

Courses

Economics, Networks and Business Analytics

Academic Year 2019 - 2020

Advanced Econometrics

Abstract: This module covers some of the most important methodological issues arising in any field of applied economics when the main scope of the analysis is to estimate causal effects. A variety of methods will be illustrated using theory and papers drawn from the recent applied literature. The aim of the module is to bridge the step from a technical econometrics course to doing applied research. The emphasis will be on the application of the methods, rather than the technical details about them. As such, the goal is to provide students with enough knowledge to understand when these techniques are useful and how to implement each method in their empirical research.

The assessment is based on the production of a short empirical project. To do the project students will need to provide a clear research question and a feasible empirical strategy; collect relevant data; implement an appropriate method chosen among one of those explored in the module; draw conclusions and write up the results in a standard academic style in less than 3,000 words.

Topics and Selected Readings:

1. Regression and Causality
 - a. Properties of the Conditional Expectation Function
 - b. Bad controls
 - c. Omitted variable bias
 - d. Measurement errors
 - e. Simultaneous equations
 - f. How to write an empirical project
2. Instrumental variables
 - a. Basics/recap
 - b. IV and causality
 - c. IV with heterogeneous treatment effects – LATE
 - d. Weak instruments
 - e. The bias of 2SLS
 - f. Application II: Miguel et al (2004) on rainfall, economic growth and conflict
 - g. Application III: Nunn (2009) on slave trades and economic performances
3. The Evaluation Problem and Randomised Experiments
 - a. Introduction to the evaluation problem
 - b. Randomised Experiments
 - c. Practical problems when running experiments
 - d. Dulfo et al (2007) on randomization in development
 - e. Application I: Krueger (1999) on class size and educational test scores
 - f. Application II: Blundell et al (2004) on education and earnings in the UK
4. Quasi-Experiments
 - a. Matching
 - b. Propensity Score Matching
 - c. Evaluating the validity of matching estimators
 - d. Application I: Caliendo et al., (2005) on job creation in Germany
 - e. Application II: Jones and Olken (2009) on assassination and institutions
5. Differences-in-Differences
 - a. Basics
 - b. Regression Differences-in-Differences
 - c. The Synthetic Control Method

- d. Application I: Card & Krueger (1994) on minimum wage and unemployment
- e. Application II: Abadie & Gardeazabal (2003) on the effect of terrorism in the Basque region
- f. Application III: Autor (2003) on unjust dismissal doctrine and employment
- 6. Regression Discontinuity Design
 - a. Sharp RD
 - b. Fuzzy RD
 - c. Running RD Models
 - d. Application I: Lee (2008) on U.S. House elections
 - e. Application II: Angrist & Lavy (1999) on scholastic achievement

Hours: 20

Professors/Lecturers: Francesco Serti (IMT Lucca)

Available for: Economics, Networks and Business Analytics

Advanced Methods for Complex Systems I

Abstract: This interdisciplinary course aims at introducing rigorous tools from statistical physics, information theory and probability theory to investigate real-world complex systems arising in different fields of research. First, some key aspects of complexity encountered in physical, biological, social, economic and technological systems will be reviewed. Then, emphasis will be put on the construction of theoretical models based on the concept of constrained randomness, i.e. the maximisation of the entropy subject to suitable constraints. This will lead to the introduction of maximum-entropy models that serve as mathematical benchmarks for the properties of highly heterogeneous complex systems. Special cases of interest include statistical ensembles of complex networks and of multivariate time-series with given properties. Comparisons between model outcomes and empirical properties will be presented systematically. Full mathematical derivations of the models, as well as methods of statistical inference, model selection and computer codes for parameter estimation on empirical data will be provided.

The course will include a combination of recent and ongoing research in the NETWORKS unit at IMT Lucca, thereby offering directions for possible PhD projects in this area.

Prerequisites: solid mathematical background, scientific curiosity, interest in multidisciplinary, passion for theory.

Hours: 20

Professors/Lecturers: Diego Garlaschelli (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Advanced Methods for Complex Systems II

Abstract: The second part of the course “Advanced Methods for Complex Systems” focuses on advanced practical applications of the concepts introduced in the first part. In particular, emphasis will be put on the successful areas of pattern detection and network reconstruction from partial information. Network pattern detection is the identification of robust empirical patterns (like scale invariance, clustering, assortativity, reciprocity, motifs, etc.) that are widespread across real-world networks and that deviate systematically from some null hypothesis formalised in terms of a suitable random graph model. The models introduced in part I will then be used here for pattern detection purposes. The problem of community detection will also be covered, with an emphasis on the differences between finding communities in network data and in correlation matrices constructed from (e.g. financial or neural) time series databases. The problem of network reconstruction from partial topological information will be

addressed concentrating on the reconstruction of financial and interbank networks from node-specific properties, with the purpose of improving stress tests and systemic risk estimates in real markets and offering better tools to policy makers. The statistical physics methods recently found by central banks to be the best-performing reconstruction techniques will be reviewed in detail.

The course will include a combination of recent and ongoing research in the NETWORKS unit at IMT Lucca, thereby offering directions for possible PhD projects in this area.

Prerequisites: solid mathematical background, scientific curiosity, interest in multidisciplinary, successful completion of the course “Advanced Methods for Complex Systems I”. Note: completion of this second part of the course is not required in order to move on to the third part (parts II and III can be understood in parallel independently of each other, after part I is completed), although it would surely provide a useful overview of practical motivations for part III.

