economies

Article

Exploring Trends in Innovation within Digital Economy Research: A Scientometric Analysis

Lazuardi Imani Hakam [1,*], Eeng Ahman [1], Disman Disman [1], Hari Mulyadi [1] and Dzikri Firmansyah Hakam [2]

[1] Faculty of Economics and Business Education, Universitas Pendidikan Indonesia, Bandung 40154, Indonesia; eengahman@upi.edu (E.A.); disman@upi.edu (D.D.); harimulyadi@upi.edu (H.M.)
[2] School of Business Management, Institut Teknologi Bandung (ITB), Bandung 40132, Indonesia; dzikri.hakam@sbm-itb.ac.id
* Correspondence: lazuardi.imani@upi.edu

Abstract: Significant advancements have been made in studying innovation within the digital economy over the past 20 years. Research on innovation and the digital economy is crucial since it changes all facets of human existence, including business models and entrepreneurial trends. Research regarding innovation in the digital economy has experienced growth over time. However, only a small number of research works have investigated their references using the most widely utilized citation mapping approach, scientometric analysis. This scientometric analysis used 822 published innovation and digital economy research papers from 2000 to August 2023 from the Scopus database. Data analysis and visualization were carried out using biblioshiny (bibliometric package) in R and VOSviewer. According to the data, the study on innovation within the digital economy has grown by 22.75% yearly since 2000. This study offers valuable insight for society, academics, academic institutions, researchers, policymakers, and businesses. The findings reveal the pivotal aspects of the research, derived from the most frequently referenced subjects, publications, authors, and keywords to determine current and future trends in innovation in the digital economy.

Keywords: innovation; digital economy; scientometrics; research trends; biblioshiny; VoSviewer

Citation: Hakam, Lazuardi Imani, Eeng Ahman, Disman Disman, Hari Mulyadi, and Dzikri Firmansyah Hakam. 2023. Exploring Trends in Innovation within Digital Economy Research: A Scientometric Analysis. *Economies* 11: 269. https://doi.org/10.3390/economies11110269

Academic Editor: Weixin Yang

Received: 4 September 2023
Revised: 13 October 2023
Accepted: 24 October 2023
Published: 1 November 2023

1. Introduction

Digital technology has substantially altered the speed at which the economy operates. Digital economy refers to institutional categories (concepts) that include high-level accomplishments and innovative digital technology (Teece 2018, 2020; Trusova 2019; Zhou et al. 2022). The digital economy improves the efficacy of social production. Concurrently, a digital economy relies on professional and market expertise, innovation, and a creative society (Chen et al. 2022; Dai et al. 2022; Imamov and Semenikhina 2019). The digital economy encompasses any economic activity dependent on or considerably boosted by digital inputs, such as digital technologies, infrastructure, services, and data. Digital economy refers to all processes and customers, including the government, who use digital inputs in their economic activity. With digitalization, a business model's innovation pattern shifts (Tapscott 2016). Businesses must generate innovations and develop a business plan that is competitive in the market to keep up with technological, economic, and social change (Teece 2018). This condition makes it difficult to understand the current body of knowledge, creating a significant threat of ignoring crucial topics and questions for future study and practice improvement. To address this scientific issue, it is required to thoroughly evaluate and analyze innovation within digital economy research.

The previous literature that has tried to find research trends in the digital economy (Sorescu and Schreier 2021; Grau-Sarabia and Fuster-Morell 2021; Nambisan et al. 2019; Zhang et al. 2017; Agbozo 2020) has provided valuable insights, yet these reviews come with certain limitations. Firstly, these reviews have taken a qualitative approach, relying

on manual evaluations, which makes them susceptible to subjective biases, lack of reproducibility, and diminished reliability (Yu and Liao 2016). Secondly, the existing review studies have had restricted viewpoints. For instance, Zhang et al. (2017) concentrated on digital innovation, while Agbozo (2020) conducted a bibliometric analysis of the digital economy in Russia. However, their investigations were confined within a specific country, offering a retrospective summary of past endeavors rather than guidance for future directions. Given these factors, these previous review studies do not comprehensively understand the cutting-edge advancements in digital economy research. A comprehensive analysis that can provide a holistic view and insight into innovation within the digital economy is yet to be undertaken.

To address this gap, this study is the first to systematically examine the core concepts and the overall landscape of the collective knowledge concerning innovation within the digital economy using quantitative methods. This study contributes to innovation and the digital economy by identifying the scope and assessing the quality of existing knowledge and determining the best topics to focus future research efforts on.

This study aims to use scientometric analysis to answer the following research questions:

1. What are the most relevant keywords related to innovation in digital economy research?
2. What are the most influential journals and prolific authors in innovation and digital economy studies?
3. What are the most prevalent topics of innovation in the digital economy among scholars?
4. What are upcoming publication trends regarding studies on innovation in the digital economy?

The findings of this study provide insightful information to a wide range of professionals and experts in various disciplines, as well as to individuals researching the digital economy. These insights, which cover innovation trends, well-known authors, and current topics, can be valuable for directing decision-making and research directions in business, technology, entrepreneurship, and government. Businesses and organizations that operate in the digital economy can use the information from this study to help them develop their innovation strategy, which will help them stay competitive and adjust to the rapidly changing technological and commercial environment. Universities and other educational institutions can use this research to create curricula and courses on innovation in the digital economy that provide students with access to the most recent data and trends. The results of this study can also be used by policymakers and government organizations interested in encouraging innovation and digital transformation to develop programs and policies that support innovation in the digital economy. The study can discover promising areas of innovation within the digital economy, enabling investors and funding organizations looking for opportunities in research and development to allocate resources more effectively.

The remaining part of this research is organized as follows. Methods are discussed in Section 2. Section 3 examines the analysis of scientometric results. The conclusion of the work is presented in Section 4.

2. Methodology

Researchers can examine the state of knowledge in a particular topic through bibliometric analysis, systematic literature reviews, and scientometric analysis. Every technique has specific advantages and goals. A scientometric analysis is a quantitative method that quantifies and evaluates scientific research's emergence, dissemination, and effect. Scientometric analysis can offer data-driven insights into trends, significant authors, research subjects, and new publication trends that align with the research questions. It provides a thorough, data-driven assessment of the field's development and is exceptionally proficient at predicting upcoming research trends (Rojas-Sánchez et al. 2023; Fu et al. 2023).

On the other hand, a systematic literature review is a qualitative method that offers a thorough and objective account of the body of literature on a particular topic. It works best when researchers seek to provide an in-depth qualitative examination of already-known information and pinpoint gaps in the body of knowledge. For making recommendations

for policies and evidence-based decision-making, this method is applicable. A bibliometric analysis uses numbers to evaluate the significance and influence of particular books, authors, or journals. It is helpful when researchers seek to analyze the scope and significance of specific research contributions, and it is especially successful when analyzing citation trends (Linnenluecke et al. 2020; Cuéllar-Rojas et al. 2022).

Because this study focuses on quantitative measurements, trends, and data-driven insights into innovation in the digital economy, scientometric analysis is the best method to apply in the present study. It fits in well with the research topics of this study, enabling the researcher to present a thorough and evidence-based assessment of the current level of knowledge in this field. Figure 1 illustrates the method in this study.

