MA mini-Course

Multiple Indicator Measurement

(with special reference to education and occupation)

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Lecture 5a: Recapitulation

Organization of the course

- Six lectures (following last years lectures 1-4)
  - 5a. Recapitulation
  - 5b. Status attainment and the measurement of education and occupation
  - 6a. Occupation coding
  - 6b. Simultaneous Equation Modeling
  - 7b. Status Attainment and Social Reproduction in Suriname
  - 7b. Attitudes toward Income Inquality in Suriname

Assignments and grade

- Three assignments:
  - A. Coding occupations
  - B. Submit three non-overlapping (!) questions
  - C. Calculate your own status attainment model
- Your grade will be an average of the three assignments.
- Proportional to 3 credit points

Standard operations (‘Stappenplan’)

- Measure as many indicators as you can, but preferably 3-4.
- Make sure that the indicators:
  - Are consistently scored in the same direction (otherwise: reverse coding).
  - Have the same metric of measurement (otherwise: standardize).
- Perform factor analysis to confirm that a single latent variable is causing the relationship between the indicators (otherwise: remove indicators).
- Perform a reliability analysis on the remaining indicators (express as Cronbach’s alpha).
- Construct an index variable by taking means of the standardized indicators.
- Restandardize the index.

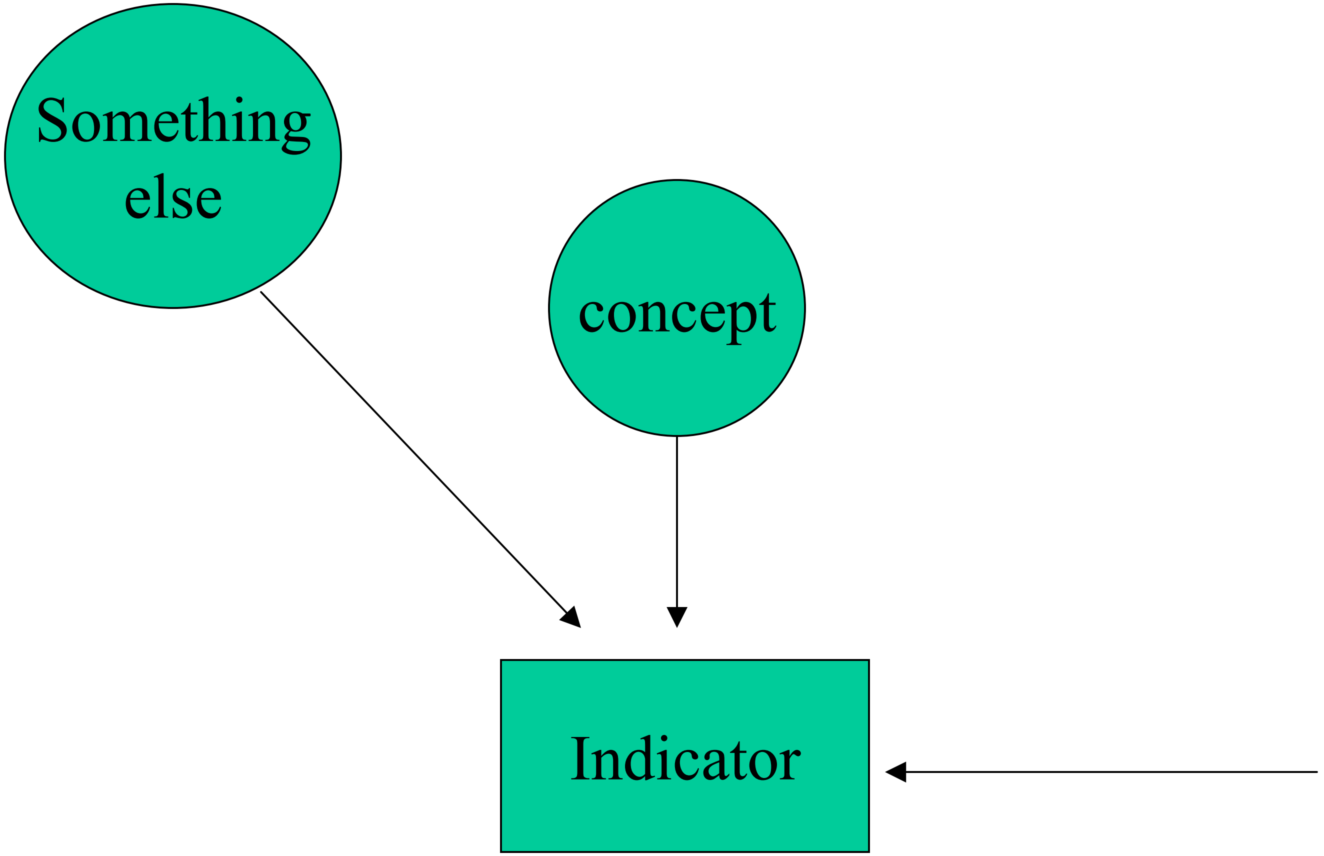
Measurement

- Measurement = expressing a concept into a numerical indicator.
- Two types of error occur:
  - Invalidity: The indicator does not measure what you intended to measure; the indicator (also) measures something else.
  - Unreliability: The indicator does not measure in a stable way – it records a different result every time you use it.

(In)Validity and (Un)Reliability

- Invalidity: systematic error – the error is the same every time you try to measure.
- Unreliability: random error – the error is different every time you try to measure.
- Both can be quantified and corrected, but this requires different research designs.
- Validity presupposes reliability: you can only start looking at validity, once you have a stable measure.
- Validity is the ultimate aim of measurement, reliability the first step.

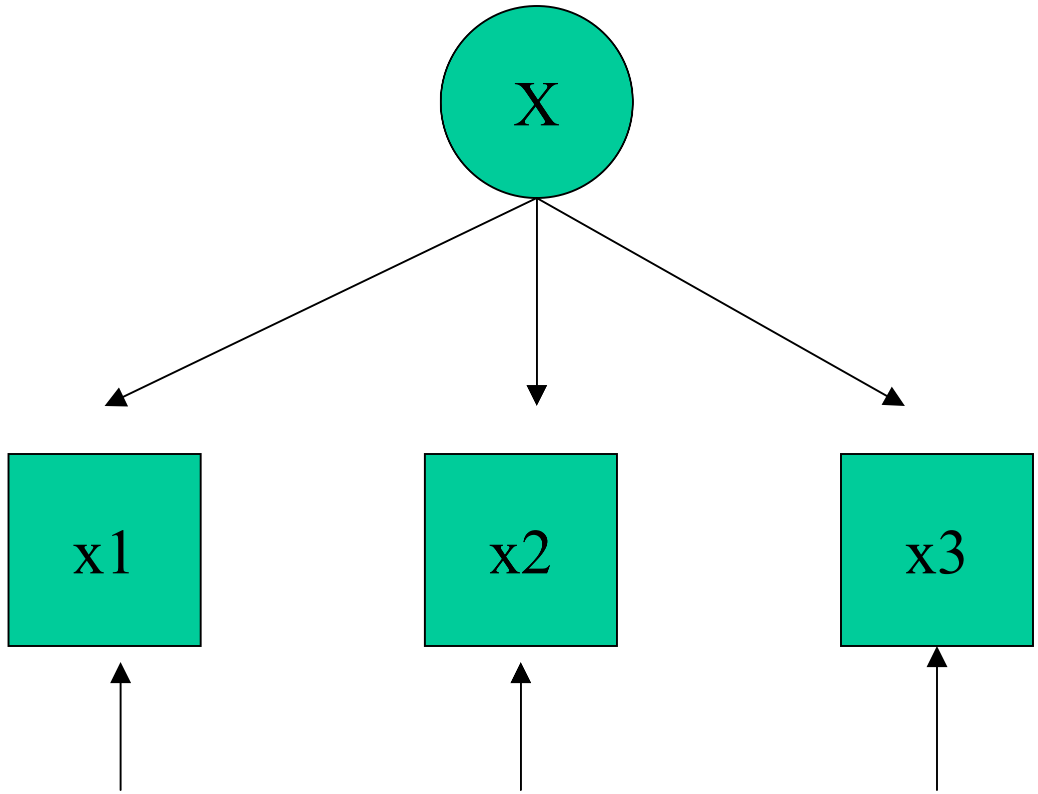
A causal model for measurement



Multiple indicator measurement

- Social science concepts are often measured via multiple indicators.
- Each of the indicators are supposed to be independently measured: the random error are uncorrelated.
- More often than not, the indicators are NOT strictly repeat (=equivalent) measures. In stead the cover different aspects of the concept.

