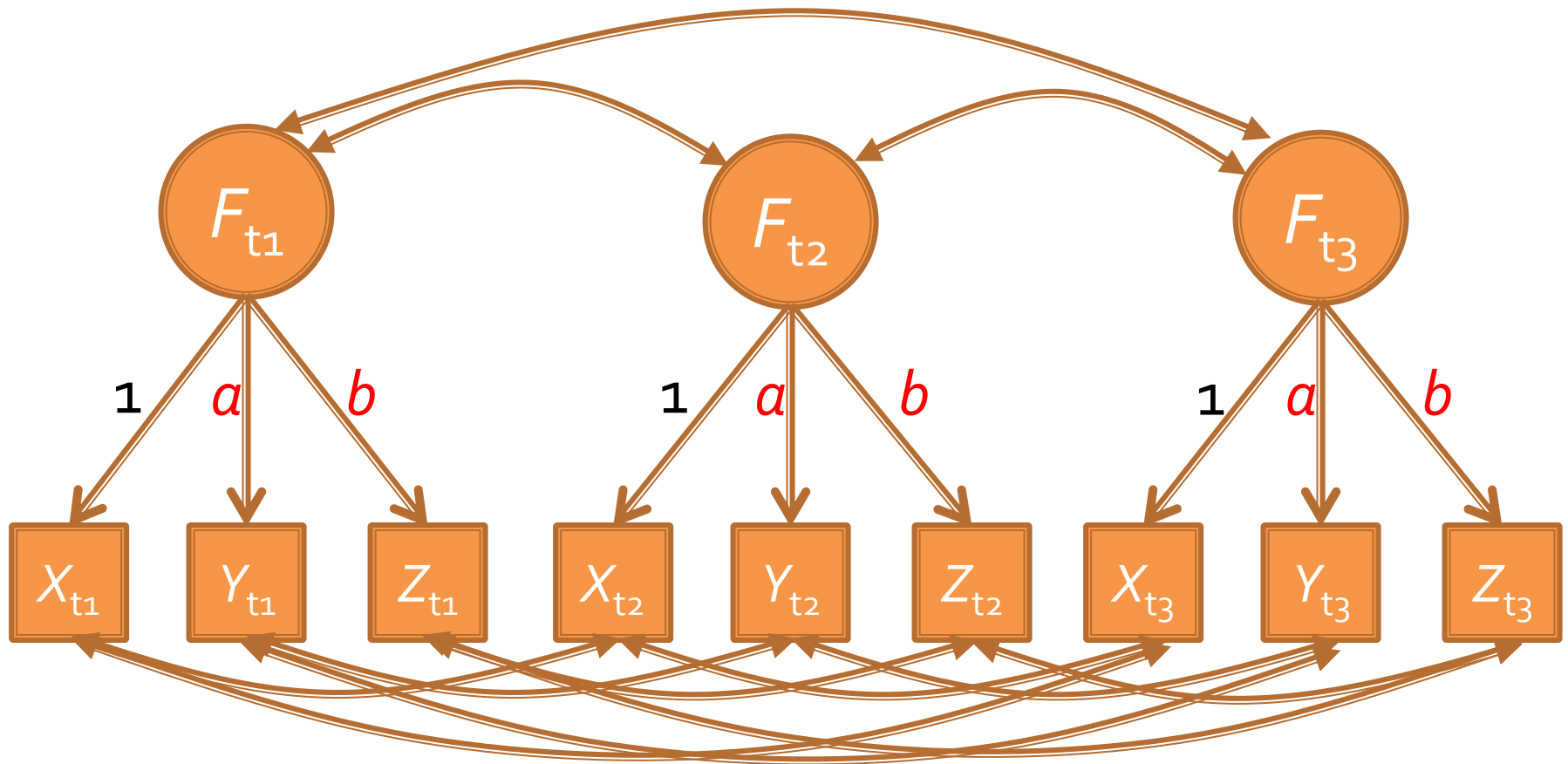
Simulation

Parent Model



Simulation

Nested Model

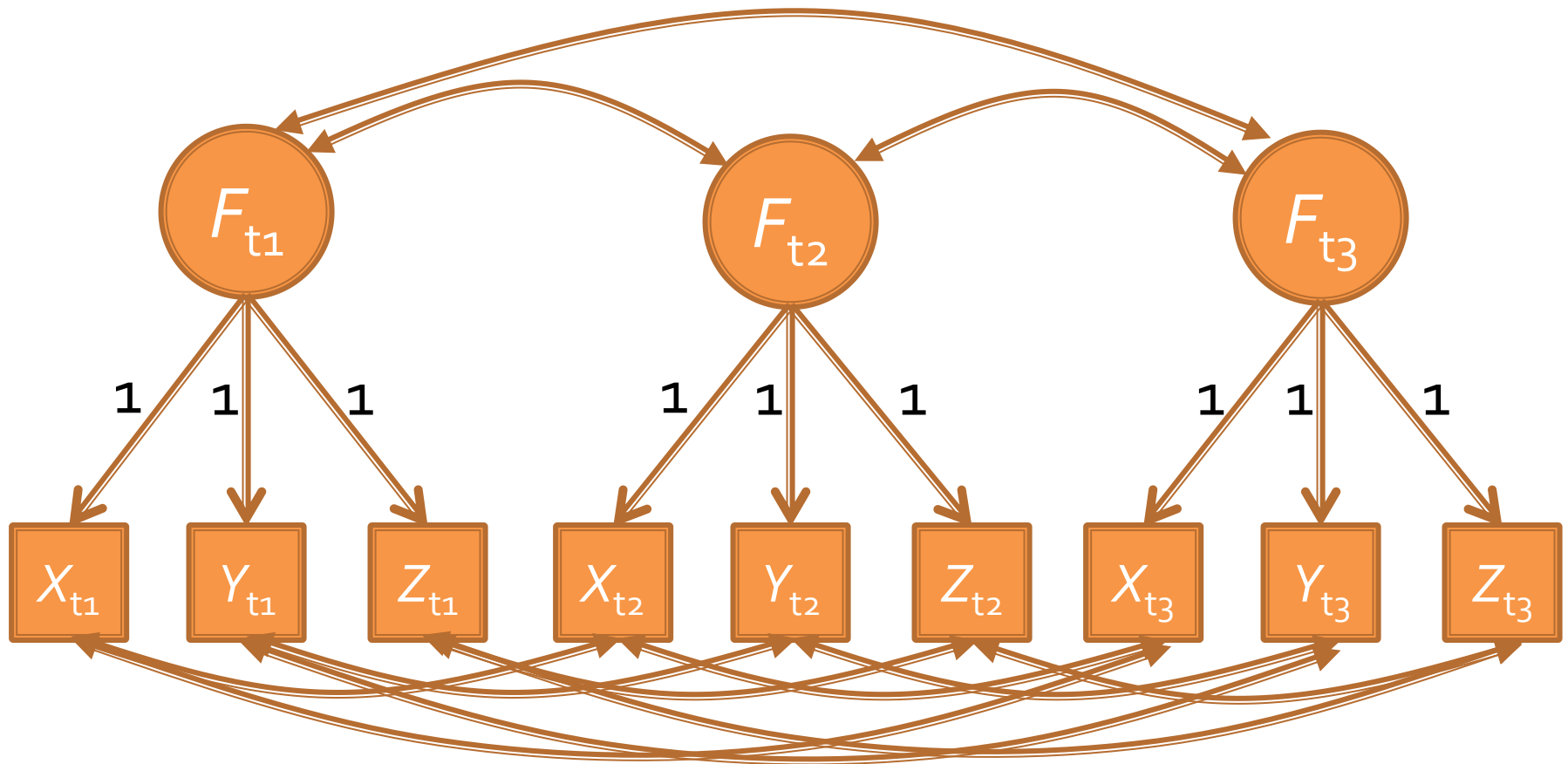


Simulation

- Sample size: 125, 250, 500, 1000
- Severity of misspecification: None, Trivial, Severe

