Partial Least Squares Structural Equation Modeling IIIa

Evaluation of formative measurement models

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Outline

Outcome

This lecture will help you to understand

- The necessary steps for an assessment of the formative measurement model
  - Convergent validity
  - Collinearity issues
  - Significance and relevance

Recap - reflective and formative

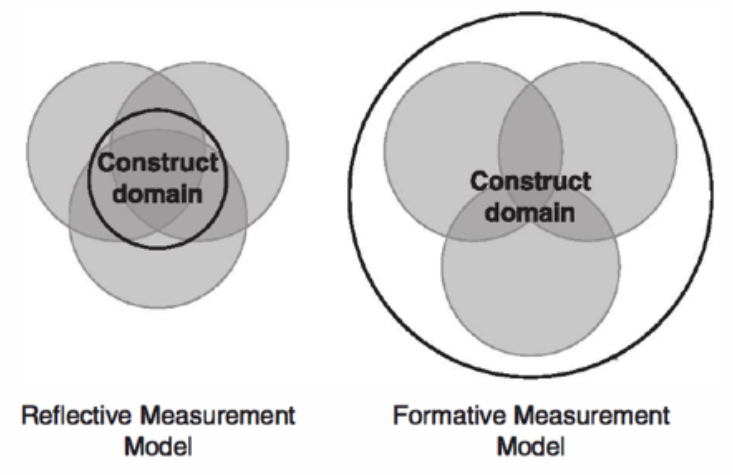

Figure: The conceptual difference between formative and reflective measures. (Source: Hair et al. 2022)

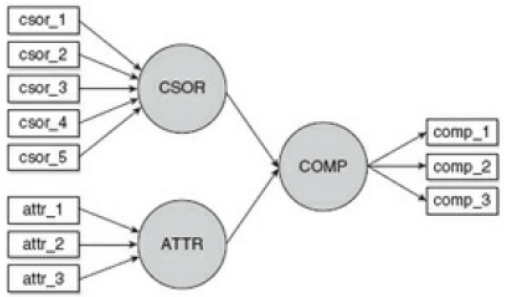

Figure: Model with reflective (right) and formative (left) measurements. (Source: Hair et al. 2022)

General considerations

- Formative measures do not necessarily covary, so we cannot use correlation patterns to evaluate the formative measurement models
- First establish content or face validity before empirically evaluating the formatively measured constructs – does it make sense to use this set of indicators to measure this construct?
  - Content specification: Clearly specify the domain of the construct which the indicators should cover
  - Develop a good formative index: Conduct thorough literature review to ensure reasonable theoretical grounding