Multiple indicator causal measurement model



Questions

- How can we calculate the measurement relationships X → x1, X→ x2, X→ x3?
- What does this show us about random and systematic measurement error?
- How many indicators do we need?
- How does the measurement quality of the indicators make a difference?

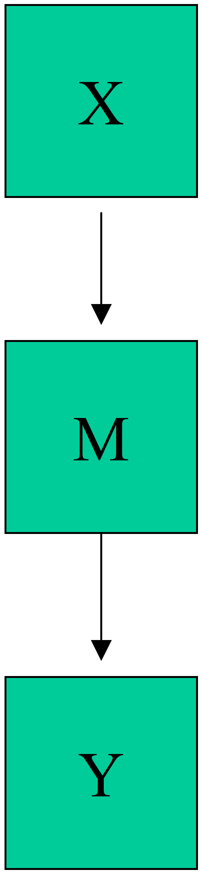
Calculating measurement relationships

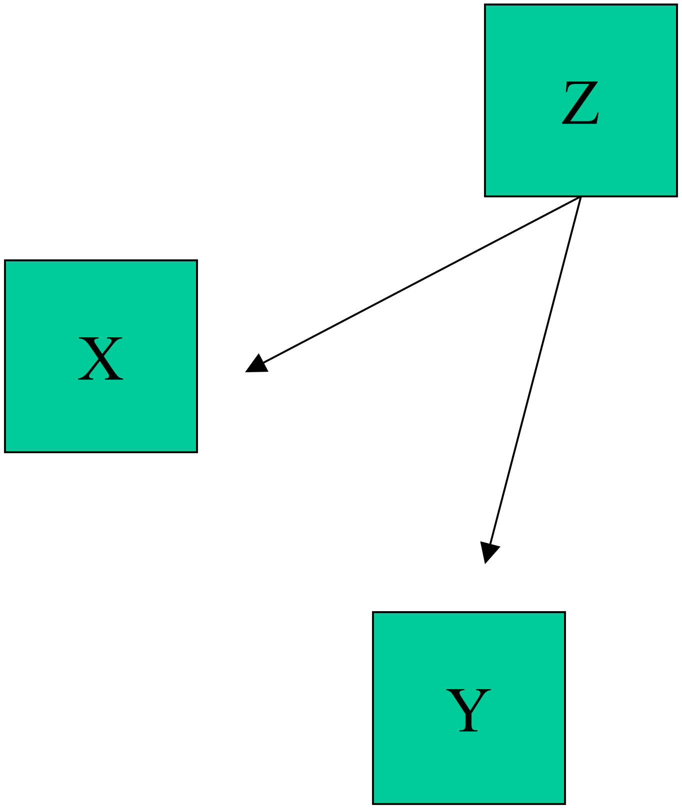
- The measurement model is a simple causal model with one *latent* variable.
- Causal (‘path’) analysis of correlations can be applied:

  Total correlation = direct effect + ***indirect effect*** + ***spurious effect***

- Indirect effect: product of direct effects.
- Spurious effect: product of confounding effects.

