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Anatomy of Digital Leadership Studies: An Analysis with Topic Modeling Approaches

Osman Akarsu[1], **Hüseyin Parmaksız**[2]

Abstract: *This study aims to identify trends in digital leadership and analyze frequently used terms and their underlying topic structures in a significant data context. To achieve this, the study used topic modeling approaches (TMA) applied to the academic literature on digital leadership. A total of 847 articles published between 2014 and 2024 from Web of Science, Scopus, DergiPark, and Council of Higher Education Thesis Center databases were collected and analyzed using TMA. In particular, latent Dirichlet allocation (LDA) and BERTopic, which are among the TMA approaches, were used to provide a comprehensive review of the field as well as a comparative analysis of the methodologies. Generative artificial intelligence is used to make the results obtained with the topic modeling approaches more meaningful. In particular, OpenAI's GPT-3.5-turbo model was used to automatically summarize the topics identified with LDA and BERTopic and generate appropriate thematic headings. The results reveal that the concept of digital leadership in the literature is primarily focused on overcoming organizational challenges through innovation and transformation. Key themes identified include the adoption of innovative strategies for digital transformation, the development of new business models, and the role of digital leadership in quality management, technological analysis, and performance improvement through effective technology, knowledge, and social management. Overall, these findings provide valuable insights for future research by suggesting potential variables and research questions, clarifying academic trends in the field, and providing a new method for mapping this emerging area of study.*

Keywords: Digital Leadership, Topic Modeling Approaches, Domain Mapping, Generative AI, Artificial Intelligence

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1. Introduction

Advances in technology and related change affect many aspects, from our lifestyle to the way we do business, from our competencies to the structure of industry. In today's digital world, conventional leadership is gradually being replaced by digital leadership (Chatterjee et al., 2022: 46; Erhan et al., 2022: 1524), and new ways of working (Yopan et al., 2022: 3) and business models (Faiz et al., 2024) are formed by these digital leaders. As the effects of digital transformation continue unabated, the need for digital leaders to manage this transformation is increasing. Schoemaker et al. (2018: 15) stated in their study that the world in which businesses operate today has become not only riskier but also more volatile, uncertain, complex and ambiguous. This field mapping attempts to determine the study trends in the literature on digital

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[1] Asst. Prof., PhD., Bilecik Seyh Edebali University, Faculty of Economics and Administrative Sciences, Department of Management Information Systems, Bilecik, Turkiye, osman.akarsu@bilecik.edu.tr (Corresponding Author)

[2] Asst. Prof., PhD., Bilecik Seyh Edebali University, Faculty of Economics and Administrative Sciences, Department of Management Information Systems, Bilecik, Turkiye, huseyin.parmaksiz@bilecik.edu.tr

leadership as the main concept of the study, which we base its theoretical foundations on leadership from the actor's perspective and dynamic capabilities theory, containing important justifications and potential implications in terms of theory and practice.

Since digital leadership is a developing phenomenon in literature, it is seen that a comprehensive and holistic evaluation has not been made. Since the existing studies were conducted in the early stages of technological change and transformation (Avolio et al., 2000), it was stated that the inclusiveness of the field was limited and fragmented (Schwarzmüller et al., 2018: 114). In addition, it can be stated that the review studies of the existing literature are mostly bibliometric studies with a small number of samples (Karakose et al., 2022) and similar fields of activity. It is seen that a detailed and comprehensive mapping of the digital leadership phenomenon from the perspective of diversity, equality and inclusion (Banks et al., 2022: 4) has not been made (Tigre et al., 2023). It has been observed that the existing studies in literature are mostly addressed in the banking and retail sectors, and it has been recommended that the phenomenon should be evaluated in different sectors such as health, tourism, and education (Erhan et al., 2022: 1538; Kohli & Johnson, 2011). In response to these calls, this study is important in terms of presenting a comprehensive evaluation for academia and practice. The research gap regarding the methodological similarity and scope limitation (Lin, 2024) of existing studies is intended to be filled by focusing on a new method and many more articles than existing studies. The importance of trying to draw the big picture on a subject that has not yet completed its maturity, whose academic interest is increasing, and the importance of practical implications for today's digital businesses is beyond explanation.

In an era of rapid technological evolution, digital leadership plays a key role in aligning organizational capabilities with emerging technologies. By promoting a shared vision and encouraging collaboration, digital leaders enable organizations to align their technological capabilities with strategic goals, thereby improving performance (Tanniru, 2018). Digital leaders create an environment for innovation and adaptation by enabling organizations to effectively use digital tools and reshape organizational structures to meet market demands (Türk, 2023). By integrating resources and promoting technological literacy, these leaders help close digital skill gaps and increase readiness for change (Özmen et al., 2020). Digital leaders facilitate organizational restructuring through dynamic capabilities, ensuring evolutionary fitness by shaping external environments and aligning multiple innovations to achieve market success (Helfat et al., 2009).

This study aims to determine the study trend of the field and the most frequently used terms and latent topic structures in big data related to the phenomenon by using topic modeling approaches (TMA) for academic studies on the concept of digital leadership. As a method, latent Dirichlet allocation (LDA) and BERTopic, one of the TMA, which is one of the soft computing applications and has recently become widespread in academia, were used. LDA is a topic modeling approach that identifies hidden topic hierarchies in large-scale text data. BERTopic is a topic modeling technique that makes use of BERT (Bidirectional Encoder Representations from Transformers), a powerful language model developed by Google. BERTopic and LDA are both techniques used for topic modeling in natural language processing (NLP). BERTopic generates more complex and meaningful topics using large language models such as BERT, while LDA offers a simpler and statistical approach based on word relations. BERTopic offers a more flexible and customizable structure with advanced features such as semi-supervised and dynamic modeling, while LDA is a more traditional and statistical method. The findings of the study obtained by applying these two new methods show that the concept of digital leadership, which has emerged as a phenomenon developing with the digital revolution, is often referred to in the relevant literature as being the conductor who performs digital transformation in organizations, seeking and finding innovation in today's digital businesses living in the information age and implementing it in the organization, Industry 4.0, organizational knowledge management that increases business performance, its impact and role in competition, empowerment of employees with its structure that transforms the industry and the sector, and safe and sustainable future leadership, and introduces many new theoretical and practical concepts.

For these reasons, a new type of bibliometric analysis, the topic modeling approach, has been adopted in this study. This method aims to identify the study trend, and the most frequently used terms related to digital leadership and the hidden subject structures in the big data related to the phenomenon. In

addition, the operation of an artificial intelligence-supported evaluation process with this approach has the potential to shed light on the field at the point of including more than one model. The research questions we seek to answer in this study are as follows:

1. What is the distribution of topics in digital leadership studies between 2014-2024?
2. What are the research trends in digital leadership studies?
3. What are the most frequently used terms in digital leadership studies?
4. What is the latent topic(s) that stand out in big data including digital leadership studies?
5. What are the implications of digital leadership studies for future research?

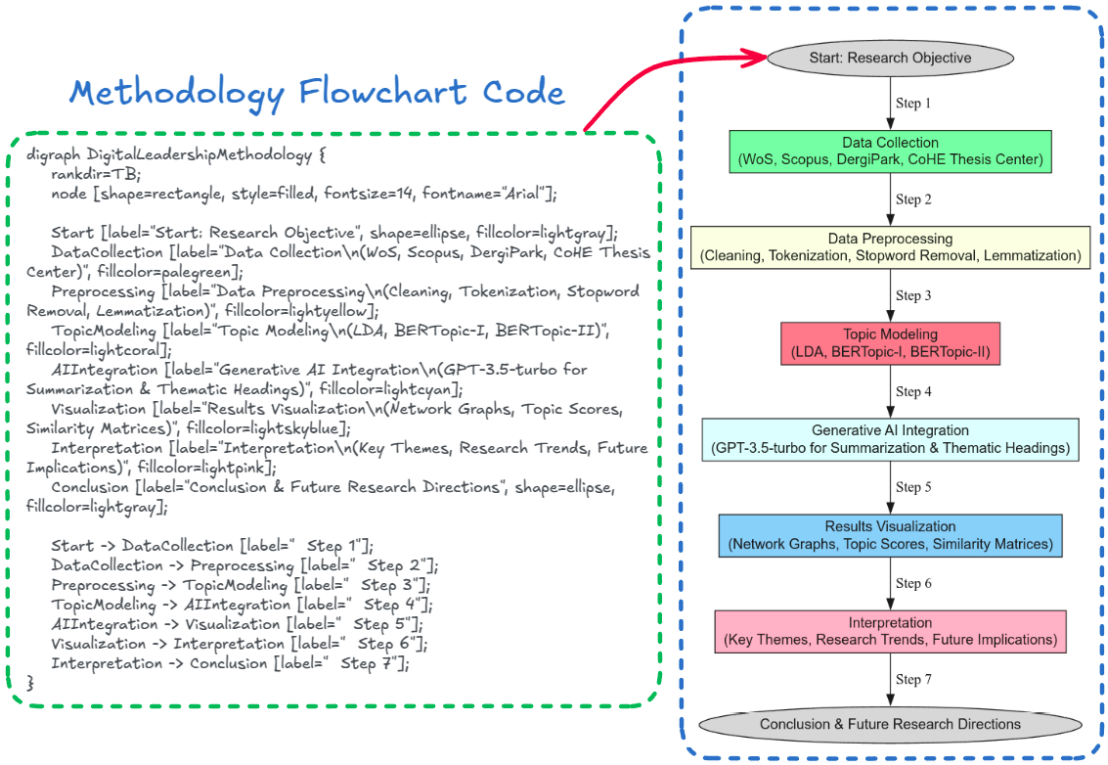
The contribution of this study to the field is that it addresses latent issues in the digital leadership literature using a new method, using big data and expresses theoretical and practical implications. The goal of this study is to examine the literature in the field of digital leadership in depth, identify the study gaps and hidden structures in this field, and fill them by mapping the existing literature. For this purpose, a new bibliometric analysis method, LDA and BERTopic methods, were used to identify the main sources in the literature and to identify and understand the development in the related field. In the study, both of the topic modeling approaches were operated, the inclusiveness of the method was aimed, and the comparative situation was revealed. The difference between TMA from the bibliometric tools in the existing literature and its contribution to academia can be expressed as the fact that it considers the word association, does not need manual classification and is flexible enough to reveal the hidden structures behind the words. In literature, it is advised to address the digital leadership phenomenon comprehensively and holistically, especially with different bibliometric models (Tigre et al., 2023: 60). In the literature, it is stated that the phenomenon should be evaluated with bibliometric analyses that are free from geographical prejudices and have high inclusiveness on how cultural and contextual differences affect digital leadership, as it focuses on more easily accessible data from certain regions (Espina-Romero et al., 2023: 20). For these reasons, within the scope of this study, this new business culture and the leadership offered have important suggestions for the development of organizations and their adaptation to changing conditions. Especially after COVID-19, it has holistic contributions to the phenomenon in a sense that meets the requirements of the GiG economy, which involves the use of temporary or freelance workers to perform jobs, we witness the rapid increase in the post-pandemic period.