Assessment procedure

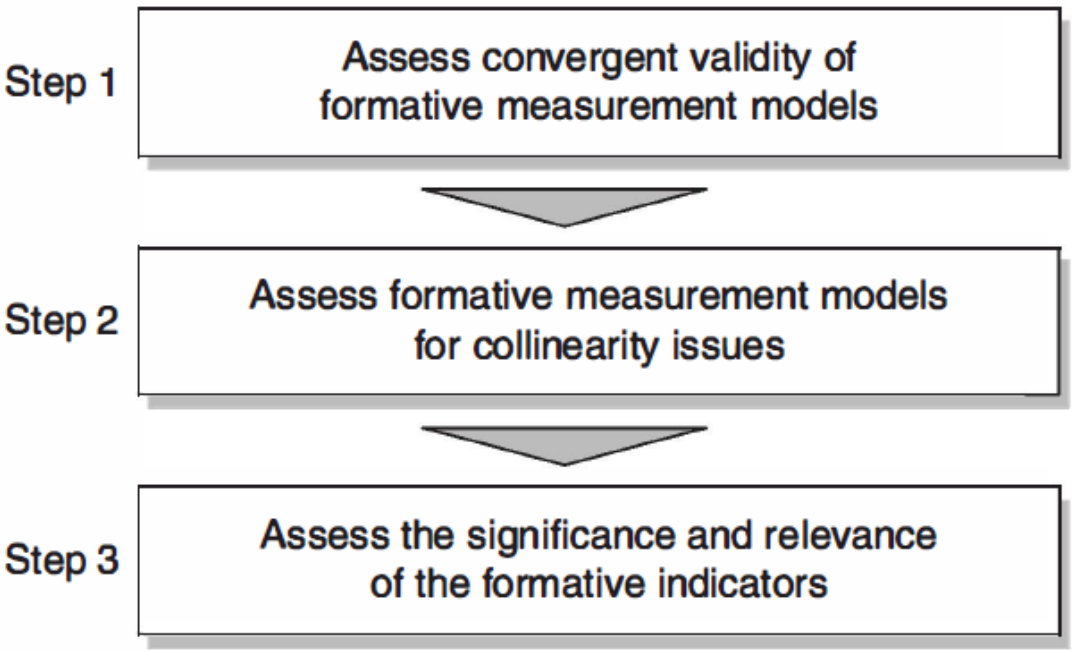

Figure: Fig 5.1

Assess convergent validity

- Convergent validity is the extent to which a formatively measured construct correlates positively with other (reflective) measures of the same construct
- Path coefficient between Y_1 and Y_2 at least above 0.7
- Reflective measures must also be included in the data collection (use scale handbooks to assist in selecting reflective measures)
- Alternatively use global single item that summarize essence of construct

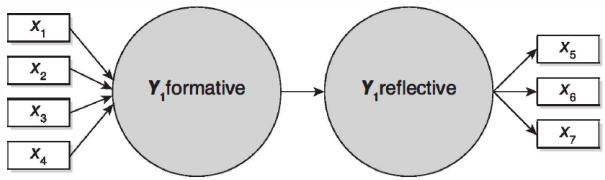

Figure: Redundancy analysis for convergent validity assessment. (Source: Hair et al. 2022)

Collinearity issues

- Perfect collinearity in a formative measurement model: Two indicators have a correlation of 1 $\rightarrow$ cannot estimate the model
- (Multi)collinearity in a formative measurement model: High correlation between two (or more) formative indicators
  - Increase standard errors (harder to find significant effects) of the outer weights
  - Outer weight estimates becomes very sensitive to small changes in model or sample data

Assessing and dealing with collinearity issues I

- Tolerance: The amount of variance in one formative indicator, not explained by the other indicators from the same construct
- How to calculate the tolerance of a variable, say x, (TOL_x):
  - Regress x on the rest of the indicators from the same construct
  - Obtain its R^2 value (the variance in x that can be explained from the other indicators)

$$TOL_x = 1 - R^2$$

- Variance inflation factor (VIF): Measures how much the variance of an estimated regression coefficient (weight) increases due to collinearity

$$VIF_x = 1/TOL_x$$

- Tolerance < 0.2 or VIF > 5 indicates potential collinearity problems

Assessing and dealing with collinearity issues II

- Possible treatment of collinearity issues
  - Remove indicators
  - Set up a formative-formative higher order construct (not treated in this course)
- Have content validity of the construct in mind (will the indicators capture the intended content of the construct)
- If we cannot mitigate the collinearity problems, we cannot interpret the formative measurement model (but the constructs relationships with other constructs can still be analysed) – consider to dismiss the use of a formative measurement model
- When collinearity is not a problem, then we can proceed to test for significance of the weights

Assess significance and relevance of formative indicators

- The outer weights represent each indicators relative contribution to the construct
- Absolute contribution: The information an indicator provides to the construct without considering any other indicator. Measured by the outer loading (the correlation between construct and indicator)
- Comparison of formatively measured constructs between different models should be done with caution

