세미나자료집 12-S39

청소년도덕성 진단검사도구 표준화연구 II

제2차 콜로키움 자료집

-Mplus를 활용한 잠재계층분석의 이론과 적용-

일시 | 2012년 9월 6일(목) 14:00-18:00
장소 | 한국청소년정책연구원 10층 세미나실
주최 | 한국청소년정책연구원

한국청소년정책연구원
National Youth Policy Institute

■ 청소년도덕성 진단검사도구 표준화연구 Ⅱ

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세 부 일 정

〈청소년 도덕성 검사도구 표준화 연구 II〉
Mplus를 활용한 잠재계층분석의 이론과 적용

시간	내용	비고
14:00~14:10	개회 및 발표자 소개	김영한 연구위원 (한국청소년정책연구원)
14:10~14:20	환영인사	이재연 원장 (한국청소년정책연구원)
14:20~17:30	발표	신택수 교수 (명지대)
17:30~18:00	질의응답	참석자 전원

목 차

Mplus를 활용한 잠재계층분석의 이론과 적용

신택수

(명지대학교 교수)

Latent Class Analysis (LCA)

- Latent Class Analysis (LCA)
  1. is a statistical modeling techniques that are becoming more commonly used in behavioral and social science research.
  2. aims to uncover unobserved heterogeneity in a population and to find substantively meaningful groups of people that are similar in their responses to measured variables or growth trajectories (Muthén, 2004).
  3. 특정 모집단에 존재하는 비관측 이질성(unobserved heterogeneity)을 추적
  4. Examples of the use of LCA can be found throughout the behavioral and social sciences, such as the analysis of data on Antisocial Personality Disorder (Bucholz, Hesselbrock, Heath, Kramer, & Schuckit, 2000) exploring whether subtypes exist with respect to different symptoms, analysis of clinically diagnosed eating disorders identifying four symptom-related subgroups (Keel et al., 2004), and analysis of Attention Deficit/Hyperactivity Disorder (ADHD; Rasmussen et al., 2002) exploring typologies of activity disorders. For an overview of applications and recent developments in LCA, see the edited book by Hagenaars and McCutcheon (2002).

Latent Class Analysis (LCA)

- History and Development
  1. Lazarsfeld and Henry (1968) introduced the LCA model as a way to identify a latent categorical attitude variable that was measured by dichotomous survey items. LCA models identify a categorical latent class variable measured by a number of observed response variables.
  2. The objective is to categorize people into classes using the observed items and identify items that best distinguish between classes.
  3. LCA 분석에서는 잠재요인과 집단 확률 모수를 추정.
     - 불연속 변인 분석의 경우 잠재요인 모수는 조건부 요인 확률에 해당하며 이 확률을 바탕으로 하위 집단을 구분하게 된다. 또한, 해당 집단에 소속될 개인 확률에 대한 정보도 제공하며 집단 확률 모수는 각 집단의 상대적인 크기를 의미한다
     - 연속 변인을 이용한 LCA의 경우 문항 모수는 집단별 잠재변인의 평균과 분산이 되며 집단 확률모수는 불연속 변인 분석과 동일하게 특정 모집단 내에 존재하는 하위 잠재집단의 상대적 크기를 나타낸다.

Finite Mixture Modeling

- LCA와 GMM은 FMM을 기반으로 수립된 분석 기법
- 만약 세 개의 잠재집단이 혼합하여 하나의 군집분포를 이룰 경우 FMM 수리모형을 다음과 같다.

$$f(x) = p_1 g_1(x) + p_2 g_2(x) + p_3 g_3(x)$$

$$g_1(x) = \frac{1}{\sigma_1 \sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu_1}{\sigma_1}\right)}$$

$$g_2(x) = \frac{1}{\sigma_2 \sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu_2}{\sigma_2}\right)}$$

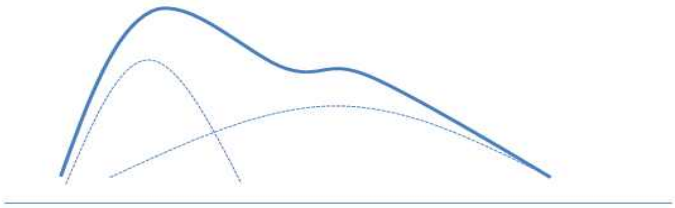
$$g_3(x) = \frac{1}{\sigma_3 \sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu_3}{\sigma_3}\right)}$$

Finite Mixture Modeling

- **위 그림에서 하위집단이 존재하지 않는 경우**

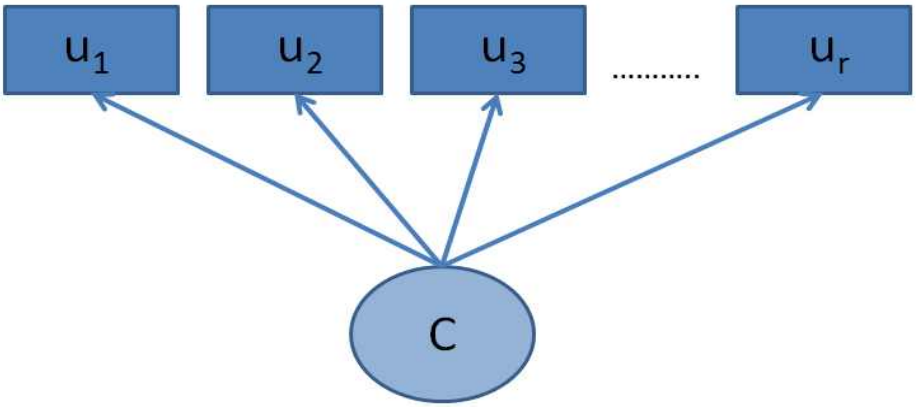
1. p_1이 1인 경우
2. 세 집단의 특성이 다르지 않은 경우 즉, 세 분포의 평균과 분산이 모두 일치할 때

- **하위집단이 존재하는 경우**



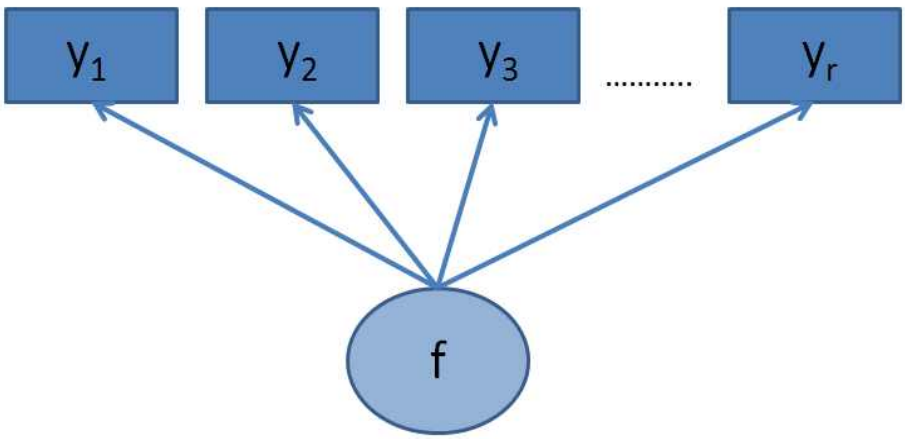
Latent Class Analysis (LCA)

- General latent class analysis model diagram



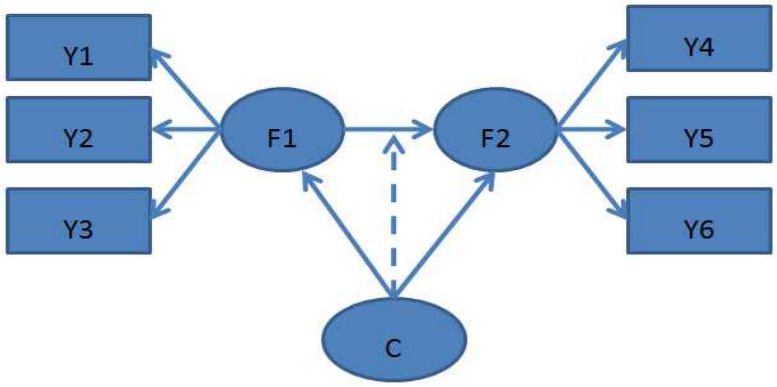
Latent Class Analysis (LCA)

- Factor mixture modeling



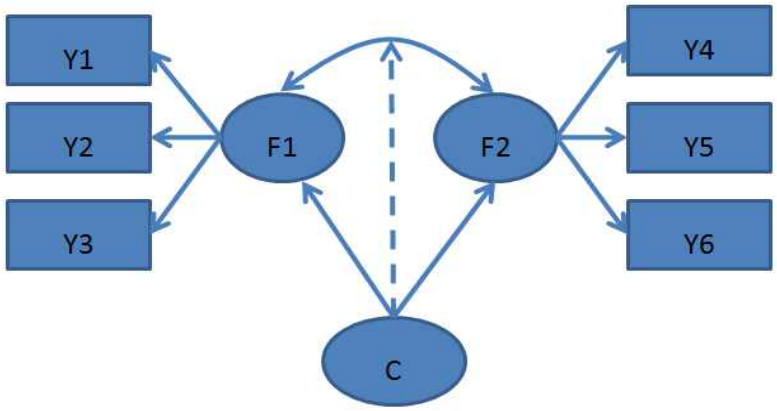
Latent Class Analysis (LCA)

- Structural Equation Mixture Modeling 01



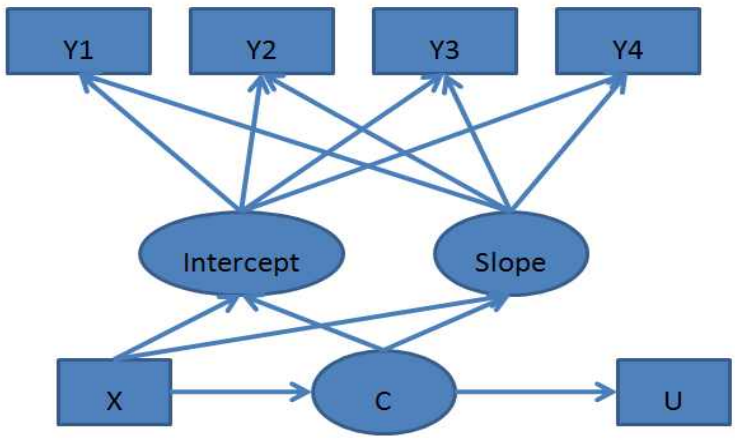
Latent Class Analysis (LCA)

- Structural Equation Mixture Modeling 02



Latent Class Analysis (LCA)

- Growth Mixture Modeling



Latent Class Analysis (LCA)

- Model Fit Analysis: Which model will you choose?

1. IC fit (Information Criteria) indices

$$AIC = -2\log L + 2P$$

$$BIC = -2\log L + P \times \log(n)$$

$$\textit{Adjusted } BIC = -2\log L + P \times \left(\frac{n+2}{24}\right)$$

2. Lo-Mendell-Rubin Fit testing (LMR)

$$LR = -2[\log L(\hat{\theta}_r) - \log L(\hat{\theta}_u)$$

Latent Class Analysis (LCA)

- Model Fit Analysis: Which model will you choose?

3. Bootstrap Likelihood Ratio Test (BLRT)

가. 초기 *k*-1 집단과 *k* 집단 모형의 로그 우도차이를 계산한다.
나. 영가설 모형인 *k*-1 집단에서 다량의 부트스트랩 표본을 추출하여 로그우도를 추정하여 *k* 집단 로그우도와의 차이를 계산한다.
다. 해당 과정을 반복하고 로그우도 차이의 참의 분포(true distribution)를 추정한다.
라. 마지막으로 전 단계에서 추정된 분포를 바탕으로 통계 검증(*p*-value)을 실시한다. 만약, 영가설을 기각하게 되면 잠재집단의 수는 *k* 개가 된다는 것이고, 반대로 채택하면 적절한 집단의 수는 *k*-1 개가 된다(신택수, 2010; Nylund, Asparouhov, & Muthén, 2007).

4. Bayesian Method

5. Formann(2003)의 *RCL*

Latent Class Analysis (LCA)

- Model Fit Analysis: Which model will you choose?

6. The results of Prior LCA Studies

가. IC 지수 중에서는 BIC가 가장 신뢰도가 높음(Yang, 2006; Tofighi & Enders, 2007). AIC는 상대적으로 하위 잡단의 수를 과대 추정할 가능성이 높음

나. CAIC가 AIC보다 우수하기는 하나 표본의 수가 작을 경우 CAIC도 문제가 있음

다. LMR은 상대적으로 하위집단의 수를 과소추정함 (Roeder & Wasserman, 1997; Jedidi, Jagpal, & DeSarbo, 1997)

라. McLachlan과 Peel(2000)와 Nylund, Asparouhov와 Muthén(2007)는 모든 지수 중에서 BLRT가 다양한 연구조건에서 가장 정확하게 모형의 수를 추정

LCA is a Perfect tool?

- 집단의 수 추정에 있어 군집분포의 형태(aggregated distribution shape)가 미치는 영향(Bauer & Curran, 2003)

The question may be raised, how are we to discriminate between a true curve of skew type and a compound curve [or mixture], supposing we have no reason to suspect our statistics *a priori of mixture. I have at present* been unable to find any general condition among the moments, which would be impossible for a skew curve and possible for a compound, and so indicate compoundness (Pearson, 1895; p. 394)

- 군집분포의 형태에 따른 모수 추정의 왜곡 (신택수, 2011)
- 공변인이 투입되기 전과 후의 집단 소속 확률 변화(신택수, 2011)
- 복잡한 알고리듬에 의한 수렴 실패 확률 증가 (신택수, 2010, 2011)
- 표본의 수에 민감/최소 필요 표본의 수
- 설명/해석 가능한 소속집단확률의 최소 기준점?

LCA should not be used?

Cluster Method	Adequate Assumption	Algorithm Stability	Allows for different scale types	Research Type	Optimal determination of # of classes
K-means	No	Yes	No	Exploratory	Not clear
Hierarchical	No	Yes	No	Exploratory	Not clear
Two-step Cluster	No	Yes	No	Exploratory	Not clear
Multidimensional Scaling	No	Yes	Yes, but unreliable	Exploratory	Not clear
LCA	Yes	Dissatisfied	Yes	Exploratory /Confirmatory	Relatively Clear

Today….

- We will overview the modeling package Mplus (http://www.statmodel.com/).
- Importing data
- Syntax
- A few examples
- Then, Latent Class Analysis

Mplus

- What is it? A flexible, syntax-driven modeling package
- Originally designed for SEM
- Now, Mplus handles a wide spectrum of models (multilevel, categorical, etc)
  - A good option for survey data Estimation is state-of-the-art
  - Handles sampling weights & plausible values

- What is doesn't do (well) Data manipulation: A general package is also necessary (SPSS, SAS, etc)
- Limited capacity: means, missing, a few others

Other SEM softwares

- LISREL and SIMPLIS (1993)
- EQS (EQuationS)
- AMOS (Analysis of MOment Structures) in SPSS (Statistical Package for Social Sciences)
- proc CALIS (Covariance Analysis and LInear Structural Equations) in SAS (Statistical Analytic Systems)
- RAMONA (Reticular Action Model Or Near Approximation)
- SEPATH (SEM and PATH analysis)
- NORM, ENCOV, MX, and proc IML using SAS

Support: Teaching you to fish

- SEMNET (structural equation modeling discussion network):
  - http://www2.gsu.edu/~mkteer/semnet.html
  - A good resource

- Mplus discussion: http://statmodel.com/cgi-bin/discus/discus.cgi
  - Generally, Bengtor Linda Muthén promptly respond

- Each other ! (Especially, Structural Equation Modeling: A multidisciplinary Journal)

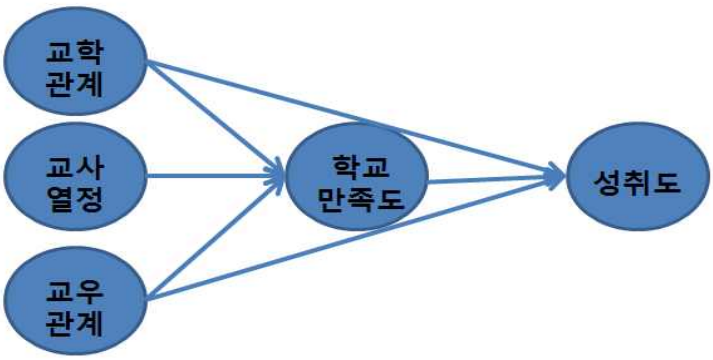
General Format

- Mplus commands in sections, which include:
  TITLE:
  DATA:
  VARIABLE:
  ANALYSIS:
  MODEL:
  OUTPUT:

- Other commands that we'll discuss (probably not, tough):
  DEFINE:
  SAVEDATA:
  PLOT:
  MONTECARLO:

EXAMPLE

- KEDI DATA (예제.sav; KEDI01.dat)



EXAMPLE01.inp

- TITLE:
- DATA:

- Data format –ASCII, free or fixed. We'll mainly use fixed format
- From SAS (or SPSS), save data as *.dat–variable names are not included in .dat file.*

TITLE: KEDI WORKSHOP01;

!Note: Comments begin with '!'

DATA: FILE = c:\KEDI01.dat;

EXAMPLE01.inp

- VARIABLE

NAMES = SID SCHID GENDER Y1-Y31;

USEVARIABLES = Y6-Y31;

! If dependent vars are categorical or binary ones, then

! categocial = Y1-Y4;

! binary = Y1-Y4;

! count = Y1-Y4;

EXAMPLE01.inp

- ANALYSIS

```
TYPE = GENERAL; ! MODEL = MEANSTRUCTURE OR NOMEANSTRUCTURE;
            ! REGRESSION, PATH, CFA, SEM, GROWTH MODEL, SURVIVAL ANALYSIS
            ! RANDOM = RANDOM SLOPE AND INTERCEPT
            ! COMPLEX NEVER USED BEFORE

! TYPE = MIXTURE;
! CATEGORIAL LATENT VARIABLE AND/OR FINITE MIXTURE MODEL (LATENT CLASS
    MODEL);
! LOGLINAER MODEL, MULTIPLE GROUP ANALYSIS

! TYPE = TWOLEVEL;
! TYPE = EFA;

ITERATIONS = 100000000;

ESTIMATOR = ML; ! FOR CONTINUOUS
! ESTIMATOR = MLR; ! FOR BOTH DIS-CONTINUOUS AND CONTINUOUS
! ML PARAMETER ESTIMATE WITH ROBUST CHI-SQUARED TEST AND SE.

CONVERGENCE = 0.00005;
```

EXAMPLE01.inp

- MODEL

```
F1 BY Y6-Y11; !교학관계
F2 BY Y12-Y15; ! 교우관계
F3 BY Y16-Y19; ! 교사열정
F4 BY Y20-Y28; ! 학교만족도
F5 BY Y29-Y31; ! 학업성취도
! BY STATEMENT = FACTOR ANALYSIS

F4 ON F1 F2 F3;
F5 ON F1-F4;
! ON STATEMENT = CAUSAL ANALYSIS (REGRESSSION)

F1 WITH F2;
F2 WITH F3;
F1 WITH F3;
! WITH STATEMENT = CORRELATION ANALYSIS

! F1@0 Y1@0; ! RESIDUAL VAR = 0
! [F1@0] [Y1@0] ! LATENT MEAN OR INTERCEPT = 0;

! F4 ON F1@2 F2 F3; FIXED REGRESSION COEF = 0
! F4 ON F1*2 F2 F3; STARTING VALUE = 0;
```

EXAMPLE01.inp

OUTPUT: STANDARDIZED; ! PROVIDING STANDARDIZED SOLUTION
! MODINDICES ! MODIFICATION INDEX
! TECH 1; NOTIFYING MODEL PARAMETER
! TECH 2; NEVER USED BEFORE
! TECH 3; PROVIDING ESTIMATED COVARAINCE MATRIX
! TECH 4; ! PROVIDING ESTIMATED MEAN, COVARAINCE, CORREALTION FOR LV
! TECH 5; OPTIMIZATION HISTORY
! TECH 6; OPTIMIZATION HISTORY FOR CATEGORICAL V
! TECH 7; NEVER USED BEFORE
! TECH 8; OPTIMIZATION HISTORY
! TECH 9; FOR SIMULATION PROCESS
! TECH 10; FOR CATEGORICAL V ANALYSIS
! TECH 11; PROVIDING LO-MENDELL-RUBIN TEST FOR LATENT CLASS ANALYSIS
! TECH 12: FOR LATENT CLASS ANALYSIS BUT HARDLY USED
! TECH 13: TESTING MULTIVARIATE NORMALITY (MARDIA'S MEASURE)
! TECH 14; LRT BOOTSTRAP TEST FOR LATENT CLASS ANALYSIS

ex14.inp

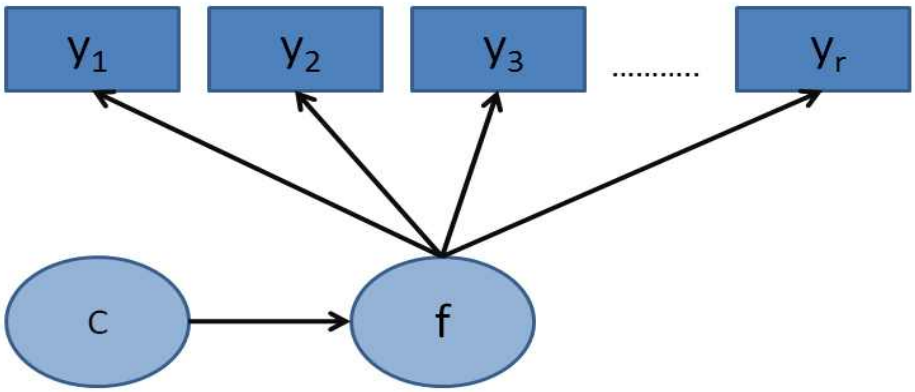
- Data file ex07.dat

  변수명: id 성별 Y1-Y5 연도별 청소년활동 참여수준 (0 = X, 1= 참여)

```
Title:
 Latent Class Analysis.
 Data: File = c:\ex07.dat;
 Variable:
  names      = ID GENDER Y1-Y5;
  usevariables = Y1-Y5;
  categorical  = Y1-Y5;
  classes = c(2); !c(#)은 하위 집단의 수
 Analysis:
  Type=mixture; ! 혼합모형의 경우 이를 뜻하는 mixture를 지정해 주어야 함.
 Output:
  tech11 tech14;
```

Latent Class Analysis (LCA)

- Factor mixture modeling



ex15.inp &...

