ADA
ADVANCED DATA
ANALYTICS IN BUSINESS

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Evaluation of ADA Study Programs,, Evaluator 2 (Angela Bitto-Nemling)

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Abstract	After first version of curriculum, content of courses and methodology finished, two external experts were engaged in order to evaluate the quality of the developed master program. This report represents their evaluation. On the basis of the report, consortium will correct the elements of the master program if necessary.

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TABLE OF CONTENTS

1 INTRODUCTION AND STRUCTURE OF REPORT

The intention of this document is to evaluate and comment on the structure and suitability of three ADA study programmes.

This report is structured the following way. Section 1 gives an overview of this report. Section 2 offers a very short executive summary of the main findings. Next the individual programmes themselves are being evaluated. Section 3 covers the ADA programme at the University of Novi Sad, Section 4 covers the ADA programme at the University of Belgrade and Section 5 covers the ADA programme at the University of Nis. Section 6 offers links to comparable programmes from other universities.

For each programme itself the following points are being analysed in subsections: Subsection 1 discusses the overall information available. This is restricted only to information available in English. Subection 2 analyses the structure of the programme and Subsection 3 lists courses and their contents. Subsection 4 discusses information regarding academic teaching personal. Subsection 5 takes a look at the details on outline of the master thesis and internship and, Subsection 6 discusses competencies acquired and Subsection 7 states prerequisites for enrolment. Subsection 8 discusses gender, legal, ethical and bias aspects. Subsection 9 gives references to documents and links used. Subsection 10 concludes.

2 EXECUTIVE SUMMARY

In the following the most important points are listed for each programme. This shall give the reader a quick overview of what will follow in the more detailed reports in Section 3-5.

Ada at University of Novi Sad :

- Information is detailed and available.
- The programme accounts for 120 ECTS and runs over 4 semesters.
- The master thesis accounts for 18 ECTS, while the internship accounts for 4 ETCS.
- There exists a zero-subject course before the start of the master programme for interested students to get well prepared.
- International, well-educated teachers, 25 % are female.
- The programme itself is well-structured.
- Courses are suitable for an advanced analytics master programme.
- No further information on competencies acquired is provided.
- Gender, bias, ethical and legal aspects of data analytics are not part of the curriculum.
- Small class size of 25 students only enables an intense knowledge transfer from teachers to students.
- Based on the reviewed documents the ADA study programme at the University of Novi Sad deems suitable for equipping students with the necessary competencies for working in a data analytics environment.

- The workload in this programme can be described as appropriate to challenging.

Ada at University of Belgrade :

- Information is detailed and available.
- The programme accounts for 90 ECTS and runs over 3 semesters.
- The term paper accounts for 5 ECTS, the master thesis accounts for 10 ECTS, while the internship accounts for 3 ETCS.
- Courses are suitable for an advanced analytics master programme.
- Full list of competencies upon graduation is available. Courses deem fitting for acquiring these competencies.
- Gender aspects are not part of the curriculum.
- Ethical concerns are being discussed within the Big Data course.
- Programme is well-structured, graduates will benefit from in-depth knowledge in mathematical subjects.
- 50% of all teaching personal is female.
- Small class size of 25 students only enables an intense knowledge transfer from teachers to students.
- The study book links to copyright protected material and books. This seems unfitting for a university programme.
- The workload in this programme can be described as appropriate to challenging in a positive way.
- Based on the reviewed documents the ADA study programme at the University of Belgrade deems suitable for equipping students with the necessary competencies for working in an advanced data analytics environment.

Ada at University of Nis :

- Too little overall information is available.
- The programme accounts for 90 ECTS and runs over 3 semesters.
- The master thesis accounts for 20 ECTS, while the internship accounts for 10 ETCS.
- No information about qualifications of the teaching personal. 50 % of teachers are female.
- No information on enrolment prerequisites.
- No information on overall competencies acquired upon graduation.
- Clear structure or focus of the programme is missing. Course content seems somewhat redundant.
- It is questionable to what extent graduates will have required advanced knowledge.
- The programme seems to focus on applying competencies on real-life problems and somewhat neglects an in-depth theoretical foundation.
- The workload in this programme can be described as too little for a master's programme.

- Based on the reviewed documents the ADA study programme at the University of Nis there is room for improvement to equip students with the necessary competencies for working in an advanced data analytics environment.

3 ADVANCED DATA ANALYTICS IN BUSINESS (UNIVERSITY OF NOVI SAD)

The study programme Advanced Data Analytics in Business at the University of Novi Sad offers the following general learning outcome: mastering competencies in understanding big data, their preparation, modelling, evaluation, and implementation of solutions in business, through the application of programming, statistics, machine learning, data manipulation, visualization, and respecting codes of ethics.

The study programme is intended for a relatively small audience of 25 students only.

3.1 MATERIAL AVAILABLE FOR PROSPECTIVE STUDENTS

Information about the programme in English is extensively available and detailed. Prospective students are well informed before the start of the programme.

3.2 STRUCTURE OF THE PROGRAMME

The programme is spread out over four semesters, where the last semester is dedicated to the master thesis. In total the programme accounts to 120 ECTS. The curriculum contains eight compulsory and five elective courses that are taught over three semesters. All courses carry the same number of ECTS, i.e., 7 points, while the practice in the company carries 4 ECTS. The study program has a total of 8 compulsory courses (a total of 56 points), a basket of 10 elective courses from which 5 are chosen (a total of 35 points).

One zero subject (Data campus) is planned for students to acquire the necessary prior knowledge for easier attendance of classes in the master's program later. The zero subject is performed before the beginning of regular classes in the program and is not obligatory for students.

3.3 COURSES

The list of courses offered in this programme can be found in the following. The content and goals are described in detail and students are well prepared to know what to expect.

Academic Writing

The goal of the course is to develop student's ability to write research papers and other academic texts. Student understands research principles, knows how to write research questions, hypothesis and objectives, design adequate literature review, acquire the ability to access and extract relevant information from relevant data sources, write an effective research proposal.

