



Bootstrapping in Amos

Changya Hu, Ph.D. NCCU

What's bootstrapping and why we need it?

✓ It's a resampling method

- Creating an sampling distribution to estimate standard errors, and create the confidence intervals.

✓ It's important for mediation analysis

- To confirm the mediation effect
 - Because of its accuracy for computing confidence intervals for mediation effect when the mediation effect is nonzero.
- As an aid to nonnormal data
 - The assumption of SEM is the data has a multivariate normal distribution, but many empirical studies failed.
 - The resampling method has more accurate Type I error rates and power than single sample method that assumes a normal distribution.

Benefits of bootstrap procedure

✓ SEM approach

- If the variables have measurement errors, the significance of the mediation effect is likely to be underestimated.
 - Using SEM can deal with the measurement error problem.

✓ Benefits

- It allows researchers to assess the stability of parameter estimates
- It can be applied when the assumptions of large sample size and multivariate normality may not hold.
 - Needs at least moderate sample sizes

The procedure of bootstrapping in Amos

The screenshot displays the Amos software interface. On the left is a toolbar with various icons. The main window shows a path diagram with nodes: e4 (error term) pointing to depres4 (observed variable); selfest (latent variable) pointing to self1, self2, self3, self4, and self5 (observed variables); and e14 (error term) pointing to selfest. Each path has a coefficient of 1. A red arrow points to the 'Analysis Properties' button in the toolbar.

Analysis Properties dialog box tabs: Estimation, Numerical, Bias, **Output**, **Bootstrap**, Permutations, Random #, Title.

Bootstrap tab settings:

- ☐ Perform bootstrap: 200 (Number of bootstrap samples)
- ☐ Percentile confidence intervals: 90 (PC confidence level)
- ☐ Bias-corrected confidence intervals: 90 (BC confidence level)
- ☐ Bootstrap ADF
- ☐ Bootstrap ML
- ☐ Bootstrap GLS
- ☐ Bootstrap SLS: 1 (Bootfactor)
- ☐ Bootstrap ULS
- ☐ Monte Carlo (parametric bootstrap)
- ☐ Report details of each bootstrap sample
- ☐ Bollen-Stine bootstrap

Output tab settings:

- ☐ Bootstrap ADF
- ☐ Bootstrap ML
- ☐ Bootstrap GLS
- ☐ Bootstrap SLS
- ☐ Bootstrap ULS
- ☐ Monte Carlo (parametric bootstrap)
- ☐ Report details of each bootstrap sample
- ☐ Bollen-Stine bootstrap

And click on the Output and Bootstrapping tab

The procedure of bootstrapping in Amos

File Edit View Diagram Analyze Tools Plugins Help

Group number 1

Default model

Unstandardized estimates
Standardized estimates

ex1_path.amw
ex2_CFA.amw
ex3_full.amw
ex4_Bootstrapping.amw

Analysis Properties

Estimation Numerical Bias Output Bootstrap Permutations Random # Title

To test the mediation effect

☒ Indirect, direct & total effects

☒ Minimization history

☒ Standardized estimates

☒ Squared multiple correlations

☐ Sample moments

☐ Implied moments

☐ All implied moments

☐ Residual moments

☐ Modification indices

☐ Factor score weights

☐ Covariances of estimates

☐ Correlations of estimates

☐ Critical ratios for differences

☐ Tests for normality and outliers

☐ Observed information matrix

4 Threshold for modification indices

Diagram illustrating a mediation model:

- Latent variable: selfest
- Observed variable: depres4 (indicated by a box)
- Latent variable: self1, self2, self3, self4, self5
- Error terms: e4, e5, e6, e7, e8, e9, e14
- Path coefficients: 1 (from e4 to depres4, e14 to selfest, and from selfest to self1 through self5)

The procedure of bootstrapping in Amos

File Edit View Diagram Analyze Tools Plugins Help

Group number 1

Default model

Unstandardized estimates
Standardized estimates

ex1_path.amw
ex2_CFA.amw
ex3_full.amw
ex4_Bootstrapping.amw

Analysis Properties

Estimation Numerical Bias Output Bootstrap Permutations Random # Title

Usually 500 or 1,000 (Cheung & Lau, 2008)

☒ Perform bootstrap 1000 Number of bootstrap samples

☐ Percentile confidence intervals 90 PC confidence level

☒ Bias-corrected confidence intervals 95 BC confidence level

Determine the Type I error rate

☐ Bootstrap ADF ☐ Monte Carlo (parametric bootstrap)

☒ Bootstrap ML ☐ Report details of each bootstrap sample

☐ Bootstrap GLS ☐ Bollen-Stine bootstrap

☐ Bootstrap SLS 1 Bootfactor

☐ Bootstrap ULS

Diagram illustrating a path model structure. A latent variable 'selfest' is measured by five observed variables: 'self1', 'self2', 'self3', 'self4', and 'self5'. Each observed variable has a loading of 1 and is associated with an error term (e5, e6, e7, e8, e9). Additionally, 'selfest' is measured by 'depress4' (loading 1, error e4) and 'e14' (loading 1).

