Bibliometric Analysis of Publications on Digital Innovation and Sustainability

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ABSTRACT

The main purpose of this study is to conduct bibliometric analysis through visual mapping of publications in digital innovation and sustainability indexed in Web of Science and SCOPUS databases. The bibliometric method was preferred to map the changes in publications in the field in a certain period. The VOSviewer and BibExcel software were used for network maps of the trend of publications during the examined period. The study analyzed 670 articles published in 168 journals to reveal the state of the intellectual structure and emerging trends in the field. For this purpose, co-word, citation, co-citation, author, and country productivity were analyzed. In the examined period, Germany had the most digital innovation and sustainability publications, and Romania had the fewest publications. The co-word analysis identified a thematic relationship among the frequently co-occurring keywords "value, digital talent, and business models". In addition, it has been determined that Vinit Parida is the most published author, and Youngjin Yoo is the most cited author. It was determined that publications started to increase in 2017 and increased rapidly, especially after 2019. It can be argued that the search for innovative applications, forced by the pandemic conditions, effectively increased the number of publications after 2019.

Key Words: *Digital Innovation, Sustainability, Bibliometric Analysis*

JEL Classification: *O32, Q55, Q56*

Dijital İnovasyon ve Sürdürülebilirlik Konulu Yayınların Bibliyometrik Analizi

ÖZ

Bu çalışmanın temel amacı Web of Science ve SCOPUS veritabanlarında indekslenen dijital inovasyon ve sürdürülebilirlik alanındaki yayınların görsel haritalaması yoluyla bibliyometrik analiz yapmaktır. Belirli bir dönemde alandaki yayınlardaki değişimlerin haritalandırılmasında bibliyometrik yöntem tercih edilmiştir. İncelenen dönemdeki yayın trendinin ağ haritaları için VOSviewer ve BibExcel yazılımı kullanıldı. Çalışmada 168 dergide yayımlanan 670 makale analiz edilerek alandaki entelektüel yapının durumu ve ortaya çıkan eğilimler ortaya çıkarıldı. Bu amaçla ortak kelime, alıntı, ortak alıntı, yazar ve ülke verimliliği analiz edilmiştir. İncelenen dönemde en fazla dijital inovasyon ve sürdürülebilirlik yayınına Almanya, en az yayına ise Romanya sahip oldu. Ortak kelime analizi, sıklıkla birlikte ortaya çıkan "değer, dijital yetenek ve iş modelleri" anahtar kelimeleri arasında tematik bir ilişki tespit etti. Ayrıca en çok kitap yayınlayan yazarın Vinit Parida, en çok alıntı yapılan yazarın ise Youngjin Yoo olduğu belirlenmiştir. Yayınların 2017 yılında artmaya başladığı ve özellikle 2019 sonrasında yayın artış hızının ivme kazandığı tespit edilmiştir. Pandemi koşullarının zorladığı yenilikçi uygulama arayışlarının 2019 sonrasında etkili bir şekilde yayın sayısını artırdığı ileri sürülebilir.

Anahtar Kelimeler: *Dijital İnovasyon, Sürdürülebilirlik, Bibliyometrik Analiz*

JEL Sınıflandırması: *O32, Q55, Q56*

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INTRODUCTION

The importance of digital technologies in the survival and sustainability of businesses in a destructive competitive environment is increasing day by day. Businesses benefit from digital technology in decision processes, production processes, different product designs, providing high-quality products and services, and saving time and cost. This situation increases the ability of companies to make digital innovations. Businesses' adoption of digital innovation strategies necessitates significant changes in their organizational structures, product development logic, and digital environment analysis (Hogan et al., 2011). For this reason, digital innovation is seen as the most reliable tool for the sustainability of all institutions and organizations (Brynjolfsson and McAfee 2014). There have been significant publications in the literature on digital innovation and sustainability, but it is seen that bibliometric studies that allow seeing the course of these publications in the period under review have not been conducted. This research is thought to be important in terms of filling this gap in the literature.

In a process where digital technologies are an essential tool for doing business, sustainability needs to be supported by digital innovations (Cillo et al., 2019; Cobo et al., 2011). The analysis of large data pools, visual mapping and bibliometric research makes it possible to view the relevant literature as a whole. Thanks to bibliometric studies, it is possible to summarize a particular research area. Environmental and climate-oriented problems, which have gained more importance with the pandemic, increase the importance of sustainability. Water crisis, environmental pollution, depleted water and energy resources are becoming increasingly important for the future of humanity. International organizations also accept that one of the most effective ways of ensuring sustainability is digital innovation (UNDP, 2021). Accenture's (2021) research focuses on the necessity of considering digital innovation and sustainability together. According to Accenture's 2021 Technology Vision report, the use of cloud computing technologies in business processes reduces carbon emissions by 84%. This shows the importance of digital innovation in sustainability in business and management processes.

This research conducts a bibliometric analysis of publications on digital innovation and sustainability through visual mapping. The research determines the productivity of research components (authors, journals, countries, institutions, etc.) in the field of digital innovation and sustainability, emerging trends in the field and the current intellectual structure. The findings obtained from bibliometric studies are important in determining how the related discipline has developed, revealing the problems or deficiencies and guiding the studies (Şakar and Cerit, 2013). The basic question of this research was determined as “how did the publications on digital innovation and sustainability follow in the period under review? Additionally, the research answers the following sub-questions:

1) What is the overall perspective presented in the literature regarding digital innovation and sustainability during the reviewed period?

2) What are the most discussed research topics in the field?

3) Which journals, authors and countries stand out on digital innovation and sustainability in the period under review?