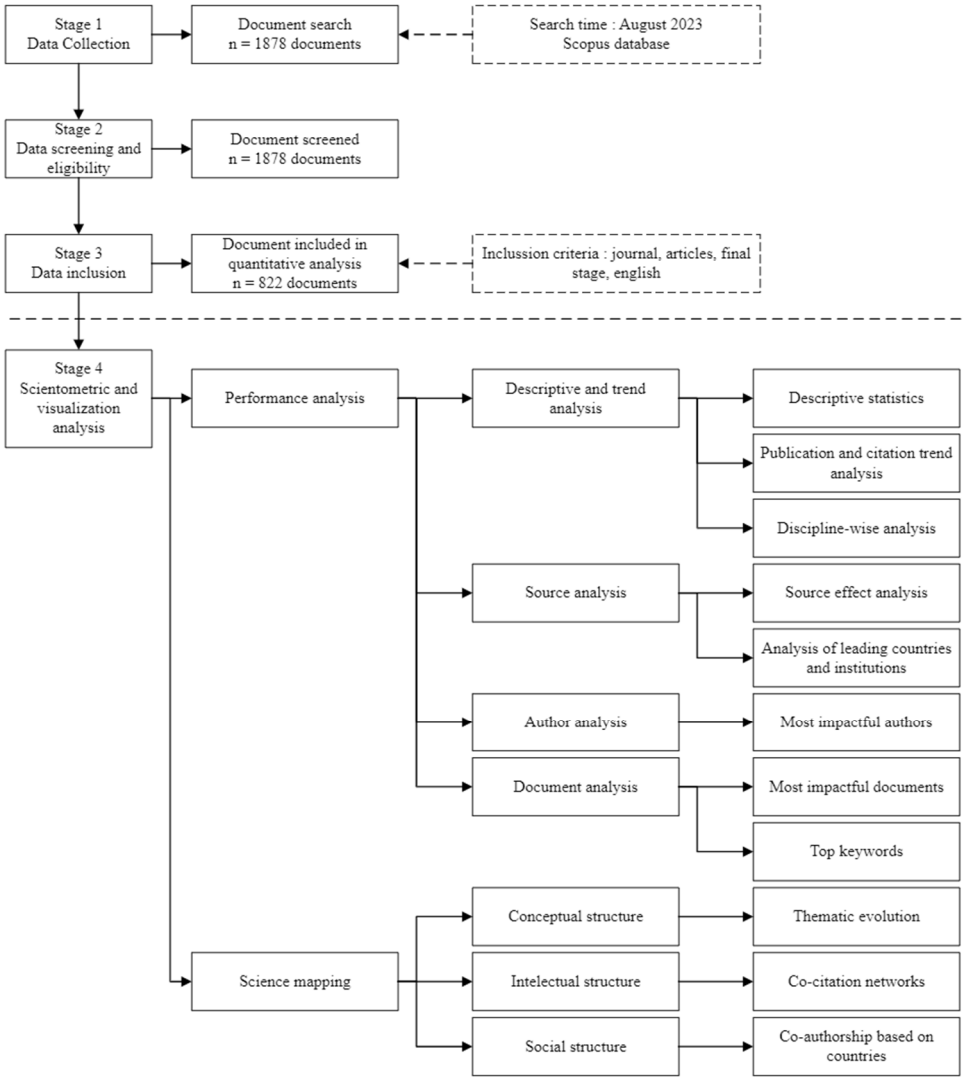


Figure 1. Methodology for article selection and analysis process.

We used the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines for this scientometric analysis to ensure an impartial and transparent approach. We use this approach from Stage One to Stage Three. Stage Four is the data processing stage with scientometric analysis and visual mapping, the method we used adapted from Moher et al. (2010) and Leitão et al. (2023).

In the first stage, we specify the strings to look for in the Scopus database. The Scopus database website search engine is used in this study. We ran an English language bibliographic data search to collect the most relevant number of papers. The Scopus database is used in the scientometric analysis. Due to its extensive coverage, sophisticated

search features, data citations, and normalization choices, the Scopus database is helpful for scholars performing scientometric research (Kumar and Rahaman 2019). Researchers can access a variety of scientific literature, examine citation trends, and compare papers objectively using the Scopus search engine, which improves the accuracy and validity of this scientometric study (Baas et al. 2020; Kumpulainen and Seppänen 2022). A data search was carried out in August 2023. The keywords we used were innovation and digital economy on all subjects. From the investigation we undertook in this first phase, we obtained 1878 documents.

'Innovation' serves as a fundamental pillar of this research objective. It is central to understanding how organizations, industries, and economies adapt and thrive in an era characterized by rapid technological change and digital transformation. Innovation, encompassing both product and process innovation, is crucial for enhancing competitiveness, driving growth, and fostering sustainability in contemporary economies. 'Digital economy' is a strategic contextual frame for this research (Sorescu and Schreier 2021; Hanna 2020). In the 21st century, the digital economy is a transformative force that reshapes industries, markets, and business models. The digitalization of economic activities and the influence of digital technologies on economic development are essential considerations for our study. By selecting 'innovation' and 'digital economy' as our keywords, we aimed to delve into the intricate relationship between innovation dynamics and the pervasive influence of digitalization on economic activities (Xu and Li 2022; Yu et al. 2023).

In the second stage, duplicates were removed, and the article title, abstract, and keywords were read. The article content was thoroughly analyzed when necessary to ensure consistent analysis and significance. In the third stage, we determined the inclusion criteria, including documents that had to be in the form of articles at the final stage, sourced from journals, and published from 2000 to August 2023. This research analysis does not include other documents, such as books, news articles, and book reviews. So the final string used in the Scopus database was as follows TITLE-ABS-KEY ("innovation" AND "digital economy") AND PUBYEAR > 1999 AND PUBYEAR < 2024 AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT -TO (PUBSTAGE, "final")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")). In the third stage, 822 documents in the form of articles were produced, ready to be used as data sources for scientometric analysis.

The minimum sample size for scientometric analysis varies depending on the nature of the analysis and the population being studied. According to Rogers et al. (2020), sample sizes of 200–1000 papers provide a good guide to achieving relative (but not absolute) significance. Bujang and Adnan (2016) recommends using power analysis to know the minimum article count for scientometric analysis in this study. We used power analysis using G*Power ver. 3.1.9.7 to estimate the minimum sample size for this scientometric study (Table 1). This study does not attempt to provide a detailed explanation of the mathematics behind power analysis. Nevertheless, we may explain several essential factors in such an analysis as follows:

- Power (π) = P (rejecting $h_0 \mid h_0$ is false). We set the power at 0.8 and 0.9, which means that we wanted a sample size that is large enough that we will correctly reject the null 80% and 90% of the time when it is false. A bigger value can be used if more power is thought to be required, but doing so will also call for a larger sample size.
- Alpha (α) = P (rejecting $h_0 \mid h_0$ is true). We set $\alpha = 0.05$ (medium) and 0.01 (low), which are commonly used criteria for rejection. The differences between null and alternative hypotheses must be large enough that we would expect to only reject the null 5% and 1% of the time when the null is true.
- Effect Size (ρ): The smaller the sample size required to yield statistically significant effects, the higher the effect size. We set $\rho = 0.1$ (small), 0.3 (medium), and 0.5 (large) based on G*Power ver. 3.1.9.7.
- N is the required sample size given the values for α, effect size, and π that have been established. In this instance, the researcher has stated the other variables, and N is an estimate.

Table 1. Estimated sample size for one-sample *t*-test.

Alpha (α)	Power (π)	Effect Size (ρ)	N
0.05	0.8	0.1	614
0.05	0.8	0.3	64
0.05	0.8	0.5	21
0.01	0.9	0.1	1290
0.01	0.9	0.3	135
0.01	0.9	0.5	42

In the fourth stage, we carried out scientometric analysis and visual mapping. Scientometric analysis is a broad term that encompasses bibliometric analysis and extends it to include other quantitative methods for studying science and technology (Patra and Muchie 2021; Bornmann and Leydesdorff 2014). Scientometric research involves using mathematical and statistical techniques to analyze scientific publications, citations, and other related data to understand the structure and dynamics of scientific knowledge (Shushanyan and Ohanyan 2021). This method aims to map the scientific landscape, identify research trends, and measure the impact and influence of scientific research (Patra and Muchie 2021; Bornmann and Leydesdorff 2014). Scientometric analysis can include co-citation, co-word, and network analysis to visualize the relationships between authors, documents, and research categories (da Rosa et al. 2023).

Scientometric analysis was carried out using two applications, including the biblioshiny application and VOSviewer (Oyewola and Dada 2022). The type of analysis that can be carried out in the biblioshiny application includes performance analysis. At the same time, in science mapping, one analysis uses VOSviewer, namely co-authorship based on countries, which examines social structure. Performance analysis is divided into four data analyses, including descriptive analysis, which consists of descriptive statistics, publication and citation trend analysis, and discipline-wise analysis. Second, a source analysis consisted of source effect analysis and analysis of leading countries and institutions. The third analysis was carried out by analyzing the most impactful authors. The fourth analysis was document analysis, which consists of the most impactful documents and top keywords. In the science mapping stage, the conceptual structure was determined through thematic evolution, and the intellectual structure was determined through co-citation networks using the biblioshiny package in the R application.

