

Seminar on

**The Role of National Statistical Offices in  
the production of Leading, Composite  
and Sentiment Indicators**

6 - 7 July 2017

**Geneva**

# From indicators to their synthesis.

Methodological issues in the construction of  
complex indicators

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# Premise

## Synthesis of indicators

We need to start by

- sketching out the main methodological steps aimed at **developing indicators**
- clarifying the different issues to face in **synthesizing indicators**

1.

Developing indicators  
and managing the  
complexity

# Developing indicators

(1) a normative exercise



# Developing indicators

(1) a normative exercise

Indicator



what relates  
concepts to reality  
through observation

but ..... what actually is an “indicator”?

# Developing indicators

(1) a normative exercise

Indicator



not

a simply crude statistical information

but

a measure organically connected to a  
conceptual model

# Developing indicators

## (1) a normative exercise

**Indicators should be developed and managed so that they ...**

- ... represent different aspects of the reality,
- ... picture the reality in an interpretable way, and
- ... allow meaningful stories to be told



# Developing indicators

(1) a normative exercise

## **RISK**

lack of any logical cohesion and consistency

deforming reality through distorted results

(hidden - sometime - by using and applying  
sophisticated procedures and methods)

# Developing indicators

## (1) a normative exercise

normative nature of the selection of indicators  
cannot be denied

the process contains a “subjective” component

# Developing indicators

## (2) the hierarchical design

# Developing indicators

## (2) the hierarchical design

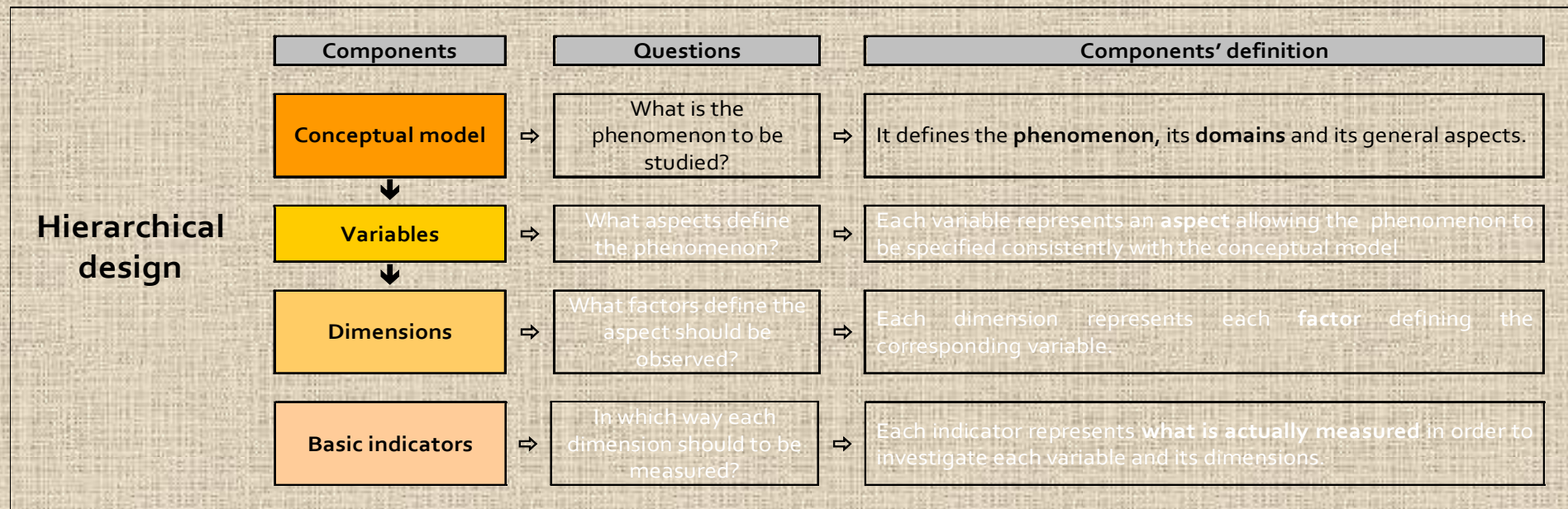
Process allowing indicators to be developed

*hierarchical design* → requires the definition of the different subsequent components



# Developing indicators

## (2) the hierarchical design

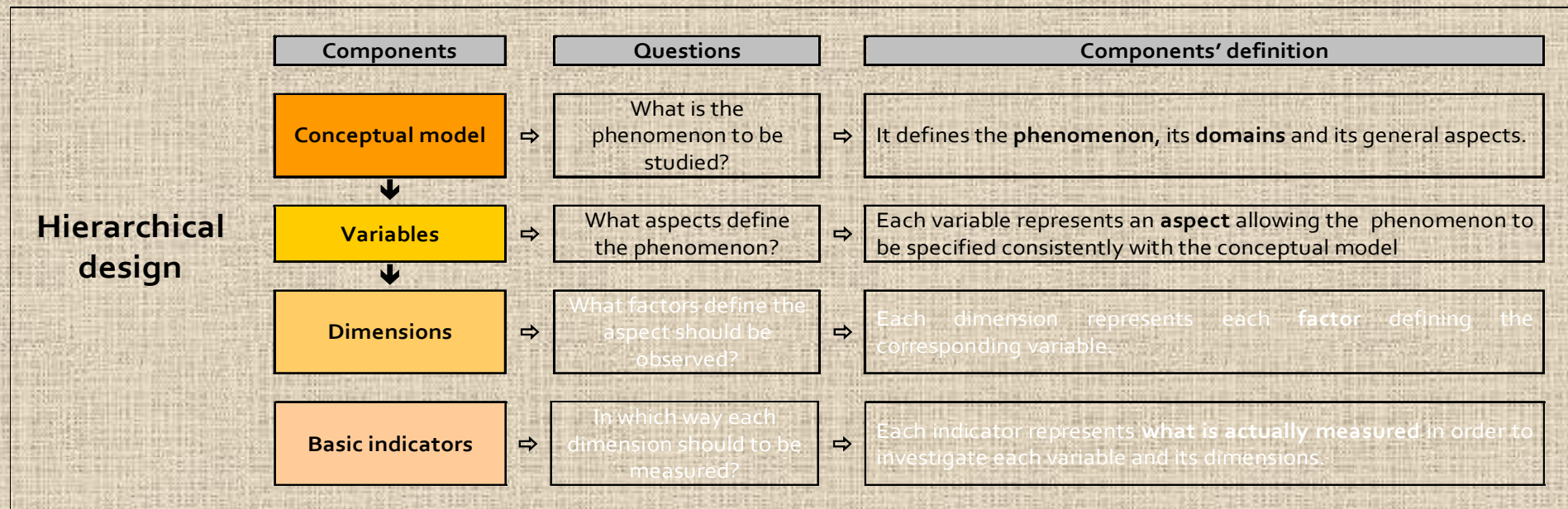


- a) the model aimed at data construction,
- b) the spatial and temporal ambit of observation,
- c) the aggregation levels (among indicators and/or among observation units),
- d) the models allowing interpretation and evaluation.



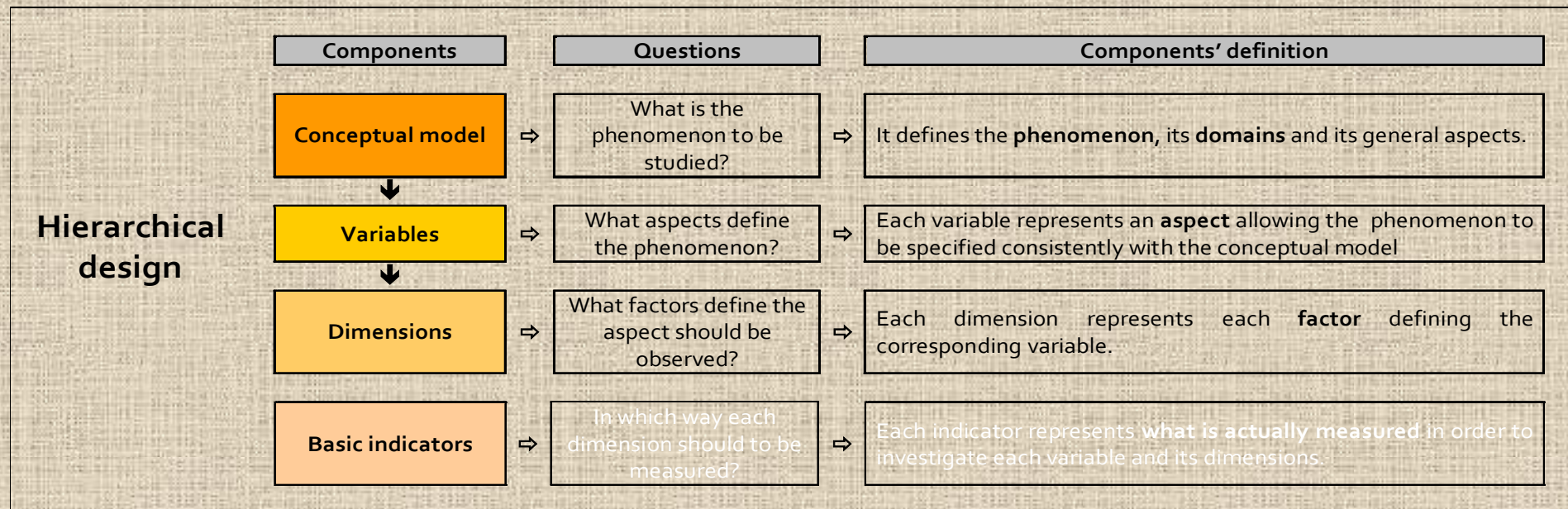
# Developing indicators

## (2) the hierarchical design



# Developing indicators

## (2) the hierarchical design



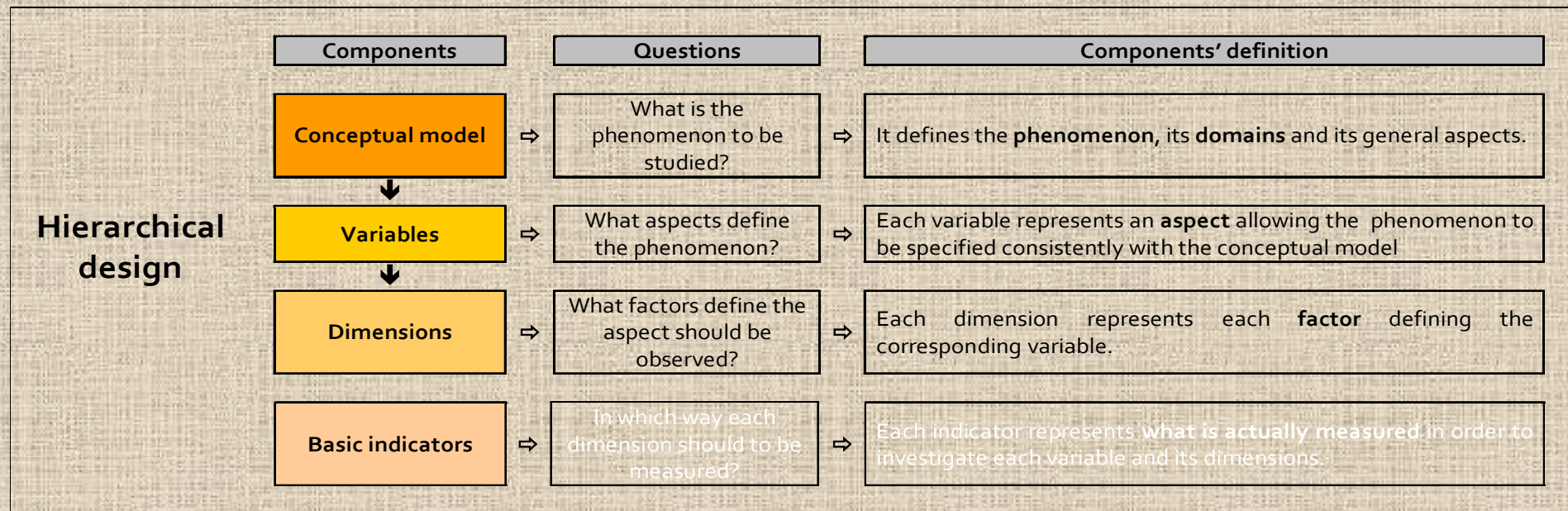
“Dimensionality” → theoretical

Two different situations can be observed:

- *uni-dimensional* → variable assumes a unique, fundamental underlying dimension
- *multidimensional* → variable assumes two or more underlying factors

# Developing indicators

## (2) the hierarchical design



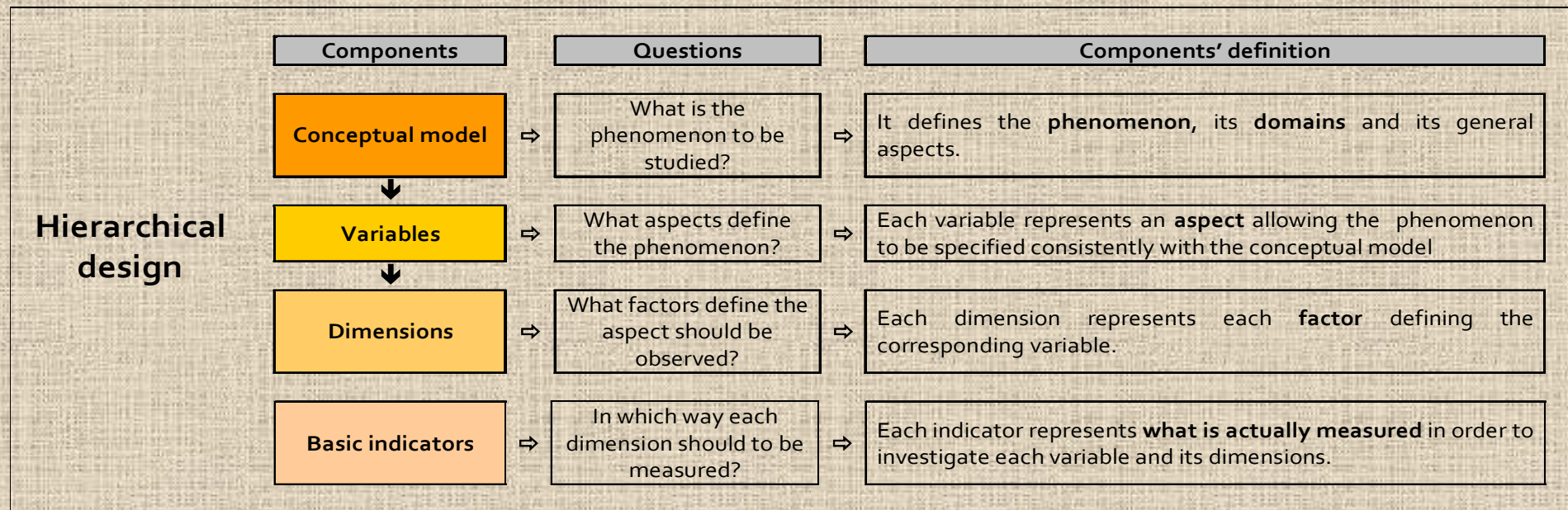
“Dimensionality” → theoretical

The correspondence between the defined dimensionality and the selected indicators has to be demonstrated empirically by testing the selected **model of measurement**.



# Developing indicators

## (2) the hierarchical design



### Each indicator (K. Land)

- represents a component in a model
- can be measured and analysed to compare different situations/groups ... to observe evolutions along time)
- can be related and integrated (aggregated) to specify the model

# Developing indicators

## (2) the hierarchical design

**Defining domains**



# Developing indicators

## (2) the hierarchical design

### Defining domains

- each variable
- each dimension

refers to domains

# Developing indicators

## (2) the hierarchical design

### Defining domains

Segments of the reality in which the relevant concepts and their dimensions have to be observed and assessed

# Developing indicators

## (2) the hierarchical design

How many indicators?

1<sup>o</sup> option

Each variable measured by one indicator

*single-indicator approach*

# Developing indicators

## (2) the hierarchical design

How many indicators?

1° option

Each variable measured by one indicator

*single-indicator approach*

*weak → low precision and low accuracy*





# Developing indicators

## (2) the hierarchical design

How many indicators?

2° option

Each variable measured by more than one  
indicator

*multi-indicator approach*



# Developing indicators

## (2) the hierarchical design

How many indicators?

2° option

Each variable measured by more than one indicator

*multi-indicator approach*

*Necessary with multidimensional variables*



# Developing indicators

## (3) the model of measurement

# Developing indicators

## (3) the model of measurement



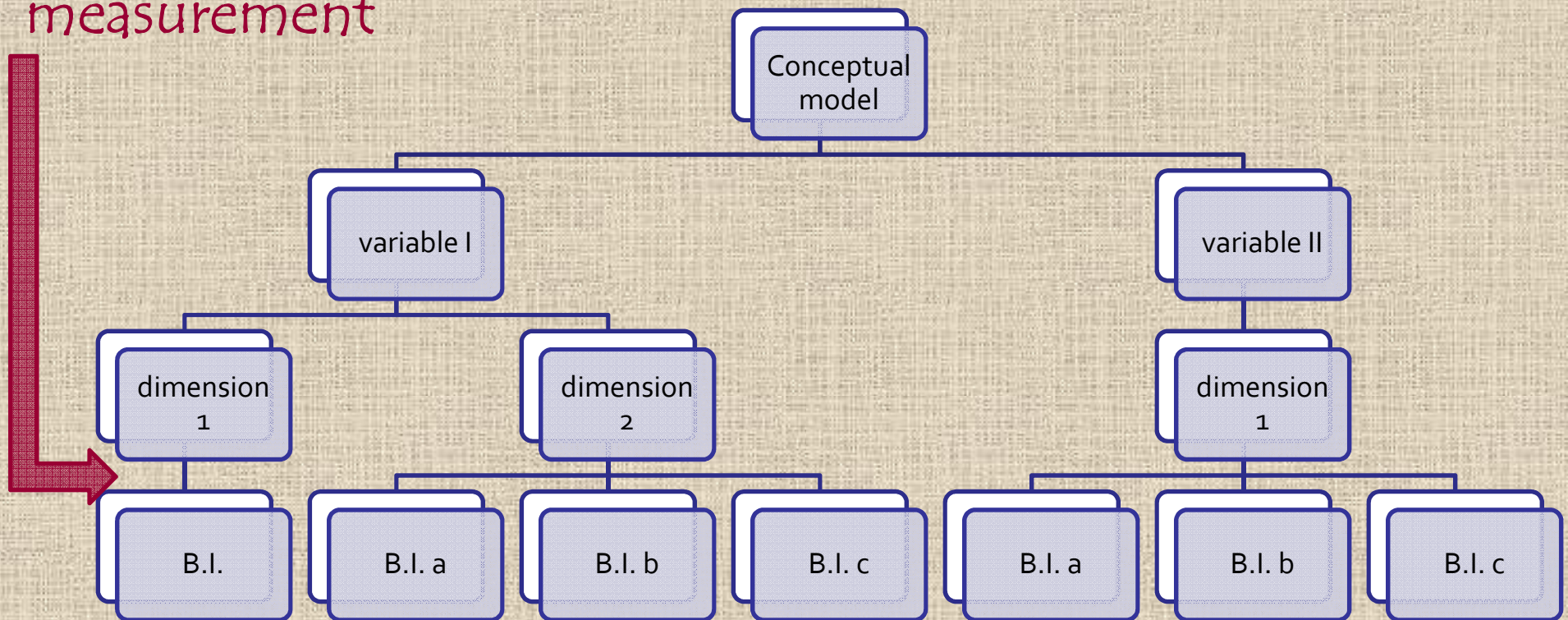
relationship between  
**variable and indicators**

model of measurement

# Developing indicators

## (3) the model of measurement

model of  
measurement





# Developing indicators

## (3) the model of measurement

**Two different models:**

**reflective**

**formative**



# Developing indicators

## (3) the model of measurement

**Two different models:**

**reflective**

**formative**

# Developing indicators

## (3) the model of measurement

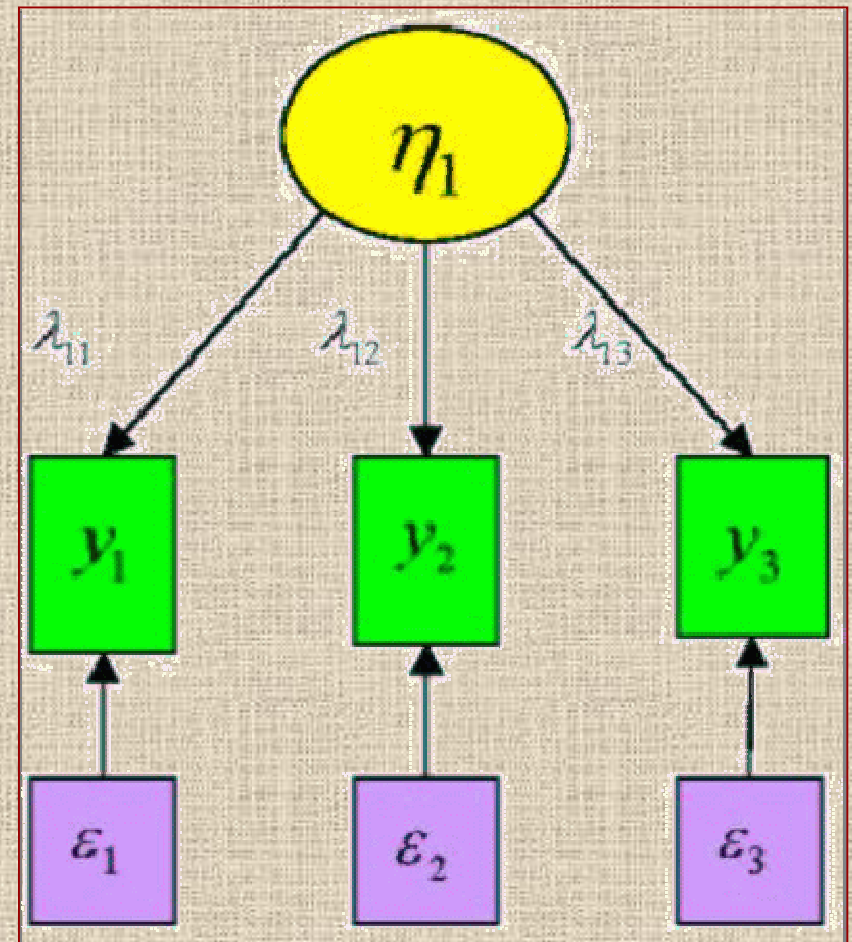
indicators  $\rightarrow$  *functions of latent variable*

explanatory perspective  $\rightarrow$  *top-down*



changes in the latent variable are reflected in changes in the observable indicators