The result of bootstrapping in Amos

File Edit View Diagram Analyze Tools Plugins Help

Group number 1

OK: Default model

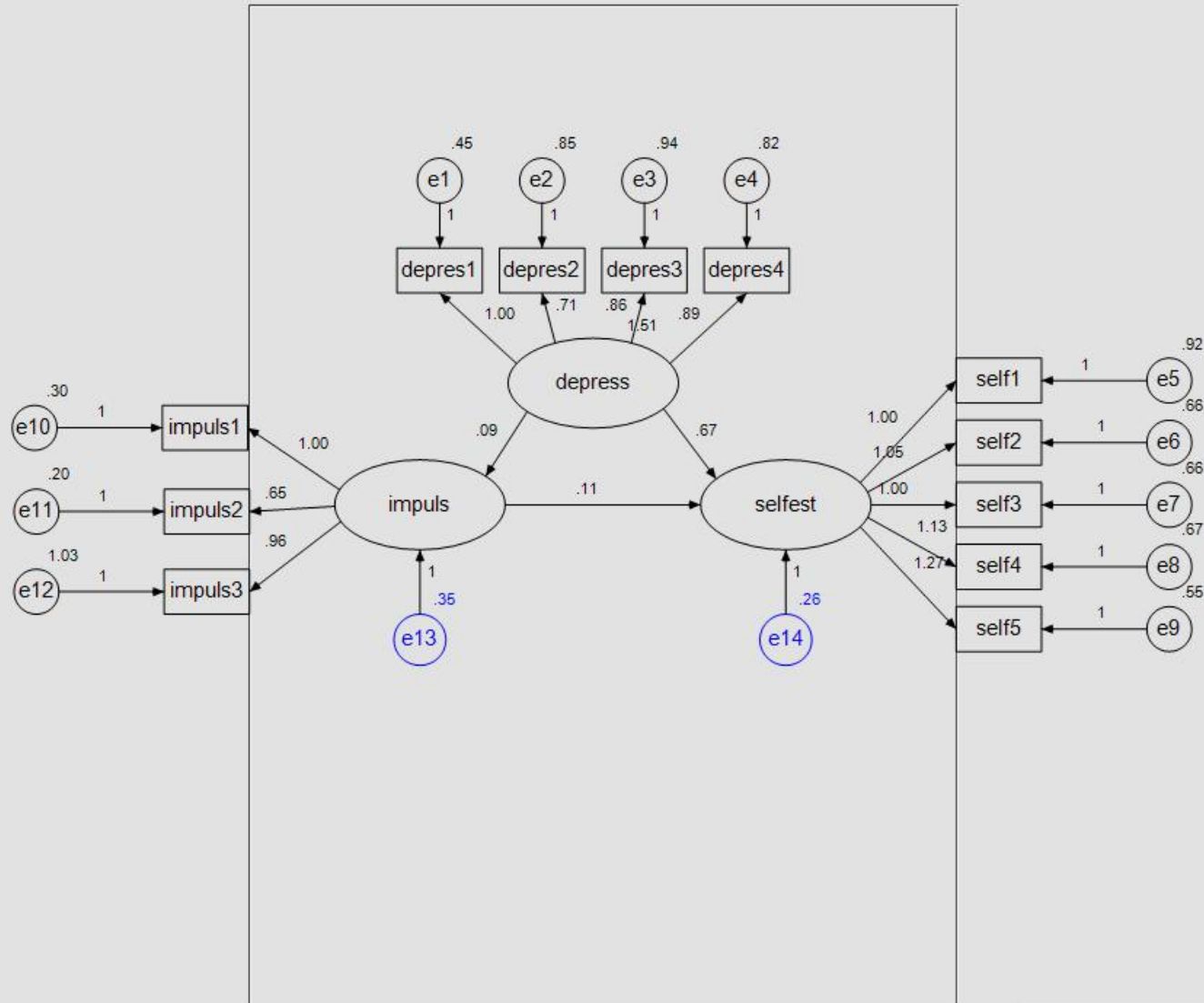
Unstandardized estimates
Standardized estimates