The rest of the article is structured as follows. In the methodology section, Topic Modeling Approaches are briefly presented and the similarities and differences, advantages and limitations of the applied models are given. In the next section, the topics, terms, potential study areas, and variables in the digital leadership literature are presented. The findings offer valuable insights in terms of providing potential variables and research questions for future studies, determining the academic trend of the field, showing emerging new topics, and mapping an emerging field with a new method. In the conclusion section, the findings of the study are discussed with the existing literature, the limitations of the study are stated and suggestions for future studies are made.

2. Methodology

The research process in digital leadership involves defining the objective, collecting data from sources like WoS, Scopus, DergiPark, and CoHE Thesis Center, preprocessing it, applying topic modeling techniques like LDA, BERTopic-I and BERTopic-II, and integrating Generative AI using GPT-3.5-turbo for summarization and thematic heading generation. The results are analyzed using visualization techniques like network graphs, topic scores, and similarity matrices. Key themes and research trends are interpreted, providing insights and recommendations for future research. Figure 1 also presents a flowchart illustrating the research process.

Figure 1. Flowchart Illustrating the Research Process



2.1. Topic Modeling Approaches

This research, which addresses the status of digital leadership in the literature, adopts the TMA as a method. Topic modeling approaches, which include machine learning and statistical research, are developed to detect word trends in documents. Topic modeling analyses concepts rather than individual words. Topic modeling is a powerful technique in the field of natural language processing (NLP) that helps to identify hidden topics in large text corpora. LDA, latent semantic analysis (LSA), non-negative matrix factorization (NMF), and BERTopic are four popular methods widely used in the literature. In this study, LDA and two different BERTopic structures are used. For BERTopic-I, vector representations (embeddings) of abstracts were created using the SentenceTransformer library and the 'allenai-specter' model. These vector representations were used for dimensionality reduction with the principal component analysis (PCA) algorithm. Using the K-means clustering algorithm, the number of clusters was determined on the data reduced by PCA. In BERTopic-II, the 'all-MiniLM-L6-v2' model was used for vector representations (embeddings). Dimensionality reduction was performed with UMAP (Uniform Manifold Approximation and Projection) algorithm instead of PCA and clustering was performed with HDBSCAN (Hierarchical Density-Based Spatial Clustering of Applications with Noise) algorithm instead of K-means.

2.2. Latent Dirichlet Allocation

LDA is a topic modeling approach that reveals hidden topic patterns in large-scale text data. This method, which is widely used in natural language processing (NLP), analyses the relationships between words in a collection of documents to determine the probability that each document belongs to certain topics. LDA is a probabilistic model used to understand how documents in a text collection are distributed across various hidden topics (Blei et al., 2003). By basing a given document on multiple topics, it assumes that each word can come from different topics. This assumption suggests that documents do not consist of a single topic and that each document may contain several topics. It is critical to optimize the performance of the LDA model and reveal the hidden topic structure in the dataset more effectively, and therefore determining the most

optimized number of topics (t) should be prioritized (Akbulut & Tonta, 2022; Lafferty & Blei, 2009: 178; Ponweiser, 2012).

Studies by authors such as Arun et al. (2010), Cao et al. (2009), Deveaud et al. (2014), and Griffiths and Steyvers (2004) are often used to determine the number of topics that should be given as input to the LDA algorithm. These metrics include statistical or geometric approaches used to evaluate the performance of the LDA model and to determine the optimal number of topics. Each metric provides a different perspective on topic distributions or topic-phrase relationships, allowing LDA to more effectively reveal the hidden topic structure in the dataset.

In order to determine the optimum selection of the number of topics (t), LDA's document-construction matrix (M) should be decomposed into two components, the topic-construction matrix (M1) and the document-subject matrix (M2). Working as a non-negative matrix factorization (NMF) method, LDA transforms the document-content matrix (Cd*w) into the product of two matrices, namely the subject-content matrix (M1d*t) and the document-content matrix (M2t*w). In this process, the singular value distributions of the topic-term matrix and the distribution of the document-topic vector are analyzed using symmetric Kullback-Leibler (KL) divergence. The symmetric KL divergence supports the optimal selection of the number of topics by measuring the similarity of the distributions obtained from the matrix factors (Akbulut & Tonta, 2022: 194). Since the determination of the optimum number of topics directly affects the quality of matrix partitioning, this method aims to minimize the deviation values that arise by increasing the number of topics. This approach, proposed by Arun et al. (2010), enables the LDA model to perform better by detecting the high bias values arising from non-optimal topic number selections.

In order to evaluate the performance of the LDA model, it is important to consider the point where the average cosine distance between topics reaches a minimum (Cao et al., 2009). In this approach, the distance between topics is used to evaluate the meaningfulness of word assignments and whether the topic structure is discrete and independent (Akbulut & Tonta, 2022). To measure the correlation between topics, the standard cosine distance is calculated for each pair of topics (Ti, Tj). The lower the correlation value, the more independent and disjoint the topics are (Cao et al., 2009). In this process, the average cosine distance between all topic pairs is used to measure the stability and consistency of the topic structure. When the scores of the first two criteria are minimum, the optimum performance of the LDA model is obtained based on the assumption that the optimal number of topics is determined for the relevant dataset (Akbulut & Tonta, 2022: 194; Holliger, 2018).

Deveaud et al. (2014) introduced the latent concept modeling (LCM) technique, which aims to maximize the difference values between subjects to generate distinct and meaningful topics. The LDA model uses an argmax[n] operator to determine the most important word clusters for each subject using the probability distribution $P\_TM(w|k) = \phi\_(k,w)$. The number of latent ideas in the query is calculated by maximizing the information dissimilarity (D) between all topic matches, which improves the performance of the LDA model by reducing topic similarity (Akbulut & Tonta, 2022: 194-195; Deveaud et al., 2014: 67).

In the approach proposed by Griffiths and Steyvers (2004), the Markov Chain Monte Carlo (MCMC) algorithm and Bayesian model are used together to infer the number of topics (Akbulut & Tonta, 2022). In this method, in the process of assigning words to topics, predictions are made by considering the posterior distribution. The MCMC algorithm provides fast and high-performance calculations by effectively sampling complex probability distributions using repeated random sampling (Akbulut & Tonta, 2022: 195).

The LDA method allows for adjustments to the number of features and Dirichlet prior parameters to reduce the entropy of the predictive distribution (Zhang et al., 2016: 1763). However, this is only effective for small-scale corpora of natural language documents with skewed word frequency (Akbulut & Tonta, 2022). Hyperparameters are ineffective for tweaking prediction performance when the corpus is vast (Wallach et al., 2009; Zhang et al., 2016: 1772). As a result, topic model implementations often use fixed concentration parameters and symmetric Dirichlet priors, as tweaking parameters have minimal practical significance (Akbulut & Tonta, 2022; Wallach et al., 2009: 1763). A substantial corpus typically comprises 1000-2000 documents and 5000-7000 words (Akbulut & Tonta, 2022; Crossley et al., 2017; Deerwester et al., 1990: 394).

2.3. BERTopic

BERTopic is a topic modeling technique that makes use of BERT (Bidirectional Encoder Representations from Transformers), a powerful language model developed by Google. BERTopic is a topic modeling technique that uses transformers and c-TF-IDF to generate dense clusters and obtain interpretable topics. It also exhibits algorithmic similarities because it is built on Top2Vec (Grootendorst, 2020). What sets BERTopic apart from Top2Vec is its use of a class-based term frequency-inverse document frequency (c-TF-IDF) method, which evaluates the significance of terms within a specific group and creates a term representation (Sánchez-Franco & Rey-Moreno, 2022). This method aims to create meaningful and easily interpretable topics by preserving important words in topic definitions. BERTopic provides flexibility by supporting different types of topic modeling techniques. These techniques include guided and supervised approaches, semi-supervised models, manual multi-topic distributions, hierarchical and class-based methods, dynamic and incremental modeling, multimodal and multi-aspect analyses, text generation and zero-shot approaches using large language models (LLM). Furthermore, BERTopic is equipped with new features such as merge models and seed words-based approaches. This flexibility makes BERTopic usable and customizable in different application areas.

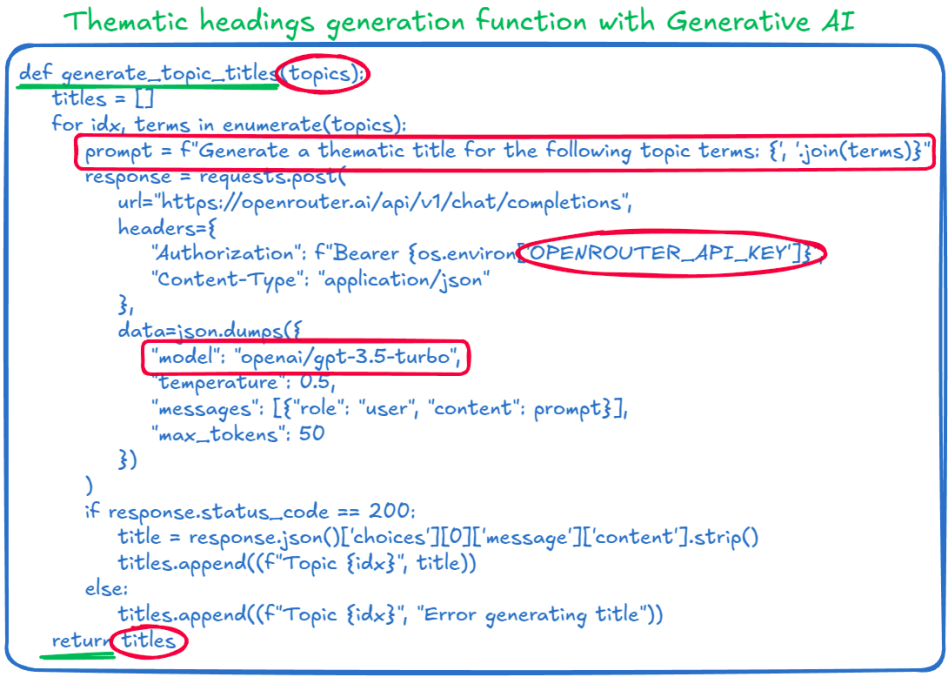
BERTopic has four main components: transformer embedding model, UMAP dimensionality reduction method, HDBSCAN clustering algorithm, and cluster labelling using c-TF-IDF (Grootendorst, 2022). Transformer embedding is one of the basic steps that BERTopic uses to transform text data into dense vector embedding. In this process, choosing a suitable embedding model is critical for the success of the other steps. BERTopic supports multiple libraries for converting texts into embeddings. These libraries include Sentence Transformers, Flair, SpaCy, Gensim and USE (from the TensorFlow Hub). Of these libraries, sentence transformers have the largest collection of high-performing sentence embedding models, which can be found by searching for ‘sentence-transformers’ on the HuggingFace Hub. The first result of this search is the model ‘sentence-transformers/all-MiniLM-L6-v2’. Figure 16 shows the most downloaded ‘sentence-transformers’ models on the Hugging Face Hub platform.