Hours: 20

Professors/Lecturers: Diego Garlaschelli (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Advanced Methods for Complex Systems III

Abstract: The third part of the course “Advanced Methods for Complex Systems” focuses heavily on deeper theoretical aspects and their consequences. Particular emphasis will be put on the distinction between maximum-entropy models of complex systems with “soft” and “hard” properties. In statistical physics, the resulting models are known as the “canonical” and “microcanonical” ensembles respectively. Many of the results in statistical physics (e.g. the calculation of certain entropies), discrete mathematics (e.g. the combinatorial enumeration of possible configurations of a system with given properties), and information theory (e.g. the calculation of the maximum compressibility of information sequences) rely of the concept of “ensemble equivalence”, i.e. the asymptotic equivalence of soft and hard ensembles in the large size limit. Surprisingly, various complex systems have been found to violate the property of ensemble equivalence. For these systems, the standard approach is not appropriate and new developments are needed. Several intriguing challenges open up, including the uniform sampling of realisations of large complex systems, the combinatorial enumeration of systems with heterogeneous constraints and the recalculation of traditional information-theoretic bounds on communication. Examples of these open challenges will be provided, along with tentative solutions that are underway.

The course will include a combination of recent and ongoing research in the NETWORKS unit at IMT Lucca, thereby offering directions for possible PhD projects in this area.

Prerequisites: unlimited passion for theory and multidisciplinary, successful completion of the course “Advanced Methods for Complex Systems I”. Note: knowledge of the content of the course “Advanced Methods for Complex Systems II” is not required (parts II and III can be understood in parallel independently of each other, after part I is completed), although it would surely provide a useful overview of practical motivations for this part.

Hours: 20

Professors/Lecturers: Diego Garlaschelli (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Advanced Numerical Analysis

Abstract:

1. General considerations on matrices

Matrices: definitions and properties; norm of matrices

The condition number of a matrix

Sparse matrices and sparse formats (sparsity, structure, functionals)

The role of the PDE discretization (e.g., parameter dependence)

2.a Direct methods for general linear systems

Factorizations: definitions and properties

Factorization algorithms

Cost and numerical stability

2.b Direct methods for sparse linear systems

Factorizations of banded matrices

Ordering strategies to minimize the fill-in of a matrix

Solution of sparse triangular systems

Sparse matrices in Matlab: memorization and handling

Predefined functions for the direct solution of systems

3. Numerical solution of large-scale linear systems

Krylov subspace methods (CG, MINRES, GMRES, IDR family)

Structured problems

Preconditioning

Algebraic multigrid methods (hints)

Numerical experiments with Matlab and the IFISS package

4. Numerical solution of eigenvalue problems

Standard and generalized eigenproblems

Typical numerical methods

Equation of motion in structural dynamics: quadratic eigenproblems

Hours: 20

Professors/Lecturers: Valeria Simoncini (Università di Bologna); Benedetta Morini (Università degli Studi di Firenze)

Available for: Computer Science and System Engineering; Economics, Networks and Business Analytics

Advanced Topics in Network Theory: Algorithms and Applications

Abstract: Centrality metrics and spectral properties of graphs.

Community detection.

Bipartite and multilayer networks.

Applications: World Trade Web

Lecture 1: Centrality metrics

Lecture 2: Spectral properties

Lecture 3: Rankings and reputation on graphs
Lecture 4: Community detection in networks I
Lecture 5: Community detection in networks II
Lecture 6: Bipartite networks
Lecture 7: Multilayer networks
Lecture 8: World Trade Web
Lecture 9: Infrastructural network I
Lecture 10: Infrastructural network II

Hours: 10

Professors/Lecturers: Guido Caldarelli (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Advanced Topics in Network Theory: Brain Networks

Abstract: We shall provide the theoretical basis of the measurements and analysis of the various kind of network we can define in the brain.

Hours: 10

Professors/Lecturers: Guido Caldarelli (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Advanced Topics in Network Theory: Complex Networks and Python

Abstract: The course must be intended as a laboratory for the theoretical parts explained in the course of Introduction to Complex Networks, It will cover the basic preparation of the pc for the python coding and some example of interest in order to be able to start computational actiity in the field of complex networks.

Hours: 10

Professors/Lecturers: Guido Caldarelli (IMT Lucca)

Compulsory for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Advanced Topics in Network Theory: Dynamical Processes of Networks

Abstract: Mean field and master equations.
Percolation and epidemic models.
Contagion: the case of financial networks.
Applications of network theory.

Lecture 1: Master equations for network models

Lecture 2: Fitness and relevance models

Lecture 3: Epidemic processes in mean fields
Lecture 4: Epidemics on networks
Lecture 5: Scaling and percolation on networks
Lecture 6: Contagion in financial network I
Lecture 7: Contagion in financial network II
Lecture 8: Game theory on networks
Lecture 9: Evolutionary network games
Lecture 10: Networks from time series and visibility graph

Hours: 10

Professors/Lecturers: Guido Caldarelli (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Advanced Topics in Network Theory: Statistical Mechanics of Networks

Abstract: Information theory, Exponential Random Graphs.
Hypothesis testing on networks.
Reconstruction of networks.