GROUP NUMBER 1
Check for incomplete data
Scanning Depress
Default model
Minimization
Minimum was achieved
Writing output
Chi-square = 5007.6, df = 78

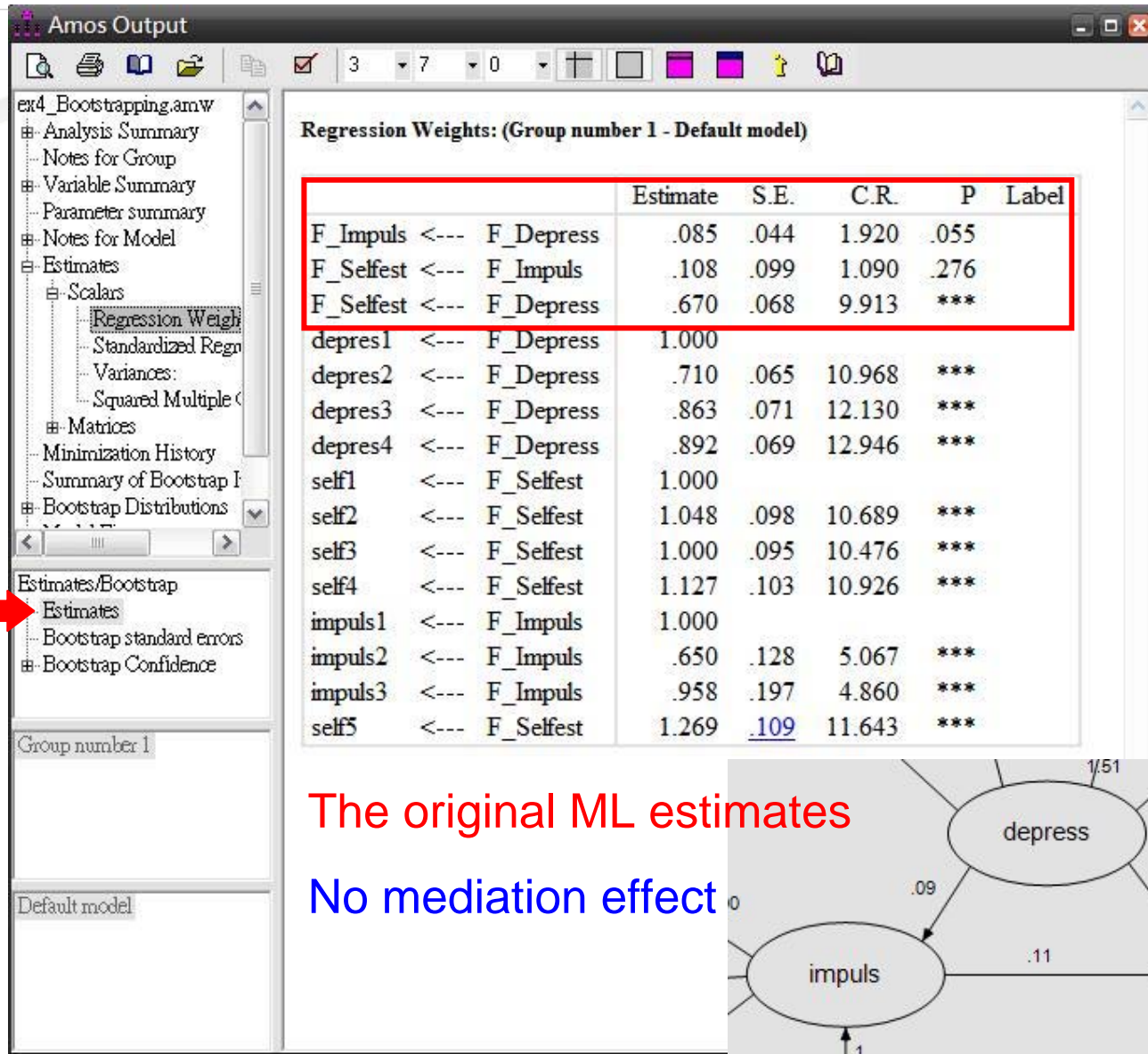
Scanning Depress
Default model
Minimization
Iteration 8
Minimum was achieved
Writing output
Chi-square = 122.8, df = 51

Bootstrap
Sample 1000
BC confidence intervals
Pass 1
Pass 2
Pass 3
Pass 4
Pass 5
Pass 6
Pass 7
Pass 8