2.4. Generative AI

Headings may be generated automatically using generative AI models such as GPT, T5, BART, and GEMMA using topic phrases collected by LDA and BERTopic. These methods may generate relevant and summary titles by analyzing subject phrases in their context. While GPT-3 and GPT-4 excel in creating natural and contextually relevant titles, T5 and BART are especially good at summarizing and generating titles. Generative AI techniques also enable researchers to investigate enormous amounts of data using natural language prompts, yielding insights that older approaches may miss (Perkins & Roe, 2024: 393). Furthermore, using AI technologies like ChatGPT in theme analysis raises crucial questions about future research methods (Turobov et al., 2024: 10).

In this investigation, OpenAI's GPT-3.5-turbo model was employed. This enhanced version of the GPT-3 family is used for activities such as text generation, summary, and header construction. API-based AI services, like OpenRouter, Groq, NVIDIA, Together, Hugging Face, Cohere AI, AI21 Labs, Replicate, ElevenLabs, Anthropic, and DeepSeek Chat, may also construct thematic headers based on topic terms extracted by LDA, BERTopic-I, and BERTopic-II. Our thematic headings generating tool for topics and words generated by LDA, BERTopic-I, and BERTopic-II algorithms as illustrated in Figure 2 (Thematic Headings Generation Process), uses the "openai/gpt-3.5-turbo" model via the OpenRouter API.

Figure 2. Thematic Headings Generation Process



2.5. Web Scraping

Libraries such as Selenium and BeautifulSoup are used to collect summaries and metadata of articles and theses from websites. Selenium provides browser automation, loads web pages and retrieves the page source (Khder, 2021: 158-159). BeautifulSoup is used to parse these HTML sources and obtain article and thesis links, titles, and content. The information obtained is saved in different formats such as JSON, CSV, and XML for later processing.

In the study, Python-based software was developed to automatically collect studies on "digital leadership" from the online databases of DergiPark (https://dergipark.org.tr/, publicly supported platform that includes academic journals in Türkiye) and Council of Higher Education (CoHE) Thesis Center (tez.yok.gov.tr). The software systematically collects thesis and article information using web scraping methods. For this purpose, the web browser was automated using the Selenium library and interaction with HTML elements was provided. WebDriverManager provided automatic loading of the Chrome WebDriver component; in addition, json, csv, bs4, and pandas libraries stored the obtained data in a structured manner. The operation of the software can be summarized as follows: First, access was provided to the specified URL, and the relevant search terms and date range were entered. Then, Turkish and English abstract information was systematically retrieved for each article and thesis and saved in JSON and CSV format. Page transitions were performed by checking the existing article and thesis numbers and data duplication was prevented.

2.6. Data Set

The study uses Web of Science (WoS) and Scopus platforms to analyze global trends in the field of digital leadership. To assess the adoption of the “digital leadership” phenomenon in Türkiye, DergiPark, a platform hosting Turkish academic journals, is included as an additional data source. Furthermore, the Council of Higher Education (CoHE) Thesis Center is also included to examine the growing momentum of master's and doctoral theses in this field.

When detailed content analysis is required, full article texts are typically used. However, this approach demands additional processing power and more complex pre-processing steps. In contrast,

abstracts offer several advantages, including efficiency, focus, and accuracy. They provide concise yet representative information, making them a preferred and prioritized resource in this study.

While creating the digital leadership-themed data set, abstracts of articles and theses from the last decade (2014-2024) were collected from WOS, Scopus, DergiPark (a publicly supported platform that includes academic journals in Türkiye), and CoHE Thesis Center websites. WOS and Scopus platforms provide support for easily exporting the data of relevant academic studies. Web scraping was performed with Python to export data from Dergipark and the CoHE Thesis Center. From the abstracts obtained from WOS database, Scopus database, DergiPark platform and CoHE Thesis Center, a total of 847 academic study abstracts were obtained after the common ones in WOS and Scopus were checked for duplicates and after removing the duplicates and empty abstracts.

We retrieved 711 records from Web of Science with the query *"(((TS=(DIGITAL leadership)) AND DT=(Article OR Review)) AND WC=(Business OR Management)) AND LA=(English)) AND PY=(2014-2024)"*, 137 records from Scopus with the query *"(TITLE-ABS-KEY ("digital leadership") AND (DOCTYPE (ar) OR DOCTYPE (re)) AND (PUBYEAR > 2013 AND PUBYEAR < 2025)) AND (LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA, "MANA")) AND (LIMIT-TO (LANGUAGE, "English"))"*, 29 records from DergiPark with the query *"(title: 'digital leadership' AND keywords: 'digital leadership') AND (pubyear: (>=2014 AND <=2024))"*, and 40 records were obtained from the CoHE Thesis Center with the 'Digital Leadership' themed query in the summary information of theses published between 2014-2024. Between 2014 and 2024, 40 theses on the issue of digital leadership were recognized in the CoHE Thesis Center, including one thesis in 2020, three in 2021, ten in 2022, seven in 2023, and nineteen in 2024. A total of 12 doctoral theses were done, seven in 2024, two in 2023, and three in 2022, with the remaining 28 being master's theses. According to these findings, the notion of "digital leadership" is gaining popularity in Turkish academic studies.

Google Trends data is a powerful tool for analyzing the popularity trends of certain keywords over time. In this study, the level of interest in the concept of "digital leadership" between 2014 and 2024 was examined. In Figure 3, the data obtained from Google Trends reveals how this concept has evolved over time and in which periods it has gained more importance. The analysis results show that digital leadership has become a growing focus of attention, especially in recent years. This increase can be explained by factors such as the acceleration of digital transformation processes, institutions turning to technology-focused strategies, and leadership models adapting to the requirements of the digital age. The findings reveal that digital leadership is gaining more and more importance not only in academic circles, but also in the business world and the public. This trend indicates that research and applications on digital leadership will increase even more in the future. The study provides an important starting point for understanding the global popularity of digital leadership and evaluating trends in this area. Figure 4 and Figure 5 provide a graphical analysis to represent which categories of studies the WOS and Scopus databases commonly contain.

Figure 3. Popularity Trends Between 2014-2024 (Digital Leadership)

Figure 4. Distribution of the Obtained Data According to Scientific Fields (WOS)

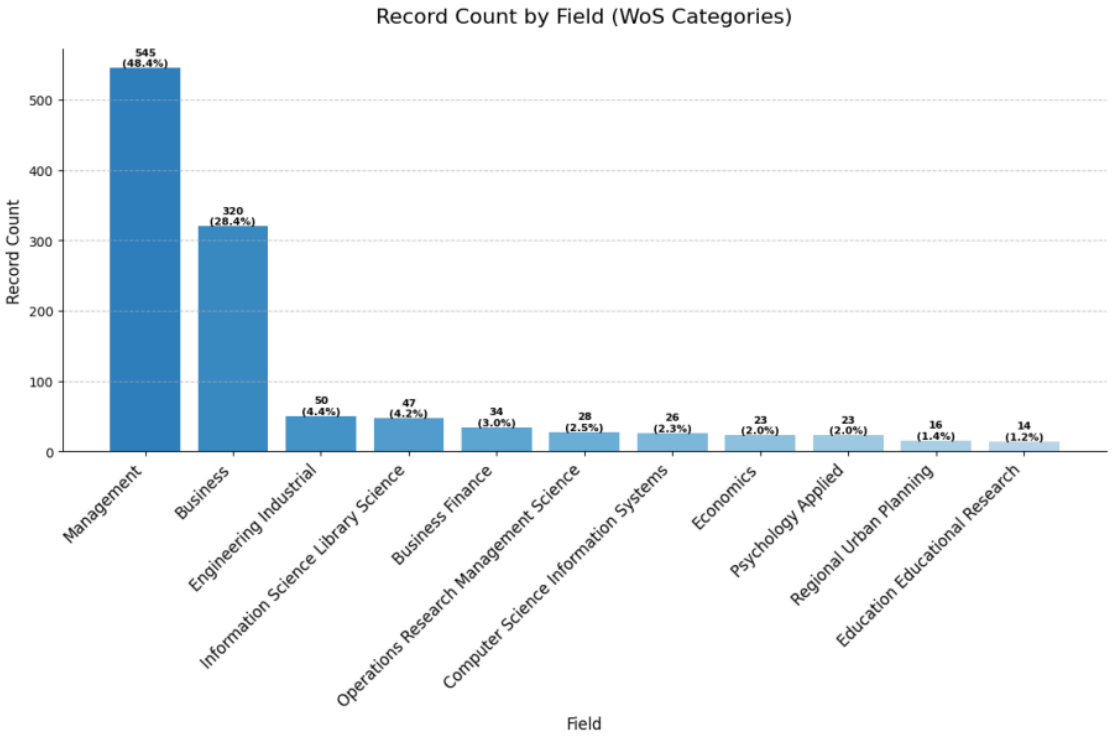
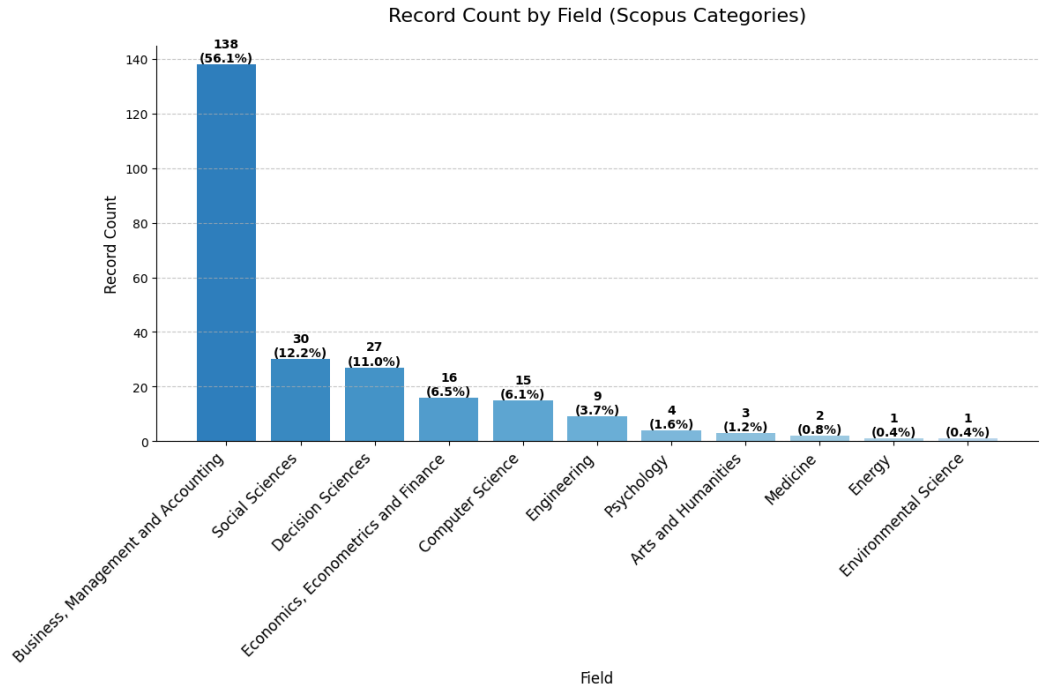