4) How are the journals and citations distributed according to Bradford's Law?

I. CONCEPTUAL FRAMEWORK

A. Digital Innovation and Sustainability

Innovation refers to the implementation of a novel or substantially improved product, good, service, process, or marketing method. It involves the conversion of creative ideas into outputs that generate value. The use of digital technologies in the innovation process is called "digital innovation." Digital innovation requires the execution of technological processes and applications in the digital environment, the infrastructure being suitable for digital transformation and the dissemination of digital experiences (Nambisan et al., 2017; Yoo et al., 2010). It is expected that the most important benefit of digital transformation will be to increase the sustainability capabilities of companies.

Sustainability holds significant importance both economically and in terms of climate and environmental preservation, particularly in highly competitive environments. The development of innovative products that prioritize environmental considerations plays a crucial role in addressing economic and ecological crises (Melane-Lavado et al., 2018). In light of this, the relationship between innovation and sustainability is often encapsulated by the concept of "sustainable innovation." The literature explores the interconnectedness of innovation and sustainability, emphasizing their joint significance (Maier et al., 2020). The entrepreneurial abilities of companies are of great importance in the development of new products and processes in sustainable companies. Bringing the employees together on online platforms to reveal the said talent is important in generating creative ideas (Veloso et al., 2020). In the current business landscape, there is a growing preference for sustainable innovations, as they possess substantial potential to drive technological advancements, transform products, and reshape markets.

Digital innovation and sustainability play a critical role in contexts where scarce resources are at stake. The imperative of resource replenishment is fundamental for achieving sustainability within a competitive market (Mauri-Castello et al., 2019). Furthermore, alongside financial and economic considerations, the competence of human resources holds significant importance in ensuring the sustainability of companies. Developments in global job markets, increasing risk factors, intensive work programs increase the importance of sustainability. This process also gives rise to diverse "digital workspaces" that exist outside traditional organizational structures. Digital innovations in all these areas are critical success factors for organizations to achieve a sustainable competitive advantage.

B. Bibliometric Method

Synthesizing past research findings is an essential task in expanding a research field's scope. Academics use two traditional methods to make sense of

previous findings: systematic literature review (qualitative approach) and meta-analysis (quantitative approach). The significant expansion of the volume of scientific research in recent years makes it difficult for researchers to follow the relevant literature in their field. This challenge requires using methods that reveal the richness of data, predict and filter the effects of essential studies, and discover the basic structure of a scientific field (Zupic and Cater, 2015). This necessity has accelerated the emergence of the bibliometric method, a third method that is increasingly used and maps the development of scientific fields with a quantitative approach (Cobo et al., 2011). The cumulative nature of scientific knowledge reflects the evolutionary nuances in the scientific field (Donthu et al., 2021). The bibliometric method contributes to theoretical progress by allowing the capture and visual mapping of evolutionary nuances on temporal and spatial dimensions (Palmatier et al., 2018).

The bibliometric method is used for different reasons, such as exploring article and journal performance, collaboration patterns, trends in research components, and the intellectual structure of a scientific field. The popularity of the bibliometric method in interdisciplinary research stems from its benefits in processing large volumes of scientific data and creating high research impact (Donthu, 2021). The data at the heart of bibliometric analysis is extensive and objective. However, their interpretations are often based on objective (e.g., performance analysis) and subjective (e.g., thematic analysis) evaluations. Bibliometric analysis is helpful for deciphering cumulative scientific knowledge and evolutionary nuances in the field by rigorously making sense of large volumes of unstructured data. Bibliometric analysis provides an overview of the field by looking at it from a single point, identifying knowledge gaps in the field, and positioning contributions to the field (Öztürk, 2021). Bibliometric methods also reveal informal research networks and patterns in the literature (Zupic and Cater, 2015), such as "invisible theoretical perspectives" that lie below the surface but are not formally linked (Vogel, 2012).

Citations are the most objective and simple measure of the impact of publications in a research field. Citation analysis is a science mapping technique that assumes that citations reflect intellectual connections between publications and are formed when one publication cites another. In this analysis, the impact of a publication is determined by the number of citations it receives. This determination gives researchers insight into the intellectual dynamics of the scientific field examined (Donthu et al., 2021). Co-citation analysis is a science mapping technique that assumes that publications that are frequently cited together are thematically similar. In a co-citation network, two publications are linked when they appear together in another publication's reference list. Analysis can be used to reveal the intellectual structure, such as the underlying themes of a research field (Öztürk, 2021; Donthu et al., 2021). Another science mapping technique is co-word analysis. While citation analysis and co-citation analysis focus on publications, the unit of analysis of co-word analysis is words. Co-word analysis is a technique that examines the actual content of the publication. Words in the co-word analysis are

generally obtained from author keywords from article titles and abstracts. In co-word analysis, words that frequently appear together are assumed to have a thematic relationship (Eck, 2009).

One of the basic bibliometric laws that shows the productivity of journals and how relevant literature is distributed in journals is Bradford's Law of Distribution (Batra et al., 2023). This law assumes that there is always a small core group of journals that cover a significant percentage (one-third) of the articles in a research field. A second, more numerous groups of journals contains another third of the articles in that field. However, a group containing a much larger journals covers the remaining third of the studies in that field (Echchakoui, 2020). This indicates that a small number of journals in a particular field cover a significant portion of the total articles in the field. With such an approach, it is possible to separate the set of journals in a research field according to the content of the studies published in these journals. Accordingly, scientific journals can be evaluated in three groups according to the content of the studies they publish: journals directly related to the relevant research field, journals closely related to the field, and journals distantly related to the field (Zupic and Cater, 2015).

