Structural Equation Modeling

(Covariance Structure Analysis)

Fundamentals and Application

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Outline

- Research Map
- What is SEM
- Basic Idea of SEM
- Case Study
- Journal Paper
- Q and A

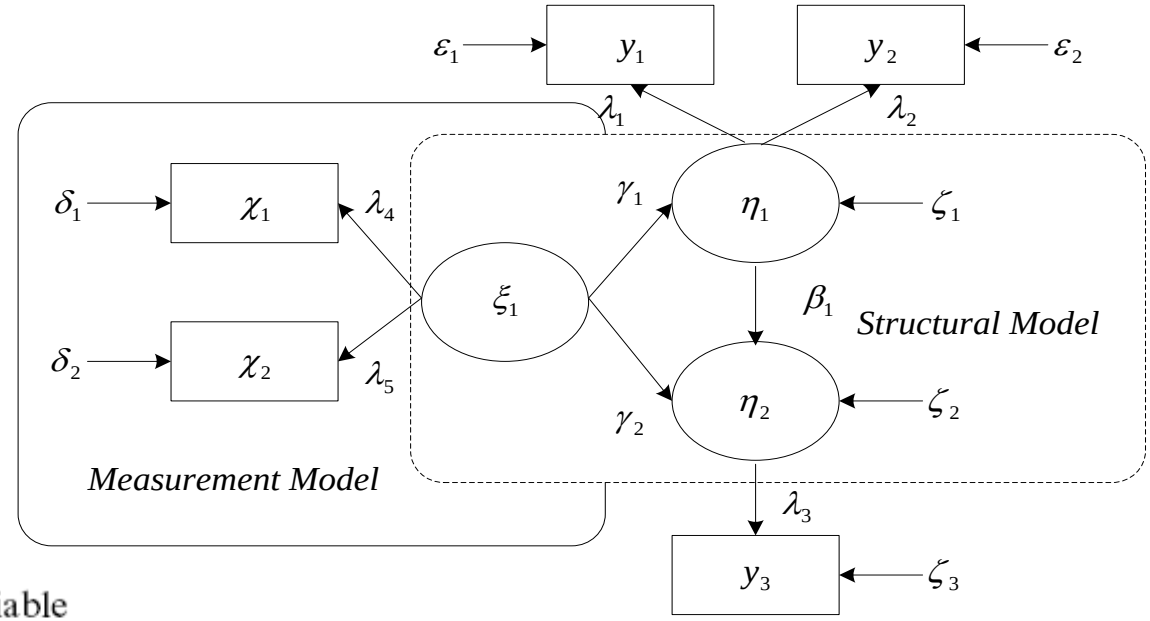
Research Map

- Research Map
  - MCDM[1] (multi-criteria decision making), SEM[2], Catastrophe Theory[3], Chaos Theory[4], Multivariate Analysis[5] (Basic Analysis)
  - Multivariate Analysis (Probity Analysis[1], Logistic Regression[2], Discriminate Analysis, Cluster Analysis), Fuzzy Set Theory[3], Grey Theory[4], Data Mining[5], Game Theory[6], Time Series Analysis[7], ANN[8] (artificial neural network), Gas[9] (genetic algorithms),
- The purpose of this brief is:
  - explain the concept of SEM modeling, its major objectives and advantages
  - show how useful structural models are in solving research problems within the tourism discipline
  - present the major steps involved in the formulation and testing of a Lisrel model through our case

What is SEM

- Lisrel stands for LInear Structural RELationships and is a computer program for covariance structure analysis.
- It is a multivariate technique which combines (confirmatory) factor analysis modeling from psychometric theory and
- The measured (observed) variables in SEM have a finite number of values.
  - Examples of measured variables are distance, cost, size, weight or height.
- On the other hand, latent (unobserved) variables are not directly observed, have an infinite number of values, and are usually continuous.
  - Examples of latent constructs are attitudes, customer satisfaction, perception of value or quality.
- Latent variables are theoretical constructs which can only be determined to exist as a combination of other measurable variables.
- When using SEM these latent constructs are termed "exogenous" (independent) constructs and "endogenous“ (dependent) constructs.