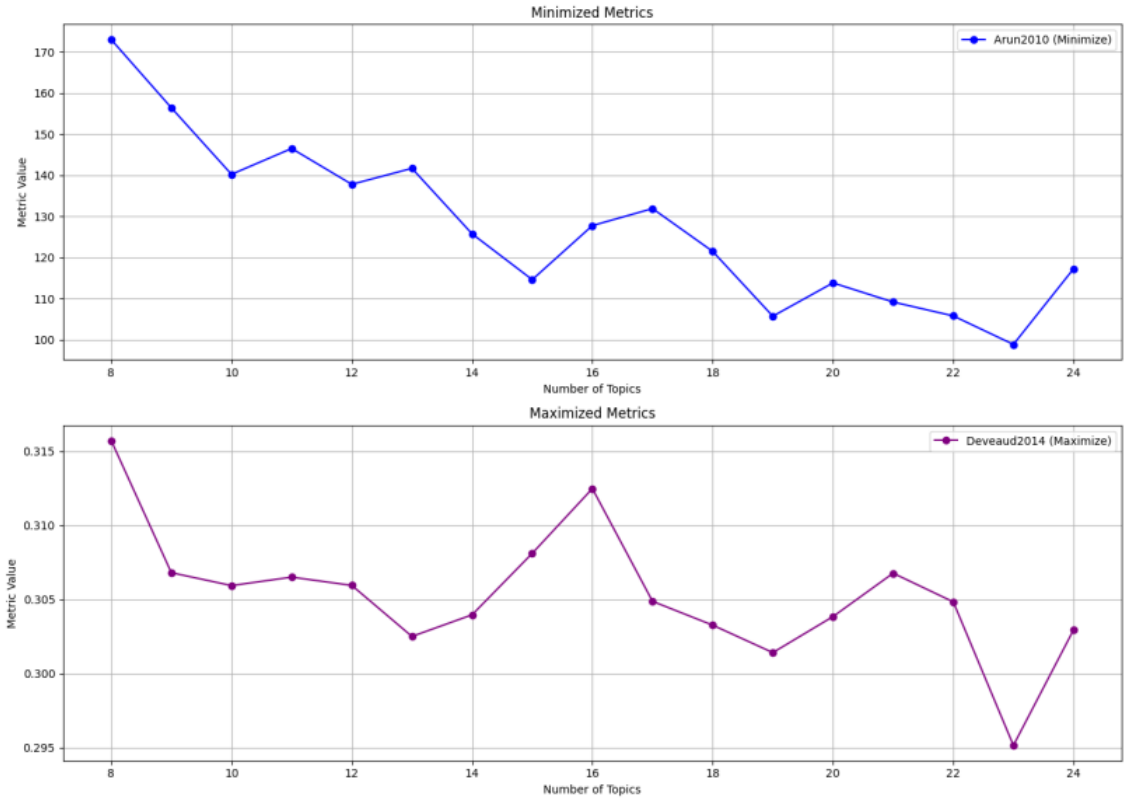
Figure 5. Distribution of the Obtained Data According to Scientific Fields (Scopus)



In the study, the optimum number of topics and the topic determination process with the LDA method were discussed in detail using the CSV file in which we collected the summaries of academic studies on the theme of "digital leadership".

The main reason for choosing this method in the study is that it is supported by empirical findings that it is more effective in measuring the semantic coherence of topics compared to other methods. Deveaud's method maximizes the information differences between topic distributions, resulting in a more distinct and meaningful emergence of topics. This feature plays a critical role in improving topic modeling performance, especially in large-scale text datasets. Deveaud, which is the maximized metric with empirical methods, was selected to determine the optimum number of topics and is visualized in Figure 6. First, the data was taken from the CSV file as a dataframe with pandas, and the "Abstract" and "Title" columns were cleaned, and stop words and extra words (such as "findings", "study", "data" etc.) were removed. This process was carried out to ensure that the LDA model works with a more meaningful and clean vocabulary. Then, a dictionary was created from the cleaned texts using the Gensim library. The corpus was created to represent the document-word matrix required for the LDA model.

Figure 6. Examining Optimal Topic Determination Metrics with LDA



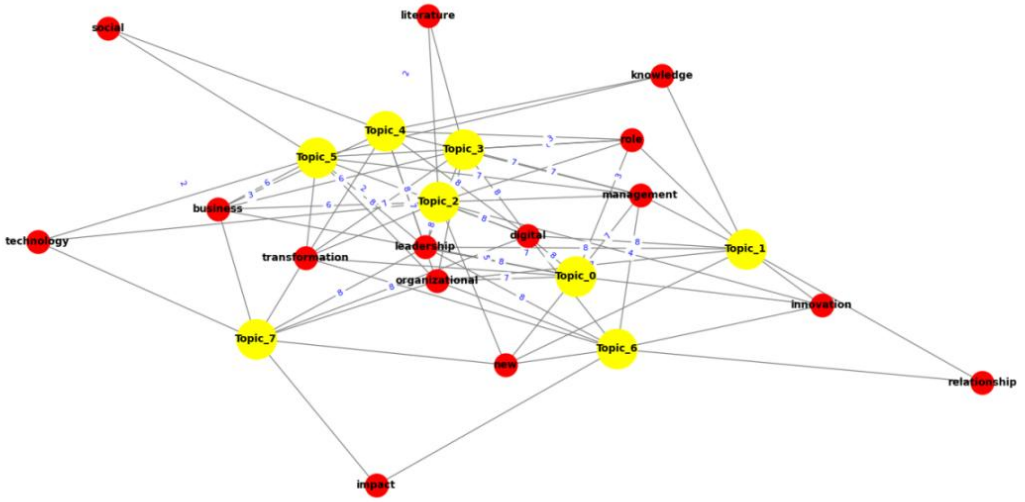
3. Results

In order to determine the status of the literature on digital leadership and to evaluate the performance of the LDA model, different metrics such as Griffiths 2004, CaoJuan2009, Arun2010 and Deveaud2014 were used. These metrics were used to determine the optimal number of topics for the LDA model. In particular, the Deveaud2014 metric in Figure 6 helped to select the optimal number of topics by maximizing topic consistency. The results obtained were visualized graphically and how the metrics changed for different numbers of topics was examined. After determining the optimal number of topics, the LDA model was trained with this number of topics, and keywords were extracted for each topic. Based on these keywords, thematic headings were created for better expression of the topics using Generative AI models via the OpenRouter API and are presented in Table 1.

Table 1. Topic – Terms Determined by LDA and Thematic Headings Created by GEN AI

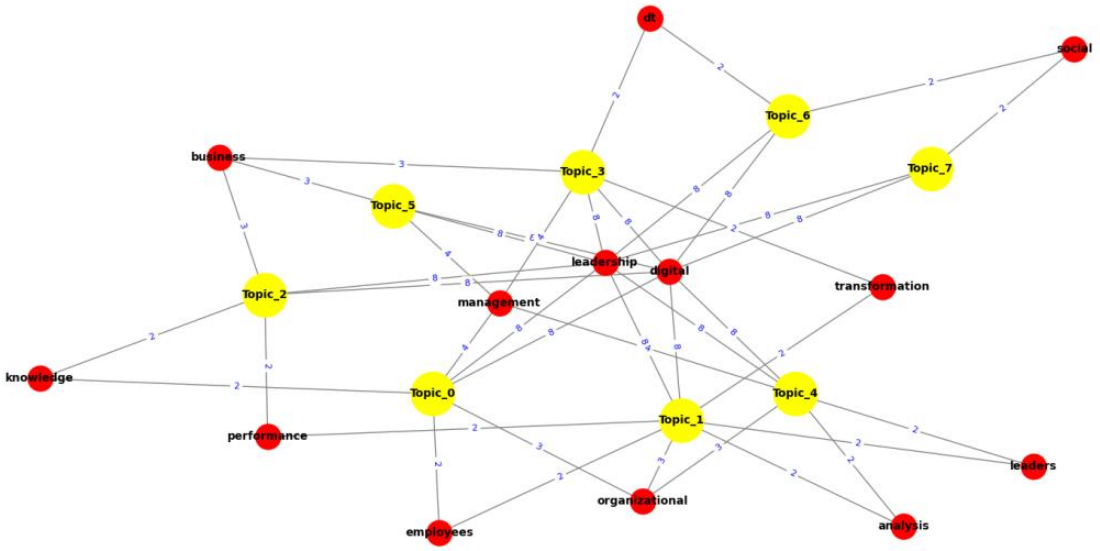
Topic Numbers	Terms of Topics Determined by LDA	Thematic Titles of Topics Determined with LDA Using Generative Artificial Intelligence
Topic 0:	['digital', 'leadership', 'business', 'innovation', 'transformation', 'management', 'culture', 'organizational', 'new', 'role']	Leading the Digital Transformation: Cultivating Innovative Business Culture and Organizational Management, The Digital Leadership Revolution: Transforming Business through Innovation and Organizational Culture
Topic 1:	['digital', 'leadership', 'new', 'management', 'relationship', 'role', 'organizational', 'managers', 'innovation', 'knowledge']	The Evolution of Digital Leadership in Organizational Management: Navigating New Roles and Relationships through Innovation and Knowledge, Digital Leadership in the New Era: Managing Relationships and Driving Innovation
Topic 2:	['digital', 'leadership', 'business', 'new', 'technology', 'innovation', 'role', 'management', 'transformation', 'literature']	The Digital Leadership Revolution: Business Transformation through New Technology and Innovation in Literature, Digital Leadership: Navigating Business Transformation through New Technology and Innovation in Literature
Topic 3:	['digital', 'leadership', 'transformation', 'organizational', 'business', 'management', 'literature', 'factors', 'quality', 'role']	The Digital Leadership Imperative: Transforming Organizational Business Management through Literature and Quality Factors, Digital Leadership Transformation: The Key Factors in Organizational Business Management Literature
Topic 4:	['digital', 'leadership', 'business', 'organizational', 'performance', 'transformation', 'management', 'social', 'role', 'knowledge']	Leading the Digital Transformation: Harnessing Organizational Performance and Social Knowledge, Navigating the Digital Leadership Landscape: Transforming Business Performance through Organizational Management and Social Knowledge Roles
Topic 5:	['digital', 'organizational', 'leadership', 'transformation', 'management', 'social', 'business', 'knowledge', 'role', 'technology']	The Evolution of Digital Leadership: Transforming Organizational Management in a Social Business Environment, The Digital Evolution: Transforming Organizational Leadership in the Social Business Era
Topic 6:	['digital', 'leadership', 'transformation', 'innovation', 'leaders', 'impact', 'organizational', 'management', 'new', 'relationship']	Leading Digital Transformation: Innovating Organizational Management for Impactful Relationships, Digital Leadership Transformation: Innovating for Impact in Organizational Management
Topic 7:	['digital', 'leadership', 'new', 'technology', 'transformation', 'industry', 'business', 'model', 'organizational', 'impact']	The Digital Leadership Revolution: Transforming Industries with New Technology and Organizational Models, The Digital Leadership Revolution: Transforming Industries with New Technology and Organizational Models

Figure 7. Networkx Graph for Topic and Term Relationship Determined with LDA



The topics and terms discovered by the LDA technique are visualized in Figure 7 using the NetworkX module in Python to better grasp the underlying semantic structure of the text data and to examine topic-term correlations. This technique allows the identification of themes and related expressions recognized by the LDA model using graph theory. In the network structure, nodes represent topics and terms, while edges reflect the connections between terms and specific topics, as well as the weights of these relationships. This visualization is useful for facilitating topic interpretation, analyzing the roles of words among themes, and identifying trends in text data.