Indirect and Spurious effects: Mediation and Confounding





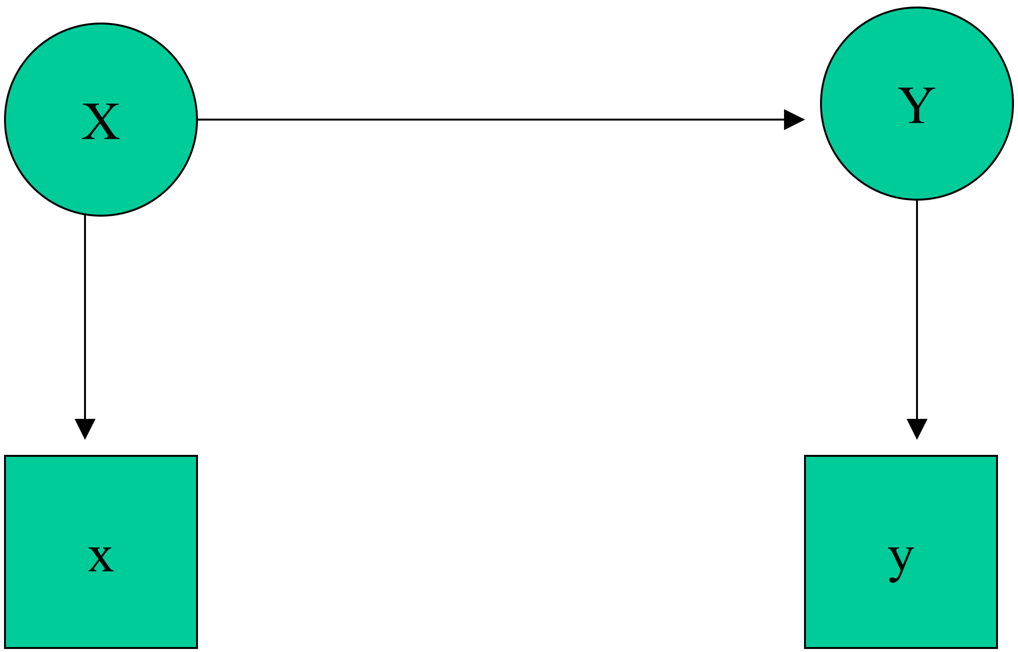
How many indicators?

- A model with 3 measured indicators and 1 latent variable is just identified.
- We cannot have more than one latent variable (=cannot detect invalidity).
- If we have 2 indicators, we can still assess total reliability, but not not for each indicator separately.
- If we have 4 or more indicators, the model is overidentified and we can start looking at invalidity (= multiple latent variables).

How many indicators? (2)

- The more indicators, the better.
- With bad indicators, you can still have good measurement, provided you have many indicators.
- However, if you have many indicators, multidimensionality (= multiple latent variables = invalid (=impure) measurement) in likely to occur.