3. Results

3.1. Descriptive and Trend Analysis

Table 2 provides a descriptive summary of the literature examined for this research. According to the primary information and document categories, 822 articles were published in 399 sources between 2000 and 2023. Only 137 of the 822 documents, or 16.67%, had a single author. This area of research involves much collaboration. The average number of citations per document in this corpus is 12.24, demonstrating the high citation level published in this field.

Figure 2 shows the increased trend of publications and provides information on how the academic community and other audiences respond to innovation within digital economy research. An in-depth analysis of the data from 2000 to 2023 has revealed changes in publishing and citation rates over 23 years. This thorough investigation shows that the number of innovations within digital economy research publications has increased steadily and noticeably each year by an average of 22.75%. This increase suggests a significant growth in the body of knowledge produced over time. Interestingly, even while the number of articles published has significantly increased, the growth in article citations is not directly correlated with the publication count. This indicates various factors at play, such as varying

levels of engagement with different types of content, varying quality of research, or shifts in research focus over the years (Abramo et al. 2023).

Table 2. Summary of the descriptive information.

Description	Indicator	Result
Main Information	Timespan	2000:2023
	Sources (Journals)	399
	Documents	822
	Annual Growth Rate %	22.75
	Document Average Age	2.41
	Average citations per doc	12.24
	References	40,332
Document Types	Article	822
Document Contents	Keywords Plus (ID)	1712
	Author's Keywords (DE)	2606
Authors	Authors	1953
	Authors of single-authored docs	137
Author Collaboration	Single-authored docs	142
	Co-Authors per Doc	3.15
	International co-authorships %	14.84

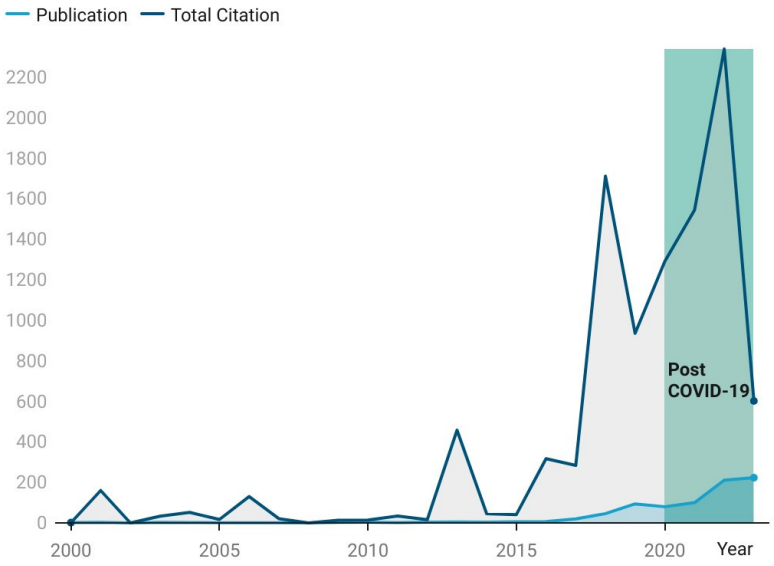


Figure 2. Publication and citation per year: innovation within digital economy research.

Between 2017 and 2022, as indicated in Figure 2, there was a significant increase in the number of research publications, reflecting a growing interest in investigating innovation within the digital economy. On the other hand, the period from 2000 to 2016 observed a modest output ranging from one to seven documents, with no articles released in 2002 and 2008. The turning point emerged in 2017 when there was a marked increase in the production of published articles, a trend that has persisted and increased from 20 documents to 223 by August 2023.

Over 23 years, 822 documents were published. This extended timeline indicates the enduring nature of innovation within digital economy research, though there remains room for more development. The growing interest among researchers in disseminating papers about innovation within the digital economy is attributed to the accelerated pace of technological advancements, compounded by the disruptive impact of the COVID-19 pandemic, which started in 2020 (Hui et al. 2023; Zhang et al. 2022b).

Nevertheless, a notable observation from the analysis is that the publication of innovative research within the digital economy mirrors technological advancements. This alignment highlights the interconnected nature of research and technical progress. As technology evolves, the study produced within the digital economy develops in parallel, indicating a dynamic relationship between academic inquiry and practical application (Sorescu and Schreier 2021).

The significant rise in citations for research on innovation in the digital economy is one of the data's most important findings. The increase in citations from 2000 to 2023 highlights this field of study's growing importance and influence. This increase in citations shows that the academic and professional communities are connecting with and citing these discoveries in their work, which shows that they are becoming more aware of the importance of innovation in the digital economy (Sorescu and Schreier 2021; Yu et al. 2023).

Comprehension of research developments and assessing the significance of scientific literature require a knowledge of the distribution of documents across publications in bibliometric and scientometric analysis (Mejia et al. 2021; Ellegaard and Wallin 2015). Figure 3 illustrates the distribution of articles across various journals concerning innovation in the digital economy. Among these journals, innovation in digital economy research thoroughly conducted in the journal "Sustainability" stands out as the most comprehensive. The second position is held by "Frontiers in Environmental Science," followed by "Environmental Science and Pollution Research," which has relevance to the topic. The dataset further unveils a range of published articles from 9 to 93 across these journals. Therefore, innovation research in the digital economy can be developed or combined with technology, environment, energy, economics, and psychology disciplines.

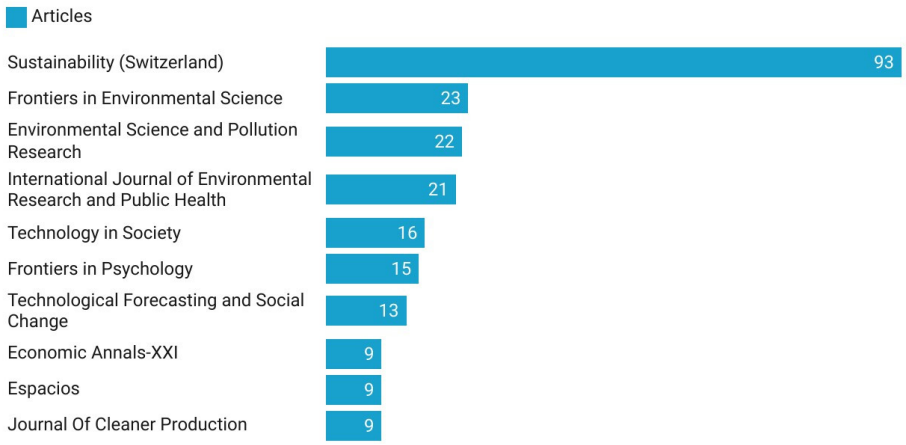


Figure 3. Distribution of articles on the topic innovation in the digital economy.

3.2. Source Analysis

In scientific publications, citations are used for research assessment, including measuring performance by examining the number of publications produced. Then, the journal's quality is evaluated by evaluating articles that can impact a field and assessed by a citation matrix. This study shows how active and productive a field of research is, seen from the total number of article citations, not just the number of published articles (Ellegaard and Wallin 2015).

The analysis effect of the source identifies the most relevant and influential research sources concerning innovation in the digital economy. There are 822 documents from 399 distinct sources, such as journals, retrieved from the Scopus database. Table 3 depicts the distribution of the leading ten most pertinent sources. The journal "Sustainability" ranks first in the number of articles published, with 93, followed by "Technology in Society" (16), and "Technological Forecasting and Social Change" (13). "Sustainability" has the highest journal score across all bibliometric measures, including publication, total citation, h-index, g-index, and m-index, as shown in Table 2.

Table 3. The Effect of the Sources.