Basic Idea of SEM



x – measured independent variable
y – measured dependent variable
ξ – latent exogenous construct explained by x-variables
η – latent endogenous construct explained by y-variables
δ – error for x-variable
ε – error for y-variable
λ – correlation between measured variables and all latent constructs
γ – correlation between latent constructs ξ (exogenous) and η (endogenous)
ϕ – correlation between exogenous latent constructs ξ
β – correlations between endogenous latent constructs η.

Basic Idea of SEM

References

Development of a Theoretical Model

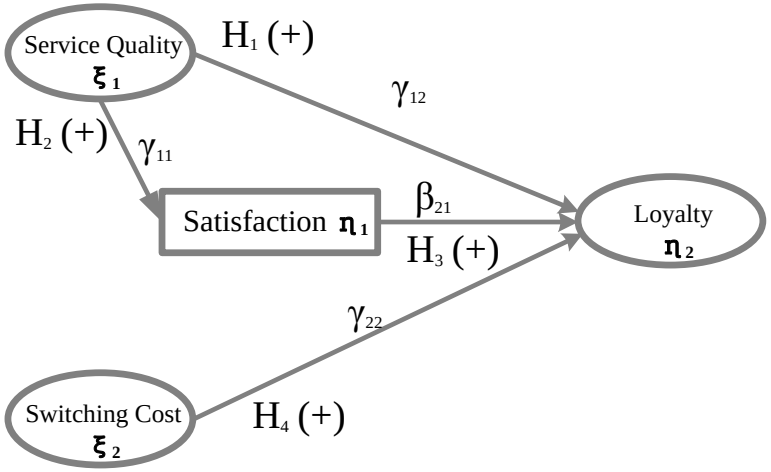
Questionnaire Design and Data Select

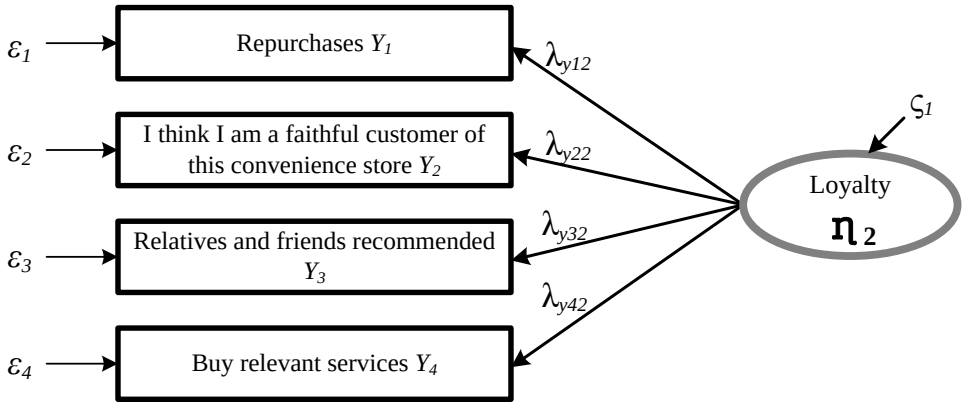
Data Input (Sample Size and Matrix Type)

