JOHN MOLSON SCHOOL OF BUSINESS
DEPARTMENT OF DECISION SCIENCES AND M.I.S.

ADMI 820W Course Outline
Winter 2008

Measurement, Factor Analysis and Structural Equation Modelling (SEM)

Instructor:	**Dr. Jamshid Etezadi**	**Telephone:**	**848-2424 Ext. 3695**
Office:	**GM 209-5**	**email:**	**etezadi@jmsb.concordia.ca**
Class time:	**Monday 9:00 - 12:00**	**Location of class:**	**GM 600-24**
Office hours:	**Thursday 12:00-14:00 or by appointment**		

Course Description:

This course is intended to provide a comprehensive introduction to social science measurement models and structural equation modeling (SEM) commonly known as the LISREL/EQS models. The emphasis is on applications; however, students will obtain a conceptual understanding of the relevant theory.

Objectives:

At the end of the course students should be able to:

1. Understand the process of measurement in social science, the meaning of reliability, validity and apply them for operationally defining various concepts that they may used in their research.

2. Differentiate between the classical approaches and the modern approaches for assessing psychometric properties of a measurement instrument.

3. Assess reliability and validity of a measurement instrument by a variety of methods.

4. Understand the applications of factor analysis in the literature and evaluate them critically.

5. Demonstrate skill and self-confidence in undertaking a psychometric study.

6. Apply factor analysis and the related techniques to an area of empirical research.

7. Evaluate the effect of measurement error on validity of statistical inference and utilize techniques for correcting parameter estimates in the presence of measurement error.

8. Formulate their research problems into testable hypotheses through structural equation modelling.

9. Use a structural equation-modeling program such as EQS or LISREL in a meaningful fashion.

Instructional Method:

The course will be taught using a lecture, discussion, and report model. Major issues and concepts will be initially introduced by the instructor in a lecture format with discussion of related readings.

To consolidate understanding, students are expected to study these concepts and report on a topic of their choice with consent and guidance from the instructor. In addition to lecture and discussion, to facilitate students' understanding, the instructor will provide examples of computer input and output of relevant topics.

Course Content:

The course is divided into four major parts. In the first part, after a general overview of multivariate regression, covariance algebra, and path diagrams, LISREL/EQS notations will be introduced. In the second part, after a review of path analysis (models with only observed variables) classical measurement models and the consequences of measurement error will be covered. In the third part, the exploratory and the confirmatory factor analysis models will be introduced and treated as general measurement models. The concept of reliability and validity as an integral part of measurement will be further discussed in this section. Finally, in the fourth section, the factor analysis model will be generalised to structural equation model with observed and latent variables. The topics covered under theses sections are:

1. Introduction

covariances and correlations
LISREL and EQS notations
path diagrams
total, direct, and indirect effects
empirical examples

2. Path analysis, Classical Measurement Models and Consequences of Measurement Error

models with only observed variables
recursive and nonrecursive models identification rules
estimation and model evaluation
classical measurement models
consequence of measurement error in modelling data
  univariate consequences
  bivariate and simple regression consequences
  consequences in multiple regression
consequences of measurement error in multiple equations
empirical examples

3. Exploratory and Confirmatory Factor Analysis

component theory
approximate methods
common factor model
confirmatory factor analysis
maximum likelihood estimation and Heywood cases
conditions for identification
goodness-of- fit tests
estimation of factor scores
validity (content, construct, criterion, convergent, and discriminant)

reliability and alternatives to classical reliability measures
non-linear relations and interaction terms
multitrait-multimethod designs
comparison of models
application examples

4. Structural Equation Models with Observed and Latent Variables

model specification
identification rules
estimation and model evaluation
goodness-of-fit tests
recursive and nonrecursive models
estimation of means and intercepts
missing values
equality and inequality constraints
quadratic and interaction terms in the model
distributional assumptions
categorical observed variables
assumptions violation and robustness studies
examples of specific applications (multilevel data, longitudinal analysis – growth curve model)

Prerequisites:

Linear statistical models (multivariate analysis)
Some knowledge of matrix algebra

Text Books:

There is not a single textbook that provides a good coverage of the course material with a mathematical language understandable by typical business students. The following two books provide plenty of data analysis examples using the EQS program. The EQS manual can also be used as an excellence reference. Covery all major SEM articles till 2006.