- Data file ex05.dat

```
Title: Latent Class Analysis.
 Latent Class Analysis.
 Data: File = c:\ex05.dat;
 Variable:
   names      = SCHID Y1-Y23;
   usevariables = Y1-Y2; ! 읽기와 수학성취도 점수
   classes = c(2); !c(#)은 하위 집단의 수
 Analysis:
   Type=mixture; ! 혼합모형의 경우 이를 뜻하는 mixture를 지정해 주어야 함.
 Output:
   tech11 tech14;
```

ex15.out

집단 수(k) / IC	2	3	4	5
AIC	11128.816	11078.390	11046.942	11037.368
BIC	11128.816	11078.390	11046.942	11037.368
보정된 BIC	11128.816	11078.390	11046.942	11037.368

Likelihood testing	집단1 Vs 집단2	집단2 Vs 집단3	집단3 Vs 집단4	집단4 Vs 집단5
LMR	225.824**	53.659*	35.612*	34.370
BLRT	237.471**	56.426**	37.448**	36.143**

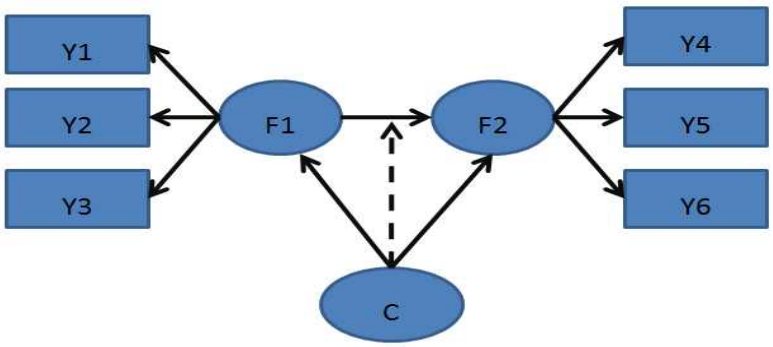
ex16.inp

- Data file ex05.dat

```
Title: Latent Class Analysis.
 Latent Class Analysis.
 Data: File = c:\ex05.dat;
 Variable:
   names       = SCHID Y1-Y23;
   usevariables = Y1-Y2 Y6-Y7; ! 읽기와 수학성취도 점수 Y6: gender Y7:SES
   classes = c(3);
 Analysis:
   Type=mixture;
MODEL:
 %OVERALL% ! 잠재계층모형에서 모형 COMMAND에 필수적으로 들어가는 OVERALL
 C ON Y6 Y7; ! 계층의 특성(계층 1보다 계층 2에 남자/여자가 더 많을까?)
                        (계층 1보다 계층 3에 SES가 높은 학생들이 더 많을까?)
 Output:
   tech11 tech14;
```

Latent Class Analysis (LCA)

- Structural Equation Mixture Modeling



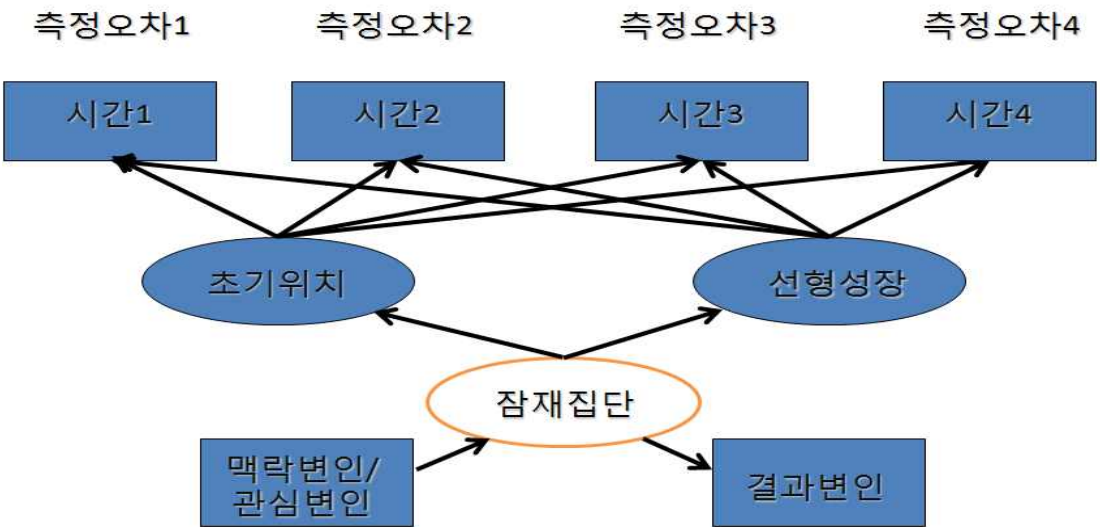
ex17.inp & ex17_1.inp

- Data file ex01.dat

```
TITLE: LATENT CALSS ANALYSIS;
DATA: FILE = c:\ex01.dat;
VARIABLE:
  NAMES = SID SCHID GENDER Y1-Y8;
  USEVARIABLES = Y1-Y8;
  CLASSES = C(2);
ANALYSIS:
TYPE = MIXTURE;
MODEL:
%OVERALL%
F1 BY Y1-Y4;
F2 BY Y5-Y8;
F2 ON F1;
%C#1%
[F1 F2];
F2 ON F1;
OUTPUT: TECH11 TECH14;
```

- **결과 해석 :** 교사/학생관계가 교우관계에 더 긍정적으로 영향을 미치는 집단이 존재하나 이러한 집단의 특성에 있어 성별의 차이는 없다.

성장혼합모형



성장혼합모형

- 잠재계층분석이 가장 활발하게 적용되고 있는 모형
- 특정 모집단에 존재하는 비관측 이질성(unobserved heterogeneity)을 추적하는 것으로 종단성장연구에서는 비슷한 성장궤적을 가지는 의미 있는 잠재집단을 찾는 분석에 활용되고 있음.
- 전통적인 분석기법에서는 모든 연구 대상자가 하나의 모집단에서 나온다고 가정하여 전체 집단을 대표하는 성장 분석에 그 초점을 두고 있다. 더불어, 성장에 영향을 미치는 요인의 효과 또한 각 개인에 걸쳐 동일하게 적용된다고 가정하고 있다. 하지만, 전체 집단 내에서도 서로 다른 성장 궤적을 나타내는 하위 집단이 존재하는 것을 볼 수 있음.
- 이질적 성장경향을 나타내는 잠재집단을 추적하고 특정 변인과 개별 집단과의 관계를 분석

ex18.inp

- Data file ex08.dat
  - 변인 명: Y1-Y4: 1-4차년도 읽기성적 Y5:특수프로그램등록유무
    Y6: 영어교육프로그램등록유무

```
TITLE: LATENT CALSS ANALYSIS;
DATA: FILE = c:\ex08.dat;
VARIABLE:
  NAMES = Y1-Y6;
  USEVARIABLES = Y1-Y4;
  CLASSES = C(2);
ANALYSIS:
TYPE = MIXTURE;
MODEL:
%OVERALL%
IINT SLO QUA | Y1@0 Y2@1 Y3@2 Y4@;

OUTPUT: TECH11 TECH14;
```

성장혼합모형

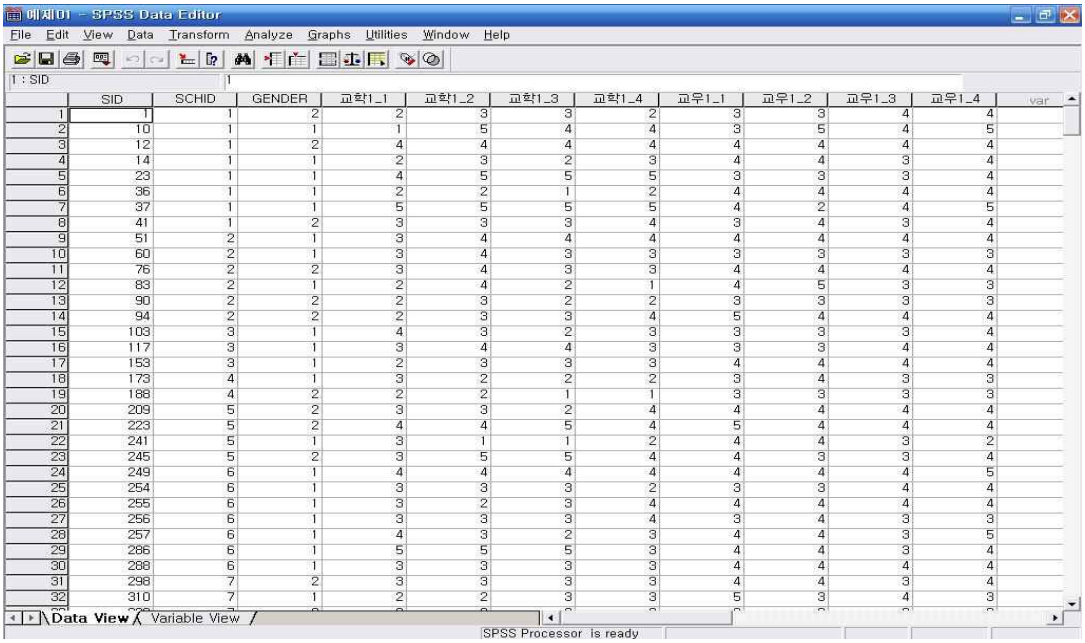
- Please find ex09.sav

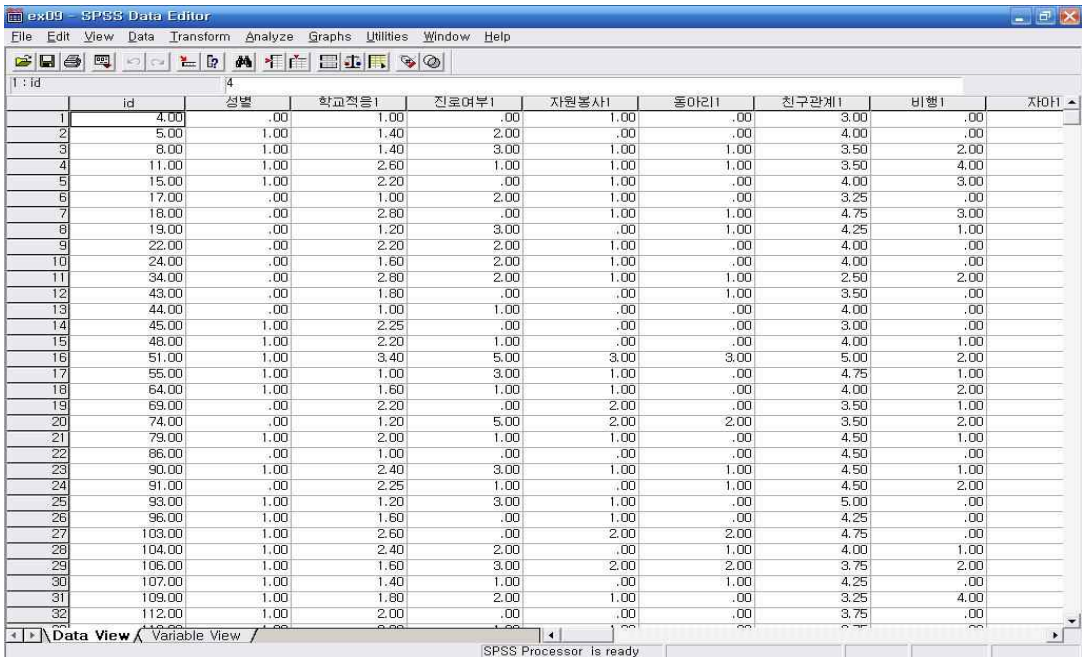
- Please DO WHATEVER YOU WANT within
  - Latent Growth Modeling
  - Growth Mixture Modeling

-부록-

(Data, Syntax, Output)

Data


예제01 - SPSS Data Editor
File Edit View Data Transform Analyze Graphs Utilities Window Help
1 : SID
SID SCHID GENDER 교학1_1 교학1_2 교학1_3 교학1_4 교우1_1 교우1_2 교우1_3 교우1_4 var
1 1 1 2 2 3 3 2 3 3 4 4
2 10 1 1 1 5 4 4 3 5 4 5
3 12 1 2 4 4 4 4 4 4 4 4
4 14 1 1 2 3 2 3 4 4 3 4
5 23 1 1 4 5 5 5 3 3 3 4
6 36 1 1 2 2 1 2 4 4 4 4
7 37 1 1 5 5 5 5 4 2 4 5
8 41 1 2 3 3 3 4 3 4 3 4
9 51 2 1 3 4 4 4 4 4 4 4
10 60 2 1 3 4 3 3 3 3 3 3
11 76 2 2 3 4 3 3 4 4 4 4
12 83 2 1 2 4 2 1 4 5 3 3
13 90 2 2 2 3 2 2 3 3 3 3
14 94 2 2 2 3 3 4 5 4 4 4
15 103 3 1 4 3 2 3 3 3 3 4
16 117 3 1 3 4 4 3 3 3 4 4
17 153 3 1 2 3 3 3 4 4 4 4
18 173 4 1 3 2 2 2 3 4 3 3
19 188 4 2 2 2 1 1 3 3 3 3
20 209 5 2 3 3 2 4 4 4 4 4
21 223 5 2 4 4 5 4 5 4 4 4
22 241 5 1 3 1 1 2 4 4 3 2
23 245 5 2 3 5 5 4 4 3 3 4
24 249 6 1 4 4 4 4 4 4 4 5
25 254 6 1 3 3 3 2 3 3 4 4
26 255 6 1 3 2 3 4 4 4 4 4
27 256 6 1 3 3 3 4 3 4 3 3
28 257 6 1 4 3 2 3 4 4 3 5
29 286 6 1 5 5 5 3 4 4 3 4
30 288 6 1 3 3 3 3 4 4 4 4
31 298 7 2 3 3 3 3 4 4 3 4
32 310 7 1 2 2 3 3 5 3 4 3
Data View Variable View
SPSS Processor is ready


ex09 - SPSS Data Editor
File Edit View Data Transform Analyze Graphs Utilities Window Help
1 : id
id 성별 학교적응1 진로여부1 자원봉사1 돌아리1 친구관계1 비행1 자아1
1 4.00 .00 1.00 .00 1.00 .00 3.00 .00
2 5.00 1.00 1.40 2.00 .00 .00 4.00 .00
3 8.00 1.00 1.40 3.00 1.00 1.00 3.50 2.00
4 11.00 1.00 2.60 1.00 1.00 1.00 3.50 4.00
5 15.00 1.00 2.20 .00 1.00 .00 4.00 3.00
6 17.00 .00 1.00 2.00 1.00 .00 3.25 .00
7 18.00 .00 2.80 .00 1.00 1.00 4.75 3.00
8 19.00 .00 1.20 3.00 .00 1.00 4.25 1.00
9 22.00 .00 2.20 2.00 1.00 .00 4.00 .00
10 24.00 .00 1.60 2.00 1.00 .00 4.00 .00
11 34.00 .00 2.80 2.00 1.00 1.00 2.50 2.00
12 43.00 .00 1.80 .00 .00 1.00 3.50 .00
13 44.00 .00 1.00 1.00 .00 .00 4.00 .00
14 45.00 1.00 2.25 .00 .00 .00 3.00 .00
15 48.00 1.00 2.20 1.00 .00 .00 4.00 1.00
16 51.00 1.00 3.40 5.00 3.00 3.00 5.00 2.00
17 55.00 1.00 1.00 3.00 1.00 .00 4.75 1.00
18 64.00 1.00 1.60 1.00 1.00 .00 4.00 2.00
19 69.00 .00 2.20 .00 2.00 .00 3.50 1.00
20 74.00 .00 1.20 5.00 2.00 2.00 3.50 2.00
21 79.00 1.00 2.00 1.00 1.00 .00 4.50 1.00
22 86.00 .00 1.00 .00 .00 .00 4.50 .00
23 90.00 1.00 2.40 3.00 1.00 1.00 4.50 1.00
24 91.00 .00 2.25 1.00 .00 1.00 4.50 2.00
25 93.00 1.00 1.20 3.00 1.00 .00 5.00 .00
26 96.00 1.00 1.60 .00 1.00 .00 4.25 .00
27 103.00 1.00 2.60 .00 2.00 2.00 4.75 .00
28 104.00 1.00 2.40 2.00 .00 1.00 4.00 1.00
29 106.00 1.00 1.60 3.00 2.00 2.00 3.75 2.00
30 107.00 1.00 1.40 1.00 .00 1.00 4.25 .00
31 109.00 1.00 1.80 2.00 1.00 .00 3.25 4.00
32 112.00 1.00 2.00 .00 .00 .00 3.75 .00
Data View Variable View
SPSS Processor is ready

Syntax

【ex. 14】

```
Title:
     Latent Class Analysis.
  Data: File = c:₩ex07.dat;
  Variable:
     names          = ID GENDER Y1-Y5;
     usevariables = Y1-Y3;
     categorical   = Y1-Y3;
     classes = c(2);
  Analysis:
     Type=mixture;
  Output:
     tech11 tech14;

PLOT: TYPE = PLOT3;
SERIES = Y1(1) Y2(2) Y3(3);
```

【ex. 14-1】

```
Title:
     Latent Class Analysis.
  Data: File = c:₩ex07.dat;
  Variable:
     names          = ID GENDER Y1-Y5;
     usevariables = Y1-Y3;
     categorical   = Y1-Y3;
     classes = c(3);
  Analysis:
     Type=mixture;
  Output:
     tech11 tech14;

PLOT: TYPE = PLOT3;
SERIES = Y1(1) Y2(2) Y3(3);
```

【ex. 15】

```
Title: Latent Class Analysis.
  Latent Class Analysis.
  Data: File = c:₩ex05.dat;
  Variable:
     names          = SCHID Y1-Y23;
     usevariables = Y1-Y2;
     classes = c(2);
  Analysis:
     Type=mixture;
  Output:
     tech11 tech14;

PLOT:
TYPE = PLOT3;
SERIES = Y1(1) Y2(2);
```

【ex. 15-1】

```
Title: Latent Class Analysis.
  Latent Class Analysis.
  Data: File = c:₩ex05.dat;
  Variable:
     names          = SCHID Y1-Y23;
     usevariables = Y1-Y2;
     classes = c(3);
  Analysis:
     Type=mixture;
  Output:
     tech11 tech14;

PLOT:
TYPE = PLOT3;
SERIES = Y1(1) Y2(2);
```