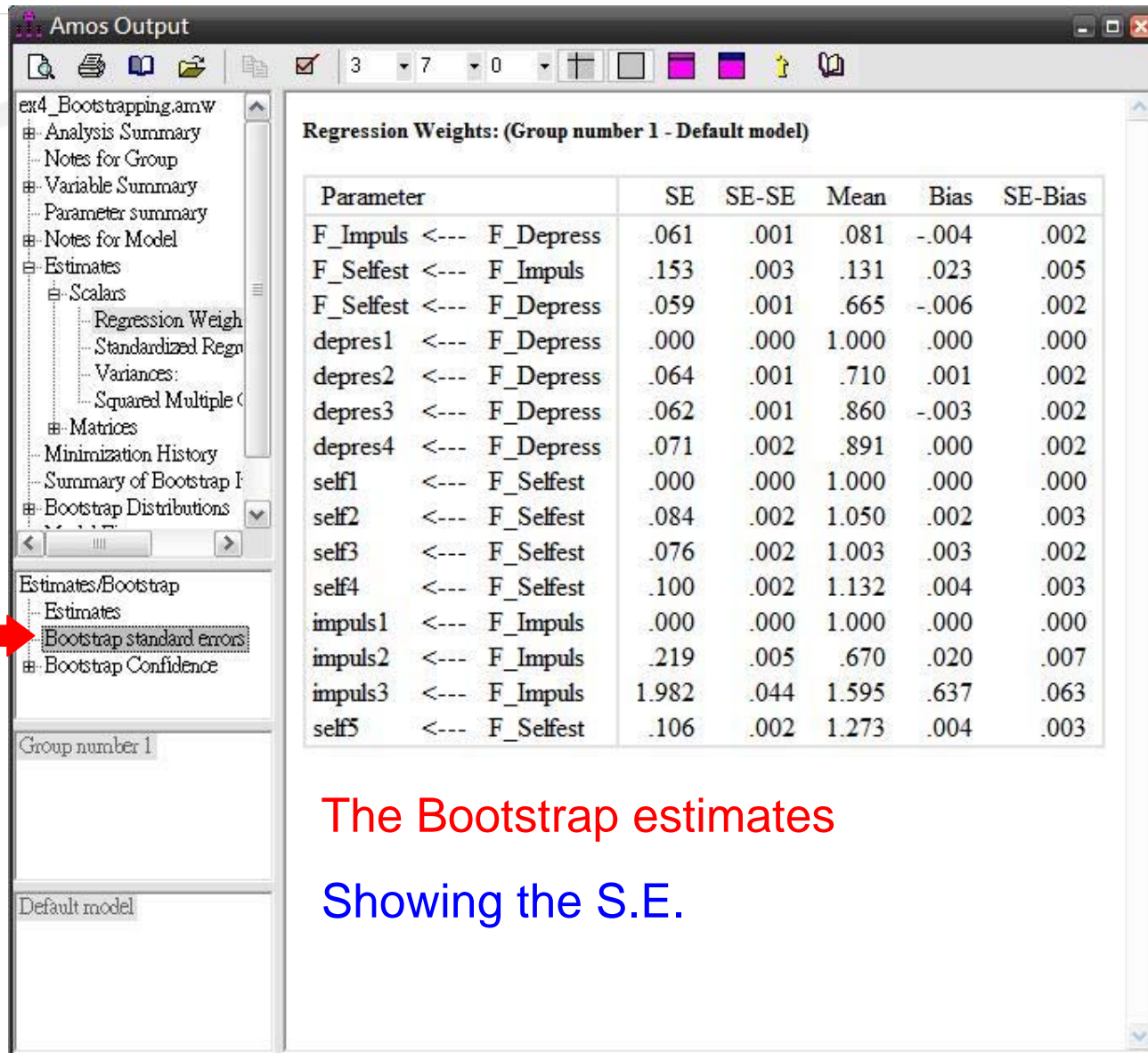
ext1_path.amw
ext2_CFA.amw
ext3_full.amw
ext4_Bootstrapping.amw



The result of bootstrapping in Amos



The result of bootstrapping in Amos



Amos Output

ex4_Bootstrapping.amw

- Analysis Summary
 - Notes for Group
- Variable Summary
- Parameter summary
- Notes for Model
- Estimates
 - Scalars
 - Regression Weights
 - Standardized Regression Weights
 - Variances
 - Squared Multiple Correlations
- Matrices
- Minimization History
- Summary of Bootstrap I
- Bootstrap Distributions

