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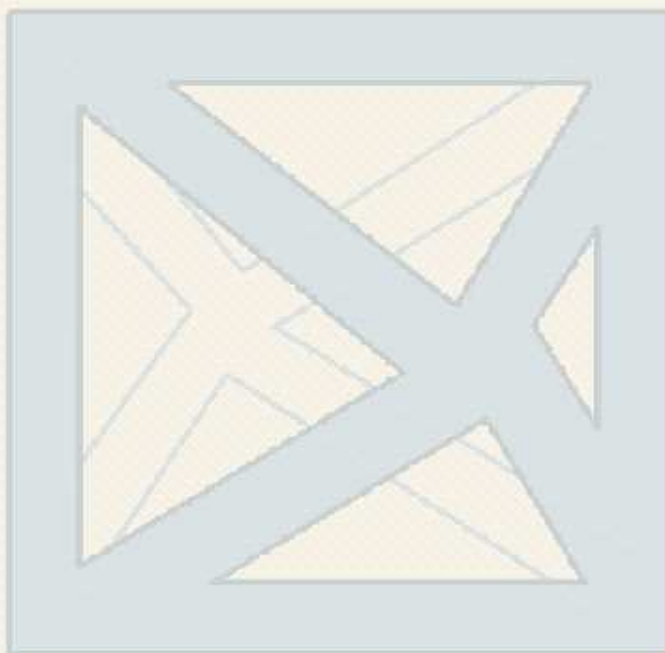
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Università degli Studi di Firenze  
*Dipartimento di Studi Sociali*

# Indicatori complessi



Filomena Maggino

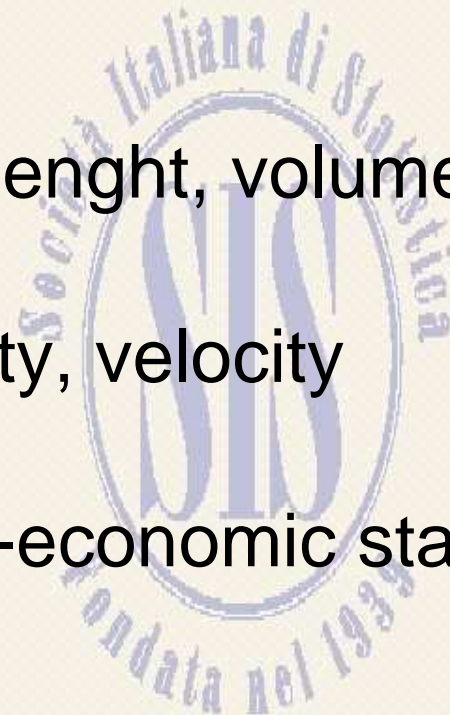
[filomena.maggino@unifi.it](mailto:filomena.maggino@unifi.it)



# Introduction

## Measuring processes by:

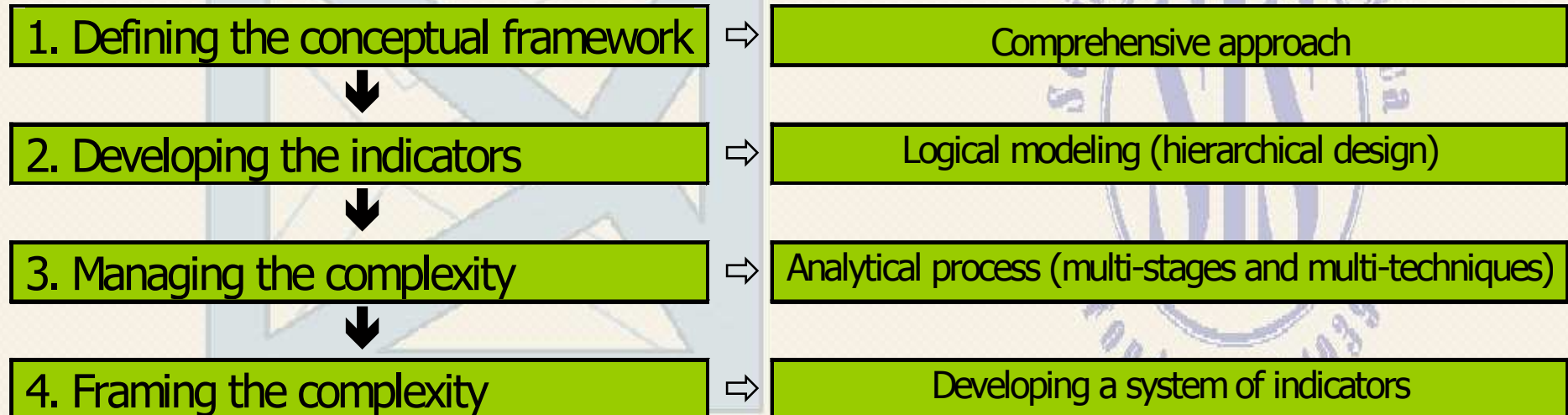
- 📌 a **fundamental** process  $\Rightarrow$  length, volume
- 📌 a **deriving** process  $\Rightarrow$  density, velocity
- 📌 a **defining** process  $\Rightarrow$  socio-economic status





# Introduction

In social sciences,  
the measurement process requires a design  
allowing indicators to be defined:





# Introduction

*Defining the conceptual framework*

*Developing the indicators*

*Managing the complexity*

*Framing the complexity*



**1.**

***Defining the conceptual framework***

***Developing the indicators***

***Managing the complexity***

***Framing the complexity***



# Defining the conceptual framework

Measuring social phenomena



different conceptual frameworks



*comprehensive*



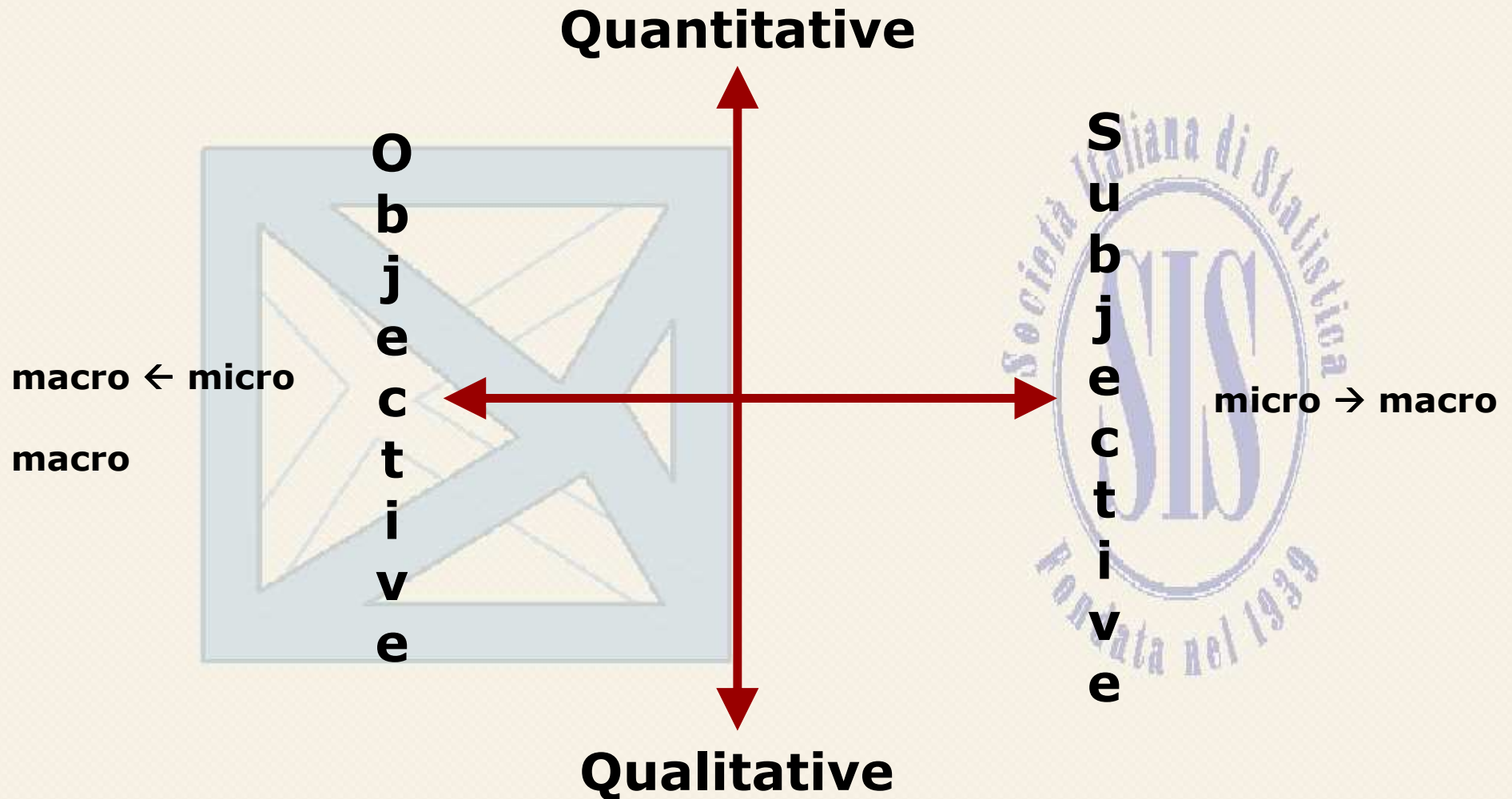
Integration between

**objective** and **subjective** information



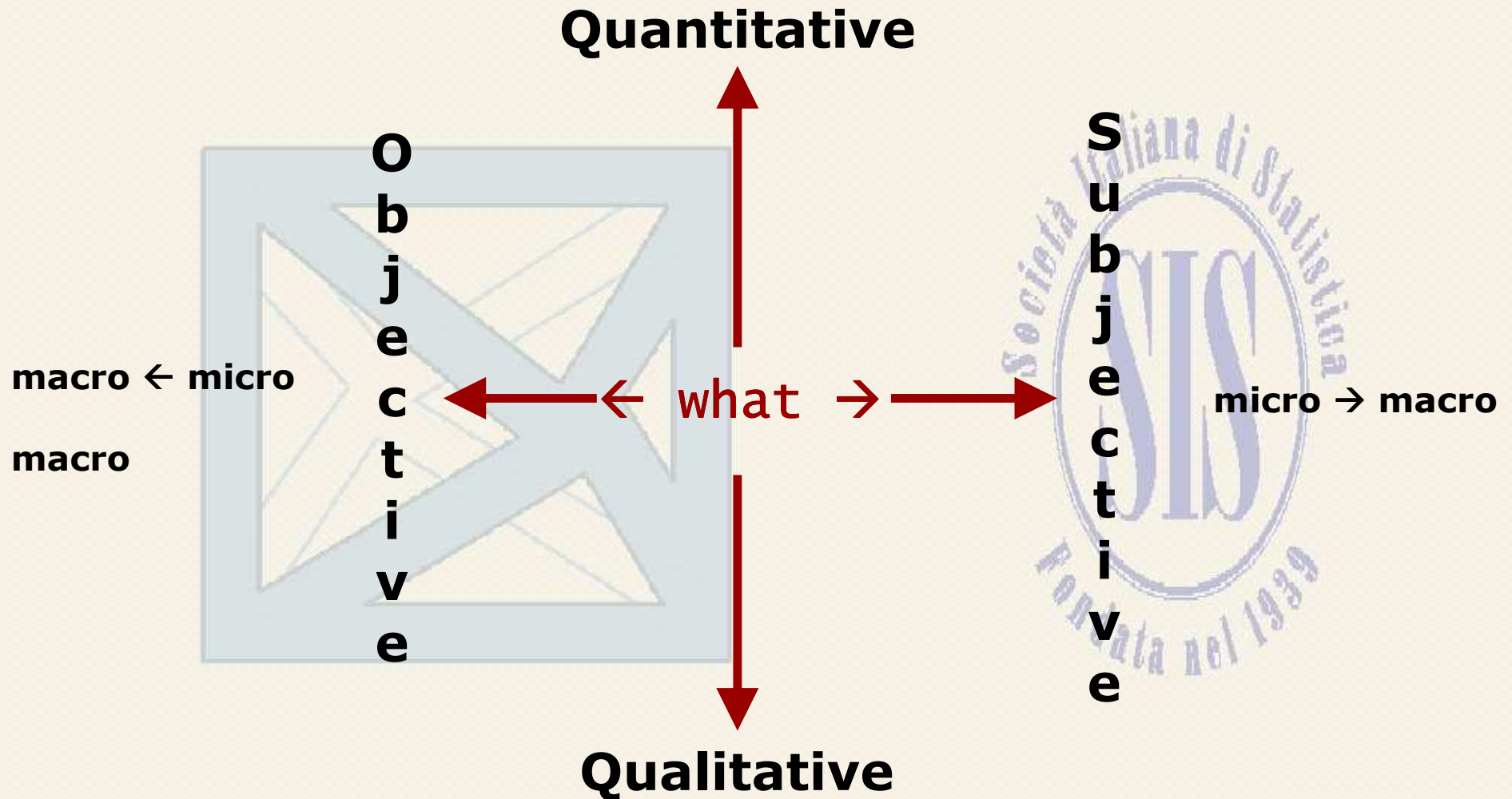


# Defining the conceptual framework



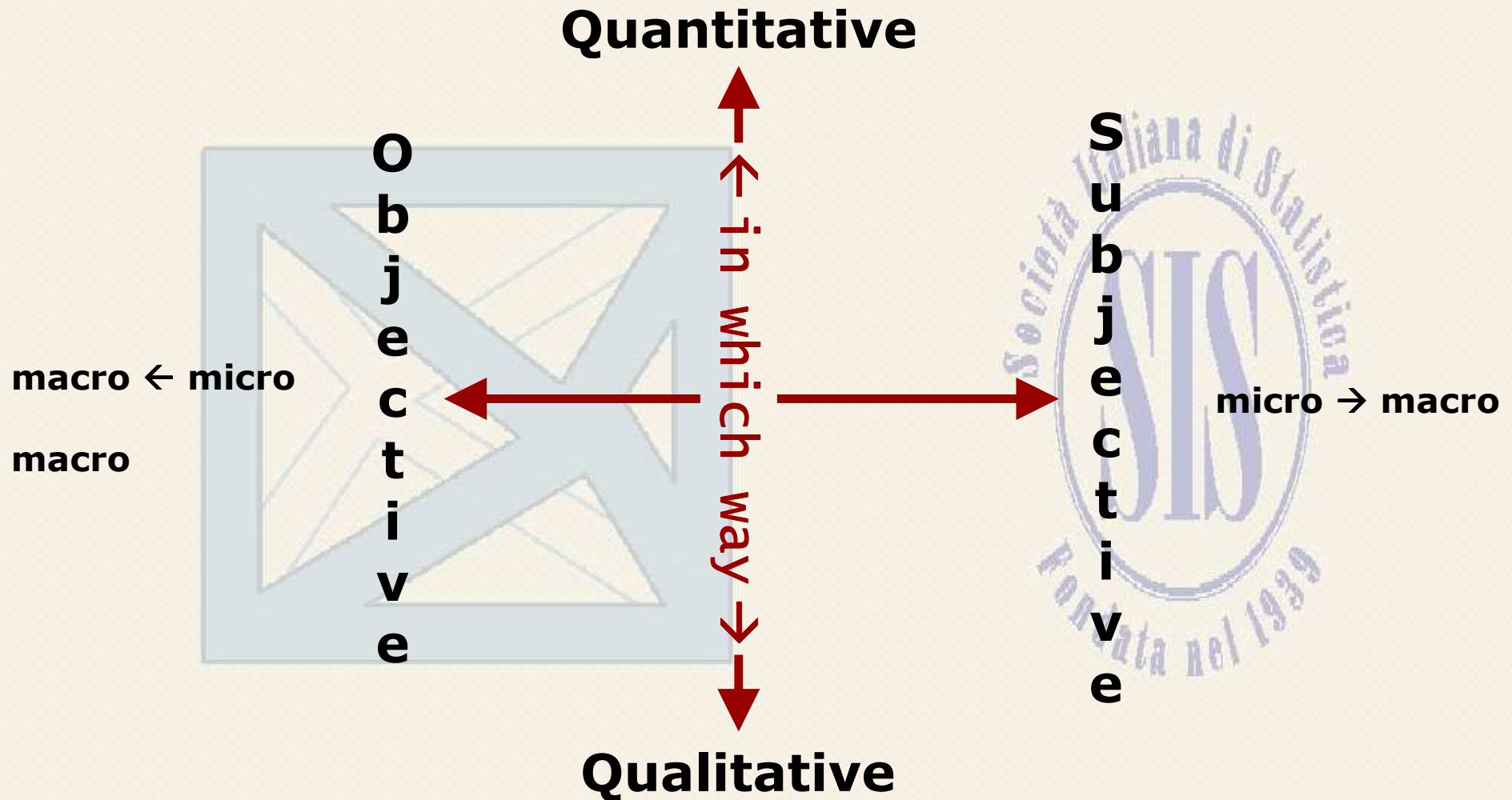


# Defining the conceptual framework





# Defining the conceptual framework





## 2.

***Defining the conceptual framework***

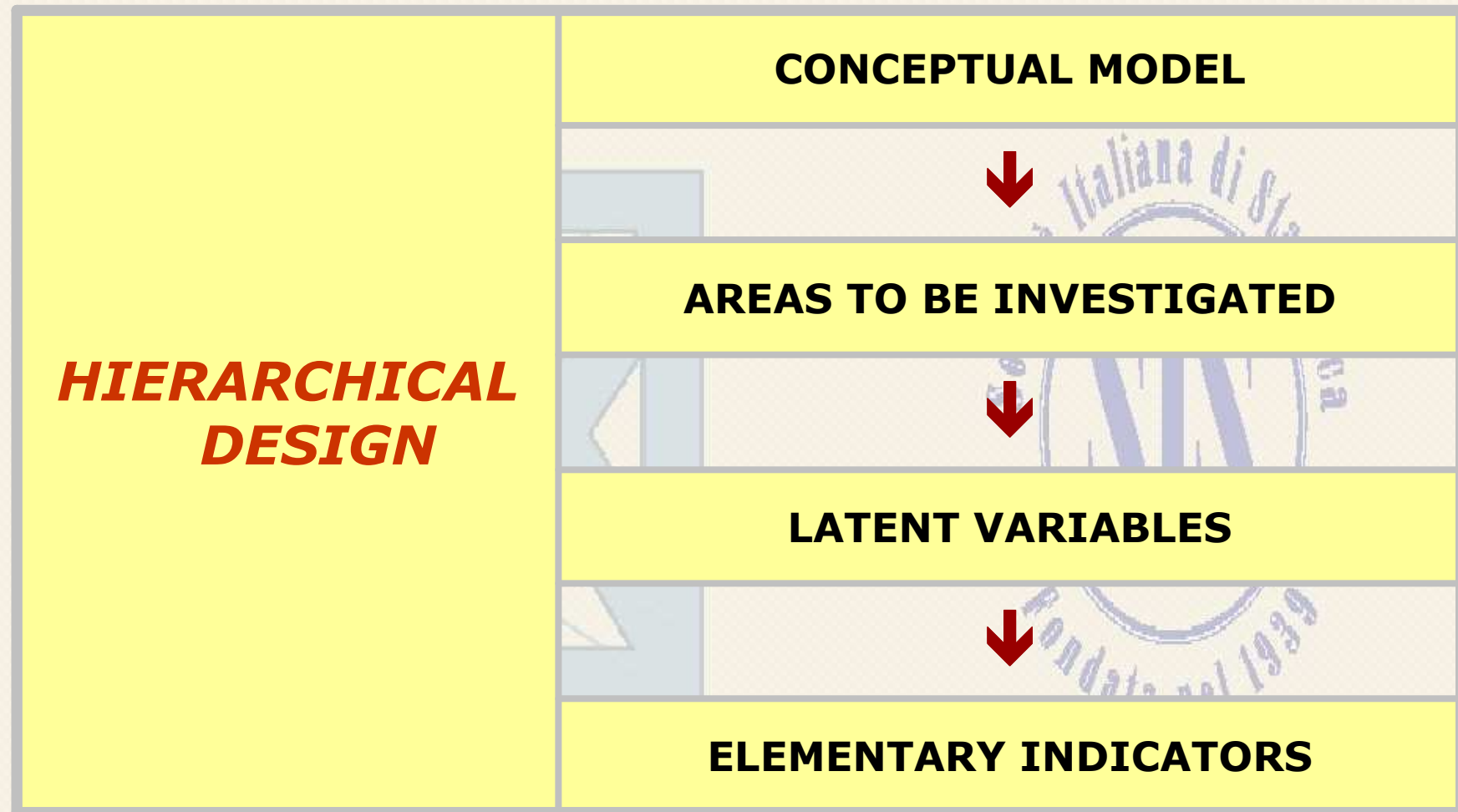