【ex. 15-2】

```
Title: Latent Class Analysis.
  Latent Class Analysis.
  Data: File = c:₩ex05.dat;
  Variable:
    names          = SCHID Y1-Y23;
    usevariables = Y1-Y2;
    classes = c(4);
  Analysis:
    Type=mixture;
  Output:
    tech11 tech14;

PLOT:
TYPE = PLOT3;
SERIES = Y1(1) Y2(2);
```

【ex. 15-3】

```
Title: Latent Class Analysis.
  Latent Class Analysis.
  Data: File = c:₩ex05.dat;
  Variable:
    names          = SCHID Y1-Y23;
    usevariables = Y1-Y2;
    classes = c(5);
  Analysis:
    Type=mixture;
  Output:
    tech11 tech14;

PLOT:
TYPE = PLOT3;
SERIES = Y1(1) Y2(2);
```

【ex. 16】

```
Title: Latent Class Analysis.
  Latent Class Analysis.
  Data: File = c:₩ex05.dat;
  Variable:
    names          = SCHID Y1-Y23;
    usevariables = Y1-Y2 Y6-Y7;
    classes = c(3);
  Analysis:
    Type=mixture;
MODEL:
   %OVERALL%
   C ON Y6 Y7;
  Output:
    tech11 tech14;

PLOT:
TYPE = PLOT3;
SERIES = Y1(1) Y2(2);
```

【ex. 17】

```
TITLE: LATENT CALSS ANALYSIS;
DATA: FILE = c:₩ex01.dat;
VARIABLE:
   NAMES = SID SCHID GENDER Y1-Y8;
   USEVARIABLES = Y1-Y8;
   CLASSES = C(2);
ANALYSIS:
TYPE = MIXTURE;
MODEL:
%OVERALL%
F1 BY Y1-Y4;
F2 BY Y5-Y8;
F2 ON F1;
%C#1%
[F1 F2];
F2 ON F1;
%C#2%
[F1 F2];
F2 ON F1;

OUTPUT: TECH11 TECH14;
```

【ex. 17-1】

```
TITLE: LATENT CALSS ANALYSIS;
DATA: FILE = c:₩ex01.dat;
VARIABLE:
    NAMES = SID SCHID GENDER Y1-Y8;
    USEVARIABLES = GENDER Y1-Y8;
    CLASSES = C(2);
ANALYSIS:
TYPE = MIXTURE;
ALGORITHM=INTEGRATION;
MODEL:
%OVERALL%
F1 BY Y1-Y4;
F2 BY Y5-Y8;
F2 ON F1;
C ON GENDER;
%C#1%
[F1 F2];
F2 ON F1;
%C#2%
[F1 F2];
F2 ON F1;

OUTPUT: TECH11 TECH14;
```

【ex. 18】

```
TITLE: LATENT CALSS ANALYSIS;
DATA: FILE = c:₩ex08.dat;
VARIABLE:
    NAMES = Y1-Y6;
    USEVARIABLES = Y1-Y4;
    CLASSES = C(2);
ANALYSIS:
TYPE = MIXTURE;
MODEL:
%OVERALL%
IINT SLO QUA | Y1@0 Y2@1 Y3@2 Y4@3;
OUTPUT: TECH11 TECH14;
PLOT:
TYPE = PLOT3;
SERIES = Y1(1) Y2(2) Y3(3) Y4(4);
```

【ex. 18-1】

```
TITLE: LATENT CALSS ANALYSIS;
DATA: FILE = c:₩ex08.dat;
VARIABLE:
    NAMES = Y1-Y6;
    USEVARIABLES = Y1-Y4;
    CLASSES = C(3);
ANALYSIS:
TYPE = MIXTURE;
MODEL:
%OVERALL%
IINT SLO QUA | Y1@0 Y2@1 Y3@2 Y4@3;

OUTPUT: TECH11 TECH14;

PLOT:
TYPE = PLOT3;
SERIES = Y1(1) Y2(2) Y3(3) Y4(4);
```

【ex. 18-2】

```
TITLE: LATENT CALSS ANALYSIS;
DATA: FILE = c:₩ex08.dat;
VARIABLE:
    NAMES = Y1-Y6;
    USEVARIABLES = Y1-Y6;
    CLASSES = C(2);
ANALYSIS:
TYPE = MIXTURE;
MODEL:
%OVERALL%
INT SLO QUA | Y1@0 Y2@1 Y3@2 Y4@3;
C ON Y5 Y6;

OUTPUT: TECH11 TECH14;

PLOT:
TYPE = PLOT3;
SERIES = Y1(1) Y2(2) Y3(3) Y4(4);
```

Output

【ex. 14】

```
Mplus VERSION 6.12

MUTHEN & MUTHEN
06/12/2012    4:45 PM

INPUT INSTRUCTIONS

  Title:
      Latent Class Analysis.
    Data: File = c:₩ex07.dat;
    Variable:
      names          = ID GENDER Y1-Y5;
      usevariables = Y1-Y3;
      categorical   = Y1-Y3;
      classes = c(2);
    Analysis:
      Type=mixture;
    Output:
      tech11 tech14;

  PLOT: TYPE = PLOT3;
  SERIES = Y1(1) Y2(2) Y3(3);



INPUT READING TERMINATED NORMALLY

Latent Class Analysis.

SUMMARY OF ANALYSIS

Number of groups                                 1
Number of observations                         670

Number of dependent variables                    3
Number of independent variables                  0
Number of continuous latent variables            0
Number of categorical latent variables           1

Observed dependent variables

  Binary and ordered categorical (ordinal)
   Y1          Y2          Y3

Categorical latent variables
    C

Estimator                                      MLR
Information matrix                        OBSERVED
Optimization Specifications for the Quasi-Newton Algorithm for
Continuous Outcomes
  Maximum number of iterations                 100
  Convergence criterion                0.100D-05
Optimization Specifications for the EM Algorithm
  Maximum number of iterations                 500
  Convergence criteria
    Loglikelihood change               0.100D-06
    Relative loglikelihood change      0.100D-06
    Derivative                         0.100D-05
Optimization Specifications for the M step of the EM Algorithm for
Categorical Latent variables
  Number of M step iterations                    1
  M step convergence criterion         0.100D-05
  Basis for M step termination           ITERATION
Optimization Specifications for the M step of the EM Algorithm for
Censored, Binary or Ordered Categorical (Ordinal), Unordered
Categorical (Nominal) and Count Outcomes
  Number of M step iterations                    1
  M step convergence criterion         0.100D-05
  Basis for M step termination           ITERATION
  Maximum value for logit thresholds            15
  Minimum value for logit thresholds           -15
  Minimum expected cell size for chi-square  0.100D-01
Optimization algorithm                         EMA
Random Starts Specifications
  Number of initial stage random starts         10
  Number of final stage optimizations            2
  Number of initial stage iterations            10
  Initial stage convergence criterion    0.100D+01
```

```
  Random starts scale                                    0.500D+01
  Random seed for generating random starts                       0
Link                                                        LOGIT

Input data file(s)
  c:₩ex07.dat
Input data format  FREE


UNIVARIATE PROPORTIONS AND COUNTS FOR CATEGORICAL VARIABLES

    Y1
      Category 1    0.261        175.000
      Category 2    0.739        495.000
    Y2
      Category 1    0.475        318.000
      Category 2    0.525        352.000
    Y3
      Category 1    0.455        305.000
      Category 2    0.545        365.000


RANDOM STARTS RESULTS RANKED FROM THE BEST TO THE WORST
LOGLIKELIHOOD VALUES

Final stage loglikelihood values at local maxima, seeds, and initial stage start
numbers:

          -1290.045  939021           8
          -1290.045  608496           4



THE MODEL ESTIMATION TERMINATED NORMALLY



MODEL FIT INFORMATION

Number of Free Parameters                        7

Loglikelihood

          H0 Value                       -1290.045
          H0 Scaling Correction Factor       1.000
            for MLR

Information Criteria

          Akaike (AIC)                    2594.091
          Bayesian (BIC)                  2625.642
          Sample-Size Adjusted BIC        2603.416
            (n* = (n + 2) / 24)

Chi-Square Test of Model Fit for the Binary and Ordered Categorical
(Ordinal) Outcomes

          Pearson Chi-Square

          Value                              0.000
          Degrees of Freedom                     0
          P-Value                           1.0000

          Likelihood Ratio Chi-Square

          Value                              0.000
          Degrees of Freedom                     0
          P-Value                           1.0000



FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASSES
BASED ON THE ESTIMATED MODEL

    Latent
    Classes

       1          513.75691          0.76680
       2          156.24309          0.23320


FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASS
PATTERNS
BASED ON ESTIMATED POSTERIOR PROBABILITIES

    Latent
```

Classes

1	513.75691	0.76680
2	156.24309	0.23320

CLASSIFICATION QUALITY

Entropy	0.531

CLASSIFICATION OF INDIVIDUALS BASED ON THEIR MOST LIKELY LATENT CLASS MEMBERSHIP

Class Counts and Proportions

Latent Classes		
1	562	0.83881
2	108	0.16119

Average Latent Class Probabilities for Most Likely Latent Class Membership (Row)
by Latent Class (Column)

	1	2
1	0.865	0.135
2	0.255	0.745

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Latent Class 1				
Thresholds				
Y1$1	-1.567	0.298	-5.252	0.000
Y2$1	-0.371	0.160	-2.315	0.021
Y3$1	-0.800	0.314	-2.550	0.011
Latent Class 2				
Thresholds				
Y1$1	0.210	0.521	0.403	0.687
Y2$1	0.813	0.420	1.935	0.053
Y3$1	2.633	3.255	0.809	0.419
Categorical Latent Variables				
Means				
C#1	1.190	0.717	1.660	0.097

RESULTS IN PROBABILITY SCALE

Latent Class 1				
Y1				
Category 1	0.173	0.043	4.052	0.000
Category 2	0.827	0.043	19.413	0.000
Y2				
Category 1	0.408	0.039	10.540	0.000
Category 2	0.592	0.039	15.276	0.000
Y3				
Category 1	0.310	0.067	4.617	0.000
Category 2	0.690	0.067	10.280	0.000
Latent Class 2				
Y1				
Category 1	0.552	0.129	4.287	0.000
Category 2	0.448	0.129	3.475	0.001
Y2				
Category 1	0.693	0.089	7.744	0.000
Category 2	0.307	0.089	3.434	0.001
Y3				
Category 1	0.933	0.204	4.584	0.000
Category 2	0.067	0.204	0.329	0.742

LATENT CLASS ODDS RATIO RESULTS

Latent Class 1 Compared to Latent Class 2

Y1				
Category > 1	5.910	3.036	1.947	0.052
Y2				
Category > 1	3.269	1.328	2.461	0.014
Y3				
Category > 1	30.993	98.036	0.316	0.752

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix (ratio of smallest to largest eigenvalue)	0.810E-03

TECHNICAL 11 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

VUONG-LO-MENDELL-RUBIN LIKELIHOOD RATIO TEST FOR 1 (H0) VERSUS 2 CLASSES

H0 Loglikelihood Value	-1310.046
2 Times the Loglikelihood Difference	40.002
Difference in the Number of Parameters	4
Mean	3.877
Standard Deviation	3.017
P-Value	0.0000

LO-MENDELL-RUBIN ADJUSTED LRT TEST

Value	38.522
P-Value	0.0000

TECHNICAL 14 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

Random Starts Specification for the k-1 Class Model for Generated Data

Number of initial stage random starts	0
Number of final stage optimizations for the initial stage random starts	0

Random Starts Specification for the k Class Model for Generated Data

Number of initial stage random starts	20
Number of final stage optimizations	5
Number of bootstrap draws requested	Varies

PARAMETRIC BOOTSTRAPPED LIKELIHOOD RATIO TEST FOR 1 (H0) VERSUS 2 CLASSES

H0 Loglikelihood Value	-1310.046
2 Times the Loglikelihood Difference	40.002
Difference in the Number of Parameters	4
Approximate P-Value	0.0000
Successful Bootstrap Draws	10

PLOT INFORMATION

The following plots are available:

- Histograms (sample values)
- Scatterplots (sample values)
- Sample proportions
- Estimated probabilities

Beginning Time:	16:45:00
Ending Time:	16:45:02
Elapsed Time:	00:00:02

MUTHEN & MUTHEN
3463 Stoner Ave.
Los Angeles, CA 90066

Tel: (310) 391-9971
Fax: (310) 391-8971
Web: www.StatModel.com
Support: Support@StatModel.com

【ex. 14-1】

```
Mplus VERSION 6.12
MUTHEN & MUTHEN
06/12/2012    4:47 PM

INPUT INSTRUCTIONS

  Title:
      Latent Class Analysis.
    Data: File = c:₩ex07.dat;
    Variable:
      names          = ID GENDER Y1-Y5;
      usevariables = Y1-Y3;
      categorical   = Y1-Y3;
      classes = c(3);
    Analysis:
      Type=mixture;
    Output:
      tech11 tech14;

  PLOT: TYPE = PLOT3;
  SERIES = Y1(1) Y2(2) Y3(3);



INPUT READING TERMINATED NORMALLY


Latent Class Analysis.

SUMMARY OF ANALYSIS

Number of groups                                 1
Number of observations                         670

Number of dependent variables                    3
Number of independent variables                  0
Number of continuous latent variables            0
Number of categorical latent variables           1
```

```
Observed dependent variables

  Binary and ordered categorical (ordinal)
   Y1            Y2            Y3

Categorical latent variables
   C


Estimator                                      MLR
Information matrix                        OBSERVED
Optimization Specifications for the Quasi-Newton Algorithm for
Continuous Outcomes
  Maximum number of iterations                 100
  Convergence criterion                0.100D-05
Optimization Specifications for the EM Algorithm
  Maximum number of iterations                 500
  Convergence criteria
    Loglikelihood change               0.100D-06
    Relative loglikelihood change      0.100D-06
    Derivative                         0.100D-05
Optimization Specifications for the M step of the EM Algorithm for
Categorical Latent variables
  Number of M step iterations                    1
  M step convergence criterion         0.100D-05
  Basis for M step termination           ITERATION
Optimization Specifications for the M step of the EM Algorithm for
Censored, Binary or Ordered Categorical (Ordinal), Unordered
Categorical (Nominal) and Count Outcomes
  Number of M step iterations                    1
  M step convergence criterion         0.100D-05
  Basis for M step termination           ITERATION
  Maximum value for logit thresholds            15
  Minimum value for logit thresholds           -15
  Minimum expected cell size for chi-square  0.100D-01
Optimization algorithm                         EMA
Random Starts Specifications
  Number of initial stage random starts         10
  Number of final stage optimizations            2
  Number of initial stage iterations            10
  Initial stage convergence criterion    0.100D+01
  Random starts scale                    0.500D+01
  Random seed for generating random starts       0
Link                                         LOGIT
```

```
Input data file(s)
  c:₩ex07.dat
Input data format  FREE


UNIVARIATE PROPORTIONS AND COUNTS FOR CATEGORICAL VARIABLES

    Y1
      Category 1    0.261       175.000
      Category 2    0.739       495.000
    Y2
      Category 1    0.475       318.000
      Category 2    0.525       352.000
    Y3
      Category 1    0.455       305.000
      Category 2    0.545       365.000


RANDOM STARTS RESULTS RANKED FROM THE BEST TO THE WORST
LOGLIKELIHOOD VALUES

Final stage loglikelihood values at local maxima, seeds, and initial stage start
numbers:

          -1290.045  903420           5
          -1290.045  unperturbed      0



    WARNING:  WHEN ESTIMATING A MODEL WITH MORE THAN TWO
CLASSES, IT MAY BE
    NECESSARY TO INCREASE THE NUMBER OF RANDOM STARTS USING
THE STARTS OPTION
    TO AVOID LOCAL MAXIMA.

    THE STANDARD ERRORS OF THE MODEL PARAMETER ESTIMATES MAY
NOT BE
    TRUSTWORTHY FOR SOME PARAMETERS DUE TO A NON-POSITIVE
DEFINITE
    FIRST-ORDER DERIVATIVE PRODUCT MATRIX.  THIS MAY BE DUE TO
THE STARTING
    VALUES BUT MAY ALSO BE AN INDICATION OF MODEL
NONIDENTIFICATION.  THE
    CONDITION NUMBER IS          -0.153D-16.  PROBLEM INVOLVING
PARAMETER 8.

    ONE OR MORE PARAMETERS WERE FIXED TO AVOID SINGULARITY OF
THE
    INFORMATION MATRIX. THE SINGULARITY IS MOST LIKELY BECAUSE
THE
    MODEL IS NOT IDENTIFIED, OR BECAUSE OF EMPTY CELLS IN THE
JOINT
    DISTRIBUTION OF THE CATEGORICAL VARIABLES IN THE MODEL.
    THE FOLLOWING PARAMETERS WERE FIXED:
    9 10 11


THE MODEL ESTIMATION TERMINATED NORMALLY

    THE DEGREES OF FREEDOM FOR THIS MODEL ARE NEGATIVE.  THE
MODEL IS NOT
    IDENTIFIED OR TOO MANY CELLS WERE DELETED.  A CHI-SQUARE
TEST IS NOT
    AVAILABLE.



MODEL FIT INFORMATION

Number of Free Parameters                       11

Loglikelihood

          H0 Value                       -1290.045
          H0 Scaling Correction Factor       0.637
            for MLR

Information Criteria

          Akaike (AIC)                    2602.091
          Bayesian (BIC)                  2651.671
          Sample-Size Adjusted BIC        2616.745
            (n* = (n + 2) / 24)



FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASSES
BASED ON THE ESTIMATED MODEL
```

Latent Classes		
1	123.22104	0.18391
2	422.98291	0.63132
3	123.79605	0.18477

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASS PATTERNS
BASED ON ESTIMATED POSTERIOR PROBABILITIES

Latent Classes		
1	123.22102	0.18391
2	422.98293	0.63132
3	123.79605	0.18477

CLASSIFICATION QUALITY

Entropy	0.476

CLASSIFICATION OF INDIVIDUALS BASED ON THEIR MOST LIKELY LATENT CLASS MEMBERSHIP

Class Counts and Proportions

Latent Classes		
1	67	0.10000
2	495	0.73881
3	108	0.16119

Average Latent Class Probabilities for Most Likely Latent Class Membership (Row)
by Latent Class (Column)

	1	2	3
1	0.736	0.051	0.213
2	0.112	0.801	0.087
3	0.172	0.213	0.615

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Latent Class 1				
Thresholds				
Y1$1	0.205	0.602	0.341	0.733
Y2$1	1.037	25.972	0.040	0.968
Y3$1	4.067	518.648	0.008	0.994
Latent Class 2				
Thresholds				
Y1$1	-2.710	228.658	-0.012	0.991
Y2$1	-0.366	1.178	-0.310	0.756
Y3$1	-0.775	11.549	-0.067	0.946
Latent Class 3				
Thresholds				
Y1$1	0.627	201.827	0.003	0.998
Y2$1	-0.264	24.297	-0.011	0.991
Y3$1	-0.373	0.000	999.000	999.000
Categorical Latent Variables				
Means				
C#1	-0.005	0.000	999.000	999.000
C#2	1.229	0.000	999.000	999.000

RESULTS IN PROBABILITY SCALE

Latent Class 1				
Y1				
Category 1	0.551	0.149	3.701	0.000
Category 2	0.449	0.149	3.014	0.003
Y2				

Category 1	0.738	5.018	0.147	0.883
Category 2	0.262	5.018	0.052	0.958
Y3				
Category 1	0.983	8.586	0.115	0.909
Category 2	0.017	8.586	0.002	0.998

Latent Class 2

Y1				
Category 1	0.062	13.370	0.005	0.996
Category 2	0.938	13.370	0.070	0.944
Y2				
Category 1	0.410	0.285	1.438	0.151
Category 2	0.590	0.285	2.072	0.038
Y3				
Category 1	0.315	2.493	0.126	0.899
Category 2	0.685	2.493	0.275	0.784

Latent Class 3

Y1				
Category 1	0.652	45.799	0.014	0.989
Category 2	0.348	45.799	0.008	0.994
Y2				
Category 1	0.434	5.969	0.073	0.942
Category 2	0.566	5.969	0.095	0.925
Y3				
Category 1	0.408	0.000	0.000	1.000
Category 2	0.592	0.000	0.000	1.000

LATENT CLASS ODDS RATIO RESULTS

Latent Class 1 Compared to Latent Class 2

Y1				
Category > 1	0.054	12.357	0.004	0.997
Y2				
Category > 1	0.246	6.099	0.040	0.968
Y3				
Category > 1	0.008	4.182	0.002	0.998

Latent Class 1 Compared to Latent Class 3

Y1				
Category > 1	1.525	308.556	0.005	0.996
Y2				
Category > 1	0.272	13.678	0.020	0.984
Y3				
Category > 1	0.012	6.116	0.002	0.998

Latent Class 2 Compared to Latent Class 3

Y1				
Category > 1	28.160	12122.657	0.002	0.998
Y2				
Category > 1	1.107	28.184	0.039	0.969
Y3				
Category > 1	1.495	17.266	0.087	0.931

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix (ratio of smallest to largest eigenvalue) 0.153E-09

TECHNICAL 1 OUTPUT

PARAMETER SPECIFICATION FOR LATENT CLASS 1

PARAMETER SPECIFICATION FOR LATENT CLASS 2

PARAMETER SPECIFICATION FOR LATENT CLASS 3

PARAMETER SPECIFICATION FOR LATENT CLASS INDICATOR MODEL PART

LAMBDA(U)

	C#1	C#2	C#3
Y1	1	2	3
Y2	4	5	6
Y3	7	8	9

PARAMETER SPECIFICATION FOR LATENT CLASS REGRESSION MODEL PART

ALPHA(C)

	C#1	C#2	C#3
1	10	11	0

STARTING VALUES FOR LATENT CLASS 1

STARTING VALUES FOR LATENT CLASS 2

STARTING VALUES FOR LATENT CLASS 3

STARTING VALUES FOR LATENT CLASS INDICATOR MODEL PART

LAMBDA(U)

	C#1	C#2	C#3
Y1	2.040	1.040	0.040
Y2	1.102	0.102	-0.898
Y3	1.180	0.180	-0.820

STARTING VALUES FOR LATENT CLASS REGRESSION MODEL PART

ALPHA(C)

	C#1	C#2	C#3
1	0.000	0.000	0.000

TECHNICAL 11 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model
- Number of initial stage random starts 10
- Number of final stage optimizations 2

VUONG-LO-MENDELL-RUBIN LIKELIHOOD RATIO TEST FOR 2 (H0) VERSUS 3 CLASSES

WARNING: THE LIKELIHOOD RATIO TEST COMPUTATION FOR TECH11 DID NOT
TERMINATE NORMALLY BECAUSE THE LOGLIKELIHOOD VALUE FOR THE MODEL WITH ONE
LESS CLASS IS LARGER THAN THE LOGLIKELIHOOD VALUE FOR THE ESTIMATED MODEL.
USING MORE RANDOM STARTS MAY RESOLVE THE PROBLEM.