Advanced Analytics with SPSS

The main goal of this course is to familiarize students with the power and functionality of IBM SPSS Statistics as a data analysis tool and to cover standard exploratory statistical analysis of data.

This course will introduce basic methods for data import, data management, graphics, basic and advanced statistical analysis by using the SPSS software package. Learning outcome Students will develop the fundamental skills needed to prepare data sets for analysis, and to conduct statistical analyses and report those analyses. At the completion of this course, students will be able to:

- Prepare and manipulate datasets for analysis in SPSS.
- Conduct simple descriptive and graphic analyses of data in SPSS.
- Conduct advance statistical analyses of data in SPSS.
- Prepare a report with a summary of analyses conducted in SPSS.

Advanced Econometrics

Introduction of students with different methods of advanced econometric analysis, topics and methods of modern econometric analysis used in advanced data analytics and data science, training for independent empirical research. New knowledge in the field of assessment, testing and interpretation of econometric models of different kinds with use of econometric software. As software support, we are using GRETLS, EVIEWS and R language. Student is capable to identify the economic problem, to define adequate sample and to choose the best econometric model and implementing it with use of econometric software and based on obtained results to make conclusions and interpret the results.

Big Data Fundamentals

To provide the students with basic knowledge of big data: big data characteristics, storing, cleansing, and analysing big data, with the emphasis on predictive and prescriptive analytics. Students will be able to apply the methods of data collection and data analytics to solve business related problems in support of business decision making. Students will develop competencies necessary to use related software tools to perform data collection, cleansing and analytics.

Business & Decision modelling

The aim of this course is to provide students with the necessary knowledge regarding basic concepts and methods of decision-making in different areas of the economy by applying quantitative methods. Knowledge acquired in this area should point the need for certain methods in the field of economics, to make effective decisions. Students' abilities to successfully use the knowledge for recognition of different economic connections to provide support in the process of making economic decisions: optimizing business decisions; planning and optimization of inventories and costs; modelling of problems with non-fulfilment of traditional assumptions, recognition, and formulation of the decision-making process.

Business Cases

The aim of this course is to provide students with the necessary knowledge regarding practical application of data science. The idea is to support problem-based learning using real-life examples of practical application of data science in various areas of business. The course also includes research-based case studies that address current topics and critical issues in data science. Ability

of students to recognize different areas of application of methods and models of data science in practice, to provide support in economic decision-making processes: making financial decisions by applying data science; making marketing decisions by applying data science; decision making process management by applying data science; decision making in health management using data science; decision making in agricultural production using data science.

Deep Learning

Modern data analytics in business increasingly relies on machine learning techniques, i.e., quality business decisions are made after data being processed by machine learning methods. Having this in mind, machine learning and especially the segment of deep learning in business analysis represents an important apparatus of modern economic sciences, and the subject itself provides the basis for successfully mastering their basics. Particular attention is paid to the connection between theory and business, as well as the application of methods through computer work. The aim of the course for the student is to learn the basics of deep neural networks, to understand how to apply and develop a neural network and lead projects in the field of machine learning. By mastering the content of the course, students will be able to identify problems from business analysis that can be solved by machine learning techniques. The problems will come from a case study and will be equivalent to problems from practice. Theoretical and practical knowledge acquired through this course will enable them to recognize the nature of the problem, to recognize models and techniques by which the problem is solved and to look for appropriate tools. They will be able to prepare data for the model, translate the model into a form that existing tools can handle, select algorithms to solve, solve the problem and interpret the results, and propose decisions based on the results. Students will also be able to develop different neural network architectures, such as CNN, RNN, LSTM in Python programming language, to understand key parameters of neural network architecture, and to realize photo classification and perform textual data analysis using neural networks.

Designing communication of results

The goal of the course it to teach students to set of techniques and tools for extraction and transformation or raw data into meaningful and useful information for business analytics. Also, the goal is to develop ethical competences related to data collection, storing, dissemination and analysis. Learning outcome Students know to implement tools for extraction and transformation of raw data and to identify and evaluate ethical impact in data driven organisation. Students know to implement techniques for protection of privacy, ethical distribution of data and minimise negative consequences in data driven organisation.

Digital Marketing Analytics

The objective of the course is to train students for the realization of the steps in the marketing management process in the field of digital marketing. Based on the acquired knowledge, students will be able to manage the digital marketing process. It is helpful in the proper implementation of various digital marketing activities in various areas of their application.

Financial Analytics

The goal of the course is to provide students a different view on the financial data and an in-depth financial knowledge approach to improve overall financial business performances. Students can implement a large set of financial models. Through examples, they learn how to obtain raw data, perform the analysis, and generate an output properly. Therefore, students learn how to answer specific business questions and forecast possible future scenarios using real-world data available online

Machine learning

The aim of the course is that student builds an abstract thought within the area of machine learning and on the basis to master the possibilities of its application in data science. The student should apply the acquired knowledge from machine learning methods (linear regression, artificial neural networks, decision trees, associative rules, support vector machine, genetic algorithm) in solving real problems. Acquisition of modern knowledge and skills in machine learning. The student can study and solve real problems in data science by applying the acquired knowledge from the application of machine learning methods. Solving concrete problems with use of algorithms and techniques of machine learning. Introduction of main machine learning techniques. Understanding of matrix problem set up, definition of criteria functions through probabilities and solving regression and qualification problems. Understanding optimization and regularization procedures, modular approach in multilayer architecture, and ensemble of methods and techniques of dimension reduction.

