Universitat Pompeu Fabra Barcelona

Topics in Applied Economics IV: Advanced Techniques in Applied Economics

2025-2026 Academic Year
Master of Research in Economics, Finance and Management

1. Description of the subject

- Advanced Techniques in Applied Economics — Code: 32089
- Total credits: 3 ECTS — Workload: 75 hours — Term: 3rd
- Type of subject: Elective
- Department of Economics and Business
- Teaching team: Piotr Zwiernik

2. Teaching guide

Introduction

Modern applied economics increasingly involves multivariate systems in which many variables interact simultaneously. In such settings, classical regression approaches are often insufficient, and more structured modelling techniques become necessary.

This course introduces advanced statistical tools for modelling complex dependence structures in economic and financial data. The central theme is the use of structured probabilistic models — in particular graphical models and latent-variable models — to represent and estimate high-dimensional systems in a principled way.

The course develops the idea of conditional independence as a modelling tool, studies both undirected and directed graphical models, and examines how structural assumptions reduce model complexity and make inference feasible in large dimensions. It then extends this framework to latent-variable models, such as probabilistic principal component analysis and related factor models, which are widely used in applied work.

Although the course has a strong methodological component, it is designed with applied economists in mind. Each major concept is illustrated through practical examples, and explicit code in R is provided throughout. Students will gain hands-on experience implementing graphical and latent-variable models and interpreting their results in applied settings.

The primary study material consists of detailed lecture slides and worked examples.

Teaching methodology

The course combines conceptual lectures with practical demonstrations and hands-on exercises in R. Each theoretical concept is accompanied by explicit code illustrating estimation, model fitting, and interpretation.

The emphasis is on understanding modelling assumptions and their consequences in applied settings. Computational tools such as penalized likelihood methods, the Expectation–Maximization (EM) algorithm, and basic variational inference techniques are introduced through concrete examples rather than abstract derivations.

Students are expected to engage actively with the provided code and to experiment with modifications as part of the learning process.

Contents

The course is organized into five parts, combining theoretical foundations with practical implementation.

1. Structured Probabilistic Models and Conditional Independence

This part introduces graphical representations of multivariate systems and the role of conditional independence in modelling. Undirected and directed graphs are presented as tools for structuring dependence. Gaussian graphical models and the interpretation of the precision matrix are developed, with examples illustrating how structure reduces dimensionality in applied problems.

2. High-Dimensional Inference under Structural Constraints

This part studies estimation in settings where the number of variables is large relative to the sample size. Penalized likelihood methods, including the LASSO and graphical LASSO, are introduced. Students implement sparse covariance and precision matrix estimation and examine how structural assumptions improve stability and interpretability.

3. Directed Graphical Models and Structure Learning

This part develops directed acyclic graphs (DAGs) as models of asymmetric dependence. Concepts such as d-separation, Markov equivalence, and essential graphs are introduced. Basic constraint-based and score-based methods for learning graphical structure from data are illustrated through applied examples.

4. Latent Variable Models

This part introduces latent-variable extensions of graphical models. Factor models and probabilistic principal component analysis (PPCA) are presented as structured approaches to modelling hidden components that drive observed dependence. The link between latent variables and covariance structure is emphasized, with applications to economic and financial data.

5. Computational Methods for Structured and Latent Models

The final part focuses on practical estimation methods. The Expectation–Maximization (EM) algorithm is introduced for latent-variable models, and basic variational inference ideas are presented as scalable alternatives. Students implement these methods in simple models and study their behaviour in finite samples.

Assessment and Grading System

The final grade is composed of a group project (70%) and an individual component (30%).

The group project may be either empirical or theoretical. Empirical projects require the application of graphical or latent-variable modelling techniques to a real dataset, including estimation, implementation in R, and interpretation of results. Theoretical projects may focus on the analysis of a modelling framework, identifiability issues, properties of structured estimators, or extensions of methods discussed in class.

All projects must clearly state their modelling assumptions and demonstrate understanding of the underlying methodology. The final deliverable consists of a written report and an in-class presentation.

The individual component reflects active participation during lectures, and demonstrated understanding of the material through class discussions and project-related questioning.

Literature

The primary study material for the course consists of the lecture slides and worked examples discussed in class.

The following books are recommended for background reading:

Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Springer.
Lauritzen, S. L. (1996). Graphical Models. Oxford University Press.
Peters, J., Janzing, D., and Schölkopf, B. (2017). Elements of Causal Inference. MIT Press.