H0 Loglikelihood Value	-1290.045
2 Times the Loglikelihood Difference	0.000
Difference in the Number of Parameters	4
Mean	0.371
Standard Deviation	0.523
P-Value	0.8802

LO-MENDELL-RUBIN ADJUSTED LRT TEST

Value	0.000
P-Value	0.8802

TECHNICAL 14 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model
- Number of initial stage random starts 10
- Number of final stage optimizations 2

Random Starts Specification for the k-1 Class Model for Generated Data
- Number of initial stage random starts 0
- Number of final stage optimizations for the initial stage random starts 0

Random Starts Specification for the k Class Model for Generated Data
- Number of initial stage random starts 20
- Number of final stage optimizations 5

Number of bootstrap draws requested Varies

PARAMETRIC BOOTSTRAPPED LIKELIHOOD RATIO TEST FOR 2 (H0) VERSUS 3 CLASSES

WARNING: THE LIKELIHOOD RATIO TEST COMPUTATION FOR TECH14 DID NOT
TERMINATE NORMALLY BECAUSE THE LOGLIKELIHOOD VALUE FOR THE MODEL WITH ONE
LESS CLASS IS LARGER THAN THE LOGLIKELIHOOD VALUE FOR THE ESTIMATED MODEL.
INCREASE THE NUMBER OF RANDOM STARTS USING THE LRTSTARTS OPTION.

H0 Loglikelihood Value	-1290.045
2 Times the Loglikelihood Difference	0.000
Difference in the Number of Parameters	4
Approximate P-Value	1.0000
Successful Bootstrap Draws	0

PLOT INFORMATION

The following plots are available:

Histograms (sample values)
Scatterplots (sample values)
Sample proportions
Estimated probabilities

Beginning Time: 16:47:00
Ending Time: 16:47:01
Elapsed Time: 00:00:01

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【ex. 15】

Mplus VERSION 6.12
MUTHEN & MUTHEN
06/13/2012 10:22 AM

INPUT INSTRUCTIONS

```
Title: Latent Class Analysis.
  Latent Class Analysis.
  Data: File = c:₩ex05.dat;
  Variable:
    names          = SCHID Y1-Y23;
    usevariables = Y1-Y2;
    classes = c(2);
  Analysis:
    Type=mixture;
  Output:
    tech11 tech14;

PLOT:
TYPE = PLOT3;
SERIES = Y1(1) Y2(2);
```

*** WARNING in MODEL command
All variables are uncorrelated with all other variables within class.
Check that this is what is intended.
1 WARNING(S) FOUND IN THE INPUT INSTRUCTIONS

Latent Class Analysis.
Latent Class Analysis.

SUMMARY OF ANALYSIS

Number of groups	1
Number of observations	641
Number of dependent variables	2

```
Number of independent variables                                 0
Number of continuous latent variables                           0
Number of categorical latent variables                          1

Observed dependent variables

  Continuous
   Y1          Y2

Categorical latent variables
    C


Estimator                                                     MLR
Information matrix                                       OBSERVED
Optimization Specifications for the Quasi-Newton Algorithm for
Continuous Outcomes
  Maximum number of iterations                                100
  Convergence criterion                                0.100D-05
Optimization Specifications for the EM Algorithm
  Maximum number of iterations                                500
  Convergence criteria
    Loglikelihood change                               0.100D-06
    Relative loglikelihood change                      0.100D-06
    Derivative                                         0.100D-05
Optimization Specifications for the M step of the EM Algorithm for
Categorical Latent variables
  Number of M step iterations                                   1
  M step convergence criterion                         0.100D-05
  Basis for M step termination                         ITERATION
Optimization Specifications for the M step of the EM Algorithm for
Censored, Binary or Ordered Categorical (Ordinal), Unordered
Categorical (Nominal) and Count Outcomes
  Number of M step iterations                                   1
  M step convergence criterion                         0.100D-05
  Basis for M step termination                         ITERATION
  Maximum value for logit thresholds                          15
  Minimum value for logit thresholds                         -15
  Minimum expected cell size for chi-square            0.100D-01
Optimization algorithm                                       EMA
Random Starts Specifications
  Number of initial stage random starts                       10
  Number of final stage optimizations                          2
  Number of initial stage iterations                          10
  Initial stage convergence criterion                0.100D+01
  Random starts scale                                0.500D+01
  Random seed for generating random starts                    0

Input data file(s)
  c:₩ex05.dat
Input data format  FREE


RANDOM STARTS RESULTS RANKED FROM THE BEST TO THE WORST
LOGLIKELIHOOD VALUES

Final stage loglikelihood values at local maxima, seeds, and initial stage start
numbers:

          -5557.408  903420           5
          -5557.408  253358           2



THE MODEL ESTIMATION TERMINATED NORMALLY



MODEL FIT INFORMATION

Number of Free Parameters                       7

Loglikelihood

          H0 Value                       -5557.408
          H0 Scaling Correction Factor       1.059
            for MLR

Information Criteria

          Akaike (AIC)                   11128.816
          Bayesian (BIC)                 11160.058
          Sample-Size Adjusted BIC       11137.833
            (n* = (n + 2) / 24)



FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASSES
BASED ON THE ESTIMATED MODEL
```

Latent Classes		
1	415.26155	0.64783
2	225.73845	0.35217

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASS PATTERNS
BASED ON ESTIMATED POSTERIOR PROBABILITIES

Latent Classes		
1	415.26159	0.64783
2	225.73841	0.35217

CLASSIFICATION QUALITY

Entropy	0.769

CLASSIFICATION OF INDIVIDUALS BASED ON THEIR MOST LIKELY LATENT CLASS MEMBERSHIP

Class Counts and Proportions

Latent Classes		
1	421	0.65679
2	220	0.34321

Average Latent Class Probabilities for Most Likely Latent Class Membership (Row)
by Latent Class (Column)

	1	2
1	0.943	0.057
2	0.082	0.918

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Latent Class 1				
Means				
Y1	51.249	0.960	53.392	0.000
Y2	34.751	0.862	40.320	0.000
Variances				
Y1	226.215	17.042	13.274	0.000
Y2	193.531	12.624	15.331	0.000
Latent Class 2				
Means				
Y1	70.649	0.998	70.787	0.000
Y2	73.710	1.646	44.794	0.000
Variances				
Y1	226.215	17.042	13.274	0.000
Y2	193.531	12.624	15.331	0.000
Categorical Latent Variables				
Means				
C#1	0.610	0.117	5.195	0.000

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix (ratio of smallest to largest eigenvalue)	0.203E-01

TECHNICAL 11 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model	
Number of initial stage random starts	10
Number of final stage optimizations	2

VUONG-LO-MENDELL-RUBIN LIKELIHOOD RATIO TEST FOR 1 (H0) VERSUS 2 CLASSES

H0 Loglikelihood Value	-5676.144
2 Times the Loglikelihood Difference	237.471
Difference in the Number of Parameters	3
Mean	4.925
Standard Deviation	5.090
P-Value	0.0000

LO-MENDELL-RUBIN ADJUSTED LRT TEST

Value	225.824
P-Value	0.0000

TECHNICAL 14 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

Random Starts Specification for the k-1 Class Model for Generated Data

Number of initial stage random starts	0
Number of final stage optimizations for the initial stage random starts	0

Random Starts Specification for the k Class Model for Generated Data

Number of initial stage random starts	20
Number of final stage optimizations	5
Number of bootstrap draws requested	Varies

PARAMETRIC BOOTSTRAPPED LIKELIHOOD RATIO TEST FOR 1 (H0) VERSUS 2 CLASSES

H0 Loglikelihood Value	-5676.144
2 Times the Loglikelihood Difference	237.471
Difference in the Number of Parameters	3
Approximate P-Value	0.0000
Successful Bootstrap Draws	5

PLOT INFORMATION

The following plots are available:

Histograms (sample values, estimated values)
Scatterplots (sample values, estimated values)
Sample means
Estimated means
Sample and estimated means
Observed individual values
Estimated individual values
Estimated means and observed individual values
Estimated means and estimated individual values
Mixture distributions

Beginning Time: 10:22:10
Ending Time: 10:22:11
Elapsed Time: 00:00:01

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【ex. 15-1】

```
Mplus VERSION 6.12
MUTHEN & MUTHEN
06/13/2012  10:23 AM

INPUT INSTRUCTIONS

  Title: Latent Class Analysis.
    Latent Class Analysis.
    Data: File = c:₩ex05.dat;
    Variable:
      names          = SCHID Y1-Y23;
      usevariables = Y1-Y2;
      classes = c(3);
    Analysis:
      Type=mixture;
    Output:
      tech11 tech14;

  PLOT:
  TYPE = PLOT3;
  SERIES = Y1(1) Y2(2);



*** WARNING in MODEL command
  All variables are uncorrelated with all other variables within class.
  Check that this is what is intended.
   1 WARNING(S) FOUND IN THE INPUT INSTRUCTIONS



Latent Class Analysis.
Latent Class Analysis.

SUMMARY OF ANALYSIS

Number of groups                                 1
Number of observations                         641

Number of dependent variables                    2
Number of independent variables                  0
Number of continuous latent variables            0
Number of categorical latent variables           1

Observed dependent variables

  Continuous
   Y1          Y2

Categorical latent variables
    C


Estimator                                      MLR
Information matrix                        OBSERVED
Optimization Specifications for the Quasi-Newton Algorithm for
Continuous Outcomes
  Maximum number of iterations                 100
  Convergence criterion                0.100D-05
Optimization Specifications for the EM Algorithm
  Maximum number of iterations                 500
  Convergence criteria
    Loglikelihood change               0.100D-06
    Relative loglikelihood change      0.100D-06
    Derivative                         0.100D-05
Optimization Specifications for the M step of the EM Algorithm for
Categorical Latent variables
  Number of M step iterations                    1
  M step convergence criterion         0.100D-05
  Basis for M step termination           ITERATION
Optimization Specifications for the M step of the EM Algorithm for
Censored, Binary or Ordered Categorical (Ordinal), Unordered
Categorical (Nominal) and Count Outcomes
  Number of M step iterations                    1
  M step convergence criterion         0.100D-05
  Basis for M step termination           ITERATION
  Maximum value for logit thresholds            15
  Minimum value for logit thresholds           -15
  Minimum expected cell size for chi-square    0.100D-01
Optimization algorithm                         EMA
Random Starts Specifications
  Number of initial stage random starts         10
  Number of final stage optimizations            2
  Number of initial stage iterations            10
  Initial stage convergence criterion  0.100D+01
```

```
  Random starts scale                                    0.500D+01
  Random seed for generating random starts                       0

Input data file(s)
  c:₩ex05.dat
Input data format  FREE


RANDOM STARTS RESULTS RANKED FROM THE BEST TO THE WORST
LOGLIKELIHOOD VALUES

Final stage loglikelihood values at local maxima, seeds, and initial stage start
numbers:

          -5529.195  462953           7
          -5529.195  unperturbed      0



     WARNING:  WHEN ESTIMATING A MODEL WITH MORE THAN TWO
CLASSES, IT MAY BE
     NECESSARY TO INCREASE THE NUMBER OF RANDOM STARTS USING
THE STARTS OPTION
     TO AVOID LOCAL MAXIMA.


THE MODEL ESTIMATION TERMINATED NORMALLY



MODEL FIT INFORMATION

Number of Free Parameters                       10

Loglikelihood

          H0 Value                          -5529.195
          H0 Scaling Correction Factor          1.283
            for MLR

Information Criteria

          Akaike (AIC)                     11078.390
          Bayesian (BIC)                   11123.021
          Sample-Size Adjusted BIC         11091.271
```

```
          (n* = (n + 2) / 24)


FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASSES
BASED ON THE ESTIMATED MODEL

    Latent
   Classes

       1          320.04615          0.49929
       2          122.29612          0.19079
       3          198.65773          0.30992


FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASS
PATTERNS
BASED ON ESTIMATED POSTERIOR PROBABILITIES

    Latent
   Classes

       1          320.04604          0.49929
       2          122.29605          0.19079
       3          198.65792          0.30992


CLASSIFICATION QUALITY

     Entropy                         0.690


CLASSIFICATION OF INDIVIDUALS BASED ON THEIR MOST LIKELY LATENT
CLASS MEMBERSHIP

Class Counts and Proportions

    Latent
   Classes

       1             333          0.51950
       2             112          0.17473
       3             196          0.30577
```

Average Latent Class Probabilities for Most Likely Latent Class Membership (Row)
by Latent Class (Column)

	1	2	3
1	0.845	0.089	0.065
2	0.177	0.822	0.000
3	0.095	0.002	0.902

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Latent Class 1				
Means				
Y1	58.541	1.524	38.413	0.000
Y2	38.748	1.288	30.084	0.000
Variances				
Y1	131.566	21.823	6.029	0.000
Y2	205.785	30.739	6.695	0.000
Latent Class 2				
Means				
Y1	33.437	2.561	13.055	0.000
Y2	30.277	2.616	11.572	0.000
Variances				
Y1	131.566	21.823	6.029	0.000
Y2	205.785	30.739	6.695	0.000
Latent Class 3				
Means				
Y1	72.511	1.447	50.112	0.000
Y2	75.336	1.914	39.365	0.000
Variances				
Y1	131.566	21.823	6.029	0.000
Y2	205.785	30.739	6.695	0.000

Categorical Latent Variables

Means				
C#1	0.477	0.135	3.543	0.000
C#2	-0.485	0.255	-1.903	0.057

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix (ratio of smallest to largest eigenvalue)	0.840E-02

TECHNICAL 11 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

VUONG-LO-MENDELL-RUBIN LIKELIHOOD RATIO TEST FOR 2 (H0) VERSUS 3 CLASSES

H0 Loglikelihood Value	-5557.408
2 Times the Loglikelihood Difference	56.426
Difference in the Number of Parameters	3
Mean	12.553
Standard Deviation	15.042
P-Value	0.0210

LO-MENDELL-RUBIN ADJUSTED LRT TEST

Value	53.659
P-Value	0.0247

TECHNICAL 14 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

Random Starts Specification for the k-1 Class Model for Generated Data

```
          Number of initial stage random starts                    0
          Number of final stage optimizations for the
             initial stage random starts                           0
       Random Starts Specification for the k Class Model for Generated Data
          Number of initial stage random starts                   20
          Number of final stage optimizations                      5
       Number of bootstrap draws requested                     Varies


     PARAMETRIC BOOTSTRAPPED LIKELIHOOD RATIO TEST FOR 2 (H0) VERSUS 3 CLASSES

          H0 Loglikelihood Value                          -5557.408
          2 Times the Loglikelihood Difference               56.426
          Difference in the Number of Parameters                  3
          Approximate P-Value                                0.0000
          Successful Bootstrap Draws                              5

     WARNING:  THE BEST LOGLIKELIHOOD VALUE WAS NOT REPLICATED IN 3 OUT OF 5
     BOOTSTRAP DRAWS.  THE P-VALUE MAY NOT BE TRUSTWORTHY DUE TO LOCAL
     MAXIMA.  INCREASE THE NUMBER OF RANDOM STARTS USING THE LRTSTARTS OPTION.



PLOT INFORMATION

The following plots are available:

  Histograms (sample values, estimated values)
  Scatterplots (sample values, estimated values)
  Sample means
  Estimated means
  Sample and estimated means
  Observed individual values
  Estimated individual values
  Estimated means and observed individual values
  Estimated means and estimated individual values
  Mixture distributions

     Beginning Time:  10:23:42
        Ending Time:  10:23:44
       Elapsed Time:  00:00:02
```