*reflective*



# Developing indicators

## (3) the model of measurement

**Two different models:**

**reflective**

**formative**

# Developing indicators

## (3) the model of measurement

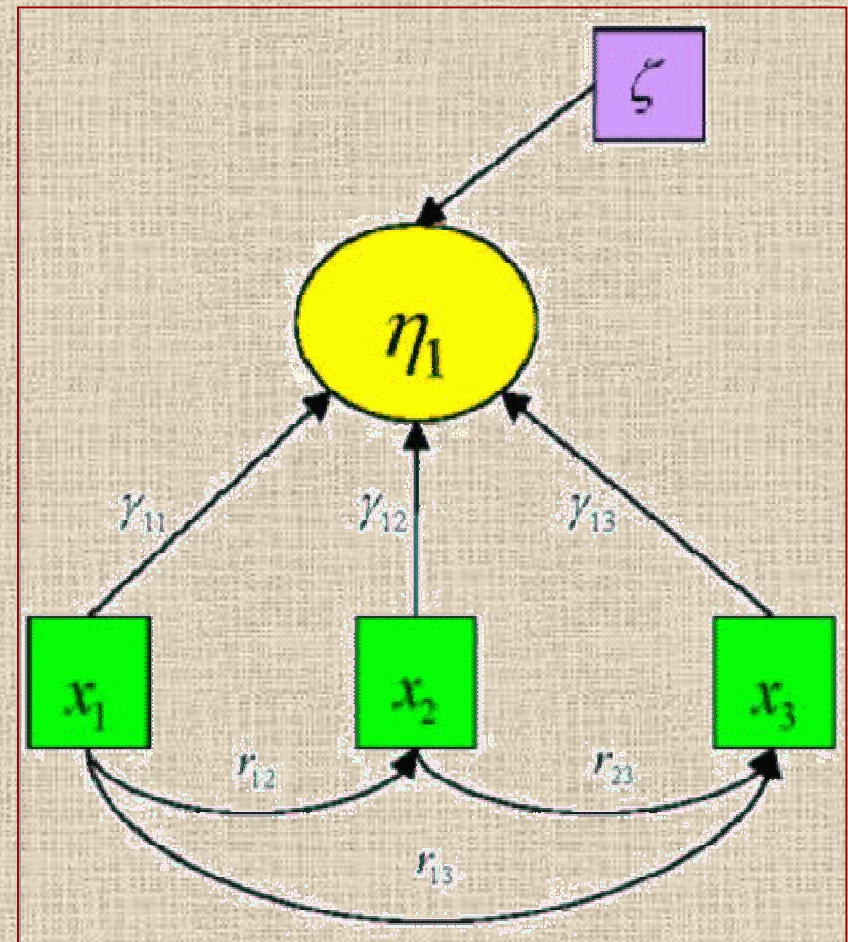
*formative*

indicators  $\rightarrow$  *causal in nature*

explanatory perspective  $\rightarrow$  *bottom-up*



changes in the indicators determine changes in the definition / value of the latent variable





# From basic indicators to systems of indicators

Proper and accurate application of the hierarchical design



complex structure



each indicator measures and represents a distinct component of the phenomenon of interest

# From basic indicators to systems of indicators

Proper and accurate application of the  
hierarchical design

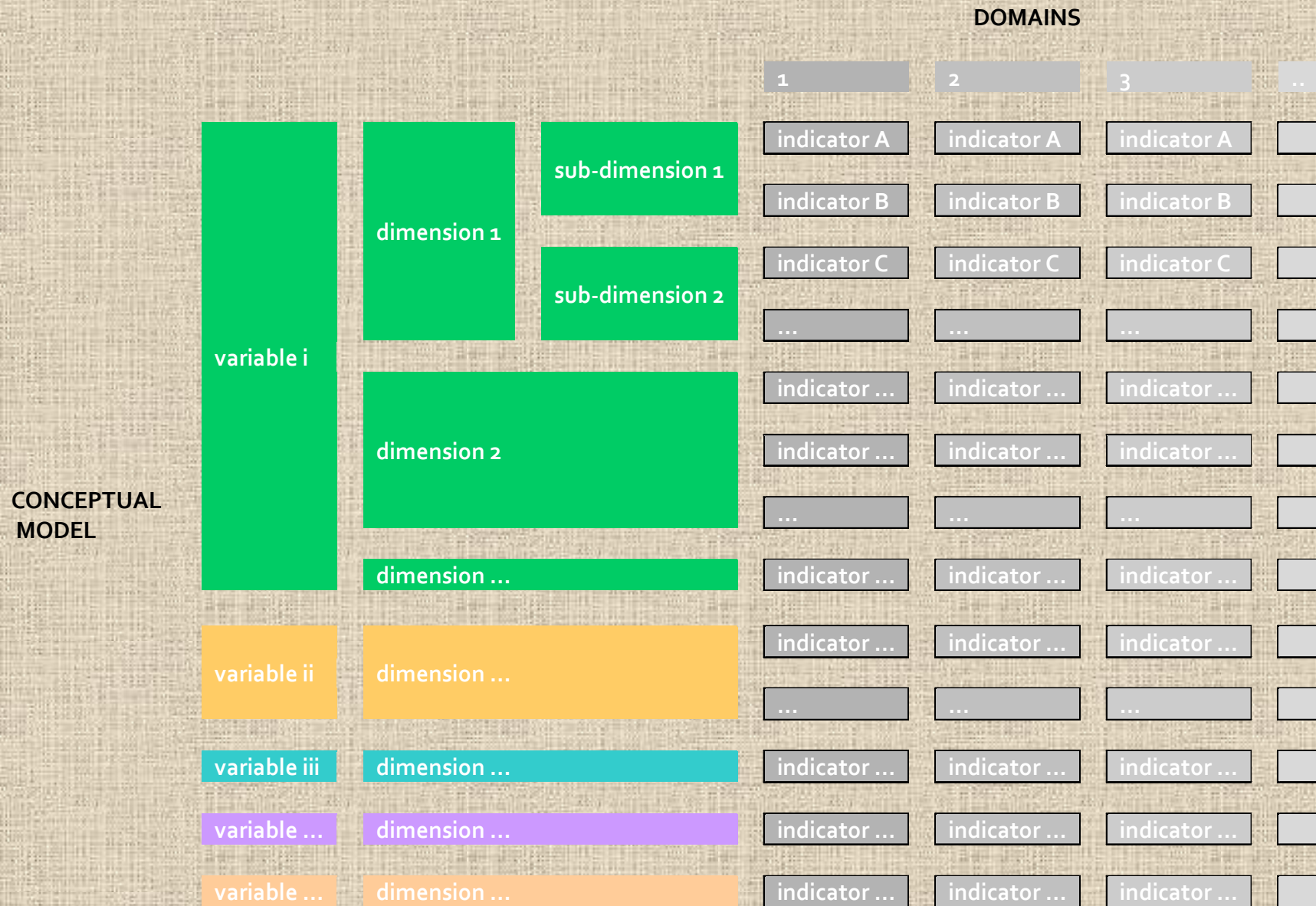


complex structure



*System of indicators*

# From basic indicators to systems of indicators



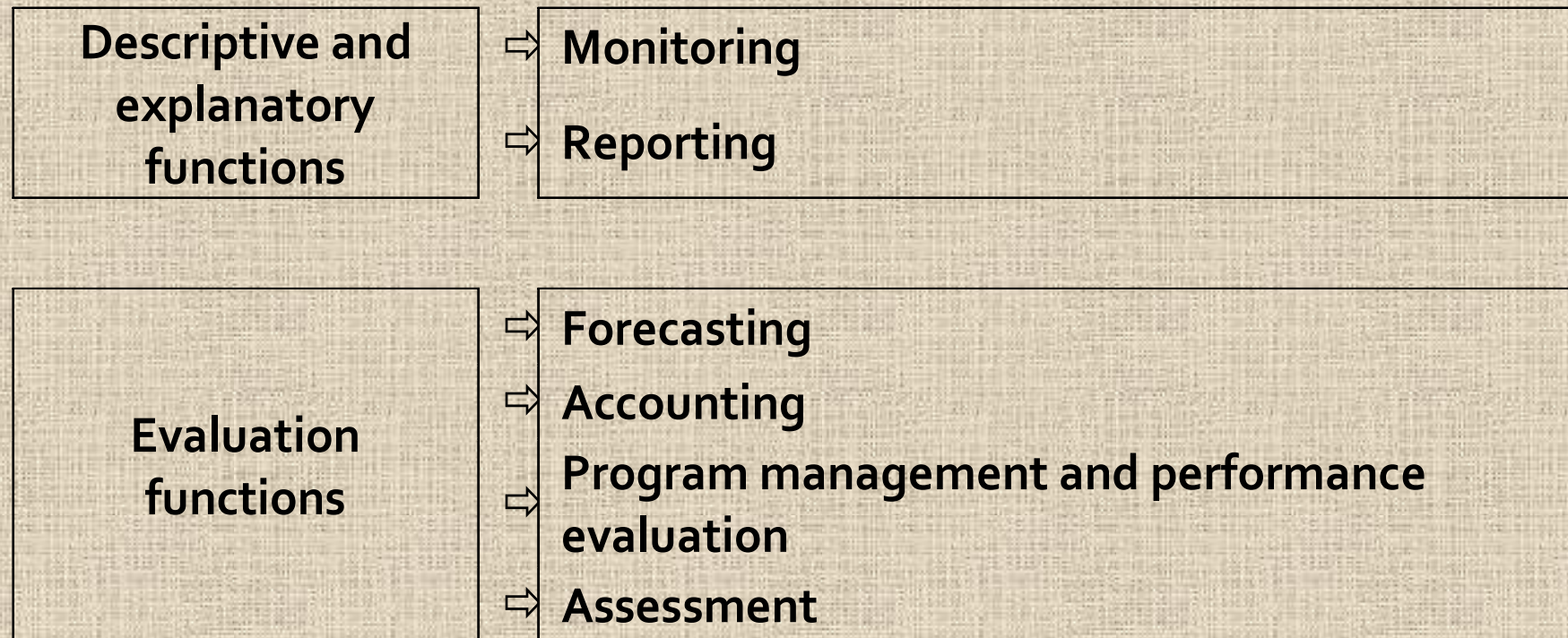
# From basic indicators to systems of indicators