Lecture 1: Basics of Information Theory
Lecture 2: Complex Networks Randomization
Lecture 3: Exponential Random Graphs
Lecture 4: maximum Likelihood Estimation
Lecture 5: Hypothesis testing on networks
Lecture 6: Early warnings in economic and financial networks
Lecture 7: Gravity Models of Trade
Lecture 8: Reconstruction algorithms I
Lecture 9: Reconstruction algorithms II

Hours: 10

Professors/Lecturers: Guido Caldarelli (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Advanced Topics of Control Systems: Numerical Methods for Optimal Control

Abstract: This course will cover a selected advanced topic in control, identification, or dynamical optimization.

Prerequisites: Linear algebra and matrix computation, calculus and mathematical analysis, control systems, numerical optimization.

Hours: 20

Professors/Lecturers: Mario Zanon (IMT Lucca)

Available for: Computer Science and System Engineering; Economics, Networks and Business Analytics

Analytics in Economics and Management

Abstract: The aim of this course is to teach students how to produce a research paper in economics and management using hands-on empirical tools for different data structures. We will bridge the gap between applications of methods in published papers and practical lessons for producing your own research. After introductions to up-to-date illustrative contributions to literature, students will be asked to perform their own analyses and comment results after applications to microdata provided during the course.

How productive is a firm, an industry or a country? Why? Where is it more profitable to locate an economic activity? Who buys what products? How long can we expect a company to outlive its competitors? What is the relationship between economic welfare and size of a city? How do economic agents interact socially in a geographic space or in a workplace?

The objective is to develop a critical understanding of the iterative research process leading from real economic data to the choice of the best tools available from the analyst kit. Students are expected to be familiar with macroeconomics, microeconomics and econometrics from the first-year sequence.

Final scores will be based 50% on individual presentations of a selected supplemental reading and 50% on an individual homework.

Hours: 20

Professors/Lecturers: Massimo Riccaboni (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Applications of Stochastic Processes

Abstract: This course offers an introduction to stochastic processes as a practical modelling tool for the quantitative analysis of systems. It covers the fundamentals of Markov chains, and presents algorithms and state-of-the-art software applications and libraries for their numerical solution and simulation. The class of Markov Population Processes is presented, with its most notable applications to as diverse disciplines as chemistry, ecology, systems biology, health care, computer networking, and electrical engineering. Finally, the course will examine the computational issues arising from the modelling of large-scale systems, reviewing effective approximation methods based ordinary differential equation (fluid) limits, moment-closure techniques, and hybrid models. Prerequisites: fundamentals of probability theory; knowledge of the topics of "Stochastic Processes and Stochastic Calculus" is useful but not necessary.

Hours: 20

Professors/Lecturers: Mirco Tribastone (IMT Lucca)

Available for: Computer Science and System Engineering; Economics, Networks and Business Analytics

Behavioral Economics

Abstract: The course is a self-contained presentation and discussion of the state-of-the-art research in behavioral economics, an area merging economics and psychology for the purpose of modelling and predicting human decision-making and behavior.

The goal of the course is to provide an all-purpose introduction to behavioral economics as well as to offer hooks and suggestions for cutting-edge research projects.

While a general understanding of game theory is welcome, no prerequisite is strictly necessary.

Specific topics covered:

1. What is Behavioral Economics? An economist's take on surprising human behaviors, with a reference to why psychologists and neuroscientists are hardly surprised
2. Rationality with cognitive bounds: Searching for predictable mistakes
3. Beyond homo economicus: Searching for predictable other-regarding preferences
4. A case study in behavioral game theory: Foundations of human prosociality
5. A discussion on methods: Experiments by economists in the lab and in the field, with a reference to how psychologists and neuroscientists would disagree

Hours: 20

Professors/Lecturers: Ennio Bilancini (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Business Model for Emerging Markets

Abstract: Teaching contents:

1. The economy of the intangibles
2. Manufacturing and robot
3. Strategy and business model
4. How to model a business
5. How to model a business in a complex scenario
6. What make market emerging? Not only new lands.
7. The Blockchain technology and the future
8. Initial Coins Offering (ICO) compressed between Business plan and White paper
9. Possible value of Blockchain technology for Small and medium Italian sized business
10. A global value chain approach to protect and foster strategic identity

Business case

Students will learn how to evaluate strategies, as well as how to locate sources of potential competitive advantage from a perspective that, for the purpose of this course, encompasses the internal and dynamic fit of a strategy. They will also learn how to identify organizational barriers and corporate behaviors that sustain or challenge the development and execution of strategies, and the competitive advantage of a company.

Hours: 20

Professors/Lecturers: Nicola Lattanzi (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Computer Programming and Methodology

Abstract: This course aims at introducing to students principles and methodologies of computer programming. Emphasis is on good programming style, techniques and tools that allow efficient design, development and maintenance of software systems. The course focuses on the design of computer applications drawing attention to modern software engineering principles and programming techniques, like object-oriented design, decomposition, encapsulation, abstraction, and testing. A significative case

study is used to allow students to experiment with the principles and techniques considered in this course. Depending on the background of the class, Java, C++, and/or Python are considered in the course.

