FORMATIIVISTA MITTAAMISTA EI OLE OLEMASSA, MUTTA FORMATIIVISET MALLIT VOIVAT OLLA HYÖDYLLISIÄ

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Psychological Methods

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In Defense of Causal–Formative Indicators: A Minority Report

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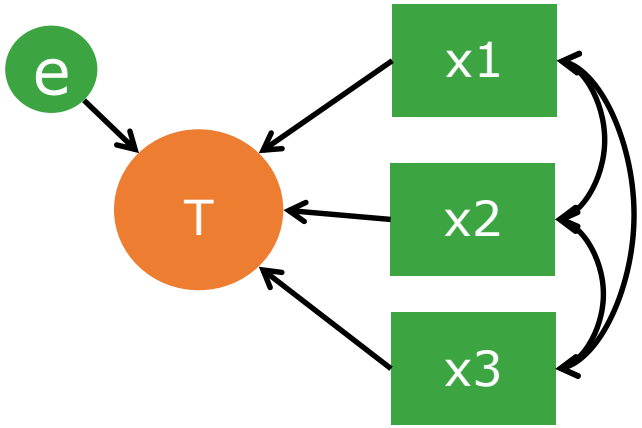
Causal–formative indicators directly affect their corresponding latent variable. They run counter to the predominant view that indicators *depend* on latent variables and are thus often controversial. If present, such indicators have serious implications for factor analysis, reliability theory, item response theory, structural equation models, and most measurement approaches that are based on reflective or effect indicators. *Psychological Methods* has published a number of influential articles on causal and formative indicators as well as launching the first major backlash against them. This article examines 7 common criticisms of these indicators distilled from the literature: (a) A construct measured with "formative" indicators does not exist independently of its indicators; (b) Such indicators are causes rather than measures; (c) They imply multiple dimensions to a construct and this is a liability; (d) They are assumed to be error-free, which is unrealistic; (e) They are inherently subject to interpretational confounding; (f) They fail proportionality constraints; and (g) Their coefficients should be set in advance and not estimated. We summarize each of these criticisms and point out the flaws in the logic and evidence marshaled in their support. The most common problems are not distinguishing between what we call causal–formative and composite–formative indicators, tautological fallacies, and highlighting issues that are common to all indicators, but presenting them as special problems of causal–formative indicators. We conclude that measurement theory needs (a) to incorporate these types of indicators, and (b) to better understand their similarities to and differences from traditional indicators.

Keywords: causal indicators, formative indicators, composites, measurement models, structural equation models

Formative measurement

Formative measurement?

- Measures cause the construct
- A CEO responding positively to a survey causes the firm to be innovative
- How you respond to questions about your income, education, etc. defines your socio economic status



. . . Formative indicators are not measures at all.
—Lee, Cadogan, and Chamberlain (2013, p. 12)

Disciplines such as IS should consider avoiding formative measurement . . . editors should question and perhaps even temporarily discourage the use of formative measurement.
—Hardin and Marcoulides (2011, p. 761)

The shortcomings of formative measurement lead to the inexorable conclusion that formative measurement models should be abandoned.
—Edwards (2011, p. 383)

Bollen, K. A., & Diamantopoulos, A. (2017). In defense of causal-formative indicators: A minority report. *Psychological Methods*, *22*(3), 581–596. https://doi.org/10.1037/met0000056 p. 581

Guidelines for using formative measurement

Table 1
Conceptual Checks and Empirical Test for Determining Whether Indicators Are Causal–Formative or Reflective (Effect)

Conceptual check	
Mental experiment (see Bollen, 1989; Bollen & Lennox, 1991)	1. *Reflective (effect) indicators*: Imagine a change in latent variable net of other indicator influences. Will this lead to a change in the indicators? 2. *Causal–formative indicators*: Imagine a change in the indicator net of other latent variable influences. Will this lead to a change in the latent variable?
Empirical test	
Vanishing tetrad test (see Bollen & Ting, 2000) **Fallacy: rejection of one model does not imply acceptance of another**	1. Based on hypotheses and mental experiments, formulate one or more measurement models with causal–formative indicators, reflective (effect) indicators, or some combination. 2. Calculate chi-square test for each model and assess fit. 3. Compare any of the competing models that are nested in their vanishing tetrads. 4. Choose the hypothesized model with the best fit.