Element	h_index	g_index	m_index	Total Citation	Total Publication	First Year Publication
Sustainability (Switzerland)	13	26	2.167	793	93	2018
Technology In Society	10	16	1.429	332	16	2017
Technological Forecasting And Social Change	9	13	0.391	342	13	2001
Environmental Science And Pollution Research	8	16	4.000	267	22	2022
Journal Of Cleaner Production	6	9	3.000	183	9	2022
Economic Annals-Xxi	5	9	0.833	86	9	2018
International Journal Of Environmental Research And Public Health	5	9	2.500	111	21	2022
Journal Of Business Research	5	6	1.667	426	6	2021
Technovation	5	5	0.278	393	5	2006
Energy Economics	4	4	1.333	395	4	2021

According to Figure 4, China led in generating innovation within the digital economy research, having published 318 articles. The United Kingdom (UK) secured the second position with 33 publications. Following closely, the United States (US) stood in third place with 19 publications, followed by Australia with 14. Among the ten countries shown in Figure 4, only Finland exhibited a notably high international collaboration ratio in research related to digital economy innovation. In addition, an interesting fact that can be obtained from Figure 4 is that many articles on innovation in the digital economy were written in developed countries (China, the UK, the USA, Australia, Italy, Finland, and Korea). Three others were developing countries (Ukraine, Indonesia, and Romania).

Figure 4. Top 10 countries publishing articles on the topic innovation in the digital economy.

For several reasons, developed nations outperform emerging ones in their study of innovation in the digital economy. These developed nations have more resources, advanced infrastructure, well-established educational institutions, and financial systems to encourage R&D. They invest in cutting-edge technologies and devote significant financial resources to luring top talent, which promotes innovation (Zhang 2022). Additionally, developed countries are at the forefront of technical innovation and digital infrastructure, successfully integrating digital technology into their economies. Their developed digital ecology provides a favorable setting for research and experimentation. These countries highly value knowledge-based economies and innovation-driven growth because they understand how important innovation is to maintain economic progress and competitiveness (Yu and Yan 2021; Aparicio et al. 2023). Institutional solid structures and policies in developed nations assist R&D by protecting intellectual property rights, supportive laws, and efficient

governance frameworks, fostering a situation conducive to researchers and innovators (Zhang 2022).

Developing nations are also investing more in R&D in this area as they see the value of the digital economy (Tran et al. 2022). Governments and international organizations support their efforts to close the research gap even though developing countries encounter obstacles like limited facilities and funding. Developing countries work to build their digital economies. They want to take advantage of the possibilities of the digital economy for their expansion and advancement (Lazović et al. 2022).

Figure 5 demonstrates additional prominent institutions determined by their published article count. Xinjiang University leads as an academic institution with a cumulative publication index (CPI) of 37, while the University of Jyväskylä follows with 32 publications. Similarly, the University of International Business and Economics, like Wuhan University, generated 25 articles each. Therefore, many authors come from Chinese, Finnish, and Russian educational institutions that research innovation in the digital economy.

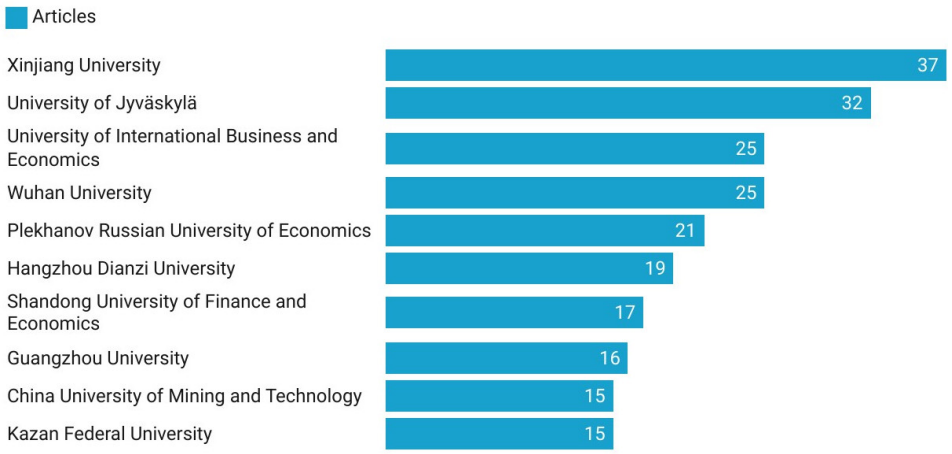


Figure 5. The top 10 institutions publishing articles on innovation within the digital economy topic.

3.3. Author Analysis

Citation analysis is a reliable tool for investigating an author's productivity and impact on academic publications (Nightingale and Marshall 2012). An insightful visualization of this concept is presented in Figure 6, showcasing the preeminent article authors who have significantly contributed to the discourse surrounding innovation within the digital economy over multiple years.

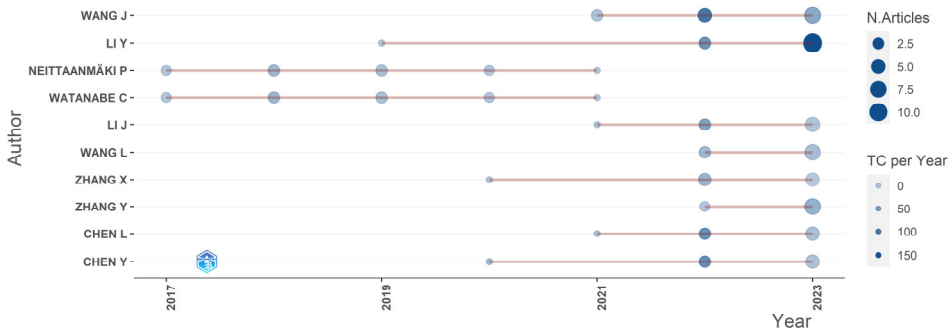


Figure 6. Top authors' production over time.

Varying dot sizes characterize this visual representation, and each dot works as a visual marker denoting the relative annual outcomes achieved by different authors. Notably, the size of the dot corresponds to the magnitude of an author's influence, reflecting their impact on the scholarly landscape. Furthermore, the varying shades of the dots introduce

an additional layer of information. Darker dots signify more citations in research, spotlighting the authors whose work has resonated profoundly within the academic community (Nightingale and Marshall 2012). Through this intricate interplay of dot sizes and shades, Figure 6 effectively encapsulates the dynamic nature of research productivity, impact, and influence across authors focused on the theme of innovation within the digital economy.

Based on Figure 6, research on innovation in the digital economy began to be actively published in 2017. Ten researchers actively publish research on innovation within the digital economy. In 2017, Neitaanmaki P and Watanabe C actively researched this topic until 2021. From 2019, author Li Y actively wrote articles until 2023, with the highest number of citations among other writers.

3.4. Document Analysis

Document analysis identified the knowledge area's intellectual structure by analyzing the amount and authority of referenced literature (Galais et al. 2022). Scopus's top 10 most cited publications are in Table 4, with worldwide citation counts ranging from 130 to 549. Articles from Cardona et al. (2013), Ren et al. (2021), and Teece (2018) learned the most worldwide citations, receiving 549, 378, and 289. The ten articles in Table 4 address some main keywords regarding innovation, technology, digitization, digital economy, and business. These primary keywords are the basis for developing research on innovation within the digital economy. Authors with more citations indicate that published articles are more adaptive and influence the research topic.

Table 4. Top 10 cited documents of innovation in digital economy research.

Ref.	Title	Year	Total Citations	Author Keywords
(Teece 2018)	Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world	2018	549	Appropriability Complementarity General-purpose technology Licensing Platform Standards Technology policy
(Cardona et al. 2013)	ICT and productivity: Conclusions from the empirical literature	2013	378	Information and communication Technologies Productivity Growth accounting General-purpose technology
(Ren et al. 2021)	Digitalization and energy: How does internet development affect China's energy consumption?	2021	289	Digitalization Internet development Energy consumption China
(Li 2020)	The digital transformation of business models in the creative industries: A holistic framework and emerging trends	2020	226	Business model Portfolio model Holistic framework Creative industry Digital technology Digital economy Transformation Innovation
(Scuotto et al. 2016)	Internet of Things: Applications and challenges in smart cities: a case study of IBM smart city projects	2016	225	Open innovation Internet of things Smart City IBM
(Soto-Acosta 2020)	COVID-19 Pandemic: Shifting digital transformation to a high-speed gear	2020	179	COVID-19 Digital Transformation Digitalization Digital economy Innovation

Table 4. *Cont.*

Ref.	Title	Year	Total Citations	Author Keywords
(Pan et al. 2022)	Digital economy: An innovation driver for total factor productivity	2022	172	Digital economy Total factor productivity Principal component analysis Nonlinear relationship Regional diversity
(Lee 2001)	An analytical framework for evaluating e-commerce business models and strategies	2001	138	Internet Economy Innovation Strategy
(Ma and Zhu 2022)	Innovation in emerging economies: Research on the digital economy driving high-quality green development	2022	135	Digital economy High-quality green development Smart city Spillover effects
(Su et al. 2006)	Linking innovative product development with customer knowledge: A data-mining approach	2006	130	Customer knowledge management Data mining Innovative product development Mobile commerce Web-based market survey

Examining the utilization of keywords in a scholarly work is a method employed within academia to identify prevailing patterns and areas of expertise. This technique involves pinpointing the most recurrent phrases in authors' keywords to characterize a given subject (Chen and Xiao 2016). Illustrated in Figure 7 are keywords that accumulate substantial citations, frequently initiating keyword lists and their temporal distribution. The diagram's dot varies in size: the smallest encompasses 0–100 occurrences, followed by enlarging dots for 100–200 and 200–300 occurrences.