## (1) functions



# From basic indicators to systems of indicators

## (1) functions



They can be seen in cumulative terms (each one requires the previous one)

# From basic indicators to systems of indicators

## (2) characteristics of indicators

Indicators developed through the hierarchical process are seen in relation to each other and show a meaningful and precise position in the system consistently with the conceptual model

# From basic indicators to systems of indicators

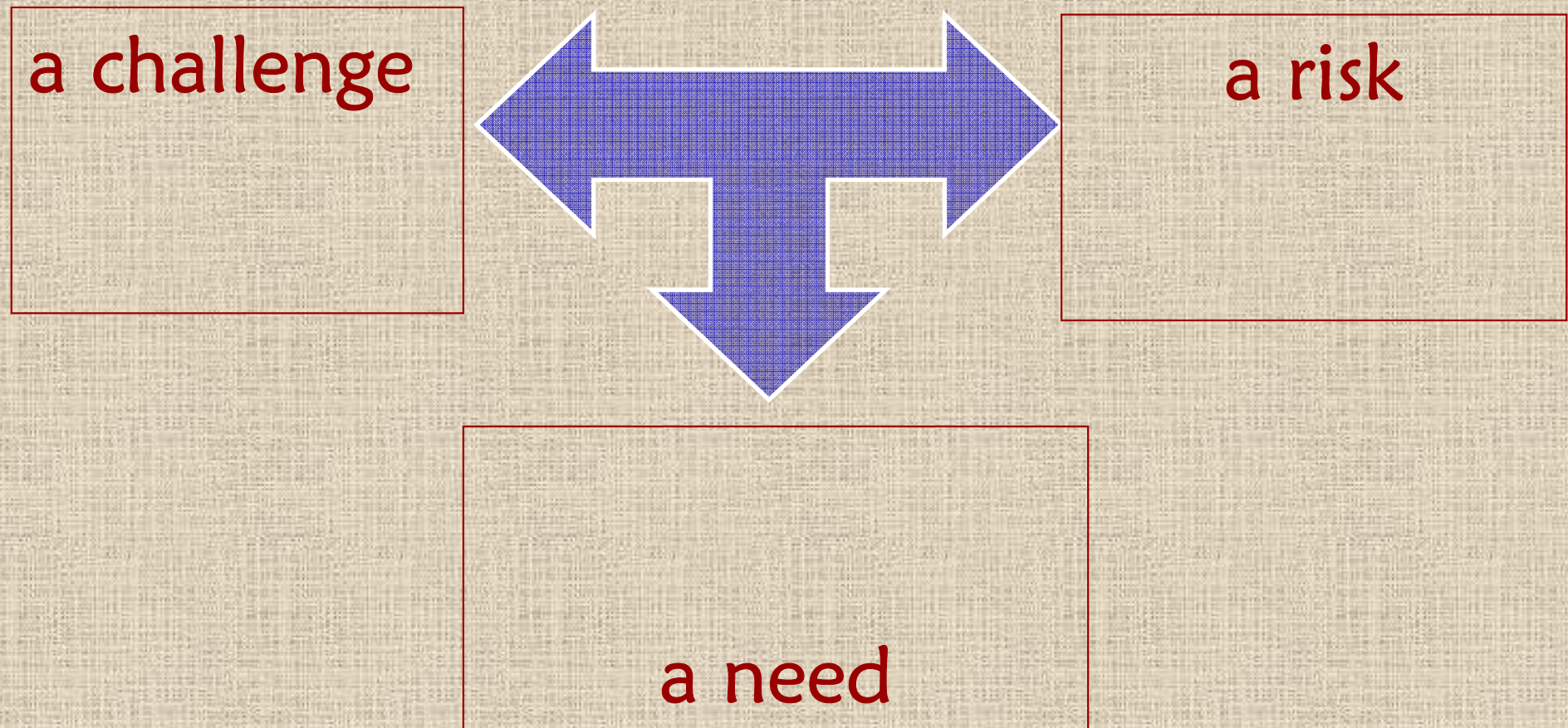
## (2) characteristics of indicators

- (i) the *perspective* through which the indicators are reporting the phenomenon to be observed
- (ii) the *communication context* in which the indicators are used
- (iii) the *interpretation* attributed to the indicators in statistical analyses
- (iv) the *criteria* of their adoption
- (v) their *quality*

# Managing indicators: instructions for use

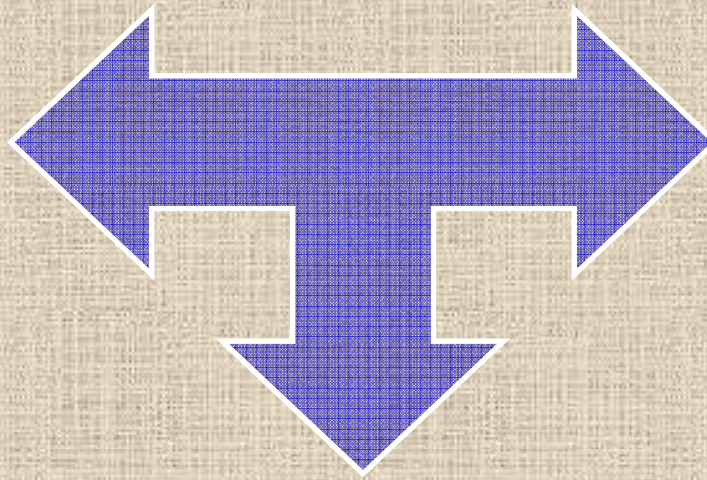


# Managing indicators: instructions for use



# Managing indicators: instructions for use

a challenge  
↓  
*complexity*



# Managing indicators: instructions for use

## (1) A challenge: complexity

- **Multidimensionality**

different aspects to be identified, not necessarily consistent among them

- **Nature**

- objective vs. subjective
- quantity vs. quality

- **Levels of observation**

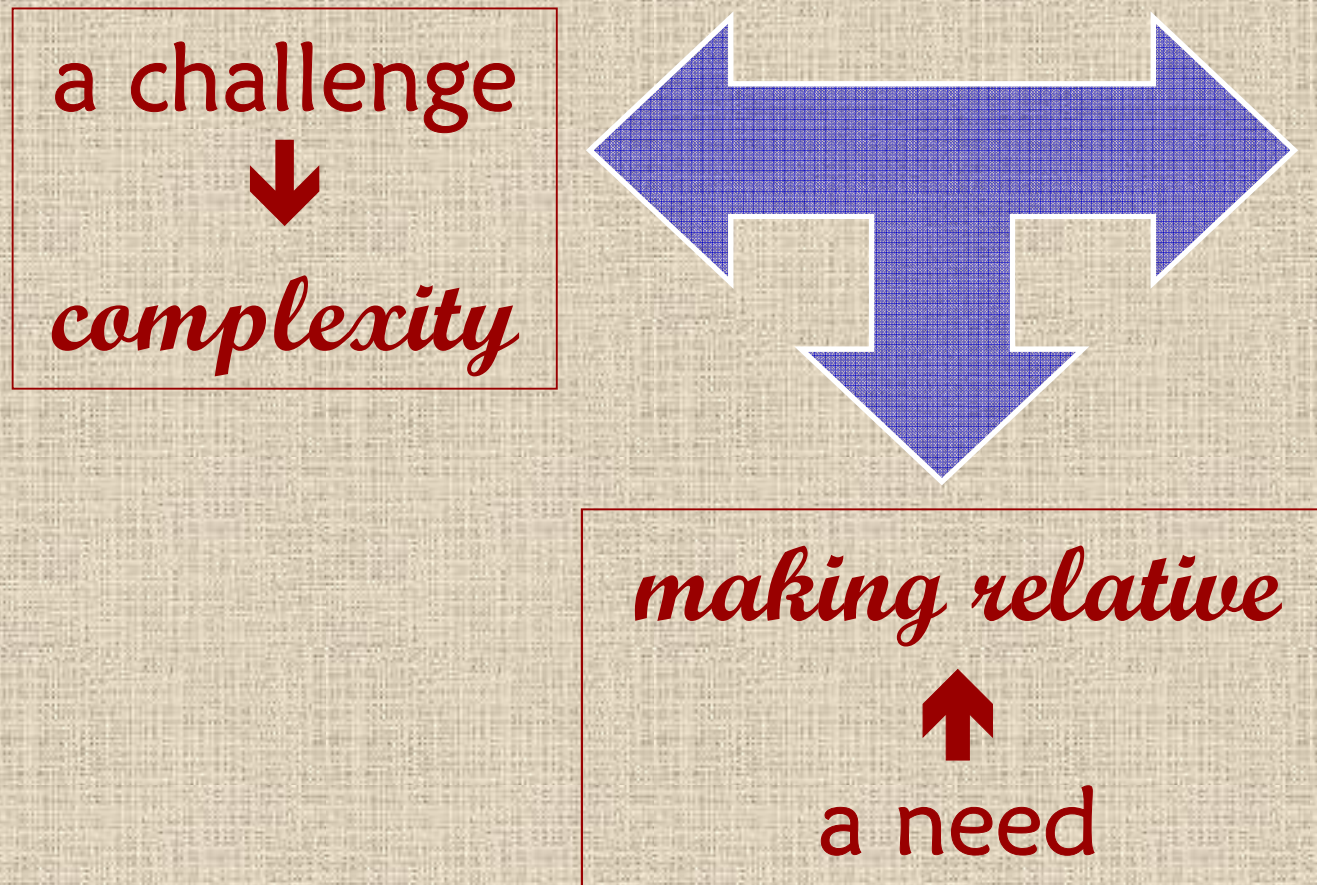
- micro vs. macro

- **Dynamics**

- internal levels vs. external conditions
- trends, not necessarily linear
- relationships between phenomena



# Managing indicators: instructions for use





# Managing indicators: instructions for use

## (2) A need: making relative

From the conceptual point of view

in terms of

- **consistency** with the reference concept
- **adequacy** with reference to territory

e.g., nr. of beds in hospital

# Managing indicators: instructions for use

## (2) A need: making relative

Making relative has strong implications with reference to *comparability* of indicators

# Managing indicators: instructions for use

## (2) A need: making relative

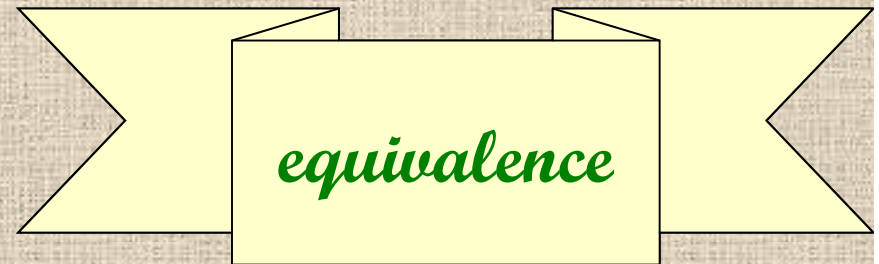
Making relative has strong implications with reference to *comparability* of indicators

	over time	across territories / areas	between groups
concepts			
data			
analysis			

# Managing indicators: instructions for use

## (2) A need: making relative

Making relative has strong implications with reference to *statistical treatment* of indicators



- Sampling design
- Questionnaire design
- Data collection method
- ...