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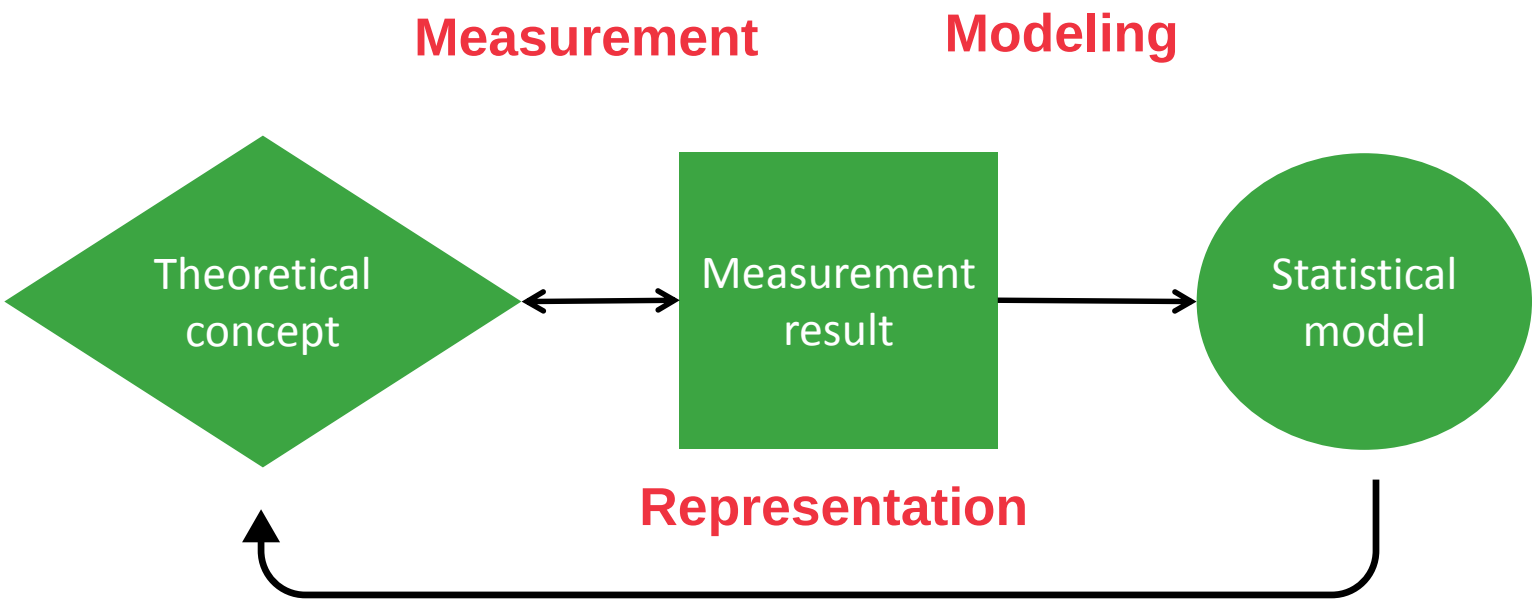
Measurement and modeling



