



# Structural Equation Modeling

Mgmt 290  
Lecture 9 – Equivalent Models, Nested Models and Causal Structure

Nov. 21, 2005

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## What are good results?

- (1) Model fits with data.
- (2) Expected Paths are still in the model and their coefficients are significant.

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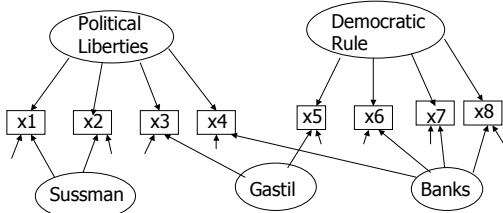
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## (1) Using SEM to study measurement validity

**MTMM**



**ATM Model** - Additive trait-method model

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# ATM Model for MTMM – Multitrait Multimethod

$$I = aT + bM + e$$

- **Application in**
- Organizational research
- Applied psychology
- E Business research
- Marketing research

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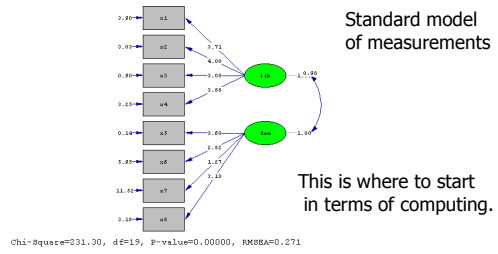
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# Demo Measurement Model 0




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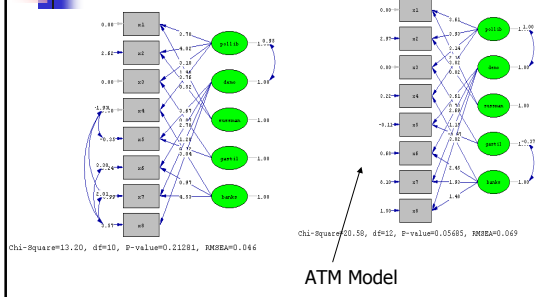
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# Demo Measurement Model 1




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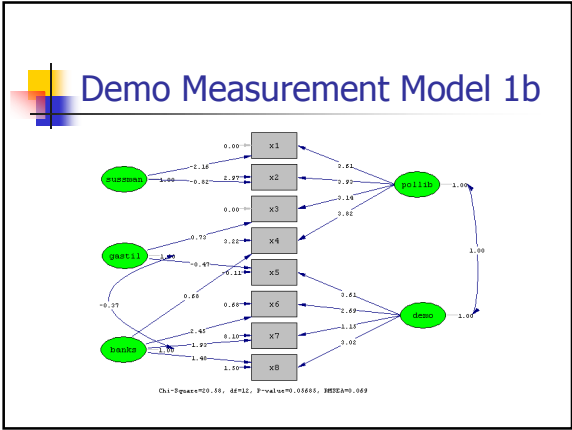
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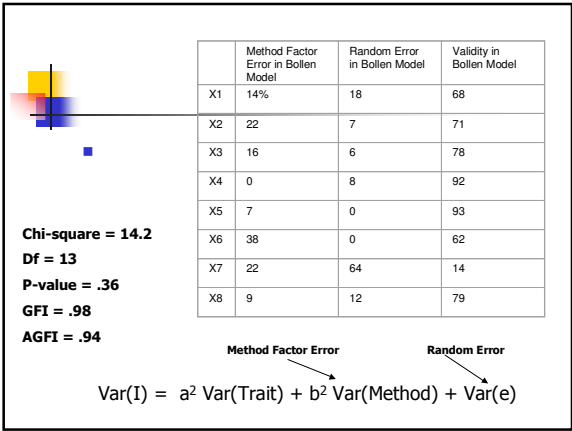
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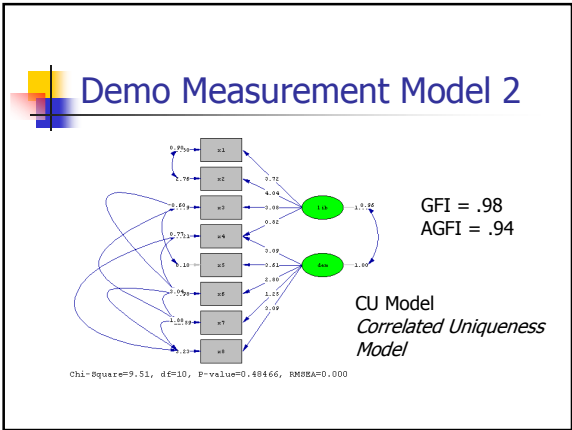
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## (2) Equivalent models