In this research, Web of Science (WoS) and Scopus databases were used together. Comparisons between WoS and Scopus reveal some of the advantages or uniquenesses of WoS. WoS provides a wider range of years than Scopus (Goodman and Deis, 2007). However, in WoS, the scope of English journals in Western languages is broader (Archambault et al., 2006). WoS offers a variety of information across many different disciplines (Chirici, 2012). Zyoud et al. (2017) state that WoS contains the most reliable and highly effective scientific studies with these aspects. On the other hand, the most significant advantage of Scopus is that it has a broader publication scope (Karasözen et al., 2011). For example, Mingers and Lipitakis (2010) argue that WoS includes publications in management and business literature in a narrower scope, while Goodman and Deis (2007) state that Scopus offers a superior journal selection. The scope of non-English publications in Scopus is wider than in WoS. For this reason, the number of publications from developing countries is higher than WoS (Echchakoui, 2020). Although each database has many uniquenesses and advantages, there is also a high degree of correlation between them (Archambault et al., 2009). For example, Gavel and Iselid (2008) suggest that WoS covers 54% of Scopus' journal titles, while Scopus covers 84% of WoS's titles. Comparisons between WoS and Scopus regarding the conduct of bibliometric analyses do not indicate the superiority of one over the other (Caputo and Kargina, 2022). Due to their correlation and complementary nature, data from both databases were combined and used in this research.

II. METHOD

A. Research Design

The bibliometric method is used to reveal trends in article and journal performance, collaboration models and research components and to explore the intellectual structure of a particular field in the literature (Donthu et al., 2021). Bibliometric analysis is a method employed to examine various parameters of

scholarly articles, including publication year, authorship, affiliated institution, country of origin, keywords, study titles, and citation counts (Zupic and Cater, 2015; Yılmaz, 2017; Oztürk, 2021). Distinct from literature reviews, the bibliometric method emphasizes the evaluation of the overall structure of a specific research domain, providing insights into the evolving trends exhibited by publications within the defined timeframe. Bibliometric method was preferred because it is a method that is suitable for seeing the development of a discipline in a certain period, conceptual structures, research results in the discipline, and determining the role of researchers and institutions. Another technique used in bibliometric research is visual mapping. This technique describes how a particular field of research is structured intellectually, socially and conceptually. Bibliometric maps, which provide a visual presentation of bibliometric data, enable performance measurements and see the sub-areas in the literature and their relations with each and mutual interaction (Cobo et al., 2011). In this study, VOSviewer and BibExcel softwares were used to visualize the dataset as it offers advanced and valid techniques in the science mapping process.

B. Analysis of Data

In the study, a bibliometric analysis was carried out by conceptual analysis of 670 articles identified according to the exclusion and inclusion criteria from 1245 articles on digital innovation and sustainability, and by extracting the links between concepts through visual mapping. For this purpose, analyses such as co-citation analysis, bibliographic coupling, co-authorship and co-word analysis were conducted. Bibliometric analyzes are done through performance analysis and scientific mapping. While performance analysis deals with the research output in any scientific field, scientific mapping examines the relationship between various aspects of a research effort. This study uses both tools to analyze digital innovation and sustainability comprehensively. In the first step, a performance analysis was conducted based on the Web of Science and Scopus database data, providing a descriptive overview of the field of digital innovation and sustainability. In the second step, scientific mapping was conducted with three different analyses: co-word analysis, citation and co-citation analysis.

In the data analysis process, the number of articles in which the key concepts of digital innovation and sustainability are mentioned, the countries that use these concepts the most, the researchers who publish on the subject and the most cited publications from these publications were analyzed. The publications' distribution produced by years and the number of citations the institutions that contributed to these publications and prominent researchers were determined. In the study, 670 articles indexed as SSCI (Social Sciences Citation Index), Science Citation Index Expanded (SCI-E), A&HCI (Arts and Humanities Citation Index) and ESCI (Emerging Social Citation Index) in Web of Science (WoS) and SCOPUS databases were analyzed. VOSviewer software and its clustering-based network inference algorithm were used in the analysis (Waltman et al., 2010; Eck and Waltman, 2009).

C. Process

In order to provide an objective assessment of the scientific output in the digital innovation and sustainability literature and to identify publications, authors and journals that have a greater impact on the field, a systematic literature review was first conducted. The literature review process identified relevant articles, the database used and search terms/keywords. In the next step, criteria for inclusion/exclusion of articles were identified. Next, studies on digital innovation and sustainability were selected, followed by the bibliographic database that formed the basis of the research. To provide comprehensive research content, articles published in the WoS and SCOPUS databases between 2002 and 2021 were used. The number of articles in SSCI, SCI-E, A&HCI and ESCI are 281, 61, 2, and 197 respectively. In the pre-selection of relevant articles for the bibliographic search, a search query was created with various terms and synonyms for "sustainability" and "digital innovation". In VOSviewer network visualizations, items are represented by circles and labels. The higher the weight of the element, the larger the circle and label. Connections between items are visualized with lines (Lu et al., 2012).

Table 1. Search Terms and Databases

	Bibliographic Databases		
Keywords	WoS	SCOPUS	Merged
"digital innovation" OR "digitalization" OR "digital transformation" AND "Sustainability"	541	704	687

Publications were searched in relevant databases using the keywords shown in Table 1. A topic search was conducted covering a wide range of terminology related to the research areas of "Sustainability" and "Digital Innovation". Relevant keywords listed in Table 1 were searched within the title, abstract and author keywords. In the filtering process, research and review articles published in English in the field of business and management were selected as inclusion criteria. Document type was used as exclusion criteria. Documents such as books, book chapters, and proceedings were excluded from the analysis.