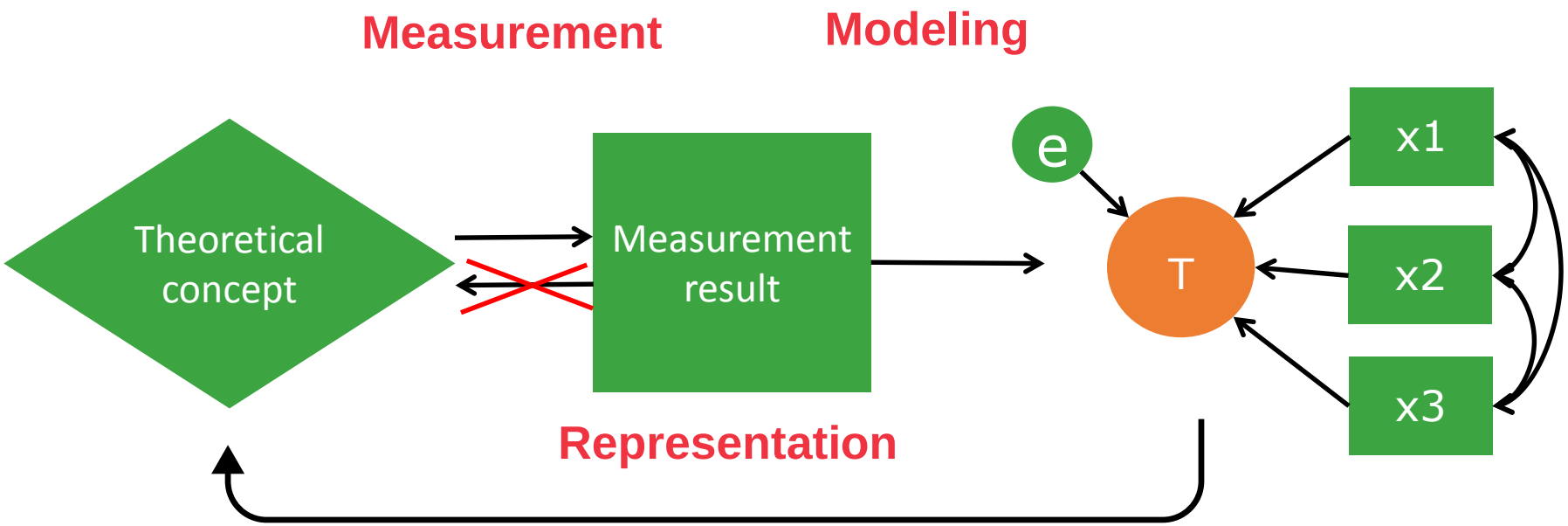
Markus, K. A. (2018). Three conceptual impediments to developing scale theory for formative scales. *Methodology*, *14*(4), 156–164. https://doi.org/10.1027/1614-2241/a000154

Items as causes of constructs

Third, I hypothesize that the conflation of item scores with the attributes that one interprets the items as assessing poses a third conceptual impediment to progress. Consider the following characterization: "That is, a change in SES is not expected to lead to a change in each of these indicators. Rather, a change in one or more of these indicators leads to a change in SES" (Bollen, 1984, p. 380). Presumably, no one means to suggest that one can improve one's SES by changing one's answers to three survey items. Clearly, then, one must take Bollen to refer here to the attributes that the items assess. However, scales do not comprise attributes, they comprise items. Likewise, item scores determine scale scores. Thus, formative measurement theory needs to better maintain this distinction in order to provide a clear-headed account of formative scales.

Markus, K. A. (2018). Three conceptual impediments to developing scale theory for formative scales. *Methodology*, *14*(4), 156–164. https://doi.org/10.1027/1614-2241/a000154 pp. 157-158

Measurement and modeling



Formative models might be useful but are not measurement (Markus & Borsboom, 2013, Chapter 6, Rhemtulla et al 2015)

Markus, K. A., & Borsboom, D. (2013). Frontiers in test validity theory: measurement, causation and meaning. New York, N.Y.: Psychology Press. (pp 32-33)

Rhemtulla, M., Bork, R. van, & Borsboom, D. (2015). Calling Models With Causal Indicators “Measurement Models” Implies More Than They Can Deliver. *Measurement: Interdisciplinary Research and Perspectives*, *13*(1), 59–62. http://doi.org/10.1080/15366367.2015.1016343

Alternatives to formative measurement models

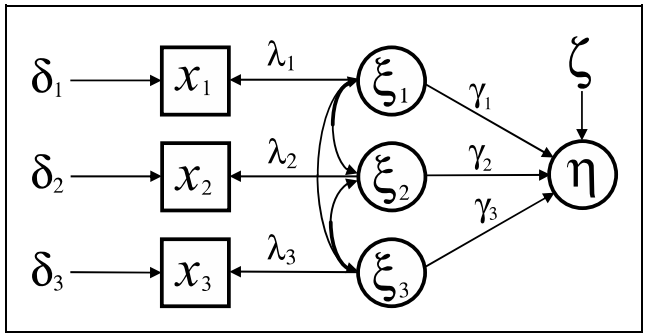


Figure 5. Model that replaces formative measures with facet constructs and single reflective measures

Aguinis, H., & Edwards, J. R. (2014). Methodological Wishes for the Next Decade and How to Make Wishes Come True. *Journal of Management Studies*, *51*(1), 143–174. https://doi.org/10.1111/joms.12058