Managing, Storage and Visualising Big Data

The goal of the course is to give students an in-depth understanding of a wide range of fundamental Big Data Management systems. This course focuses on the "variety" of the 3Vs in big data, where how to store, index and query various types of data in a real-world application. Moreover, this course provides knowledge needed for solving big data management problems, which include data cleaning, data integration, data update, query processing and to learn students how to use tools for visualising big data for business analytics. The basic outcomes concern: 1) Problem Solving: Ability to model and implement efficient big data solutions for various application areas using appropriately selected tools and architectures. 2) Critical Analysis: Ability to analyse big data infrastructures and their components, to compare and evaluate them, and make appropriate design choices when solving real-world problems. 3) Communication: Ability to motivate and explain trade-offs in big data platform design and analysis in written and oral form. Student is capable of visualising big data in an effective way and to draw conclusions in the context of business analytics

Master Thesis

The goal of the work on the master thesis and its presentation is for student to prove that can conduct autonomous and creative approach in the application of practical and theoretical knowledge in the field of business analytics. Students finishing master thesis in the field of business analytics are competent to solve real-life problems in this area. Student has comprehensive knowledge and understanding of all courses of study program, and ability to solve real-life problems through use of scientific methods. Student is capable of writing and presenting the results of his work.

Quantitative fundamentals

The goal of this course is to review several mathematical and statistical concepts and to develop basic arithmetic and algebra skills relevant for the study of data science. The course takes a practical, applied approach to mathematics and statistics to increase student appreciation of the material. After completing the course, students can understand various quantitative and statistical methods, understand data, and draw inference from data, to pose and solve financial-based problems by using previously stated methods on company-specific data.

R for Data Science

The goal of the course is students to teach students at the beginning basic tools for management of big data in R language and later advanced tools and be capable to program in R language. The entire course is in the context of business environment and through examples of good praxis, because the final goal is for student to develop competencies related to R language to implement them for the need of business analytics in fast and efficient way. Students know and understands R language, uses R studio, ggplot2, tidyverse and collection of packages for massive data. Student imports, manipulates, analyse and models data. Student knows how to communicate results of analysis to final users.

Social Media Analytics

To familiarize students with a) social media sites as the data sources for business analytics, b) the power and significance of user-generated content, and c) various possibilities of analysis of social media content which allows companies to observe the overall market position of a company, product, or competition. To teach students to obtain relevant data from the Internet, to retrieve them and visualize them, to analyse textual content from social media, as well as the emotions from user-generated content from social media. After completing this course the student has the knowledge to solve complex problems which require application of categorization and clustering of texts, topic modelling, and sentiment analysis; Student has the knowledge to select adequate data source and to retrieve the data from the Internet; Student has the knowledge to create dataset and to prepare it for analysis; Student knows to visualize data (graphical representation of large amount of data, word clouds, and similar); Student knows how to choose an adequate approach to analyse data and to practically apply clustering, classification techniques, association rules on data from the Internet; Student knows to interpret obtained results.

Supply chain and Operational Analytics

Goal of the course is a mastery of the essential elements of the supply chain analytics: Data management - collection, cleaning, manipulation, visualisation; Segmentation - products, suppliers, and customers; Forecasting - techniques, aggregation, Demand management – process metrics, price optimization. Student knows to explain the importance of supply analytics, efficiently handles the available business information/data, can use analytical tools like Python, R, SPSS and MS excel efficiently in order to take managerial decisions more effectively.

Time Series Analysis

The goal of the course is to illustrate time series analysis using many applications in fields of economics and finance, but also in other fields of science. Students will be given fundamental grounding in the application of such widely used tools in modelling time series. The models pass through the phases of identification, diagnostics, and forecasting. By the end of this course, students will be familiar with the implementation of time series models using adequate statistical software along with the interpretation for results derived from model implementation.

Transaction-based analytics & Recommendation systems

The goal of the course is to enable students to pre-process data sets from the web, which are not in a matrix format ready for modelling (Design Matrix) and to use the prepared data within specific Data Mining tasks and Data Science frameworks. The students should understand that in most cases transaction-based data contains more than one dimension of information, e.g., online customer action over time. Also, they should understand when and if a data set is not a Design Matrix ready to be used for Machine Learning (supervised and unsupervised) but rather requires a semiautomatic conversion into e.g., Rating Matrices, which can be binary or integer/real-valued. When a conversion into one (or more) rating matrix/matrices is possible then the students should be able to conduct Association Analysis as well as being able to design Recommender Systems using Collaborative Filtering. The difference between Collaborative Filtering and Content-based Filtering is relevant and students should be able to create hybrid recommenders. Students should be aware of the importance of the excerpt of the data used for modelling (e.g., a certain timeframe or demographic structure). Finally, students should be able to conduct Feature Engineering if a semi-automatic conversion is not possible, e.g., a RMF analysis for online store data.

3.4 TEACHERS

Details for all teaching personal regarding name, title, education, academic career, and representative scientific publications is available. Furter details are given on teaching experience of these people. About 25% of all teachers are female.
Beside the teachers from University of Novi Sad, the courses are delivered by professors from Tor Vergata University in Rome, Vienna University of Economics and Business, University of Applied Sciences in Ulm, University of Macedonia in Thessaloniki, CY Cergy Paris Université, and Centre for Research and Technology Hellas.

3.5 Master Thesis and Internship

Credit value of the final thesis is 18 ECTS.

The goal of the work on the master thesis and its presentation is for student to prove that is able to conduct autonomous and creative approach in the application of practical and theoretical knowledge in the field of business analytics. Learning outcome Students finishing master thesis in the field of business analytics are competent to solve real-life problems in this area. Student has comprehensive knowledge and understanding of all courses of study program, and ability to solve reallife problems through use of scientific methods. Student is capable of writing and presenting the results of his work

The internship accounts for 4 ECTS.

Goal of the internship is acquiring necessary knowledge and experience about work and organization of companies in the field of business analytics, and also possibility of implementing previously obtained knowledge into real-life situations. Learning outcome Student is capable of implementing previously acquired theoretical and practical knowledge into solving concrete real-life problems in companies in the field of business analytics. Student has valuable knowledge and experience in the field of business analytics obtained through work in real-life conditions. There is no theoretical part. The practical part will be defined for every student individually, through cooperation with representatives of companies or institutions where internship will be conducted, in line with requirements of profession of business analytics.