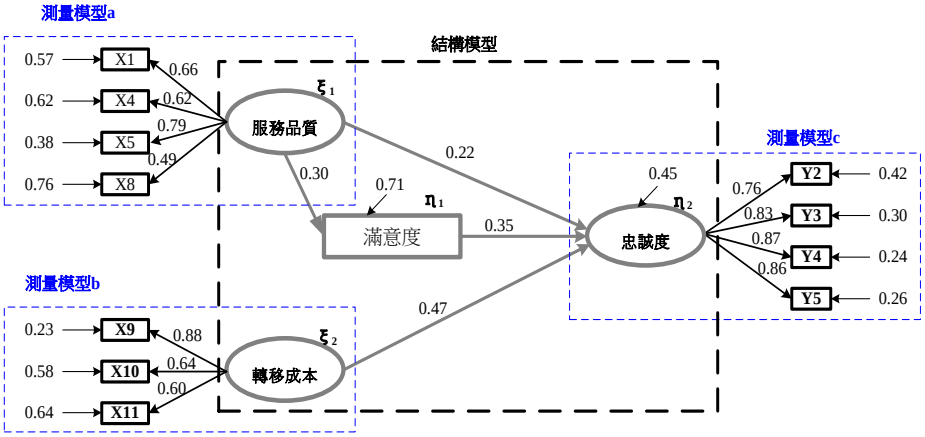
Parameter Estimation

Modification of the Model if Theoretically Justified

Final Model








```
TITLE Latent variable Path Model
DATA NI=12 NO=320 MA=CM
CM SY
0.34
0.15  0.41
0.18  0.32  0.62
0.19  0.30  0.40  0.61
0.17  0.30  0.37  0.39  0.49
0.09  0.12  0.13  0.12  0.12  0.48
0.08  0.10  0.11  0.12  0.12  0.19  0.44
0.08  0.10  0.12  0.11  0.11  0.18  0.22  0.41
0.07  0.08  0.13  0.13  0.12  0.16  0.17  0.21  0.81
0.14  0.21  0.32  0.32  0.29  0.08  0.09  0.08  0.07  0.71
0.14  0.18  0.27  0.33  0.26  0.06  0.07  0.06  0.14  0.50  1.29
0.09  0.13  0.23  0.23  0.19  0.08  0.07  0.07  0.15  0.39  0.57  1.18
LA; SA1 LY1 LY2 LY3 LY4 SQ1 SQ2 SQ3 SQ4 SC1 SC2 SC3
MODEL NY=5 NE=2 NK=2 NX=7 PS=DI GA=FU BE=FU
LE; 滿意度 忠誠度
LK; 服務品質 轉移成本
FREE LY(3,2) LY(4,2) LY(5,2) LX(2,1) LX(3,1) LX(4,1)
     LX(6,2) LX(7,2)
FIX TE 1
VALUE 1 LY(1,1) LY(2,2) LX(1,1) LX(5,2)
PD
OUTPUT SE TV RS MR AM FS EF SS SC MI
```

Goodness of Fit Statistics

Degrees of Freedom = 50

Minimum Fit Function Chi-Square = 70.07 (P = 0.032)