Only research and review articles published in journals were included because they were peer-reviewed, reviewed by other scientific experts in the same field, and offered greater assurance of rigor than other types of documents. Conference proceedings are excluded because they are not peer-reviewed and are included in the gray literature. Moreover, book chapters lacking empirical information and articles with insufficient scientific rigor were excluded from the analysis. Articles that did not include the concepts of digital innovation, digitalization, digital transformation and sustainability in the title, abstract or keywords were excluded. Duplicate articles in WoS and SCOPUS (112 articles) were then excluded. After applying the initial filters, the remaining articles underwent an additional round of screening to ensure their relevance to the subjects of sustainability and digital innovation. The titles, abstracts and keywords of a total of 687 articles were manually assessed. During this stage, 17 articles were excluded

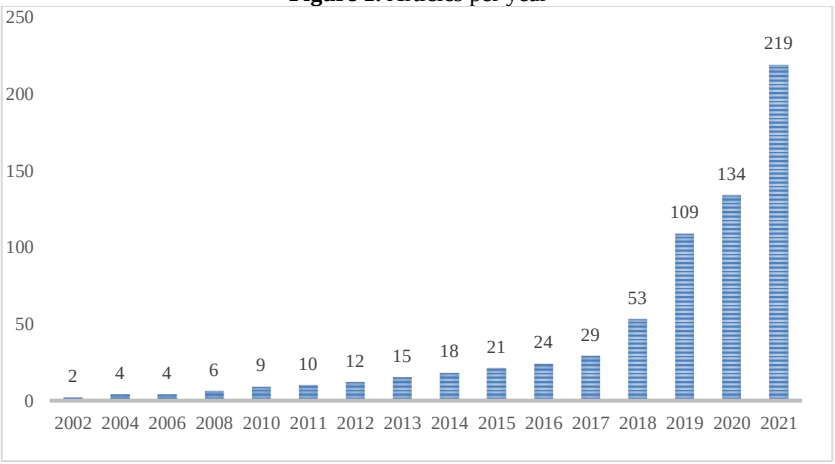
as they did not align with the research scope, while 670 articles were retained for further analysis. The contributions of the research components to the field were examined and 670 articles were presented from an explanatory perspective based on certain bibliometric indicators.

III. FINDINGS

A. Article Types and Numbers

Findings obtained after applying the principles of inclusion, most of the 670 articles (323, 94%) were research articles, and 40 (6%) were review articles. These numbers show that researchers concentrate on empirical studies. As shown in Figure 1 below, while the number of researchers between 2002 and 2016 followed a stable upward trend, the field's studies increased after 2017. 145 (21%) of the 670 studies included in the analysis in 14 years from 2002 to 2016 belong to this period. The remaining 525 studies (79%) emerged over four years.

Figure 1. Articles per year



Notes: N = 670 articles. Source: Own elaboration

B. Findings by Journals

The journals in which seven or more articles are published in digital innovation and sustainability, the impact factors of the journals in 2020 and their total citations are shown in Table 2. Out of the 670 articles analyzed, it was found that 351 (52%) were published in the 25 journals listed in Table 2. Technological Forecasting and Social Change are the most productive journal with 57 articles. This journal is followed by "Journal of Business Research" with 40 articles and "MIS Quarterly" with 18 articles. The first three journals account for 17% of the total articles. The average impact factor of the 25 journals listed in Table 2 is 5.96. The impact factor serves as a measure of the number of citations received by articles published in a journal, thereby indicating the journal's quality and influence. It is noteworthy that all journals included in Table 2 exhibit relatively high impact factor values. Publications on digital innovation and sustainability were published in journals with high impact factors. The average impact factor is 5.96. The top three journals publishing 115 out of 670 articles have an above-average impact factor.

Table 2. Most Relevant Sources in Digital Innovation and Sustainability

Sources	Database	Number of articles	Impact factor	Total citations
Technological Forecasting and Social Change	Common	57	8.59	752
Journal of Business Research	Common	40	7.55	938
MIS Quarterly	Common	18	7,19	2120
Industrial Marketing Management	Common	17	6.96	399
Journal of Business & Industrial Marketing	Common	17	3.46	107
Journal of Manufacturing Technology Management	Scopus	15	7.54	203
Electronic Markets	Common	13	4.76	101
European Journal of Innovation Management	Scopus	13	4.69	97
Information & Management	Scopus	12	7.55	154
Journal of Strategic Information Systems	Common	12	11.02	453
Organization Science	Common	12	5.00	1141
Information and Organization	WoS	11	6.30	278
Innovation-Organization & Management	Common	11	2.37	51
Research Policy	Scopus	11	8.11	375
International Jour. of Ent. Behavior & Research	WoS	10	4.41	158
Journal of Information Technology	Scopus	10	5.82	554
Technology Analysis & Strategic Management	Common	10	2.87	78
Research-Technology Management	Common	9	3.39	330
Business Strategy and The Environment	Common	8	10.30	9
Journal of Product Innovation Management	Common	8	6.98	59
Journal of Retailing and Consumer Services	WoS	8	7.13	166
Technovation	Common	8	6.60	74
Business Horizons	Scopus	7	6.36	268
Electronic Commerce Research and Applications	Common	7	6.01	65
Journal of Enterprise Information Management	Common	7	5.39	29

Note: The citation counts for the journals were determined using VOSviewer software.