EQS 6 Structural Equations Program Manual, Multivariate Software, Inc. Peter M. Bentler (2004). ISBN 1-885898-03-7. (Available through the FristClass groupware, JMSB)

Byrne, B. M., (2006) *Structural Equation Modeling with EQS*, Second Edition, Lawrence Erlbaum Associates (For additional examples)

Supplementary Books:

Bollen, Kenneth A., (1989), *Structural Equations with Latent Variables*, John Wiley and Sons, New York. (A good classical book – difficult to obtain)

David Kaplan, "Structural Equation Modeling: Foundations and Extensions", Sage Publications, 2000

Geoffrey M. Maruyama (1997), *Basics of Structural Equations Modeling*, Sage publications, California.
Kline, R. B. (1998), Principle and Practice of Structural Equation Modeling, New York: The Guilford press.

Mueller, R.O. (1996), *Basic Principles of Structural Equation Modeling*, Springer-Verlag, New York.

Evaluation:

Evaluation will be based on assignments, data analysis projects, a final project, presentation of a topic of your choice, and active class participation as follows:

Active participation in class discussions	5%
Assignments and data analysis	40%
Presentation of a topic of your choice	15%
Final project	40%

ACADEMIC INTEGRITY

The integrity of University academic life and of the degrees, diplomas and certificates the University confers is dependent upon the honesty and soundness of the instructor-student learning relationship and, in particular, that of the evaluation process. As such, all students are expected to be honest in all of their academic endeavors and relationships with the University (Undergraduate Calendar, Section 16.3.13). All students enrolled at Concordia are expected to familiarize themselves with the contents of the code. You are strongly encouraged to visit the following web address: http://johnmolson.concordia.ca/ugrad/codeofconduct.pdf, which provides useful information about proper academic conduct.

Tentative Reading List and Weekly Schedule Time

Week 1 (January 7) - Introduction to class and overview of the Path Analysis, LISREL and EQS Models

This class provides a road map of the course, the rational for studying SEM and introduces the path analysis notation. The LISREL and EQS models both in the form of path analysis and matrix notations will be also introduced. Readings:

Bollen, Kenneth A. (1989), *Structural Equations with Latent Variables*, New York: John Wiley and Sons. (Chapter 2)

Christof Nachtigall, Ulf Kroehne, Friedrich Funke, Rolf Steyer (2003). (Why) Should We Use SEM?: Pros and Cons of Structural Equation Modeling, Methods of Psychological Research Online 2003, Vol.8, No.2, pp. 1-22 (Internet: http://www.mpr-online.de, University of Koblenz-Landau)

David Kaplan, "Structural Equation Modeling: Foundations and Extensions", Sage Publications, 2000. (Chapter 1 and Chapter 2, pages 13-19)

Geoffrey M. Maruyama (1997), *Basics of Structural Equations Modeling*, Sage publications, California (chapters 3 & 8)

Week 2 (January 14) – Structural Equation Models with Observed Variables

David Kaplan, "Structural Equation Modeling: Foundations and Extensions", Sage Publications, 2000. (Chapter 2, pages 19-40)

Bollen, Kenneth A. (1989), *Structural Equations with Latent Variables*, New York: John Wiley and Sons. (Chapter 4)

Geoffrey M. Maruyama (1997), *Basics of Structural Equations Modeling*, Sage publications, California (chapters 3 & 4)

Greenland, Sander, James J. Schlesselman, and Michael H. Criqui (1986), The Fallacy of Employing Standardized Regression Coefficients and Correlations as Measures of Effect, American *Journal of Epidemiology*, 123 (February), 203-208.

Week 3 (January 21) - EQS Demo and review of the EQS model

EQS 6 Structural Equations Program Manual, Multivariate Software, Inc. Peter M. Bentler (2004). (Chapter 2, pages 23-34, Chapter 3)

Byrne, B. M. (1994), *Structural Equation Modeling with EQS and EQS/Windows*, Sage Publications, London

Week 4 (January 28) - Effect of Measurement Error, Classical Measurement Model and Exploratory Factor Analysis

Rigdon, Edward E. (1994), Demonstrating the Effects of Unmodeled Random Measurement Error, *Structural Equation Modeling*, 1 (4), 375-380.

Wang, Jichuan, James H. Fisher, Harvey A. Siegal, Russel S. Falck, and Robert G. Carlson (1995), Influence of Measurement Errors on HIV Risk Behavior Analysis: A Case Study Examining Condom Use Among Drug Users, *Structural Equation Modeling*, 2 (4), 319-334.

David Kaplan, "Structural Equation Modeling: Foundations and Extensions", Sage Publications, 2000. (Chapter 3, pages 40-48)

Bollen, Kenneth A. (1989), *Structural Equations with Latent Variables*, New York: John Wiley and Sons. (Chapter 5)

McDonald, R. P. (1985), *Factor Analysis and Related Methods*, Lawrence Erlbaum Associates, New Jersey.

