UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Laboratory of Data Management and Synthetic Indicators for Sustainability

2627-2-F7603Q028

Aims

By the end of this course, students will be able to define, implement, and interpret synthetic indicators to measure sustainability and to apply the main machine learning approaches for the analysis of complex data systems defined by macro indicators of sustainability. In particular, they will be able to:

- define synthetic indicators and master the fundamental elements of multivariate analysis and multicriteria decision making, selecting the proper method (knowledge and understanding)
- explain the methods, critically interpret the constructed indicators, and evaluate the characteristics, fields of application, advantages, and disadvantages of the individual machine learning techniques (knowledge and understanding; making judgements)
- perform statistical analysis using statistical software to implement and compute indicators, and choose and manage the investigation approaches most suited to the purposes of the analysis (applying knowledge and understanding)
- communicate the results and explain the methods to an audience that might not be familiar with statistical or machine learning methods (communication skills)
- learn independently and explore further methodological extensions or novel national and international indicators (learning skills)

Contents

- Definition of conceptual model and indicator
- Indicator construction
- Computation using statistical software and interpretation of indicators
- Examples of national and international indicators for sustainability
- Data structure and data pre-processing in the framework of machine learning; covariance and correlation

- Strategies for data exploration and the rationalization of complex problems: Principal Component Analysis
- Distances for similarity and diversity measures
- Supervised modelling for the analysis of indicators for sustainability
- Strategies for Multicriteria Decision Making
- Practical experience and case studies

Detailed program

Definition of conceptual model and indicator:

- Introduction to the core definitions of conceptual frameworks and indicators
- Classification of indicator types based on the analyzed phenomenon, scope, information content, and structural construction

Steps to construct indicators:

- Developing a robust theoretical framework
- Criteria for variable selection and data screening
- Missing data treatment and imputation techniques
- Normalization, weighting, and aggregation methods

Computation using statistical software and interpretation of indicators

- Hands-on computational implementation of indicators using statistical software
- Practical guidelines for the correct interpretation of synthetic indexes

Examples of national and international indicators for sustainability
Review of international frameworks (e.g., indicators designed to monitor the progress of the UN Sustainable Development Goals).

The structure of multivariate data:

- Covariance and correlation
- Data scaling and pre-treatment: centering, auto-scaling, range scaling, variance scaling

Strategies for data exploration and the rationalization of complex problems:

- Analysis of the structure and exploration of data related to complex systems in the framework of macro synthetic indicators for sustainability
- Principal Component Analysis (PCA): scores and loadings; eigenvalues and definition of significant components (rank analysis)
- Examples of PCA and case studies

Analysis of similarity and diversity in complex systems:

- The concepts of analogy, similarity, dissimilarity and distance
- Distance and similarity measures for quantitative and binary data
- Cluster Analysis: examples and case studies

Supervised modelling for the analysis of indicators for sustainability:

- The concept of bias and validation methods; validation techniques of supervised models

- Multivariate regression and classification methods: examples and case studies

Strategies for Multicriteria Decision Making:

- Desirability and utility functions for the rational ranking of multivariate data; Pareto front
- Examples and case studies

Prerequisites

Basic concepts of descriptive statistics

Teaching form

Synthetic Indicators for Sustainability
Face-to-face lectures and practical laboratory activities:

- 10 hours, in-person lectures, delivered didactics
- 10 hours, in-person lectures, interactive teaching
- 10 hours, in-person lectures, interactive teaching to produce a report on a case study, to be analysed by the students in groups

Machine Learning and Ai-Applications for Data Management
Face-to-face lectures and practical laboratory activities:

- 10 hours, in-person lectures, delivered didactics
- 10 hours, in-person lectures, interactive teaching
- 10 hours, in-person lectures, interactive teaching to produce a report on a case study, to be analysed by the students in groups

Textbook and teaching resource

- OECD/European Union/EC-JRC (2008), Handbook on Constructing Composite Indicators: Methodology and User Guide, OECD Publishing, Paris, https://doi.org/10.1787/9789264043466-en.
- Mazziotta, M., & Pareto, A. (2025). Statistics for Composite Indicators. Springer.
- Slides
- Scientific papers made available on the e-learning website of the course
- Data and code for practical sessions made available on the e-learning website of the course

Semester

First semester

Assessment method

Students will prepare a report and a presentation on a case study provided by the teachers and developed in groups. The presentation will take place during the last lecture of the course.
The exam consists of an oral exam, which comprises the discussion of the topics covered in the course and the discussion of the report, with a mark between 18 and 30/30. The presentation is an integral part of the assessment: it adds up to a maximum of 2 points to the mark of the oral exam, only if the latter is equal to or higher than 18.
The assessment focuses on the following points: (1) knowledge and understanding; (2) correct use of terminology; (3) ability to analyse data and critically assess results; (4) ability to explain the methods used and communicate the results.

Office hours

By appointment scheduled via email

Sustainable Development Goals

QUALITY EDUCATION