Normal Theory Weighted Least Squares Chi-Square = 74.06

Estimated Non-centrality Parameter (NCP) = 24.06

90 Percent Confidence Interval for NCP = (4.92 ; 51.17)

Minimum Fit Function Value = 0.22

Population Discrepancy Function Value (F0) = 0.075

90 Percent Confidence Interval for F0 = (0.015 ; 0.16)

Root Mean Square Error of Approximation (RMSEA) = 0.039

90 Percent Confidence Interval for RMSEA = (0.018 ; 0.057)

P-Value for Test of Close Fit (RMSEA < 0.05) = 0.84

Expected Cross-Validation Index (ECVI) = 0.41

90 Percent Confidence Interval for ECVI = (0.35 ; 0.49)

ECVI for Saturated Model = 0.49

ECVI for Independence Model = 7.67

Chi-Square for Independence Model with 66 Degrees of Freedom = 2421.57

Independence AIC = 2445.57

Model AIC = 130.06

Saturated AIC = 156.00

Independence CAIC = 2502.79

Model CAIC = 263.57

Saturated CAIC = 527.93

Normed Fit Index (NFI) = 0.97

Non-Normed Fit Index (NNFI) = 0.99

Parsimony Normed Fit Index (PNFI) = 0.74

Comparative Fit Index (CFI) = 0.99

Incremental Fit Index (IFI) = 0.99

Relative Fit Index (RFI) = 0.96

Critical N (CN) = 347.71

Root Mean Square Residual (RMR) = 0.030

Standardized RMR = 0.045

Goodness of Fit Index (GFI) = 0.96