Figure 8. Networkx Graph for Topic and Term Relationship Determined with BERTopic-I



In BERTopic-I, principal component analysis (PCA) and K-means clustering were chosen due to their effectiveness in generating distinct and well-separated clusters. PCA reduces the dimensionality of the data while preserving the most significant variance, which helps in creating more interpretable and separable clusters. K-means, on the other hand, is a widely used clustering algorithm that partitions data into a predefined number of clusters based on distance metrics, making it suitable for creating clear and distinct groupings.

In contrast, for BERTopic-II, UMAP (Uniform Manifold Approximation and Projection) and HDBSCAN (Hierarchical Density-Based Spatial Clustering of Applications with Noise) were preferred. UMAP is particularly effective for projecting high-dimensional data into lower dimensions while preserving both local and global structures, which is crucial for maintaining the integrity of the data's underlying patterns. HDBSCAN, a density-based clustering algorithm, offers greater flexibility by identifying clusters of varying shapes and sizes and automatically detecting noise or outliers, making it ideal for handling complex and irregular data distributions. This combination allows for a more nuanced and flexible clustering approach, especially when dealing with diverse and high-dimensional datasets.

By using these methods, BERTopic-I focuses on creating distinct clusters through dimensionality reduction and centroid-based clustering, while BERTopic-II leverages the strengths of density-based clustering and advanced projection techniques to handle more complex data structures. This dual approach ensures that the topic modeling process is both robust and adaptable to different types of data.

The topic determination process was discussed in detail on the dataset using BERTopic and K-means clustering methods. Abstracts were extracted from the "abstract" column in the dataset and unnecessary words such as stop words were cleaned to create a cleaner text base. This process is important for the BERTopic model to extract more meaningful and consistent topics. Vector representations of the abstracts

(embeddings) were created using the "allenai-specter" model with the SentenceTransformer library. These vector representations were used for dimension reduction with the PCA algorithm. While PCA reduces the dimensions for better grouping of the data, the best number of components was determined as 76 in our study to preserve 90% of the variance in the dataset.

Using the K-means clustering algorithm, the number of clusters was determined by the data reduced with PCA. Different metrics such as the Silhouette Score, Davies-Bouldin Score and Calinski-Harabasz Score were used to determine the optimal number of clusters. The best number of clusters was selected as the number of clusters that gave the best values of these metrics. After determining the number of clusters as 8 in our study, the BERTopic model was trained with this number of clusters, and keywords were extracted for each topic. In order to optimize the performance of the model, the number of topics (reduce_topics) was applied and as a result, meaningful topics were determined. The keywords extracted for each topic were created as thematic headings using Generative AI models via the OpenRouter API and are presented in Table 2. In addition, Figure 8 is presented to facilitate the examination of topic-term correlations determined by BERTopic-I.

Table 2. Topic - Terms Determined by BERTopic-I and Thematic Headings Created by GEN AI

Topic Numbers	Count	Terms Relating to Topics Determined by Bert	Thematic Titles of Topics Determined by Bert Using Generative Artificial Intelligence
Topic 0:	140	[‘learning’,’digital’,’employees’,’employee’, ’education’,’knowledge’,’management’,’organizational’,’communication’,’leadership’]	"Digital Learning: Empowering Employees for Organizational Success"
Topic 1:	133	[‘digital’,’leadership’,’transformation’,’performance’,’organizational’,’employees’,’effect’,’innovative’,’leaders’,’analysis’]	"Digital Leadership Transformation: Maximizing Organizational Performance through Innovative Employee Analysis"
Topic 2:	111	[‘innovation’,’digital’,’leadership’,’firm’,’firms’,’performance’,’capabilities’,’knowledge’,’business’,’smes’]	"Driving Digital Innovation: Leadership and Capabilities for SME Performance"
Topic 3:	108	[‘digital’,’transformation’,’business’,’dt’,’management’,’leadership’,’managers’,’new’,’technology’,’role’]	"The Evolving Role of Digital Transformation in Business Management and Leadership"
Topic 4:	105	[‘leadership’,’digital’,’leaders’,’analysis’,’organizational’,’remote’,’management’,’styles’,’literature’,’field’]	"Exploring the Evolving Landscape of Digital Leadership: An Analysis of Organizational Management Styles in the Remote Work Era"
Topic 5:	101	[‘industry’,’factors’,’quality’,’management’, ’manufacturing’,’digital’,’business’,’ai’,’supply’,’leadership’]	"Driving Success: The Intersection of Industry, Quality Management, and Digital Business Leadership"
Topic 6:	84	[‘digital’,’construction’,’social’,’sustainability’,’sustainable’,’leadership’,’tourism’,’green’,’entrepreneurship’,’dt’]	"Building a Sustainable Future: Digital Leadership in Green Tourism Entrepreneurship"
Topic 7:	64	[‘social’,’media’,’marketing’,’twitter’,’digital’,’brand’,’information’,’online’,’leadership’,’platform’]	"Digital Brand Leadership: Harnessing the Power of Social Media Marketing on Twitter"

The importance levels of the most important words for each topic in BERTopic-I are shown in Figure 9 with the "Topic Word Scores" graph. It is used to better understand the content of the topics and to visualize the keywords represented by each topic. For each topic, the BERTopic-I model calculates the importance of the words to the topic (e.g., TF-IDF scores or c-TF-IDF scores) and ranks the words using these scores.

In topic modeling, c-TF-IDF scores play a crucial role in identifying the most representative words for each topic. A higher c-TF-IDF score indicates that a word is more specific to a particular topic, distinguishing it from others in the corpus (Egger & Yu, 2022: 6). Conversely, lower scores suggest that a word is more commonly used across multiple topics, reducing its discriminative power. To enhance the interpretability and effectiveness of topic modeling, it is essential to have highly distinctive words with elevated c-TF-IDF scores

within each topic. In the presented graph, for instance, the word "digital" in Topic 1 exhibits one of the highest scores (approximately 0.1), highlighting its strong association with that topic. Similarly, "industry" in Topic 5 emerges as a key defining term due to its relatively high score. The presence of such dominant words helps in clearly differentiating topics, ensuring that the extracted themes are meaningful and distinct.

Figure 9. Topic Word Scores Graph (BERTopic-I)

Figure 10. Topic Word Scores Graph (BERTopic-II)

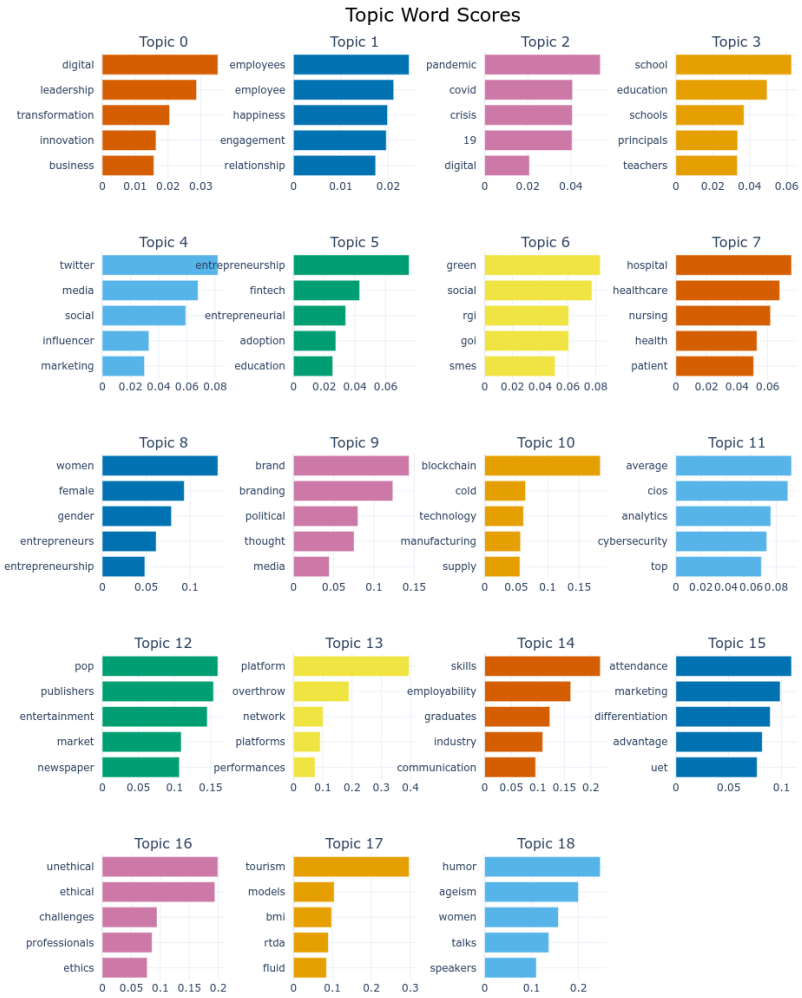


Figure 10 shows the importance levels of the most important words for each topic out of 18 topics identified with BERTopic-II. It was used to better grasp the essence of the topics and to visualize the keywords represented by each topic.

The most important words from the topics determined by BERTopic-II were determined by C-TF-IDF. A general representation of this process is presented in Figure 11.

