

# Structural Equation Modeling

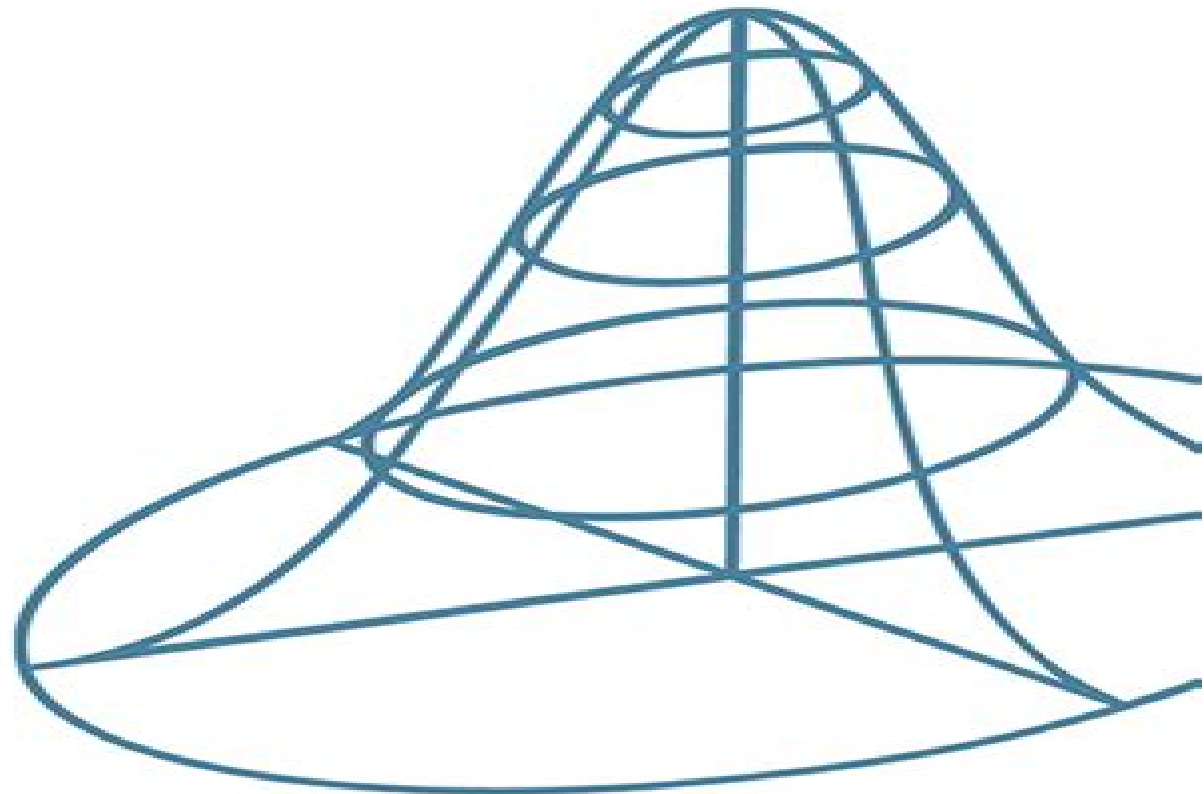
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# Nonlinear Structural Equation Models

**Tao Wei**



## **Nonlinear Structural Equation Models:**

*Nonlinear Structural Equation Models* Casey L. Codd, 2011 Abstract Structural equation modeling is a popular statistical method in the social and behavioral sciences but it has largely been restricted to modeling linear relationships among latent variables This can be attributed to the fact that traditional estimation methods for SEM are based on linear relationships among the manifest and latent variables and are not appropriate for nonlinear models This thesis will illustrate how marginal maximum likelihood can be used to estimate a general nonlinear structural equation model and how this method can be implemented in SAS Proc NLMIXED Attention will also be given to the issue of model selection in nonlinear structural equation modeling An example using psychological data will be presented to illustrate the utility of this method

Interaction and Nonlinear Effects in Structural Equation Modeling Randall E. Schumacker, 2017-07-05 This volume provides a comprehensive presentation of the various procedures currently available for testing interaction and nonlinear effects in structural equation modeling By focusing on various software applications the reader should quickly be able to incorporate one of the procedures into testing interaction or nonlinear effects in their own model Although every attempt is made to keep mathematical details to a minimum it is assumed that the reader has mastered the equivalent of a graduate level multivariate statistics course which includes adequate coverage of structural equation modeling This book will be of interest to researchers and practitioners in education and the social sciences