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【ex. 15-2】

```
Mplus VERSION 6.12
MUTHEN & MUTHEN
06/13/2012  10:24 AM

INPUT INSTRUCTIONS

  Title: Latent Class Analysis.
    Latent Class Analysis.
    Data: File = c:₩ex05.dat;
    Variable:
      names          = SCHID Y1-Y23;
      usevariables = Y1-Y2;
      classes = c(4);
    Analysis:
      Type=mixture;
    Output:
      tech11 tech14;

  PLOT:
  TYPE = PLOT3;
  SERIES = Y1(1) Y2(2);



*** WARNING in MODEL command
  All variables are uncorrelated with all other variables within class.
  Check that this is what is intended.
   1 WARNING(S) FOUND IN THE INPUT INSTRUCTIONS



Latent Class Analysis.
Latent Class Analysis.

SUMMARY OF ANALYSIS

Number of groups                                 1
Number of observations                         641

Number of dependent variables                    2
Number of independent variables                  0
Number of continuous latent variables            0
Number of categorical latent variables           1

Observed dependent variables

  Continuous
   Y1          Y2

Categorical latent variables
    C


Estimator                                      MLR
Information matrix                        OBSERVED
Optimization Specifications for the Quasi-Newton Algorithm for
Continuous Outcomes
  Maximum number of iterations                 100
  Convergence criterion                 0.100D-05
Optimization Specifications for the EM Algorithm
  Maximum number of iterations                 500
  Convergence criteria
    Loglikelihood change                0.100D-06
    Relative loglikelihood change       0.100D-06
    Derivative                          0.100D-05
Optimization Specifications for the M step of the EM Algorithm for
Categorical Latent variables
  Number of M step iterations                    1
  M step convergence criterion          0.100D-05
  Basis for M step termination           ITERATION
Optimization Specifications for the M step of the EM Algorithm for
Censored, Binary or Ordered Categorical (Ordinal), Unordered
Categorical (Nominal) and Count Outcomes
  Number of M step iterations                    1
  M step convergence criterion          0.100D-05
  Basis for M step termination           ITERATION
  Maximum value for logit thresholds            15
  Minimum value for logit thresholds           -15
  Minimum expected cell size for chi-square 0.100D-01
Optimization algorithm                         EMA
Random Starts Specifications
  Number of initial stage random starts         10
  Number of final stage optimizations            2
  Number of initial stage iterations            10
  Initial stage convergence criterion   0.100D+01
  Random starts scale                   0.500D+01
```

```
   Random seed for generating random starts                    0

Input data file(s)
  c:₩ex05.dat
Input data format  FREE


RANDOM STARTS RESULTS RANKED FROM THE BEST TO THE WORST
LOGLIKELIHOOD VALUES

Final stage loglikelihood values at local maxima, seeds, and initial stage start
numbers:

          -5510.471  939021          8
          -5520.756  127215          9



     WARNING:  WHEN ESTIMATING A MODEL WITH MORE THAN TWO
CLASSES, IT MAY BE
     NECESSARY TO INCREASE THE NUMBER OF RANDOM STARTS USING
THE STARTS OPTION
     TO AVOID LOCAL MAXIMA.


     WARNING:  THE BEST LOGLIKELIHOOD VALUE WAS NOT REPLICATED.
THE
     SOLUTION MAY NOT BE TRUSTWORTHY DUE TO LOCAL MAXIMA.
INCREASE THE
     NUMBER OF RANDOM STARTS.


THE MODEL ESTIMATION TERMINATED NORMALLY



MODEL FIT INFORMATION

Number of Free Parameters                       13

Loglikelihood

          H0 Value                          -5510.471
          H0 Scaling Correction Factor          1.147
            for MLR
```

```
Information Criteria

          Akaike (AIC)                       11046.942
          Bayesian (BIC)                     11104.961
          Sample-Size Adjusted BIC           11063.687
            (n* = (n + 2) / 24)



FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASSES
BASED ON THE ESTIMATED MODEL

    Latent
   Classes

       1        124.98950          0.19499
       2        315.12544          0.49162
       3        193.74945          0.30226
       4          7.13562          0.01113


FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASS
PATTERNS
BASED ON ESTIMATED POSTERIOR PROBABILITIES

    Latent
   Classes

       1        124.98951          0.19499
       2        315.12543          0.49162
       3        193.74945          0.30226
       4          7.13562          0.01113


CLASSIFICATION QUALITY

     Entropy                         0.774


CLASSIFICATION OF INDIVIDUALS BASED ON THEIR MOST LIKELY LATENT
CLASS MEMBERSHIP

Class Counts and Proportions
```

Latent Classes		
1	116	0.18097
2	327	0.51014
3	192	0.29953
4	6	0.00936

Average Latent Class Probabilities for Most Likely Latent Class Membership (Row)
by Latent Class (Column)

	1	2	3	4
1	0.842	0.158	0.000	0.001
2	0.083	0.858	0.056	0.002
3	0.000	0.083	0.912	0.005
4	0.009	0.028	0.049	0.914

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Latent Class 1				
Means				
Y1	33.966	2.370	14.330	0.000
Y2	28.708	1.538	18.665	0.000
Variances				
Y1	118.941	11.822	10.061	0.000
Y2	182.662	11.908	15.339	0.000
Latent Class 2				
Means				
Y1	58.972	1.498	39.377	0.000
Y2	38.863	1.280	30.357	0.000
Variances				
Y1	118.941	11.822	10.061	0.000
Y2	182.662	11.908	15.339	0.000
Latent Class 3				
Means				
Y1	73.271	1.003	73.068	0.000
Y2	75.520	1.691	44.658	0.000
Variances				
Y1	118.941	11.822	10.061	0.000
Y2	182.662	11.908	15.339	0.000
Latent Class 4				
Means				
Y1	28.694	14.066	2.040	0.041
Y2	84.529	5.448	15.517	0.000
Variances				
Y1	118.941	11.822	10.061	0.000
Y2	182.662	11.908	15.339	0.000
Categorical Latent Variables				
Means				
C#1	2.863	0.797	3.594	0.000
C#2	3.788	0.812	4.666	0.000
C#3	3.301	0.809	4.082	0.000

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix (ratio of smallest to largest eigenvalue) 0.950E-03

TECHNICAL 11 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

VUONG-LO-MENDELL-RUBIN LIKELIHOOD RATIO TEST FOR 3 (H0) VERSUS 4 CLASSES

H0 Loglikelihood Value	-5529.195
2 Times the Loglikelihood Difference	37.448
Difference in the Number of Parameters	3
Mean	1.760
Standard Deviation	17.806
P-Value	0.0323

LO-MENDELL-RUBIN ADJUSTED LRT TEST

Value	35.612
P-Value	0.0364

TECHNICAL 14 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

Random Starts Specification for the k-1 Class Model for Generated Data

Number of initial stage random starts	0
Number of final stage optimizations for the initial stage random starts	0

Random Starts Specification for the k Class Model for Generated Data

Number of initial stage random starts	20
Number of final stage optimizations	5
Number of bootstrap draws requested	Varies

PARAMETRIC BOOTSTRAPPED LIKELIHOOD RATIO TEST FOR 3 (H0) VERSUS 4 CLASSES

H0 Loglikelihood Value	-5529.195
2 Times the Loglikelihood Difference	37.448
Difference in the Number of Parameters	3
Approximate P-Value	0.0000
Successful Bootstrap Draws	10

PLOT INFORMATION

The following plots are available:

Histograms (sample values, estimated values)
Scatterplots (sample values, estimated values)
Sample means
Estimated means
Sample and estimated means
Observed individual values
Estimated individual values
Estimated means and observed individual values
Estimated means and estimated individual values
Mixture distributions

Beginning Time:	10:24:09
Ending Time:	10:24:13
Elapsed Time:	00:00:04

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【ex. 15-3】

```
Mplus VERSION 6.12
MUTHEN & MUTHEN
06/13/2012  10:24 AM

INPUT INSTRUCTIONS

  Title: Latent Class Analysis.
    Latent Class Analysis.
    Data: File = c:₩ex05.dat;
    Variable:
      names          = SCHID Y1-Y23;
      usevariables = Y1-Y2;
      classes = c(5);
    Analysis:
      Type=mixture;
    Output:
      tech11 tech14;

  PLOT:
  TYPE = PLOT3;
  SERIES = Y1(1) Y2(2);


*** WARNING in MODEL command
  All variables are uncorrelated with all other variables within class.
  Check that this is what is intended.
   1 WARNING(S) FOUND IN THE INPUT INSTRUCTIONS


Latent Class Analysis.
Latent Class Analysis.

SUMMARY OF ANALYSIS

Number of groups                                 1
Number of observations                         641

Number of dependent variables                    2
Number of independent variables                  0
Number of continuous latent variables            0
Number of categorical latent variables           1
```

```
Observed dependent variables

  Continuous
   Y1          Y2

Categorical latent variables
    C


Estimator                                      MLR
Information matrix                        OBSERVED
Optimization Specifications for the Quasi-Newton Algorithm for
Continuous Outcomes
  Maximum number of iterations                 100
  Convergence criterion                 0.100D-05
Optimization Specifications for the EM Algorithm
  Maximum number of iterations                 500
  Convergence criteria
    Loglikelihood change                0.100D-06
    Relative loglikelihood change       0.100D-06
    Derivative                          0.100D-05
Optimization Specifications for the M step of the EM Algorithm for
Categorical Latent variables
  Number of M step iterations                    1
  M step convergence criterion          0.100D-05
  Basis for M step termination           ITERATION
Optimization Specifications for the M step of the EM Algorithm for
Censored, Binary or Ordered Categorical (Ordinal), Unordered
Categorical (Nominal) and Count Outcomes
  Number of M step iterations                    1
  M step convergence criterion          0.100D-05
  Basis for M step termination           ITERATION
  Maximum value for logit thresholds            15
  Minimum value for logit thresholds           -15
  Minimum expected cell size for chi-square     0.100D-01
Optimization algorithm                         EMA
Random Starts Specifications
  Number of initial stage random starts         10
  Number of final stage optimizations            2
  Number of initial stage iterations            10
  Initial stage convergence criterion     0.100D+01
  Random starts scale                     0.500D+01
  Random seed for generating random starts        0

Input data file(s)
```

c:₩ex05.dat
Input data format FREE

RANDOM STARTS RESULTS RANKED FROM THE BEST TO THE WORST LOGLIKELIHOOD VALUES

Final stage loglikelihood values at local maxima, seeds, and initial stage start numbers:

-5502.684	253358	2
-5520.234	unperturbed	0

WARNING: WHEN ESTIMATING A MODEL WITH MORE THAN TWO CLASSES, IT MAY BE
NECESSARY TO INCREASE THE NUMBER OF RANDOM STARTS USING THE STARTS OPTION
TO AVOID LOCAL MAXIMA.

WARNING: THE BEST LOGLIKELIHOOD VALUE WAS NOT REPLICATED. THE
SOLUTION MAY NOT BE TRUSTWORTHY DUE TO LOCAL MAXIMA. INCREASE THE
NUMBER OF RANDOM STARTS.

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 16

Loglikelihood

H0 Value	-5502.684
H0 Scaling Correction Factor for MLR	1.335

Information Criteria

Akaike (AIC)	11037.368
Bayesian (BIC)	11108.777
Sample-Size Adjusted BIC (n* = (n + 2) / 24)	11057.978

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASSES BASED ON THE ESTIMATED MODEL

Latent Classes		
1	11.08345	0.01729
2	41.55567	0.06483
3	222.43403	0.34701
4	181.35463	0.28292
5	184.57222	0.28794

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASS PATTERNS
BASED ON ESTIMATED POSTERIOR PROBABILITIES

Latent Classes		
1	11.08345	0.01729
2	41.55571	0.06483
3	222.43406	0.34701
4	181.35457	0.28292
5	184.57221	0.28794

CLASSIFICATION QUALITY

Entropy 0.736

CLASSIFICATION OF INDIVIDUALS BASED ON THEIR MOST LIKELY LATENT CLASS MEMBERSHIP

Class Counts and Proportions

Latent Classes		

1	10	0.01560
2	36	0.05616
3	219	0.34165
4	188	0.29329
5	188	0.29329

Average Latent Class Probabilities for Most Likely Latent Class Membership (Row)
by Latent Class (Column)

	1	2	3	4	5
1	0.853	0.001	0.016	0.037	0.094
2	0.001	0.821	0.000	0.178	0.000
3	0.000	0.000	0.801	0.135	0.064
4	0.010	0.064	0.153	0.769	0.004
5	0.003	0.000	0.096	0.002	0.898

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Latent Class 1				
Means				
Y1	34.641	13.967	2.480	0.013
Y2	82.853	9.772	8.479	0.000
Variances				
Y1	85.198	11.076	7.692	0.000
Y2	187.938	15.495	12.129	0.000
Latent Class 2				
Means				
Y1	23.090	4.305	5.363	0.000
Y2	25.455	1.997	12.743	0.000
Variances				
Y1	85.198	11.076	7.692	0.000
Y2	187.938	15.495	12.129	0.000
Latent Class 3				
Means				
Y1	63.661	1.897	33.560	0.000
Y2	39.903	1.782	22.391	0.000
Variances				
Y1	85.198	11.076	7.692	0.000
Y2	187.938	15.495	12.129	0.000
Latent Class 4				
Means				
Y1	44.370	3.105	14.289	0.000
Y2	34.337	2.508	13.692	0.000
Variances				
Y1	85.198	11.076	7.692	0.000
Y2	187.938	15.495	12.129	0.000
Latent Class 5				
Means				
Y1	74.114	1.024	72.368	0.000
Y2	75.802	1.767	42.903	0.000
Variances				
Y1	85.198	11.076	7.692	0.000
Y2	187.938	15.495	12.129	0.000
Categorical Latent Variables				
Means				
C#1	-2.813	1.013	-2.776	0.006
C#2	-1.491	0.464	-3.213	0.001
C#3	0.187	0.197	0.947	0.344
C#4	-0.018	0.206	-0.086	0.932

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix (ratio of smallest to largest eigenvalue)	0.167E-02

TECHNICAL 11 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

VUONG-LO-MENDELL-RUBIN LIKELIHOOD RATIO TEST FOR 4 (H0) VERSUS 5 CLASSES

H0 Loglikelihood Value	-5520.756
2 Times the Loglikelihood Difference	36.143
Difference in the Number of Parameters	3
Mean	34.974
Standard Deviation	57.716
P-Value	0.3170

LO-MENDELL-RUBIN ADJUSTED LRT TEST

Value	34.370
P-Value	0.3281

TECHNICAL 14 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

Random Starts Specification for the k-1 Class Model for Generated Data

Number of initial stage random starts	0
Number of final stage optimizations for the initial stage random starts	0

Random Starts Specification for the k Class Model for Generated Data

Number of initial stage random starts	20
Number of final stage optimizations	5
Number of bootstrap draws requested	Varies

PARAMETRIC BOOTSTRAPPED LIKELIHOOD RATIO TEST FOR 4 (H0) VERSUS 5 CLASSES

H0 Loglikelihood Value	-5520.756
2 Times the Loglikelihood Difference	36.143
Difference in the Number of Parameters	3
Approximate P-Value	0.0000
Successful Bootstrap Draws	10

WARNING: THE BEST LOGLIKELIHOOD VALUE WAS NOT REPLICATED IN 8 OUT OF 10
BOOTSTRAP DRAWS. THE P-VALUE MAY NOT BE TRUSTWORTHY DUE TO LOCAL
MAXIMA. INCREASE THE NUMBER OF RANDOM STARTS USING THE LRTSTARTS OPTION.

PLOT INFORMATION

The following plots are available:

- Histograms (sample values, estimated values)
- Scatterplots (sample values, estimated values)
- Sample means
- Estimated means
- Sample and estimated means
- Observed individual values
- Estimated individual values
- Estimated means and observed individual values
- Estimated means and estimated individual values
- Mixture distributions

Beginning Time:	10:24:54
Ending Time:	10:24:58
Elapsed Time:	00:00:04

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【ex. 16】

```
Mplus VERSION 6.12
MUTHEN & MUTHEN
06/13/2012  10:40 오전 10:28 2012-08-30M

INPUT INSTRUCTIONS

  Title: Latent Class Analysis.
    Latent Class Analysis.
    Data: File = c:₩ex05.dat;
    Variable:
      names          = SCHID Y1-Y23;
      usevariables = Y1-Y2 Y6-Y7;
      classes = c(3);
    Analysis:
      Type=mixture;
  MODEL:
     %OVERALL%
     C ON Y6 Y7;
    Output:
      tech11 tech14;

  PLOT:
  TYPE = PLOT3;
  SERIES = Y1(1) Y2(2);



*** WARNING in MODEL command
  Variable is uncorrelated with all other variables within class:  Y1
*** WARNING in MODEL command
  Variable is uncorrelated with all other variables within class:  Y2
*** WARNING in MODEL command
  At least one variable is uncorrelated with all other variables within class.
  Check that this is what is intended.
   3 WARNING(S) FOUND IN THE INPUT INSTRUCTIONS
```

```
Latent Class Analysis.
Latent Class Analysis.

SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                         641

Number of dependent variables                                    2
Number of independent variables                                  2
Number of continuous latent variables                            0
Number of categorical latent variables                           1

Observed dependent variables

  Continuous
   Y1          Y2

Observed independent variables
   Y6          Y7

Categorical latent variables
   C


Estimator                                                      MLR
Information matrix                                        OBSERVED
Optimization Specifications for the Quasi-Newton Algorithm for
Continuous Outcomes
  Maximum number of iterations                                 100
  Convergence criterion                                0.100D-05
Optimization Specifications for the EM Algorithm
  Maximum number of iterations                                 500
  Convergence criteria
    Loglikelihood change                               0.100D-06
    Relative loglikelihood change                      0.100D-06
    Derivative                                         0.100D-05
Optimization Specifications for the M step of the EM Algorithm for
Categorical Latent variables
  Number of M step iterations                                    1
  M step convergence criterion                         0.100D-05
  Basis for M step termination                         ITERATION
Optimization Specifications for the M step of the EM Algorithm for
Censored, Binary or Ordered Categorical (Ordinal), Unordered
```

```
Categorical (Nominal) and Count Outcomes
  Number of M step iterations                          1
  M step convergence criterion                  0.100D-05
  Basis for M step termination                  ITERATION
  Maximum value for logit thresholds                  15
  Minimum value for logit thresholds                 -15
  Minimum expected cell size for chi-square     0.100D-01
Optimization algorithm                               EMA
Random Starts Specifications
  Number of initial stage random starts              10
  Number of final stage optimizations                 2
  Number of initial stage iterations                 10
  Initial stage convergence criterion           0.100D+01
  Random starts scale                           0.500D+01
  Random seed for generating random starts              0

Input data file(s)
  c:₩ex05.dat
Input data format  FREE


RANDOM STARTS RESULTS RANKED FROM THE BEST TO THE WORST
LOGLIKELIHOOD VALUES

Final stage loglikelihood values at local maxima, seeds, and initial stage start
numbers:

          -5513.230  unperturbed      0
          -5544.410  939021           8



     WARNING:  WHEN ESTIMATING A MODEL WITH MORE THAN TWO
CLASSES, IT MAY BE
     NECESSARY TO INCREASE THE NUMBER OF RANDOM STARTS USING
THE STARTS OPTION
     TO AVOID LOCAL MAXIMA.


     WARNING:  THE BEST LOGLIKELIHOOD VALUE WAS NOT REPLICATED.
THE
     SOLUTION MAY NOT BE TRUSTWORTHY DUE TO LOCAL MAXIMA.
INCREASE THE
     NUMBER OF RANDOM STARTS.
```

```
THE MODEL ESTIMATION TERMINATED NORMALLY



MODEL FIT INFORMATION

Number of Free Parameters                       14

Loglikelihood

          H0 Value                          -5513.230
          H0 Scaling Correction Factor          1.191
            for MLR

Information Criteria

          Akaike (AIC)                      11054.460
          Bayesian (BIC)                    11116.942
          Sample-Size Adjusted BIC          11072.493
            (n* = (n + 2) / 24)



FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASSES
BASED ON THE ESTIMATED MODEL

    Latent
   Classes

       1        128.60889          0.20064
       2        320.14235          0.49944
       3        192.24876          0.29992


FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASS
PATTERNS
BASED ON ESTIMATED POSTERIOR PROBABILITIES

    Latent
   Classes

       1        128.60890          0.20064
       2        320.14235          0.49944
       3        192.24875          0.29992
```

CLASSIFICATION QUALITY

Entropy	0.695

CLASSIFICATION OF INDIVIDUALS BASED ON THEIR MOST LIKELY LATENT CLASS MEMBERSHIP

Class Counts and Proportions

Latent Classes		
1	120	0.18721
2	332	0.51794
3	189	0.29485

Average Latent Class Probabilities for Most Likely Latent Class Membership (Row)
by Latent Class (Column)

	1	2	3
1	0.818	0.181	0.001
2	0.090	0.849	0.061
3	0.003	0.087	0.910

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Latent Class 1				
Means				
Y1	34.114	2.715	12.566	0.000
Y2	30.571	2.306	13.259	0.000
Variances				
Y1	135.623	17.851	7.597	0.000
Y2	201.353	23.220	8.671	0.000
Latent Class 2				
Means				
Y1	59.172	1.577	37.515	0.000
Y2	39.041	1.413	27.629	0.000
Variances				
Y1	135.623	17.851	7.597	0.000
Y2	201.353	23.220	8.671	0.000
Latent Class 3				
Means				
Y1	72.297	1.266	57.121	0.000
Y2	76.150	1.735	43.882	0.000
Variances				
Y1	135.623	17.851	7.597	0.000
Y2	201.353	23.220	8.671	0.000
Categorical Latent Variables				
C#1 ON				
Y6	0.486	0.353	1.377	0.168
Y7	-0.010	0.009	-1.132	0.258
C#2 ON				
Y6	1.067	0.267	3.990	0.000
Y7	-0.027	0.007	-3.719	0.000
Intercepts				
C#1	-0.089	0.511	-0.175	0.861
C#2	1.343	0.364	3.684	0.000

LOGISTIC REGRESSION ODDS RATIO RESULTS

Categorical Latent Variables

C#1 ON	
Y6	1.625
Y7	0.990
C#2 ON	

Y6	2.907			
Y7	0.973			

ALTERNATIVE PARAMETERIZATIONS FOR THE CATEGORICAL LATENT VARIABLE REGRESSION

Parameterization using Reference Class 1

C#2 ON				
Y6	0.581	0.346	1.679	0.093
Y7	-0.017	0.010	-1.771	0.077
C#3 ON				
Y6	-0.486	0.353	-1.377	0.168
Y7	0.010	0.009	1.132	0.258
Intercepts				
C#2	1.432	0.532	2.691	0.007
C#3	0.089	0.511	0.175	0.861