Edwards, J. R. (2011). The Fallacy of Formative Measurement. *Organizational Research Methods*, *14*(2), 370–388. https://doi.org/10.1177/1094428110378369

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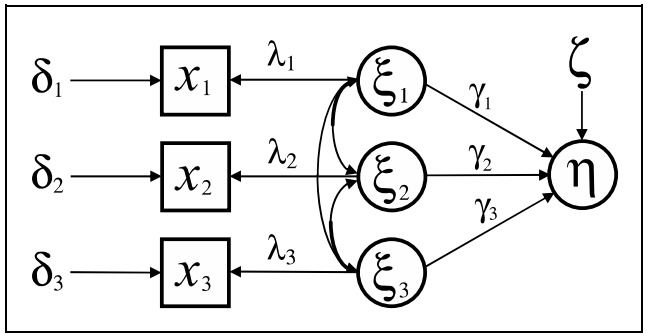

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Alternatives to formative measurement models

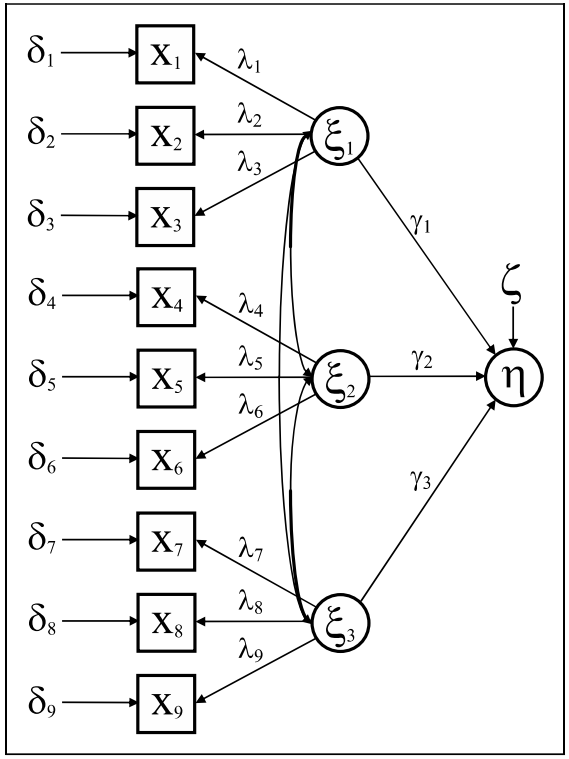


Figure 6. Model that replaces formative measures with facet constructs and multiple reflective measures

Aguinis, H., & Edwards, J. R. (2014). Methodological Wishes for the Next Decade and How to Make Wishes Come True. *Journal of Management Studies*, *51*(1), 143–174. https://doi.org/10.1111/joms.12058