**Assessing Local Influence for Nonlinear Structural Equation Models with Ignorable Missing Data** Sik-Yum Lee, 2018 A method is proposed in this paper to assess the local influence of minor perturbation for a nonlinear structural equation model with missing data that are missing at random The main idea is to apply Zhu and Lee's 2001 approach to the conditional expectation of the complete data log likelihood function in the corresponding EM algorithm for deriving the conformal normal curvature Building blocks for achieving the diagnostic measures are computed via latent variables that are generated by the Gibbs sampler and Metropolis Hastings algorithm It is shown that the proposed methodology is feasible for a wide variety of perturbation schemes To illustrate the methodology results that are obtained from analysis of an artificial example and a real example are presented

**Exploring Fit for Nonlinear Structural Equation Models** Phillip Isaac Pfleger, 2019 This thesis shows that an effective strategy for determining whether a nonlinear model is preferable to a linear one involves using the R squared to compare models that have been fit to the same data An R squared that is much larger for the nonlinear model than the linear model suggests that the linear model may be less desirable than the nonlinear model

*Non-linear Structural Equation Models* Fan Yang Jonsson, 1997

**Likelihood Based Procedures for General Nonlinear Structural Equation Analysis** Yan Zhao, 2002 Valid Statistical inferences in nonlinear structural equation models are of great interest recently This dissertation aims at fitting a nonlinear structural equation model consisting of two parts a general nonlinear measurement model relating observed variables or indicators to unobserved concepts or latent variables and a nonlinear simultaneous

structural model describing relationships among the latent variables For model identification we assume an explicitly solved reduced structural model exists This dissertation is composed of two papers The first paper deals with the case where the latent variables in the reduced structural model are normally distributed We developed maximum likelihood estimation by a Monte Carlo EM algorithm The asymptotic covariance matrix of the estimator is computed by the inverse of the empirical observed information matrix Initial values of the parameters for general and special reduced structural models are presented For a Monte Carlo EM algorithm we developed a new procedure both to choose the Monte Carlo sample size for computing the expectation in the E step and to stop the algorithm Simulation studies for structural equation models with a variety of structural models are presented to assess the performance of our stopping rule and the estimators The second paper develops distribution free statistical procedures without specifying distribution forms of the latent variables We use the normal mixtures as a flexible distribution family A pseudo maximum likelihood estimation procedure is introduced by first obtaining the measurement model parameters by factor analysis then maximizing the pseudo likelihood the likelihood evaluated at the measurement model parameters estimates with respect to the structural equation model parameters The asymptotic covariance matrix of the measurement parameters estimates is computed by non parametric bootstrap which is combined with the empirical information matrix of all parameters for the full likelihood to produce an estimate of the asymptotic covariance of the reduced model parameters estimates Simulation studies are presented

**Nonlinear Structural Equation Modeling with the Theory of Planned Behavior** Jost Reinecke, 2001      Structural Equation Modeling Sik-Yum Lee, 2007-04-04 Winner of the 2008 Ziegel Prize for outstanding new book of the year Structural equation modeling SEM is a powerful multivariate method allowing the evaluation of a series of simultaneous hypotheses about the impacts of latent and manifest variables on other variables taking measurement errors into account As SEMs have grown in popularity in recent years new models and statistical methods have been developed for more accurate analysis of more complex data A Bayesian approach to SEMs allows the use of prior information resulting in improved parameter estimates latent variable estimates and statistics for model comparison as well as offering more reliable results for smaller samples Structural Equation Modeling introduces the Bayesian approach to SEMs including the selection of prior distributions and data augmentation and offers an overview of the subject's recent advances Demonstrates how to utilize powerful statistical computing tools including the Gibbs sampler the Metropolis Hasting algorithm bridge sampling and path sampling to obtain the Bayesian results Discusses the Bayes factor and Deviance Information Criterion DIC for model comparison Includes coverage of complex models including SEMs with ordered categorical variables and dichotomous variables nonlinear SEMs two level SEMs multisample SEMs mixtures of SEMs SEMs with missing data SEMs with variables from an exponential family of distributions and some of their combinations Illustrates the methodology through simulation studies and examples with real data from business management education psychology public health and sociology Demonstrates the application of

the freely available software WinBUGS via a supplementary website featuring computer code and data sets Structural Equation Modeling A Bayesian Approach is a multi disciplinary text ideal for researchers and students in many areas including statistics biostatistics business education medicine psychology public health and social science *Handbook of Latent Variable and Related Models*, 2011-08-11 This Handbook covers latent variable models which are a flexible class of models for modeling multivariate data to explore relationships among observed and latent variables Covers a wide class of important models Models and statistical methods described provide tools for analyzing a wide spectrum of complicated data Includes illustrative examples with real data sets from business education medicine public health and sociology