Hours: 30

Professors/Lecturers: Mirco Tribastone (IMT Lucca)

Available for: Computer Science and System Engineering; Economics, Networks and Business Analytics

Critical Thinking (long seminar without exam)

Abstract: Constructing and evaluating arguments is fundamental in all branches of science, as well as in everyday life. The seminar provides the basic skills and tools to recognize correct forms of inference and reasoning, detect the unsound or fallacious ones, and assess the strength of various kinds of argument. The toolbox includes elementary deductive logic, naïve set theory, patterns of inductive and abductive inference, and elements of statistical and probabilistic reasoning. By engaging in real-world exercises of correct and incorrect reasoning, students will familiarize with the analysis of basic epistemological notions (truth vs. certainty, knowledge vs. belief, theory vs. evidence, etc.) and of common heuristics and biases as studied in cognitive psychology and behavioral economics. No previous knowledge of logic, philosophy, or advanced mathematics is required.

Hours: 10

Professors/Lecturers: Gustavo Cevolani (IMT Lucca)

Available for: Economics, Networks and Business Analytics

Data Science Lab

Abstract: The aim of this class is to provide students with R language fundamentals and basic syntax. In particular, lessons will cover the following topics:

- Overview of R features
- The basics (vectors, matrices, objects, manipulation, basic statements)
- Reading data from files
- Probability distributions
- Basic statistical models
- Graphical procedures
- R packages overview

Hours: 40

Professors/Lecturers: Tbd; Valentina Tortolini (IMT Lucca)

Available for: Computer Science and System Engineering; Economics, Networks and Business Analytics

Decision-Making in Economics and Management

Abstract: The main goals of the course are:

(1) to take economic theories and methodologies out into the world, applying them to interesting questions of individual behavior and societal outcomes;

(2) to develop a basic understanding of human psychology and social dynamics as they apply to marketing contexts;

(3) to become familiar with the major theory and research methods for analyzing consumer behavior;
(4) to develop market analytics insight into consumer actions.

Most of time will be devoted to close reading of research papers, including discussion of the relative merits of particular methodologies. Students will participate actively in class discussion, engage with cutting-edge research, evaluate empirical data, and write an analytical paper. The course aims at enabling students to develop and enhance their own skills and interests as applied microeconomists.

Hours: 10

Professors/Lecturers: Massimo Riccaboni (IMT Lucca)

Available for: Economics, Networks and Business Analytics

Econometrics I

Abstract:

- Review of Asymptotic Theory
- Theory and Algebra of OLS
- Inference, non-spherical Errors and Clustering
- Structural Models, Identification and Causality
- Simultaneous Equation Models, 2SLS and 3SLS
- Introduction to M-Estimation
- Generalized Method of Moments
- Maximum Likelihood Estimation

Hours: 20

Professors/Lecturers: Paolo Zacchia (IMT Lucca)

Compulsory for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Econometrics II

Abstract: This module covers the most important topics of modern microeconometrics. A variety of methods are illustrated with a hands-on-tool approach, combining theory and practice. The objective is to develop a critical understanding of the iterative research process leading from real economic issues to the choice of the best tools available from the analyst kit. The assessment is based on the production of a short empirical project (50%), a written exam (30%) and the presentation/replication of a published scientific article (20%).

- 1) Introduction to Microeconometrics
 - i) Heterogeneity and Microdata
 - ii) The Potential Outcome Model
 - iii) Exogeneity and Identification
 - iv) Parametric, Semiparametric and Non-parametric Models
 - v) The Local Polynomial Regression Model
 - vi) The Kernel Density Estimation

- 2) Survey Design, Sampling and Variance
 - i) Survey design and Sampling Techniques

- ii) The Heckman Correction
 - iii) One-way and Two-way Analysis of Variance
 - iv) Analysis of Covariance
- 3) Linear Panel Models
- i) Pooled Models
 - ii) The Fixed Effects Estimator
 - iii) The Random Effects Estimator
 - iv) Mixed Models
 - v) GMM Estimators for Panel Data
 - vi) Application: Firms, Productivity and Technical Change (Industrial Organization)
- 4) The Evaluation Problem
- i) Randomized Experiments
 - ii) Matching Models
 - iii) The Difference-in-difference Estimators
 - iv) Instrumental Variables
 - v) Regression Discontinuity Design
 - vi) Models with Control Functions
 - vii) Application: Evaluation of Active Labor Markets Programs (Labor economics)
- 5) Repeated Measures and Longitudinal Designs
- i) Experiments and Quasi-experiments
 - ii) Longitudinal Designs and Repeated Measures
 - iii) Between-subjects Hypothesis Testing
 - iv) Application: Behaviorally Motivated Policies (Behavioral/Experimental Economics)
- 6) Multinomial Models
- i) A Review of Logit and Probit Models
 - ii) The Multinomial Logit Model
 - iii) The Conditional Logit Model
 - iv) The Nested Logit Model
 - v) The Ordered Probit Model
 - vi) Application: Location Choices and Agglomeration Economies (Economic Geography)
- 7) Models for Count Data
- i) Poisson Regression Model
 - ii) Negative Binomial Regression Model
 - iii) Hurdle Models
 - iv) Application: Technology Diffusion from Patent Data (Economics of Innovation)
- 8) Survival/Duration Models
- i) On Censoring and Truncation
 - ii) The Kaplan-Meier Curve
 - iii) The Cox Regression Model
 - iv) The Weibull Model
 - v) Application: Market Access for Pharmaceutical Products (Health Economics)

Hours: 20

Professors/Lecturers: Armando Rungi (IMT Lucca)

Compulsory for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Evolutionary Game Theory

Abstract: The course provides an overview of the state of the art of evolutionary game theory which is useful to the potential researcher in the area as well as the interested scholar who works in a related field (behavioral sciences, social sciences, complexity studies). Evolutionary methods allow to study how behaviors and traits evolve in a population of interacting agents. The object of evolution can be a biological or cultural trait or a profile of strategies in a game. The process by which it changes can depend on fitness, imitation or optimization, possibly as the outcome of a deliberative process.