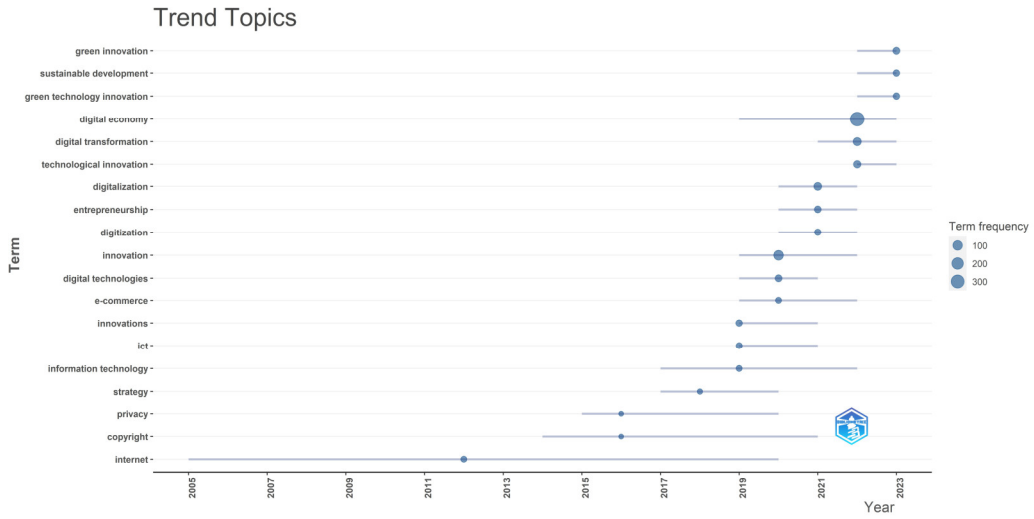


Figure 7. Topic timeline.

From 2005 to 2020, the most extensively discussed subject was the internet, while copyright took precedence in 2014, followed by privacy in 2015, and technology information with strategy in 2017. Some topics frequently discussed in 2019 are innovations and ICT, followed by e-commerce, digital technology, and innovation, with the highest occurrences (200). In 2020, three topics with the same occurrences (100) were digitalization, entrepreneurship, and digitalization. The digital economy is the topic with the highest frequency, followed by digital transformation and technological innovation. Present trends have incorporated words like green technology innovation, sustainable development, and green innovation from 2020 until 2023.

From Figure 7, it can be concluded that topics in innovation research in the digital economy are continuously developing. The topics discussed initially were related to developments and problems that arose due to the increasing intensity of internet use in all aspects of life. Issues that arise from using the internet include copyright and privacy. The keywords for innovation are starting to develop into technological innovation, green technology innovation, and green innovation. This development shows that more innovation research is increasingly aware that innovation is not only to increase the output of a business or economic growth but also must consider environmental sustainability aspects.

The global COVID-19 outbreak in 2020 has further brought attention to the issues of global warming and protecting the environment. ESG (environmental, social, and governance) issues and the need for sustainable development have received more attention due to the problem (Hermundsdottir et al. 2022; Filho et al. 2021), policies increasingly promote and support the development of green technologies. The encouragement indicates that governments and policymakers know how important green innovation is to supporting national green growth and resolving environmental problems (Peng et al. 2021; Wu et al. 2022).

3.5. Conceptual Structure

Thematic developments were analyzed by splitting and comparing combined periods. This approach is used to track the evolution of numerous themes in the academic discipline throughout time (Mozelius and Humble 2022). Figure 8 depicts the results of the thematic evolution study, which describes how topics appear, disappear, merge, or resurface over time. This study is separated into three periods: 2000–2010, 2011–2020, and 2021–2023. Thematic map reading is undertaken to understand how a subject evolves into other thematic categories as a combination of themes.

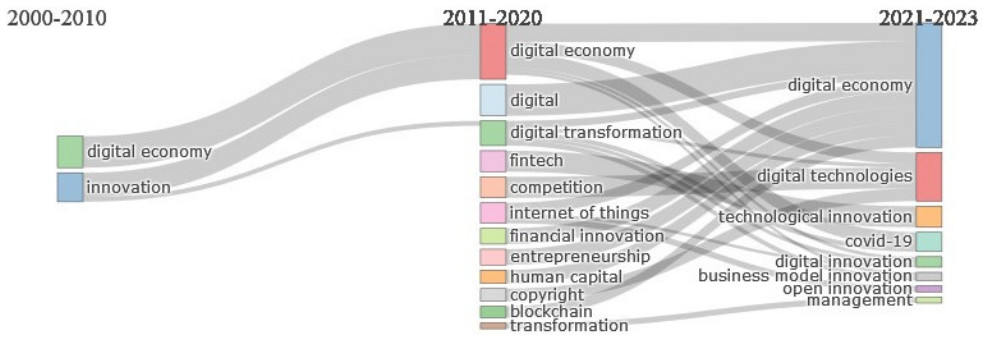


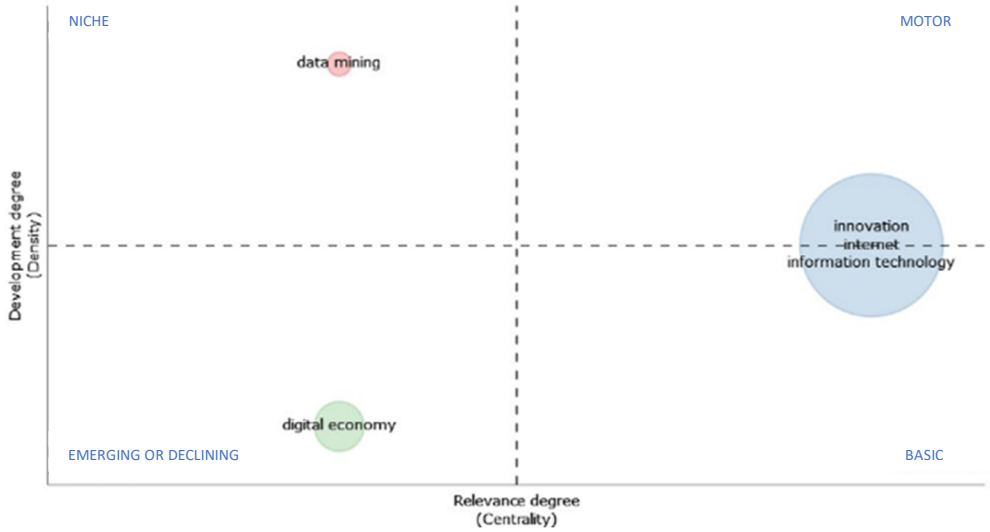
Figure 8. Thematic evolution.

Thematic evolution from 2000 to 2023 demonstrates that the initial theme that emerged in 2000–2010 was the digital economy and innovation, whereas, in 2011–2020, the digital economy and innovation merged and reformed the theme of the digital economy, while innovation formed a new theme, namely digital transformation, which evolves into the digital economy, digital technology, digital innovation, business model innovation, and open innovation in 2021–2023. In 2011–2020, new themes emerged: digital, fintech, competition, the internet of things, financial innovation, entrepreneurship, human capital, copyright, and blockchain evolving into a digital economy, besides transformation developing into management in 2021–2023. The digital economy topic from 2011–2020 has grown into new themes such as digital technologies, business model innovation, digital innovation, and COVID-19 keywords that first appeared in 2021–2023. The digital economy dominates and receives a lot of emphasis in the 2021–2023 timeframe.