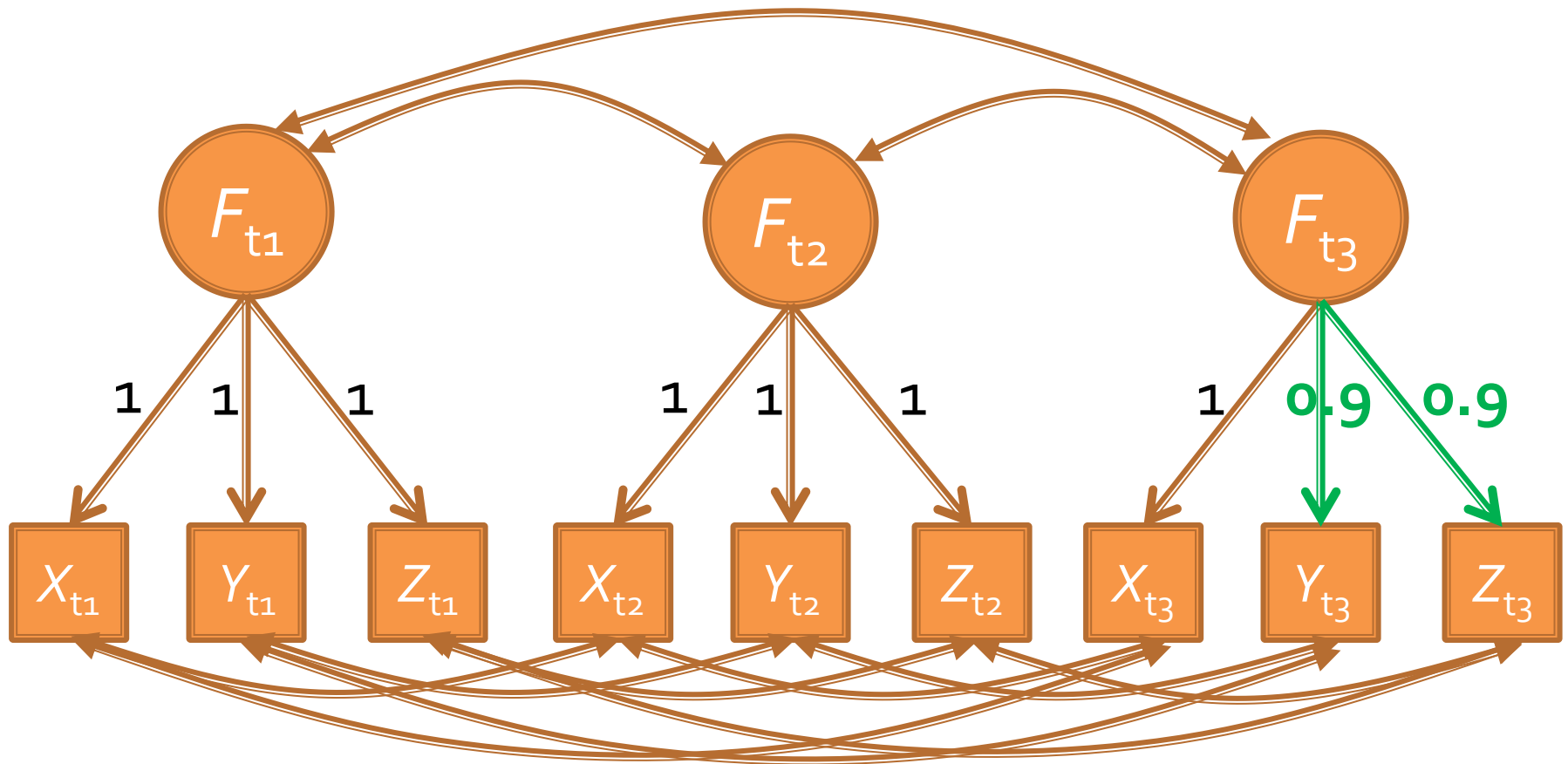
Simulation

Longitudinal Weak Invariance: **No Misspecification**



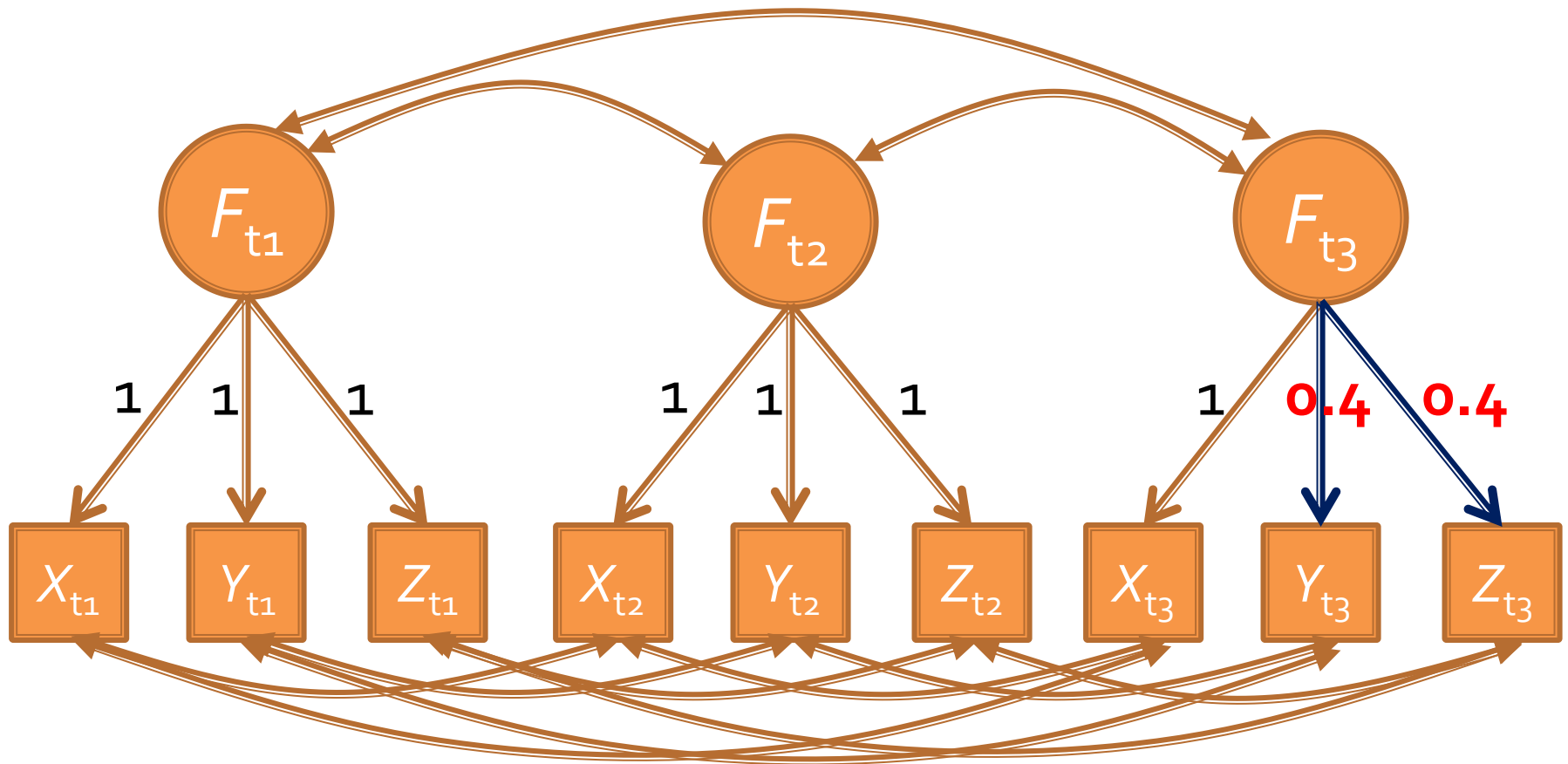
Simulation

Longitudinal Weak Invariance: **Trivial Misspecification**



Simulation

Longitudinal Weak Invariance: Severe Misspecification