Decision-making process for keeping or deleting formative indicators

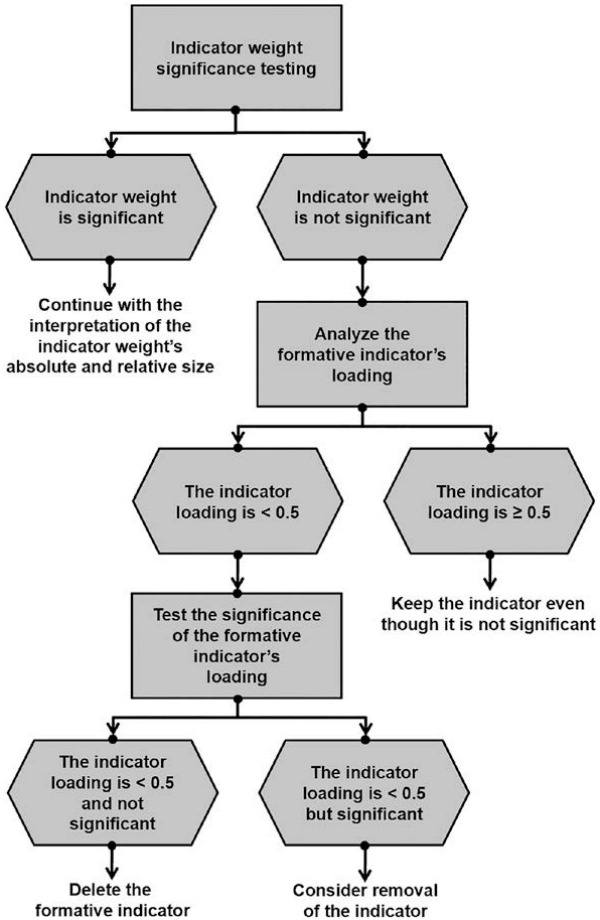

Figure: Fig 5.2

Bootstrapping

- Data is not assumed to be normally distributed when using PLS-SEM and significance testing is routinely conducted using bootstrapping