# Managing indicators: instructions for use

## (2) A need: making relative

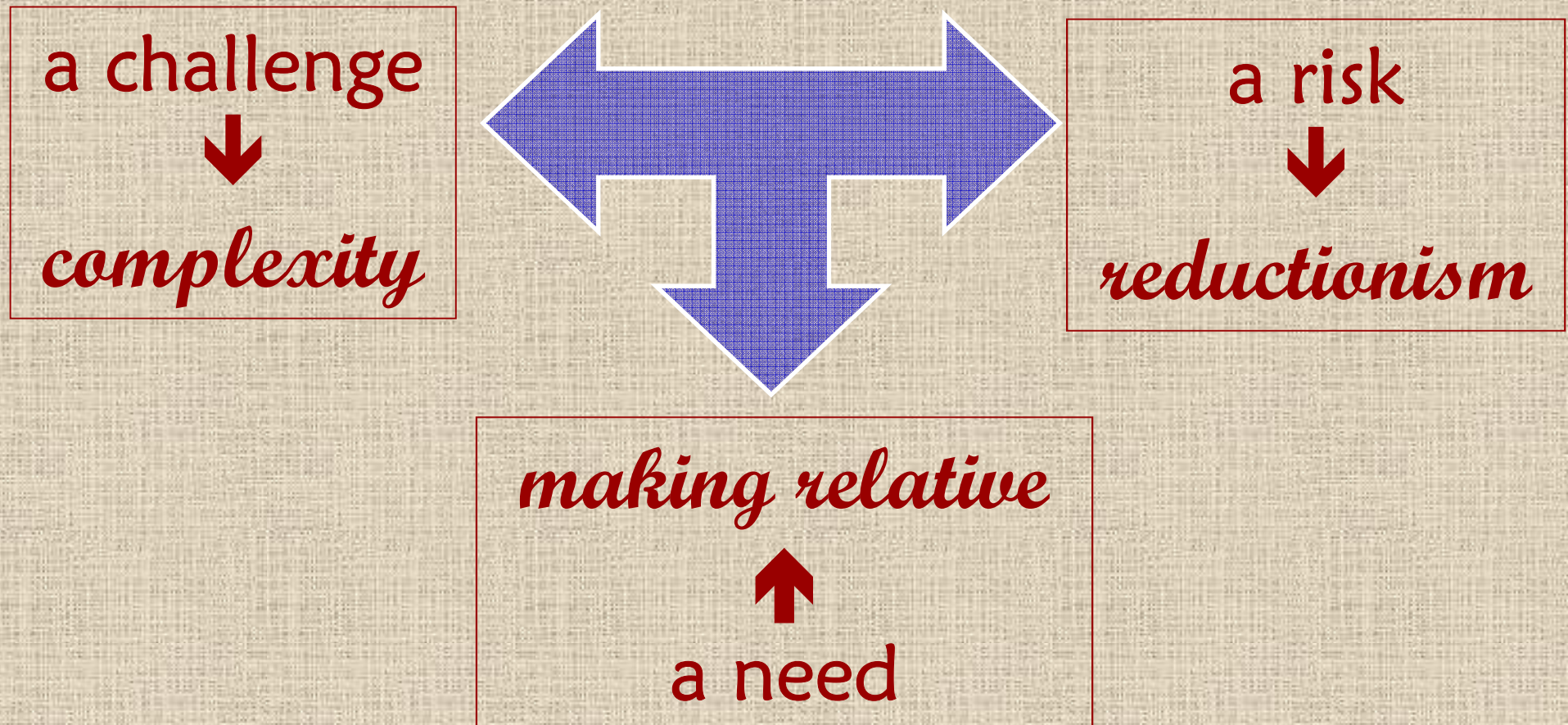
Making relative has strong implications with reference to *statistical treatment* of indicators



Which should consider:

- data properties
- original meaning of indicators
- values to be emphasized or penalized
- whether or not absolute value are used
- whether or not cases are compared to each other or to a reference unit
- whether or not units are evaluated across time

# Managing indicators: instructions for use



# Managing indicators: instructions for use

## (3) A risk: reductionism

*reductionism*



**unavoidable**

**dangerous**

Managing indicators: instructions for use

(3) A risk: reductionism

**System of indicators**



Managing indicators: instructions for use

(3) A risk: reductionism

## System of indicators

The **complexity** of the system of indicators may **require** approaches allowing more **synthetic views** through more comprehensive measures ...

Managing indicators: instructions for use

(3) A risk: reductionism

## **System of indicators**

... by taking into account that  
all elements included in the system are  
**organically integrated**



**they are not chosen independently**

Managing indicators: instructions for use

(3) A risk: reductionism

**System of indicators**

Reducing data complexity

to be considered as integral part of the process  
leading to indicators development

Managing indicators: instructions for use

(3) A risk: reductionism

**System of indicators**

Reducing data complexity



Solutions



Managing indicators: instructions for use

(3) A risk: reductionism

## **System of indicators**

(a) reducing the number of indicators

Managing indicators: instructions for use

(3) A risk: reductionism

## **System of indicators**

(a) reducing the number of indicators



**Need of a solid conceptual framework**

# Managing indicators: instructions for use

(3) A risk: reductionism

## System of indicators

(a) reducing the number of indicators



Statistical rational → correlations

# Managing indicators: instructions for use

(3) A risk: reductionism

## System of indicators

(a) reducing the number of indicators



Statistical rational → correlations

*nr. of firemen vs. amount of damages of fires*



Managing indicators: instructions for use

(3) A risk: reductionism

**System of indicators**

(b) synthesizing indicators

# Managing indicators: instructions for use

(3) A risk: reductionism

## System of indicators

(b) synthesizing indicators



Statistical rational → correlations

*e.g. composite indicators*

# Managing indicators: instructions for use

## (3) A risk: reductionism

### **System of indicators**

#### (b) synthesizing indicators

- answer the call by 'policy makers' for condensed information
- improve the chance to get into the media
- allow to make multi-dimensional phenomena uni-dimensional
- allow situations across time more to be easily compared
- compare cases (e.g. countries) in a transitive way (ranking and benchmarking)
- allow clear cut answers to defined questions (related to change across time, difference between groups of population or comparison between cities, countries, and so on)

(Noll, 2009)

2.

Dealing with syntheses  
in a system of indicators



# Introduction

**A synthesis should be meaningful**

# Introduction

**Meaningful → telling stories**

# Introduction

**What makes a synthesis meaningful**

# Introduction

Conceptual framework

producing a



# Introduction

**System of indicators**

# Introduction

Statistics offer many instruments  
aimed at synthesizing ...

But

*synthesizing indicators is not  
only a matter of having  
analytical instruments*

# Aspects of the system that can be synthesized

*synthesis of units (cases, subjects, etc.)*

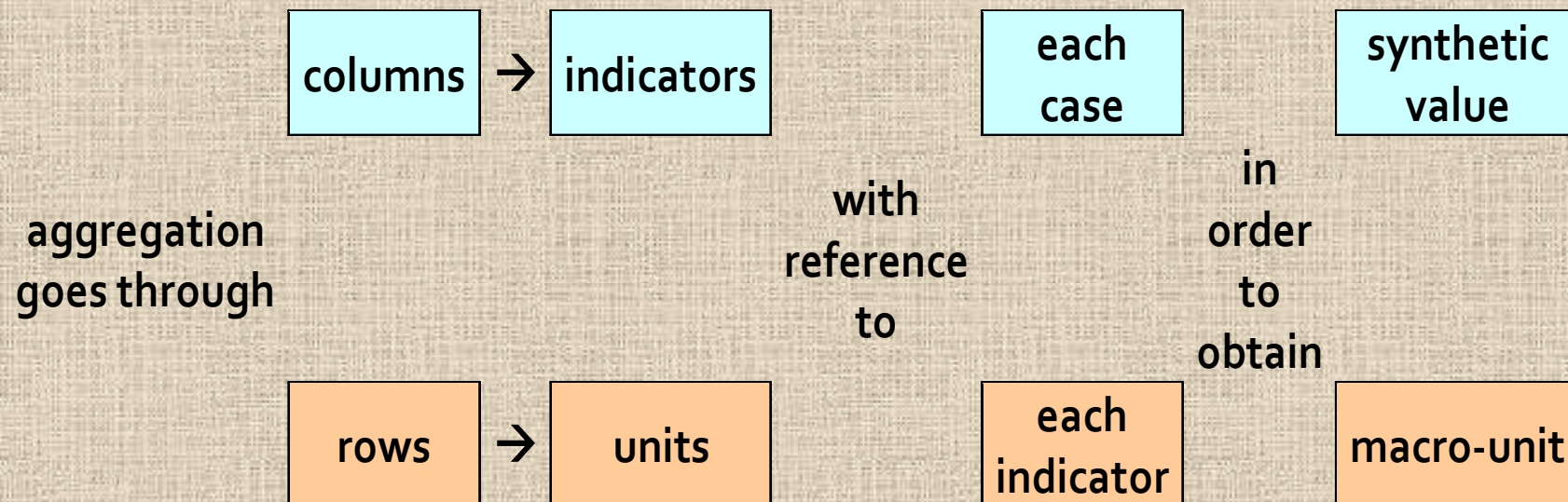
aggregating the individuals' value of indicators  
observed at micro level

*synthesis of basic indicators*

aggregating the values referring to several  
indicators for each unit (micro or macro)



# Aspects of the system that can be synthesized



# Synthesizing indicators

# Synthesizing indicators

Different perspectives to be taken into account:

- *conceptual design* that guided in defining the indicators (variables, dimensions, domains)
- *theoretical definition* of the indicators (reflective or formative indicators)
- *technical issues of synthesis* (weighting, aggregation techniques)

# Synthesizing indicators

- a. Conceptual perspective
- b. Model-of-measurement perspective
- c. Technical perspective



# Synthesizing indicators

- a. Conceptual perspective
- b. Model-of-measurement perspective
- c. Technical perspective

# Synthesizing indicators

## a. Conceptual perspective

**Consistent application of the hierarchical  
design**



***complex structure***

# Synthesizing indicators

## a. Conceptual perspective

- variables
- indicators
- domains
- cases
- etc.