3.6 Prerequisites for Enrolment

The conditions of enrolment are defined precisely and the are available to the general public.

The study program Advanced Data Analytics in Business can be enrolled by all students with completed bachelor studies of a minimum of three years with 180 ECTS points, or minimum 4 years with 240 ECTS. Ranking of candidates for the enrolment at master studies is based on the following criteria:

- General average grade obtained at bachelor studies;
- Length of studies at bachelor studies;
- Number of ECTS points at bachelor studies from courses related with data science.

3.7 Competences acquired

Although the competencies acquired in this programme are not further detailed, the list of courses and the descriptions therein can serve as a blueprint for deriving the competencies acquired upon graduation.

3.8 Gender, Bias, Ethical and Legal Aspects

Gender studies is not part of this programme. No individual course discussing gender and bias in this programme is present.

Furthermore, ethical, and legal challenges that arise when dealing with real data are not discussed in an individual course.

3.9 Documents and Links underlying this Report

The following documents have been considered:

https://www.ef.uns.ac.rs/ofakultetu/studijski-programi/mas-advanced-data-analytics-in-business.php

https://www.ef.uns.ac.rs/ofakultetu/studijski-programi/mas-advanced-data-analytics-in-business-files/advanced-data-analytics-in-business-curriculum.pdf

Additional Information

https://www.ada.ac.rs/sp-uns/

3.10 Conclusion

The Ada programme at the University of Novi Sad can be regarded as a well-planned and structured study programme. Students will be provided with the necessary information before the start of the programme and additionally a zeros subject course can be selected as to prepare students before the start of the programme. Details on course content, process of the master thesis and procedure of the internship are available. Graduates will be fluent in the most important tools and have required in-depth knowledge not only from a theoretical but also from an applied perspective. Academic teaching personal is international, well-educated, and at least 25% are female. The very small number of only 25 students will additionally allow for a very intense transfer of knowledge between the teachers and the students. Competencies acquired in this programme can only be deducted from the course content details as no detailed list on competencies in being given. Working with data and data analytics does offer the opportunity to discuss gender and bias topics. This ADA programme does not offer courses related to gender and or bias or legal and ethical issues in data topics. Gender studies and bias in data analytics studies is not part of the programme. The workload within this curriculum does seem to be appropriate for a master's programme.

Based on the reviewed documents the ADA study programme at the University of Novi Sad deems suitable for equipping students with the necessary competencies for a data analytics environment.

4 ADVANCED DATA ANALYTICS IN BUSINESS (UNIVERSITY OF BELGRADE)

The study programme Advanced Data Analytics in Business at the University of Belgrade offers a well-structured programme allowing students to dive deeply into the universe of data analytics and equip graduates perfectly with the required competencies in todays data driven landscape. Upon completion of this programme students will have become true experts in data analytics. They will be equipped with sound mathematical foundations and thinking which will further allow them to quickly adapt to new technologies and requirements. Many of the courses offered present their topics putting them also in the context of collaboration and communication skills, legal regulations and ethical norms.

Only 25 applicants are being accepted to this progamme.

4.1 MATERIAL AVAILABLE FOR PROSPECTIVE STUDENTS

The material available for prospective students can be described as being extensively available.

4.2 STRUCTURE OF THE PROGRAMME

This programme is a 3-semester programme with a total number of ECTS credits of 90. The program also includes a mandatory internship (capstone project / practicum) worth 3 ECTS for students to get practical experience in working on data analytics projects, a mandatory qualification paper (term paper) (5ECTS), as well as mandatory master thesis (10 ECTS). Courses are worth 6-10 ECTS credits.

4.3 COURSES

This programme covers three main subjects of modern data analytics - mathematical/statistical foundations, technological foundations, and applications. For each group several elective courses can be chosen. For mathematics 3 out of 6 offered courses need to be chosen. For the technological foundations 3 out of 9 offered courses need to be chosen. For the Applications group, 2 out of 8 courses need to be elected. This programme does not dictate any compulsory courses – all courses are elective.

There are three groups of elective courses in the study program Advanced Data Analytics. The first group covers mathematical and statistical foundations of data analytics, such as calculus, linear algebra, discrete structures, and the like, for students who need to improve their background in mathematics (Discrete structures, Mathematical Foundations of Data Analysis, Analytics, and optimization) and probability and statistics (Introduction to statistical inference, Models of statistical learning, Introduction to complex networks theory). The second group covers computing skills, tools, and technologies for data analytics. These include programming, database technologies and working with large volumes of data (Programming, Databases, Big data analytics), different topics in artificial intelligence necessary for advanced data analytics (Artificial intelligence / Machine learning, Neural networks, and deep learning), and specific topics and tools

that help data analysts in working on practical problems (Data visualization, Text mining and social network analysis). The third group is about applying data analytics skills, tools, and techniques in different domains. The current focus is on social and life sciences, but the study program is open for extensions by elective courses covering other domains.

In the following detailed course descriptions are given. The courses offered are suitable for achieving the outlines competences after graduation.

Mathematical Foundations of Data Analysis

Acquisition of general and specific knowledge of Linear Algebra and Numerical Analysis. Upon completion of the course, students have the basic knowledge of linear algebra and numerical methods. They can solve problems in these fields and to apply acquired concepts and techniques in other fields.

Discrete structures

Mastering some standard topics of discrete mathematics as basics of mathematical logic and graph theory, relational structures, finite automata, and formal languages. The subject matter of this course is to teach the students the ways of formal deductions, to make them familiar with important applications of mathematical formalizations in the organization and the search of a large data basis as an important foundation for advanced analysis of data.

Analytics and optimization

Introduction to analytics and optimization with aim of optimal decision making using quantitative models and methods. Students will be able to identify and analyse real world problems and data collected in the process. Students will be able to formulate real world problem as an optimization problem. Students will be able to use optimization methods and techniques (especially methods and techniques for solving linear and integer programming models).
Students will be able to analyse and visualize results.