- 2 models are equivalent if they are equally well compatible with the statistical evidence
- 2 models are equivalent if they imply the same set of probability distribution for the observable vector (Koopmans and Reiersol)
- If they reproduce the same set of positive definite covariance matrices (Joreskog and Sorbom)

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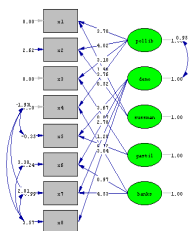
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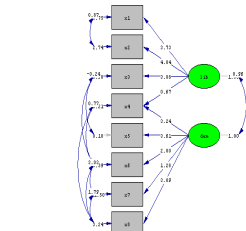
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## 2 Equivalent Models



Chi-Square=13.20, df=10, P-value=0.21281, RMSEA=0.046



Chi-Square=13.11, df=11, P-value=0.21628, RMSEA=0.046

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## Common Equivalent Models for MTMM – ATM and CU (2 Approaches)

- Method Factor CFA (ATM Model)
- Correlated Uniqueness Model

Sometimes, logics and intuition are needed to justify the preference of one model over another equivalent model.

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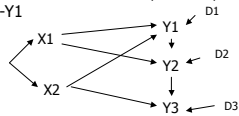
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## More on equivalent models 1

- Lee-Hershberger replacing rules may be used to generate equivalent models (see Kline book 153-156)
- At subsequent places in the model where two endogenous variables have the same causes and their relations to prior and subsequent variables are unidirectional, all the following may be substituted for one another:  $Y1 \rightarrow Y2$ ,  $Y2 \rightarrow Y1$ ,  $D1 \leftrightarrow D2$ , and  $Y1 \rightarrow Y2$  &  $Y2 \leftarrow Y1$

Page 155 lists 4 equivalent models




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## More on equivalent models 2

- Complicated models may have hundreds or even thousands of equivalent models
- Researchers often fail to consider equivalent models

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## (3) Nested Models

- One model M1 is nested within another model M2 if one may arrive at the parameter vector for M1 by placing constraints on the parameter vector for M2.
- M1 will have fewer parameter estimates, therefore a larger Degree of Freedom than M2.
- M1 can not include new parameters that do not appear in M2.

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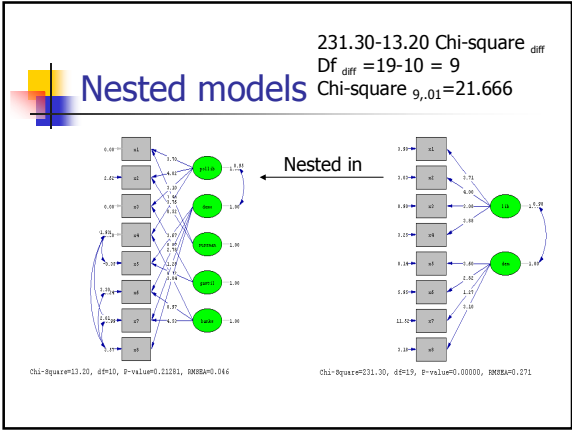
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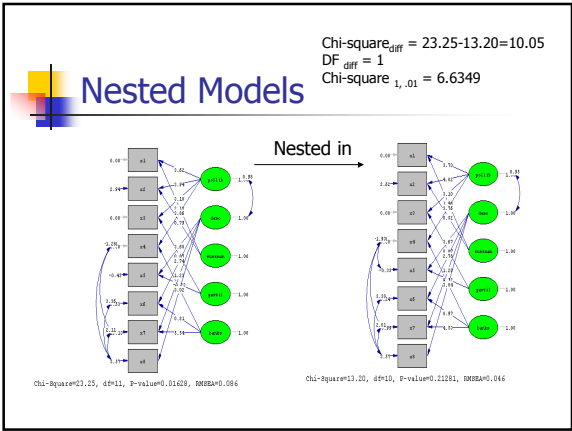
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- ### Null Models
- Independence model
  - Covariance among all manifest variables are constrained to 0
  - Null model is always nested within all other models with the same set of vars