# Synthesizing indicators

## a. Conceptual perspective





# Synthesizing indicators

## a. Conceptual perspective

The synthesis can be achieved through different perspectives:

# Synthesizing indicators

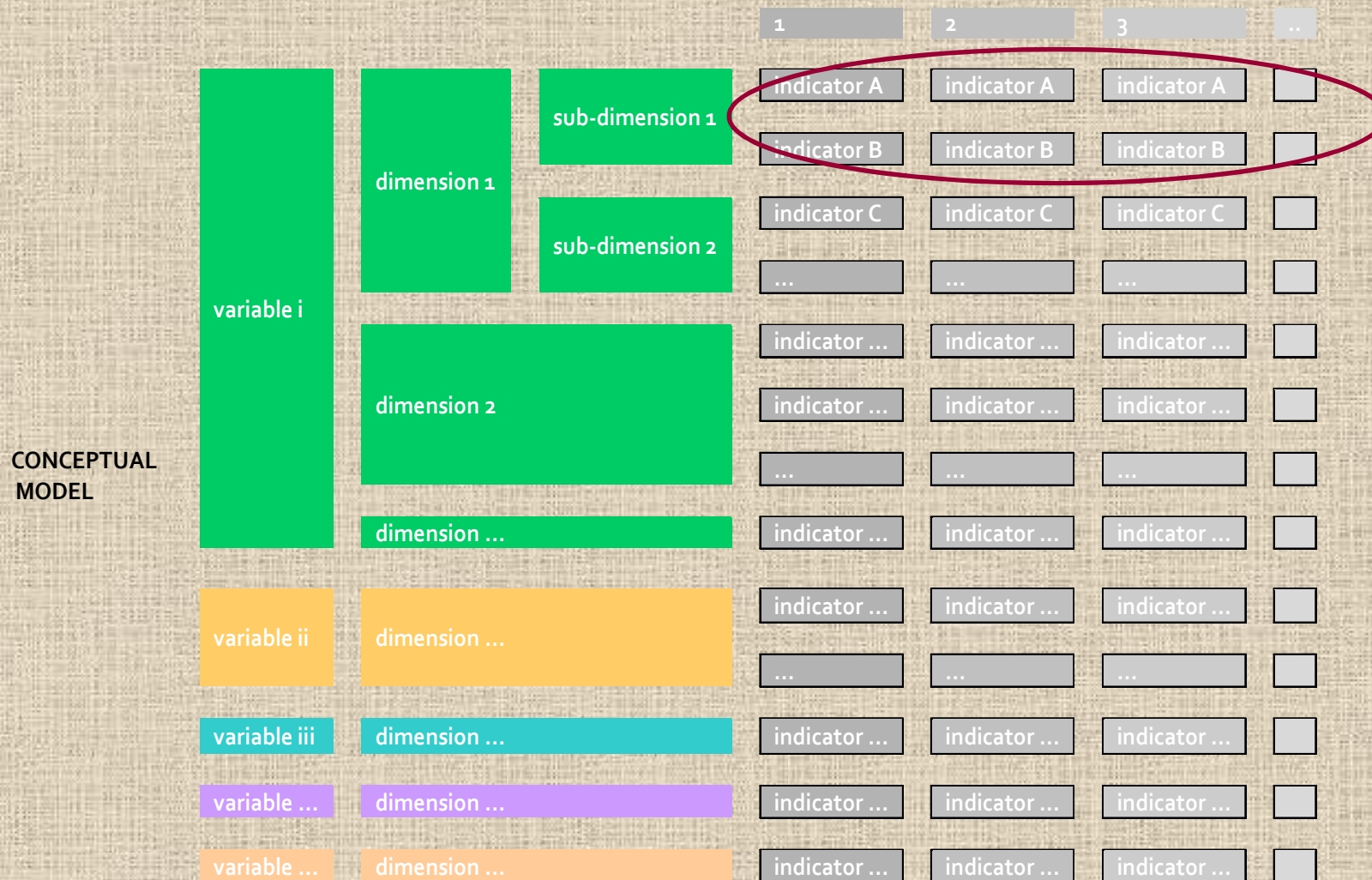
## a. Conceptual perspective



# Synthesizing indicators

## a. Conceptual perspective

## DOMAINS



# Synthesizing indicators

## a. Conceptual perspective





# Synthesizing indicators

## a. Conceptual perspective



# Synthesizing indicators

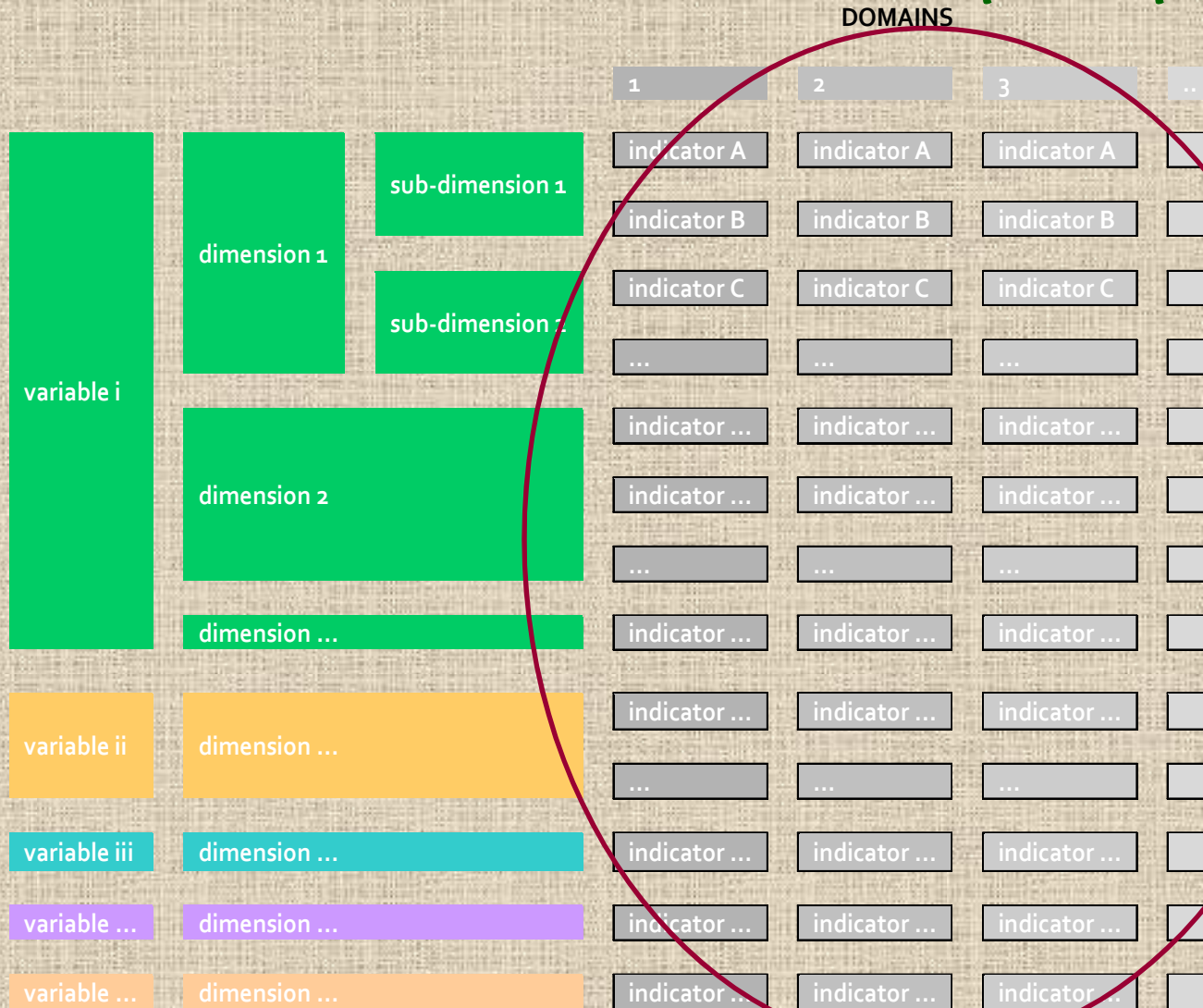
## a. Conceptual perspective



# Synthesizing indicators

## a. Conceptual perspective

CONCEPTUAL  
MODEL



# Synthesizing indicators

- a. Conceptual perspective
- b. Model-of-measurement perspective
- c. Technical perspective