***Developing the indicators***

***Managing the complexity***

***Framing the complexity***



# Developing the indicators





# Developing the indicators

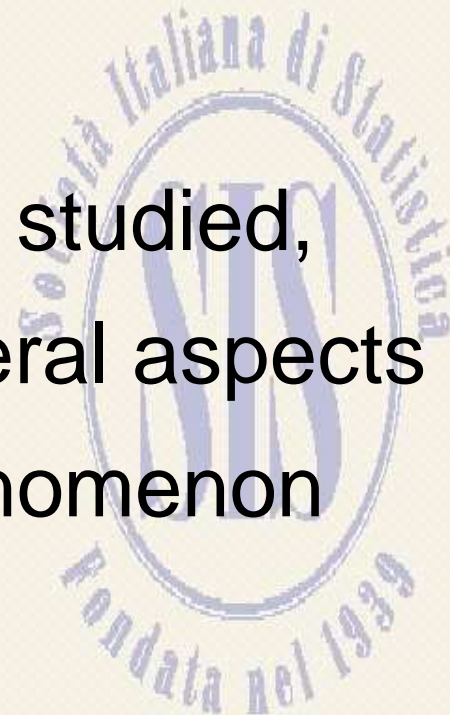
**Conceptual model** ↴

defines

the phenomenon to be studied,  
the domains and the general aspects  
characterizing the phenomenon



***process of abstraction***





# Developing the indicators

## Areas to be investigated



different aspects  
allowing the phenomenon  
to be specified consistently  
with the conceptual model





# Developing the indicators

## Latent variables ↴

elements to be observed  
in order to define  
the corresponding area

Their definition requires:



theoretical assumptions (dimensionality)



empirical statements





# Developing the indicators

## Elementary indicators ↴

what can be actually measured  
in order to investigate the variable

They are defined by:



appropriate techniques

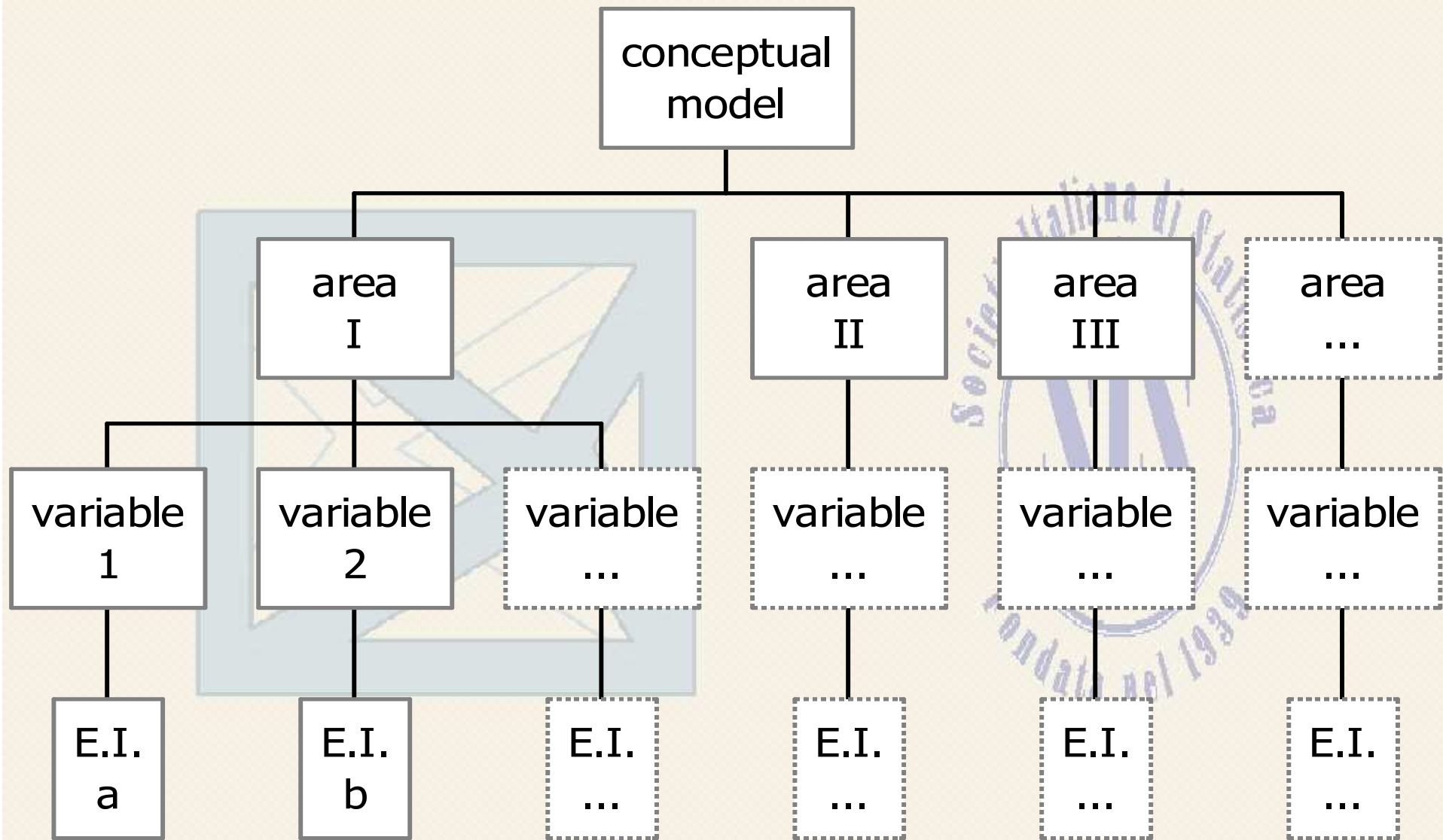


a system allowing observed values  
to be interpreted and evaluated



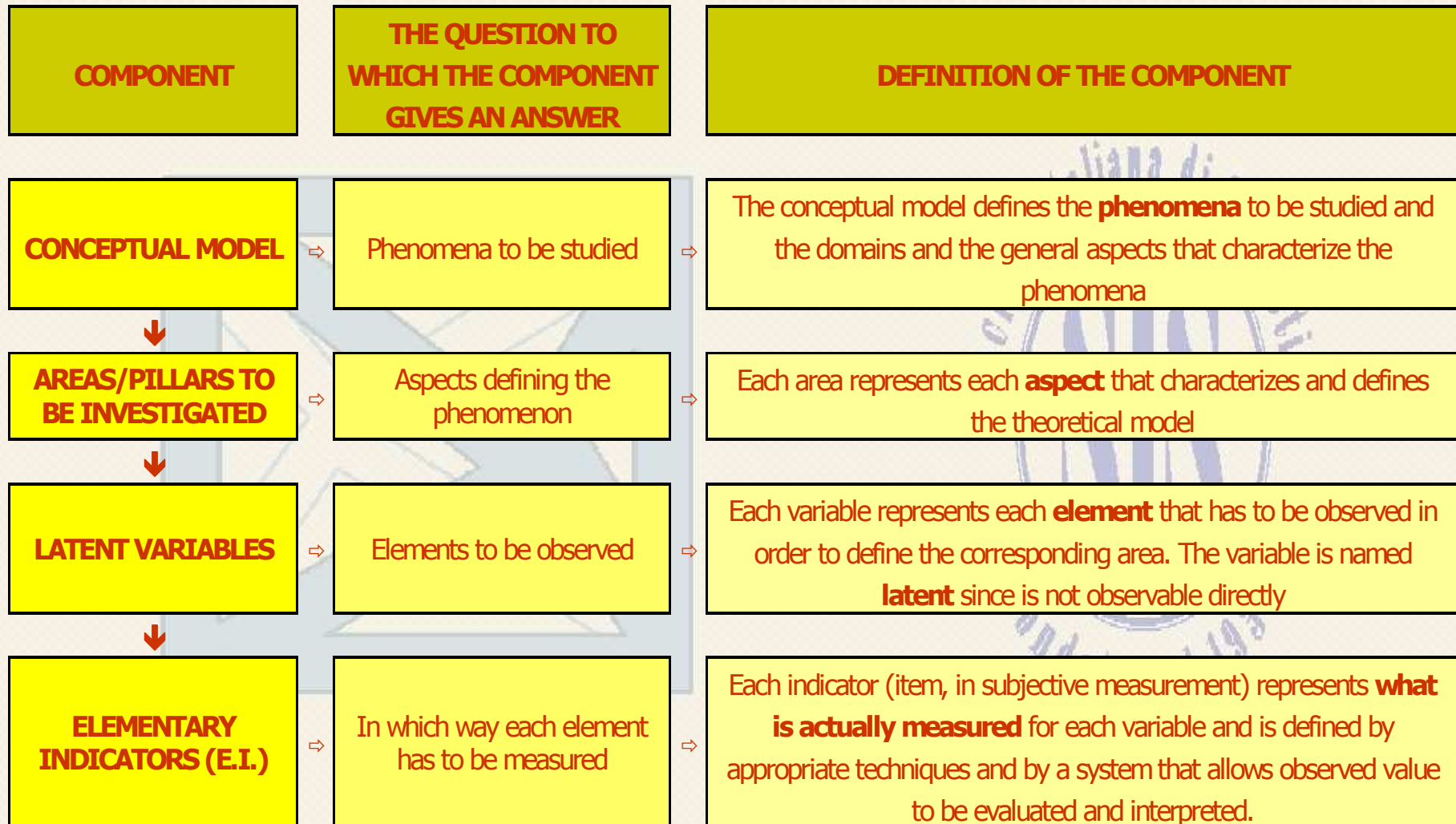


# Developing the indicators





# Developing the indicators





# Developing the indicators

## Definition of relationships between



latent variables and corresponding indicators  $\Rightarrow$  **model of measurement**



latent variables



elementary indicators





# Developing the indicators

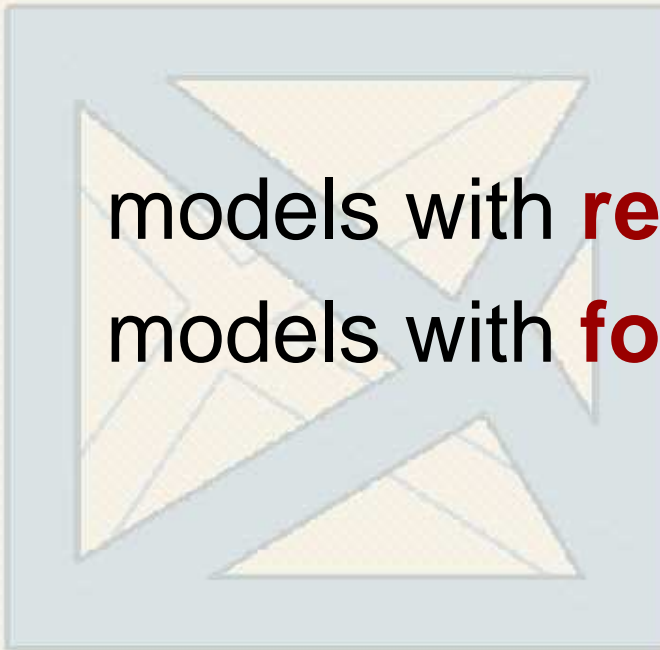
Two different conceptual approaches:



models with **reflective** indicators



models with **formative** indicators





# Developing the indicators

## Models with **reflective** indicators

*indicators* → ***functions of the latent variable***

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



***top-down*** explanatory approach



# Developing the indicators

## Models with **formative** indicators

*indicators* → ***causal in nature***

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

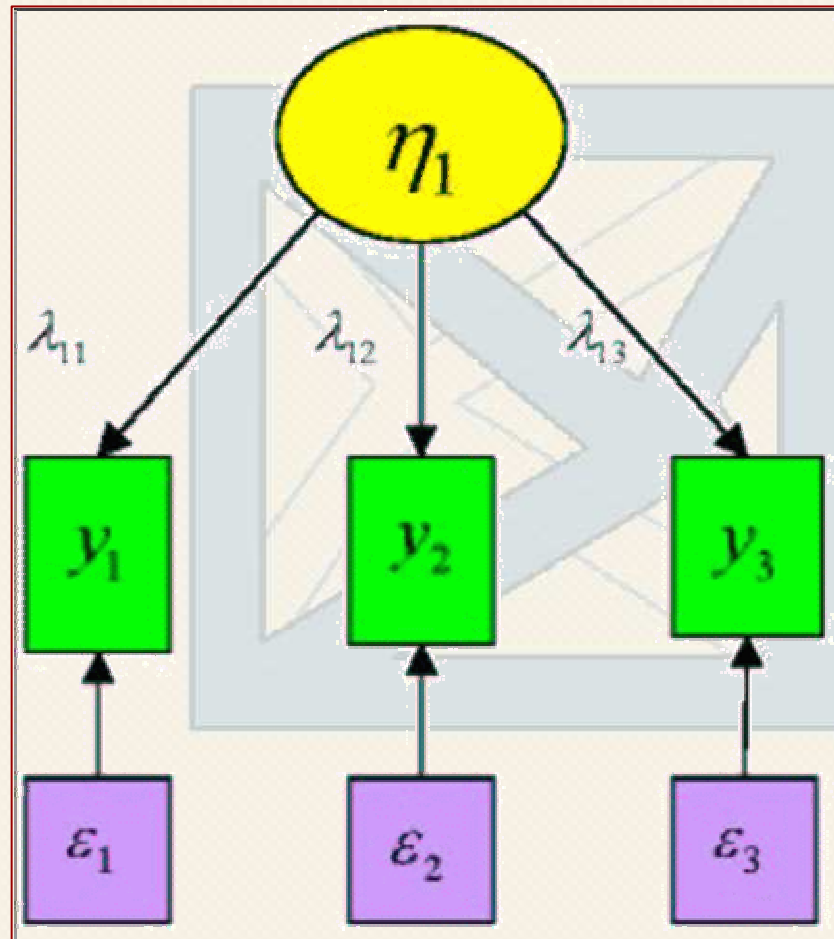


***bottom-up*** explanatory approach

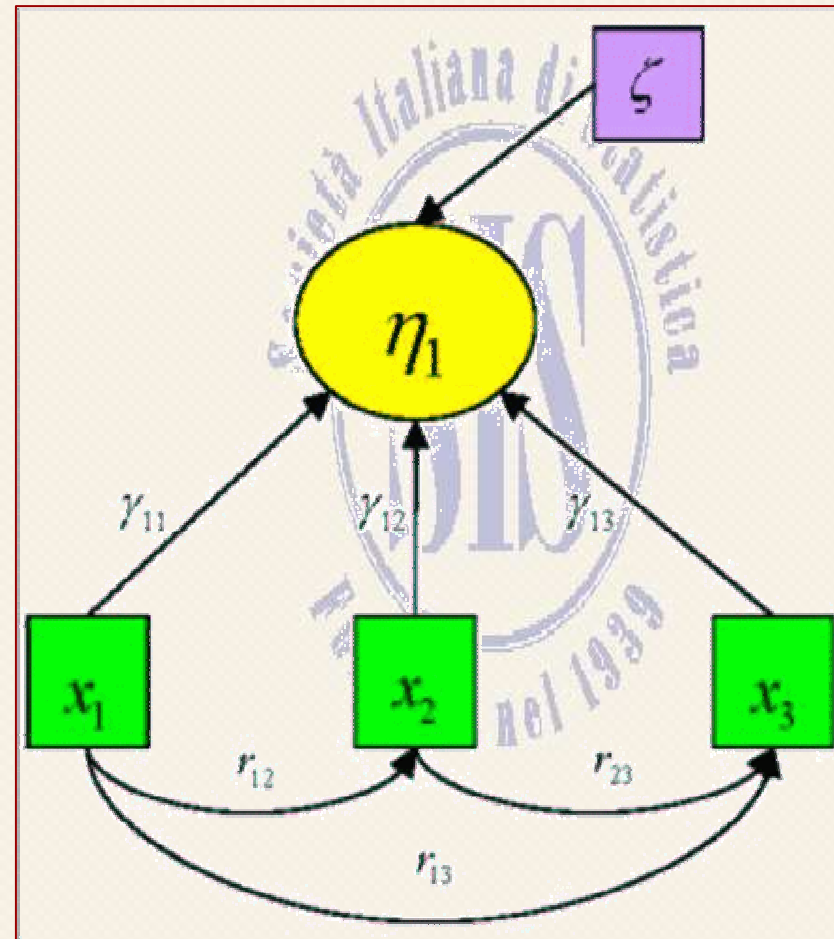


# Developing the indicators

## Reflective



## Formative





# 3.

***Defining the conceptual framework***

***Developing the indicators***

***Managing the complexity***

***Framing the complexity***



# Managing the complexity

Consistent application of the hierarchical design produces a **complex** data structure.

The complexity refers to  
**three data dimensions**  
to be managed





# Managing the complexity



## ***Elementary Indicators***

(several indicators for each variables)



## observed ***Cases/Units***

(several units for each observation)



## ***Variables***

(several variables are defined)





# Managing the complexity

## *Strategies to manage the complexity*



each data dimension may require a particular treatment:





# Managing the complexity

- A. aggregation of elementary indicators
- B. aggregation of cases/units
- C. integration of different variables





# Managing the complexity

Stage	Perspectives		Level of analysis	Analytical issues
i	<b>Aggregating elementary indicators</b>	Creation of complex indicators by aggregating elementary indicators	From elementary indicators to complex indicators	<ul style="list-style-type: none"> <li>• Reflective approach → synthetic indicators</li> <li>• Formative approach → composite indicators</li> </ul>
↓				
ii	<b>Relating variables</b>	Understanding relationships between characteristics in order to integrate / merge information (e.g. objective and subjective)	Micro level	Different solutions (consistently with conceptual framework)
↓				
iii	<b>Aggregating observed units</b>	Creation of macro-units by aggregating elementary units	From micro units to macro units	Following <ul style="list-style-type: none"> <li>- homogeneity criterion</li> <li>- functionality criterion</li> </ul>
↓				
iv	<b>Relating variables</b>	Understanding relationships between characteristics in order to integrate / merge information (e.g. objective and subjective)	Macro level	Different solutions (consistently with conceptual framework)



# Managing the complexity: A

**Aggregating elementary indicators:**

**two different criteria**





# Managing the complexity: A

## ↓ **Reflective** criterion

↳ *(homogeneity)*

↳ **Synthetic indicator**

## ↓ **Formative** criterion

↳ *(heterogeneity)*

↳ **Composite indicator**





# Managing the complexity: A

## 📌 **Reflective** approach

**Properties of reflective indicators (Diamantopoulos & Winklhofer, 2001):**

- indicator are interchangeable (the removal of an indicator does not change the essential nature of the underlying construct),
- correlations between indicators are explained by the measurement model,
- two uncorrelated indicators cannot measure the same construct (internal consistency),
- each indicator has error term,
- the measurement model can be estimated in the ambit of a larger model that incorporates effects of the latent variable.



# Managing the complexity: A

## 📌 Reflective approach

assessment of reliability and validity



statistical approach



consistent with → **factor models**





# Managing the complexity: A

## 📌 **Reflective** approach

### ASSUMPTION

Total variance of each indicator = sum of **three** uncorrelated components:

- **common variance**
  - explained by → latent variable
  - measured by → correlation between indicators
- **specific variance**
  - not correlated with the other indicators
- **error**, portion of the total variance
  - not correlated with the previous





