UNIVERSITATEA LUCIAN BLAGA DIN SIBIU

Doctoral School: Social Sciences

Doctoral domain: Cybernetics and Statistics

PhD THESIS

THE CYBERNETIC APPROACH OF BUSINESS PROCESSES USING DATA SCIENCE TOOLS

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KEYWORDS: Data Science, Data Analysis, Business Processes, Recommender Systems, Economic Impact, Intelligent Organization.

1. RESEARCH DIRECTIONS AND OBJECTIVES

Emphasizing the need for organizational capabilities and the tools needed to develop this capability, the PhD thesis investigates how data analytics helps optimize business performance and processes by adapting to the customers it interacts with.

The main objectives of the research were:

1. Determining how data analysis can contribute to creating value for companies.
2. Assessing the importance of resources and organizational capabilities that contribute to the development of data analysis capability for companies
3. Analyzing the impact of the use of data analysis on the development of company performance.
4. Providing insight into the challenges and opportunities of implementing recommendation systems in e-commerce, providing practical guidance for future developments.
5. Development of a personalized recommendation system capable of exposing user preferences based on interaction data on e-commerce sites.
6. Analysis of the impact of the recommendation system on user involvement and sales parameters in the context of the websites of some restaurants in the city of Sibiu.

The present thesis makes significant contributions to the understanding and application of data analysis in the business context, especially in the HoReCa sector in Sibiu. The first part of the research synthesizes and extends existing theories about data analytics, highlighting how they can be applied to drive innovation and economic growth. In particular, the thesis introduces the concept of predictive analytics of big data as an essential factor of business innovation and growth, highlighting the role of advanced technologies and analytical skills in shaping business strategies. An important theoretical contribution is the modelling of the relationships between managerial skills, analytical techniques and corporate performance, illustrated by the development of a recommendation model that integrates machine learning techniques with collaborative and content-based filtering. This model offers a new perspective on how emerging technologies can be used to personalize the customer experience and optimize sales processes.

The research also demonstrates the practical applicability of data analysis in improving customer interaction and optimizing sales processes by implementing a recommendation system in e-commerce sites. The developed system was tested in a real context, on the websites of two

restaurants in Sibiu, providing empirical data that validates the positive impact of personalized recommendations on the number of orders, products ordered and customer satisfaction. Moreover, the research provides a detailed framework for evaluating and interpreting the effectiveness of recommender systems, thus improving the understanding of the links between recommendation technology, consumer behaviour and financial performance of companies. From a scientific point of view, the thesis extends the existing literature by exploring the role of big data and predictive analytics in shaping business decisions in the HoReCa sector, presenting the steps to integrate, adapt and implement the recommendation model that uses both matrix factorization and collaborative filtering , demonstrating its effectiveness in increasing sales and improving user experience.

2. THESIS STRUCTURE

The introduction of the thesis emphasizes the growing importance of data in modern society, generated through various daily interactions, such as the use of the Internet and connected devices. Data science is an interdisciplinary field essential for extracting valuable insights from this data, with applications in numerous economic sectors such as finance, commerce, and education. Smart organizations can adapt their strategy and infrastructure to gain a competitive advantage through effective use of data analytics. Data science technologies offer companies opportunities to improve performance and reduce costs, helping to optimize decisions and increase business value.

The doctoral thesis is structured in six main chapters, each addressing essential aspects of the integration of data science in the business processes of the HoReCa sector in Sibiu. In the introduction, the research directions and objectives of the paper are presented. Research methodology as well as research hypotheses also appear.

Chapter 1 addresses the role and influence of data science in intelligent organizations, highlighting how modern companies exploit large volumes of data to solve complex business problems and gain competitive advantage. In this context, chapter 1 explores various areas of data science applicability, such as the healthcare industry, banking, marketing, sales, HoReCa and tourism. For example, in healthcare, predictive analytics on big data has enabled the optimization of patient flow in hospitals, reducing waiting times and improving operational efficiency. In the banking sector, data science facilitates credit assessment and fraud detection, contributing to more informed financial decisions and risk management. An interesting aspect addressed in this chapter is the

integration of cybernetics concepts, which emphasizes the importance of the adaptability and complexity of organizational systems in the context of data analysis, highlighting how the diversified regulations of the business environment can be effectively managed through the use of advanced data science technologies.