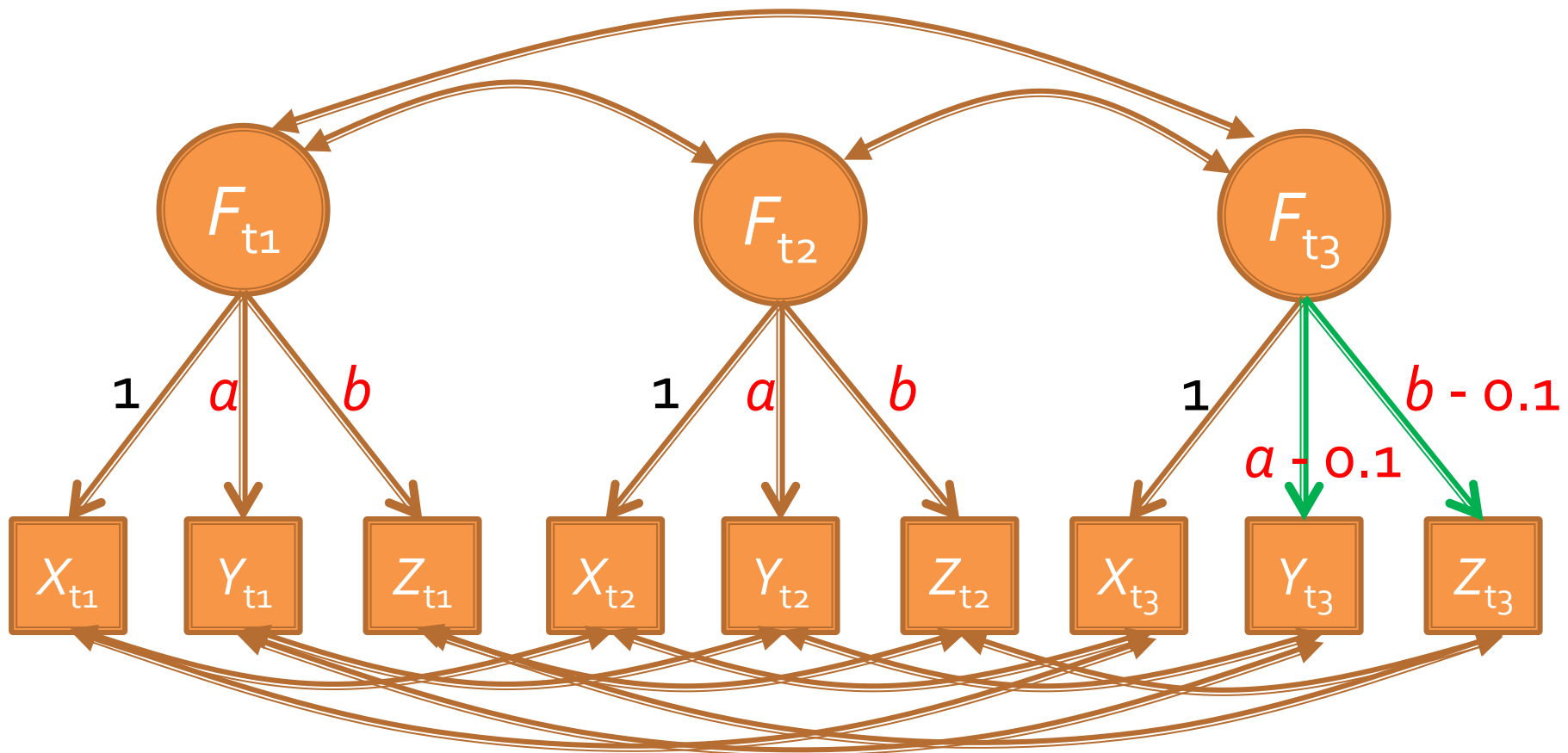


Simulation

- Sample size: 125, 250, 500, 1000
- Severity of misspecification: None, Trivial, Severe
- Three selection methods:
 - Chi-square difference test
 - Change in CFI $< .002$ (Meade et al., 2008)
 - Parametric Bootstrap
 - No misfit / Fixed / Random / Maximal