Estimates/Bootstrap

- Estimates
- Bootstrap standard errors**
- Bootstrap Confidence

Group number 1

Default model

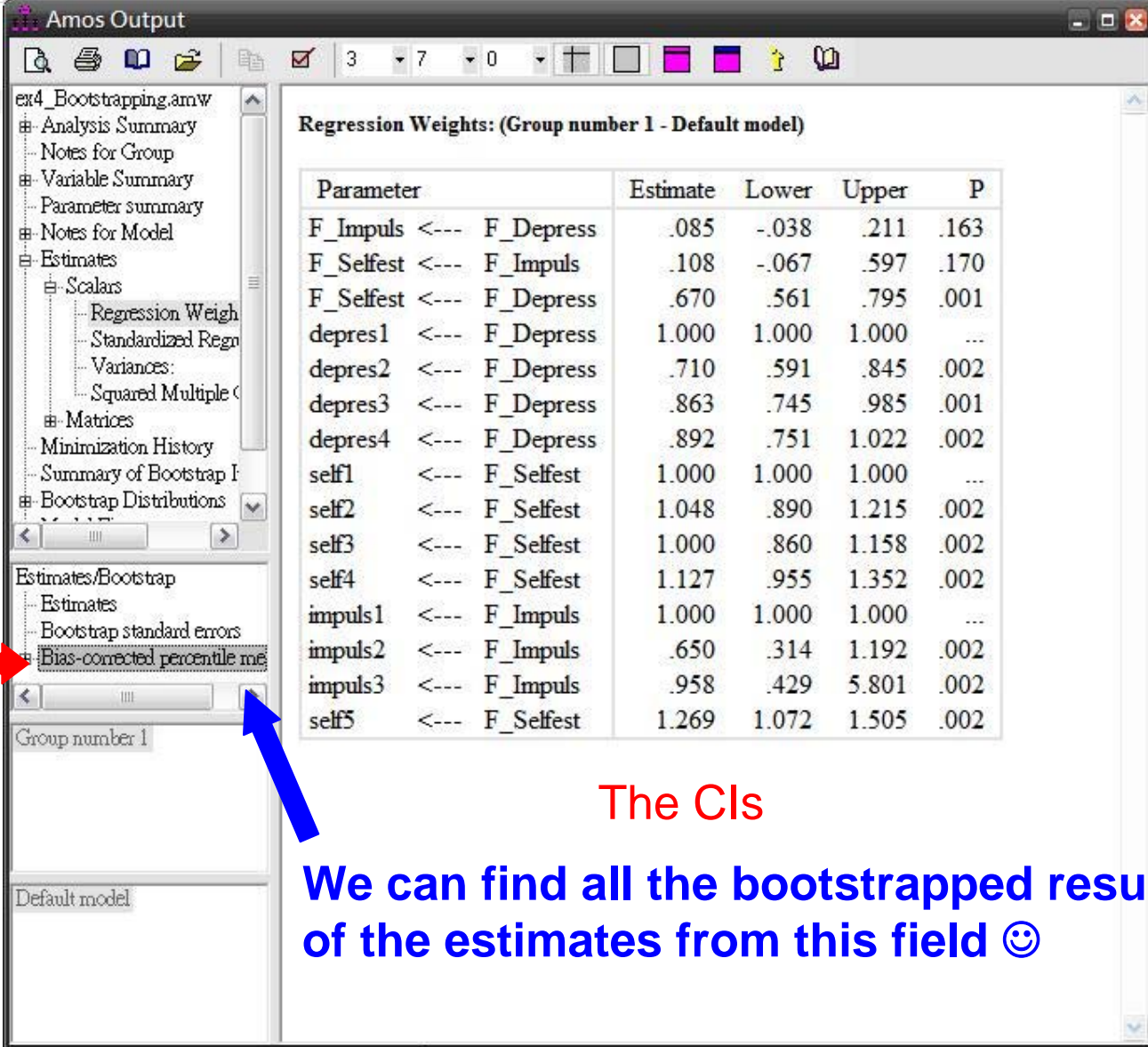
Regression Weights: (Group number 1 - Default model)

Parameter	SE	SE-SE	Mean	Bias	SE-Bias
F_Impuls <--- F_Depress	.061	.001	.081	-.004	.002
F_Selfest <--- F_Impuls	.153	.003	.131	.023	.005
F_Selfest <--- F_Depress	.059	.001	.665	-.006	.002
depres1 <--- F_Depress	.000	.000	1.000	.000	.000
depres2 <--- F_Depress	.064	.001	.710	.001	.002
depres3 <--- F_Depress	.062	.001	.860	-.003	.002
depres4 <--- F_Depress	.071	.002	.891	.000	.002
self1 <--- F_Selfest	.000	.000	1.000	.000	.000
self2 <--- F_Selfest	.084	.002	1.050	.002	.003
self3 <--- F_Selfest	.076	.002	1.003	.003	.002
self4 <--- F_Selfest	.100	.002	1.132	.004	.003
impuls1 <--- F_Impuls	.000	.000	1.000	.000	.000
impuls2 <--- F_Impuls	.219	.005	.670	.020	.007
impuls3 <--- F_Impuls	1.982	.044	1.595	.637	.063
self5 <--- F_Selfest	.106	.002	1.273	.004	.003

The Bootstrap estimates

Showing the S.E.