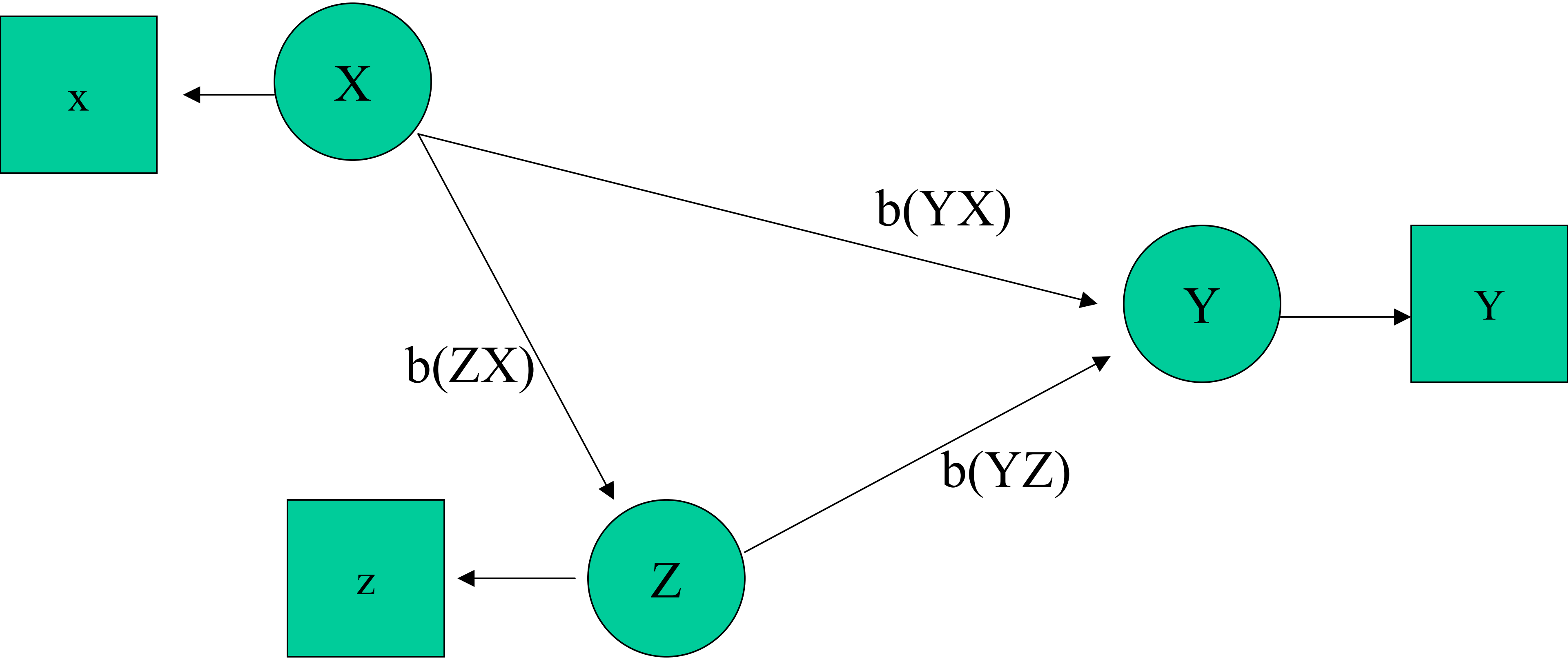
A model with random measurement error



Consequences of (random) measurement error

- Let’s assume that in a bivariate causal relationship the two variables are measured with random error.
- Using the elementary algebra of path analysis we see that such measurement error reduces (‘attenuates’) the observed effect relative to the true effect.
- We can turn this argument around (‘correction for attenuation’): if we would know the measurement relationships, we could estimate the true relationship from the observed relationship.

Elementary causal model with measurement error



Random measurement and partial effects

- Effects of random measurement error become more complicated when we look at the consequences on direct, indirect and confounding effects.
- Measurement error :
  - In the intervening variable <u>reduces</u> the estimated indirect effect and <u>enlarges</u> the estimated direct effect.
  - In the confounding variable: <u>reduces</u> the estimated spurious association and <u>enlarges</u> the estimated direct effect.
  - In the outcome variable: <u>no change</u> in ratio of direct and indirect effects.
- The first two forms of measurement error lead to **BIAS**, the latter does **NOT**.

Systematic error (invalidity)

- Systematic error arises when measurement error is influenced by other variables, inside or outside the model.
- The various kinds of validity often distinguished in methodological textbooks (construct, content, predictive, discriminant), are not very helpful.
- But the most common textbook definition is: a measure is valid if it measures what you intend to measure (and nothing else).
- The most useful model to think of is the multiple common factor model: indicator is influenced by multiple true scores.