Week 5 (February 4) - Confirmatory Factor Analysis and demonstration of the EQS input/output

David Kaplan, "Structural Equation Modeling: Foundations and Extensions", Sage Publications, 2000. (Chapter 3, pages 48-54)

EQS 6 Structural Equations Program Manual, Multivariate Software, Inc. Peter M. Bentler (2004). (Chapter 2, pages 34-41)

Bollen, Kenneth A. (1989), *Structural Equations with Latent Variables*, New York: John Wiley and Sons. (Chapter 7)

Week 6 (February 11) - Measurement Models continued and Assessing Model Fit

Miller, Michael B. (1995), Coefficient Alpha: A Basic Introduction From the Perspectives of Classical Test Theory and Structural Equation Modeling, *Structural Equation Modeling,* 2 (3), 255-273.

Bollen, Kenneth A. (1989), *Structural Equations with Latent Variables*, New York: John Wiley and Sons. (Chapter 6)

Bollen, Kenneth A. (1984), Multiple Indicators: Internal Consistency or No Necessary Relationship?, *Quality & Quantity*, 18, 377-385.

Hu Li-tze and Bentler Peter.M (1999), "Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria Versus New Alternativs" *Structural Equation Modeling 6(1), 1-55.*

Browne, Michael W. and Robert Cudeck (1993), Alternative Ways of Assessing Model Fit, in Kenneth A. Bollen and J. Scott Long (Eds.), *Testing Structural Equation Models,* Newbury Park, CA: Sage, 136-162.

Hu, Li-Tze, and Peter M. Bentler (1995), Evaluating Model Fit, in Rick H. Hoyle (Ed.), *Structural Equation Modeling: Concepts, Issues, and Applications*, Thousand Oaks, CA: Sage, 76-99.

Raykov, Tenko and Keith F. Widaman (1995), Issues in Applied Structural Equation Modeling Research, *Structural Equation Modeling,* 2 (4), 289-318.

Rigdon, Edward E. (1996), CFI Versus RMSEA: A Comparison of Two Fit Indices for Structural Equation Modeling, *Structural Equation Modeling,* 3 (4), 369-379.

Seiger, James H. (1990), Structural Model Evaluation and Modification: An Interval Estimation Approach, *Multivariate Behavioral Research*, 25 (2), 173-180.

February 18 ========== Winter Break ==========

Week 7 (February 25) – Measurement model, Multi-Methods (MTMM) and Treatment of missing values

David Kaplan, "Structural Equation Modeling: Foundations and Extensions", Sage Publications, 2000. (Chapters 3, and 5.3)

Gerbing, David W. and James C. Anderson (1988), An Updated Paradigm for Scale Development Incorporating Unidimensionality and Its Assessment, *Journal of Marketing Research,* 25 (May), 186-192.

Segars, A. (1997), Assessing the unidimensionality of Measurement: a Paradigm and Illustration Within the context of Information Systems, Omega, Internationa *Journal of Management Sciences, 25, 107-121*.

Bagozzi, Richard P. and Todd F. Heatherton (1994), A General Approach to Representing Multifaceted Personality Constructs: Application to State Self-Esteem, *Structural Equation Modeling,* 1 (1), 35-67.

Byrne, Barbara M. (1995), Strategies in Testing for an Invariant Second-Order Factor Structure: A Comparison of EQS and LISREL, *Structural Equation Modeling,* 2 (1), 53-72.

Brown, R. L. (1994), Efficacy of the Indirect Approach for Estimating Structural Equation Models With Missing Data: A Comparison of Five Methods, *Structural Equation Modeling,* 1 (4), 287-316.

Week 8 (March 3) – The General SEM Model, Multiple Group Analysis

Bollen, Kenneth A. (1989), *Structural Equations with Latent Variables*, New York: John Wiley and Sons. (Chapters 6, 8)

EQS 6 Structural Equations Program Manual, Multivariate Software, Inc. Peter M. Bentler (Chapter 8)

David Kaplan, "Structural Equation Modeling: Foundations and Extensions", Sage Publications, 2000. (Chapter 4)

Byrne, B. M., (2006) Structural Equation Modeling with EQS, Second Edition, Lawrence Erlbaum Associates (For additional examples)

Week 9 (March 10) Causality, MIMIC and Latent variable Interaction

Bullock, Heather E., Lisa L. Harlow, and Stanley A. Mulaik (1994), Causation Issues in Structural Equation Modeling Research, *Structural Equation Modeling,* 1 (3), 253-267.