# Managing the complexity: A

## 📌 Reflective approach

### ASSUMPTION

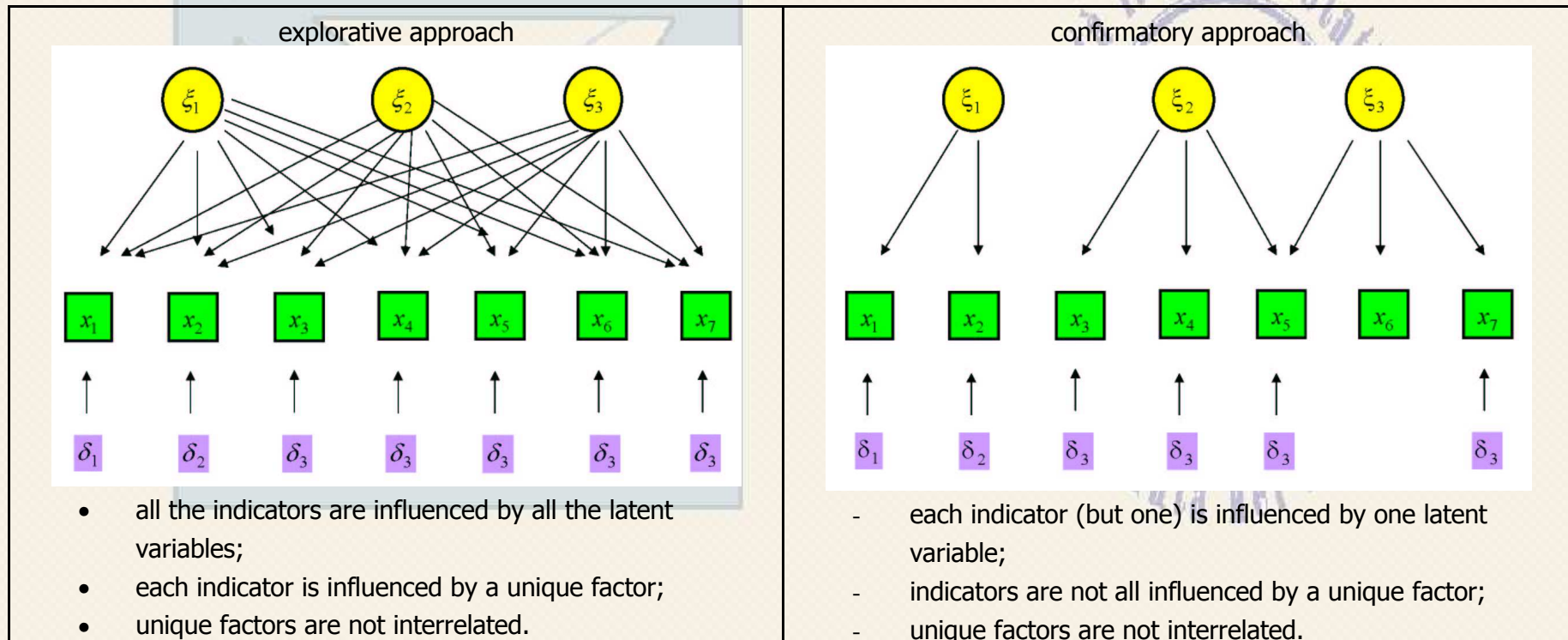
total variance	=	common variance			+	specific variance	+	error		
$\sigma_{x_i}^2$	=	$\sigma_{x_{ic}}^2$			+	$\sigma_{x_{is}}^2$	+	$\sigma_{x_{ie}}^2$		
total variance	=	communality			+	unique variance (uniqueness)				
$\sigma_{x_i}^2$	=	$h_{x_i}^2$			+	$\delta_{x_i}^2$				
total variance		reliable variance					+	error		
$\sigma_{x_i}^2$	=	$h_{x_i}^2 + \sigma_{x_{is}}^2$					+	$1 - (h_{x_i}^2 + \sigma_{x_{is}}^2)$		
$\sigma_{x_i}^2$	=	$\lambda_{x_i\xi_1}^2$	+	$\lambda_{x_i\xi_2}^2$	+	...	+	$\lambda_{x_i\xi_m}^2$	+	$(1 - h_{x_i}^2)$
fundamental equation of common factor model										
$\sigma_{x_i}^2 = \sum_{j=1}^m \lambda_{x_i\xi_j}^2 + \delta_{x_i}^2$										



# Managing the complexity: A

## 📌 Reflective approach

### ASSUMPTION





# Managing the complexity: A

## 📌 Reflective approach

### PARTICULAR APPROACHES:

			Scaling models' characteristics						
			Dimensionality	Nature of data	Scaling technique	Criterion for testing the model	Standard of measurement: final (synthetic) score assigned to		
Scaling models	Additive	Uni-dimensional	Uni	Single-stimulus	Not-comparative	Internal consistency	Cases		
		Multidimensional	Multi	Single-stimulus	Not-comparative	<i>Dimensionality of the items</i>	Cases		
	Cumulative	Thurstone model (differential scale)		Uni	Stimulus comparison	Comparative (pair comparison or rank-order)	Metrics between items	Items	
		Q methodology		Uni	Stimulus comparison	Comparative (rank-order or comparative rating)		Items	
		Deterministic	Guttman		Uni	Single-stimulus	Not-comparative	Scalogram analysis: reproducibility, scalability and ability to predict	Cases and items
			Multidimensional Scalogram Analysis (MSA)		Bi			Regionality and contiguity	Cases and items
			Partial Ordered Scalogram Analysis (POSA)		Bi			Correct representation	Cases and items
	Probabilistic	Monotone (one or more parameters)			Single-stimulus	Not-comparative	<ul style="list-style-type: none"> <li>parameters estimation (maximum likelihood)</li> <li>goodness of fit (misfit and residuals analysis)</li> </ul>	Cases and items (without condensation)	
	Perceptual Mapping	Multidimensional scaling		Multi	Similarities	Comparative (pair comparison)	Goodness of fit of distances to proximities (stress, alienation)	Items	
		Unfolding		Uni & Multi	Preferential choice	Comparative	Goodness of fit of distances to ordinal preferences	Cases and items	
	Conjoint model			Multi	Preferential choice	Comparative (rank-order)	Goodness of fit of the model (part-worth) to the ranking	Items at individual level	



# Managing the complexity: A

## 📌 **Formative** approach

Properties of formative indicators (Diamantopoulos & Winklhofer, 2001):

- indicator are not interchangeable (omitting an indicator is omitting part of the construct),
- correlations between indicators are not explained by the measurement model,
- two uncorrelated indicators can both serve as meaningful indicators of the same construct (internal consistency is not important),
- indicators do not have error terms



# Managing the complexity: A

## 📌 **Formative** approach

### ASSUMPTION

The latent variable = linear sum of indicators:

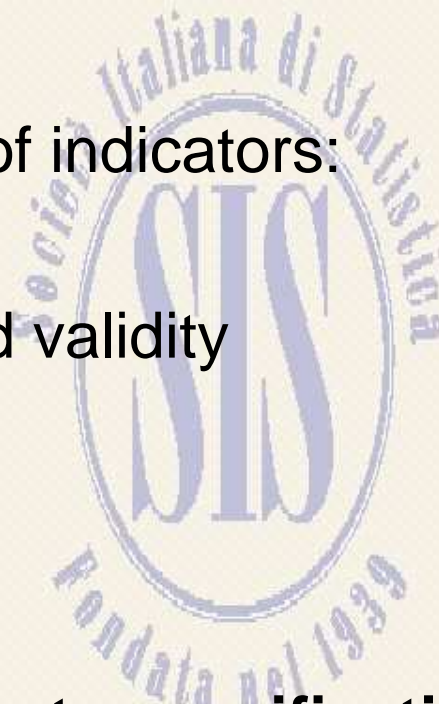
assessment of reliability and validity



statistical approach



consistent with → **principal components specification**





# Managing the complexity: A

## 📌 **Formative** approach

### PARTICULAR APPROACH: COMPOSITE INDICATORS

The methodology requires techniques aimed at

1. verifying the **dimensionality** of elementary indicators (*dimensional analysis*)
2. defining the **importance** of elementary indicators (*weighting criteria*)
3. identifying the **aggregating technique** (*aggregating-over-indicators techniques*)
4. assessing the **robustness** of the synthetic indicator → correct and stable measures (*uncertainty analysis, sensitivity analysis*)
5. assessing the **discriminant capacity** of the synthetic indicator (*ascertainment of selectivity and identification of cut-point or cut-off values*)



# Managing the complexity: B

**Aggregating observed units:  
from micro to macro units**





# Managing the complexity: B

Aggregation of cases/units is required in order to lead information to be analysed at the same level

		<b>LEVEL of observation</b>	
		<b>Micro</b>	<b>Macro</b>
<b>INFORMATION</b>	<b>objective</b>	individual living conditions	population or territory information
	<b>subjective</b>	subjective well-being	<i>not observable</i>



# Managing the complexity: B

## Objective information

### **a. Compositional**

e.g. proportion of people living in poverty

### **b. Contextual**

not observable at individual level





# Managing the complexity: B

## Subjective information

- a. Aggregation through **homogeneity** criterion (typologies)  $\Rightarrow$  analytical approaches
- b. Aggregation through **functionality** criterion (areas, ...)  $\Rightarrow$  analytical approaches?



# Managing the complexity: B

## a. *Homogeneity criterion*

*the values are aggregated if  
the individual cases are  
homogeneous according to  
the characteristics of interest*





# Managing the complexity: B

## *b. Functionality criterion*

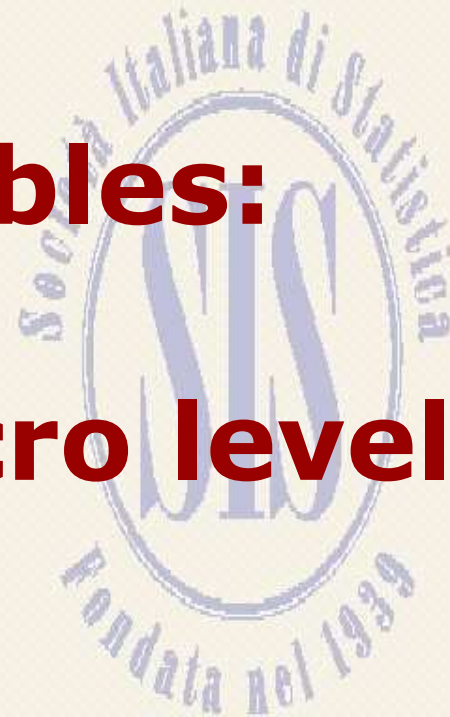
*the values are aggregated if  
the individuals belong to  
pre-existent higher-level units  
defined in terms of:*

- **groups** (social, generational, etc.)
- **areas** (geographical, administrative, etc.)
- **time periods** (years, decades, etc.)