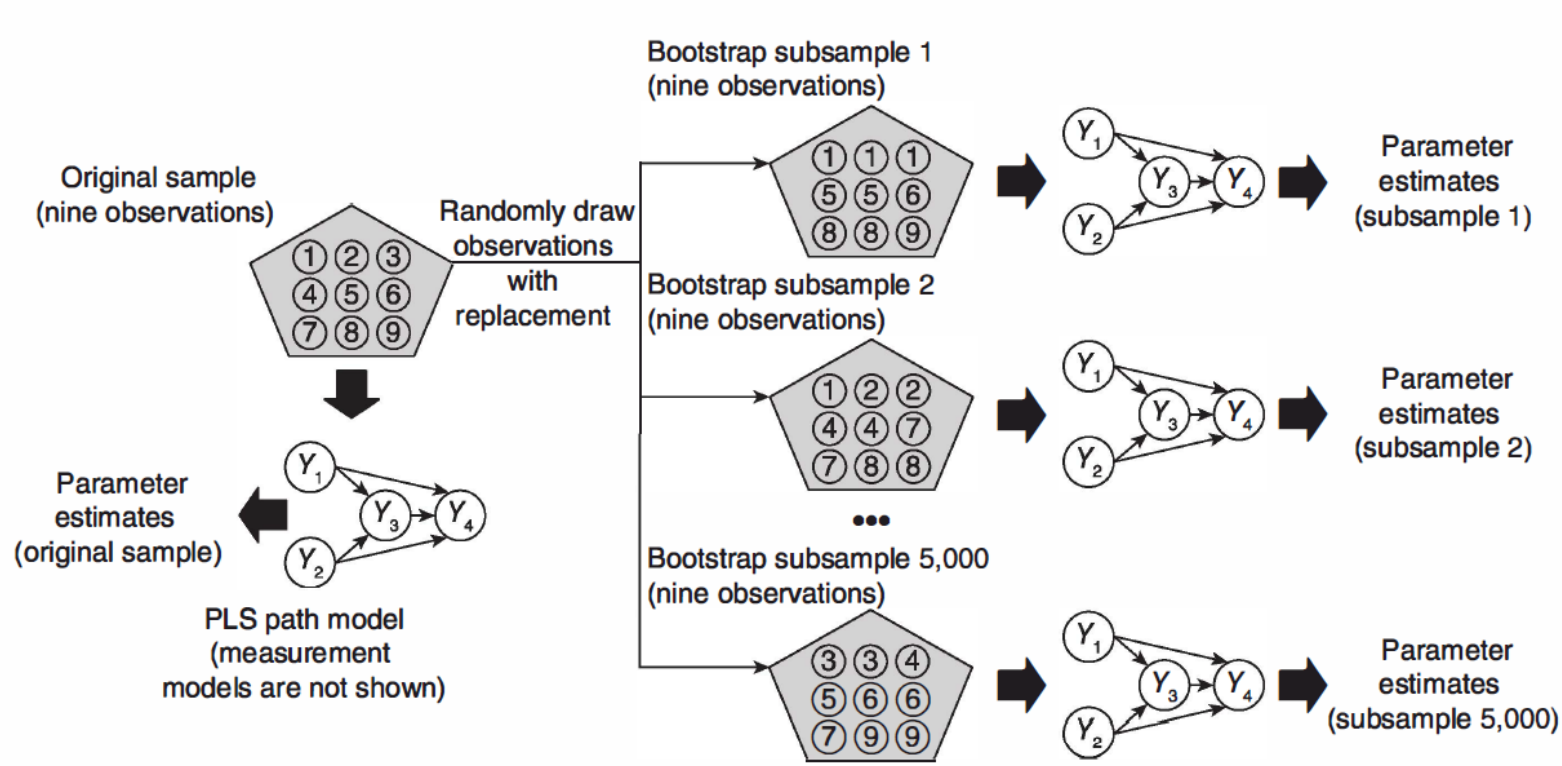

Figure: Bootstrapping. (Source: Hair et al. 2022)

Bootstrapping - significance testing

- The bootstrap distribution (of the estimated coefficients) can be viewed as a reasonable approximation of an estimated coefficient's distribution in the population
- Let $se^*_{w_1}$ be the standard error of an outer weight, which is calculated from the bootstrap sample. Then use Student's t-test to test for significance of w_1:

$$t = \frac{w_1}{se^*_{w_1}}$$

- Degrees of freedom: n-k-1, where n is the number of observations and k is the number of indicators relating to the specific construct

Bootstrapping - confidence interval

- Percentile confidence intervals
  - Let B be the number of bootstrap samples. Order the B bootstrap estimates, from smallest to largest
  - The 95% confidence interval lower bound: The value of the (ordered) bootstrap estimate that have 2.5% of the bootstrap estimates being smaller. Similarly for the upper bound (but replacing 2.5% with 97.5%)
  - Can be biased for small sample size (i.e. under 300) or non-symmetric distribution of the parameters
- Studentized bootstrap confidence intervals
  - Let an outer weight, w_1, have bootstrap standard error se^*_{w1}, then the corresponding $100(1-\alpha)\%$ confidence interval is $[w_1 - t_{1-\alpha/2} \times se^*_{w1}; w_1 + t_{1-\alpha/2} \times se^*_{w1}]$