1. Overview of Evolutionary Game Theory
2. Deterministic evolutionary dynamics
3. Stochastic evolutionary models

Hours: 20

Professors/Lecturers: Ennio Bilancini (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Experimental Economics

Abstract: TBD

Hours: 20

Professors/Lecturers: Tbd

Available for: Economics, Networks and Business Analytics

Firms, Business Analytics and Managerial Behavior

Abstract: Teaching contents:

1. Theory of the Firm
2. The system of force in a business organization
3. The balance between efficiency of the production and effectiveness in results
4. Business performance and ways to represent
5. The financial statement
6. How to read and comprehend performances and results
7. Methodology and tools for Balance sheet analysis
8. Prevision versus prediction and business analytics
9. Entrepreneurship and management in complex scenario
10. Neuroscience, decision making process and managerial behavior

Business case

Students will learn how to evaluate strategies, as well as how to locate sources of potential competitive advantage from a perspective that, for the purpose of this course, encompasses the internal and dynamic fit of a strategy. They will also learn how to identify organizational barriers and corporate behaviors that sustain or challenge the development and execution of strategies, and the competitive advantage of a company.

Hours: 20

Professors/Lecturers: Nicola Lattanzi (IMT Lucca)

Compulsory for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Foundations of Probability and Statistical Inference

Abstract: This course covers the fundamental concepts of probability and statistical inference. Some proofs are sketched or omitted in order to have more time for examples, applications and exercises. In particular, the course deals with the following topics:

- probability space, random variable, expectation, variance, cumulative distribution function, discrete and absolutely continuous distributions,
- random vector, joint and marginal distributions, joint cumulative distribution function, covariance,
- conditional probability, independent events, independent random variables, conditional probability density function, order statistics,
- multivariate Gaussian distribution, copula functions,
- probability
- generating function, Fourier transform/characteristic function,
- types of convergence and some related important results,
- point estimation, interval estimation, hypothesis testing, linear regression, introduction to Bayesian statistics.

Hours: 30

Professors/Lecturers: Irene Crimaldi (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Funding and Management of Research and Intellectual Property (long seminar without exam)

Abstract: The long seminar aims at providing an overview on the management of intellectual property rights (copyright transfer agreements, open access, patents, etc.). Funding opportunities for PhD students, post-docs, and researchers are also presented (scholarships by the Alexander von Humboldt Foundation; initiatives by the Deutscher Akademischer Austausch Dienst; scholarships offered by the Royal Society in UK; bilateral Italy-France exchange programmes; Fulbright scholarships; Marie Curie actions; grants for researchers provided by the European Research Council). For each funding scheme, specific hints on how to write a proposal are given.

Hours: 10

Professors/Lecturers: Marco Paggi (IMT Lucca)

Available for: Computer Science and System Engineering; Economics, Networks and Business Analytics

Game Theory

Abstract: The course covers the basics of non-cooperative game theory and information economics. The goal is to equip students with an in-depth understanding of the main concepts and tools of game theory in order to enable them to successfully pursue research in applied areas of economics and related disciplines, and to provide a solid background for students who are planning to concentrate on economic theory.

The course starts with a detailed description of how to model strategic situations as a game. It proceeds

by studying basic solution concepts and their main refinements (dominance and iterative dominance, Nash equilibrium, correlated equilibrium, subgame perfect equilibrium, weak perfect Bayesian equilibrium, sequential equilibrium), strategic interaction under incomplete information (Bayesian games, Bayesian Nash equilibrium), and asymmetric information (adverse selection, signaling, screening, moral hazard, and the principal agent problem). The discussion of all theoretical concepts will be accompanied by representative applications from economics. The course is mostly self-contained, but students should be familiar with basic concepts from calculus, linear algebra, and probability theory.

Hours: 20

Professors/Lecturers: Ennio Bilancini (IMT Lucca)

Compulsory for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Global Law

Abstract: The course illustrates how globalization affects the international legal context and how global regulatory regime emerge and develop. With the examples taken from several different sectors, such as world trade, Internet, sports, finance, environment, public health, cultural heritage, the course will focus on the regulatory, institutional and procedural dimensions of international organizations and on the relationships between these latter and domestic legal orders.

Hours: 10

Professors/Lecturers: Lorenzo Casini (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Identification, Analysis and Control of Dynamical Systems

Abstract: The course provides an introduction to dynamical systems, with emphasis on linear systems in state-space form. After introducing the basic concepts of stability, controllability and observability, the course covers the main techniques for the synthesis of stabilizing controllers (state-feedback controllers and linear quadratic regulators) and of state estimators (Luenberger observer and Kalman filter). The course also briefly covers data-driven approaches of parametric identification to obtain models of dynamical systems from a set of data, with emphasis on the analysis of the robustness of the estimated models w.r.t. noise on data and on the numerical implementation of the algorithms.

Prerequisites: Linear algebra and matrix computation, calculus and mathematical analysis.