Simulation

Fixed Misspecification

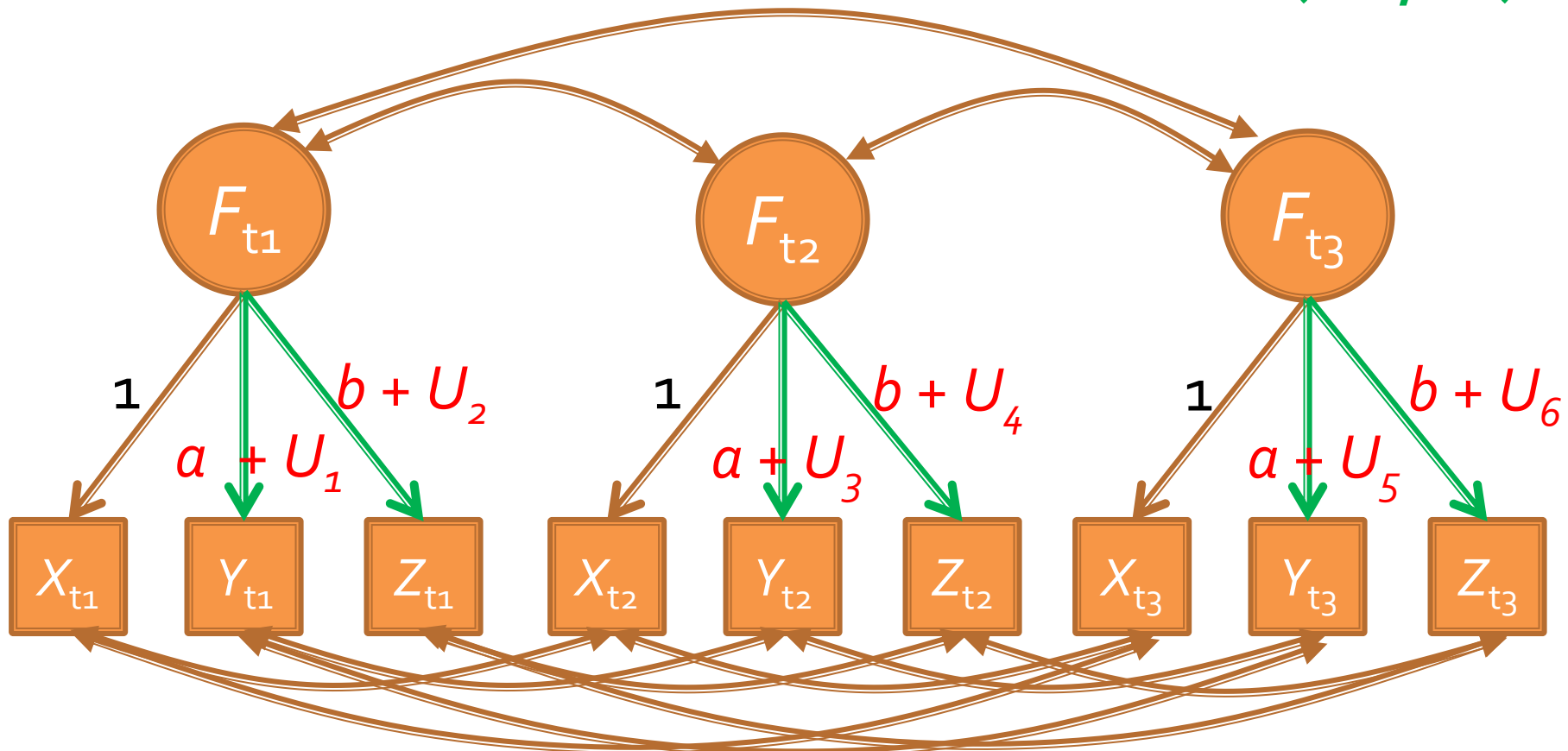


Population RMSEA $\approx .045$

Simulation

Random Misspecification

U_1 to U_6 = A random draw from a uniform distribution $(-0.1, 0.1)$



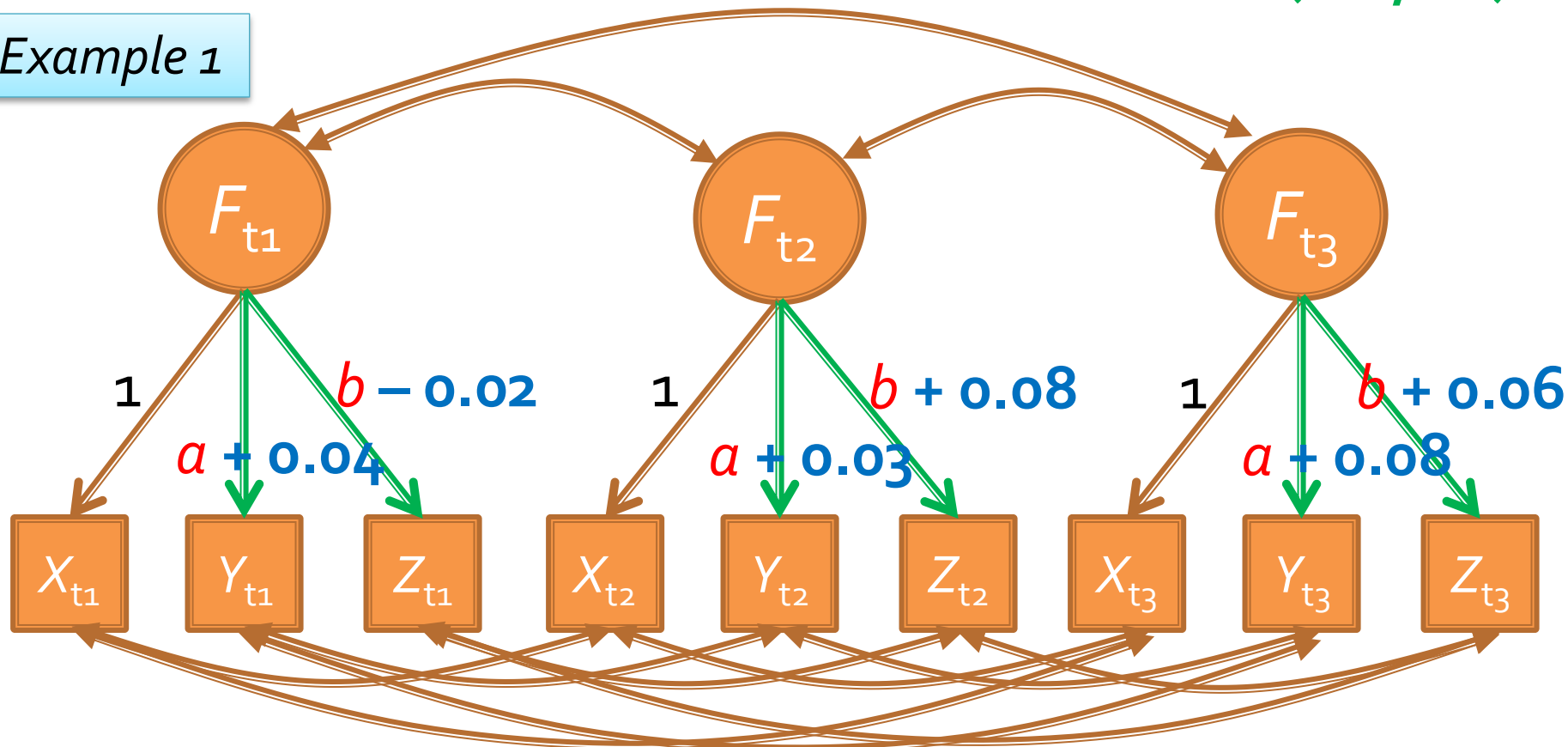
Average Population RMSEA $\approx .051$

Simulation

Random Misspecification

U_1 to U_6 = A random draw from a uniform distribution $(-0.1, 0.1)$

Example 1



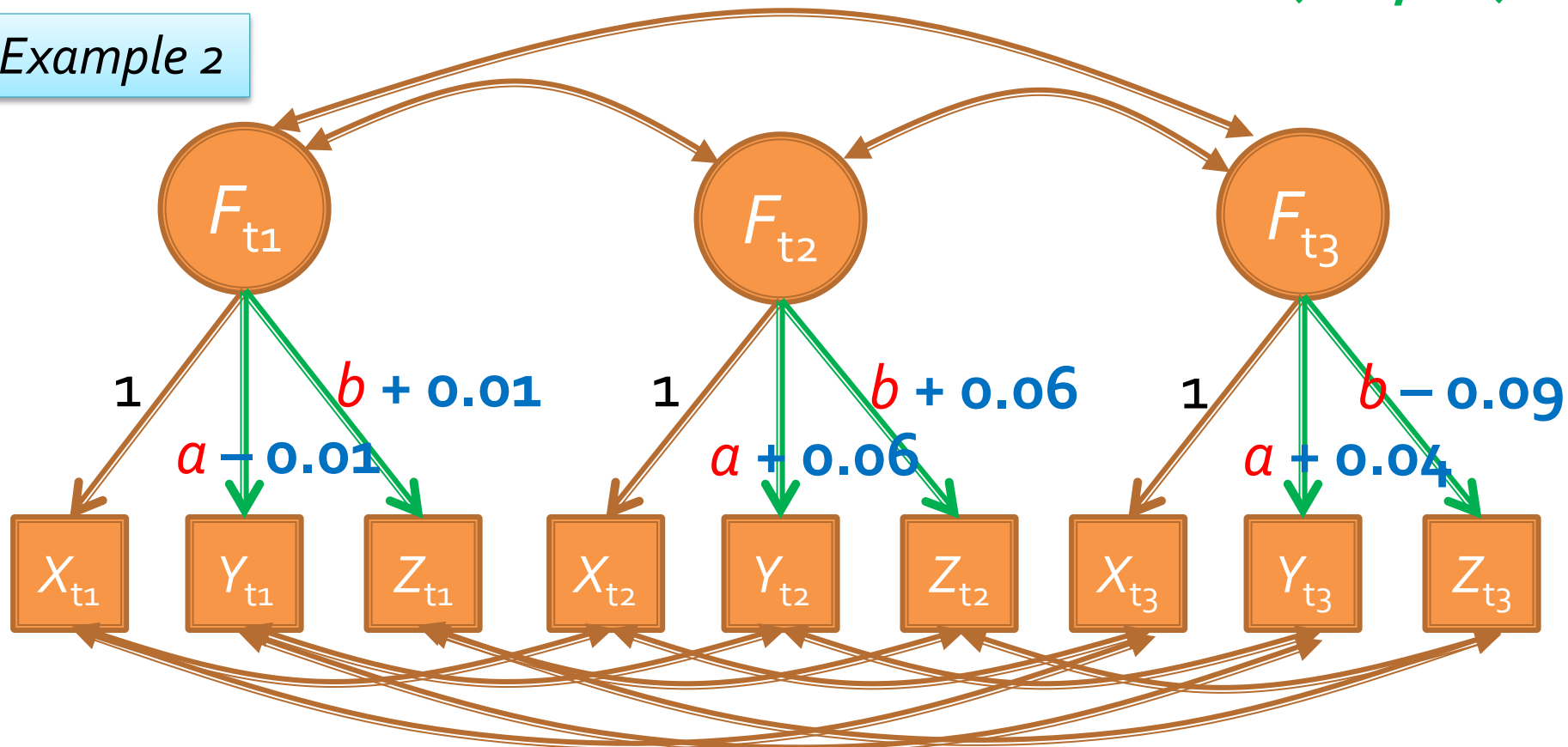
Average Population RMSEA $\approx .051$

Simulation

Random Misspecification

U_1 to U_6 = A random draw from a uniform distribution (-0.1, 0.1)