Parameterization using Reference Class 2

C#1 ON				
Y6	-0.581	0.346	-1.679	0.093
Y7	0.017	0.010	1.771	0.077
C#3 ON				
Y6	-1.067	0.267	-3.990	0.000
Y7	0.027	0.007	3.719	0.000
Intercepts				
C#1	-1.432	0.532	-2.691	0.007
C#3	-1.343	0.364	-3.684	0.000

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix (ratio of smallest to largest eigenvalue)	0.177E-04

TECHNICAL 11 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

VUONG-LO-MENDELL-RUBIN LIKELIHOOD RATIO TEST FOR 2 (H0) VERSUS 3 CLASSES

H0 Loglikelihood Value	-5544.410
2 Times the Loglikelihood Difference	62.361
Difference in the Number of Parameters	5
Mean	13.259
Standard Deviation	12.907
P-Value	0.0076

LO-MENDELL-RUBIN ADJUSTED LRT TEST

Value	60.489
P-Value	0.0088

TECHNICAL 14 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

Random Starts Specification for the k-1 Class Model for Generated Data

Number of initial stage random starts	0
Number of final stage optimizations for the initial stage random starts	0

Random Starts Specification for the k Class Model for Generated Data

Number of initial stage random starts	20
Number of final stage optimizations	5
Number of bootstrap draws requested	Varies

PARAMETRIC BOOTSTRAPPED LIKELIHOOD RATIO TEST FOR 2 (H0) VERSUS 3 CLASSES

H0 Loglikelihood Value	-5544.410
2 Times the Loglikelihood Difference	62.361
Difference in the Number of Parameters	5
Approximate P-Value	0.0000
Successful Bootstrap Draws	5

```
     WARNING:  THE BEST LOGLIKELIHOOD VALUE WAS NOT REPLICATED IN
5 OUT OF 5
     BOOTSTRAP DRAWS.  THE P-VALUE MAY NOT BE TRUSTWORTHY DUE
TO LOCAL
     MAXIMA.  INCREASE THE NUMBER OF RANDOM STARTS USING THE
LRTSTARTS OPTION.


PLOT INFORMATION

The following plots are available:

  Histograms (sample values, estimated values)
  Scatterplots (sample values, estimated values)
  Sample means
  Estimated means
  Sample and estimated means
  Adjusted estimated means
  Observed individual values
  Estimated individual values
  Estimated means and observed individual values
  Estimated means and estimated individual values
  Adjusted estimated means and observed individual values
  Adjusted estimated means and estimated individual values
  Mixture distributions
  Estimated probabilities for a categorical latent variable as a
    function of its covariates

     Beginning Time:  10:40:37
        Ending Time:  10:40:40
       Elapsed Time:  00:00:03


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```

【ex. 17】

```
Mplus VERSION 6.12
MUTHEN & MUTHEN
06/13/2012  10:55 AM

INPUT INSTRUCTIONS

  TITLE: LATENT CALSS ANALYSIS;
  DATA: FILE = c:₩ex01.dat;
  VARIABLE:
     NAMES = SID SCHID GENDER Y1-Y8;
     USEVARIABLES = Y1-Y8;
     CLASSES = C(2);
  ANALYSIS:
  TYPE = MIXTURE;
  MODEL:
  %OVERALL%
  F1 BY Y1-Y4;
  F2 BY Y5-Y8;
  F2 ON F1;
  %C#1%
  [F1 F2];
  F2 ON F1;
  %C#2%
  [F1 F2];
  F2 ON F1;

  OUTPUT: TECH11 TECH14;


INPUT READING TERMINATED NORMALLY



LATENT CALSS ANALYSIS;

SUMMARY OF ANALYSIS
```

```
Number of groups                                                 1
Number of observations                                         500

Number of dependent variables                                    8
Number of independent variables                                  0
Number of continuous latent variables                            2
Number of categorical latent variables                           1

Observed dependent variables

  Continuous
   Y1          Y2          Y3          Y4          Y5          Y6
   Y7          Y8

Continuous latent variables
   F1          F2

Categorical latent variables
   C


Estimator                                                      MLR
Information matrix                                        OBSERVED
Optimization Specifications for the Quasi-Newton Algorithm for
Continuous Outcomes
  Maximum number of iterations                                 100
  Convergence criterion                                0.100D-05
Optimization Specifications for the EM Algorithm
  Maximum number of iterations                                 500
  Convergence criteria
    Loglikelihood change                               0.100D-06
    Relative loglikelihood change                      0.100D-06
    Derivative                                         0.100D-05
Optimization Specifications for the M step of the EM Algorithm for
Categorical Latent variables
  Number of M step iterations                                    1
  M step convergence criterion                         0.100D-05
  Basis for M step termination                         ITERATION
Optimization Specifications for the M step of the EM Algorithm for
Censored, Binary or Ordered Categorical (Ordinal), Unordered
Categorical (Nominal) and Count Outcomes
  Number of M step iterations                                    1
  M step convergence criterion                         0.100D-05
  Basis for M step termination                         ITERATION
  Maximum value for logit thresholds                          15
  Minimum value for logit thresholds                         -15
  Minimum expected cell size for chi-square            0.100D-01
Optimization algorithm                                       EMA
Random Starts Specifications
  Number of initial stage random starts                       10
  Number of final stage optimizations                          2
  Number of initial stage iterations                          10
  Initial stage convergence criterion                0.100D+01
  Random starts scale                                0.500D+01
  Random seed for generating random starts                     0

Input data file(s)
  c:₩ex01.dat
Input data format  FREE


RANDOM STARTS RESULTS RANKED FROM THE BEST TO THE WORST
LOGLIKELIHOOD VALUES

3 perturbed starting value run(s) did not converge in the initial stage
optimizations.

Final stage loglikelihood values at local maxima, seeds, and initial stage start
numbers:

          -4710.097  415931          10
          -4732.846  939021          8



     WARNING:  THE BEST LOGLIKELIHOOD VALUE WAS NOT REPLICATED.
THE
     SOLUTION MAY NOT BE TRUSTWORTHY DUE TO LOCAL MAXIMA.
INCREASE THE
     NUMBER OF RANDOM STARTS.

     ONE OR MORE PARAMETERS WERE FIXED TO AVOID SINGULARITY OF
THE
     INFORMATION MATRIX. THE SINGULARITY IS MOST LIKELY BECAUSE
THE
     MODEL IS NOT IDENTIFIED, OR BECAUSE OF EMPTY CELLS IN THE
JOINT
     DISTRIBUTION OF THE CATEGORICAL VARIABLES IN THE MODEL.
     THE FOLLOWING PARAMETERS WERE FIXED:
     28 29
```

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 31

Loglikelihood

H0 Value	-4710.097
H0 Scaling Correction Factor for MLR	1.655

Information Criteria

Akaike (AIC)	9482.195
Bayesian (BIC)	9612.848
Sample-Size Adjusted BIC (n* = (n + 2) / 24)	9514.452

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASSES BASED ON THE ESTIMATED MODEL

Latent Classes		
1	217.77304	0.43555
2	282.22696	0.56445

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASS PATTERNS
BASED ON ESTIMATED POSTERIOR PROBABILITIES

Latent Classes		
1	217.77306	0.43555
2	282.22694	0.56445

CLASSIFICATION QUALITY

Entropy 0.217

CLASSIFICATION OF INDIVIDUALS BASED ON THEIR MOST LIKELY LATENT CLASS MEMBERSHIP

Class Counts and Proportions

Latent Classes		
1	204	0.40800
2	296	0.59200

Average Latent Class Probabilities for Most Likely Latent Class Membership (Row)
by Latent Class (Column)

	1	2
1	0.657	0.343
2	0.283	0.717

MODEL RESULTS

		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Latent Class 1					
F1	BY				
Y1		1.000	0.000	999.000	999.000
Y2		1.041	0.077	13.603	0.000
Y3		1.245	0.103	12.115	0.000
Y4		1.052	0.077	13.613	0.000
F2	BY				
Y5		1.000	0.000	999.000	999.000
Y6		0.948	0.060	15.878	0.000
Y7		0.936	0.071	13.194	0.000

Y8	0.830	0.078	10.634	0.000
F2 ON				
F1	1.014	0.168	6.048	0.000
Means				
F1	0.115	0.159	0.728	0.467
Intercepts				
Y1	3.014	0.109	27.532	0.000
Y2	3.251	0.116	28.008	0.000
Y3	3.107	0.135	22.972	0.000
Y4	3.159	0.116	27.227	0.000
Y5	3.573	0.070	50.817	0.000
Y6	3.502	0.070	50.099	0.000
Y7	3.400	0.067	50.485	0.000
Y8	3.655	0.059	62.148	0.000
F2	-0.109	0.122	-0.891	0.373
Variances				
F1	0.503	0.071	7.069	0.000
Residual Variances				
Y1	0.507	0.058	8.712	0.000
Y2	0.491	0.064	7.732	0.000
Y3	0.315	0.066	4.795	0.000
Y4	0.419	0.044	9.532	0.000
Y5	0.302	0.040	7.507	0.000
Y6	0.366	0.085	4.297	0.000
Y7	0.351	0.078	4.485	0.000
Y8	0.490	0.063	7.815	0.000
F2	0.245	0.038	6.524	0.000
Latent Class 2				
F1 BY				
Y1	1.000	0.000	999.000	999.000
Y2	1.041	0.077	13.603	0.000
Y3	1.245	0.103	12.115	0.000
Y4	1.052	0.077	13.613	0.000
F2 BY				
Y5	1.000	0.000	999.000	999.000
Y6	0.948	0.060	15.878	0.000
Y7	0.936	0.071	13.194	0.000

Y8	0.830	0.078	10.634	0.000
F2 ON				
F1	-0.075	0.151	-0.501	0.616
Means				
F1	-0.178	0.000	999.000	999.000
Intercepts				
Y1	3.014	0.109	27.532	0.000
Y2	3.251	0.116	28.008	0.000
Y3	3.107	0.135	22.972	0.000
Y4	3.159	0.116	27.227	0.000
Y5	3.573	0.070	50.817	0.000
Y6	3.502	0.070	50.099	0.000
Y7	3.400	0.067	50.485	0.000
Y8	3.655	0.059	62.148	0.000
F2	0.233	0.000	999.000	999.000
Variances				
F1	0.503	0.071	7.069	0.000
Residual Variances				
Y1	0.507	0.058	8.712	0.000
Y2	0.491	0.064	7.732	0.000
Y3	0.315	0.066	4.795	0.000
Y4	0.419	0.044	9.532	0.000
Y5	0.302	0.040	7.507	0.000
Y6	0.366	0.085	4.297	0.000
Y7	0.351	0.078	4.485	0.000
Y8	0.490	0.063	7.815	0.000
F2	0.245	0.038	6.524	0.000
Categorical Latent Variables				
Means				
C#1	-0.259	0.555	-0.467	0.641

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix (ratio of smallest to largest eigenvalue) 0.511E-04

TECHNICAL 11 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

VUONG-LO-MENDELL-RUBIN LIKELIHOOD RATIO TEST FOR 1 (H0) VERSUS 2 CLASSES

H0 Loglikelihood Value	-4732.846
2 Times the Loglikelihood Difference	45.496
Difference in the Number of Parameters	4
Mean	23.689
Standard Deviation	22.402
P-Value	0.1400

LO-MENDELL-RUBIN ADJUSTED LRT TEST

Value	43.737
P-Value	0.1530

TECHNICAL 14 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

Random Starts Specification for the k-1 Class Model for Generated Data

Number of initial stage random starts	0
Number of final stage optimizations for the initial stage random starts	0

Random Starts Specification for the k Class Model for Generated Data

Number of initial stage random starts	20
Number of final stage optimizations	5
Number of bootstrap draws requested	Varies

PARAMETRIC BOOTSTRAPPED LIKELIHOOD RATIO TEST FOR 1 (H0) VERSUS 2 CLASSES

H0 Loglikelihood Value	-4732.846
2 Times the Loglikelihood Difference	45.496
Difference in the Number of Parameters	4
Approximate P-Value	0.0000
Successful Bootstrap Draws	10

WARNING: THE BEST LOGLIKELIHOOD VALUE WAS NOT REPLICATED IN 9 OUT OF 10
BOOTSTRAP DRAWS. THE P-VALUE MAY NOT BE TRUSTWORTHY DUE TO LOCAL
MAXIMA. INCREASE THE NUMBER OF RANDOM STARTS USING THE LRTSTARTS OPTION.

Beginning Time:	10:55:15
Ending Time:	10:55:26
Elapsed Time:	00:00:11

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【ex. 17-1】

```
Mplus VERSION 6.12
MUTHEN & MUTHEN
06/13/2012  10:57 AM

INPUT INSTRUCTIONS

  TITLE: LATENT CALSS ANALYSIS;
  DATA: FILE = c:₩ex01.dat;
  VARIABLE:
     NAMES = SID SCHID GENDER Y1-Y8;
     USEVARIABLES = GENDER Y1-Y8;
     CLASSES = C(2);
  ANALYSIS:
  TYPE = MIXTURE;
  ALGORITHM=INTEGRATION;
  MODEL:
  %OVERALL%
  F1 BY Y1-Y4;
  F2 BY Y5-Y8;
  F2 ON F1;
  C ON GENDER;
  %C#1%
  [F1 F2];
  F2 ON F1;
  %C#2%
  [F1 F2];
  F2 ON F1;



  OUTPUT: TECH11 TECH14;



INPUT READING TERMINATED NORMALLY
```

```
LATENT CALSS ANALYSIS;

SUMMARY OF ANALYSIS

Number of groups                                 1
Number of observations                         500

Number of dependent variables                    8
Number of independent variables                  1
Number of continuous latent variables            2
Number of categorical latent variables           1

Observed dependent variables

  Continuous
   Y1          Y2          Y3          Y4          Y5          Y6
   Y7          Y8

Observed independent variables
   GENDER

Continuous latent variables
   F1          F2

Categorical latent variables
   C


Estimator                                      MLR
Information matrix                        OBSERVED
Optimization Specifications for the Quasi-Newton Algorithm for
Continuous Outcomes
  Maximum number of iterations                 100
  Convergence criterion                 0.100D-05
Optimization Specifications for the EM Algorithm
  Maximum number of iterations                 500
  Convergence criteria
    Loglikelihood change                0.100D-02
    Relative loglikelihood change       0.100D-05
    Derivative                          0.100D-02
Optimization Specifications for the M step of the EM Algorithm for
Categorical Latent variables
  Number of M step iterations                    1
  M step convergence criterion          0.100D-02
  Basis for M step termination           ITERATION
```

Optimization Specifications for the M step of the EM Algorithm for
Censored, Binary or Ordered Categorical (Ordinal), Unordered
Categorical (Nominal) and Count Outcomes

Number of M step iterations	1
M step convergence criterion	0.100D-02
Basis for M step termination	ITERATION
Maximum value for logit thresholds	15
Minimum value for logit thresholds	-15
Minimum expected cell size for chi-square	0.100D-01
Optimization algorithm	EMA
Integration Specifications	
Type	STANDARD
Number of integration points	15
Dimensions of numerical integration	0
Adaptive quadrature	ON
Random Starts Specifications	
Number of initial stage random starts	10
Number of final stage optimizations	2
Number of initial stage iterations	10
Initial stage convergence criterion	0.100D+01
Random starts scale	0.500D+01
Random seed for generating random starts	0
Cholesky	OFF

Input data file(s)
  c:₩ex01.dat
Input data format FREE

RANDOM STARTS RESULTS RANKED FROM THE BEST TO THE WORST LOGLIKELIHOOD VALUES

3 perturbed starting value run(s) did not converge in the initial stage optimizations.

Final stage loglikelihood values at local maxima, seeds, and initial stage start numbers:

-4709.936	415931	10
-4709.937	285380	1

THE ONE OR MORE PARAMETERS WERE FIXED TO AVOID SINGULARITY OF INFORMATION MATRIX. THE SINGULARITY IS MOST LIKELY BECAUSE THE MODEL IS NOT IDENTIFIED, OR BECAUSE OF EMPTY CELLS IN THE JOINT DISTRIBUTION OF THE CATEGORICAL VARIABLES IN THE MODEL.
THE FOLLOWING PARAMETERS WERE FIXED:
28 29

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 32

Loglikelihood

H0 Value	-4709.936
H0 Scaling Correction Factor for MLR	1.682

Information Criteria

Akaike (AIC)	9483.873
Bayesian (BIC)	9618.740
Sample-Size Adjusted BIC (n* = (n + 2) / 24)	9517.170

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASSES
BASED ON THE ESTIMATED MODEL

Latent Classes		
1	216.49177	0.43298
2	283.50823	0.56702

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASS PATTERNS
BASED ON ESTIMATED POSTERIOR PROBABILITIES

Latent Classes		
1	216.21844	0.43244
2	283.78156	0.56756

CLASSIFICATION QUALITY

Entropy	0.221

CLASSIFICATION OF INDIVIDUALS BASED ON THEIR MOST LIKELY LATENT CLASS MEMBERSHIP

Class Counts and Proportions

Latent Classes		
1	197	0.39400
2	303	0.60600

Average Latent Class Probabilities for Most Likely Latent Class Membership (Row)
by Latent Class (Column)

	1	2
1	0.663	0.337
2	0.282	0.718

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Latent Class 1				
F1 BY				
Y1	1.000	0.000	999.000	999.000
Y2	1.041	0.077	13.578	0.000
Y3	1.244	0.103	12.074	0.000
Y4	1.051	0.077	13.574	0.000
F2 BY				
Y5	1.000	0.000	999.000	999.000
Y6	0.946	0.060	15.658	0.000
Y7	0.937	0.072	13.083	0.000
Y8	0.832	0.080	10.341	0.000
F2 ON				
F1	1.009	0.167	6.054	0.000
Means				
F1	0.034	0.161	0.210	0.834
Intercepts				
Y1	3.108	0.113	27.397	0.000
Y2	3.348	0.121	27.569	0.000
Y3	3.223	0.142	22.653	0.000
Y4	3.257	0.121	26.981	0.000
Y5	3.035	0.100	30.458	0.000
Y6	2.994	0.111	27.028	0.000
Y7	2.896	0.104	27.855	0.000
Y8	3.208	0.087	36.842	0.000
F2	0.505	0.206	2.445	0.014
Variances				
F1	0.500	0.071	7.013	0.000
Residual Variances				
Y1	0.506	0.058	8.690	0.000
Y2	0.491	0.064	7.730	0.000
Y3	0.315	0.066	4.774	0.000
Y4	0.420	0.044	9.465	0.000
Y5	0.302	0.040	7.475	0.000
Y6	0.368	0.086	4.257	0.000
Y7	0.350	0.079	4.454	0.000
Y8	0.489	0.063	7.737	0.000
F2	0.246	0.039	6.239	0.000
Latent Class 2				
F1 BY				
Y1	1.000	0.000	999.000	999.000
Y2	1.041	0.077	13.578	0.000
Y3	1.244	0.103	12.074	0.000
Y4	1.051	0.077	13.574	0.000

F2 BY				
Y5	1.000	0.000	999.000	999.000
Y6	0.946	0.060	15.658	0.000
Y7	0.937	0.072	13.083	0.000
Y8	0.832	0.080	10.341	0.000
F2 ON				
F1	-0.064	0.197	-0.325	0.745
Means				
F1	-0.280	0.000	999.000	999.000
Intercepts				
Y1	3.108	0.113	27.397	0.000
Y2	3.348	0.121	27.569	0.000
Y3	3.223	0.142	22.653	0.000
Y4	3.257	0.121	26.981	0.000
Y5	3.035	0.100	30.458	0.000
Y6	2.994	0.111	27.028	0.000
Y7	2.896	0.104	27.855	0.000
Y8	3.208	0.087	36.842	0.000
F2	0.771	0.000	999.000	999.000
Variances				
F1	0.500	0.071	7.013	0.000
Residual Variances				
Y1	0.506	0.058	8.690	0.000
Y2	0.491	0.064	7.730	0.000
Y3	0.315	0.066	4.774	0.000
Y4	0.420	0.044	9.465	0.000
Y5	0.302	0.040	7.475	0.000
Y6	0.368	0.086	4.257	0.000
Y7	0.350	0.079	4.454	0.000
Y8	0.489	0.063	7.737	0.000
F2	0.246	0.039	6.239	0.000

Categorical Latent Variables

C#1 ON				
GENDER	-0.237	0.731	-0.325	0.745
Intercepts				
C#1	0.076	0.824	0.092	0.927

LOGISTIC REGRESSION ODDS RATIO RESULTS

Categorical Latent Variables

C#1 ON	
GENDER	0.789

ALTERNATIVE PARAMETERIZATIONS FOR THE CATEGORICAL LATENT VARIABLE REGRESSION

Parameterization using Reference Class 1

C#2 ON				
GENDER	0.237	0.731	0.325	0.745
Intercepts				
C#2	-0.076	0.824	-0.092	0.927

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix (ratio of smallest to largest eigenvalue)	0.660E-04

TECHNICAL 11 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

VUONG-LO-MENDELL-RUBIN LIKELIHOOD RATIO TEST FOR 1 (H0) VERSUS 2 CLASSES

H0 Loglikelihood Value	-4732.846
2 Times the Loglikelihood Difference	45.818
Difference in the Number of Parameters	5
Mean	35.003
Standard Deviation	33.198
P-Value	0.2661

LO-MENDELL-RUBIN ADJUSTED LRT TEST