# Synthesizing indicators

## b. Model-of-measurement perspective

Synthesizing indicators



relationship between  
variable and indicators

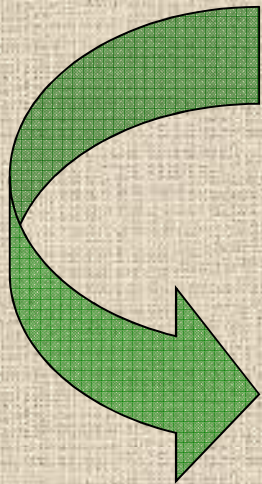
# Synthesizing indicators

## b. Model-of-measurement perspective

Synthesizing indicators



relationship between  
**variable and indicators**

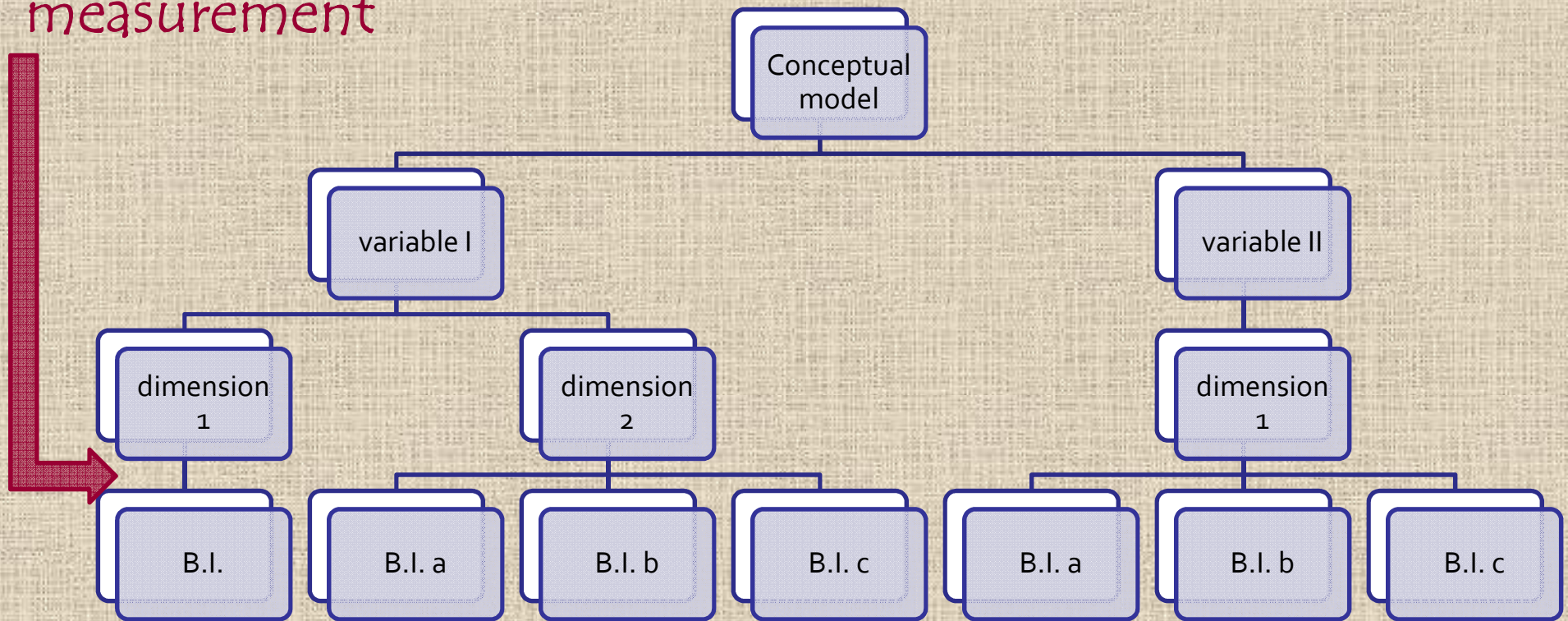


model of measurement

# Synthesizing indicators

## b. Model-of-measurement perspective

model of  
measurement



# Synthesizing indicators

## b. Model-of-measurement perspective

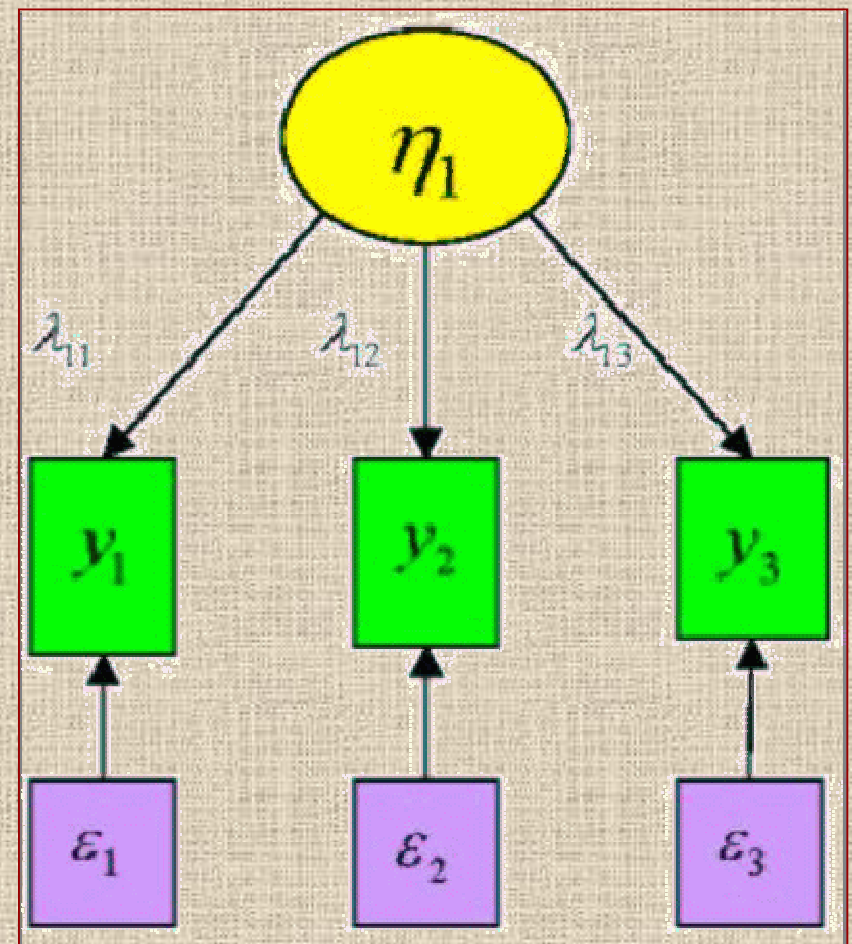
indicators  $\rightarrow$  *functions of latent variable*

explanatory perspective  $\rightarrow$  *top-down*



changes in the latent variable are reflected in changes in the observable indicators

*reflective*





# Synthesizing indicators

## b. Model-of-measurement perspective

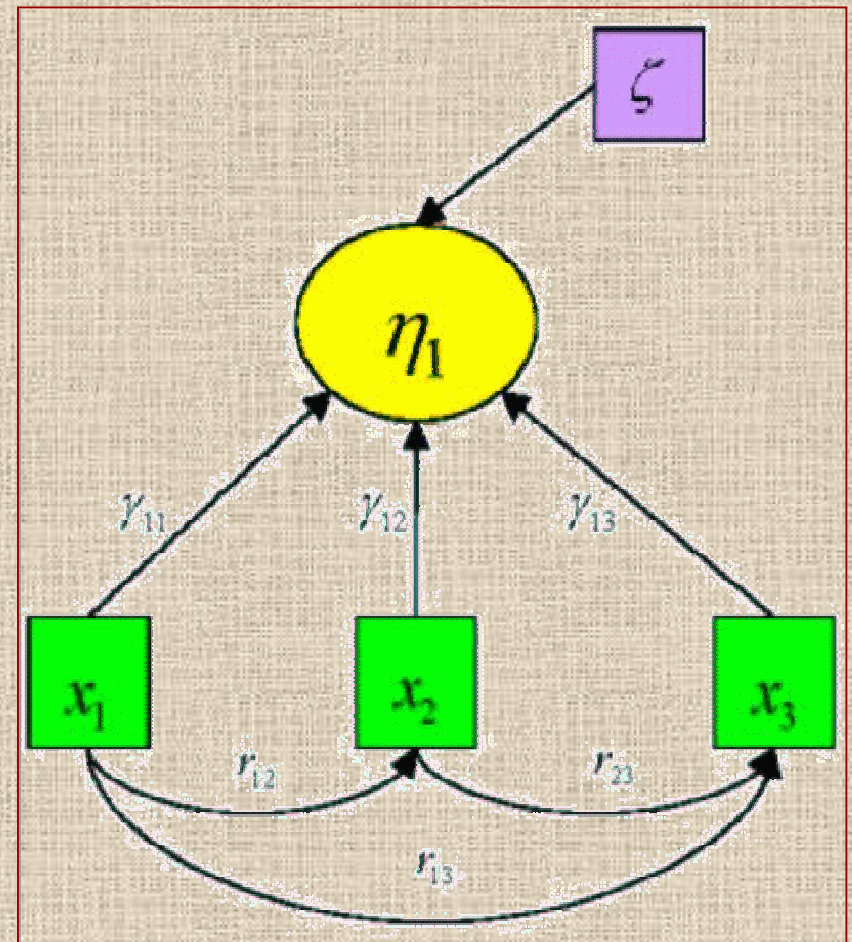
*formative*

indicators → *causal in nature*

explanatory perspective → *bottom-up*



changes in the indicators determine changes in the definition / value of the latent variable



# Synthesizing indicators

## b. Model-of-measurement perspective

### Aggregation based upon latent variables

When basic indicators are

- Reflective → **high correlations**
  - variables difficult to observe
  - synthesis easily interpretable
- Formative → **no correlation**
  - variables difficult to interpret
  - variable with normative meaning

# Synthesizing indicators

## b. Model-of-measurement perspective

### Aggregation based upon latent variables

The hypothesis can be tested through **structural models** which

- can estimate correlations between latent variables
- can not produce individual scores (undetermined scores)

# Synthesizing indicators

- a. Conceptual perspective
- b. Model-of-measurement perspective
- c. Technical perspective



# Synthesizing indicators

## c. Technical perspective

Two different general approaches

- **aggregative-compensative techniques**
  - based on correlations (reflective approach)
  - based on weights (formative approach)
- **non-aggregative synthetic techniques**
  - based on discrete mathematics

# Synthesizing indicators

c. Technical perspective

aggregative-compensative  
techniques

# Synthesizing indicators

## c. Technical perspective

1. **level of aggregation** (*micro/macro level*)
2. **dimensionality** (*dimensional analysis*)
3. **importance** of each indicator (*weighting criteria*)
4. **aggregating approach** (aggregation technique)

# Synthesizing indicators

## c. Technical perspective

1. level of aggregation (*micro/macro level*)
2. dimensionality (*dimensional analysis*)
3. **importance** of each indicator (*weighting criteria*)
4. **aggregating approach** (aggregation technique)



formative  
indicators



# Synthesizing indicators

## c. Technical perspective

### 1. Level of aggregation

In many cases, indicators observed at micro (individual level)  
can be synthesized at

**micro level**

**or**

**macro level**

# Synthesizing indicators

c. Technical perspective

## 2. Dimensionality

*Highly correlated indicators*

**Reflective** → indicators refer to the same conceptual dimension



**Consistency**

They can be synthesized

# Synthesizing indicators

c. Technical perspective

## 2. Dimensionality

*Highly correlated indicators*

**Formative** → redundant indicators



### **Redundancy**

two indicators highly correlated are considered redundant

*Recommendation* → select only one

# Synthesizing indicators

## c. Technical perspective

### 3. Importance

#### *weighting system*

**Weight** → indicator's importance in measuring the conceptual dimension



# Synthesizing indicators

c. Technical perspective

## 3. Importance

*weighting system*

**Weight** → indicator's importance in measuring the conceptual dimension



who / what defines the importance

# Synthesizing indicators

## c. Technical perspective

### 4. Aggregating approach

#### *Choosing the aggregation technique*

**criteria** → does the aggregating technique ...

- > admit **compensability** among the indicators?
- > require **comparability** among indicators? (direction and distribution)
- > require **homogeneity** in indicators' levels of measurement?

# Synthesizing indicators

## c. Technical perspective

More over ...