Example 2



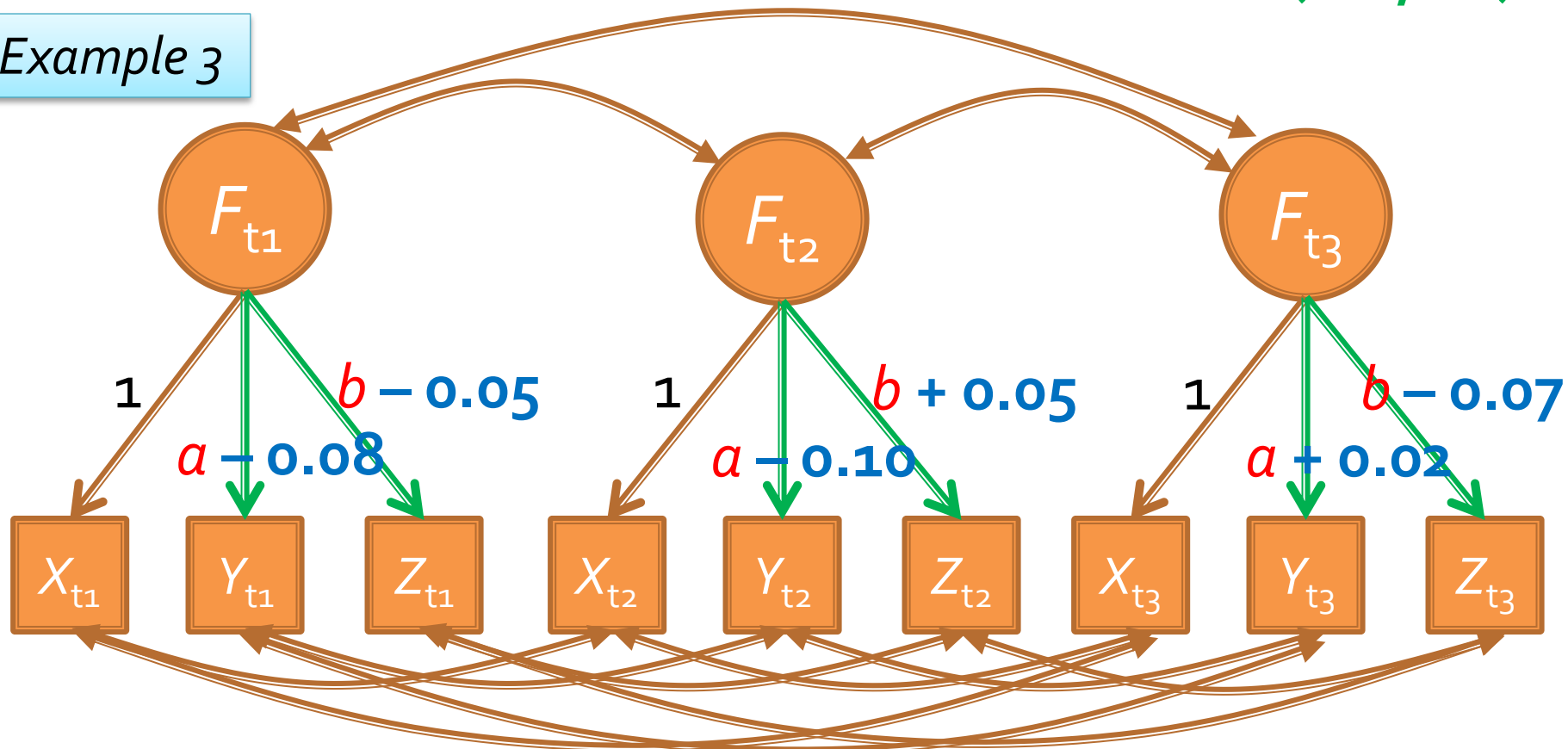
Average Population RMSEA $\approx .051$

Simulation

Random Misspecification

U_1 to U_6 = A random draw from a uniform distribution (-0.1, 0.1)

Example 3

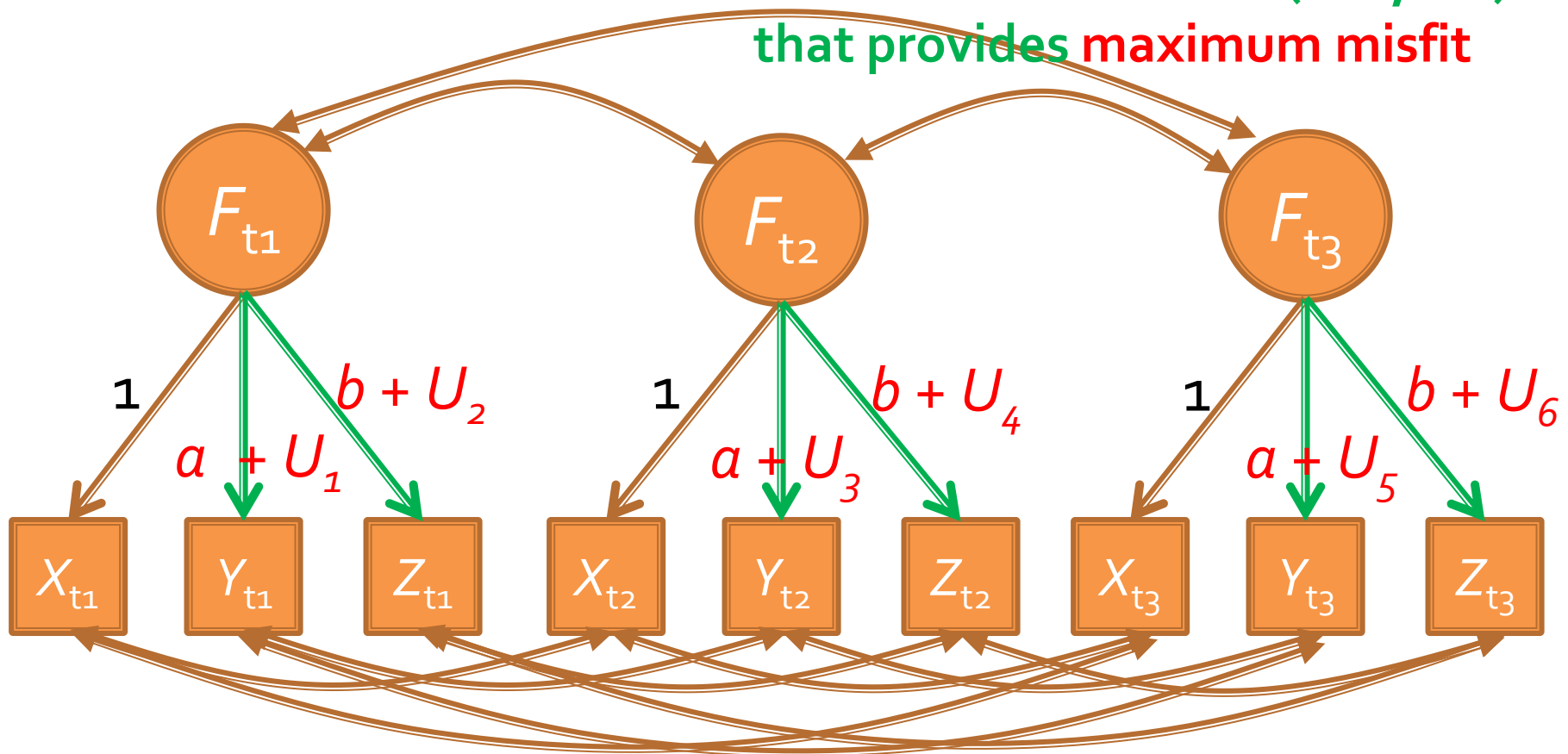


Average Population RMSEA $\approx .051$

Simulation

Maximal Misspecification

U_1 to U_6 = An only set of draw from a uniform distribution $(-0.1, 0.1)$ that provides maximum misfit