Mulaik, Stanley A., and Lawrence R. James (1995), Objectivity and Reasoning in Science and Structural Equation Modeling, in Rick H. Hoyle (Ed.), *Structural Equation Modeling: Concepts, Issues and Applications*, Thousand Oaks, CA: Sage, 118-137.

Algina, J., & Moulder, B.C. (2001). A Note on Estimating the Jöreskog-Yang Model for Latent Variable Interaction Using LISREL 8.3. Structural Equation Modeling, 8, 40-52.

Bollen and Paxton (1998), "Interactions of Latent Variables in Structural Equation Modeling," Structural

Equation Modeling, 5 (3), 267-293.

Kenny, D. A., & Judd, C. M. (1984). Estimating the nonlinear and interactive effects of latent variables. Psychological Bulletin, 96, 201-210.

Etezadi-Amoli, Jamshid and Roderick P. McDonald (1983), A Second Generation Nonlinear Factor Analysis, *Psychometrika*, 48 (September), 315-342.

Week 10 (March 17)) Mean and covariance structure, Analysis of Categorical Data, (sample size and power in SEM),

David Kaplan, "Structural Equation Modeling: Foundations and Extensions", Sage Publications, 2000. (Chapters 4.5 and 6.2)

Bollen, Kenneth A. (1989), *Structural Equations with Latent Variables*, New York: John Wiley and Sons. (pages 306-311, 433-439)

Kaplan, David (1995), Statistical Power in Structural Equation Modeling, in Rick H. Hoyle (Ed.), *Structural Equation Modeling: Concepts, Issues and Applications*, Thousand Oaks, CA: Sage, 100-117.

Saris, Willem E. and Albert Satorra (1993), Power Evaluations in Structural Equation Models, in Kenneth A. Bollen and J. Scott Long (Eds.), *Testing Structural Equation Models,* 181-204, Newbury Park, CA: Sage.

Week 11 (March 31) Multilevel Modelling and PLS

David Kaplan, "Structural Equation Modeling: Foundations and Extensions", Sage Publications, 2000. (Chapter 7)

EQS 6 Structural Equations Program Manual, Multivariate Software, Inc. Peter M. Bentler (2004). ISBN 1-885898-03-7. (Chapter 11)

Byrne, B. M., (2006) Structural Equation Modeling with EQS, Second Edition, Lawrence Erlbaum Associates (Capter 13)

Kaplan and Elliott (1997), "A Didactic Example of Multilevel Structural Equation Modeling Applicable to the Study of Organizations," Structural Equation Modeling, 4 (January), 1-24.

Chin (1998), "The Partial Least Squares Approach to Structural Equation Modeling," In Marcoulides (ed.), Modern Business Research Methods, Mahwah, NJ: LEA;

Homburg (2001), "Buyer-Supplier Relationships and Customer Firm Costs." Journal of Marketing, 65 (January), 29-43.

Reading: Roderick P. McDonald (1996), "Path Analysis with Composite Variables," Multivariate Behavioral Research, 31, 239-270.

You can download Mart PLS program and relaytted referencec from :
“ http://www.smartpls.de/forum”

Week 12 (April 7) Longitudinal Analysis and wrap up

David Kaplan, "Structural Equation Modeling: Foundations and Extensions", Sage Publications, 2000. (Chapter 8)

Byrne, B. M., (2006) Structural Equation Modeling with EQS, Second Edition, Lawrence Erlbaum Associates (Chapter 12)

Chou, Bentler and Pentz (1998), "Comparison of Two Statistical Approaches to Study Growth Curves: The Multilevel Model and the Latent Curve Analysis," Structural Equation Modeling, 5 (3), 247-266.

Week 13 (April 14) Presentation of projects

Reporting SEM Results

Boomsma, A. (2000). Reporting analyses of covariance structures. Structural Equation Modeling, 7, 461-483.

Hoyle, R.H., & Panter, A.T. (1995). Writing about structural equation models. In In R. H. Hoyle (Ed.), Structural equation modeling: Comments, issues, and applications. (pp. 56-77). Thousand Oaks, CA: Sage.

McDonald, R.P., Ho, M-H. R. (2002). Principles and practice in reporting structural equation analyses. Psychological Methods, 7, 64-82.

Hoyle, Rick H. and Abigail T. Panter (1995), Writing About Structural Equation Models, in Rick H. Hoyle (Ed.), *Structural Equation Modeling: Concepts, Issues and Applications*, Thousand Oaks, CA: Sage, 158-176.

Raykov, Tenko, Adrian Tomer, and John R. Nesselroade (1991), Reporting Structural Equation Modeling Results in Psychology and Aging: Some Proposed Guidelines, *Psychology and Aging*, 6 (4), 499-503.