Syllabus

Course Description

Course Title	Statistical Methods
Course Code	27502
Course Title Additional	
Scientific-Disciplinary Sector	STAT-01/A
Language	English
Degree Course	Master in Data Analytics for Economics and Management
Other Degree Courses (Loaned)	M1 Statistical methods for business analysis is loaned from course 25559 – Master in Entrepreneurship and Innovation (LM-77 EI) M2 Advanced statistics is loaned from course 73006 – Master in Computing for Data Science (LM-18)
Lecturers	Prof. Alessandro Casa, Alessandro.Casa@unibz.it https://www.unibz.it/en/faculties/economics-management/academic-staff/person/46549
Teaching Assistant	
Semester	Second semester
Course Year/s	1
CP	12
Teaching Hours	M1: 36 hours M2: 40 hours
Lab Hours	M1: 18 hours M2: 20 hours
Individual Study Hours	-
Planned Office Hours	M1: 18 hours M2: 18 hours
Contents Summary	M1: This module begins with a review of key principles of statistical inference and then introduces core concepts in statistical learning. Topics include linear regression and its extensions, advanced regression techniques such as decision trees, logistic regression, classification methods, model selection strategies, and

	unsupervised learning approaches like principal component analysis and clustering. Throughout the course, students will work hands-on in R, applying techniques to real-world datasets drawn from business scenarios. By the end, students will be able to choose suitable statistical models, apply them to a range of business problems, and effectively communicate their analytical insights M2: • Parameter estimation: maximum likelihood methods • Parameter estimation: Bayesian inference • Time series: components and forecasting • Time series: causal relationship tests • Missing data • Elements of statistics for Big Data
Course Topics	M1: - Review of statistical inference: random variables, confidence intervals, and hypothesis testing. - Introduction to statistical learning concepts: basic vocabulary and notions, parametric and nonparametric approaches, predictive and inferential objectives, bias-variance trade off, supervised and unsupervised learning - Linear regression and extensions: simple and multiple linear regression, model estimation and assessment, model assumptions, inferential tools, qualitative predictors, interaction effects, polynomial regression, basic notions on nonparametric regression - Classification: introduction to classification, logistic regression, model estimation, evaluation of classifiers - Other supervised learning techniques: trees, splines, additive models - Model selection/assessment and evaluation of model complexity: resampling methods, cross-validation and information criteria - Unsupervised learning: clustering tools such as k-means and hierarchical clustering, principal component analysis - Applications with the R software M2: The module covers selected topics in statistical inference, time series, and computational statistics. Topics include the method of moments, maximum-likelihood and Bayesian estimation, Monte Carlo methods and the bootstrap, and

	likelihood ratio testing. ARMA and regression modelling for time series data and forecasting. Techniques for dealing with missing data. The course alternates front classes and lab activity, where the methodologies discussed are applied to real and simulated data. This course, by combining theory, computer simulations, and applications, aims to provide a deep understanding and operational knowledge of core techniques in statistical analysis that can be applied to both applied data analysis and theoretical research.
Keywords	Statistical learning, regression, classification, clustering, dimensionality reduction, model selection, statistical inference, Bayesian statistics, time series modelling, big data, parameter estimation, computational statistics, statistical and data analysis
Recommended Prerequisites	M1: No formal prerequisites are required. Nonetheless, knowledge of basic concepts in descriptive and inferential statistics is useful, and attending a pre-course in mathematics/statistics is recommended. M2: the module builds on fundamental concepts of mathematics and statistics. In particular, students are expected to have basic knowledge of Calculus, Linear Algebra, Probability Theory, and Mathematical Statistics, as well as good programming skills. Students should not worry if some of these topics are not fully mastered. A recap of the essential concepts, including key definitions and examples, will be provided during the first week of the course to ensure students feel supported and confident in following the course.
Propaedeutic Courses	
Teaching Format	M1: In-person lectures and computer labs. Whenever possible, lectures will be structured to prioritize in-class time for discussions, and practical applications. M2: Frontal lectures, discussions and exercises on computer.
Mandatory Attendance	Recommended, but not required. M2: Non-attending students have to contact the lecturer at the