Hours: 20

Professors/Lecturers: Alberto Bemporad (IMT Lucca)

Available for: Computer Science and System Engineering; Economics, Networks and Business Analytics

Industrial Organization

Abstract: This course will survey recent developments in theory and empirics of firm dynamics and its importance for aggregate outcomes such as innovation, growth and international trade. In particular, this class will center around the following questions:

- a) what are the key empirical regularities on firm dynamics and what are the principal measurement issues?
- b) what drives firms' size and growth dynamics?
- c) what determines the dynamics of entrepreneurial growth and innovation by firms?
- d) how do different sources of firm-level heterogeneity influence aggregate outcomes?
- e) what drives the rise and fall of inter-firm collaboration and trade networks?

This is a second year Ph.D. course. Students are expected to be familiar with macroeconomics, microeconomics and econometrics from the first-year sequence.

Hours: 20

Professors/Lecturers: Massimo Riccaboni (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Introduction to Cognitive and Social Psychology

Abstract: This course will provide an introduction to general themes in Cognitive and Social Psychology. In the first part of the course, we will review seminal findings that had a major impact on our knowledge of cognitive processes and social interactions, as well as more recent studies that took advantage of neuroimaging, electrophysiology and brain stimulation methods to shed new light on decision-making and social behaviors. During the second part of the course, students will be asked to perform a brief presentation of a research article and to critically discuss positive aspects and limitations of the study. The course will include seminars and lectures by renowned researchers in the field and will educate PhD candidates about the influence of social aspects of the human nature on cognitive and brain functioning (and vice-versa) in an intellectually motivating manner.

Hours: 24

Professors/Lecturers: Pietro Pietrini (IMT Lucca); Emiliano Ricciardi (IMT Lucca)

Available for: Economics, Networks and Business Analytics

Introduction to Complex Systems and Networks

Abstract: Complexity, self-similarity, scaling, self-organised criticality.
 Definition of graphs, real networks and their properties.
 Models of static networks, models of network growth.

- Lecture 01 Graph Theory Introduction
- Lecture 02 Properties of Complex Networks
- Lecture 03 Communities
- Lecture 04 Different Kind of Graphs
- Lecture 05 Ranking
- Lecture 06 Static Models of Graphs
- Lecture 07 Dynamical Models of Graphs
- Lecture 08 Fitness Models
- Lecture 09 World Trade Web
- Lecture 10 Financial Networks

Hours: 10

Professors/Lecturers: Guido Caldarelli (IMT Lucca)

Compulsory for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Introduction to Economics

Abstract: (P. Zacchia): Brief introduction to microeconomics designed for students without previous exposure to it.

This module will cover the following topics, focusing on the interplay between formal models and intuitions:

- Individual choice;
- Equilibrium in competitive markets;
- Imperfectly competitive markets;
- Issues of market failures;
- Concepts of information economics.

(F. Serti): This course will provide with a basic introduction of the main notions in Macroeconomics. Its main goal is to give students a big picture of the macroeconomy and the link between output, employment, and inflation in the short term.

After introducing the fundamentals, the course will then introduce basic macroeconomic models such as the Keynesian AD-AS model and the IS-LM model.

The course will also give some introductory notions of the Phillips curve and its relation with the IS-LM model.

Hours: 20

Professors/Lecturers: Paolo Zacchia (IMT Lucca); Francesco Serti (IMT Lucca)

Available for: Economics, Networks and Business Analytics

Machine Learning

Abstract: The course provides an introduction to basic concepts in machine learning. Topics include: learning theory (bias/variance tradeoff; Vapnik-Chervonenkis dimension and Rademacher complexity, cross-validation, feature selection); supervised learning (linear regression, logistic regression, support vector machines); unsupervised learning (clustering, principal and independent component analysis); semisupervised learning (Laplacian support vector machines); online learning (perceptron algorithm); hidden Markov models.

Hours: 20

Professors/Lecturers: Giorgio Stefano Gnecco (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Macroeconomics

Abstract: Search models. Equilibrium search and matching. Two-sided search model. Efficiency wages. Implicit contacts. Insider-outsider models. Traditional Keynesian Theories of Fluctuations. The Lucas Imperfect-Information Model and The Lucas Critique. The New Keynesian Economics. Consumption. Investment.

Hours: 30

Professors/Lecturers: Francesco Turino (Universitat d'Alcant)

Specializing course for: Economics, Networks and Business Analytics

Management of Complex Systems: Approaches to Problem Solving

Abstract: Methods and approach to problem solving. Problem analysis; analysis of complex systems (related to cultural heritage, such as a city of art organization, promotion, etc.). The course will include practical simulations. The course will be linked to a seminar on specific case studies.

Hours: 40

Professors/Lecturers: Andrea Zocchi; Dario Cacciatore (Whirlpool Corporation)

Available for: Economics, Networks and Business Analytics

Matrix Algebra

Abstract: This course is aimed to review the basic concepts of linear algebra:

1. Systems of linear equations: solution by Gaussian elimination, $PA=LU$ factorization, Gauss-Jordan method.
2. Vector spaces and subspaces, the four fundamental subspaces, and the fundamental theorem of linear algebra.
3. Determinant and eigenvalues, symmetric matrices, spectral theorem, quadratic forms.
4. Cayley-Hamilton theorem, functions of matrices, and application of linear algebra to dynamical linear systems.
5. Iterative methods for systems of linear equations.
6. Ordinary least squares problem, normal equations, $A=QR$ factorization, condition number, Tikhonov regularization.
7. Singular-value decomposition, Moore-Penrose pseudoinverse.
8. An economic application of linear algebra: the Leontief input-output model.