As shown in Table 2, Technological Forecasting and Social Change is the journal that publishes the most (57 articles) on the key concepts researched. The journal's impact factor is also 8.59, and the relevant articles received 752 citations. The Journal of Business Research published 40 articles in the period under review, and the impact factor of the journal is 7.55. The total number of citations to articles published within the scope of the research in the period examined in the journal is 938. 18 articles were published in the period examined in the MIS Quarterly, and the journal's impact factor was 7.19. During this period, articles published on the research topic received 2120 citations. Organization Science is the journal that received the most citations from the articles published on digital innovation and sustainability in the period under review. The journal has published 12 articles on digital innovation and sustainability in this process. A total of 1141 citations were made to the articles published in the journal on the research topic. Among the journals analyzed, the Journal of Enterprise Information Management had the lowest number of publications within the reviewed period. Only seven articles were published in the journal between 2002-2021.

Upon a detailed examination of the aims and scopes of the journals with the highest concentration of studies, it becomes evident that those journals predominantly prioritize the acceptance of empirical articles. Another notable finding is that among the 25 most productive journals, the Journal of Product Innovation Management stands out as the only journal focused specifically on innovation, despite its relatively smaller number of publications.

C. Findings According to The Authors

A total of 1689 authors contributed to 670 articles constituting the sample. While the authors of single-author documents are 67, multi-author documents are 1622. Table 3 displays authors who involved in more than three articles. Notably, Parida emerges as the most prolific author, having contributed a total of 24 articles. These articles have garnered significant attention, with a cumulative citation count of 719. This score shows that Parida is the most cited author. The most cited article of Parida's 24 articles is Digitalization capabilities as enablers of value co-creation in service firms (2016). Parida's article, which highlights the importance of digital capabilities in stakeholder interaction and value creation within the realms of digital innovation and sustainability, holds substantial potential to advance the field. Furthermore, it was discovered that the most highly cited researcher, with a remarkable citation count of 1719, is Yoo, Y.

Table 3. The most prolific authors

Authors	No of articles	Total citations
Parida, V.	24	719
Dong, J. Q.	11	237
Sjodin, D.	9	111
Wincent, J.	9	375
Kraus, S.	8	217
Nambisan, S.	8	1320
Henfridsson O.	7	1021
Kohtamaki M.	7	224
Lyytinen K.	7	1642
Yoo Y.	6	1719
Gebauer H.	5	192
Holmstrom J.	5	221
Berente N.	4	179
Bouncken R.B.	4	67
Caputo A.	4	55
Hagberg J.	4	195
Kowalkowski C.	4	195
Vom Brocke J.	4	178

Note: The Table 3 includes authors who involved in more than three articles

Considering single or multiple author status it was determined that 67 of the articles had a single author. A significant proportion of these articles, specifically 96%, were authored by multiple individuals, indicating a strong inclination towards collaborative work among authors in the field.

D. Findings by Universities

818 of the 670 articles examined were produced by researchers working at different universities. Only one study received contributions from researchers at 502 of these universities. Table 4 presents the universities that have displayed high productivity in the field of digital innovation and sustainability, contributing five or more articles based on the number of publications. In Table 4, it is seen that the universities that contribute the most to the field are in Northern European countries such as Sweden, Finland and Denmark. The Luleå University of Technology is the university that contributes the most to the field, with 29 articles that have received 720 citations.

Table 4. Most productive universities

Affiliations	No of articles	Total citations
Luleå University of Technology	29	720
University of Vaasa	29	670
Copenhagen Business School	21	272
University of St. Gallen	21	550
Chalmers University of Technology	16	205
Case Western Reserve University	15	2120
Hanken School of Economics	14	380
University of Bayreuth	12	116
University of Gothenburg	12	443
University of Groningen	12	275
University of Oulu	12	71
University of Southeastern Norway	12	207
Stockholm School of Economics	11	113
University of Liechtenstein	11	178
Aalto University	10	180
City, University of London	10	232
Linkoping University	9	386
University of Warwick	9	375
Aarhus University	8	14
Georgia State University	8	273

Note: The table includes universities that have made significant contributions to research with more than five articles

E. Findings about Countries

The research comprises 670 studies authored by researchers from 50 different countries. Table 5 exhibits the countries that have demonstrated significant productivity in contributing to digital innovation and sustainability, based on the number of articles and total citations. The table specifically presents the major countries that have contributed six or more articles to the field. Notably, Germany leads with 85 articles, followed closely by the United States of America with 79 articles, and Sweden with 62 articles. England and Italy also exhibit notable contributions with 60 and 50 articles, respectively. Collectively, researchers from

these top five countries in Table 5 have produced 336 articles, accounting for 50.14% of the total 670 articles.

Table 5. Most productive countries

Country	Number of articles	Single Country Publications	Multiple Country Publications
Germany	85	55	30
USA	79	50	29
Sweden	62	41	21
United Kingdom	60	27	33
Italy	50	29	21
Finland	41	22	19
China	29	18	11
Netherlands	27	17	10
France	25	9	16
Spain	25	13	12
Denmark	23	12	11
Norway	22	14	8
Australia	16	6	10
Switzerland	15	8	7
India	11	6	5
Austrıa	8	3	5
Brazil	8	4	4
Canada	8	5	3
Singapore	7	2	5
Romania	6	5	1

Note: The table includes countries that have made substantial contributions to the field with six or more articles.

IV. SCIENCE MAPPING

In this section, the interactions and structural connections between the components of digital innovation and sustainability research are assessed. The objective is to identify the most frequently used keywords in the studies, known as the most studied subtopics, as well as the most cited studies. Additionally, this analysis aims to uncover the networks of studies and journals within the field. For this reason, three different bibliometric methods were used in this section: co-word analysis, citation analysis and co-citation analysis. In bibliometric studies, analysis (classification) and visualization processes are generally used. Throughout the analysis, similarity matrices were computed and relationships between various items such as articles, authors, journals, and keywords were examined. Researchers often employ software tools like Pajek, BibExcel, SciMat, and VOSviewer to conduct these analyses. For this particular study, BibExcel and VOSviewer were utilized as bibliometric software tools.