The result of bootstrapping in Amos



Amos Output

ex4_Bootstrapping.amw

- Analysis Summary
- Notes for Group
- Variable Summary
- Parameter summary
- Notes for Model
- Estimates
 - Scalars
 - Regression Weights
 - Standardized Regression Weights
 - Variances
 - Squared Multiple Correlations
 - Matrices
 - Minimization History
 - Summary of Bootstrap I
 - Bootstrap Distributions

Estimates/Bootstrap

- Estimates
- Bootstrap standard errors
- Bias-corrected percentile method

Group number 1

Default model

Regression Weights: (Group number 1 - Default model)

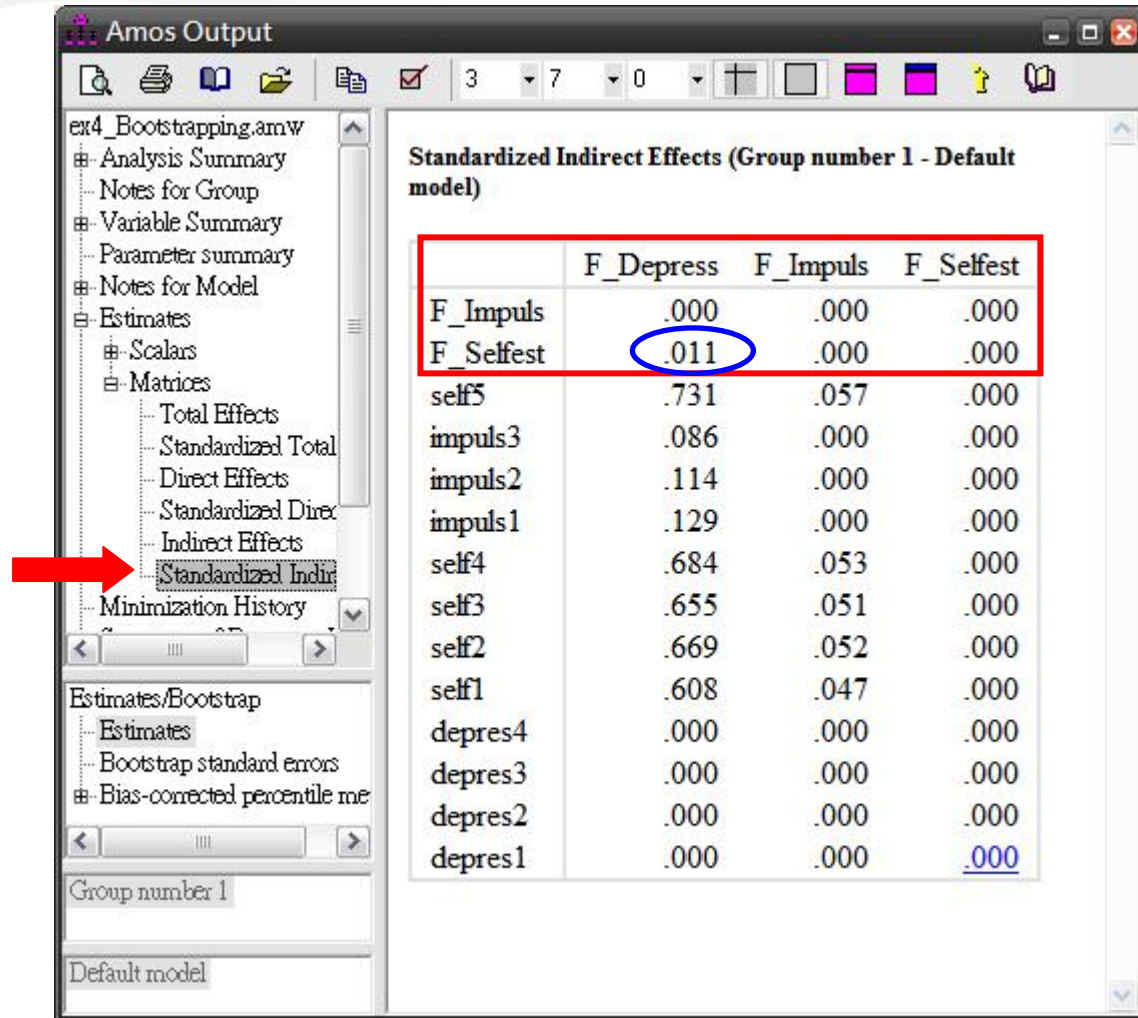
Parameter	Estimate	Lower	Upper	P
F_Impuls <--- F_Depress	.085	-.038	.211	.163
F_Selfest <--- F_Impuls	.108	-.067	.597	.170
F_Selfest <--- F_Depress	.670	.561	.795	.001
depres1 <--- F_Depress	1.000	1.000	1.000	...
depres2 <--- F_Depress	.710	.591	.845	.002
depres3 <--- F_Depress	.863	.745	.985	.001
depres4 <--- F_Depress	.892	.751	1.022	.002
self1 <--- F_Selfest	1.000	1.000	1.000	...
self2 <--- F_Selfest	1.048	.890	1.215	.002
self3 <--- F_Selfest	1.000	.860	1.158	.002
self4 <--- F_Selfest	1.127	.955	1.352	.002
impuls1 <--- F_Impuls	1.000	1.000	1.000	...
impuls2 <--- F_Impuls	.650	.314	1.192	.002
impuls3 <--- F_Impuls	.958	.429	5.801	.002
self5 <--- F_Selfest	1.269	1.072	1.505	.002