```
          Value                                 44.390
          P-Value                                0.2792


TECHNICAL 14 OUTPUT

     Random Starts Specifications for the k-1 Class Analysis Model
        Number of initial stage random starts                10
        Number of final stage optimizations                   2

     Random Starts Specification for the k-1 Class Model for Generated Data
        Number of initial stage random starts                 0
        Number of final stage optimizations for the
           initial stage random starts                        0
     Random Starts Specification for the k Class Model for Generated Data
        Number of initial stage random starts                20
        Number of final stage optimizations                   5
     Number of bootstrap draws requested                  Varies


     PARAMETRIC BOOTSTRAPPED LIKELIHOOD RATIO TEST FOR 1 (H0)
VERSUS 2 CLASSES

          H0 Loglikelihood Value                       -4732.846
          2 Times the Loglikelihood Difference           45.818
          Difference in the Number of Parameters             5
          Approximate P-Value                           0.0000
          Successful Bootstrap Draws                         5


     Beginning Time:  10:57:36
        Ending Time:  10:57:43
       Elapsed Time:  00:00:07


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```

【ex. 18】

```
Mplus VERSION 6.12
MUTHEN & MUTHEN
06/13/2012  11:15 AM

INPUT INSTRUCTIONS

  TITLE: LATENT CALSS ANALYSIS;
  DATA: FILE = c:₩ex08.dat;
  VARIABLE:
     NAMES = Y1-Y6;
     USEVARIABLES = Y1-Y4;
     CLASSES = C(2);
  ANALYSIS:
  TYPE = MIXTURE;
  MODEL:
  %OVERALL%
  IINT SLO QUA | Y1@0 Y2@1 Y3@2 Y4@3;

  OUTPUT: TECH11 TECH14;

  PLOT:
  TYPE = PLOT3;
  SERIES = Y1(1) Y2(2) Y3(3) Y4(4);


INPUT READING TERMINATED NORMALLY

LATENT CALSS ANALYSIS;

SUMMARY OF ANALYSIS

Number of groups                                         1
Number of observations                                 600

Number of dependent variables                            4
Number of independent variables                          0
Number of continuous latent variables                    3
Number of categorical latent variables                   1

Observed dependent variables

  Continuous
   Y1          Y2          Y3          Y4
```

```
Continuous latent variables
   IINT          SLO           QUA

Categorical latent variables
   C


Estimator                                                MLR
Information matrix                                  OBSERVED
Optimization Specifications for the Quasi-Newton Algorithm for
Continuous Outcomes
  Maximum number of iterations                          100
  Convergence criterion                         0.100D-05
Optimization Specifications for the EM Algorithm
  Maximum number of iterations                          500
  Convergence criteria
    Loglikelihood change                        0.100D-06
    Relative loglikelihood change               0.100D-06
    Derivative                                  0.100D-05
Optimization Specifications for the M step of the EM Algorithm for
Categorical Latent variables
  Number of M step iterations                             1
  M step convergence criterion                  0.100D-05
  Basis for M step termination                  ITERATION
Optimization Specifications for the M step of the EM Algorithm for
Censored, Binary or Ordered Categorical (Ordinal), Unordered
Categorical (Nominal) and Count Outcomes
  Number of M step iterations                             1
  M step convergence criterion                  0.100D-05
  Basis for M step termination                  ITERATION
  Maximum value for logit thresholds                   15
  Minimum value for logit thresholds                  -15
  Minimum expected cell size for chi-square     0.100D-01
Optimization algorithm                                EMA
Random Starts Specifications
  Number of initial stage random starts                 10
  Number of final stage optimizations                    2
  Number of initial stage iterations                    10
  Initial stage convergence criterion           0.100D+01
  Random starts scale                           0.500D+01
  Random seed for generating random starts              0

Input data file(s)
  c:₩ex08.dat
Input data format  FREE


RANDOM STARTS RESULTS RANKED FROM THE BEST TO THE WORST LOGLIKELIHOOD
VALUES

Final stage loglikelihood values at local maxima, seeds, and initial stage start numbers:

          -8693.900  127215           9
          -8704.430  253358           2


     WARNING:  THE BEST LOGLIKELIHOOD VALUE WAS NOT REPLICATED.  THE
     SOLUTION MAY NOT BE TRUSTWORTHY DUE TO LOCAL MAXIMA.  INCREASE THE
     NUMBER OF RANDOM STARTS.


THE MODEL ESTIMATION TERMINATED NORMALLY

     WARNING:  THE LATENT VARIABLE COVARIANCE MATRIX (PSI)  IN CLASS 1
     IS NOT POSITIVE DEFINITE.  THIS COULD INDICATE A NEGATIVE VARIANCE/
     RESIDUAL VARIANCE FOR A LATENT VARIABLE, A CORRELATION GREATER OR
EQUAL
     TO ONE BETWEEN TWO LATENT VARIABLES, OR A LINEAR DEPENDENCY AMONG
MORE
     THAN TWO LATENT VARIABLES.  CHECK THE TECH4 OUTPUT FOR MORE
INFORMATION.
     PROBLEM INVOLVING VARIABLE QUA.


     WARNING:  THE LATENT VARIABLE COVARIANCE MATRIX (PSI)  IN CLASS 2
     IS NOT POSITIVE DEFINITE.  THIS COULD INDICATE A NEGATIVE VARIANCE/
     RESIDUAL VARIANCE FOR A LATENT VARIABLE, A CORRELATION GREATER OR
EQUAL
     TO ONE BETWEEN TWO LATENT VARIABLES, OR A LINEAR DEPENDENCY AMONG
MORE
     THAN TWO LATENT VARIABLES.  CHECK THE TECH4 OUTPUT FOR MORE
INFORMATION.
     PROBLEM INVOLVING VARIABLE QUA.



MODEL FIT INFORMATION

Number of Free Parameters                       17

Loglikelihood

          H0 Value                          -8693.900
          H0 Scaling Correction Factor          1.356
            for MLR

Information Criteria

          Akaike (AIC)                      17421.799
          Bayesian (BIC)                    17496.547
          Sample-Size Adjusted BIC          17442.577
```

(n* = (n + 2) / 24)

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASSES
BASED ON THE ESTIMATED MODEL

Latent Classes		
1	13.80438	0.02301
2	586.19562	0.97699

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASS PATTERNS
BASED ON ESTIMATED POSTERIOR PROBABILITIES

Latent Classes		
1	13.80439	0.02301
2	586.19561	0.97699

CLASSIFICATION QUALITY

Entropy	0.961

CLASSIFICATION OF INDIVIDUALS BASED ON THEIR MOST LIKELY LATENT CLASS MEMBERSHIP

Class Counts and Proportions

Latent Classes		
1	12	0.02000
2	588	0.98000

Average Latent Class Probabilities for Most Likely Latent Class Membership (Row)
by Latent Class (Column)

	1	2
1	0.844	0.156
2	0.006	0.994

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Latent Class 1				
IINT |				
Y1	1.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	1.000	0.000	999.000	999.000
Y4	1.000	0.000	999.000	999.000
SLO |				
Y1	0.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	2.000	0.000	999.000	999.000
Y4	3.000	0.000	999.000	999.000
QUA |				
Y1	0.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	4.000	0.000	999.000	999.000
Y4	9.000	0.000	999.000	999.000
SLO WITH				
IINT	-22.890	18.689	-1.225	0.221
QUA WITH				
IINT	3.902	4.531	0.861	0.389
SLO	-5.165	3.995	-1.293	0.196
Means				
IINT	163.324	4.821	33.875	0.000
SLO	37.870	5.016	7.550	0.000
QUA	-7.385	1.278	-5.780	0.000
Intercepts				
Y1	0.000	0.000	999.000	999.000
Y2	0.000	0.000	999.000	999.000
Y3	0.000	0.000	999.000	999.000
Y4	0.000	0.000	999.000	999.000
Variances				
IINT	264.832	24.003	11.033	0.000
SLO	27.984	19.283	1.451	0.147
QUA	0.615	0.920	0.668	0.504
Residual Variances				
Y1	25.792	19.909	1.296	0.195
Y2	44.503	7.721	5.764	0.000
Y3	12.097	5.442	2.223	0.026
Y4	41.395	16.284	2.542	0.011

Latent Class 2

IINT |				
Y1	1.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	1.000	0.000	999.000	999.000
Y4	1.000	0.000	999.000	999.000
SLO |				
Y1	0.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	2.000	0.000	999.000	999.000
Y4	3.000	0.000	999.000	999.000
QUA |				
Y1	0.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	4.000	0.000	999.000	999.000
Y4	9.000	0.000	999.000	999.000
SLO WITH				
IINT	-22.890	18.689	-1.225	0.221
QUA WITH				
IINT	3.902	4.531	0.861	0.389
SLO	-5.165	3.995	-1.293	0.196
Means				
IINT	196.767	0.769	255.936	0.000
SLO	12.484	0.417	29.957	0.000
QUA	-1.757	0.121	-14.490	0.000
Intercepts				
Y1	0.000	0.000	999.000	999.000
Y2	0.000	0.000	999.000	999.000
Y3	0.000	0.000	999.000	999.000
Y4	0.000	0.000	999.000	999.000
Variances				
IINT	264.832	24.003	11.033	0.000
SLO	27.984	19.283	1.451	0.147
QUA	0.615	0.920	0.668	0.504
Residual Variances				
Y1	25.792	19.909	1.296	0.195
Y2	44.503	7.721	5.764	0.000
Y3	12.097	5.442	2.223	0.026
Y4	41.395	16.284	2.542	0.011

Categorical Latent Variables

Means

C#1	-3.749	0.495	-7.569	0.000

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix 0.340E-05
(ratio of smallest to largest eigenvalue)

TECHNICAL 11 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model
Number of initial stage random starts 10
Number of final stage optimizations 2

VUONG-LO-MENDELL-RUBIN LIKELIHOOD RATIO TEST FOR 1 (H0) VERSUS 2 CLASSES

H0 Loglikelihood Value -8711.459
2 Times the Loglikelihood Difference 35.118
Difference in the Number of Parameters 4
Mean 5.658
Standard Deviation 10.075
P-Value 0.0122

LO-MENDELL-RUBIN ADJUSTED LRT TEST

Value 33.797
P-Value 0.0142

TECHNICAL 14 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model
Number of initial stage random starts 10
Number of final stage optimizations 2

Random Starts Specification for the k-1 Class Model for Generated Data
Number of initial stage random starts 0
Number of final stage optimizations for the initial stage random starts 0
Random Starts Specification for the k Class Model for Generated Data
Number of initial stage random starts 20
Number of final stage optimizations 5
Number of bootstrap draws requested Varies

PARAMETRIC BOOTSTRAPPED LIKELIHOOD RATIO TEST FOR 1 (H0) VERSUS 2 CLASSES

H0 Loglikelihood Value	-8711.459
2 Times the Loglikelihood Difference	35.118
Difference in the Number of Parameters	4
Approximate P-Value	0.0000
Successful Bootstrap Draws	20

SAMPLE STATISTICS FOR ESTIMATED FACTOR SCORES

SAMPLE STATISTICS

Means

	IINT	SLO	QUA	C_IINT	C_SLO
1	195.997	13.068	-1.886	196.027	13.032

Means

	C_QUA
1	-1.878

Covariances

	IINT	SLO	QUA	C_IINT	C_SLO
IINT	273.759				
SLO	-28.729	32.334			
QUA	5.142	-7.690	1.915		
C_IINT	273.456	-28.729	5.137	273.361	
C_SLO	-28.368	32.334	-7.684	-28.617	32.631
C_QUA	5.064	-7.690	1.914	5.113	-7.748

Covariances

	C_QUA
C_QUA	1.927

Correlations

	IINT	SLO	QUA	C_IINT	C_SLO
IINT	1.000				
SLO	-0.305	1.000			
QUA	0.225	-0.977	1.000		
C_IINT	1.000	-0.306	0.224	1.000	
C_SLO	-0.300	0.995	-0.972	-0.303	1.000
C_QUA	0.220	-0.974	0.996	0.223	-0.977

Correlations

	C_QUA
C_QUA	1.000

PLOT INFORMATION

The following plots are available:

- Histograms (sample values, estimated factor scores, estimated values)
- Scatterplots (sample values, estimated factor scores, estimated values)
- Sample means
- Estimated means
- Sample and estimated means
- Observed individual values
- Estimated individual values
- Estimated means and observed individual values
- Estimated means and estimated individual values
- Mixture distributions

Beginning Time: 11:15:31
Ending Time: 11:15:36
Elapsed Time: 00:00:05

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【ex. 18-1】

```
Mplus VERSION 6.12
MUTHEN & MUTHEN
06/13/2012  11:16 AM

INPUT INSTRUCTIONS

  TITLE: LATENT CALSS ANALYSIS;
  DATA: FILE = c:₩ex08.dat;
  VARIABLE:
      NAMES = Y1-Y6;
      USEVARIABLES = Y1-Y4;
      CLASSES = C(3);
  ANALYSIS:
  TYPE = MIXTURE;
  MODEL:
  %OVERALL%
  IINT SLO QUA | Y1@0 Y2@1 Y3@2 Y4@3;

  OUTPUT: TECH11 TECH14;

  PLOT:
  TYPE = PLOT3;
  SERIES = Y1(1) Y2(2) Y3(3) Y4(4);



INPUT READING TERMINATED NORMALLY



LATENT CALSS ANALYSIS;

SUMMARY OF ANALYSIS

Number of groups                                 1
Number of observations                         600

Number of dependent variables                    4
Number of independent variables                  0
Number of continuous latent variables            3
Number of categorical latent variables           1

Observed dependent variables

  Continuous
   Y1          Y2          Y3          Y4

Continuous latent variables
   IINT        SLO         QUA

Categorical latent variables
   C


Estimator                                      MLR
Information matrix                        OBSERVED
Optimization Specifications for the Quasi-Newton Algorithm for
Continuous Outcomes
  Maximum number of iterations                 100
  Convergence criterion                 0.100D-05
Optimization Specifications for the EM Algorithm
  Maximum number of iterations                 500
  Convergence criteria
    Loglikelihood change                0.100D-06
    Relative loglikelihood change       0.100D-06
    Derivative                          0.100D-05
Optimization Specifications for the M step of the EM Algorithm for
Categorical Latent variables
  Number of M step iterations                    1
  M step convergence criterion          0.100D-05
  Basis for M step termination           ITERATION
Optimization Specifications for the M step of the EM Algorithm for
Censored, Binary or Ordered Categorical (Ordinal), Unordered
Categorical (Nominal) and Count Outcomes
  Number of M step iterations                    1
  M step convergence criterion          0.100D-05
  Basis for M step termination           ITERATION
  Maximum value for logit thresholds            15
  Minimum value for logit thresholds           -15
  Minimum expected cell size for chi-square     0.100D-01
Optimization algorithm                         EMA
Random Starts Specifications
  Number of initial stage random starts         10
  Number of final stage optimizations            2
  Number of initial stage iterations            10
  Initial stage convergence criterion   0.100D+01
  Random starts scale                    0.500D+01
  Random seed for generating random starts       0

Input data file(s)
  c:₩ex08.dat
Input data format  FREE


RANDOM STARTS RESULTS RANKED FROM THE BEST TO THE WORST LOGLIKELIHOOD
VALUES
```

Final stage loglikelihood values at local maxima, seeds, and initial stage start numbers:

-8687.021	903420	5
-8687.021	127215	9

WARNING: WHEN ESTIMATING A MODEL WITH MORE THAN TWO CLASSES, IT MAY BE
NECESSARY TO INCREASE THE NUMBER OF RANDOM STARTS USING THE STARTS OPTION
TO AVOID LOCAL MAXIMA.

THE MODEL ESTIMATION TERMINATED NORMALLY

WARNING: THE LATENT VARIABLE COVARIANCE MATRIX (PSI) IN CLASS 1
IS NOT POSITIVE DEFINITE. THIS COULD INDICATE A NEGATIVE VARIANCE/
RESIDUAL VARIANCE FOR A LATENT VARIABLE, A CORRELATION GREATER OR EQUAL
TO ONE BETWEEN TWO LATENT VARIABLES, OR A LINEAR DEPENDENCY AMONG MORE
THAN TWO LATENT VARIABLES. CHECK THE TECH4 OUTPUT FOR MORE INFORMATION.
PROBLEM INVOLVING VARIABLE QUA.

WARNING: THE LATENT VARIABLE COVARIANCE MATRIX (PSI) IN CLASS 2
IS NOT POSITIVE DEFINITE. THIS COULD INDICATE A NEGATIVE VARIANCE/
RESIDUAL VARIANCE FOR A LATENT VARIABLE, A CORRELATION GREATER OR EQUAL
TO ONE BETWEEN TWO LATENT VARIABLES, OR A LINEAR DEPENDENCY AMONG MORE
THAN TWO LATENT VARIABLES. CHECK THE TECH4 OUTPUT FOR MORE INFORMATION.
PROBLEM INVOLVING VARIABLE QUA.

WARNING: THE LATENT VARIABLE COVARIANCE MATRIX (PSI) IN CLASS 3
IS NOT POSITIVE DEFINITE. THIS COULD INDICATE A NEGATIVE VARIANCE/
RESIDUAL VARIANCE FOR A LATENT VARIABLE, A CORRELATION GREATER OR EQUAL
TO ONE BETWEEN TWO LATENT VARIABLES, OR A LINEAR DEPENDENCY AMONG MORE
THAN TWO LATENT VARIABLES. CHECK THE TECH4 OUTPUT FOR MORE INFORMATION.
PROBLEM INVOLVING VARIABLE QUA.