Full corporate reputation model

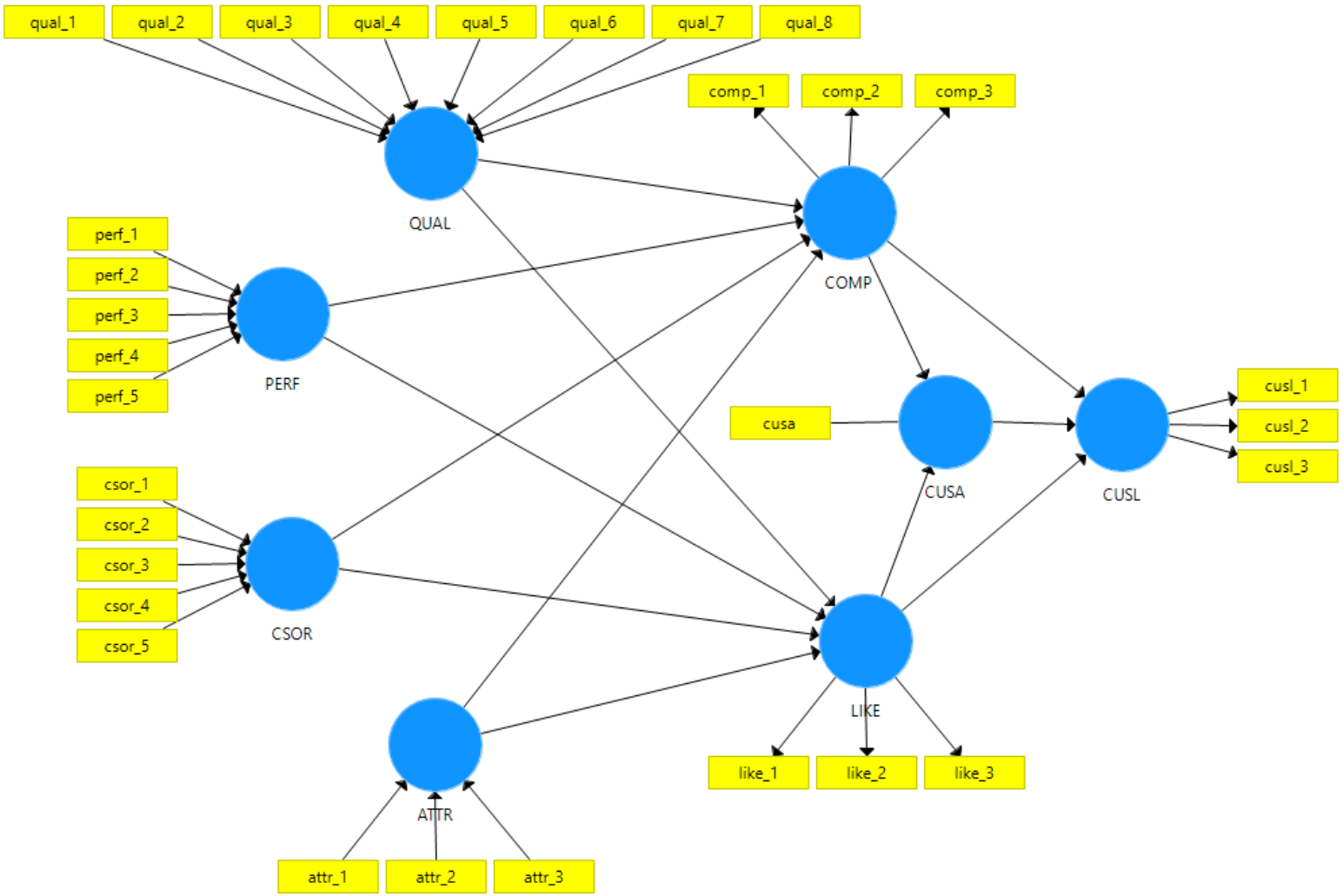

Figure: Full corporate reputation model. (Source: Hair et al. 2022)

Drivers of corporate reputation

The drivers can inform the company on how to improve their reputation

- Quality (QUAL): Quality of products, services and customer orientation
- Performance (PERF): Economic and managerial performance
- Attractiveness (ATTR): How attractive is the company to employees
- Corporate social responsibility (CSOR): Does the company behave in a social responsible way

Formative indicators

Quality (QUAL)	
qual_1	The products/services offered by [the company] are of high quality.
qual_2	[The company] is an innovator, rather than an imitator with respect to [industry].
qual_3	[The company]'s products/services offer good value for money.
qual_4	The services [the company] offered are good.
qual_5	Customer concerns are held in high regard at [the company].
qual_6	[The company] is a reliable partner for customers.
qual_7	[The company] is a trustworthy company.
qual_8	I have a lot of respect for [the company].
Performance (PERF)	
perf_1	[The company] is a very well-managed company.
perf_2	[The company] is an economically stable company.
perf_3	The business risk for [the company] is modest compared to its competitors
perf_4	[The company] has growth potential.
perf_5	[The company] has a clear vision about the future of the company.

Corporate Social Responsibility (CSOR)	
csor_1	[The company] behaves in a socially conscious way.
csor_2	[The company] is forthright in giving information to the public.
csor_3	[The company] has a fair attitude toward competitors.
csor_4	[The company] is concerned about the preservation of the environment.
csor_5	[The company] is not only concerned about profits.
Attractiveness (ATTR)	
attr_1	[The company] is successful in attracting high-quality employees.
attr_2	I could see myself working at [the company].
attr_3	I like the physical appearance of [the company] (company, buildings, shops, etc.).

Figure: Table 5.3

Justification for measuring drivers as formative

"*Intuitively, it is possible for a company to be forthright in giving information to the public, while simultaneously not necessarily behaving in a socially conscious way (in the eyes of the stakeholders). Therefore, these indicators need not necessarily correlate from a theoretical point of view*"
(Source: Eberl 2010, Handbook of Partial Least Squares: Concepts, Methods and Applications)

Corporate reputation model – formative measurement evaluation

- Convergent validity: Path coefficients above 0.7 for all formatively measured constructs in the redundancy analyses
- Collinearity: No collinearity issues, for all formative indicators the VIF's are below the conservative threshold of 3
- Significance and relevance of indicators
  - The following formative indicators have non-significant weights: *qual_2, qual_3, qual_4, csor_2* and *csor_4*
  - However, all these indicators have loadings above 0.5, so we keep them in the model

Exercises

- Complete exercise 1, 2, 3, and 4 on page 111 in Hair et al. 2021.