Introduction to Statistical Inference

Acquiring the ability to conduct statistical analysis, to interpret the obtained results, and to learn from the basic statistical methods and models how to study the observed phenomena as the subject of quantitative analysis. Getting acquainted with modern statistical software. After the course, student will acquire the basics needed for understanding the concepts of advanced data analytics in contemporary statistical software.

Models of Statistical Learning

Acquiring the ability to employ advanced models of statistical learning, to interpret the obtained results, and the ability to recognize the model of statistical learning suitable for solving the given problem. Mastering the usage of advanced features of modern statistical and simulation software. After completing the course, students will acquire the experience in understanding the concepts of advanced models of statistical learning in contemporary statistical and simulation software and the experience needed for their application in real-word business problems.

Introduction to complex networks theory

Acquiring basic knowledge about complex networks, methods, and tools for the quantitative analysis of their structure, and applications. Students will acquire the basic concepts of theory of complex networks and be able to use various techniques of network analysis. Students will be able to map the data to various types of networks, do the statistical analysis of their structure and infer system properties based on the results of statistical analysis.

Programming

Detailed introduction to current programming languages, methods, and techniques in advanced data analytics. Students will master appropriate programming methods and techniques using state-of-the-art programming languages in advanced data analysis.

Databases

Acquiring basic knowledge of databases and database management systems. Students will be able to identify data requirements and to design databases. They will get familiar with a database architecture and components, and they will learn to use query languages to access and manipulate data in the databases of different types.

Big Data Analytics

This course will cover the basic concepts of big data analytics, methodologies for analysing structured and unstructured data with emphasis on the relationship between the Data Scientist and the business needs. After the course, student will be able to critically analyse existing Big Data datasets and implementations, taking practicality, and usefulness metrics into consideration. Moreover, to understand and demonstrate advanced knowledge of statistical data analytics as applied to large data sets.

Data Visualization

Detailed introduction to current visualization tools, methods, and techniques in advanced data analytics. Students will master appropriate programming methods and techniques for data visualization using state-of-the-art programming languages in advanced data analysis.

Artificial Intelligence / Machine Learning

Mastering the fundamentals, techniques, and applications of artificial intelligence. Students will learn basic concepts and techniques of artificial intelligence and gain practical skills for their application in advanced data analysis.

Neural networks and deep learning

To learn basic concepts and algorithms in the field of neural networks and deep learning, and methods for application of these technologies in various domains. Students will learn basic neural network concepts, types, and application procedures, and develop skills required for their practical application.

Text Mining

The goal of this course is to guide and assist students in developing a solid understanding of a typical text mining workflow, in learning principal text mining methods and techniques, including those used in text classification and clustering, topic modelling, key-terms extraction, and text summarization. Students will be guided in developing working knowledge of text mining in R and/or Python programming language(s). Students will be able to apply text mining methods and techniques to classify and cluster unstructured text-based content, as well as to extract key terms and main topics from such content. They will also know how to evaluate the performance of individual methods and techniques, as well as how to benchmark different methods and techniques.

Social Network Analysis

The goal of this course is too guide and assist students in learning about main concepts, methods, and techniques of social network analysis (SNA) and in developing a solid understanding of i) the kinds of analytical questions and/or problems that can be dealt with using the SNA approach; ii) pros and cons of individual SNA methods and techniques, as to be able to select appropriate SNA methods / techniques for a particular problem / question as well as in acquiring practical skills in the analysis of network data, using publicly available SNA software tools and datasets. Students will develop a solid understanding of main SNA concepts, methods, and techniques. They will also get an insight into the potentials and limitations of these methods and techniques, and thus be able to choose appropriate one(s) for a particular application case. Furthermore, they will acquire practical skills in using SNA software tools for doing network analysis with real-world datasets.

Introduction to time series analysis

Acquiring basic knowledge about theoretical and applied aspects of time series analysis. Students will acquire knowledge about basic concepts of time series analysis and their application to data science. They will be able to analyse in detail continuous and discrete time series, to describe their characteristics, to choose a proper theoretical model and to infer the interaction matrix based on time series correlations.

Data analysis in fundamental and clinical medicine

Adopting new knowledge and skills related to data analytics in medicine. Training students for data processing in fundamental and clinical medical disciplines. Students will master analysis of data obtained by processing signals in the field of electrocardiography, electroencephalography, microscopy, and other methods used in modern medical diagnostics. Students will also be familiarized with the basics of medical statistics, with reference to statistical analytical tests in medical research and computer methods for statistical processing of medical data. Within this course, students will also gain basic knowledge of medical informatics.

Data analysis in biological sciences

Analysing complex biological data. Students will acquire new knowledge and skills in the field of data analysis in biology. Modern computational methods used in molecular and cell biology will be presented. Students will also be able to analyse complex data obtained by processing microscopic images in histology. In addition to the image processing, this subject will also focus on aspects of signal processing in neurosciences such as resting membrane potential, action potential, local potentials, etc. Students will also be familiarized with the foundations of biostatistics, and with applying modern statistical tests in biological sciences.

Advanced data analysis in pharmaceutical research and development

Students will acquire new knowledge and skills in the field of data analysis in pharmaceutical research and development. Knowledge of recent and advanced computational methods of rational drug design, which include ligand-based methods (QSAR, pharmacophore analysis, virtual screening of ligands databases) or structure-based methods (virtual docking, molecular dynamics). Students will master advanced theoretical methods and acquire skills for use of various programs for determining bioactive conformations of ligands, formation, and validation of QSAR models, virtual screening, virtual docking, and molecular dynamics. Knowledge of creating in silico methods and optimal procedure for rational design, evaluation, and selection of novel drug candidates with improved pharmacological, physicochemical, and pharmacokinetic properties. Students will be introduced with methods which are used in quality control of finished drug products with special concern about certificate of analysis. They will gather knowledge about different separation mechanisms in selected chromatographic systems to apply predictive mathematical models in description of retention behaviour of analytes, as molecules with specific chemical structures. Based on that, they will be able to perform analysis of quantitative relationship between structure and retention behaviour (QSRR study), to define optimal chromatographic conditions for quality control of drugs and to evaluate the significance of selected structural characteristics and physicochemical properties on retention of molecules in chromatographic system.