# Managing the complexity: C

**Relating variables:  
(at micro and macro level)**





# Managing the complexity: C

- i. Structural models approach
- ii. Multi-level approach
- iii. Life-course perspective
- iv. Composite indicators





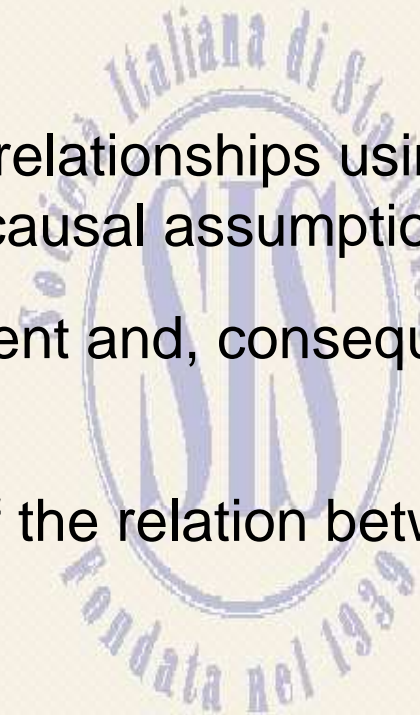
# Managing the complexity: C

## i. Structural models approach

**OBJECTIVE** → testing and estimating causal relationships using a combination of statistical data and qualitative causal assumptions

**PROS** → estimation of reliability of measurement and, consequently, structural relations between latent variables

**CONS** → strong acceptance of the direction of the relation between objective and subjective indicators is required





# Managing the complexity: C

## ii. Multi-level approach

**OBJECTIVE** → simultaneous analysis of outcomes in relation to determinants measured at different levels

**PROS** → description of relationships between subjective well-being (“outcome” variable), individual objective characteristics (micro-level living conditions), and territorial characteristics (macro-level living conditions)

**CONS** → strong assumption is required: people living in the same territory share the same macro-level living conditions that contributes - together with the micro-level living conditions - to subjective well-being



# Managing the complexity: C

## iii. Life-course perspective

**OBJECTIVE** → status at any given individual state (age, sex, marital status) not only reflecting contemporary conditions but also embodying prior living circumstances

**PROS** → possibility to study people's developmental trajectories (environmental and social) over time, by considering also the historical period in which they live, in reference to their society's social, economic, political, and ecological context

**CONS** → difficulty to obtain detailed and consistent individual longitudinal data and by the complexity of managing, analysing, and modelling this kind of data



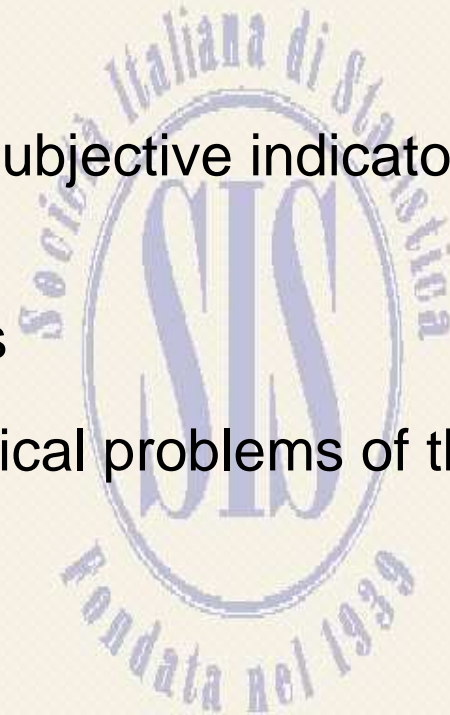
# Managing the complexity: C

## iv. Composite indicators

**OBJECTIVE** → aggregation of objective and subjective indicators in a unique value referring to each unit of interest

**PROS** → manageability of the obtained results

**CONS** → conceptual, interpretative and analytical problems of the obtained aggregation





# 4.

***Defining the conceptual framework***

***Developing the indicators***

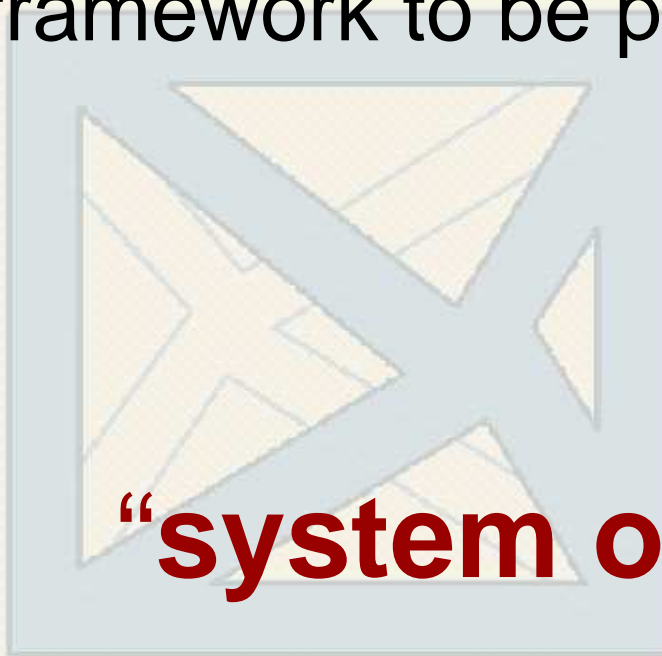
***Managing the complexity***

***Framing the complexity***



# Framing the complexity

A frame is needed allowing the conceptual framework to be put in a concrete form



**“system of indicators”**





# Framing the complexity

Characteristics of information in systems of indicators:

- 📌 **Objectivity** → equal, comparable results
- 📌 **Quantification** → quantitative values
- 📌 **Efficiency and fidelity** → communication of results
- 📌 **Economicity** → simple, standardized, up-to-datable information
- 📌 **Generalization** → exportability of the system
- 📌 **Joint development** → shared by all the actors



# Framing the complexity

Basic requirements defining a system of indicators:

## Key Elements

- Conceptual Framework requested in order to identify and justify the selection of dimension to be measured
- System Architecture requested in order to support the basic structure and to define the measurement procedures
- Definition and selection of the dimension to be measured
- Identification of units to be monitored
- Organization of measuring and monitoring procedures

## Formal criteria to be respected

- Comprehensiveness
- Consistency
- Non redundancy
- parsimoniousness



# Framing the complexity

- A** Functions of systems of indicators
- B** Elements defining a system of indicators
- C** Characteristics of indicators within a system





# Framing the complexity: A

**A.**

**Functions of systems of indicators**





# Framing the complexity: A

Functions can be seen in cumulative terms (each requires the previous) :

- 📌 Monitoring
- 📌 Reporting
- 📌 Forecasting
- 📌 Program/performance evaluation
- 📌 Accounting
- 📌 Assessment





# Framing the complexity: A

- 📌 **Monitoring** → capacity of the system to monitor changes over time and meet the need of improving knowledge
- 📌 Reporting
- 📌 Forecasting
- 📌 Program/performance evaluation
- 📌 Accounting
- 📌 Assessment





# Framing the complexity: A

- 📌 Monitoring
- 📌 **Reporting** → *monitoring + analysis + interpretation*
- 📌 Forecasting
- 📌 Program/performance evaluation
- 📌 Accounting
- 📌 Assessment





# Framing the complexity: A

- 📌 Monitoring
- 📌 Reporting
- 📌 **Forecasting** → trends in observed reality
- 📌 Program/performance evaluation
- 📌 Accounting
- 📌 Assessment





# Framing the complexity: A

- 📌 Monitoring
- 📌 Reporting
- 📌 Forecasting
- 📌 **Program/performance evaluation** → problem definition, policy choice and evaluation of alternatives and program monitoring
- 📌 Accounting
- 📌 Assessment





# Framing the complexity: A

- 📌 Monitoring
- 📌 Reporting
- 📌 Forecasting
- 📌 Program/performance evaluation
- 📌 **Accounting** → supporting decision concerning the allocation and the destination of resources
- 📌 Assessment





# Framing the complexity: A

- 📌 Monitoring
- 📌 Reporting
- 📌 Forecasting
- 📌 Program/performance evaluation
- 📌 Accounting
- 📌 **Assessment** → to certificate or judge subjects (individuals or institutions) by discriminating their performances or to infer functioning of institutions, enterprises or systems.