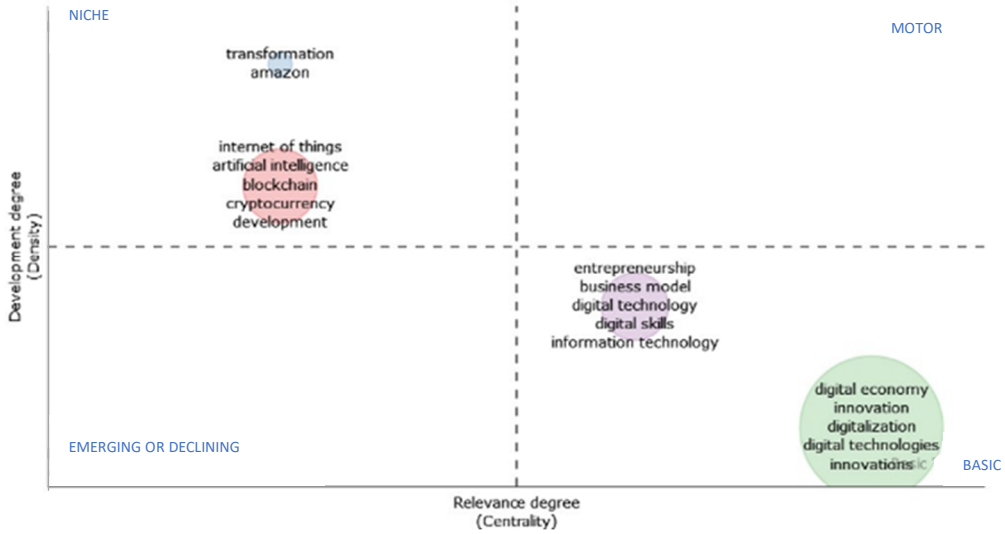
The COVID-19 pandemic and the "nescience economy" concept are closely tied to the digital economy. The pandemic has accelerated the rapid embrace of digital technologies for long-term development, underscoring the importance of digitalization for economic recovery. This acceleration of digital transformation during the pandemic has

significant implications for the broader digital economy. In contrast, increased adoption of automation and digital technologies can boost digital economic growth. The "nescience economy" concept emphasizes the critical role of digital skills, a supportive business environment, and ICT development in facilitating a successful transition to the digital economy. Therefore, authorities must consider these factors when addressing potential employment disruptions caused by automation within the digital economy (Jangjarat and Jewjinda 2023; Zemtsov 2020).

The illustration shown in Figure 9 is about thematic map analysis, which categorizes themes into four quadrants depending on density and centrality. The dots on the themed map represent the keyword with the highest occurrence value; the dot diameter is proportional to the number of times the term appears (Rejeb et al. 2023).

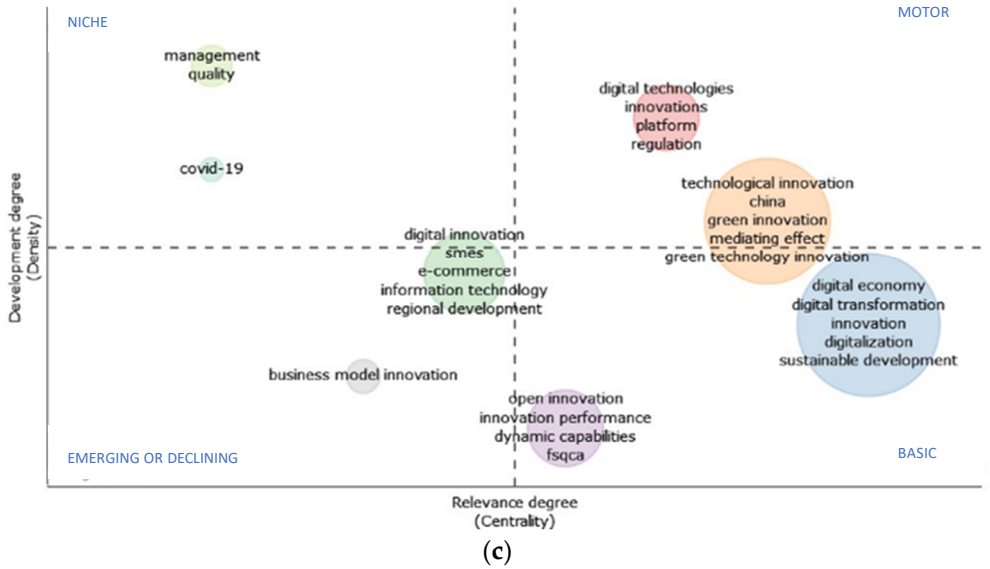


(**a**)



(**b**)

Figure 9. *Cont.*



(**c**)

Figure 9. Thematic map (**a**) 2000–2010; (**b**) 2011–2020; (**c**) 2021–2023.

The textual data underwent necessary preprocessing processes before employing theme mapping algorithms. This included eliminating frequently used words that might not have crucial thematic information. To ensure that word variations were treated as a single phrase, a stemming procedure was also used to break words down to their simplest form (for example, "digitalization," "digitalization," and "digitalization" were all mapped to "digitalization"). Several preprocessing steps are essential for the theme identification method to be accurate. The three specified timeframes (2000–2010, 2011–2020, and 2021–2023) were chosen following the study's goals. The goal was to track the development of research issues and spot changes and trends in the scholarly literature. These intervals were carefully picked to illustrate the evolution of research themes and the weight of those changes.

Individual keywords are shown as dots in Figure 9. Each dot's size reflects how frequently a specific keyword occurs in the dataset. For instance, a larger dot highlights a term's importance by showing how frequently it appears in the corpus. The researcher carefully chose the parameter settings employed in this analysis to ensure that the theme map offers insightful information. The following criteria were employed in this study (Parlina et al. 2020; Ichhpujani et al. 2021):

- Number of Words (250): This parameter specifies the maximum number of words to consider when identifying and analyzing research themes. In this case, the analysis focused on 250 words per theme.
- Min Cluster Frequency (per thousand docs) (5): This parameter sets a minimum threshold for the frequency of a theme within the corpus. Themes that appeared at least five times per thousand documents were considered relevant for inclusion in the map.
- Number of Labels (5): The number of labels represents the limit on the number of key themes explicitly labeled and presented in the map. In this study, up to five key themes were labeled.
- Label Size (0.3): Label size determines the font size or prominence of the labels associated with themes. A label size of 0.3 suggests that the labels for key themes are presented in a moderately prominent manner.
- Community Repulsion (0): Community repulsion is a parameter used to control the spatial separation of themes in the map. A value of 0 indicates that articles are not repelled from each other, potentially leading to closer clustering of related articles.
- Clustering Algorithm (Fast Greedy): The choice of the clustering algorithm is crucial for identifying related themes. The "Fast Greedy" algorithm is used for network

community detection. It helps identify closely associated themes and group them into clusters.

Based on Cobo et al. (2018), classification on the thematic map can be divided based on the degree of centrality and density. Themes in the upper-right quadrant of a thematic network (motor themes) in bibliometric analysis are well-developed and vital for a research field's structure. They have high centrality and influence in guiding research direction. Those in the upper-left quadrant of a thematic network (niche themes) in bibliometric analysis have well-developed internal ties and are minimally relevant to the field. They have low centrality and influence on the research field. In the lower-left quadrant of the thematic network, emerging or declining themes are weekly developed and marginal. They have low centrality and density. In the lower-right quadrant of a thematic network, basic themes in bibliometric analysis are less developed and significant than motor themes. They have high centrality but low influence.

In the first phase (2000–2010), a blue dot was placed between motor and basic themes. The keywords of innovation, internet, and information technology received numerous keywords and had a significant impact later. The digital economy emerged as a new focus (green dot), and data mining (in red dot) is a specialized keyword with minimal relevance to this research.