Hours: 10

Professors/Lecturers: Giorgio Stefano Gnecco (IMT Lucca)

Available for: Computer Science and System Engineering; Economics, Networks and Business Analytics

Microeconomics

Abstract: The course aims at introducing you to graduate-level microeconomic theory. Topics discussed will be:

- Consumer Theory
- Producer Theory
- Choice under uncertainty
- Partial equilibrium and market structure
- General Equilibrium
- Externalities and Public Goods
- Elements of Social Choice Theory (time permitting)

Knowledge of intermediate-level microeconomics is helpful but not necessary. The course will give

emphasis to problem solving. For this reason problem sets will be assigned during the course at dates to be communicated in class. Students will then rotate on the board in a following lecture to discuss the problems. There is no required textbook for the course. However, the material presented in class will be taken from Mas-Colell, Whinston, and Green "Microeconomic Theory", which you are encouraged to consult.

Hours: 40

Professors/Lecturers: Kenan Huremovic (IMT Lucca); Andrea Canidio (IMT Lucca)

Compulsory for: Economics, Networks and Business Analytics

Neurobiology of Emotion and Behavior

Abstract: This course will provide an introduction to general themes in Affective and Social Neurosciences, particularly focusing on the neural correlates of emotion and behavior.

Hours: 12

Professors/Lecturers: Pietro Pietrini (IMT Lucca)

Available for: Economics, Networks and Business Analytics

Numerical Methods for the Solution of Partial Differential Equations

Abstract: The course introduces numerical methods for the approximate solution of initial and boundary value problems governed by linear partial differential equations (PDEs) ubiquitous in physics, engineering, and quantitative finance. The fundamentals of the finite difference method and of the finite element method are introduced step-by-step in reference to exemplary model problems related to heat conduction, linear elasticity, and pricing of stock options in finance. Notions on numerical differentiation, numerical integration, interpolation, and time integration schemes are provided. Special attention is given to the implementation of the numerical schemes in Matlab and in the finite element analysis program FEAP fast intensive computations.

Hours: 20

Professors/Lecturers: Marco Paggi (IMT Lucca)

Available for: Computer Science and System Engineering; Economics, Networks and Business Analytics

Numerical Optimization

Abstract: Optimization plays a key role in solving a large variety of decision problems that arise in engineering (design, process operations, embedded systems), data science, machine learning, business analytics, finance, economics, and many others. This course focuses on formulating optimization models and on the most popular numerical methods to solve them. The topics covered in the course include: modeling (linear programming models, convex optimization models), basic optimization theory (optimality conditions, sensitivity, duality), algorithms for constrained convex optimization (active-set methods for linear and quadratic programming, proximal methods and ADMM, stochastic gradient, interior-point methods), line-search methods for unconstrained nonlinear programming, sequential quadratic programming.

Prerequisites: Linear algebra and matrix computation, calculus and mathematical analysis.

Hours: 20

Professors/Lecturers: Alberto Bemporad (IMT Lucca)

Available for: Computer Science and System Engineering; Economics, Networks and Business Analytics

Optimal Control

Abstract: Discrete-time optimal control: dynamic programming for finite/infinite horizon and deterministic/stochastic optimization problems. LQ and LQG problems, Riccati equations, Kalman filter. Deterministic continuous-time optimal control: the Hamilton-Jacobi-Bellman equation and the Pontryagin's principle. Examples of optimal control problems in economics. An economic application of optimal control: a dynamic limit pricing model of the firm.

Hours: 20

Professors/Lecturers: Giorgio Stefano Gnecco (IMT Lucca)

Available for: Computer Science and System Engineering; Economics, Networks and Business Analytics

Philosophy of Science (long seminar without exam)

Abstract: This is an introduction to the basic concepts and problems in the analysis of scientific reasoning and inquiry. The seminar will focus on some central patterns of reasoning and argumentation in science and critically discuss their features and limitations. Topics covered include the nature of theory and evidence, the logic of theory testing, and the debate about the aims of science and the trustworthiness of scientific results. We shall discuss classical examples and case studies from the history and practice of scientific inquiry to illustrate the relevant problems and theoretical positions. Students will freely engage in brainstorming on these topics and are welcome to propose examples, problems, and methods from their own disciplines. No previous knowledge of either logic or philosophy is required.

Hours: 10

Professors/Lecturers: Gustavo Cevolani (IMT Lucca)

Available for: Computer Science and System Engineering; Economics, Networks and Business Analytics

Political Economy

Abstract: The course is a relatively advanced (i.e. at the beginning graduate level) but essentially self-contained introduction to the methods and some major applications of modern political economy.

Topics:

- Institutions and "exogenous" differences in institutions
- At the origin of institutions: From Social Choice to Political Economics
- Median voter models
- Probabilistic voting models
- Agency models of politics: Electoral accountability and career concerns
- Partisan politicians
- Redistributive politics

- Dynamic policy problems with a focus on economic growth.

Prerequisites: The course assumes a good knowledge of macro and microeconomics (especially some growth theory, elementary taxation theory and game theory, including games with asymmetric/incomplete information and the theory of repeated games), of mathematical and statistical methods (especially static and dynamic optimization), and of econometrics (especially familiarity with the issue of causality in econometrics and IV estimation), at the level of the relevant courses offered at IMT.