A. Co-word analysis

In co-word analysis, the unit of analysis is words, and in co-word analysis, title, abstract and keywords, concepts and the relationships between them are examined in research (Ronda et al., 2012). Co-word analysis aims to find two

keywords together in different articles and show the connection between those words. It is aimed to reveal trends in the field by determining the strength of the relationship between words through co-word analysis. Co-word analysis can be performed by utilizing the titles, keywords, or abstracts of documents as the foundation for analysis. Instead of titles and abstracts, we chose to analyze by keywords because keywords fully reflect the content of a study. In order to determine the most studied concepts and sub-topics (digitalization, digital transformation) in the field of digital innovation and sustainability, we made the analysis based on the keywords of the articles.

BibExcel and VoSviewer programs were used to analyze co-words. The BibExcel software was utilized to identify the keywords that were most commonly used in the articles. The data was downloaded and saved as plain text. were downloaded and saved as plain text. To facilitate analysis in BibExcel, the downloaded *.txt file had to be restructured. As a result, the file was converted to a different file format suitable for various bibliometric analyses. This conversion allowed for efficient processing and utilization of the data within BibExcel and other bibliometric software tools. Co-occurrence analysis of keywords was performed using BibExcel. It was determined that 1320 different keywords were used in 670 articles. The minimum threshold in BibExcel is set to five views. In total, 224 of 1320 keywords appear at least five times in the dataset consisting of 670 articles. Subsequently, the data was transferred to VOSviewer, a powerful bibliometric analysis and visualization tool. Using the network data, a map was generated in VOSviewer. In this analysis, a minimum threshold of 50 was set for the total link strength of a keyword. Out of the 224 keywords, 117 keywords met this threshold and were included in the analysis and visualization process.

Figure 2. Most frequently used keywords in the digital innovation and sustainability field

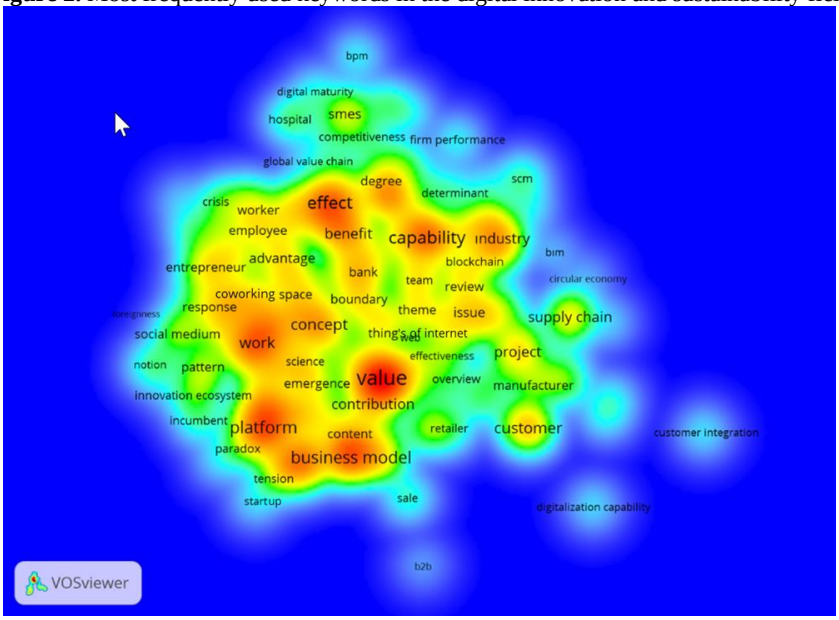
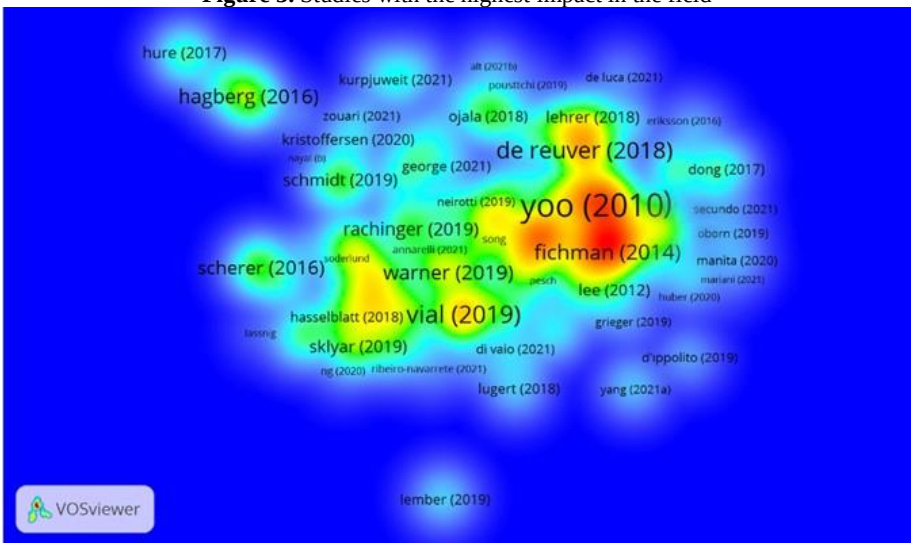


Figure 2 illustrates the frequency of usage for the keywords among the 670 articles. In the figure, the red areas represent the most frequently used words, while the yellow areas indicate less frequent usage. The green and blue areas represent the least used words. The size of the letters within the figure corresponds to the frequency of each keyword's usage. Among the keywords, the most frequently used one is "value" with 261 repetitions. Following that, "talent" appears 156 times, "business model" is mentioned 125 times, and "platform" is used 80 times. These keywords signify the recurring themes and concepts within the analyzed articles. Other commonly used keywords include influence, benefit, business, and industry. It is understood that the sub-headings expressed here are central concepts in digital innovation and sustainability.