In addition to applicability to various domains, Chapter 1 looks at the opportunities and challenges associated with using Big Data analytics. Major benefits include improving decision-making processes through access to accurate and real-time information, reducing operational costs by identifying inefficiencies, and personalizing consumer experiences to increase customer satisfaction and loyalty. However, the use of Big Data comes with significant challenges, such as managing and processing diverse and unstructured data, ensuring data security and confidentiality, and analytical complexity that can lead to erroneous interpretations if appropriate methods are not used. Chapter 1 also discusses the current state of Big Data Analytics usage within Romanian companies, highlighting the fact that although there is increased interest and significant potential for improving performance and competitiveness, actual implementation is still developing. This highlights the need for investment in modern technologies, training and the development of a data-oriented organizational culture to fully leverage the benefits offered by data science in the contemporary business environment.

Chapter 2 analyses the economic impact of data science solutions on the budgets of companies in Sibiu, highlighting how the adoption of data analysis contributes to the increase of competitiveness, innovation and operational performance of local enterprises. The study points out that the use of Big Data Analytics is closely related to increased competitiveness, identifying a direct correlation between the adoption of these technologies and the increase in the number of patent applications, indicating a significant impetus for innovation. Research, including surveys conducted in Sibiu, shows that companies that integrate advanced data analytics into their business strategies benefit from improved financial performance and increased efficiency in operations, marketing and customer relations. In addition, the use of social media data for sales optimization in e-commerce and Big Data analysis in the European tourism industry confirm the essential contribution of data science in increasing revenue and sustainable business development.

Chapter 2 also explores the organizational resources and capabilities needed to maximize the benefits of data analytics, highlighting the importance of managerial skills, a data-oriented organizational culture, and appropriate technology resources. The results of the surveys in Sibiu confirm that a culture of organizational learning and a positive attitude towards data are critical

factors in transforming data into economic value, positively influencing the performance and budgets of companies. The study also highlights the need for an integrated strategy that combines technology, strategy and human skills to fully exploit the potential of data analysis, suggesting that investments in these areas can lead to increased competitiveness and long-term financial performance of Sibiu firms.

Chapter 3 focuses on evaluating the effectiveness of using data analysis tools in adjusting business processes based on customer interactions. The main objective of the research was to develop a data analysis tool and improve the online sales process by implementing a personalized recommendations module on the WordPress platform, using web technologies such as HTML, CSS, PHP, MySQL and JavaScript. The developed module tracks user activities, such as product clicks and shopping cart interactions, to influence user behaviour and increase sales performance. The study highlighted the importance of personalizing the user experience in e-commerce, demonstrating how data-driven recommendations can increase customer satisfaction, generate impulse purchases and retain consumers, thus contributing to increased sales and overall performance of the analysed businesses, such as bundetotsibiu.ro and pizzatime.ro from Sibiu.

In addition, chapter 4 explores various types of recommendation algorithms, including content-based collaborative filtering, hybrid systems, and advanced techniques such as matrix factorization and collaborative neural filtering. The literature review highlighted the advantages and challenges associated with each type of algorithm, highlighting the need for an appropriate selection based on the specifics of the e-commerce platform and user behaviour. The research demonstrated that integrating these algorithms can significantly improve user engagement and conversion rates, but also highlighted methodological limitations, such as the lack of measurement of actual impact on business performance and the need for more in-depth future studies. The findings indicate that data analytics tools, when implemented correctly, can provide significant competitive advantages in e-commerce, helping to optimize sales processes and increase customer satisfaction by personalizing offers and improving the online shopping experience.

Chapter 5 details the results of the development and implementation of the personalized recommendation system on the two e-commerce platforms, Bundetotsibiu.ro and Pizzatime.ro. The module built on WordPress was able to effectively monitor user interactions by using a JavaScript script, storing the relevant data in custom MySQL databases. These interactions, such as product clicks and cart additions, were analysed using the Singular Value Decomposition (SVD) algorithm in Python's Surprise library to generate personalized recommendations. Recommendations were

presented to users through an elegant pop-up that updates suggestions in real time based on their recent behaviour. Implementation of this system led to significant increases in performance metrics such as number of orders and products ordered, demonstrating the effectiveness of personalization in driving sales and improving user experience.

The evaluation of the impact of the system was carried out by testing statistical hypotheses regarding changes in the number of orders, products ordered and the average duration of site visits. On Bundetotsibiu.ro, an increase of 34% in the number of orders and 20% in the products ordered was observed, on the other hand, at Pizzatime.ro, the number of orders increased by 15.5% and the products ordered by 17.8 %. Although the average duration of visits increased significantly on Bundetotsibiu.ro (+31%), this increase was not statistically significant on Pizzatime.ro (+3.25%). Statistical tests confirmed the rejection of the null hypotheses for most indicators, underlining the positive impact of the personalized recommendation system on sales performance. The findings indicate that personalization through effective recommendations can transform users' purchasing behaviour, increasing both the number and quantity of orders, although the impact on visit duration may vary by platform.