During the second phase (2011–2020), the digital economy, innovation, innovations, digital technology, and digitalization (green dot) are the predominant research topics relevant to the field and highly developed. The development of current themes results in the construction of new themes, particularly entrepreneurship, digital skills, business models, digital technology, and information technology (purple dot), which received a few presences and had an impact later. A red dot with specific themes containing the internet of things, artificial intelligence, blockchain, cryptocurrency, and development. Followed by a blue dot with fewer numbers, of terms are transformation and Amazon.

The third phase (2021–2023) focuses on the digital economy, digital transformation, innovation, digitalization, and sustainable development with the highest presence of keywords and developed potency (blue dot) followed by a purple dot with open innovation, innovation performance, dynamic capabilities, and fuzz-set qualitative comparative analysis (fsQCA). An orange dot was placed between motor and basic themes, showing the keywords of technological innovations, China, green innovations, mediating effect, and technological innovation. The red dot was placed in the motor theme, which had strong relevance to the topic, was well developed, and included themes such as digital technology, innovations, platforms, and regulation. There was management quality in niche themes, and COVID-19 had substantial importance but not relevance to the research field. The results of developing existing themes, such as digital economy, innovation, business model innovation, and digital technology information, led to the emergence of new topics.

3.6. Intellectual Structure

The co-citation map in Figure 10 illustrates the scientific structure by showing how frequently other documents quote two documents. There are two main clusters due to the co-citation analysis mapping results. The size of an article's dots represents the normalized number of citations, while the thickness of the line shows the strength of the interaction of the co-quotes between the dots in the graph. The linkages and their affinity demonstrate the two objects' relationship. The color of the box denotes the category of articles. Dots of the same color are grouped. Figure 10 shows that each box is labeled with the initial author's name and the year of publication. The analysis results show the formation of two main clusters, including the red cluster with the authors Cobo et al. (2018), Ma and Zhu (2022), and Cao et al. (2021), while in the blue cluster, there are the authors Li and Wang (2022), Ma et al. (2022), and Ma et al. (2022).

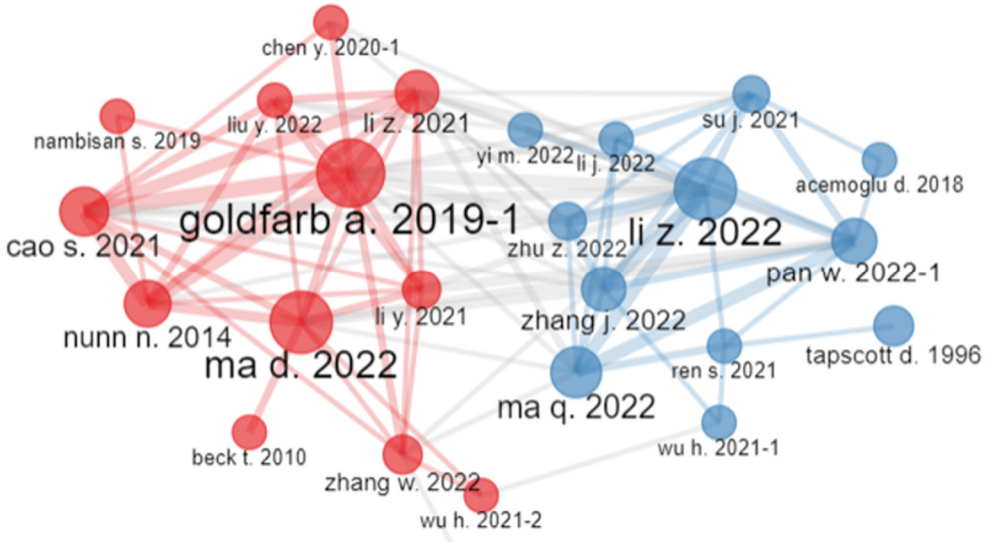


Figure 10. Co-citation network of reference. (Acemoglu and Restrepo 2018; Beck et al. 2010; Cao et al. 2021; Chen 2020; Goldfarb and Tucker 2019; Li et al. 2021a, 2021b, 2022; Liu et al. 2022; Li and Wang 2022; Ma and Zhu 2022; Ma et al. 2022; Nambisan et al. 2019; Nunn and Qian 2014; Pan et al. 2022; Ren et al. 2021; Su et al. 2021; Tapscott 2016; Wu et al. 2021a, 2021b; Yi et al. 2022; Zhang et al. 2022b, 2022c; Zhu et al. 2022).

The research from Goldfarb and Tucker (2019) showed that digital technology encodes the data into bits. The cost of storing, processing, and sending information has lowered due to this breakthrough. The study of digital economics investigates how digital technology affects business decisions. Digital technology decreases the costs of economic activity such as finding, copying, transporting, monitoring, and confirming. Ma and Zhu (2022) assessed the development of environmentally friendly practices in China and the extent of the urban digital economy. It seeks to provide a comprehensive framework for understanding the workings and effects of the digital economy. The findings suggest that the digital economy can directly stimulate high-quality, environmentally friendly development. Green technology innovations and advancements to the industrial structure are essential intermediary processes. Cao et al. (2021) examined how digital finance supports green technology innovation (GTI) and energy-environmental performance (EEP). The study shows that digital finance has a favorable impact on energy-environmental performance, mainly by promoting the development of green technologies.

The research from Li and Wang (2022) showed substantial resource endowment thresholds, urban scale thresholds, and innovative skill thresholds that would affect how the digital economy affects carbon emissions. Ma et al. (2022) showed that carbon dioxide emissions, digitalization, R&D spending, and other significant macroeconomic indicators had long-run cointegrating correlations. Additionally, it has been discovered that digitalization reduces provincial emission rates. Additionally, it is proven that spending on research and development lowers emission levels and moderates carbon dioxide emissions and digitalization. The effects of technological innovation are also found to have similar direct and moderating effects. Pan et al. (2022) applied pooled regression to examine the innovation-driven effects of the digital economy on total factor productivity (TFP) in China. The findings reveal a positive nonlinear association between province TFP and the digital economy index, indicating that the digital economy serves as a catalyst for innovation in the broad and long-term growth of TFP. Other studies on both red and blue clusters can be seen in Table A1.

3.7. Social Structure

Author collaboration is essential for comprehending the path of research in numerous disciplines because it can motivate academic centers to expand and grow their study areas

in the future. Figure 11 depicts the intellectual relationships of academics from various countries and the countries that have made the most significant citation contributions to advancing innovation in digital economy research. The VOS application employs a cut-off point of ten publications, resulting in 24 nations. The diameter of the dot symbolizes a country's total number of publications. The lines' thickness and the dot's spacing show the degree of involvement (Kirby 2023). The number of articles written by authors from two or more countries determines the degree of a country's ties. In this evaluation, China, Russia, and the UK are pioneers in conducting thorough research on digital economy innovation. Notably, among these three countries, China is the most active in researching innovation in the digital economy up to 2023.

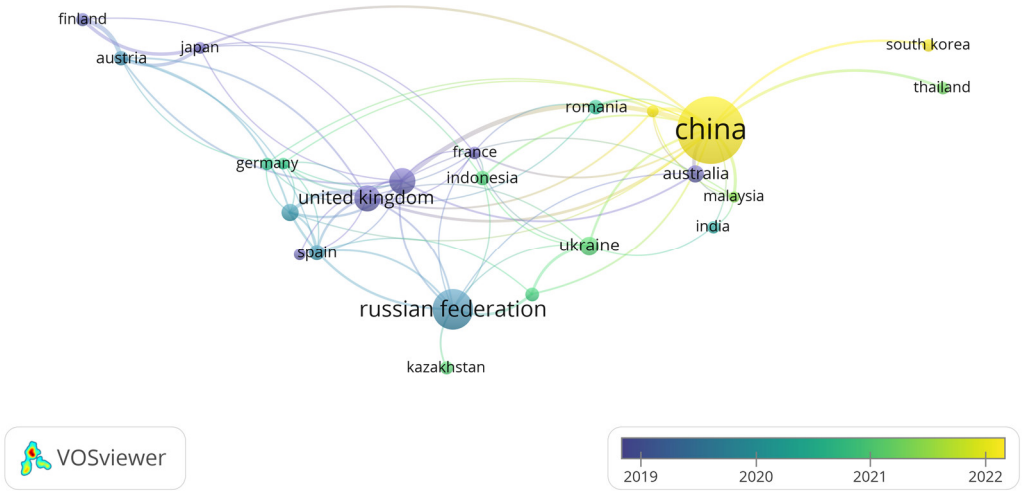


Figure 11. Co-authorship based on countries.