Figure 11. c-TF-IDF Most Important Words Graph for BERTopic-II

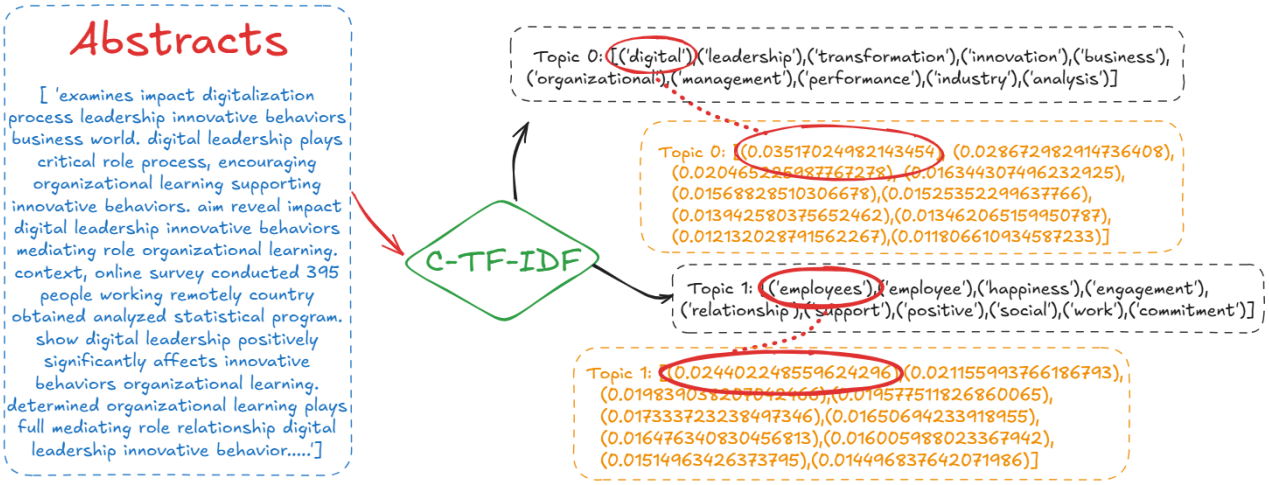
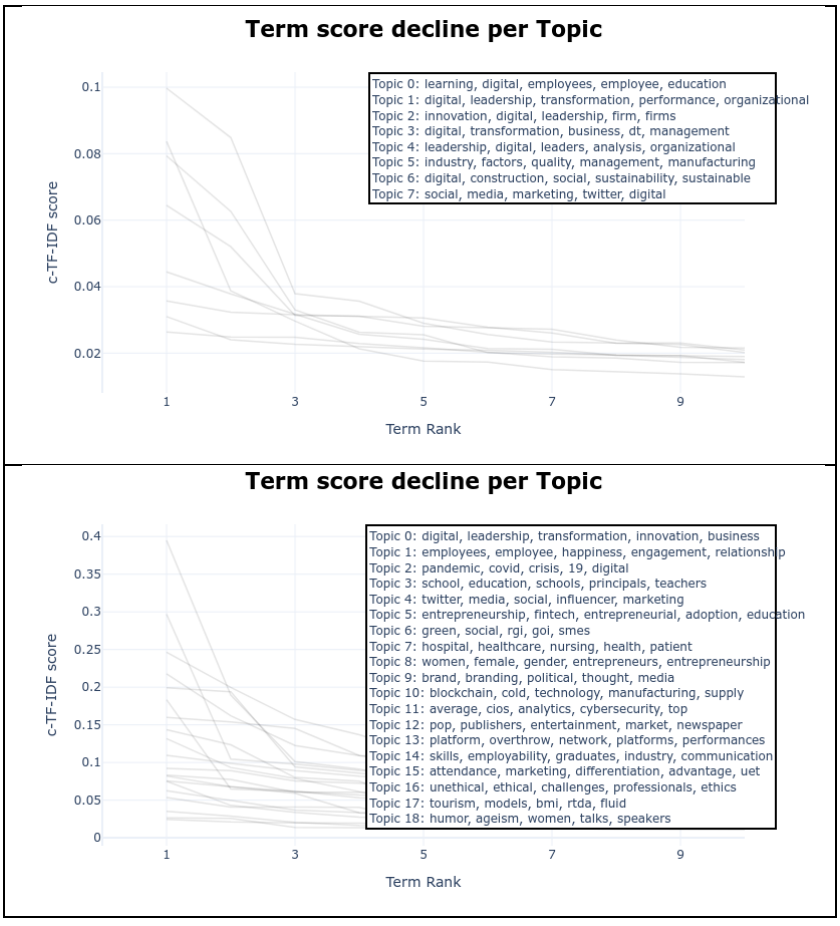


Figure 12. Term Score Decline per Topic Graph (top-BERTopic-I, bottom BERTopic-II)



The "term score decay per topic" graph in Figure 12 is a visualization tool used to evaluate the performance of the BERTopic-I and BERTopic-I models and to better understand the content of topics. It shows the decline in term scores over time for each topic and ranks the most important words to better understand the theme the topic represents. The highest-scoring words for each topic are the words that form the core of the topic, and their scores can be used to evaluate the salience and meaning of the topic. This visualization is very important for understanding how topics are formed and the words that form their basis, as well as for observing differences and similarities between topics. Overall, the "term score decay per topic" graph is a valuable tool for understanding the content of topics.

The distances between topics determined by the BERTopic-I and BERTopic-II models are visualized with the Intertopic Distance Graph. This graph helps us better understand the relationships between topics by reflecting the similarities and differences between topics. It also allows us to easily see how the topics are grouped. In the graph, each topic is represented as a point and the distance between the points indicates the similarity of the topics. Closer topics indicate that they have similar themes, while more distant topics indicate that they have different themes. In Figure 13, it is seen that BERTopic-I – Group I "[Topic 0,1,4]" is close because they have similar themes, while BERTopic-I – Group II "[Topic 2,3,5,6,7]" is far from these themes. BERTopic-II – Group I is "[0,1,2,3,4,5,7,9,10,11,12,13,14,15,16,17]" and BERTopic-II – Group II is "[8,18]". Each group is similar within itself, but different groups represent differences between the subjects.

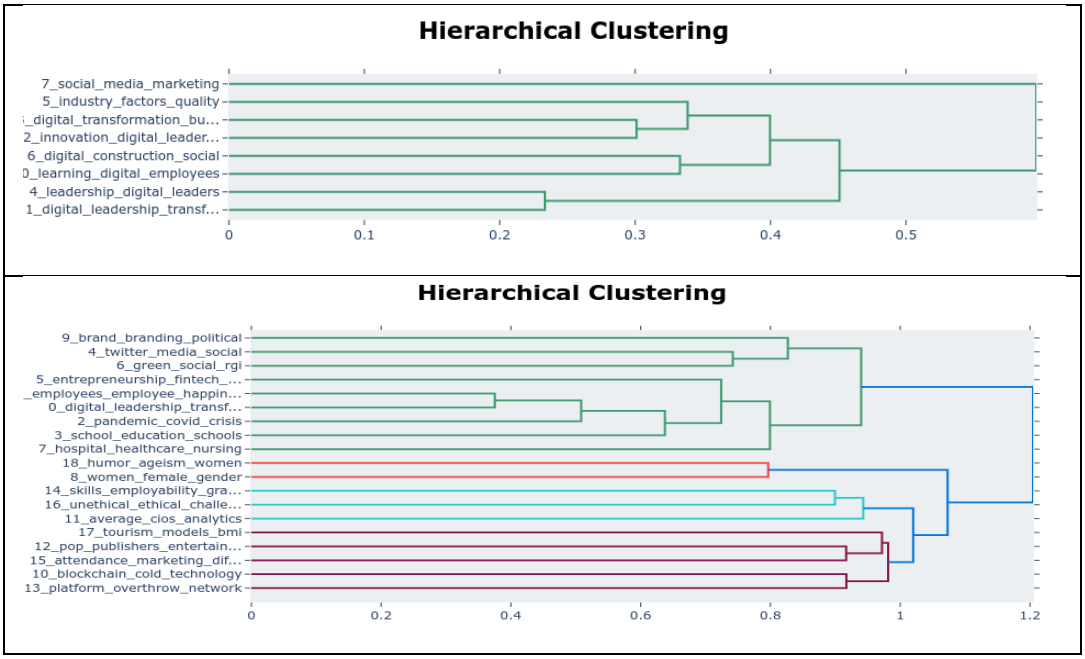
Figure 13. Intertopic Distance Map Graphs

(BERTopic-I – Group I) (BERTopic-I – Group II)

(BERTopic-II – Group I) (BERTopic-II – Group II)

A hierarchical clustering graph is a visualization tool that shows how data points or clusters are grouped in a hierarchical structure using a tree-like structure called a dendrogram. This tool helps to understand the relationships and hierarchy between clusters in cluster analysis. A hierarchical clustering graph can be created in two ways: agglomerative and divisive. In the agglomerative method, each data point is considered a separate cluster, and similar clusters are combined. In the divisive method, all data points are considered a single cluster and then divided. A dendrogram uses a horizontal axis to represent data points or clusters and a vertical axis to show similarity or distance measures. The number of clusters can be determined by selecting a threshold value on the vertical axis. Figure 14 shows the Hierarchical Clustering graphs we created for BERTopic-I and BERTopic-II.