Chapter 6 provides the conclusions of the study, highlighting the crucial importance of data analysis for business competitiveness in today's digital and international environment. Research has shown that the active use of data brings significant added value by improving internal processes, optimizing resources and increasing the quality of managerial decisions, underscoring the need for managerial skills and a data-oriented organizational culture. The implementation of a personalized recommendation system on the e-commerce platforms Bundetotsibiu.ro and Pizzatime.ro led to notable increases in the number of orders and products ordered, confirming the effectiveness of personalization in boosting sales and improving the user experience. The theoretical contributions of the study include expanding the literature on predictive analytics and modelling the relationships between managerial skills and corporate performance, while the practical contributions are manifested through the application and evaluation of a real recommender system. Scientifically, the research integrated machine learning techniques with collaborative filtering, proving their effectiveness in increasing sales. Future research directions will explore the advanced integration of artificial intelligence, the extension of applications to various industries, and the development of economic models that use data analysis variables to predict economic trends and model innovative sales policies, thereby contributing to sustainable development and adaptability businesses in the face of rapid changes in the global market.

3. PERSONAL CONTRIBUTIONS

4.1. Theoretical contributions

The present thesis makes significant contributions to the understanding and application of data analysis in the business context, especially in the HoReCa sector in Sibiu. The first part of the research synthesizes and extends existing theories about data analytics, identifying how they can be applied to drive innovation and economic growth. In particular, the thesis introduces the concept of predictive analytics of big data as an essential factor of business innovation and growth, highlighting the role of advanced technologies and analytical skills in shaping business strategies.

Another important theoretical contribution is the modelling of the relationships between managerial skills, analytical techniques and corporate performance. This is illustrated by the development of a recommendation model that integrates machine learning techniques with collaborative and content-based filtering, thereby providing new insight into how emerging technologies can be used to personalize the customer experience and optimize sales processes.

4.2. Practical contributions

This research demonstrates the practical applicability of data analytics in improving customer interaction and optimizing sales processes by implementing a recommendation system in e-commerce sites. The developed system was tested in a real context, on the websites of two restaurants in Sibiu, providing empirical data that validates the positive impact of personalized recommendations on the number of orders, products ordered and customer satisfaction.

Moreover, the research provides a detailed framework for evaluating and interpreting the effectiveness of recommender systems, thus improving the understanding of the links between recommendation technology, consumer behaviour and financial performance of companies.

4.3. Scientific contributions

From a scientific point of view, the thesis extends the existing literature by exploring the role of big data and predictive analytics in shaping business decisions in the HoReCa sector. The scientific contribution consists in presenting the integration steps, adaptation and implementation of the

recommendation model that uses both matrix factorization and collaborative and content-based filtering, demonstrating its effectiveness in increasing sales and improving user experience.

4.4. **Dissemination of results**

During the doctoral activity and the preliminary research carried out, I published as first author and co-author a number of 11 scientific articles and papers and a book chapter.

- 5 articles published in Clarivate Analytics Web of Science - WoS (ISI) indexed journals, with impact factor:
    - Cristescu, M. P., Mara, D. A., & Culda, L. C. (2024). Big Data Analytics and Its Influence on Revenue Growth in the European Tourism Industry. În V. Katsoni & G. Cassar (Ed.), Recent Advancements in Tourism Business, Technology and Social Sciences (pp. 15–26). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-54338-8_2 WOS:001289219100002
    - Cristescu, M. P., Mara, D. A., Culda, L. C., Nerișanu, R. A., Bâra, A., & Oprea, S.-V. (2023). The Impact of Data Science Solutions on the Company Turnover. Information, 14(10), Article 10. https://doi.org/10.3390/info14100573 WOS:001095503900001
    - Cristescu, M. P., Mara, D. A., Nerișanu, R. A., Culda, L. C., & Maniu, I. (2023). Analyzing the Impact of Financial News Sentiments on Stock Prices—A Wavelet Correlation. Mathematics, 11(23), 4830. https://doi.org/10.3390/math11234830 WOS:001115979700001
    - Cristescu, M. P., Nerisanu, R. A., Mara, D. A., & Oprea, S.-V. (2022). Using Market News Sentiment Analysis for Stock Market Prediction. Mathematics, 10(22), Article 22. https://doi.org/10.3390/math10224255 WOS:000887505400001
    - Cristescu, M. P., Nerișanu, R. A., Mara, D. A., Polder, R.-M., & Keresztesi, A.-A. (2023). The Role of Big Data Analytics in Increasing Competitiveness. În C. Ciurea, P. Pocatilu, & F. G. Filip (Ed.), Education, Research and Business Technologies (Vol. 321, pp. 161–175). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-6755-9_13 WOS:001012874500013
- 3 scientific papers published in BDI indexed specialized magazines:
    - Cristescu, M. P., Mara, D. A., Culda, L.-C., & Nerișanu, R. A. (2023). Applying Bert and Vader in HR Sentiment Analysis. HR and Technologies, 2, 6–23.
    - Cristescu, M. P., Mara, D. A., Nerișanu, R. A., & Culda, L. C. (2024). The Importance

of Social Media Analytics in Increasing E-Commerce Sales Capabilities. În M. Mavri, P. Ikouta Mazza, A. Karasavvoglou, & P. Polychronidou (Ed.), Economic Growth, Prosperity and Sustainability in the Economies of the Balkans and Eastern European Countries (pp. 297–311). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-58437-4_16