Practical analysis of noisy and uneven time series

Most of the phenomena in nature, medicine, science, business, and engineering are measured at certain time moments that are most often non-homogeneous in time. Extracting information from such series is a great challenge for analysts because standard techniques are mostly developed for evenly distributed time series without a prominent noise. Therefore, specific methods for analysing such time series are extremely important for all mentioned data types. This course aims to explain the theoretical and practical core of the concept of time series analysis with such disadvantageous characteristics. The student is trained for an effective analysis of noisy time series that are unevenly distributed in time, which can be encountered in the sciences, medicine, business, engineering, as well as in the analysis of the time series of social networks and those found in the sociological research.

Big Data in space science and its analysis

Daily large amounts of new data related to the cosmic research are being collected, using both ground-based and space-based telescopes, as well as those collected from missions that observe Earth from space (e.g., Copernicus program of satellites). Earth observation data from satellites can be used for various human activities on Earth, from sociological (migration monitoring), biological, industrial, telecommunication, to those related to the study of climate change. The goal of this course is to introduce students to what type of data can be obtained from space research, providing a broad and practical introduction to large data: data analysis techniques including databases, data mining, machine learning and visualization of data; data analysis tools, including the use of SQL and Python. Tools and techniques are practical, providing the foundation for future research and application. The student can handle and apply tools and techniques for processing large data in their original research areas as well as for eventual applications in the space industry.

Advanced data analysis in social sciences

Students will have the opportunity to familiarize with the advanced statistical methods and to perform analysis and interpretation of different datasets relevant for social science. The course concentrates on the practical application of advanced statistical methods and approaches in analysing social world using cross-sectional, comparative, longitudinal, and panel datasets. Application of a range of advanced statistical methods on social science datasets: correspondence analysis, linear regression, ordinal linear regression, logistic regression, nonlinear models, multilevel, structural equations. Use of the statistical packages SPSS, STATA and R Interpretation of the statistical outputs. Writing reports based on advanced statistical analysis.

Big Data in Social Sciences

The objective of the Big Data in Social Sciences course is to introduce students to the social, ethical, and methodological challenges that stem out from the use of big social data, as well as to familiarize them with the ways of overcoming these challenges in social sciences. Knowledge of different types and ways of using big data in social sciences. Knowledge of methodological possibilities and restrictions on the use of big data in social sciences. Familiarization with the ways of combined use of big data and "small / micro" data sets collected by standard social research techniques (survey research, interviews, observation, etc.). Knowledge of ethical standards in using big social data- Awareness of the legal aspects of the use of big social data- Developed ability of critical assessment of big social data

Analysis of International Research Datasets

Introduction to analysis of data from international official statistics and comparative social research databases and datasets. Getting acquainted with different international comparative databases (macro- and micro-data). Critical evaluation of reliability, validity, and comparability of international comparative data. Mastering analytical skills in usage of international and comparative data in solving different social problems and designing policies. Getting acquainted with different international comparative databases (macro- and micro-data). Critical evaluation of

reliability, validity, and comparability of international comparative data. Mastering the application of techniques of statistical analysis on international comparative data.

4.4 TEACHERS

All people teaching in this course are affiliated with various faculties or institutes at the University of Belgrade. Names, titles, and detailed research interests are available. 26 % of all teaching personal are full professors, 35% are associate professors while the rest of the teaching personal are mostly assistant professors or senior researchers. More than 50% of all teaching personal are female.

4.5 MASTER THESIS AND INTERNSHIP

The master thesis in this study programme accounts for10 ECTS points. Additional to the mandatory master thesis, a mandatory qualification paper needs to be written.

Details on the process of finding a suitable master thesis project as well as the scope of the master thesis are communicated to the prospective students. Prerequisite for the master thesis is a qualification paper defining the relevant area, topics and state of the art in that area.

The specifications for the master are defined as follows:
The student is supposed to show his/her ability to implement the required study methods and the acquired fundamental, scientific, technical and professional skills, and solve specific complex problems in the selected discipline of advanced data analytics with the use of modern computer technology and tools.
The content of the master thesis depends on the selected topic and complies with the established standards in the field and the thesis objective(s). The thesis covers the research topics and objective(s), the initial hypotheses, research methods, description of the research and results, an overview of the thesis contributions and conclusions.

After defending the qualification paper and discussing the thesis topics with the supervisor who approves the topics and objectives, the student starts to work on the thesis. During this work, the advisor conducts regular discussions with the candidate in order to learn about his/her progress, critically evaluates the progress and gives the student additional instruction in the form of guidelines or a reference to relevant literature. The supervisor also guides the student in publishing the research results.

Also, a mandatory internship needs to be conducted in this study programme. It is worth 3 ECTS points. Details on the internship are given as follows:

The goal of the internship is to prepare students for independent research and professional work in identifying and solving specific problems related to the fields studied in the Advanced data analytics degree program (in real-life contexts, such as workplace and/or research laboratories and centres). Through the internship the student will be gaining experience with and mastery of

application of modern computer technology, tools and applications in analysing complex data in selected application areas. The ability to use the acquired theoretical and practical knowledge in identifying and addressing specific data analysis problems and tasks, using quantitative methods and appropriate software tools.