Demonstrates the use of a wide variety of statistical computational and mathematical techniques **Bayesian Analysis for Finite Mixture in Nonrecursive Nonlinear Structural Equation Models** Yong Li, 2009 This paper considers finite mixtures of structural equation models with nonlinear effects of exogenous latent variables and nonrecursive relations among endogenous latent variables A Bayesian approach is developed to analyze this kind of models In order to cope with the label switching problem the permutation sampler is used to choose an appropriate identification constraint Furthermore a hybrid Markov chain Monte Carlo method that combines the Gibbs sampler Metropolis Hastings algorithm an Langevin Hastings algorithm is implemented to produce the Bayesian outputs At last the proposed approach is illustrated by a simulation study and a real example [The SAGE Handbook of Quantitative Methods in Psychology](#) Roger E Millsap, Alberto

Maydeu-Olivares, 2009-08-05 I often wonder to myself whether the field needs another book handbook or encyclopedia on this topic In this case I think that the answer is truly yes The handbook is well focused on important issues in the field and the chapters are written by recognized authorities in their fields The book should appeal to anyone who wants an understanding of important topics that frequently go uncovered in graduate education in psychology David C Howell Professor Emeritus University of Vermont Quantitative psychology is arguably one of the oldest disciplines within the field of psychology and nearly all psychologists are exposed to quantitative psychology in some form While textbooks in statistics research methods and psychological measurement exist none offer a unified treatment of quantitative psychology The SAGE Handbook of Quantitative Methods in Psychology does just that Each chapter covers a methodological topic with equal attention paid to established theory and the challenges facing methodologists as they address new research questions using that particular methodology The reader will come away from each chapter with a greater understanding of the methodology being addressed as well as an understanding of the directions for future developments within that methodological area Drawing on a global scholarship the Handbook is divided into seven parts Part One Design and Inference addresses issues in the inference of causal relations from experimental and non experimental research along with the design of true experiments and quasi experiments and the problem of missing data due to various influences such as attrition or non compliance Part Two Measurement Theory begins with a chapter on classical test theory followed by the common factor analysis model as a

model for psychological measurement The models for continuous latent variables in item response theory are covered next followed by a chapter on discrete latent variable models as represented in latent class analysis Part Three Scaling Methods covers metric and non metric scaling methods as developed in multidimensional scaling followed by consideration of the scaling of discrete measures as found in dual scaling and correspondence analysis Models for preference data such as those found in random utility theory are covered next Part Four Data Analysis includes chapters on regression models categorical data analysis multilevel or hierarchical models resampling methods robust data analysis meta analysis Bayesian data analysis and cluster analysis Part Five Structural Equation Models addresses topics in general structural equation modeling nonlinear structural equation models mixture models and multilevel structural equation models Part Six Longitudinal Models covers the analysis of longitudinal data via mixed modeling time series analysis and event history analysis Part Seven Specialized Models covers specific topics including the analysis of neuro imaging data and functional data analysis

Psychometrics  
C.R. Rao, Sandip Sinharay, 2007 This volume representing a compilation of authoritative reviews on a multitude of uses of statistics in epidemiology and medical statistics written by internationally renowned experts is addressed to statisticians working in biomedical and epidemiological fields who use statistical and quantitative methods in their work While the use of statistics in these fields has a long and rich history explosive growth of science in general and clinical and epidemiological sciences in particular have gone through a sea of change spawning the development of new methods and innovative adaptations of standard methods Since the literature is highly scattered the Editors have undertaken this humble exercise to document a representative collection of topics of broad interest to diverse users The volume spans a cross section of standard topics oriented toward users in the current evolving field as well as special topics in much need which have more recent origins This volume was prepared especially keeping the applied statisticians in mind emphasizing applications oriented methods and techniques including references to appropriate software when relevant The contributors are internationally renowned experts in their respective areas This volume addresses emerging statistical challenges in epidemiological biomedical and pharmaceutical research It features methods for assessing Biomarkers analysis of competing risks clinical trials including sequential and group sequential crossover designs cluster randomized and adaptive designs and structural equations modelling and longitudinal data analysis

Factor Analysis at 100 Robert Cudeck, Robert C. MacCallum, 2007-03-06 Factor analysis is one of the success stories of statistics in the social sciences The reason for its wide appeal is that it provides a way to investigate latent variables the fundamental traits and concepts in the study of individual differences Because of its importance a conference was held to mark the centennial of the publication of Charles Spearman's seminal 1904 article which introduced the major elements of this invaluable statistical tool This book evolved from that conference It provides a retrospective look at major issues and developments as well as a prospective view of future directions in factor analysis and related methods In so doing it demonstrates how and why factor analysis is considered to be

one of the methodological pillars of behavioral research. Featuring an outstanding collection of contributors, this volume offers unique insights on factor analysis and its related methods. Several chapters have a clear historical perspective, while others present new ideas along with historical summaries. In addition, the book reviews some of the extensions of factor analysis to such techniques as latent growth curve models, models for categorical data, and structural equation models. *Factor Analysis at 100* will appeal to graduate students and researchers in the behavioral, social health, and biological sciences who use this technique in their research. A basic knowledge of factor analysis is required, and a working knowledge of linear algebra is helpful.