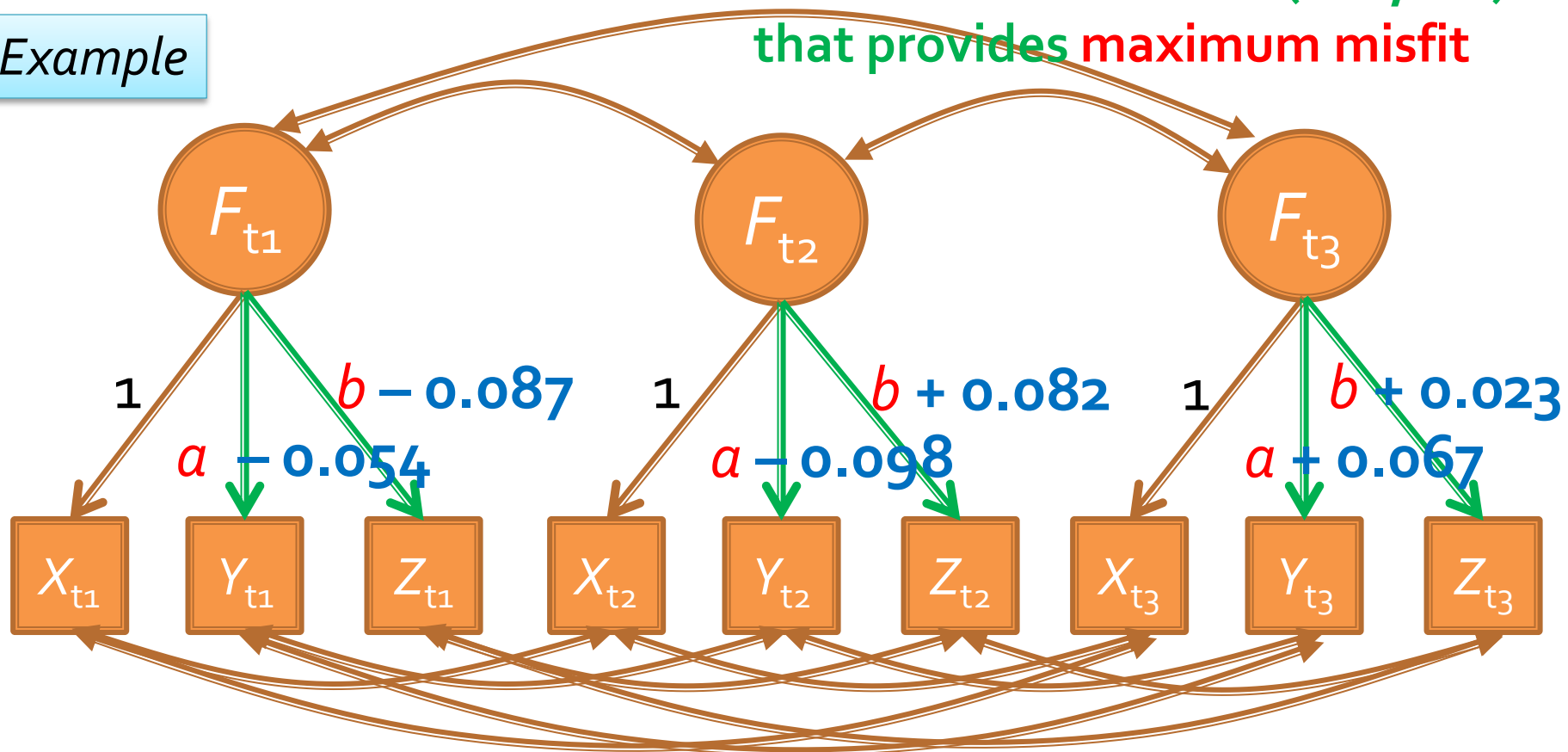
Population RMSEA $\approx .08$

Simulation

Maximal Misspecification

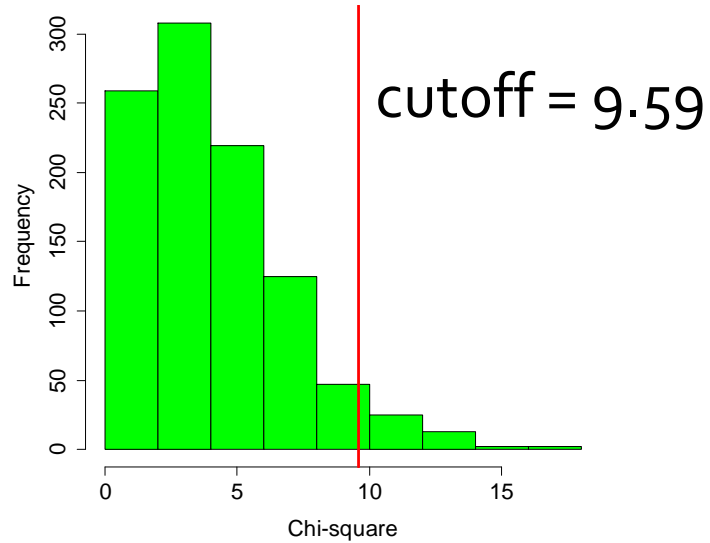
Example

U_1 to U_6 = An only set of draw from a uniform distribution $(-0.1, 0.1)$ that provides maximum misfit