B. Citation Analysis

Citation analysis provides information about the impact of the studies and is based on the fact that the studies produced by the authors are cited by other researchers (Tavares-Lehmann and Varum, 2021; Ejsmont et al., 2020). This analysis acknowledges the existence of a positive correlation between the number of citations and the impact of the cited work. It enables the identification of highly cited (or influential) studies, authors, or journals within field (Öztürk, 2021). Consequently, citation analysis offers insights into the relative influence of studies in a specific research area and their significance.

Figure 3. Studies with the highest impact in the field



To be included in the citation analysis, a study must have a minimum of 20 citations, which requires that each of the 670 articles be cited at least 20 times. The 105 articles cited here meet this criterion. Figure 3 shows the most cited authors and publications for Web of Science citations. Accordingly, Yoo, Y.'s (2010) The new organizing logic of digital innovation: An agenda for information systems research is the most cited work in the field with 738 citations. However, Fichman's (2014) work titled "Digital innovation as a fundamental and powerful concept in

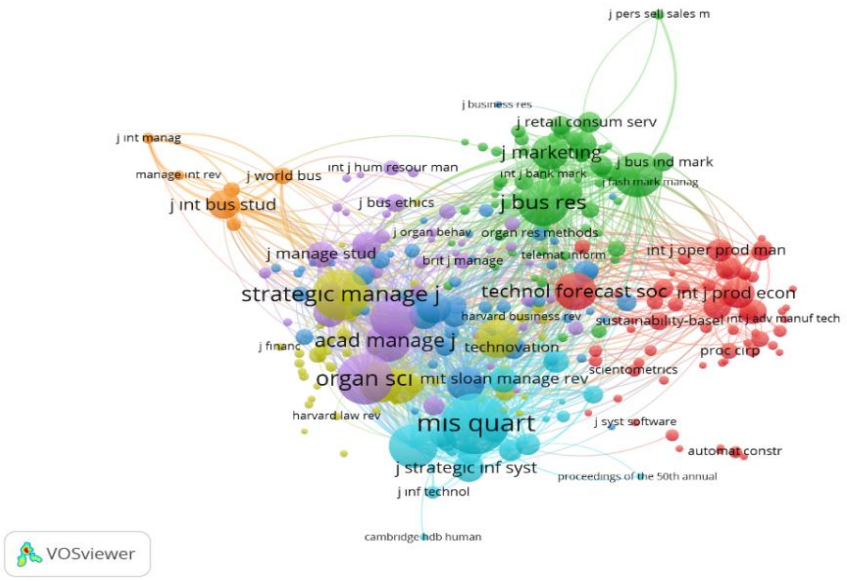
the information systems curriculum" is the second most cited author and work with 295 citations.

C. Co-citation Analysis

Co-citation analysis examines the frequency at which two studies are cited together or the frequency at which different units of analysis (such as studies, authors, or journals) are cited together within the same study (Zan, 2019). By utilizing co-citation numbers, this analysis establishes measures of similarity between studies, authors, and journals. Co-citation analysis enables the determination of the density of co-cited authors and studies, as well as the relationships among cited journals. Therefore, this analysis assumes that the more citations are made to two publications together, the higher the probability that the cited publications are related (Donthu et al., 2021). For this purpose, co-citation analysis was conducted at the journal level to determine the relationship.

To be considered in the analysis, a journal had to receive a minimum of 50 citations. Based on this criterion, a total of 128 journals met the threshold and were included. The journal-level co-citation analysis is depicted in Figure 4.

Figure 4. Co-citation analysis (journal-level)



The analysis results reveal that MIS Quarterly is the most frequently co-cited journal, with a total of 1629 co-citations. Additionally, other journals that garnered over 1000 citations include Strategic Management Journal (1142 co-citations) and Organization Science (1115 co-citations).

The most productive journals in the field of digital innovation and sustainability were evaluated for compliance with the Bradford Law. Bradford's Law, which operates on the principle of ranking journals based on their efficiency, helps identify the core journals in a particular subject area. According to this law, journals are categorized into three groups, each containing an equal number of

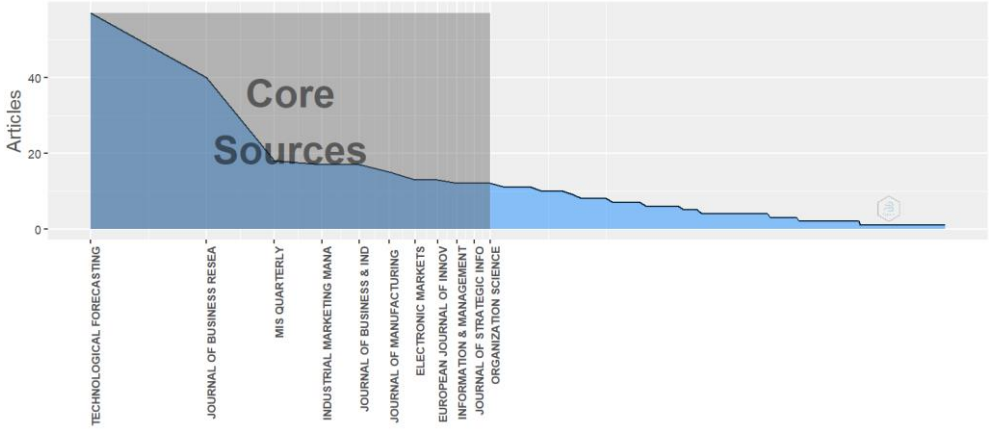
articles. The first group consists of a small number of journals, encompassing only 1/3 of the total articles. These journals are considered the core publications. The second group comprises a larger number of journals, publishing another 1/3 of all articles (Chen and Leimkuhleri, 1986). Finally, the third group includes a significantly greater number of journals and accounts for the remaining 1/3 of the articles. In this study, 226 articles were included in the analysis, 11 journals are core journals, and these are the journals falling into the first zone according to Bradford's law. The second region comprises 32 journals, whereas the third region encompasses 125 journals (Table 6).