Essential Statistical Methods for Medical Statistics J. Philip Miller, 2010-11-08. *Essential Statistical Methods for Medical Statistics* presents only key contributions which have been selected from the volume in the *Handbook of Statistics: Medical Statistics, Volume 27* (2009). While the use of statistics in these fields has a long and rich history, the explosive growth of science in general and of clinical and epidemiological sciences in particular has led to the development of new methods and innovative adaptations of standard methods. This volume is appropriately focused for individuals working in these fields. Contributors are internationally renowned experts in their respective areas. Contributors are internationally renowned experts in their respective areas. Addresses emerging statistical challenges in epidemiological, biomedical, and pharmaceutical research. Methods for assessing biomarkers, analysis of competing risks, clinical trials including sequential and group sequential crossover designs, cluster randomized and adaptive designs, structural equations modelling, and longitudinal data analysis.

*Model Selection and the Estimation of Statistical Power in Nonlinear Structural Equation Modeling* Julien Patrick Irmer, 2024.

**Basic and Advanced Bayesian Structural Equation Modeling** Sik-Yum Lee, Xin-Yuan Song, 2012-07-05. This book provides clear instructions to researchers on how to apply Structural Equation Models (SEMs) for analyzing the interrelationships between observed and latent variables. *Basic and Advanced Bayesian Structural Equation Modeling* introduces basic and advanced SEMs for analyzing various kinds of complex data, such as ordered and unordered categorical data, multilevel data, mixture data, longitudinal data, highly non-normal data, as well as some of their combinations. In addition, Bayesian semiparametric SEMs to capture the true distribution of explanatory latent variables are introduced, whilst SEM with a nonparametric structural equation to assess unspecified functional relationships among latent variables are also explored. Statistical methodologies are developed using the Bayesian approach, giving reliable results for small samples and allowing the use of prior information, leading to better statistical results. Estimates of the parameters and model comparison statistics are obtained via powerful Markov Chain Monte Carlo methods in statistical computing. Introduces the Bayesian approach to SEMs, including discussion on the selection of prior distributions and data augmentation. Demonstrates how to utilize the recent powerful tools in statistical computing, including but not limited to the Gibbs sampler, the Metropolis-Hastings algorithm, and path sampling, for producing various statistical results, such as Bayesian estimates and Bayesian model comparison statistics, in the analysis of basic and advanced SEMs. Discusses the Bayes factor.

Deviance Information Criterion DIC and  $L_{\nu}$  measure for Bayesian model comparison Introduces a number of important generalizations of SEMs including multilevel and mixture SEMs latent curve models and longitudinal SEMs semiparametric SEMs and those with various types of discrete data and nonparametric structural equations Illustrates how to use the freely available software WinBUGS to produce the results Provides numerous real examples for illustrating the theoretical concepts and computational procedures that are presented throughout the book Researchers and advanced level students in statistics biostatistics public health business education psychology and social science will benefit from this book

**International Encyclopedia of Education**, 2009-04-17 The field of education has experienced extraordinary technological societal and institutional change in recent years making it one of the most fascinating yet complex fields of study in social science Unequaled in its combination of authoritative scholarship and comprehensive coverage International Encyclopedia of Education Third Edition succeeds two highly successful previous editions 1985 1994 in aiming to encapsulate research in this vibrant field for the twenty first century reader Under development for five years this work encompasses over 1 000 articles across 24 individual areas of coverage and is expected to become the dominant resource in the field Education is a multidisciplinary and international field drawing on a wide range of social sciences and humanities disciplines and this new edition comprehensively matches this diversity The diverse background and multidisciplinary subject coverage of the Editorial Board ensure a balanced and objective academic framework with 1 500 contributors representing over 100 countries capturing a complete portrait of this evolving field A totally new work revamped with a wholly new editorial board structure and brand new list of meta sections and articles Developed by an international panel of editors and authors drawn from senior academia Web enhanced with supplementary multimedia audio and video files hotlinked to relevant references and sources for further study Incorporates ca 1 350 articles with timely coverage of such topics as technology and learning demography and social change globalization and adult learning to name a few Offers two content delivery options print and online the latter of which provides anytime anywhere access for multiple users and superior search functionality via ScienceDirect as well as multimedia content including audio and video files