# Framing the complexity: B

**B.**

**Elements defining a system  
of indicators**

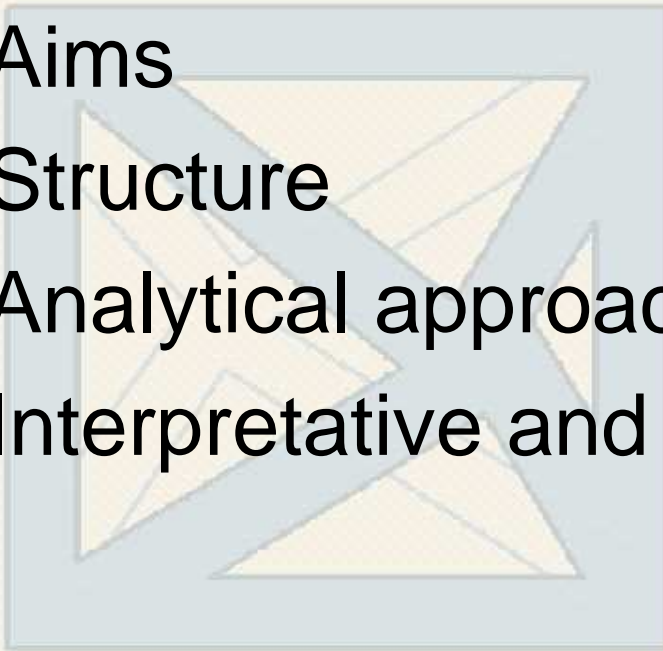




# Framing the complexity: B

## Main elements

- i. Aims
- ii. Structure
- iii. Analytical approaches
- iv. Interpretative and evaluating models





# Framing the complexity: B

## i. Aims

Conceptual → goals  
Operative → objectives  
Planning → actions



indicators	function
- input	→ measuring resources available in the system and indicating some sort of inputs into a process
- process (intermediate output)	→ monitoring the basic progress of implementing the actions defined and outlined at strategic level
- output/outcome	→ monitoring direct results of actions
- impact	→ monitoring progress and improvement towards goals and objectives achievement



# Framing the complexity: B

## ii. Structure

- 📌 **Vertical** → from local to higher level
- 📌 **Horizontal** → different ambits at the same level
- 📌 **Local** → monitoring internal organization of the level and referring to external parameters



# Framing the complexity: B

## iii. Analytical approaches

- 📌 Trend analysis
- 📌 Monitoring analysis
- 📌 Reporting analysis
- 📌 Benchmarking analysis
- 📌 Impact assessment
- 📌 Evaluation analysis





# Framing the complexity: B

## iv. Interpretative and evaluating models

The observed results can be interpreted only according to a specific reference frame.

This can also define and identify particular *standard-values*, which can be defined *a priori*, according to the objectives or empirical observations (e.g. surveys).



# Framing the complexity: C

**C.**

**Characteristics of indicators  
within a system**





# Framing the complexity: C

## Classification

- 📌 *Purposes*
- 📌 *Governance contexts*
- 📌 *Perspectives of observation*
- 📌 *Forms of observation*
- 📌 *Levels of communication*





# Framing the complexity: C

## Classification

### *Purposes*

- ⇒ **descriptive** (describing a reality)
- ⇒ **explicative** (interpreting a reality)
- ⇒ **predictive** (identifying trends)
- ⇒ **normative** (supporting decisions)
- ⇒ **problem oriented** (testing hypotheses)
- ⇒ **evaluating** practical – directionable – actionable (process – advancement – effect)





# Framing the complexity: C

## Classification

 *Governance context*

- ⇒ Public debates
- ⇒ Policy guidance
- ⇒ Administrative guidance





# Framing the complexity: C

## Classification

### *Perspective of observation*

- ⇒ **Conglomerative approach measures** ⇒ capturing advances made by the society as a whole
- ⇒ **Deprivational approach** ⇒ assessing status of the deprived

We need both, for an adequate understanding of the process



# Framing the complexity: C

## Classification

### *Forms of observation*

- ⇒ **Status indicators** ⇒ capturing a reality in a particular moment
- ⇒ **Trend indicators** ⇒ observing a reality along time  
(longitudinal design of observation)





# Framing the complexity: C

## Classification

### *Level of communication*

- ⇒ **Cold indicators** ⇒ complex and difficult, for specialists
- ⇒ **Hot indicators** ⇒ simple and easy
- ⇒ **Warm indicators** ⇒ good balance between quality, comprehensibility and resonance





# Framing the complexity: C

## Quality

- I. Methodological soundness*
- II. Integrity*
- III. Serviceability*
- IV. Accessibility*





# Framing the complexity: C

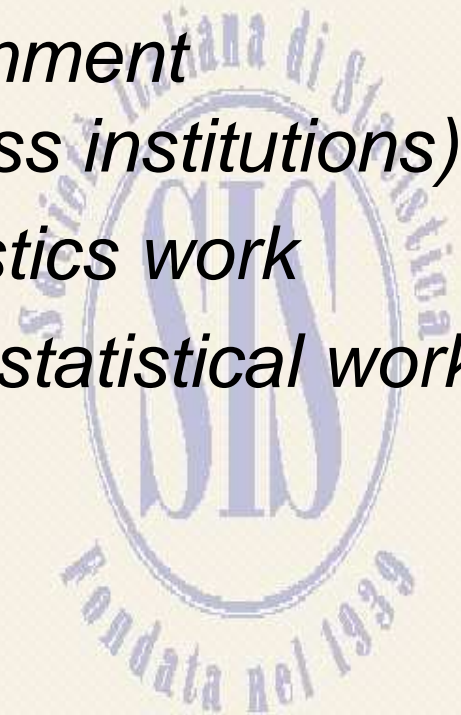
<p><b>An indicator should be able to:</b></p>	<ul style="list-style-type: none"> <li>• Define and describe</li> <li>• Observe unequivocally and stably</li> <li>• Record by a degree of distortion as low as possible</li> </ul>	<p><b>(I) METHODOLOGICAL SOUNDNESS</b></p>
	<ul style="list-style-type: none"> <li>• Adhere to the principle of objectivity</li> </ul>	<p><b>(II) INTEGRITY</b></p>
	<ul style="list-style-type: none"> <li>• Reflect adequately the conceptual model</li> <li>• Meet current ad potential users' needs</li> <li>• Be observed through realistic efforts and costs</li> <li>• Reflect the leght of time between its availability and the event of phenomenon it describes</li> <li>• Be analyzed in order to record differences and disparities</li> </ul>	<p><b>(III) SERVICEABILITY</b></p>
	<ul style="list-style-type: none"> <li>• Be spread</li> </ul>	<p><b>(IV) ACCESSIBILITY</b></p>



# Framing the complexity: C

## Prerequisite of quality

- 📌 *Legal and institutional environment  
(coordination within and across institutions)*
- 📌 *Resources available for statistics work*
- 📌 *Quality awareness informing statistical work*





# Framing the complexity: C

## Problems in selecting indicators

Different issues need to be addressed

in order to

selecting and managing indicators,

especially when this is carried out into

a complex system

allowing the accomplishment of functions like

**monitoring, reporting and accounting**



# Framing the complexity: C

## Problems in selecting indicators

Michalos (2006) identified **15** different issues related to the combination of social, economic and environmental indicators.

The issues collectively yield over **200,000** possible combinations representing at least that many different kinds of systems:



# Framing the complexity: C

## Problems in selecting indicators

- 📌 Settlement/aggregation area sizes
- 📌 Time frames
- 📌 Population composition
- 📌 Domains of life composition
- 📌 Objective versus subjective indicators
- 📌 Positive versus negative indicators
- 📌 Input versus output indicators
- 📌 Benefits and costs
- 📌 Measurement scales
- 📌 Report writers
- 📌 Report readers
- 📌 Quality-of-life model
- 📌 Distributions
- 📌 Distance impacts
- 📌 Causal relations





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**Thank you for your attention**