	start of the course to agree on the modalities of the independent study.
Specific Educational Objectives and Learning Outcomes	Intended Learning Outcomes (ILO) M1: ILO 1 Knowledge and understanding: ILO 1.1 The student acquires knowledge of the analytical techniques and tools required to understand and quantitatively analyse economic and business phenomena in order to support decision-making processes. ILO 1.2 The student consolidates knowledge of statistical inference, linear models and their generalisations, linear algebra, and optimisation techniques. ILO 1.3 The student acquires an in-depth knowledge of the main techniques of supervised and unsupervised statistical learning, which are instrumental in the development of analysis and visualisation of economic and business data. ILO 2 Applying knowledge and understanding: ILO 2.1 Ability to apply and implement analysis techniques focusing on different types of datasets such as streaming data, tabular data, documents and images and analysis on joint datasets. ILO 2.2 Ability to apply supervised and unsupervised learning, and knowledge modelling, extraction, integration, analysis and exploitation; these skills are declined in various application domains of interest to companies and public and private organisations. ILO 3 Making judgements: ILO 3.1 The student acquires the ability to apply acquired knowledge to interpret data in order to make directional and operational decisions in a business context. ILO 3.2 The student acquires the ability to apply acquired knowledge to support processes related to production, management and risk promotion activities and investment choices through the organisation, analysis and interpretation of complex databases. ILO4 Communication skills:

	ILO 4.1 The student acquires the ability to communicate effectively in oral and written form the specialised content of the individual disciplines, using different registers, depending on the recipients and the communicative and didactic purposes, and to evaluate the formative effects of his/her communication. ILO 5 Learning skills: ILO 5.1 The student acquires knowledge of scientific research tools. He/she will also be able to make autonomous use of information technology to carry out bibliographic research and investigations both for his/her own training and for further education. Furthermore, through the curricular teaching and the activities related to the preparation of the final thesis, she will be able to acquire the ability - to identify thematic connections and to establish relationships between methods of analysis and application contexts; - to frame a new problem in a systematic manner and to implement appropriate analysis solutions; - to formulate general statistical-econometric models from the phenomena studied. M2: ILO 1 Knowledge and understanding: ILO 1.1 The student acquires knowledge of the analytical techniques and tools required to understand and quantitatively analyse economic and business phenomena in order to support decision-making processes. ILO 1.2 The student consolidates knowledge of statistical inference, linear models and their generalisations, linear algebra, and optimisation techniques. ILO 1.3 The student acquires an in-depth knowledge of the main techniques of supervised and unsupervised statistical learning, which are instrumental in the development of analysis and visualisation of economic and business data. ILO 2 Applying knowledge and understanding: ILO 2.1 Ability to apply and implement analysis techniques focusing on different types of datasets such as streaming data,

	tabular data, documents and images and analysis on joint datasets. ILO 2.2 Ability to apply supervised and unsupervised learning, and knowledge modelling, extraction, integration, analysis and exploitation; these skills are declined in various application domains of interest to companies and public and private organisations. ILO 3 Making judgements: ILO 3.1 The student acquires the ability to apply acquired knowledge to interpret data in order to make directional and operational decisions in a business context. ILO 3.2 The student acquires the ability to apply acquired knowledge to support processes related to production, management and risk promotion activities and investment choices through the organisation, analysis and interpretation of complex databases. ILO4 Communication skills: ILO 4.1 The student acquires the ability to communicate effectively in oral and written form the specialised content of the individual disciplines, using different registers, depending on the recipients and the communicative and didactic purposes, and to evaluate the formative effects of his/her communication. ILO 5 Learning skills: ILO 5.1 The student acquires knowledge of scientific research tools. He/she will also be able to make autonomous use of information technology to carry out bibliographic research and investigations both for his/her own training and for further education. Furthermore, through the curricular teaching and the activities related to the preparation of the final thesis, she will be able to acquire the ability - to identify thematic connections and to establish relationships between methods of analysis and application contexts; - to frame a new problem in a systematic manner and to implement appropriate analysis solutions; - to formulate general statistical-econometric models from the phenomena studied.