MODEL FIT INFORMATION

Number of Free Parameters 21

Loglikelihood

H0 Value	-8687.021
H0 Scaling Correction Factor for MLR	1.204

Information Criteria

Akaike (AIC)	17416.042
Bayesian (BIC)	17508.378
Sample-Size Adjusted BIC (n* = (n + 2) / 24)	17441.709

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASSES
BASED ON THE ESTIMATED MODEL

Latent Classes		
1	581.26661	0.96878
2	2.01972	0.00337
3	16.71366	0.02786

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASS PATTERNS
BASED ON ESTIMATED POSTERIOR PROBABILITIES

Latent Classes		
1	581.26661	0.96878
2	2.01972	0.00337
3	16.71367	0.02786

CLASSIFICATION QUALITY

Entropy	0.967

CLASSIFICATION OF INDIVIDUALS BASED ON THEIR MOST LIKELY LATENT CLASS MEMBERSHIP

Class Counts and Proportions

Latent Classes		

1	585	0.97500
2	2	0.00333
3	13	0.02167

Average Latent Class Probabilities for Most Likely Latent Class Membership (Row)
by Latent Class (Column)

	1	2	3
1	0.991	0.000	0.009
2	0.080	0.920	0.000
3	0.120	0.000	0.880

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Latent Class 1				
IINT |				
Y1	1.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	1.000	0.000	999.000	999.000
Y4	1.000	0.000	999.000	999.000
SLO |				
Y1	0.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	2.000	0.000	999.000	999.000
Y4	3.000	0.000	999.000	999.000
QUA |				
Y1	0.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	4.000	0.000	999.000	999.000
Y4	9.000	0.000	999.000	999.000
SLO WITH				
IINT	-23.434	18.826	-1.245	0.213
QUA WITH				
IINT	4.156	4.572	0.909	0.363
SLO	-5.587	4.077	-1.370	0.171
Means				
IINT	196.801	0.827	238.004	0.000
SLO	12.488	0.449	27.819	0.000
QUA	-1.756	0.127	-13.861	0.000
Intercepts				
Y1	0.000	0.000	999.000	999.000
Y2	0.000	0.000	999.000	999.000
Y3	0.000	0.000	999.000	999.000
Y4	0.000	0.000	999.000	999.000
Variances				
IINT	263.697	23.966	11.003	0.000
SLO	29.518	19.685	1.499	0.134
QUA	0.716	0.924	0.775	0.438
Residual Variances				
Y1	19.533	20.410	0.957	0.339
Y2	45.185	7.815	5.782	0.000
Y3	12.087	5.448	2.219	0.027
Y4	41.601	16.274	2.556	0.011
Latent Class 2				
IINT |				
Y1	1.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	1.000	0.000	999.000	999.000
Y4	1.000	0.000	999.000	999.000
SLO |				
Y1	0.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	2.000	0.000	999.000	999.000
Y4	3.000	0.000	999.000	999.000
QUA |				
Y1	0.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	4.000	0.000	999.000	999.000
Y4	9.000	0.000	999.000	999.000
SLO WITH				
IINT	-23.434	18.826	-1.245	0.213
QUA WITH				
IINT	4.156	4.572	0.909	0.363
SLO	-5.587	4.077	-1.370	0.171
Means				
IINT	230.039	3.855	59.666	0.000
SLO	-16.846	5.680	-2.966	0.003
QUA	4.017	1.100	3.652	0.000
Intercepts				
Y1	0.000	0.000	999.000	999.000
Y2	0.000	0.000	999.000	999.000
Y3	0.000	0.000	999.000	999.000

Y4	0.000	0.000	999.000	999.000
Variances				
IINT	263.697	23.966	11.003	0.000
SLO	29.518	19.685	1.499	0.134
QUA	0.716	0.924	0.775	0.438
Residual Variances				
Y1	19.533	20.410	0.957	0.339
Y2	45.185	7.815	5.782	0.000
Y3	12.087	5.448	2.219	0.027
Y4	41.601	16.274	2.556	0.011

Latent Class 3

IINT |				
Y1	1.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	1.000	0.000	999.000	999.000
Y4	1.000	0.000	999.000	999.000
SLO |				
Y1	0.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	2.000	0.000	999.000	999.000
Y4	3.000	0.000	999.000	999.000
QUA |				
Y1	0.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	4.000	0.000	999.000	999.000
Y4	9.000	0.000	999.000	999.000
SLO WITH				
IINT	-23.434	18.826	-1.245	0.213
QUA WITH				
IINT	4.156	4.572	0.909	0.363
SLO	-5.587	4.077	-1.370	0.171
Means				
IINT	164.628	4.997	32.945	0.000
SLO	36.268	5.852	6.197	0.000
QUA	-7.022	1.463	-4.801	0.000
Intercepts				
Y1	0.000	0.000	999.000	999.000
Y2	0.000	0.000	999.000	999.000
Y3	0.000	0.000	999.000	999.000
Y4	0.000	0.000	999.000	999.000
Variances				
IINT	263.697	23.966	11.003	0.000
SLO	29.518	19.685	1.499	0.134
QUA	0.716	0.924	0.775	0.438
Residual Variances				
Y1	19.533	20.410	0.957	0.339
Y2	45.185	7.815	5.782	0.000
Y3	12.087	5.448	2.219	0.027
Y4	41.601	16.274	2.556	0.011

Categorical Latent Variables

Means				
C#1	3.549	0.576	6.167	0.000
C#2	-2.113	0.970	-2.178	0.029

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix (ratio of smallest to largest eigenvalue)	0.383E-07

TECHNICAL 11 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

VUONG-LO-MENDELL-RUBIN LIKELIHOOD RATIO TEST FOR 2 (H0) VERSUS 3 CLASSES

H0 Loglikelihood Value	-8693.900
2 Times the Loglikelihood Difference	13.757
Difference in the Number of Parameters	4
Mean	2.673
Standard Deviation	8.453
P-Value	0.0780

LO-MENDELL-RUBIN ADJUSTED LRT TEST

Value	13.239
P-Value	0.0844

TECHNICAL 14 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

```
Random Starts Specification for the k-1 Class Model for Generated Data
   Number of initial stage random starts                    0
   Number of final stage optimizations for the
      initial stage random starts                           0
Random Starts Specification for the k Class Model for Generated Data
   Number of initial stage random starts                   20
   Number of final stage optimizations                      5
Number of bootstrap draws requested                     Varies


     PARAMETRIC BOOTSTRAPPED LIKELIHOOD RATIO TEST FOR 2 (H0) VERSUS 3
CLASSES

          H0 Loglikelihood Value                       -8693.900
          2 Times the Loglikelihood Difference            13.757
          Difference in the Number of Parameters               4
          Approximate P-Value                             0.1071
          Successful Bootstrap Draws                          56

     WARNING:  THE BEST LOGLIKELIHOOD VALUE WAS NOT REPLICATED IN 30 OUT
OF 51
     BOOTSTRAP DRAWS.  THE P-VALUE MAY NOT BE TRUSTWORTHY DUE TO LOCAL
     MAXIMA.  INCREASE THE NUMBER OF RANDOM STARTS USING THE LRTSTARTS
OPTION.


     WARNING:  1 OUT OF 57 BOOTSTRAP DRAWS DID NOT CONVERGE.
     INCREASE THE NUMBER OF RANDOM STARTS USING THE LRTSTARTS OPTION.


SAMPLE STATISTICS FOR ESTIMATED FACTOR SCORES

     SAMPLE STATISTICS


           Means
              IINT          SLO           QUA         C_IINT        C_SLO
              ____          ____          ____        ______        _____
1          196.017        13.051        -1.883       196.065       12.992


           Means
              C_QUA
              _____
1             -1.870
           Covariances
              IINT          SLO           QUA         C_IINT        C_SLO
              ____          ____          ____        ______        _____
IINT       281.959
SLO        -36.168        39.097
QUA          6.805        -9.225         2.272
C_IINT     281.335       -35.895         6.735       280.853
C_SLO      -35.381        38.751        -9.137       -35.280       38.615
C_QUA        6.636        -9.150         2.254         6.601       -9.105

           Covariances
              C_QUA
              _____
C_QUA         2.244

           Correlations
              IINT          SLO           QUA         C_IINT        C_SLO
              ____          ____          ____        ______        _____
IINT          1.000
SLO          -0.344         1.000
QUA           0.269        -0.979         1.000
C_IINT        1.000        -0.343         0.267         1.000
C_SLO        -0.339         0.997        -0.975        -0.339         1.000
C_QUA         0.264        -0.977         0.998         0.263        -0.978


           Correlations
              C_QUA
              _____
C_QUA         1.000


PLOT INFORMATION

The following plots are available:

  Histograms (sample values, estimated factor scores, estimated values)
  Scatterplots (sample values, estimated factor scores, estimated values)
  Sample means
  Estimated means
  Sample and estimated means
  Observed individual values
  Estimated individual values
  Estimated means and observed individual values
  Estimated means and estimated individual values
  Mixture distributions

     Beginning Time:  11:16:11
        Ending Time:  11:16:32
       Elapsed Time:  00:00:21

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```

【ex. 18-2】

```
Mplus VERSION 6.12
MUTHEN & MUTHEN
06/13/2012  11:17 AM

INPUT INSTRUCTIONS

  TITLE: LATENT CALSS ANALYSIS;
  DATA: FILE = c:₩ex08.dat;
  VARIABLE:
     NAMES = Y1-Y6;
     USEVARIABLES = Y1-Y6;
     CLASSES = C(2);
  ANALYSIS:
  TYPE = MIXTURE;
  MODEL:
  %OVERALL%
  INT SLO QUA | Y1@0 Y2@1 Y3@2 Y4@3;
  C ON Y5 Y6;

  OUTPUT: TECH11 TECH14;

  PLOT:
  TYPE = PLOT3;
  SERIES = Y1(1) Y2(2) Y3(3) Y4(4);



INPUT READING TERMINATED NORMALLY



LATENT CALSS ANALYSIS;

SUMMARY OF ANALYSIS

Number of groups                                 1
Number of observations                         600

Number of dependent variables                    4
Number of independent variables                  2
Number of continuous latent variables            3
Number of categorical latent variables           1
```

```
Observed dependent variables

  Continuous
   Y1          Y2          Y3          Y4

Observed independent variables
   Y5          Y6

Continuous latent variables
   INT         SLO         QUA

Categorical latent variables
   C


Estimator                                      MLR
Information matrix                        OBSERVED
Optimization Specifications for the Quasi-Newton Algorithm for
Continuous Outcomes
  Maximum number of iterations                  100
  Convergence criterion                  0.100D-05
Optimization Specifications for the EM Algorithm
  Maximum number of iterations                  500
  Convergence criteria
    Loglikelihood change                 0.100D-06
    Relative loglikelihood change        0.100D-06
    Derivative                           0.100D-05
Optimization Specifications for the M step of the EM Algorithm for
Categorical Latent variables
  Number of M step iterations                     1
  M step convergence criterion           0.100D-05
  Basis for M step termination           ITERATION
Optimization Specifications for the M step of the EM Algorithm for
Censored, Binary or Ordered Categorical (Ordinal), Unordered
Categorical (Nominal) and Count Outcomes
  Number of M step iterations                     1
  M step convergence criterion           0.100D-05
  Basis for M step termination           ITERATION
  Maximum value for logit thresholds             15
  Minimum value for logit thresholds            -15
  Minimum expected cell size for chi-square      0.100D-01
Optimization algorithm                         EMA
Random Starts Specifications
  Number of initial stage random starts          10
  Number of final stage optimizations             2
  Number of initial stage iterations             10
  Initial stage convergence criterion    0.100D+01
  Random starts scale                    0.500D+01
  Random seed for generating random starts           0

Input data file(s)
  c:₩ex08.dat
```

Input data format FREE

RANDOM STARTS RESULTS RANKED FROM THE BEST TO THE WORST LOGLIKELIHOOD VALUES

Final stage loglikelihood values at local maxima, seeds, and initial stage start numbers:

-8671.432	939021	8
-8671.432	903420	5

WARNING: THE SAMPLE VARIANCE OF Y6 IN CLASS 2 IS 0.000.

ONE OR MORE MULTINOMIAL LOGIT PARAMETERS WERE FIXED TO AVOID SINGULARITY
OF THE INFORMATION MATRIX. THE SINGULARITY IS MOST LIKELY BECAUSE THE MODEL IS NOT IDENTIFIED, OR BECAUSE OF EMPTY CELLS IN THE JOINT DISTRIBUTION OF THE CATEGORICAL LATENT VARIABLES AND ANY INDEPENDENT VARIABLES. THE FOLLOWING PARAMETERS WERE FIXED:
19

THE MODEL ESTIMATION TERMINATED NORMALLY

WARNING: THE LATENT VARIABLE COVARIANCE MATRIX (PSI) IN CLASS 1 IS NOT POSITIVE DEFINITE. THIS COULD INDICATE A NEGATIVE VARIANCE/ RESIDUAL VARIANCE FOR A LATENT VARIABLE, A CORRELATION GREATER OR EQUAL TO ONE BETWEEN TWO LATENT VARIABLES, OR A LINEAR DEPENDENCY AMONG MORE THAN TWO LATENT VARIABLES. CHECK THE TECH4 OUTPUT FOR MORE INFORMATION.
PROBLEM INVOLVING VARIABLE QUA.

WARNING: THE LATENT VARIABLE COVARIANCE MATRIX (PSI) IN CLASS 2 IS NOT POSITIVE DEFINITE. THIS COULD INDICATE A NEGATIVE VARIANCE/ RESIDUAL VARIANCE FOR A LATENT VARIABLE, A CORRELATION GREATER OR EQUAL TO ONE BETWEEN TWO LATENT VARIABLES, OR A LINEAR DEPENDENCY AMONG MORE THAN TWO LATENT VARIABLES. CHECK THE TECH4 OUTPUT FOR MORE INFORMATION.
PROBLEM INVOLVING VARIABLE QUA.

MODEL FIT INFORMATION

Number of Free Parameters 19

Loglikelihood

H0 Value	-8671.432
H0 Scaling Correction Factor for MLR	1.339

Information Criteria

Akaike (AIC)	17380.865
Bayesian (BIC)	17464.406
Sample-Size Adjusted BIC (n* = (n + 2) / 24)	17404.087

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASSES BASED ON THE ESTIMATED MODEL

Latent Classes		
1	260.58544	0.43431
2	339.41456	0.56569

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASS PATTERNS BASED ON ESTIMATED POSTERIOR PROBABILITIES

Latent Classes		
1	260.58544	0.43431
2	339.41456	0.56569

CLASSIFICATION QUALITY

Entropy	0.502

CLASSIFICATION OF INDIVIDUALS BASED ON THEIR MOST LIKELY LATENT CLASS MEMBERSHIP

Class Counts and Proportions

Latent Classes		
1	217	0.36167
2	383	0.63833

Average Latent Class Probabilities for Most Likely Latent Class Membership (Row)
by Latent Class (Column)

	1	2
1	0.879	0.121
2	0.182	0.818

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Latent Class 1				
INT |				
Y1	1.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	1.000	0.000	999.000	999.000
Y4	1.000	0.000	999.000	999.000
SLO |				
Y1	0.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	2.000	0.000	999.000	999.000
Y4	3.000	0.000	999.000	999.000
QUA |				
Y1	0.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	4.000	0.000	999.000	999.000
Y4	9.000	0.000	999.000	999.000
SLO WITH				
INT	-38.448	20.594	-1.867	0.062
QUA WITH				
INT	7.594	4.891	1.553	0.120
SLO	-9.410	4.198	-2.242	0.025
Means				
INT	185.237	1.817	101.924	0.000
SLO	14.227	1.222	11.646	0.000
QUA	-2.119	0.306	-6.927	0.000
Intercepts				
Y1	0.000	0.000	999.000	999.000
Y2	0.000	0.000	999.000	999.000
Y3	0.000	0.000	999.000	999.000
Y4	0.000	0.000	999.000	999.000
Variances				
INT	206.998	34.077	6.074	0.000
SLO	47.274	20.019	2.361	0.018
QUA	1.519	0.936	1.623	0.105
Residual Variances				
Y1	18.867	19.429	0.971	0.332
Y2	45.280	7.463	6.067	0.000
Y3	11.976	5.145	2.328	0.020
Y4	42.408	14.558	2.913	0.004
Latent Class 2				
INT |				
Y1	1.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	1.000	0.000	999.000	999.000
Y4	1.000	0.000	999.000	999.000
SLO |				
Y1	0.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	2.000	0.000	999.000	999.000
Y4	3.000	0.000	999.000	999.000
QUA |				
Y1	0.000	0.000	999.000	999.000
Y2	1.000	0.000	999.000	999.000
Y3	4.000	0.000	999.000	999.000
Y4	9.000	0.000	999.000	999.000
SLO WITH				
INT	-38.448	20.594	-1.867	0.062
QUA WITH				
INT	7.594	4.891	1.553	0.120
SLO	-9.410	4.198	-2.242	0.025
Means				
INT	204.297	3.271	62.466	0.000
SLO	12.145	0.672	18.064	0.000
QUA	-1.700	0.202	-8.407	0.000
Intercepts				
Y1	0.000	0.000	999.000	999.000
Y2	0.000	0.000	999.000	999.000
Y3	0.000	0.000	999.000	999.000
Y4	0.000	0.000	999.000	999.000
Variances				

INT	206.998	34.077	6.074	0.000
SLO	47.274	20.019	2.361	0.018
QUA	1.519	0.936	1.623	0.105

Residual Variances

Y1	18.867	19.429	0.971	0.332
Y2	45.280	7.463	6.067	0.000
Y3	11.976	5.145	2.328	0.020
Y4	42.408	14.558	2.913	0.004

Categorical Latent Variables

C#1 ON				
Y5	2.394	0.963	2.487	0.013
Y6	1158.668	0.000	999.000	999.000

Intercepts

C#1	-1.110	0.874	-1.270	0.204

LOGISTIC REGRESSION ODDS RATIO RESULTS

Categorical Latent Variables

C#1 ON	
Y5	10.959
Y6	*********

ALTERNATIVE PARAMETERIZATIONS FOR THE CATEGORICAL LATENT VARIABLE REGRESSION

Parameterization using Reference Class 1

C#2 ON				
Y5	-2.394	0.963	-2.487	0.013
Y6	-1158.668	0.000	0.000	1.000

Intercepts

C#2	1.110	0.874	1.270	0.204

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix (ratio of smallest to largest eigenvalue)	0.102E-04

TECHNICAL 11 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

VUONG-LO-MENDELL-RUBIN LIKELIHOOD RATIO TEST FOR 1 (H0) VERSUS 2 CLASSES

H0 Loglikelihood Value	-8711.459
2 Times the Loglikelihood Difference	80.052
Difference in the Number of Parameters	6
Mean	12.266
Standard Deviation	12.060
P-Value	0.0022

LO-MENDELL-RUBIN ADJUSTED LRT TEST

Value	78.020
P-Value	0.0026

TECHNICAL 14 OUTPUT

Random Starts Specifications for the k-1 Class Analysis Model

Number of initial stage random starts	10
Number of final stage optimizations	2

Random Starts Specification for the k-1 Class Model for Generated Data

Number of initial stage random starts	0
Number of final stage optimizations for the initial stage random starts	0

Random Starts Specification for the k Class Model for Generated Data

Number of initial stage random starts	20
Number of final stage optimizations	5
Number of bootstrap draws requested	Varies

PARAMETRIC BOOTSTRAPPED LIKELIHOOD RATIO TEST FOR 1 (H0) VERSUS 2 CLASSES

H0 Loglikelihood Value	-8711.459
2 Times the Loglikelihood Difference	80.052
Difference in the Number of Parameters	6
Approximate P-Value	0.0000
Successful Bootstrap Draws	10

SAMPLE STATISTICS FOR ESTIMATED FACTOR SCORES

SAMPLE STATISTICS

Means

	INT	SLO	QUA	C_INT	C_SLO
1	196.019	13.049	-1.882	196.087	12.984

Means

	C_QUA
1	-1.862

Covariances

	INT	SLO	QUA	C_INT	C_SLO
INT	282.079				
SLO	-36.078	39.164			
QUA	6.825	-9.346	2.332		
C_INT	282.582	-36.172	6.848	283.123	
C_SLO	-36.560	39.254	-9.367	-36.691	39.380
C_QUA	6.976	-9.374	2.339	7.010	-9.407

Covariances

	C_QUA
C_QUA	2.349

Correlations

	INT	SLO	QUA	C_INT	C_SLO
INT	1.000				
SLO	-0.343	1.000			
QUA	0.266	-0.978	1.000		
C_INT	1.000	-0.344	0.266	1.000	
C_SLO	-0.347	1.000	-0.977	-0.347	1.000
C_QUA	0.271	-0.977	0.999	0.272	-0.978

Correlations

	C_QUA
C_QUA	1.000

PLOT INFORMATION

The following plots are available:

Histograms (sample values, estimated factor scores, estimated values)
Scatterplots (sample values, estimated factor scores, estimated values)

Sample means
Estimated means
Sample and estimated means
Adjusted estimated means
Observed individual values
Estimated individual values
Estimated means and observed individual values
Estimated means and estimated individual values
Adjusted estimated means and observed individual values
Adjusted estimated means and estimated individual values
Mixture distributions
Estimated probabilities for a categorical latent variable as a function of its covariates

Beginning Time: 11:17:34
Ending Time: 11:17:38
Elapsed Time: 00:00:04

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MEMO

세미나자료집 12-S39

청소년도덕성 진단검사도구 표준화연구Ⅱ 제2차 콜로키움 자료집
-Mplus를 활용한 잠재계층분석의 이론과 적용 -

인 쇄 2012년 9월 5일
발 행 2012년 9월 5일

발행처 **한국청소년정책연구원**
서울특별시 서초구 태봉로 114
발행인 이 재 연

등 록 1993. 10. 23 제 21-500호
인쇄처 (주)문영사 전화 02)2263-5087 대표 김희자