- Cristescu, M. P., Nerișanu, R. A., Mara, D. A., Keresztesi, A. A., & Polder, R. M. (2022). The Role of Big Data Analytics in Increasing Innovation as a Sustainable Goal. În Organizations and Performance in a Complex World. Springer. https://link.springer.com/book/10.1007/978-3-030-50676-6

- 3 works published in the volumes of international scientific events:
  - Cristescu, M. P., Mara, D. A., Culda, L. C., & Nerișanu, R. A. (2024). Leveraging Website Analytics to Enhance User Experience with Pop-Ups and Drive Sales Conversions. În C. Ciurea, P. Pocatilu, & F. G. Filip (Ed.), Proceedings of the 22nd International Conference on Informatics in Economy (IE 2023) (pp. 61–73). Springer Nature. https://doi.org/10.1007/978-981-99-6529-8_6
  - Cristescu, M. P., Mara, D. A., Culda, L. C., & Nerișanu, R. A. (2024). The Perceived Economic Impact of Data Science Solutions on Business Performance. În C. Ciurea, P. Pocatilu, & F. G. Filip (Eds.), Proceedings of the 23rd International Conference on Informatics in Economy (IE 2024): Recent Results in Education, Research, and Applications. Smart Innovation, Systems and Technologies. Springer Nature Singapore.
  - Mara, D. A., Cristescu, M. P., & Culda, L. C. (2024). Analyzing The Efficacy Of Personalized E-Commerce Recommendations Based On Data Analysis. În V. Katsoni & C. Costa (Eds.), Innovation and Creativity in Tourism, Business and Social Sciences - 11th International Conference – IACuDiT, Naxos, Grecia, 2024. Springer Proceedings in Business and Economics. Springer Nature Switzerland.
- 1 BDI book chapter:
  - Cristescu, M. P., Mara, D. A., Nerisanu, R. A., & Culda, L. C. (2024). Leveraging Free Tools in Financial Sentiment Analysis. În Application of Novel Research Methods: The Study of Current Economic Phenomena (Capitolul 7). Peter Lang Group AG. https://doi.org/10.3726/b21691

Last but not least, I had the opportunity to participate in teaching projects and activities that

significantly contributed to my professional and academic development. I participated in the FDI D6 project "Know-how transfer for excellence research at the "Lucian Blaga" University of Sibiu (ULBS)", where I held workshops for the development and improvement of digital skills in the field of research, focused on the advanced use of software and platforms. Later, I was Technical - IT Responsible within the "e-Teach - Upskills Digital Pedagogy for Teachers and FutureTeachers" project, where I contributed both technically and as a lecturer.

Next, I contributed to the "RbtsInMath - Developing Mathematics Achievement through Using Robotics Applications in Flipped Learning" project, having the role of Technical - IT Manager. I then continued with the "Green Deal Awareness through Augmented Reality in Primary School Education" project, where I held the same position as Technical - IT Manager, contributing to the development of the initiative.

Among these projects, we have repeatedly contributed to the "Researchers' Night" initiative, holding workshops on the presentation and use of economic-oriented web IT applications. I also benefited from internal grants and Hasso Plattner grants, which allowed me to expand my research activity.

In addition to these responsibilities, I carry out teaching activities at the Faculty of Economic Sciences of the "Lucian Blaga" University in Sibiu, where I teach the subjects "Managerial Informatics" and "Object Oriented Programming", in the specializations "Management" and "Economic Informatics in English" thus contributing to the training of future specialists in the field. All these activities strengthened my skills in the advanced use of research tools, but also those of software development, thus facilitating the realization of high quality and impactful projects in my field of study.

4. FUTURE RESEARCH DIRECTIONS

Future research directions could explore the deeper integration of machine learning and artificial intelligence technologies to refine and extend the capabilities of recommender systems. It would also be useful to expand the research to include a wider variety of industries and possible application of referral models to other geographic or market contexts.

Another area of interest could be the development of economic models that directly integrate data analysis variables to predict economic trends and shape new policies in the sales process.