Specific Educational Objectives and Learning Outcomes (additional info.)	
Assessment	The overall exam mark will be determined by the assessment of the two modules (M1+M2). M1: Assessment (for both attending and non-attending students): - Written Exam: Exercises and review questions (65% of the final grade)(ILOs 1.1, 1.2, 1.3, 3.1, 3.2, 5.1) - Data Analysis Project: Group project in which students select and analyze an interesting dataset using the tools learned in the course. Groups will present their work at the end of the course (35% of the final grade; optional)(ILOs 2.1, 2.2, 3.1, 3.2, 4.1, 5.1). Notes: - For students who do not complete the project, the written exam will count for 100% of the final grade. - Project grades remain valid for one academic year. M2: The assessment is based on class and lab participation (ILOs 1.1, 1.2, 1.3, 3.1, 3.2, 4.1), home-work exercises (2.1, 2.2, 3.1, 3.2, 4.1, 5.1) and a final written exam (ILOs 1.1, 1.2, 1.3, 3.1, 3.2, 5.1). The final written exam will include open-ended questions and exercises for students to work out, as well as computational exercises to be solved using tools and programming languages of their choice, e.g., R, Python, MATLAB.
Evaluation Criteria	M1: - Written exam: understanding of statistical concepts, correct interpretation of results of statistical analyses, clarity and precision of explanations. - Data Analysis Project: Quality and clarity of the presentation, adequacy and appropriateness of analyses with respect to dataset characteristics M2: The final grade will be determined by the homework evaluation

	(30%) and the final written exam (70%). A 2-hour and 30-minute written examination covering all course topics, comprising exercises (to be solved with or without the use of programming languages) and theoretical questions.
Required Readings	**M1:** James, G., Witten, D., Hastie, T., Tibshirani, R. An Introduction to Statistical Learning with Applications in R. Springer, 2013. Freely available at http://www- bcf.usc.edu/~gareth/ISL/ Slides and lecture notes provided **M2:** Randall Pruim, 2018, *Foundations and Applications of Statistics An Introduction Using R.* American Mathematical Society, Providence. ISBN 9781470428488. From this book we discuss topics from chapters 4 and 5. Robert Shumway and David Stoffer, 2019. *Time Series: A Data Analysis Approach Using R*. CRC Press, Boca Raton. ISBN 9780367221096. From this book we discuss chapters 1 to 4 and some optional topics from chapters 5 and 8.
Supplementary Readings	**M1:** Bishop, C. M. (2006). Pattern recognition and machine learning. New York: Springer. Agresti, A., Finlay, B. Statistica per le scienze sociali, Pearson, 2009. Hyndman, R.J. and Athanasopoulos, G. Forecasting: principles and practice, 2nd edition, OTexts: Melbourne, 2018.

	Cicchitelli, Giuseppe. Statistica. Principi e metodi. Pearson, 2008. Azzalini, Adelchi, and Bruno Scarpa. Data analysis and data mining: An introduction. OUP USA, 2012. Grigoletto, Matteo, Laura Ventura, and Francesco Pauli. Modello lineare: teoria e applicazioni con R. G Giappichelli Editore, 2017. Johnson, Richard A., and Dean W. Wichern. "Applied multivariate statistical analysis." New Jersey 405 (1992). **M2:** Additional material and readings provided in class by the lecturer.
Further Information	M2: Software used: Students are free to use tools and programming languages of their choice, e.g., R, Python, and MATLAB, for the homework and the final written exam.
Sustainable Development Goals (SDGs)	Good health and well-being, Climate action, Reduced inequalities, Decent work and economic growth

Course Module

Course Constituent Title	M1 - Statistical methods for business analysis
Course Code	27502A
Scientific-Disciplinary Sector	STAT-01/A
Language	English
Lecturers	Prof. Alessandro Casa, Alessandro.Casa@unibz.it https://www.unibz.it/en/faculties/economics-management/academic-staff/person/46549
Teaching Assistant	
Semester	Second semester
CP	6
Responsible Lecturer	