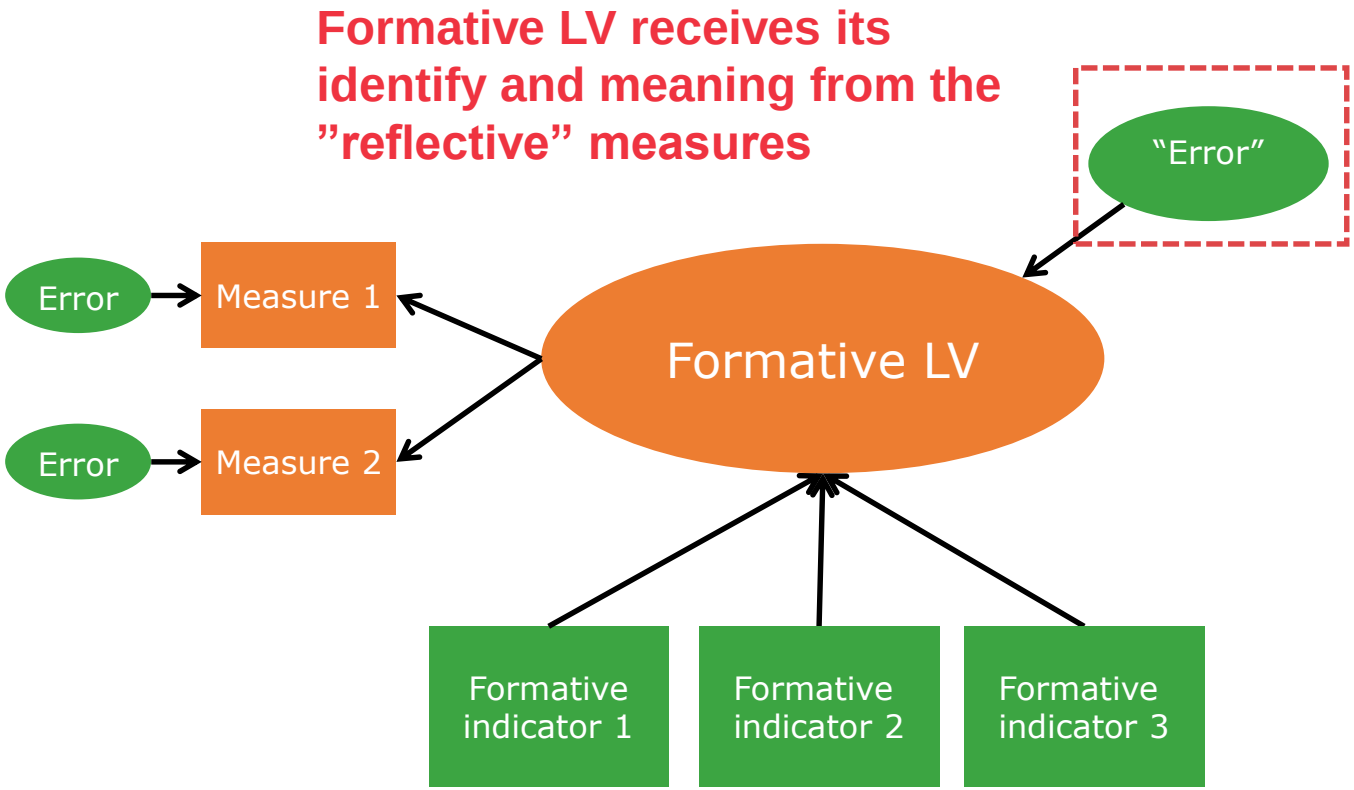
Edwards, J. R. (2011). The Fallacy of Formative Measurement. *Organizational Research Methods*, *14*(2), 370–388. https://doi.org/10.1177/1094428110378369

Summary of formative measurement

- Formative measurement does not exist
  - Items do not cause the construct
  - If they did, this would be easy to demonstrate by manipulating the measures
- Formative models (indices) can be useful
  - Items that go into the index must be validated outside the index
  - An index must be justified

Statistical issues in formative models

Identification of formative models



Aguirre-Urreta, M. I., Rönkkö, M., & Marakas, G. M. (2016). Omission of Causal Indicators: Consequences and Implications for Measurement. *Measurement: Interdisciplinary Research and Perspectives*, *14*(3), 75–97. https://doi.org/10.1080/15366367.2016.1205935
Aguirre-Urreta, M. I., Rönkkö, M., & Marakas, G. M. (2016). Omission of Causal Indicators: Consequences and Implications for Measurement – A Rejoinder. *Measurement: Interdisciplinary Research and Perspectives*, *14*(4), 170–175. https://doi.org/10.1080/15366367.2016.1257323