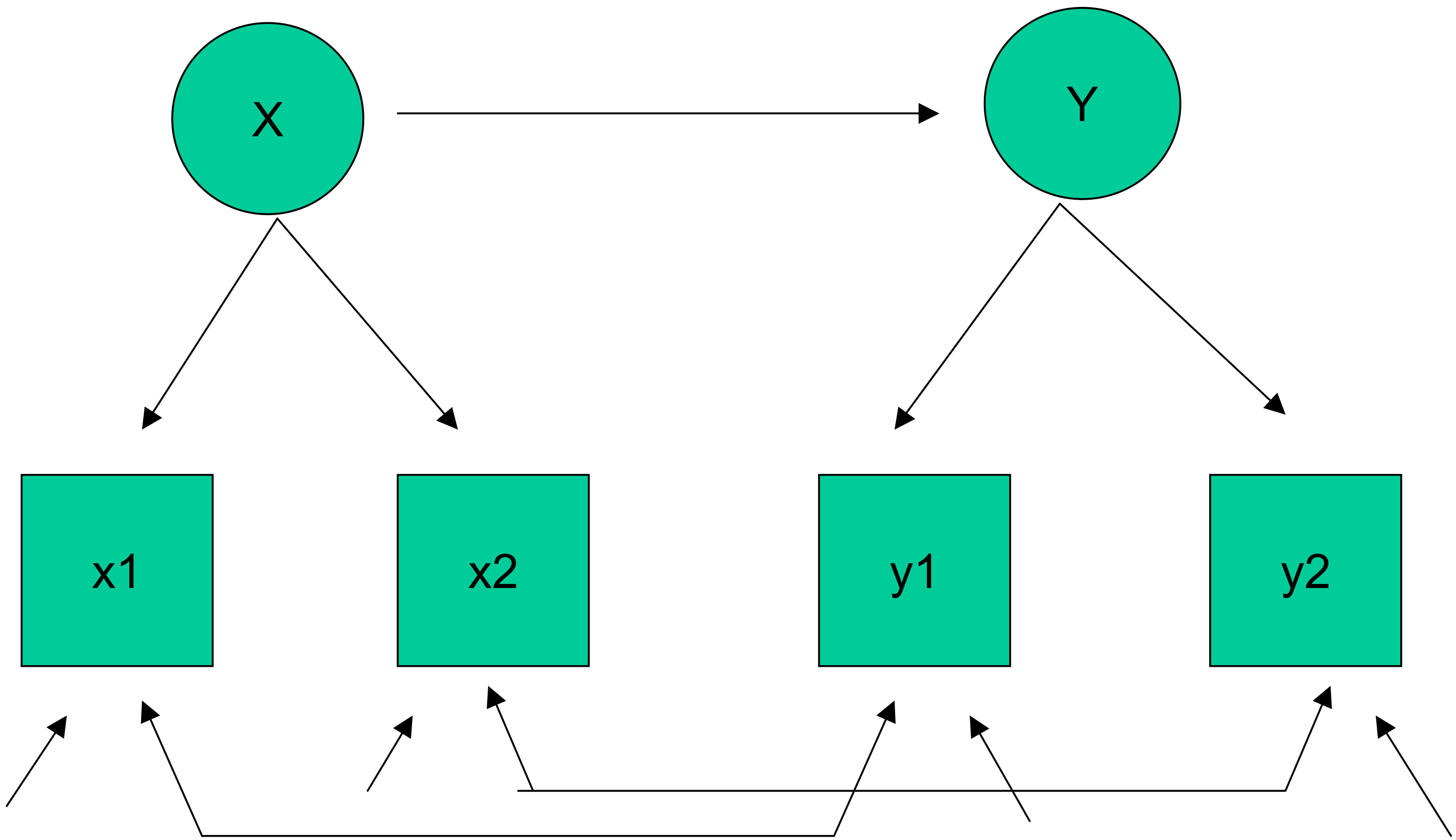
Influences of systematic error

- Influences (bias) of systematic errors cannot easily be summarized in general statements.
- Systematic error increases correlations with some variables, but which ones (inside or outside the model), depends upon the structure of the underlying process and how it is represented in your model.
- Systematic error can in some instances be quite harmless (e.g. constant error).

How can systematic error be detected?

- By repeating the error!
- I.e. repeat the error in measuring another latent variable in the model.
- With repeated systematic error, the size of the error can be estimated using a ‘correlated error term’, or using multiple factor analysis as part of the causal model.
- The is called MTMM (multiple trait, multiple method) modeling.

Elementary MTMM model



An elementary MTMM model – the algebra

- In the most elementary MTMM model we have four indicators for two latent variables: six correlations.
- The coefficients are not identified, unless using restrictive simplifications.
- However, all coefficients become identified, if the MTMM is embedded in a larger causal model.

MTMM applications

- MTMM methodology is useful:
  - For models with repeated measurement of the same traits (e.g. occupational of educational mobility – the relationship between two or more occupations / educations).
- MTMM can also be used to evalate coder quality.
- Many other applications in attitude research, in particular to question formulations, respons tendencies.