Adjusted Goodness of Fit Index (AGFI) = 0.94

Parsimony Goodness of Fit Index (PGFI) = 0.62

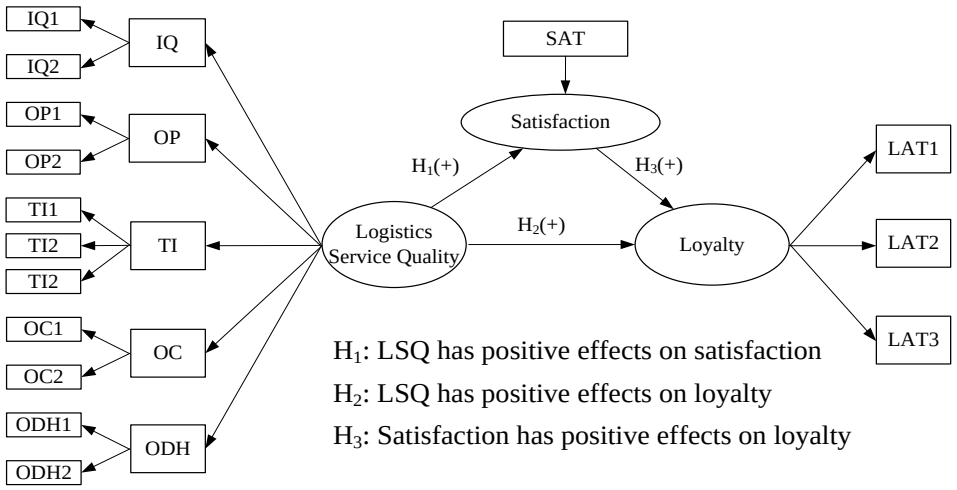
Basic Idea of SEM

SEM配適度檢定相關指標簡述如下：

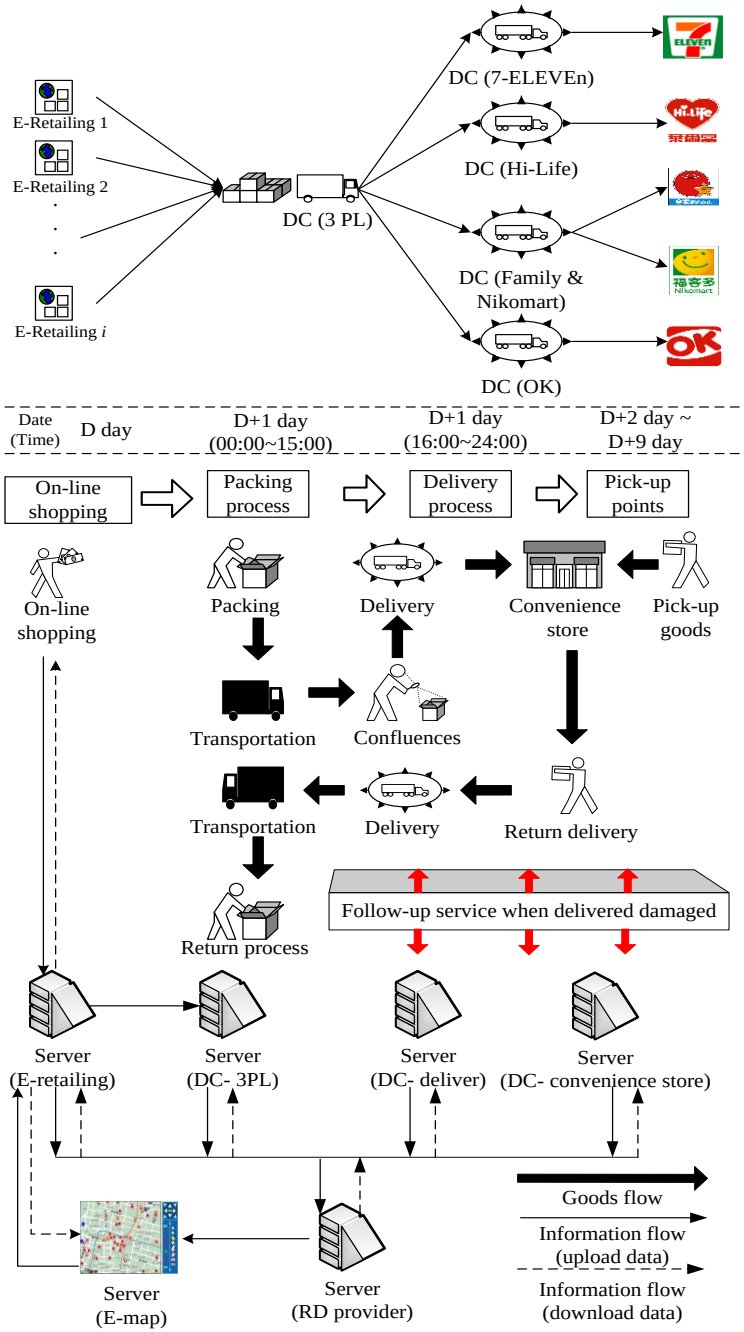
- 契合度指標（X^2 /*df*, GFI, AGFI, PGFI, NFI, NNFI）
  - (1) 卡方自由度比（X^2 /*df*）表示SEM假設模型的導出矩陣與觀察矩陣的差異程度，卡方自由度比小於2表示模型具有理想的契合度。不過卡方自由度比會受到樣本數的影響，所以也有學者建議小於5也可以接受。
  - (2) Goodness-of-Fit Index（GFI）表示假設模型可以解釋觀察變數的變異數與共變數的比例，數值介於0至1之間，一般要求GFI要大於0.9才可視為具有理想的契合度。
  - (3) Adjusted GFI（AGFI）表示模型的可解釋變異量，數值介於0至1之間，判定標準與GFI相同。
  - (4) Parsimony GFI（PGFI）反應SEM模型的簡約程度，一般要求PGFI的數值要大於0.5。
  - (5) Normed Fit Index（NFI）與Non-Normed Fit Index（NNFI）兩個指標是用來反應假設模型與另一個觀察變項間沒有任何共變假設之獨立模型的差異程度，一般可以接受的數值需大於0.9。
- 替代指標（CFI, RMSEA, CN）
  - (1) Comparative-Fit Index（CFI）反應假設模型與無任何共變關係的獨立模型之差異程度，數值介於0至1之間，其門檻值建議需大於0.9，CFI在小樣本SEM分析時常被視為重要的評估指標。
  - (2) Root Mean Square Error of Approximation（RMSEA）漸進均方根指標是在比較理論模式與完美契合之飽和模式的差異程度，數值越小表示假設模型的契合度越好，一般建議等於或小於0.05為良好適配，也有學者認為只要小於0.08便可以接受。
  - (3) Crtical N（CN）樣本指標是用來讓研究者知道所使用的樣本數是否足夠用來估計假設模型的參數及模式的適配，常見的門檻值需等於或大於200。
- 殘差分析（SRMR）
  - (1) Standardized Root Mean Square Residual（SRMR）是用來反應假設模型的參數估計所無法反應實際觀察資料的變異量，數值介於0至1之間，一般是以小於0.08當作可接受的判定標準。