Table 6. Distribution of journals according to Bradford's law

Zone	No of Journals	No of articles	Journal %
1	11	226	6,5
2	32	221	19
3	125	223	74,5
Total	168	670	100

The total number of citations in the articles included in the analysis is 13,263. 6465 of the total citations were made to the most referenced core journals in the first region (Figure 5). Of the 670 articles, most citations are made to a very small number of journals, such as Technological Forecasting and Social Change, Journal of Business Research, MIS Quarterly, and Organization Science.

Figure 5. Source clustering through Bradford's Law



The distribution of journals and citations aligns with Bradford's Law, indicating the presence of a core group of journals that can serve as a valuable reference point. Figure 5 highlights this core group of journals, which offer valuable insights for tracking developments and identifying gaps in the research on digital innovation and sustainability. By focusing on the core group of journals identified in Figure 5, researchers can gain essential clues about the current state of the literature in this field. These journals are likely to contain influential articles and provide a comprehensive overview of the advancements and areas that require further exploration in the realm of digital innovation and sustainability research.

Researchers can leverage these journals to stay informed about the latest trends, emerging concepts, and key research gaps.

DISCUSSION and CONCLUSION

The universe of this research consists of articles published on digital innovation and sustainability in WoS and SCOPUS databases between 2002-2021. In this study, according to the exclusion and inclusion criteria, 670 articles published in 168 journals in the relevant databases were analyzed. We performed concept analysis, visual mapping of connections between concepts, and bibliometric analysis in the research. In the research, we evaluated the concepts of digital innovation and sustainability as key concepts and "digitalization" and "digital transformation" as their subcomponents. The primary objective of this research is to examine the trajectory of publications regarding digital innovation and sustainability between the years 2002 and 2021. In addition, it aims to reveal the intellectual, social and conceptual structure of the field in this period and determine which journals, authors and countries stand out in the researched subject. The research was performed using visual mapping technique and bibliometric analysis method.

Research findings show that some countries, universities, journals and researchers came to the fore during the examined period. In addition, there has been a rapid increase in publications related to digital innovation and sustainability, especially after 2017. It seems that researchers paid special attention to digital innovation, especially in the last quarter of 2019. The research results point out that countries, authors and universities that attach importance to digital innovation and sustainability are the countries that have made significant progress in Industry 4.0. Considering the place of Germany and the United States in Industry 4.0, it is understood that technological progress cannot be considered independently of scientific progress (Bağcı, 2018). According to the research findings, the most commonly used keywords are impact, benefit, business, and industry. These concepts show the strong correlation between scientific progress and technological progress.

Another important finding of the study is that while the researchers' work on digital innovation and sustainability between 2002 and 2016 followed a horizontal course, publication performance was rapidly increased after 2017. In the 14 years from 2002 to 2016, only 145 (21%) of the 670 studies included in the analysis belong to this period, and the remaining 525 studies (79%) were produced in the last four years, so researchers and journal editors place more emphasis on digital innovation and sustainability it shows. These are the dates on which the studies on industry 4.0 are concentrated, and the fact that the subject of industry 4.0 cannot be considered independently of digital innovation has led to an increase in the relative number of publications on the subject after 2016. It can be argued that the wide use of digital technology in decision processes, production processes, different product designs, providing high-quality service, and time and cost risks have an impact on this effect (Brynjolfsson and McAfee, 2014). The characteristics of digital technology-based innovative products and services are high technologies

in terms of content and that they are the most reliable means of providing a competitive advantage to businesses (Lucas and Goh, 2009).

In this study, articles published in Web of Science and SCOPUS databases were examined. In future studies, it can also be added to databases such as Google Scholar, PubMed and Dimensions. In addition, researchers can make comparisons using different visual mapping programs such as Citespace and Pajek. The research includes the key concepts of digital innovation and sustainability and the components of digitalization and digital transformation. In further research, the subject can also be conducted on different topics such as digital innovation and collaborative business systems and their impact on organizational structures. The research can be studied with larger sample sizes. As a result, it has been understood that the research produced enough findings and results to show how the subject of digital innovation and sustainability followed in the examined period. The study's findings are important because they show a strong correlation between digital innovation and sustainability and that innovation in a certain field cannot be handled independently of scientific data.

Araştırma ve Yayın Etiği Beyanı

Makalenin tüm süreçlerinde Yönetim ve Ekonomi Dergisi'nin araştırma ve yayın etiği ilkelerine uygun olarak hareket edilmiştir.

Yazarların Makaleye Katkı Oranları

Makalenin tamamı Yazar tarafından kaleme alınmıştır.

Çıkar Beyanı

Yazarın herhangi bir kişi ya da kuruluş ile çıkar çatışması yoktur.

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