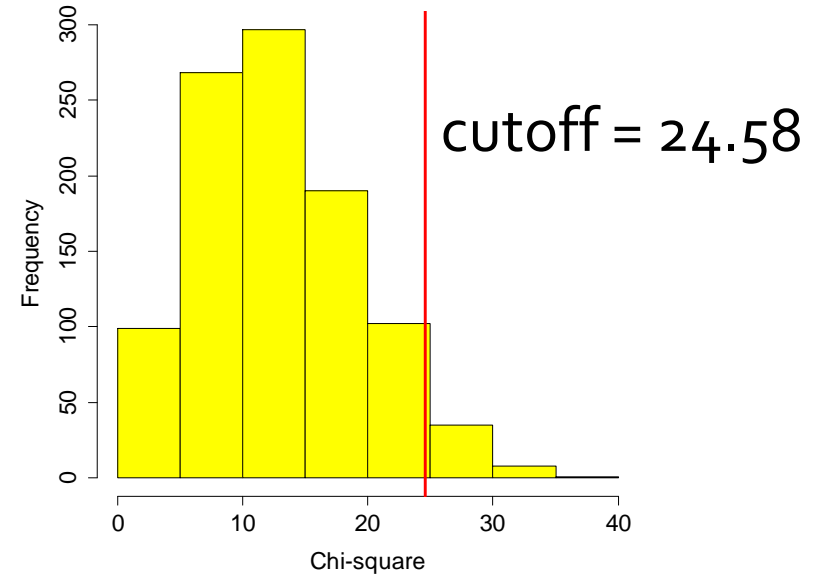


Population RMSEA $\approx .08$

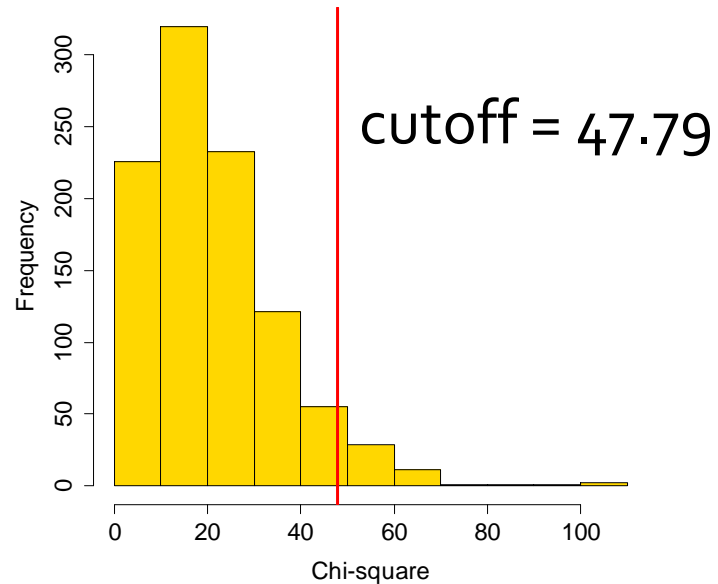
No Misspecification



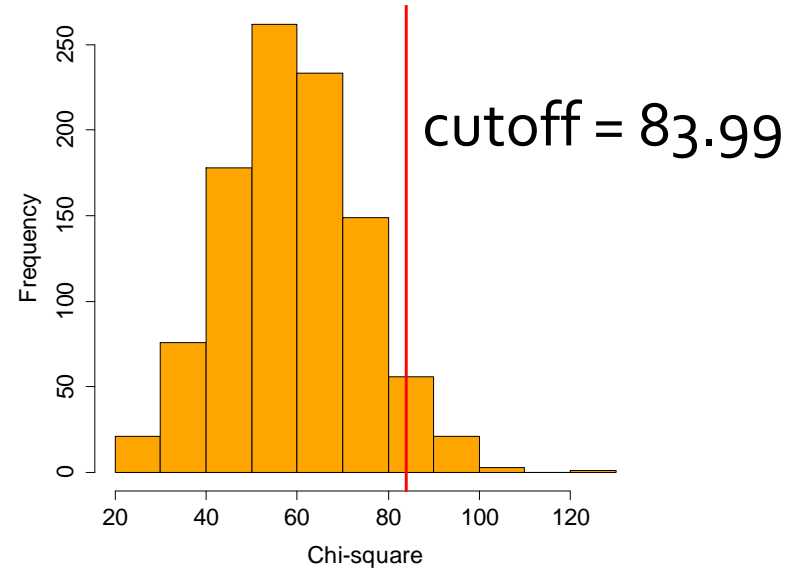
Fixed



Random



Maximal

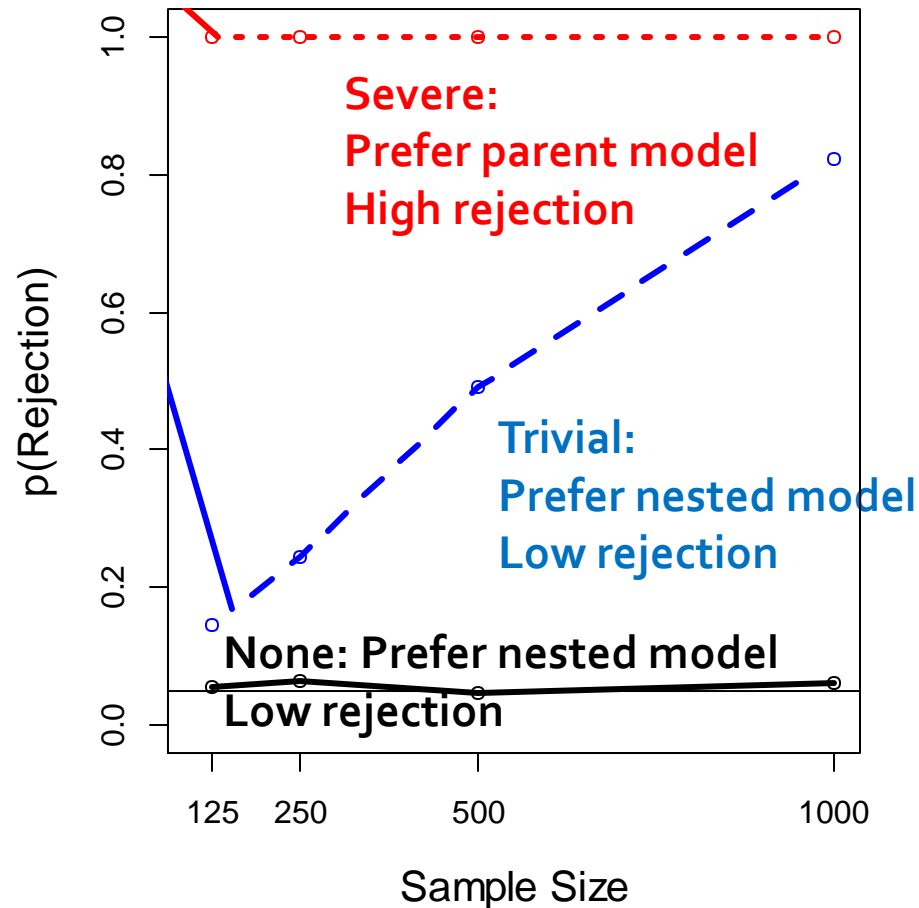


Simulation

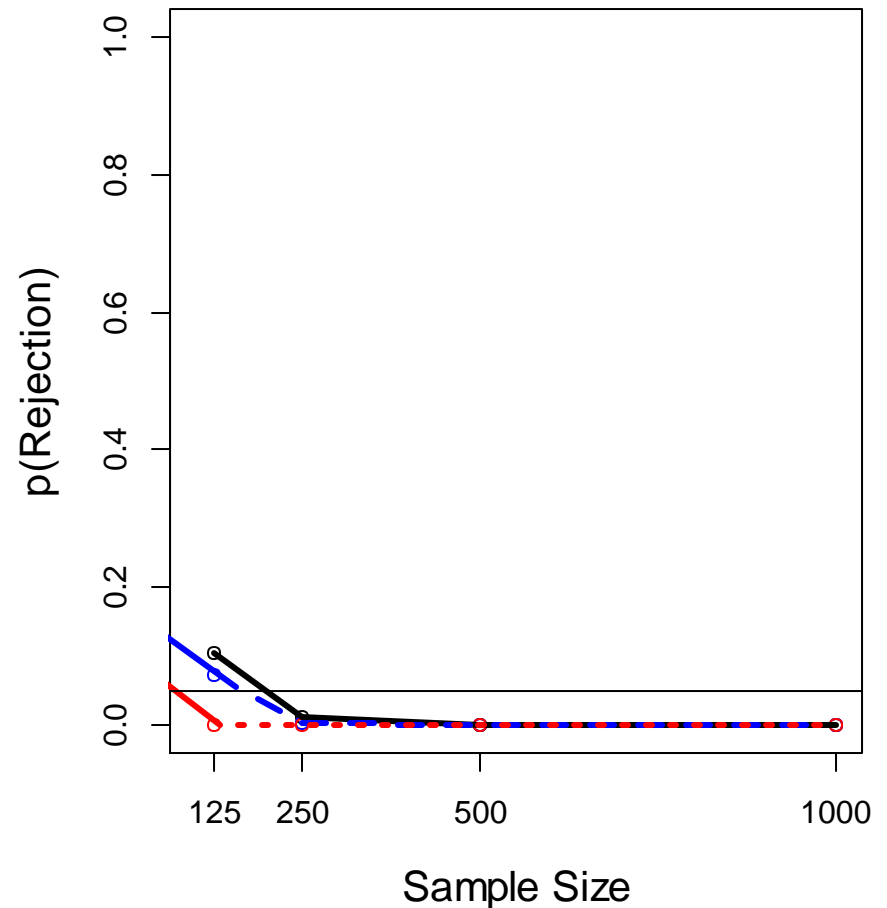
- 1,000 Replications
- Rejection Rate
 - Low when population misfit is none or trivial
 - High when population misfit is severe