1. **testing the robustness:** capacity of the synthesis to produce correct and stable measures
  - *uncertainty analysis*
  - *sensitivity analysis*

# Synthesizing indicators

## d. Criticisms

Conceptual, methodological and technical criticisms



# Synthesizing indicators

## d. Criticisms

Conceptual, methodological and technical criticisms



Aggregative -compensative approach is not able

- to reflect the complexity of a phenomenon
- to capture the complexity of variables' relationships

# Synthesizing indicators

## d. Criticisms

Who is in favor of aggregative-compensative approach



- objectively built
- easy to manage
- easy to communicate

# Synthesizing indicators

## d. Criticisms

Methodology is far from being aseptic

Each stage introduces some degree of arbitrariness in taking decisions concerning

- a. Data metrics
- b. Indicators selection
- c. Weights definition
- d. Indicators aggregation
- e. Indicators assessment

# Synthesizing indicators

## d. Criticisms

Methodology is far from being aseptic

Each stage introduces some degree of arbitrariness in taking decisions concerning

- a. Data metrics
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- e. Indicators assessment

Ordinal data  
treated as  
cardinal



# Synthesizing indicators

## d. Criticisms

Methodology is far from being aseptic

Each stage introduces some degree of arbitrariness in taking decisions concerning

- a. Data metrics
- b. Indicators selection
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Use of  
multidimensional  
analysis

# Synthesizing indicators

## d. Criticisms

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- a. Data metrics
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- e. Indicators assessment

Objective  
vs.  
subjective

# Synthesizing indicators

## d. Criticisms

Methodology is far from being aseptic

Each stage introduces some degree of arbitrariness in taking decisions concerning

- a. Data metrics
- b. Indicators selection
- c. Weights definition
- d. Indicators aggregation
- e. Indicators assessment

- No homogeneity
- Compensation
- Numerical weights

# Synthesizing indicators

## d. Criticisms

Methodology is far from being aseptic

Each stage introduces some degree of arbitrariness in taking decisions concerning

- a. Data metrics
- b. Indicators selection
- c. Weights definition
- d. Indicators aggregation
- e. Indicators assessment

Are the compared combination really comparable?



# Synthesizing indicators

c. Technical perspective

## 4. Aggregating approach

*Question*

**... and with ordinal data?**

# Synthesizing indicators

c. Technical perspective

Non-aggregative synthetic  
techniques

# Synthesizing indicators

## c. Technical perspective

### Main goal

Assessing variables in a **multidimensional ordinal** setting by:

- 1) respecting the ordinal nature of the data
- 2) avoiding any aggregation among indicators (i.e., no composite is computed)
- 3) producing a synthetic index

# Synthesizing indicators

c. Technical perspective

## Main tool

### *Partial Order Theory*

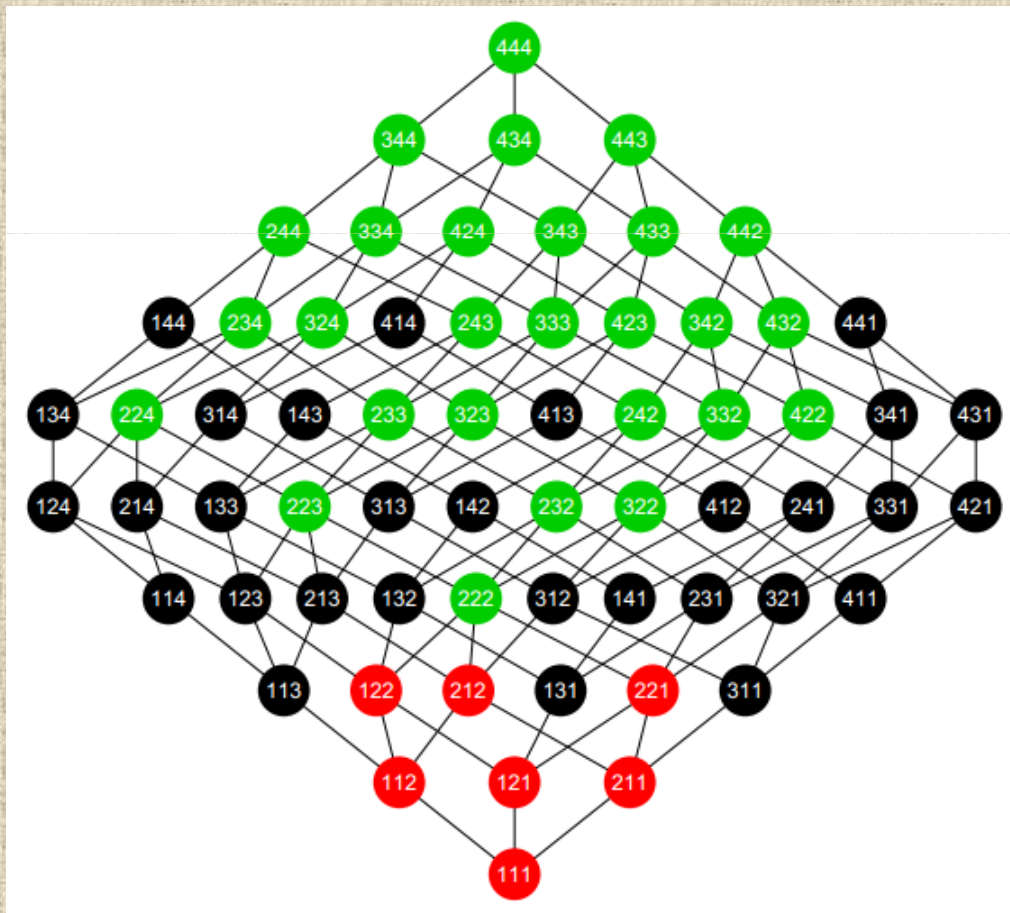
1. The focus is not on dimensions, but on «**profiles**» → combination of ordinal scores, describing the «status» of an individual.
2. Profiles → mathematically described and analyzed through Partially Ordered Set (Poset) Theory, instead of using classical linear algebra tools (variances, correlations,...)



# Synthesizing indicators

## c. Technical perspective

### *Partial Order Theory*



Only profiles linked by a descending path can be ordered.

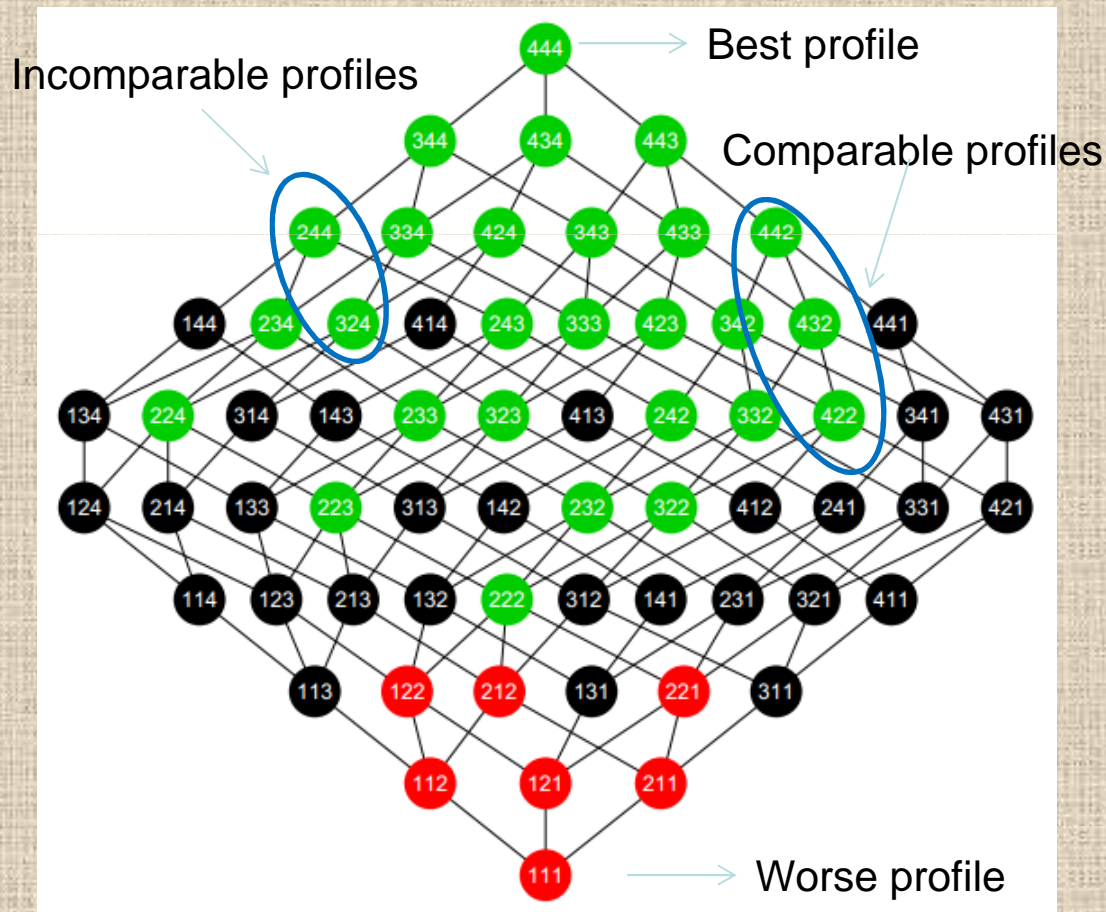
Two profiles not linked by a descending path are **incomparable**, even if they belong to different «layers»

*The meaning of the colors will be explained later*

# Synthesizing indicators

## c. Technical perspective

### *Partial Order Theory*



Only profiles linked by a descending path can be ordered.

Two profiles not linked by a descending path are **incomparable**, even if they belong to different «layers»

The meaning of the colors will be explained later

# Synthesizing indicators

c. Technical perspective

*Partial Order Theory*

How to establish the **threshold**?



normative problem



# Synthesizing indicators

## c. Technical perspective

### *Partial Order Theory*

The idea is to quantify this «relational position» in the graph.

This idea can be formalized within partial order theory.

What is important to stress here is that this way we get a  
synthetic measure of deprivation

**WITHOUT AGGREGATING ORDINAL SCORES**



Final remarks

## Final remarks

all elements composing the process should be  
**organically integrated**



they cannot be chosen independently

## Final remarks

However, sometimes they appear unconnected

*in particular*

## Final remarks

However, sometimes they appear unconnected

*in particular*

data and statistical approaches are not able to  
rebuild the conceptual framework



## Final remarks

However, sometimes they appear unconnected

*in particular*

data and statistical approaches are not able to  
rebuild the conceptual framework



This is obtained through subsequent  
approximations of the whole process

## Final remarks

Is this acceptable in a complex structure?  
How can we build a correct process without  
producing a chain of approximations?

## Final remarks

In order to obtain a meaningful and  
interpretable picture  
data should be managed in some way...  
**in other words ...**

## Final remarks

**Indicators** obtained through the hierarchical design are and remain a  
**complex system**




**Many thanks for your  
attention!!**

[filomena.maggino@uniroma1.it](mailto:filomena.maggino@uniroma1.it)

Social Indicators Research Series 70

Filomena Maggino *Editor*

# Complexity in Society: From Indicators Construction to their Synthesis

 Springer

**COMING SOON!!**