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## Incremental Fit Indices

-- compare your model with the null model

- $NFI = (F_0 - F_k) / F_0 = \chi^2_0 - \chi^2_k / \chi^2_0$
- $IFI = (F_0 - F_k) / F_0 - (df_k / (N-1))$
- $RNI = 1 - [F_k - (df_k / (N-1))] / [F_0 - (df_0 / (N-1))]$
- $CFI = 1 - \max\{[F_k - (df_k / (N-1))], 0\} / \max\{[F_0 - (df_0 / (N-1))], [F_k - (df_k / (N-1))], 0\}$

$$\chi^2 = (N-1)F$$

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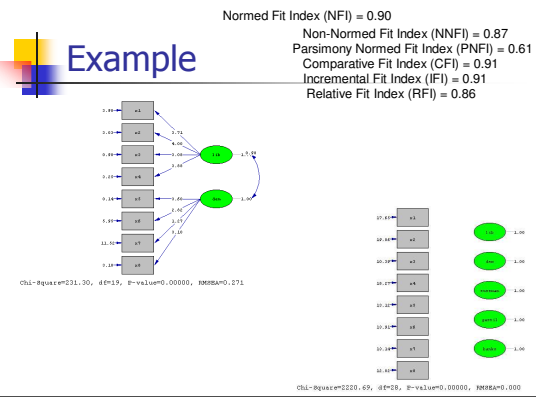
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## Example




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## Diff from GFI and others

- Normed Fit Index (NFI) = 0.90
- Non-Normed Fit Index (NNFI) = 0.87
- Parsimony Normed Fit Index (PNFI) = 0.61
- Comparative Fit Index (CFI) = 0.91
- Incremental Fit Index (IFI) = 0.91
- Relative Fit Index (RFI) = 0.86
- Critical N (CN) = 26.37
- Root Mean Square Residual (RMR) = 1.06
- Standardized RMR = 0.077
- Goodness of Fit Index (GFI) = 0.72
- Adjusted Goodness of Fit Index (AGFI) = 0.48
- Parsimony Goodness of Fit Index (PGFI) = 0.38

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## Presentation Example

- 1 Question
- 2 Path Diagram
- 3 Model Fit
- 4 Results 1
- 5 Results 2
- 6 Conclusion

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## The Research Question

- A on going debate about the impacts of democracy on economic growth
- 1) argues for direct impacts
- 2) argues for indirect impacts ONLY

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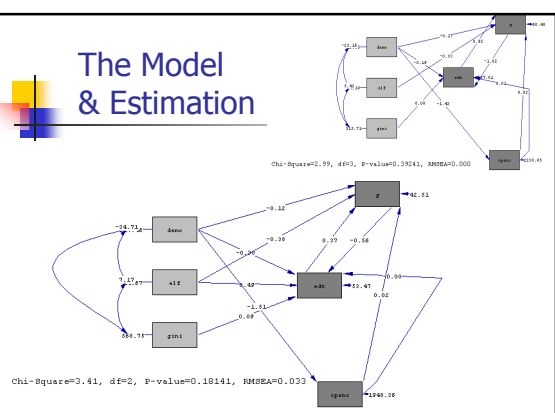
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## The Model & Estimation



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## Model Fit

- Chi square /df=3.41/2=1.705
- GFI=1
- AGFI=0.98
- SRMR=0.016

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## Results 1

		Total effects	
			demo
	demo	-----	-----
Indirect effects	g	-0.10 (0.04)	g -0.22 (0.06)
		-2.23	-3.63
	Direct effect	-0.12 (0.082) -1.46	

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## Results 2

### Structural Equations

edlt = - 0.56\*g - 0.0010\*openc - 0.30\*demo + 0.49\*elf + 0.089\*gini, Errorvar.= 53.47  
 (0.20) (0.0073) (0.084) (0.083) (0.014) (7.26)  
 -2.77 -0.14 -3.60 5.95 6.40 7.36

g = 0.37\*edlt + 0.020\*openc - 0.12\*demo - 0.38\*elf, Errorvar.= 42.51  
 (0.15) (0.0060) (0.082) (0.11) (6.50)  
 2.41 3.39 -1.46 -3.34 6.54

openc = - 1.51\*demo, Errorvar.= 1948.36  
 (0.41) (107.50)  
 -3.67 18.12

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## Conclusion

- No direct impacts
- Indirect impacts ONLY

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## Dec. 1 Presentation - 5~6 slides (use Microsoft PowerPoint)

- 1, research question (hypothesis, population/sample, variables)
- 2, Path Diagram
- 3, How good is your model fit
- 4, Findings - confirm or reject hypothesis
- 5, More Findings & Discussion (tables)
- 6, Conclusion

(7~8 minutes for presentation, 2~3 minutes for one Q&A)

please put your slides into a floppy disk and bring to the class.

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## Join the SEM Net

- **The Structural Equation Modeling Discussion Network**

- <http://www.gsu.edu/~mkteer/semnet.html>

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