Result

Chi-square difference test

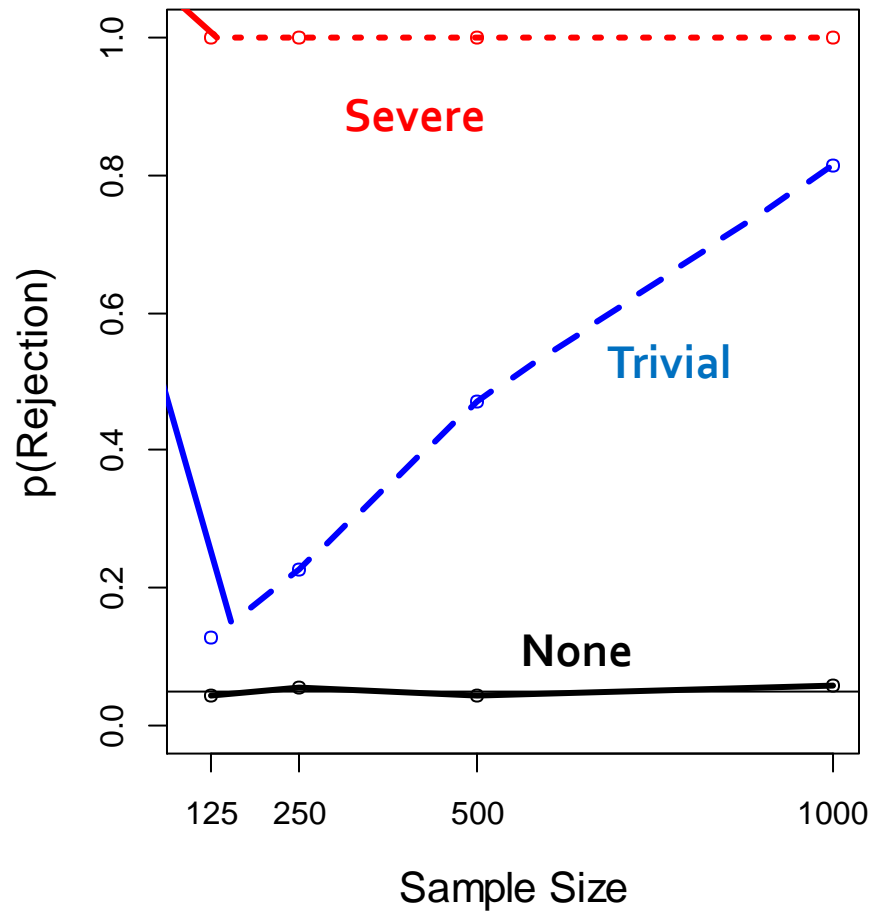


Change in CFI

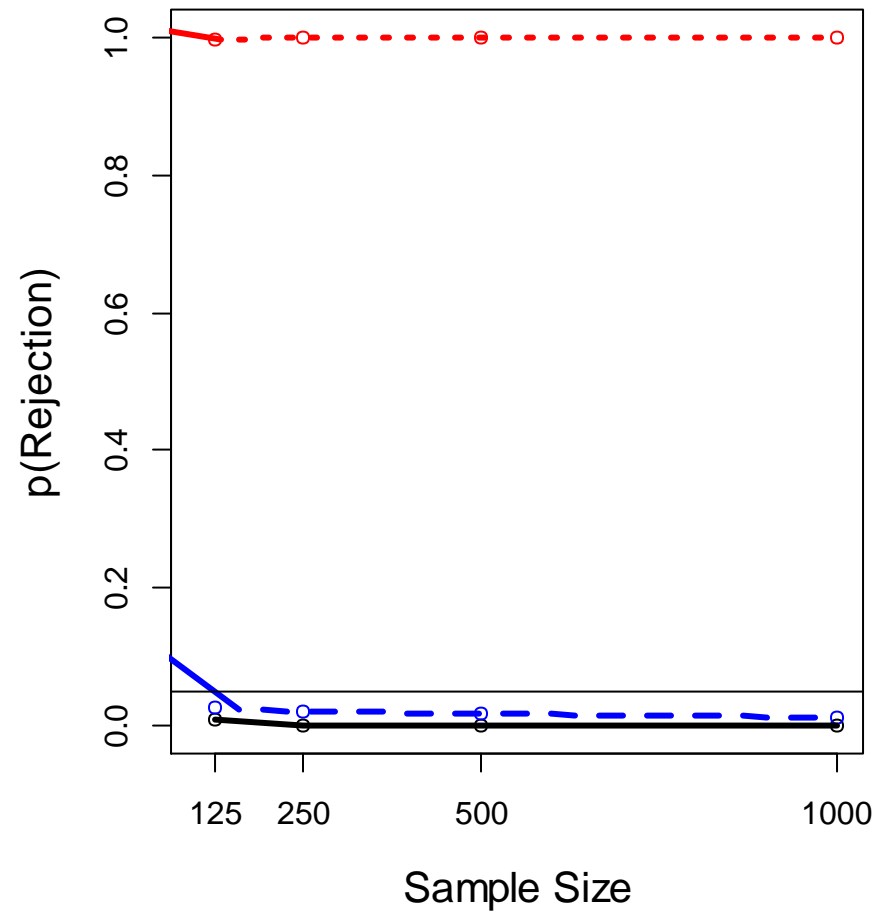


Result

PB: No misfit

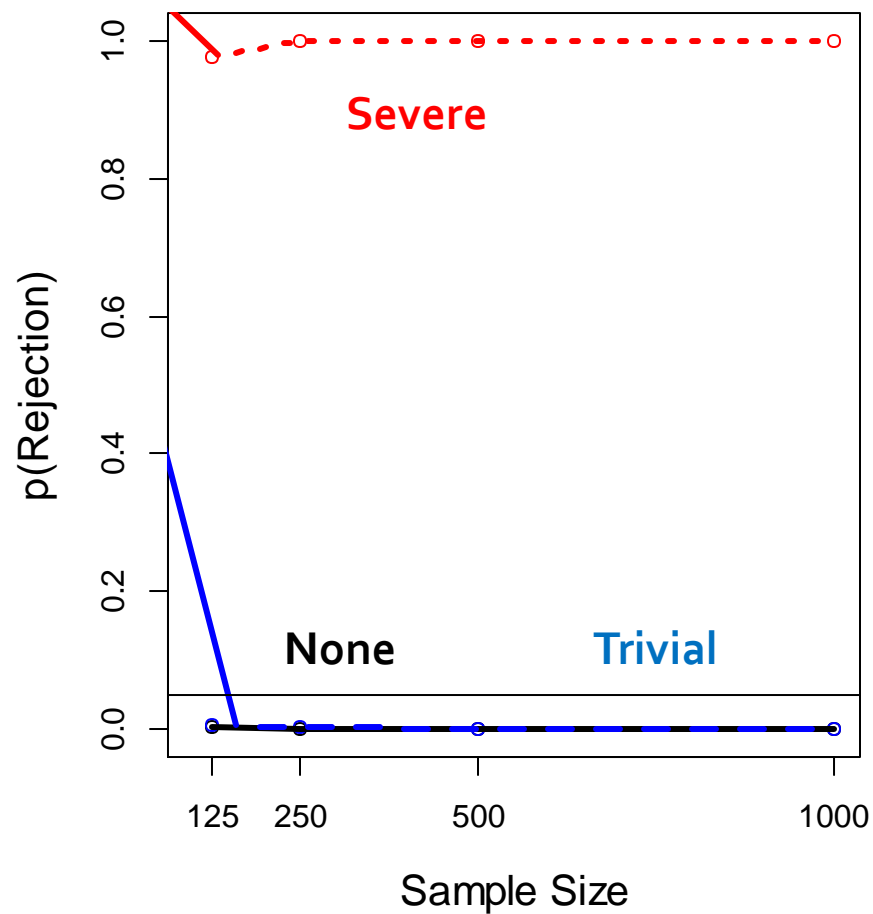


PB: Fixed method with true misfit

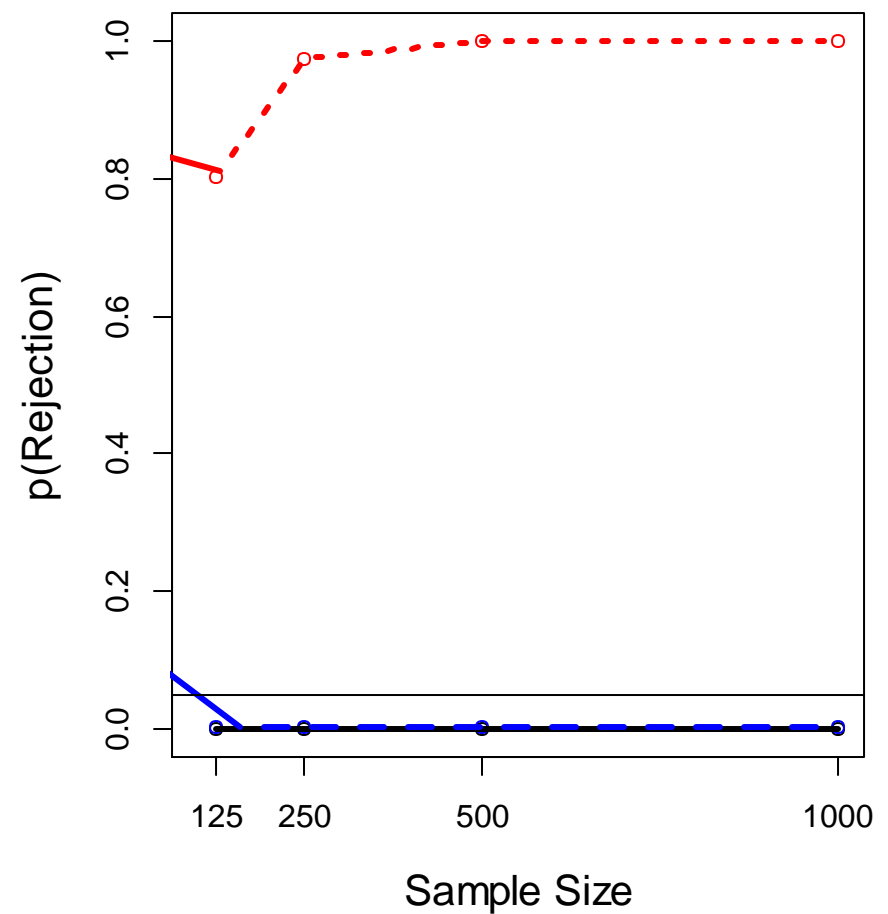


Result

PB: Random method with uniform misfit



PB: Maximal method



Discussion

- Chi-square test = Parametric bootstrap without trivial misspecification, asymptotically
 - Reject trivial misfit in large sample size
- CFI cutoff of .002 (or .01) has extremely low power
- Parametric bootstrap with defined trivial misspecification is good
 - Avoid universal cutoff criterion
 - Avoid rejection of trivial misspecification
 - Encourage Users to define trivial misspecification

Discussion

- Can develop your own simulation in R
- Parametric bootstrap approach in absolute fit and nonnested model comparison
- Semi-parametric bootstrap
- This procedure can be implemented in the *simsem* package in R

<https://www.simsem.org>

Acknowledgement

- Partial support
 - Grant NSF 1053160 (Wei Wu & Todd D. Little, co-PIs)
 - The Center for Research Methods and Data Analysis at the University of Kansas (Todd D. Little, director)

Thank you!!

Questions, Comments, Concerns