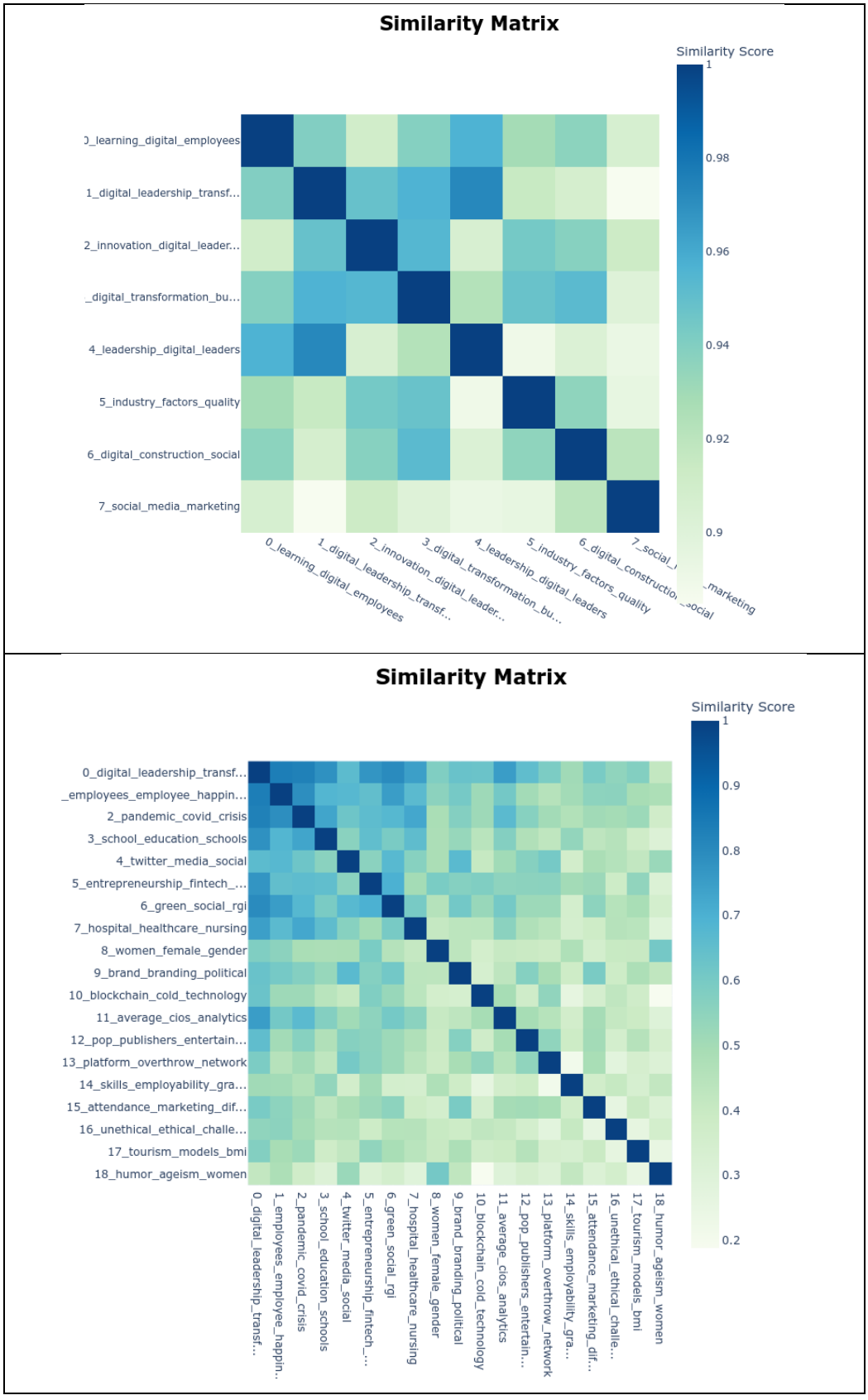
Figure 14. Topic Word Scores Graph (top-BERTopic-I, bottom BERTopic-II)



The Similarity Matrix tool was used to measure similarities and differences between topics identified by BERTopic models and is visualized comparatively in Figure 15. It shows the scores indicating similarities or differences for each topic. High scores indicate similar themes, and low scores indicate different themes. This visualization is crucial for understanding topic grouping and relationships, as well as observing differences and similarities between topics.

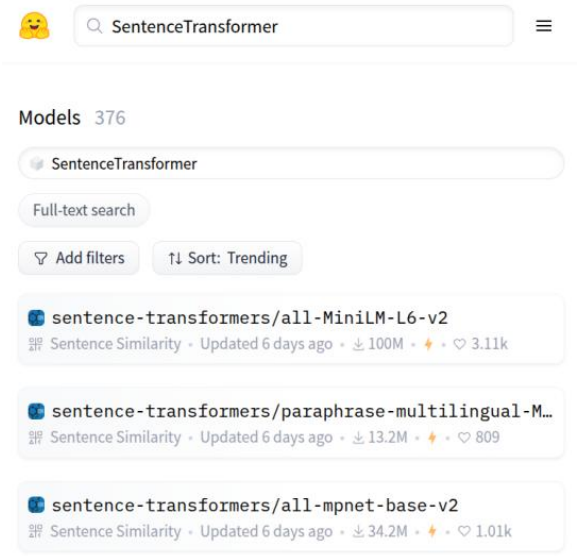
This similarity matrix graph created with BERTopic shows the thematic similarities between 8 to 18 different topics obtained from our data. Each cell of the matrix represents the similarity score between two topics, and scores closer to 1 indicate that these topics contain closer themes. When looking at the upper graph in Figure 15, for example, high similarity scores are seen between "leadership_digital" and "digital_transformation_business" or "innovation_digital_leadership", which shows that these topics have similar content. On the other hand, it is observed that some topics such as "social_media_twitter" have lower similarity with other topics (e.g. "education_the_learning"). This indicates that these topics are shaped around a more independent and different theme. As a result, the matrix shows that it is a powerful tool for understanding how topics are grouped thematically and which topics are more interconnected. It is seen that some themes in our data are highly integrated, while others are more independent and separated. This analysis shows that it is a method with advantages in terms of deriving in-depth meanings on potential relationships or separations between topics and obtaining a starting point for further studies.

Figure 15. Similarity Matrix Graph (top-BERTopic-I, bottom-BERTopic-II)



In BERTopic-II, instead of "allenai-specter" for vector representations (embeddings) of summaries, the most downloaded "all-MiniLM-L6-v2" model on the Hugging Face platform, given in Figure 16, was used. Instead of PCA, UMAP (Uniform Manifold Approximation and Projection) algorithm was used for dimension reduction and instead of K-means, HDBSCAN (Hierarchical Density-Based Spatial Clustering of Applications with Noise) algorithm was used for clustering operations.

Figure 16. Hugging Face Most Downloaded SentenceTransformer Model (all-MiniLM-L6-v2)



UMAP algorithm is used to reduce the dataset size and improve clustering. n_neighbors=15, n_components=2, min_dist=0.1 and random_state=42 parameters are used to preserve the local structure, control dimensionality reduction and provide cluster distance. Random_state is used to make the process repeatable. The selection of these parameters is optimized according to the structure of the dataset and clustering objectives. HDBSCAN algorithm is used to perform clustering on the data reduced with UMAP. This density-based algorithm detects noisy data and creates meaningful clusters by detecting outliers. min_cluster_size=2, min_samples=1, gen_min_span_tree=True and prediction_data=True parameters are used. These parameters determine the minimum number of points required to create a cluster, the minimum number of neighbors for a point to be included in the cluster, the minimum tree creation, and the storage of clustering results.

BERTopic-II is a natural language processing technique that automatically discovers and group's themes in large text sets. It analyzes text data, groups documents with similar meanings together, and creates topics representing these groups. Topics are defined by the most important words and their frequency. The get_topic_info() function provides detailed information about the identified topics, including the total number of documents, the words, and the frequency of these words. The visualize_barchart() function visualizes the distribution of topics and creates a bar chart that ranks them by the number of documents. The visualize_heatmap() function shows the similarity between topics by creating a heat map with color tones to indicate high or low similarity. The visualize_hierarchy() function creates a visual representation of the hierarchical relationships between topics, allowing us to understand how topics are connected and positioned in a larger hierarchy. The visualize_topics() function creates an Intertopic Distance Map (IDM), a visualization technique that shows the relationships and similarities between topics discovered by the BERTopic-II model. This map projects topics into a two-dimensional space according to their similarities, with each topic represented as a point on the map. The distance between points reflects the similarity between topics; similar topics are close together, and dissimilar topics are far apart.

It differs from LDA in that it applies continuous topic modeling rather than discrete topic modeling, and its stochastic nature can lead to different results with repeated modeling. In particular, Topic 0 with a count of -1 should not be considered as it always represents outliers (Egger & Yu, 2022: 6).

The get_topic(0) function returns the most important words and their frequencies corresponding to the specified topic number. For detailed analysis, the get_topic() function is called for each topic, creating a loop that retrieves the list of the most important words and frequencies for all topics. This allows for a detailed analysis of each topic, providing insight into the representation and importance of topics in the dataset. Table 3 presents the Topic-Terms determined by BERTopic-II and thematic topics generated by Generative AI.

Table 3. Topic - Terms Determined by BERTopic-II and Thematic Headings Created by GEN AI

Topic No	Count	Terms Relating to Topics Determined by Bert	Thematic Titles of Topics Determined by Bert Using Generative Artificial Intelligence
Topic 0:	506	[‘digital’,‘leadership’,‘transformation’, ‘innovation’,‘business’,‘organizational’, ‘management’,‘performance’,‘industry’,‘analysis’]	"Driving Digital Transformation: Innovative Leadership in Organizational Management and Industry Performance Analysis"
Topic 1:	58	[‘employees’,‘employee’,‘happiness’, ‘engagement’,‘relationship’,‘support’, ‘positive’,‘social’,‘work’,‘commitment’]	"Building a Culture of Positive Employee Engagement and Support"
Topic 2:	45	[‘pandemic’,‘covid’,‘crisis’,‘19’,‘digital’,‘leadership’,‘wfh’,‘learning’,‘organizational’,‘resilience’]	"Navigating the New Normal: Building Organizational Resilience through Digital Leadership in the COVID-19 Crisis"
Topic 3:	37	[‘school’,‘education’,‘schools’,‘principals’,‘teachers’,‘learning’,‘higher’,‘ei’,‘digital’,‘educational’]	"Empowering Education: Navigating the Digital Frontier in Schools"
Topic 4:	19	[‘twitter’,‘media’,‘social’,‘influencer’,‘marketing’,‘journalists’,‘fashion’,‘purchase’,‘users’,‘black’]	"The Power of Influence: Leveraging Twitter and Social Media in Fashion Marketing"
Topic 5:	16	[‘entrepreneurship’,‘fintech’,‘entrepreneurial’,‘adoption’,‘education’,‘levy’,‘personality’,‘digital’,‘technology’,‘entrepreneurs’]	"The Digital Entrepreneur: Navigating Fintech Adoption and Education in the Age of Technology"
Topic 6:	13	[‘green’,‘social’,‘rgi’,‘goi’,‘smes’,‘environmental’,‘media’,‘innovation’,‘usage’,‘sustainable’]	"Promoting Green Innovation and Sustainable Practices in Social Media for SMEs"
Topic 7:	11	['hospital’,‘healthcare’,‘nursing’,‘health’,‘patient’,‘care’,‘technology’,‘nurse’,‘performance’,‘adoption’]	"Revolutionizing Healthcare: The Impact of Technology on Nursing Performance and Patient Care Adoption"
Topic 8:	10	[‘women’,‘female’,‘gender’,‘entrepreneurs’,‘entrepreneurship’,‘tech’,‘careers’,‘email’,‘gendered’,‘publicly’]	"Breaking Barriers: Women in Tech Entrepreneurship and Gendered Careers"
Topic 9:	6	[‘brand’,‘branding’,‘political’,‘thought’,‘media’,‘analogy’,‘control’,‘school’,‘co’,‘social’]	"The Power of Branding: Political Thought and Media Control in the School of Social Co"
Topic 10:	5	[‘blockchain’,‘cold’,‘technology’,‘manufacturing’,‘supply’,‘chain’,‘q4’,‘nfts’,‘scr’,‘implementing’]	"Revolutionizing Manufacturing: Cold Chain Technology and Blockchain Implementation in Q4
Topic 11:	4	[‘average’,‘cios’,‘analytics’,‘cybersecurity’,‘top’,‘spending’,‘cdos’,‘reported’,‘cloud’,‘archetypes’]	"The Evolving Landscape of IT Leadership: Analyzing Cybersecurity Spending and Cloud Analytics Trends Among Top CIOs and CDOs"
Topic 12:	2	[‘pop’,‘publishers’,‘entertainment’,‘market’,‘newspaper’,‘pioneering’,‘business’,‘cost’,‘stage’,‘changing’]	"The Evolution of Pop Publishing: Navigating the Changing Entertainment Market"
Topic 13:	2	[‘platform’,‘overthrow’,‘network’,‘platforms’,‘performances’,‘moving’,‘works’,‘attempt’,‘leader’,‘cases’]	"The Power of Platforms: Overthrowing Networks and Leading Performances"