The CIs

We can find all the bootstrapped results of the estimates from this field 😊

The result of bootstrapping in Amos

How to check the mediation effect?



Amos Output

ex4_Bootstrapping.amw

- Analysis Summary
 - Notes for Group
- Variable Summary
- Parameter summary
- Notes for Model
- Estimates
 - Scalars
 - Matrices
 - Total Effects
 - Standardized Total
 - Direct Effects
 - Standardized Direct
 - Indirect Effects
 - Standardized Indirect**
- Minimization History

Estimates/Bootstrap

- Estimates
- Bootstrap standard errors
- Bias-corrected percentile me

Group number 1

Default model

Standardized Indirect Effects (Group number 1 - Default model)

	F_Depress	F_Impuls	F_Selfest
F_Impuls	.000	.000	.000
F_Selfest	.011	.000	.000
self5	.731	.057	.000
impuls3	.086	.000	.000
impuls2	.114	.000	.000
impuls1	.129	.000	.000
self4	.684	.053	.000
self3	.655	.051	.000
self2	.669	.052	.000
self1	.608	.047	.000
depres4	.000	.000	.000
depres3	.000	.000	.000
depres2	.000	.000	.000
depres1	.000	.000	.000

The result of bootstrapping in Amos

Amos Output

ex4_Bootstrapping.amw

- Analysis Summary
- Notes for Group
- Variable Summary
- Parameter summary
- Notes for Model
- Estimates
 - Scalars
 - Matrices
 - Total Effects
 - Standardized Total
 - Direct Effects
 - Standardized Direct
 - Indirect Effects
 - Standardized Indirect
- Minimization History

Estimates/Bootstrap

- Estimates
- Bootstrap standard errors
- Bias-corrected percentile method

Group number 1

Default model

Standardized Indirect Effects (Group number 1 - Default model)

Standardized Indirect Effects **Lower Bounds (BC)** (Group number 1 - Default model)

	F_Depress	F_Impuls	F_Selfest
F_Impuls	.000	.000	.000
F_Selfest	→ -.005	.000	.000
self5	.618	-.025	.000
impuls3	-.030	.000	.000
impuls2	-.049	.000	.000
impuls1	-.062	.000	.000
self4	.581	-.023	.000
self3	.565	-.022	.000
self2	.581	-.022	.000
self1	.528	-.021	.000
depres4	.000	.000	.000
depres3	.000	.000	.000
depres2	.000	.000	.000
depres1	.000	.000	.000