– SEM模型中，對於標準化路徑係數而言，其絕對值大於0.5以上算是大效果、0.3為中效果，小於0.1為小效果

Case Study

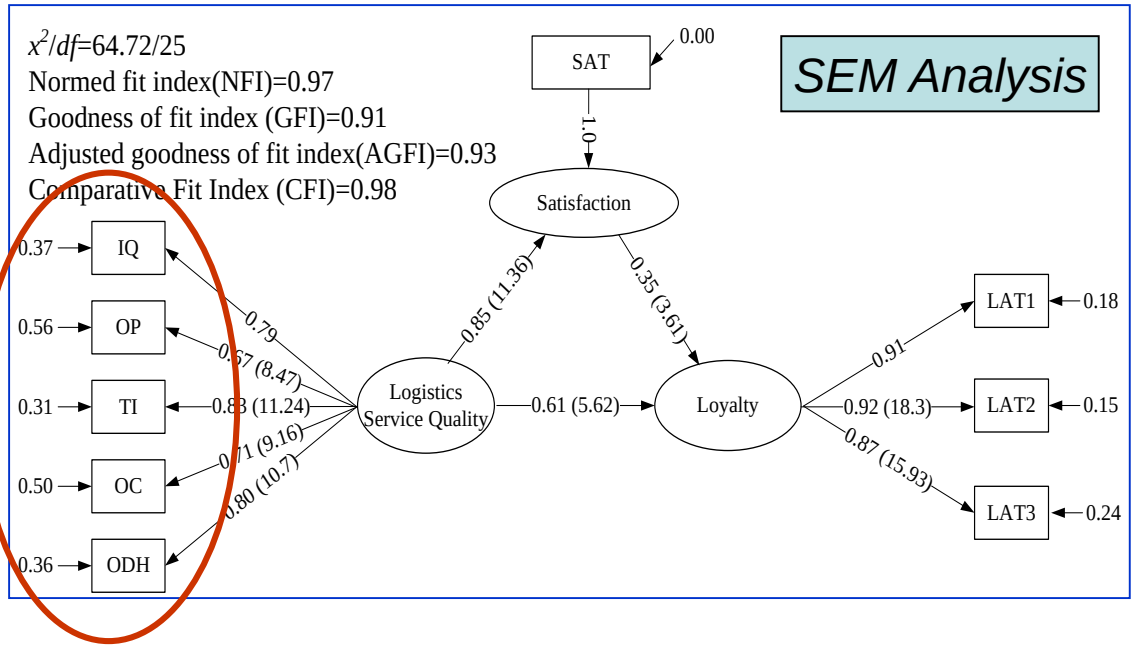


	1	2	3	4	5	6	7	8	9
1. SAT	0.493								
2. LAT1	0.398	0.543							
3. LAT2	0.418	0.446	0.534						
4. LAT3	0.457	0.518	0.498	0.732					
5. IQ	0.307	0.315	0.335	0.308	0.447				
6. OP	0.316	0.295	0.337	0.342	0.289	0.623			
7. TI	0.336	0.350	0.342	0.373	0.351	0.316	0.498		
8. OC	0.366	0.371	0.380	0.465	0.275	0.355	0.370	0.729	
9. ODH	0.354	0.369	0.382	0.368	0.291	0.261	0.314	0.328	0.489

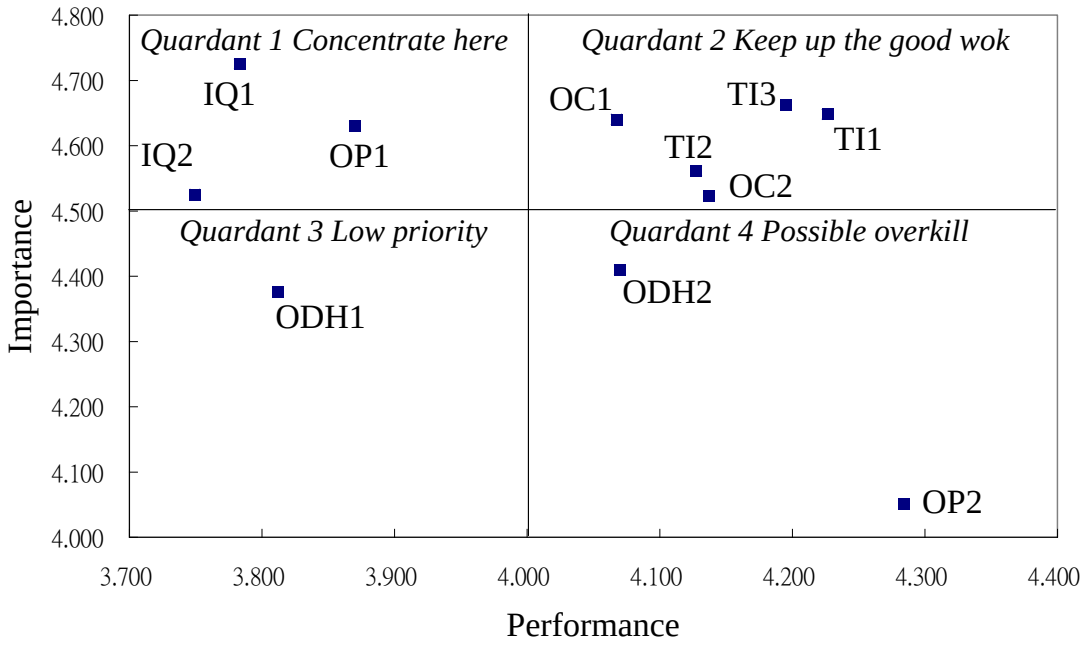


Case Study

SEM Analysis



IPA Analysis



Journal Paper

- EASTS (Eastern Asia Society for Transportation Studies)
- SCMIS 2007 (Supply Chain Management and Information Systems)
- IEEE WiCOM2007 (2007 International Symposium on Information Systems & Management)
- SOLI 2007 - 2007 IEEE-INFORMS International Conference on Service Operations and Logistics, and Informatics
- Air Transport Research Society
- International Journal of Information Systems for Logistics and Management (IJISLM)
- 中山管理評論 - Sun Yat-Sen Management Review (TSSCI)
- 中華民國運輸學會 96 年年會暨學術論文國際研討會
- 運輸學刊(TSSCI)