Discovering Structural Equation Modeling Using Stata

Revised Edition

ALAN C. ACOCK Oregon State University

A Stata Press Publication StataCorp LP College Station, Texas

Contents

	Dedication		V	
	List of tables List of figures List of boxes Preface			
	Acknowledgments			
1	Introduction to confirmatory factor analysis			
	1.1	Introduction	1	
	1.2	The "do not even think about it" approach	2	
	1.3	The principal component factor analysis approach	3	
	1.4	Alpha reliability for our nine-item scale	7	
	1.5	Generating a factor score rather than a mean or summative score	9	
	1.6	What can CFA add?	11	
	1.7	Fitting a CFA model	14	
	1.8	Interpreting and presenting CFA results		
	1.9	Assessing goodness of fit	21	
		1.9.1 Modification indices	26	
		1.9.2 Final model and estimating scale reliability	29	
	1.10	A two-factor model	33	
		1.10.1 Evaluating the depression dimension	34	
		1.10.2 Estimating a two-factor model	37	
	1.11	Parceling	45	
	1.12	2 Extensions and what is next		
	1.13	Exercises	46	

viii Contents

	1.A	Using the SEM Builder to run a CFA			
		1.A.1	Drawing the model	49	
		1.A.2	Estimating the model	53	
2	Usin	g struct	cural equation modeling for path models	59	
	2.1	Introdu	ction	59	
	2.2	Path model terminology			
		2.2.1	Exogenous predictor, endogenous outcome, and endogenous mediator variables	60	
		2.2.2	A hypothetical path model	61	
	2.3	A subst	antive example of a path model	65	
	2.4	Estima	ting a model with correlated residuals	72	
		2.4.1	Estimating direct, indirect, and total effects	73	
		2.4.2	Strengthening our path model and adding covariates	80	
	2.5	Auxilia	ry variables	83	
	2.6	Testing equality of coefficients 84			
	2.7	A cross-lagged panel design 86			
	2.8	Moderation 89			
	2.9	Nonrecursive models			
		2.9.1	Worked example of a nonrecursive model	97	
		2.9.2	Stability of a nonrecursive model	100	
		2.9.3	Model constraints	101	
		2.9.4	Equality constraints	103	
	2.10	Exercises		105	
	2.A	Using t	he SEM Builder to run path models	108	
3	Stru	tructural equation modeling 1			
	3.1	Introduction			
	3.2	The cla	The classic example of a structural equation model		
		3.2.1	Identification of a full structural equation model	117	
		3.2.2	Fitting a full structural equation model	119	
		3.2.3	Modifying our model	125	

Contents ix

		3.2.4	Indirect effects	128	
	3.3	Equalit	y constraints	129	
	3.4	Prograi	mming constraints	131	
	3.5	Structural model with formative indicators			
		3.5.1	Identification and estimation of a composite latent variable	143	
		3.5.2	Multiple indicators, multiple causes model	147	
	3.6	Exercis	ees	150	
4	Late	ent grow	vth curves	153	
	4.1	Discove	ering growth curves	153	
	4.2	A simp	le growth curve model	154	
	4.3	Identify	ying a growth curve model	157	
		4.3.1	An intuitive idea of identification	157	
		4.3.2	Identifying a quadratic growth curve	158	
	4.4	An exa	ample of a linear latent growth curve	159	
		4.4.1	A latent growth curve model for BMI	160	
		4.4.2	Graphic representation of individual trajectories (optional)	. 161	
		4.4.3	Intraclass correlation (ICC) (optional)	165	
		4.4.4	Fitting a latent growth curve	167	
		4.4.5	Adding correlated adjacent error terms	180	
		4.4.6	Adding a quadratic latent slope growth factor	181	
		4.4.7	Adding a quadratic latent slope and correlating adjacent		
			error terms	181	
	4.5	How ca	an we add time-invariant covariates to our model?	188	
		4.5.1	Interpreting a model with time-invariant covariates	192	
	4.6	-	Explaining the random effects—time-varying covariates		
		4.6.1	Fitting a model with time-invariant and time-varying covariates	195	
		4.6.2	Interpreting a model with time-invariant and		
			time-varying covariates	202	
	4.7	Consti	raining variances of error terms to be equal (optional)	203	
	4.8	Exerci	ises	207	

X Contents

5	Gro	ир сотр	parisons	209	
	5.1	Interaction as a traditional approach to multiple-group comparisons			
	5.2	The range of applications of Stata's multiple-group			
		compar	isons with sem	211	
		5.2.1	A multiple indicators, multiple causes model	211	
		5.2.2	A measurement model	212	
		5.2.3	A full structural equation model	212	
	5.3	A meas	A measurement model application		
		5.3.1	Step 1: Testing for invariance comparing women and men	. 215	
		5.3.2	Step 2: Testing for invariant loadings	219	
		5.3.3	Step 3: Testing for an equal loadings and equal error-variances model	224	
		5.3.4	Testing for equal intercepts	226	
		5.3.5	Comparison of models	227	
		5.3.6	Step 4: Comparison of means	230	
		5.3.7	Step 5: Comparison of variances and covariance of latent variables	238	
	5.4	Multiple-group path analysis			
		5.4.1	What parameters are different?	245	
		5.4.2	Fitting the model with the SEM Builder	250	
		5.4.3	A standardized solution	251	
		5.4.4	Constructing tables for publications	252	
	5.5	Multip	le-group comparisons of structural equation models	254	
	5.6	Exercises			
6	Epil	ogue—w	hat now?	265	
	6.1	What i	s next?	266	
A	The	The graphical user interface			
	A.1	Introduction			
	A.2	Menus	Menus for Windows, Unix, and Mac		
		A.2.1	The menus, explained	270	
		A.2.2	The vertical drawing toolbar	271	

C	Contents	X
•	Jonienis	Λ.

	Sub	ject index	301
	Author index		
	References		
В	Ente	287	
	A.7	Clearing preferences and restoring the defaults	285
	A.6	Postestimation commands	284
	A.5	Fitting a structural equation model	281
	A.4	Drawing an SEM model	276
	A.3	Designing a structural equation model	272