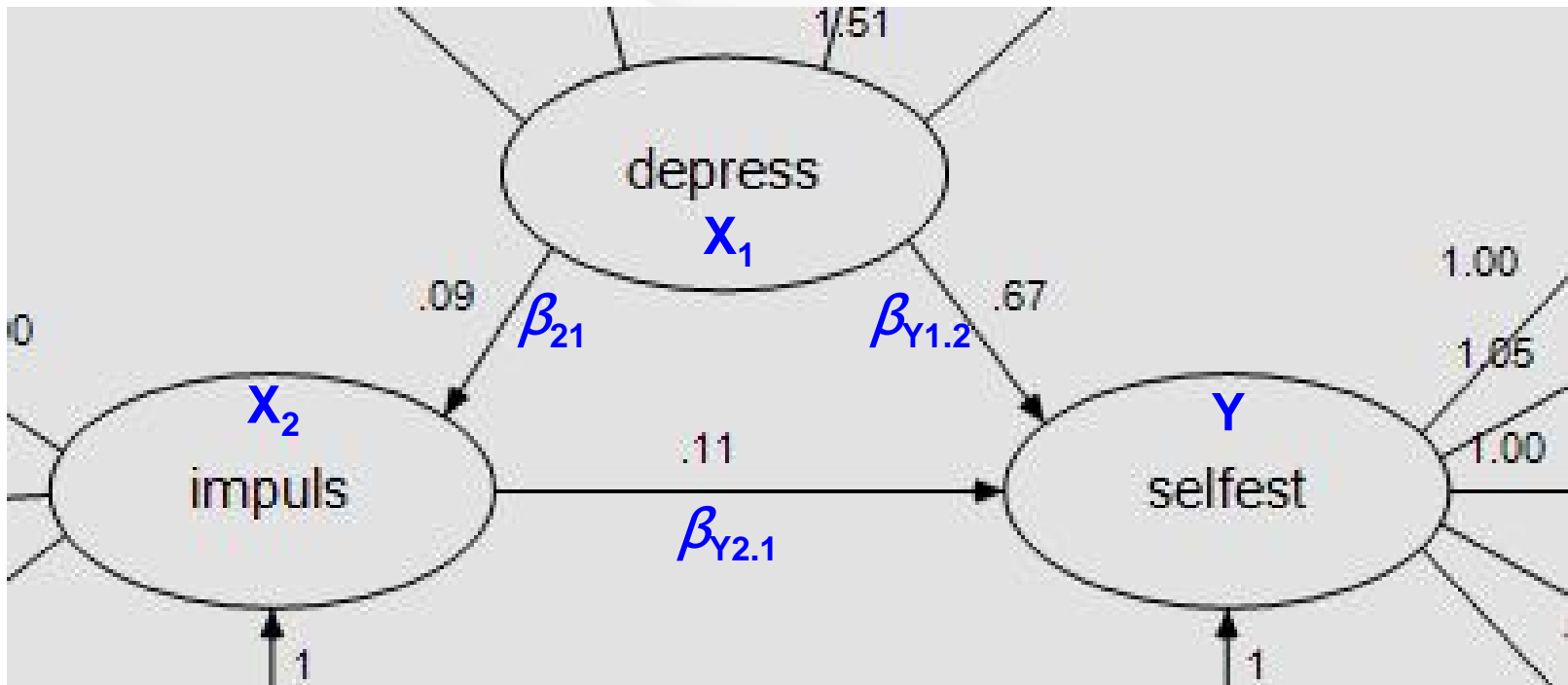
Standardized Indirect Effects **Upper Bounds (BC)** (Group number 1 - Default model)

	F_Depress	F_Impuls	F_Selfest
F_Impuls	.000	.000	.000
F_Selfest	→ .106	.000	.000
self5	.819	.184	.000
impuls3	.502	.000	.000
impuls2	.245	.000	.000
impuls1	.302	.000	.000
self4	.766	.171	.000
self3	.734	.174	.000
self2	.753	.174	.000
self1	.691	.154	.000
depres4	.000	.000	.000
depres3	.000	.000	.000
depres2	.000	.000	.000
depres1	.000	.000	.000

Indirect effect of depress on selfest is: .011 (95% CI: -.005 ~ .106)

The result of bootstrapping in Amos

Indirect effect of depress on selfest is: .011 (95% CI: -.005 ~ .106)



We cannot reject the null hypothesis, $H_0: \beta_{21} * \beta_{Y2.1} = 0$
There is no mediation effect! (Cheung & Lau, 2008)

References

- Cheung, G. W., & Lau, R. S. (2008). Testing mediation and suppression effects of latent variables: Bootstrapping with structural equation models. *Organizational Research Methods*, 11(2), 296-325.
- MacKinnon, D. P. (2008). *Introduction to Statistical Mediation Analysis*. New York, NY: Lawrence Erlbaum Associates.
- Byrne, B. M. (2001). *Structural equation modeling with AMOS: Basic concepts, applications, and programming*. Mahwah, NJ: Lawrence Erlbaum Associates.



Thank You !