Competencies which shall be acquired within the internship are as follows: Project tasks and activities related to advanced data analysis, where software technology is applied to conduct the work. Defining research tasks and objectives. Identification and description of basic problems through development of key points. Basic methods, techniques, and tools for practical project implementation – selection of appropriate computing methods related to the project objectives and/or predicted empirical research. Basic elements of presenting the results achieved and/or research conducted – electronic presentation of the project on the Internet, presentations using collaborative Internet tools, electronic portfolio presentation. Specifying an internship project – the student's tasks, activities, and responsibilities (if the project is implemented in a specific organization), mode, form and content of the final report, and the like.

4.6 Prerequisites for Enrolment

Details on enrolment are available and detailed:

Candidates of all profiles who have completed four-year undergraduate studies according to previous regulations, or four-year undergraduate academic studies (240 ECTS) can enrol in the master program Advanced Data Analytics. A person who has completed integrated studies, i.e. master academic studies, having achieved at least 300 ECTS credits (180 ECTS credits + 120 ECTS credits) can also enrol in this master program.

4.7 Competences acquired

Students will acquire a variety of competencies and communication about the expected competencies upon successful completion of this programme is clear and detailed. From the course structure outlined reaching these competences can be expected. The courses offer in this programme are suitable for achieving the outlined competences after graduation.

Students who have completed the master program Advanced Data Analytics at the University of Belgrade become competent in:

- independent work in analysing datasets of different complexity in selected domains, with advanced use of current data analysis tools and technologies
- preparing, modifying, adapting, and combining datasets for analysis, out of raw data produced from different applications and other sources
- involvement in various interdisciplinary working teams where data analysis skills in different disciplines and mastery of current data analysis tools and technologies are expected, not only in solving routine practical problems, but also in non-standard situations where creativity and research approach are required

- working with large sets of data

Subject-specific competencies of graduates include:

- ability to understand and analyse different datasets from the perspective of mathematical underpinnings of advanced data analysis (linear algebra, calculus, discrete mathematics, high-dimensional geometry, optimization, etc.)
- mastery of statistical underpinnings of advanced data analysis (data summaries, hypotheses testing, data variance, data correlation, probability, and probability distribution functions, applying descriptive and inferential statistics to datasets, etc.)
- programming using state-of-the-art programming languages in data analytics
- skills in using advanced and appropriate data visualization techniques, as well as current software tools and technologies that enable creating rich data visualizations

4.8 Gender, Bias, Ethical and Legal Aspects

Gender studies is not part of this programme. No individual course discussing gender and bias in this programme is present.

Ethical topics are being discussed with the course Big Data in Social Sciences.

4.9 Documents and Links underlying this Report

https://www.ada.ac.rs/sp-ubg/

https://ada.studije.rect.bg.ac.rs/studijski-program/

https://ada.studije.rect.bg.ac.rs/predmeti/

https://ada.studije.rect.bg.ac.rs/nastavnici/

https://ada.studije.rect.bg.ac.rs/master-thesis/

4.10 Conclusion

Overall, this programme can be regarded as well-structured and suited, well communicated, and well executed. Information for this programme is available and detailed. Prospective students will know what to expect from the courses and its workload. The courses offered are suitable for achieving the outlines competences after graduation. 50 % of all academic teaching personal are female. No gender or bias topics are being discussed within the curriculum. The relatively small number of 25 students only will be supportive for the teacher-student interaction and help gaining in depth knowledge of the most important data analytics topics. Graduates will especially benefit from the sound mathematical education in this programme. The workload within this curriculum does seem to be appropriate for a master's programme.

Based on the reviewed documents the ADA study programme at the University of Belgrade deems suitable for equipping students with the necessary competencies for a data analytics environment.

There is only one mayor shortcoming that needs to be addressed:

Course descriptions in this programme link to online sources for copyright protected books and material. One link even shows a DMCA takedown notice. (Link on the book of Neural Network Classification in this course description: https://ada.studije.rect.bg.ac.rs/predmeti/neural-networks-and-deep-learning/). Clearly such links should not be recommend and available via university study programme websites.

5 ADVANCED DATA ANALYTICS IN BUSINESS (UNIVERSITY OF NIS)

The Advanced Data Analytics in Business at the University of Nis offers to prepare students for a data driven future. This programme aims at a rigorous technical and quantitative training. The courses claim to be sector-focused with a significant share of real-case business problems.

5.1 MATERIAL AVAILABLE FOR PROSPECTIVE STUDENTS

Compared to other master programmes targeted at an international audience there is very little overall information available for this programme in English.

5.2 STRUCTURE OF THE PROGRAMME

This programme is a 3-semester programme with a total number of ECTS credits of 90. In each of the first two semesters, there are in five courses. Three core courses and two elective courses each with 6 ECTS credits. The third semester is reserved for an internship and a master thesis.

5.3 COURSES

The curriculum contains in total six compulsory and four elective courses which are taught over two semesters only. There is a focus on quantitative subjects in the second semester which present a full list of overlapping topics while either using R or Python. The courses offered fit with comparable courses in other master programmes.

All three compulsory course require basic mathematics and or statistics knowledge. Nevertheless, the offered elective course in this second semester tend to reoffer the same qualifications. Students can pick an additional introduction to the same programming language R (while terming this course “programming for business applications 2”).

In the following detailed course descriptions are given.

Introduction to Machine Learning in Business.

The goal is acquiring knowledge about fundamental machine learning models, algorithms, key design elements, and evaluation techniques. After completing the course, the students understand basic machine learning techniques, they have applied them in practice, they are able to select techniques adequate for the problem at hand, they understand how the decisions made in the algorithm design phase affect the algorithm behaviour and can estimate the quality of the obtained models.

Programming for Business Applications

The goal is acquiring knowledge about fundamental algorithmic templates as well as basics of programming in Python.

Optimization and Business Decision-Making

The goal is acquiring knowledge about operation research and decision theory methods and models used in business and economics and their training for independent empirical research in this area. After completing the course, the students understand how to apply linear programming modelling, as well as multi-criteria analysis methods in all areas of business. Through practical examples and the use of Python as an appropriate programming language, students will be able to conduct independent research and solve case-study problems.