In addition, students will be asked to read and present some articles along the way as a part of the final exam.

Hours: 20

Professors/Lecturers: Alessandro Belmonte (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Project Management

Abstract: Project management; event management; communication and marketing; practical tools of organization; budgeting. Dealing with multiple stakeholders/ Risk management / Time management / PM tips to run an international research/Management plan concept on heritage sites / When applying for funds how do we measure project success / How we manage the output of the management plan / Flat organisations.

Hours: 35

Professors/Lecturers: Tbd

Available for: Economics, Networks and Business Analytics

Scientific Writing, Dissemination and Evaluation (long seminar without exam)

Abstract: In order to ensure their widest possible dissemination, research results need to be presented in academic publications and in talks. The first goal of this course is to introduce students to basic principles of academic writing and on basic techniques to plan and deliver good academic talks. In addition, the course discusses the key principles of peer review, which is what makes science reliable knowledge. In particular, the course focuses on how to write a professional referee report.

Hours: 8

Professors/Lecturers: Tbd

Available for: Computer Science and System Engineering; Economics, Networks and Business Analytics

Socio-Economic Networks

Abstract: The topic of the course will be the analysis of socio-economic networks. The course will consist of two parts: (1) micro level networks of individuals and firms, (2) macro-level networks of sectors and countries. The first part will focus on social networks and the division of (innovative) labor within and across firm boundaries. The second part on the empirics of macro networks in economics will have a

strong focus on international trade, investments and human mobility. Both parts will give you a brief overview on the literature, which predominantly adopted an econometric approach to the analysis of networks.

Hours: 20

Professors/Lecturers: Massimo Riccaboni (IMT Lucca)

Compulsory for:

Economics, Networks and Business Analytics

Stochastic Processes and Stochastic Calculus

Abstract: This course aims at introducing some important stochastic processes and Ito stochastic calculus. Some proofs are sketched or omitted in order to have more time for examples, applications and exercises.

In particular, the course deals with the following topics:

- Markov chains (definitions and basic properties, classification of states, invariant measure, stationary distribution, some convergence results and applications, passage problems, random walks, urn models, introduction to the Markov chain Monte Carlo method),
- conditional expectation and conditional variance,
- martingales (definitions and basic properties, Burkholder transform, stopping theorem and some applications, predictable compensator and Doob decomposition, some convergence results, game theory, random walks, urn models),
- Poisson process, Birth-Death processes,
- Wiener process (definitions, some properties, Donsker theorem, Kolmogorov-Smirnov test) and Ito calculus (Ito stochastic integral, Ito processes and stochastic differential, Ito formula, stochastic differential equations, Ornstein-Uhlenbeck process, Geometric Brownian motion, Feynman-Kac representation formula).

Hours: 30

Professors/Lecturers: Irene Crimaldi (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering

Strategies and Business Behavior

Abstract: Teaching contents:

1. Market and strategy
2. Business and behavioral strategy
3. A new dimension for space and time in organization and strategy
4. Optimization and decision modeling on strategic decision making
5. Skills, competence and a new role of the human being
6. Business behavior as managerial evidence
7. Business plan: the role and function
8. Big data & decision-making process
9. Big data, machine learning for Management science
10. A multidisciplinary approach to business behavior

Business and Behavioral Strategy offers an essential view of the corporate decision-making involved in orchestrating the strategy process - the key ideas, concepts, and tools - and answer to questions like

why firms adopt different strategies and structures, why heterogeneity persists. The course will describe the decision-making in competitive markets at the business unit level in which many key strategic choices and actions are formulated and undertaken. The essential “tool-kit” that combines a broad understanding of competitive strategy analysis and the decision-making will be taught in a journey through the frameworks of the analytical and behavioral processes.

The course is divided into three parts.

1. The first focuses on the strategy problem. This part of the course starts by proposing vocabulary and models, which help understand how corporate behaviors influence corporate strategy and sustain (or tackle) competitive advantage depending on the size of the company.

Topic points:

- context and principles of strategic management;
- organizational behavior in entrepreneurial and family firms.

2. The second part focuses on how turning the data and judgment into a decision. It tackles the question of how an executive and business unit can locate opportunities to achieve sustained competitive advantage thanks to the contribution of management science framed within the strategy formulation analytical process.

Topic points:

- optimization and decision modeling;
- problem structuring;
- strategic decision making.

3. The third part focuses on how competency and behavior affect the development and execution of a successful strategy. This part of the course concludes with a discussion of why good analysis in the hands of managers who have good judgment won't naturally yield good decisions. Strategic leaders should be not only competent to read market forces but also competent “practitioner psychologists,” and what developing such competencies entails. This discussion will help surface the biases to which the decision process under review is particularly prone.

Topic points:

- cognitive biases, organization, entrepreneurial and family firm survival;
- the psychology of strategy, rational heuristics and cognitive biases.

Business case

Students will learn how to evaluate strategies, as well as how to locate sources of potential competitive advantage from a perspective that, for the purpose of this course, encompasses the internal and dynamic fit of a strategy. They will also learn how to identify organizational barriers and corporate behaviors that sustain or challenge the development and execution of strategies, and the competitive advantage of a company

Hours: 20

Professors/Lecturers: Nicola Lattanzi (IMT Lucca)

Specializing course for: Economics, Networks and Business Analytics

Also available for: Computer Science and System Engineering