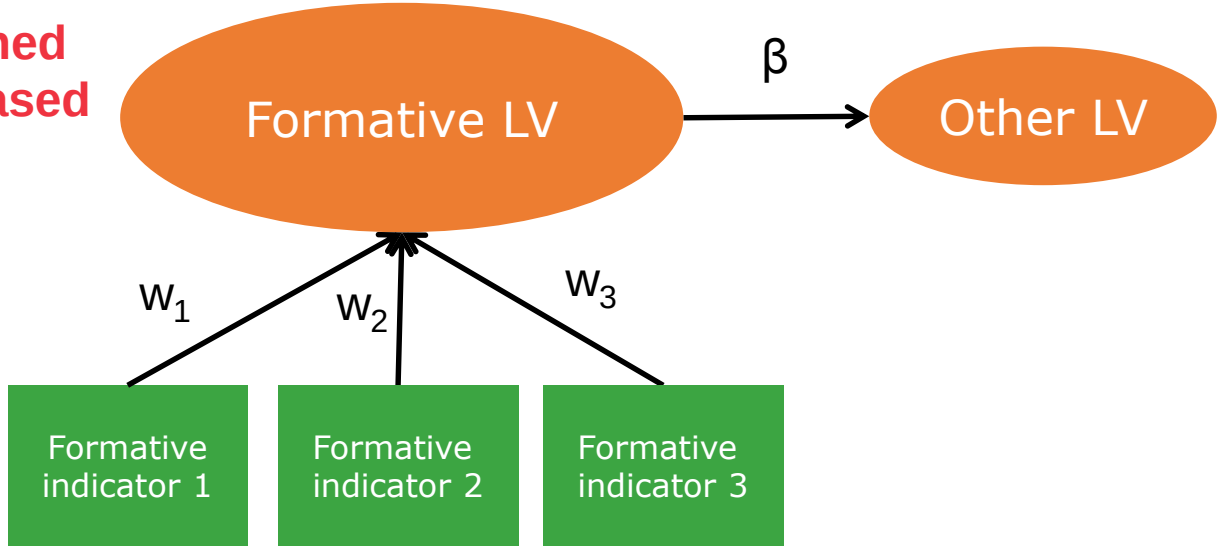
Composite model and weight calculation

Weights are defined to maximize β

- **Possible positive bias**
- **Full mediation assumed**
- **Interpretational confounding**

Solution: defined the weights based on theory

Indices



Lee, N., & Cadogan, J. W. (2013). Problems with formative and higher-order reflective variables. *Journal of Business Research*, *66*(2), 242–247. https://doi.org/10.1016/j.jbusres.2012.08.004

Multiple item indices

Scale and non-scale variables

1. How well do the following statements describe your firm?

	Strongly disagree	Disagree	Do not agree or disagree	Agree	Strongly agree
Our firm is very innovative	1	2	3	4	5
We are the technological leader in our industry	1	2	3	4	5
We are often the first to bring new product concepts to markets	1	2	3	4	5

Unidimensional scale

- Items measure the same quantity
- Items are highly correlated
- If it were not for random error (unreliability), the items would be perfectly correlated

Non-scale variables

- Items measure distinct quantities
- Items may not be highly correlated
- Example: beer, wine, and hard alcohol as sources of alcohol
- Example: various alternative ways that a company can do supply chain redesign

Perhaps an example at this point will help clarify some of the issues raised concerning multicollinearity. Suppose we are interested in estimating the effect of various school expenditure categories on student performance. It is likely that expenditures on teacher salaries, instructional materials, athletics, and so on are highly correlated: Wealthier schools tend to spend more on everything, and poorer schools spend less on everything. Not surprisingly, it can be difficult to estimate the effect of any particular expenditure category on student performance when there is little variation in one category that cannot largely be explained by variations in the other expenditure categories (this leads to high R_j^2 for each of the expenditure variables). Such multicollinearity problems can be mitigated by collecting more data, but in a sense we have imposed the problem on ourselves: we are asking questions that may be too subtle for the available data to answer with any precision. We can probably do much better by changing the scope of the analysis and lumping all expenditure categories together, since we would no longer be trying to estimate the partial effect of each separate category.

Wooldridge, J. M. (2013). *Introductory econometrics: a modern approach* (5th ed). Mason, OH: South-Western Cengage Learning. p. 96-97

Index as depedenent and independent variable

Define an index:

$C = x_1 + x_2 + x_3$

Independent variable

$y = \beta_0 + \beta_1 C + u$

$y = \beta_0 + \beta_1 x_1 + \beta_1 x_2 + \beta_1 x_3 + u$

Dependent variable

$C = \beta_0 + \beta_1 z_1 + u$

$x_1 = \beta_{01} + \beta_1 z_1 + u$

$x_2 = \beta_{02} + \beta_1 z_1 + u$

$x_3 = \beta_{03} + \beta_1 z_1 + u$

Edwards, J. R. (2001). Multidimensional constructs in organizational behavior research: An integrative analytical framework. *Organizational Research Methods*, *4*(2), 144–192.

Summary of indices

1. Items that form the index must be validated outside index construction
2. The index needs to be justified
   A. Different sources of a quantity
   B. Alternative ways that the behavior can manifest
3. Justify the use of index over separate items
4. Set the weights on conceptual grounds
   A. When in doubt, use equal weights

Probably a good idea to avoid the term ”formative”

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