*Structural Equation Modeling* Robert Cudeck, K. G. Jöreskog, Dag Sörbom, Stephen Du Toit, 2001

*Latent Variable Modeling with R* W. Holmes Finch, Brian F. French, 2015-06-26 This book demonstrates how to conduct latent variable modeling LVM in R by highlighting the features of each model their specialized uses examples sample code and output and an interpretation of the results Each chapter features a detailed example including the analysis of the data using R the relevant theory the assumptions underlying the model and other statistical details to help readers better understand the models and interpret the results Every R command necessary for conducting the analyses is described along with the resulting output which provides readers with a template to follow when they apply the methods to their own data The basic information pertinent to each model the newest developments in these areas and the relevant R code to use them are reviewed Each chapter also features an introduction



summary and suggested readings A glossary of the text's boldfaced key terms and key R commands serve as helpful resources The book is accompanied by a website with exercises an answer key and the in text example data sets Latent Variable Modeling with R Provides some examples that use messy data providing a more realistic situation readers will encounter with their own data Reviews a wide range of LVMs including factor analysis structural equation modeling item response theory and mixture models and advanced topics such as fitting nonlinear structural equation models nonparametric item response theory models and mixture regression models Demonstrates how data simulation can help researchers better understand statistical methods and assist in selecting the necessary sample size prior to collecting data [www.routledge.com/9780415832458](http://www.routledge.com/9780415832458) provides exercises that apply the models along with annotated R output answer keys and the data that corresponds to the in text examples so readers can replicate the results and check their work The book opens with basic instructions in how to use R to read data download functions and conduct basic analyses From there each chapter is dedicated to a different latent variable model including exploratory and confirmatory factor analysis CFA structural equation modeling SEM multiple groups CFA SEM least squares estimation growth curve models mixture models item response theory both dichotomous and polytomous items differential item functioning DIF and correspondance analysis The book concludes with a discussion of how data simulation can be used to better understand the workings of a statistical method and assist researchers in deciding on the necessary sample size prior to collecting data A mixture of independently developed R code along with available libraries for simulating latent models in R are provided so readers can use these simulations to analyze data using the methods introduced in the previous chapters Intended for use in graduate or advanced undergraduate courses in latent variable modeling factor analysis structural equation modeling item response theory measurement or multivariate statistics taught in psychology education human development and social and health sciences researchers in these fields also appreciate this book's practical approach The book provides sufficient conceptual background information to serve as a standalone text Familiarity with basic statistical concepts is assumed but basic knowledge of R is not

**Structural Equations with Latent Variables** Kenneth A. Bollen, 2014-08-28 Analysis of Ordinal Categorical Data Alan Agresti Statistical Science Now has its first coordinated manual of methods for analyzing ordered categorical data This book discusses specialized models that unlike standard methods underlying nominal categorical data efficiently use the information on ordering It begins with an introduction to basic descriptive and inferential methods for categorical data and then gives thorough coverage of the most current developments such as loglinear and logit models for ordinal data Special emphasis is placed on interpretation and application of methods and contains an integrated comparison of the available strategies for analyzing ordinal data This is a case study work with illuminating examples taken from across the wide spectrum of ordinal categorical applications 1984 0 471 89055 3 287 pp Regression Diagnostics Identifying Influential Data and Sources of Collinearity David A Belsley Edwin Kuh and Roy E Welsch This book provides the practicing statistician and

econometrician with new tools for assessing the quality and reliability of regression estimates Diagnostic techniques are developed that aid in the systematic location of data points that are either unusual or inordinately influential measure the presence and intensity of collinear relations among the regression data and help to identify the variables involved in each and pinpoint the estimated coefficients that are potentially most adversely affected The primary emphasis of these contributions is on diagnostics but suggestions for remedial action are given and illustrated 1980 0 471 05856 4 292 pp Applied Regression Analysis Second Edition Norman Draper and Harry Smith Featuring a significant expansion of material reflecting recent advances here is a complete and up to date introduction to the fundamentals of regression analysis focusing on understanding the latest concepts and applications of these methods The authors thoroughly explore the fitting and checking of both linear and nonlinear regression models using small or large data sets and pocket or high speed computing equipment Features added to this Second Edition include the practical implications of linear regression the Durbin Watson test for serial correlation families of transformations inverse ridge latent root and robust regression and nonlinear growth models Includes many new exercises and worked examples 1981 0 471 02995 5 709 pp

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