Teaching Hours	36
Lab Hours	18
Individual Study Hours	-
Planned Office Hours	18
Contents Summary	This module begins with a review of key principles of statistical inference and then introduces core concepts in statistical learning. Topics include linear regression and its extensions, advanced regression techniques such as decision trees, logistic regression, classification methods, model selection strategies, and unsupervised learning approaches like principal component analysis and clustering. Throughout the course, students will work hands-on in R, applying techniques to real-world datasets drawn from business scenarios. By the end, students will be able to choose suitable statistical models, apply them to a range of business problems, and effectively communicate their analytical insights
Course Topics	- Review of statistical inference: random variables, confidence intervals, and hypothesis testing. - Introduction to statistical learning concepts: basic vocabulary and notions, parametric and nonparametric approaches, predictive and inferential objectives, bias-variance trade off, supervised and unsupervised learning - Linear regression and extensions: simple and multiple linear regression, model estimation and assessment, model assumptions, inferential tools, qualitative predictors, interaction effects, polynomial regression, basic notions on nonparametric regression - Classification: introduction to classification, logistic regression, model estimation, evaluation of classifiers - Other supervised learning techniques: trees, splines, additive models - Model selection/assessment and evaluation of model complexity: resampling methods, cross-validation and information criteria - Unsupervised learning: clustering tools such as k-means and hierarchical clustering, principal component analysis - Applications with the R software
Teaching Format	In-person lectures and computer labs. Whenever possible, lectures will be structured to prioritize in-class time for discussions, and practical applications.

Required Readings	James, G., Witten, D., Hastie, T., Tibshirani, R. An Introduction to Statistical Learning with Applications in R. Springer, 2013. Freely available at http://www- bcf.usc.edu/~gareth/ISL/ Slides and lecture notes provided
Supplementary Readings	Bishop, C. M. (2006). *Pattern recognition and machine learning*. New York: Springer. Agresti, A., Finlay, B. Statistica per le scienze sociali, Pearson, 2009. Hyndman, R.J. and Athanasopoulos, G. Forecasting: principles and practice, 2nd edition, OTexts: Melbourne, 2018. Cicchitelli, Giuseppe. Statistica. Principi e metodi. Pearson, 2008. Azzalini, Adelchi, and Bruno Scarpa. Data analysis and data mining: An introduction. OUP USA, 2012. Grigoletto, Matteo, Laura Ventura, and Francesco Pauli. Modello lineare: teoria e applicazioni con R. G Giappichelli Editore, 2017. Johnson, Richard A., and Dean W. Wichern. "Applied multivariate statistical analysis." New Jersey 405 (1992).

Course Module

Course Constituent Title	M2 - Advanced statistics
Course Code	27502B
Scientific-Disciplinary Sector	STAT-01/A
Language	English
Lecturers	dr. Mufutau Ajani Rufai, MufutauAjani.Rufai@unibz.it

	https://www.unibz.it/en/faculties/engineering/academic-staff/person/48142
Teaching Assistant	
Semester	Second semester
CP	6
Responsible Lecturer	
Teaching Hours	40
Lab Hours	20
Individual Study Hours	-
Planned Office Hours	18
Contents Summary	• Parameter estimation: maximum likelihood methods • Parameter estimation: Bayesian inference • Time series: components and forecasting • Time series: causal relationship tests • Missing data • Elements of statistics for Big Data
Course Topics	This module covers selected topics in statistical inference, time series, and computational statistics. Topics include the method of moments, maximum-likelihood and Bayesian estimation, Monte Carlo methods and the bootstrap, and likelihood ratio testing. ARMA and regression modelling for time series data and forecasting. Techniques for dealing with missing data. The module alternates front classes and lab activity, where the methodologies discussed are applied to real and simulated data. This module, by combining theory, computer simulations, and applications, aims to provide a deep understanding and operational knowledge of core techniques in statistical analysis that can be applied to both applied data analysis and theoretical research.
Teaching Format	Frontal lectures, discussions and exercises on computer.
Required Readings	Randall Pruim, 2018, *Foundations and Applications of Statistics An Introduction Using R.* American Mathematical Society, Providence. ISBN 9781470428488. From this book we discuss topics from chapters 4 and 5.

	Robert Shumway and David Stoffer, 2019. *Time Series: A Data Analysis Approach Using R*. CRC Press, Boca Raton. ISBN 9780367221096. From this book we discuss chapters 1 to 4 and some optional topics from chapters 5 and 8.
Supplementary Readings	Additional material and readings provided in class by the lecturer.