Table 3. Topic - Terms Determined by BERTopic-II and Thematic Headings Created by GEN AI (Continue)

Topic No	Count	Terms Relating to Topics Determined by Bert	Thematic Titles of Topics Determined by Bert Using Generative Artificial Intelligence
Topic 14:	2	[‘skills’,‘employability’,‘graduates’,‘industry’,‘communication’,‘media’,‘fourth’,‘revolution’,‘preparing’,‘industrial’]	"Empowering Graduates: Navigating the Fourth Industrial Revolution through Industry-Relevant Skills and Effective Communication in Media"
Topic 15:	2	[‘attendance’,’marketing’,’differentiation’,’advantage’,’uet’,’r2’,’shows’,’competitive’,’traffic’,’combined’]	"Maximizing Competitive Advantage: Leveraging Attendance, Marketing, and Differentiation Strategies at UET R2 Shows"
Topic 16:	2	[‘unethical’,‘ethical’,‘challenges’,‘professionals’,‘ethics’,‘various’,‘organization’,‘behavior’,‘workplace’,‘conduct’]	" Navigating Ethical Challenges: Professional Conduct in the Workplace "
Topic 17:	2	[‘tourism’,‘models’,‘bmi’,‘rtda’,‘fluid’,‘dt’,‘ecosystem’,‘innovative’,‘business’,‘opportunities’’]	"Exploring Innovative Business Opportunities in Tourism Ecosystems: The Role of Models, BMI, RTDA, and Fluid DT"
Topic 18:	2	[‘humor’,‘ageism’,‘women’,‘talks’,‘speakers’,‘advertising’,‘status’,‘ted’,‘sooner’,‘stereotype’]	"Breaking Barriers: Challenging Ageism and Stereotypes through Humor and Empowerment in TED Talks"

4. Discussion and Implications

Recently, it has been observed that academic interest in understanding the phenomenon of digital leadership has increased (Eberl & Drews, 2021; Erhan et al., 2022; Hensellek, 2020; Malik et al., 2024). To meet this interest, some systematic literature review attempts (Berman et al., 2024; Gledson et al., 2024), qualitative research (Wahyuningsih & Asri, 2024), case studies (Khan & Sarkar, 2024), bibliometric analyses (Espina-Romero et al., 2023; Giovanni et al., 2024; Jameson et al., 2022) have been conducted. This study contributes to literature by examining the current status of the phenomenon of digital leadership in the literature. More specifically, it advances literature by presenting a new bibliometric method in the field of digital leadership and interpreting the results of a large sample in a holistic sense. The research provides several theoretical and managerial implications.

4.1. Theoretical Implications

Among the theoretical contributions of the research, it can be said that, firstly, the aspect of digital leadership that manages and organizes digital transformation processes has been identified in line with the results of the findings and expectations. This finding is consistent with the findings of previous studies that determined the effects of digital leadership on digital transformation (Brunner et al., 2021; Yao et al., 2024), but contradicts the findings of some other studies (Heubeck, 2023). This result can be interpreted as the need for some mediating variables in the effect of digital leadership on digital transformation. It can be concluded that the organizational transformation emphasized in Topic O should be carried out with innovation and analysis, and that the digital revolution can be achieved in this way. It can be interpreted as the need for a digital leader who encourages innovation to overcome the difficulties encountered in digital organizational transformation. This finding also coincides with the findings of studies in the literature stating that digital leaders are characterized by work environments that encourage resilience and where making mistakes is perceived as an experiment (Meier et al., 2017: 106).

Another finding draws attention to the role of the digital leader in innovation and relationship management in the age of information and technology. It has the potential to contribute to the field, especially in terms of establishing the relationship between digital leadership and the learning organization. This finding is consistent with the findings of previous studies examining the effects of the relationship between digital leadership and the learning organization on performance (Artüz & Bayraktar, 2021: 98; Karollah & Juned, 2023). It can be said that this result contains important findings and potential research areas, especially regarding the human resources practices of digital leaders. This finding is consistent with

the literature findings that emphasize the digital leader's "diplomatic aspect regarding human relations, inspiring, encouraging, persuading employees, and emphasizing the capacity to influence others" and motivational factors (Magesa & Jonathan, 2022: 782; Wahyuanto & Marwan, 2023: 2978). In addition, our study findings are consistent with the literature findings on the relationship between digital leadership and the well-being of managers (Zeike et al., 2019).

Another finding draws attention to quality factors while leading organizational transformation. It is seen that there is a finding related to the understanding of the services offered by digital leaders, especially in service businesses, by the customers (Desmaryani et al., 2022). At this point, the issue of quality is seen to reveal concepts such as e-loyalty, e-service quality, and e-satisfaction, and the findings of our study provide results consistent with the relevant literature (Kosasi et al., 2022; Purwanto, 2022).

Another finding is related to the fact that digital leadership changes and transforms traditional business management practices. This finding is consistent with the literature findings that digital leaders transform and change the organizational environments in which they operate (Promsri, 2019; Sainger, 2018). In addition, these results are consistent with the literature findings that claim that digital leaders accelerate organizational agility (AlNuaimi et al., 2022; Ly, 2024; Pandey et al., 2023). Our study findings are also consistent with the study findings that claim that digital leaders moderate the relationship between inter-team coordination, digital leadership ability, and innovation (Pandey et al., 2023: 7).

The results obtained in the study are consistent with most of the existing literature findings on the phenomenon of digital leadership. There are many studies in the literature that address the leader and followers, their impact, institutional goals, relationships, and change processes and approaches to digital leadership (Oberer & Erkollar, 2018; Sağbaş & Erdoğan, 2022: 26). Apart from these, there are approaches that focus on leadership roles (Magesa & Jonathan, 2022: 782-783), the characteristic features of the digital leader (Klein, 2020: 890-893), and many domestic and foreign literature that address the need for a digital leader to be data-driven, agile, and supportive (Büyükbeşe et al., 2022; Petry, 2018). The study findings are consistent with the literature that addresses the phenomenon from a competency perspective and the literature that evaluates digital leadership from a behavioral perspective (Lin, 2024; Munsamy et al., 2023; Oberer & Erkollar, 2018). The necessity of adding technological competence and social perspective to these classifications related to digital leadership can be deduced from the study findings. While competencies define the minimum knowledge, skills, and experience requirements for leaders to be able to perform digital tasks and focus on their ability, competencies are concepts related to how they bring together knowledge, skills, behaviors and attitudes in a holistic sense regarding digital tasks and how tasks are performed. A classification that considers social relations and intra-group dynamics regarding the phenomenon can develop new expansions.

As a result, this study has some new findings such as the integration of the digital leader with artificial intelligence and digital industry models, social media platforms, and the use of crowdfunding-like funding tools within the organization. In addition, China's growth in digitalization and its emphasis on managing generations and cultural influences advances the existing literature. In addition, our study findings contribute to the field by showing new phenomena such as algorithmic consumerism in terms of the marketing field, algorithmic resource use in the management field, green employee behavior, and sustainability (Shin et al., 2023), and the emphasis on ecological knowledge.

4.2. Managerial Implications

The findings of the study offer various practical suggestions and implications for organizations and their leaders. Firstly, it is aimed to draw attention to the importance of the role of digital leadership in guiding, facilitating, enabling employees and transforming the social and organizational structure in today's world where we experience digitalized business environments. This research provides a comprehensive literature summary of the digital leadership phenomenon. Moreover, this summary was carried out using one of the current research methods and artificial intelligence tools. The elements in this research findings offer many managerial implications. In the digitalized world, since the issue of organizational management has also

become digitalized, it has brought with it some problems originating from technology. It is necessary to cope with many individual, organizational, and technological elements that deeply affect the current situation of the workforce and the leader, such as technostress level, digital fatigue, zoom fatigue, automation, etc. This great dependence on technology requires some preventive, proactive and entrepreneurial decisions to be taken by this transformation in business environments. In the context of bringing young talents to the digital business environment and integrating experienced and older employees into the digital environment, new problems such as adaptation and training may be encountered. The digital leader must be ready and prepared for issues that may affect the organizational environment such as technological resistance and flexible working arrangements. In addition, the study findings provide valuable insights to leaders who want to create or integrate digital strategies in digital business environments. These insights can serve the skills of digital leaders to develop, manage, direct and implement their knowledge. The study findings can serve as a guide like an executive summary of the strategic success of digitalization in business ecosystems. They can guide leaders who want to develop their digital skills, business skills, leadership skills, and intra-team coordination skills related to transformation and adaptation. Most fundamentally, this research has suggestions for digital leaders and their organizations on issues such as creating sustainable competition, encouraging and directing innovation, coordinating processes related to digital transformation, and creating effective and accurate communication channels.

4.3. Research Limitations

This study has some strengths and weaknesses that should be noted, and some limitations due to the structure of the study. This study was conducted with cross-sectional data, and there is no claim that it covers the entire field. An analysis was made of articles in the literature between the years 2014-2024. In this respect, the most fundamental limitation of the study is that it is cross-sectional. Being a bibliometric study, the lack of quantitative research that would reflect the causal relationship regarding digital leadership studies can be counted among other research limitations. The content of the selected article and thesis abstracts and the use of only article abstracts can be expressed as another research limitation.

4.4. Future Directions of Digital Leadership Studies

Future research can shed light on studies on research topics obtained within the findings to strengthen in-depth quantitative analysis. Depending on the objectives of the study, the effects of the digital leadership phenomenon can be addressed at different levels of analysis. The topic modeling approach can be the subject of other bibliometric studies using different metrics. A meta-analysis can be conducted on different digital leadership studies. As a future research agenda, the status of digital leadership in different sectors can be examined, comparative analyses can be made, and various studies can be conducted in different work environments. A study aimed at determining the strategic priorities of digital leaders can provide valuable contributions. A comprehensive assessment can be made of the effectiveness and efficiency of digital leadership trainings. The effects of digital leadership on employees in different age groups can be measured. Research on the effects of these leaders on employees in different age groups in catching up with technological trends and activating their innovation capacities can be suggested for future studies. Initiatives targeting the research gap, especially in countries and sectors experiencing the early stages of digitalization, can be focused on by considering the calls for the importance of context (Avolio et al., 2014). Considering the findings of our study, in which we addressed the phenomenon of digital leadership in a holistic sense, it can be stated that the outputs in the form of research titles expressed in the subjects have potential for future research. An evaluation can be made in the context of the antecedents affecting digital leadership and the successors affected by digital leadership with the study findings.

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