Research Design and Visualization Techniques

Introduction to the basics of research planning, graphical presentation of data and research results Students will be introduced to the basics of research planning and visual presentation of data in programming languages Python and R.

Marketing Intelligence

Familiarize students with the most common analytical tools in market intelligence and marketing research and qualify students who have already ruled the logic of statistical thinking to independently conduct marketing research and analysis. Students will become familiar with specific marketing research techniques for analysing data once it has been collected and using those analyses to make better management decisions. Also, students will be able to use programming languages R and Python for marketing research and analysis.

Mathematics and Statistics in Business Analysis

Introducing students to the basic concepts, models and methods in mathematics and statistics and their training for the application of acquired knowledge in various fields of economics. Use of mathematical methods and accompanying software packages for discrete and dynamic analysis of models used to solve specific economic and organizational problems. Calculation and correct interpretation of basic statistical indicators, mastering the basic statistical methods and commenting on the obtained results, using appropriate software packages.

Fundamentals of Accounting and Business Finance

Besides the name of the course, there is no further information available for this course.

Time Series Forecasting

Introducing students to the basic concepts, models and methods in time series analysis and forecasting and their training for the application of acquired knowledge in various fields of economics.

Applied Econometrics

Introducing students to econometric methods and models used in business and economics and their training for independent empirical research in this area. Students will be trained to apply econometric modelling in all areas of business. Through practical examples and the use of

appropriate programming language, students will be able to conduct independent econometric research.

Quantitative Finance

The goal of this course is to extend undergraduate students' knowledge about financial market analytics as well as practitioners understand Capability to do analysis and based investment and financial decision making on quantitative data. Ability to extract information about transaction prices, yields and turnover data from relevant markets and data vendors, as well as to process information for making decisions related to securities investments (time series models, linear and nonlinear models, numerical procedures).

Programming for Business Applications II

Students will be familiar with practical applications of basic and advanced methods for statistical data analysis as well as the basics of programming in R. Introduction to basic and advanced programming techniques for statistical data analysis.

Advanced Big Data Analytics

Introducing students to the basics of advanced business data analytics. Students will be introduced to the advanced data analytics and Big Data concept using the Python and R programming languages.

Online Business and Web Analytics

The goal of this course is to extend to provide students basic data analytic knowledge applied in analysing online business, social media, and web contents. Students will be able to perform independent analysis of web data and obtained conclusions related to potential improvements of sales, product range, customer relations and digital marketing strategies.

Data Acquisition in Business Intelligence

Introduction to the basics of data acquisition from various sources and its importance for business analytics Students will be introduced to the basics of data acquisition from different sources using Python and R programming languages.

Academic Writing

The goal of this course is to develop and strengthen academic and professional writing skills of students. To improve reading, critical reasoning and research skills. To enable students to write academic and professional articles with confidence and skill. Students will be introduced to fundamental concepts of academic writing, text analysis and critical reasoning.

5.4 TEACHERS

No further details on scientific teaching personal are available besides the name of the teachers. Only twelve different people are listed as teaching personal. Their researcher profiles are not

available. About 30% of all people are female. On the overall information homepage, it is being said that in this programme also teachers from abroad are giving lectures.

5.5 Master Thesis and Internship

The master thesis credit value is 20 ECTS. It is thought to be completed in the third semester. No additional information on prerequisites or structure of the master thesis is available.

In this Master programme an internship is required. The credit value for the internship in the third semester is 10 ECTS. No further information is available.

5.6 Competences acquired

The main goal of this programme is to equip graduates both with a technical and quantitative training while also show how this knowledge can be directly applied. Further detailed competencies acquired are not further discussed in this report as there is no additional information in English available.

5.7 Prerequisites for enrolment

No information on conditions for enrolment is available in English.

5.8 Gender, Bias, Ethical and Legal Aspects

Gender studies is not part of this programme. No individual course discussing gender and bias in this programme is present.

Also ethical, and legal challenges that arise when dealing with real data are not discussed in an individual course.

5.9 Documents used for this report

For the Advanced Data Analytics Programme of University of Nis only two documents in English have been used this report. In general, there is very little overall information available for this programme.

https://www.ada.ac.rs/sp-uni/

Curriculum file http://www.ada.ac.rs/download/1211/

Course Description: http://www.ada.ac.rs/download/1214/

5.10 Conclusion

The Advanced Data Analytics in Business programme at the University of Nis offers interesting possibilities for students to touch on the topics of advanced data analytics but is limited in what it is offering or how it is communicating its contents in advance.
One shortcoming of this programme is the limited information available. Additional information on the learning outcome of this programme and details on the teaching personal would be beneficial.
Another shortcoming of the programme is the somewhat missing structure. The whole programme offers in total 90 credits only. One third of these credits are reserved for the internship and the master thesis. 24 credits go into elective course which might cover redundant subjects, scientific writing or Fundamentals of Business and Accounting. The programme misses a clear focus on in-depth courses. A list of subjects seems to be touched on a beginner's level, but advanced courses are missing. Course topics are redundant, and students might learn too little for a master's programme in this course structure.
Working with data and data analytics does offer the opportunity to discuss gender and bias topics. This ADA programme does not offer courses related to gender and or bias or legal and ethical issues in data topics.
The internship which is part of the programme offers students to apply their knowledge already early one. Unfortunately, no additional information on this internship is available.

Based on the reviewed documents the ADA study programme at the University of Nis leaves room for improvement. This impression mainly comes due to the shortage of documents and information available.

6 REFERENCES

Comparable programmes from other European and American universities:

- **Master's degree programme in Business Analytics at the University of Vienna**

  https://datascience.univie.ac.at/masters/master-business-analytics/

- **Master of Business Analytics at MIT Sloan**

  https://mitsloan.mit.edu/master-of-business-analytics/program-components/mban-curriculum

- **Master of Business Analytics**

  https://vu.nl/en/education/master/business-analytics