4. Discussion

The earlier sections thoroughly summarized the most recent studies on innovation in the digital economy. The results offer valuable insight into the field's direction, significance, and potential future directions. It also provides a snapshot of the field's progress. We explore the implications and interpretations of these findings in greater detail in this discussion, highlighting their broader applicability in business, education, and policy contexts.

The enormous increase in publications on innovation in the digital economy over the past 20 years is evidence of the field's increasing significance. The digital economy has transformed from a novel concept to an essential global economic force. In response to this change, scholars have generated extensive knowledge that aims to comprehend, maximize, and exploit the potential of digital innovation. The results of our investigation confirm the applicability of this research and attest to its endurance, demonstrating an ongoing interest in the topic.

One of the striking features of this research landscape is the pronounced level of international collaboration among authors. With most documents involving multiple authors from various countries, it is evident that innovation in the digital economy is a global concern and a collective effort. This international collaboration not only highlights the interconnectedness of research in this field but also signifies the willingness of scholars to work together in a highly dynamic and interdisciplinary environment. The global nature of these collaborations is a testament to the borderless character of the digital economy.

The thematic analysis reveals a dynamic evolution of research themes in this field. The initial focus on internet-related issues and concerns about copyright and privacy has gradually given way to a broader spectrum of topics. Notably, discussions around green technology innovation, sustainable development, and the impact of the COVID-19 pandemic on digital transformation have gained prominence in recent years. This shift reflects the field's responsiveness to real-world challenges, such as environmental sustainability and the transformative effects of global events.

The emergence of green technology innovation and sustainable development as central themes reflects the growing recognition of the digital economy's potential to contribute to or mitigate environmental challenges. It underscores the need for businesses, policymakers, and researchers to align digital innovation with sustainability goals.

The essential role of digital technology has been a frequent topic in this study environment. As shown in the co-citation analysis, digital technology continues to be a key innovation engine in the digital economy. Economic activity costs have been significantly decreased, corporate decisions have changed, and digital technology growth that promotes green and sustainable development has been made possible.

Digital technology continues to play a significant role in society, highlighting its revolutionary impact on societal structures, business models, innovation strategies, and economic activities. New forms of economic activity, the disruption of established businesses, and increased global connection have all been made possible by digital technology's ability to encode and transmit information effectively and at a lower cost.

The analysis also reveals significant geographical disparities in the output of research. China, the UK, the USA, and Australia are a few developed countries at the forefront of digital economy research. This can be attributed to their advanced infrastructure, reputable educational institutions, and innovative financial systems. These nations have made significant investments in research and development in the digital economy because they understand its strategic value.

Nevertheless, it is encouraging that developing nations are funding more research in this field. They are catching up as they realize that the digital economy has great possibilities for their growth. Despite inadequate infrastructure and financial challenges, governments and international organizations support these endeavors. Developing nations work hard to develop their digital economy and take advantage of the digital era's opportunities.

The research's findings have significant consequences for both practice and policy. Policymakers ought to invest in research that promotes sustainability and green development in light of the expanding significance of innovation in the digital economy. The dynamic interaction between digital technology and sustainability emphasizes the necessity of regulations that support environmentally conscious behavior and responsible use of technology.

To establish their digital economies, developing nations can learn from the experiences of developed ones. The effectiveness with which industrialized countries have incorporated digital technology into their economic structures emphasizes the value of investing in infrastructure, research, and education. The digital economy can be used by developing nations to boost their economies. However, it will need strategic investments and policies.

Future directions in this field should be determined by a dedication to sustainability, green innovation, and responsible use of digital technologies as this research landscape keeps evolving. Researchers must study the complex relationships between innovation, technology, and the environment. Research topics may change due to the COVID-19 pandemic and other ongoing global events, with a greater emphasis on the effects of digital transformation across different industries.

There are advantages and disadvantages to integrating digital technology into several sectors of the economy, such as healthcare, education, and finance. Researchers will need to look into how the digital economy's innovation impacts various fields and how it might help to address pressing global issues.

5. Conclusions

The fundamental goal of this study to identify the most relevant keywords, the most influential journals and prolific authors, the most prevalent topics among scholars, and upcoming publication trends regarding studies on innovation in the digital economy has been accomplished. The research has significantly contributed to our understanding of innovation in the context of the digital economy through a diligent and thorough investigation of a vast dataset over an extended time. The conclusions of this study provide insightful perspectives for the future and present intriguing opportunities for additional research and analysis in this rapidly developing field.

The article's original aspects encompass a distinctive utilization of scientometric analysis for investigating innovation within the digital economy. The study's distinctive aspect is using these analytical methods to map the research setting, identify keyword trends, and identify significant contributors. The research covers a significant period from 2000 to August 2023, allowing for the discovery of shifts and changes in research focus over time and providing a thorough picture of the field's evolution. The study's data analysis is made more credible and reliable by its reliance on the Scopus database, a highly reliable source of scholarly publications. The study's primary area of focus is innovation in the digital economy, which is a specialist area of study. This focused approach enables an in-depth analysis and deeper insights into a particular aspect of the digital economy.

Furthermore, aspiring researchers can identify new research opportunities by examining publication trends in keywords, authors, citations, sources, countries, high-impact publications by highly regarded authors, international collaboration, and thematic progression using bibliometric analysis. Insight into future research questions can also be provided by using co-occurring keywords in titles and abstracts, thus benefiting future researchers.

This study has limitations, such as relying solely on the Scopus database to find relevant papers. Furthermore, numerous documents were removed owing to a need for more pertinent information. Other academic databases could be employed in future research projects as various evaluations to provide a more thorough qualitative and quantitative assessment of innovation themes in the digital economy—for example, Web of Science (WoS) and PubMed. Limitations outweigh the advantages of the technique in scope; conducting a more rigorous evaluation of a research subject is challenging without first investigating a specific approach and model. As a result, the scientometric method concentrates on the output rather than the article's contents.

Author Contributions: Conceptualization, L.I.H.; methodology, L.I.H.; software, L.I.H.; validation, L.I.H. and D.F.H.; formal analysis, L.I.H.; investigation, L.I.H.; resources, L.I.H.; writing—original draft preparation, L.I.H.; writing—review and editing, L.I.H., E.A., D.D., H.M. and D.F.H.; visualization, L.I.H.; project administration, L.I.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Co-citation clusters as theoretical fundamentals.

Cluster	Ref.	Title	Year	Author Keywords
	(Ma and Zhu 2022)	Innovation in emerging economies: Research on the digital economy driving high-quality green development	2022	Digital economy High-quality green development Smart city Spillover effects
	(Goldfarb and Tucker 2019)	Digital economics	2019	-
	(Nunn and Qian 2014)	US food aid and civil conflict	2014	-

Table A1. *Cont.*

Cluster	Ref.	Title	Year	Author Keywords
Red	(Cao et al. 2021)	Digital finance, green technological innovation, and energy-environmental performance: Evidence from China's regional economies	2021	Digital finance Green technological innovation Energy-environmental performance Difference-in-difference model China
	(Zhang et al. 2022c)	Digital economy and carbon emission performance: Evidence at China's city level	2022	Digital economy Carbon emission performance Mediating effect Nonlinear effect Spatial spillover effect
	(Li et al. 2021a)	Energy structure, digital economy, and carbon emissions: Evidence from China	2021	Energy structure Digital economy Carbon emissions Resource-based province
	(Li et al. 2021b)	Digital economy and environmental quality: Evidence from 217 cities in China	2021	Digital economy Environment Coupling Coordination Threshold Effect PM2.5
	(Nambisan et al. 2019)	The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes	2019	Digital transformation Innovation Entrepreneurship Digital innovation Digital platforms Openness Generativity Affordance
	(Wu et al. 2021a)	How does internet development affect energy-saving and emission reduction? Evidence from China	2021	Internet development Energy saving and emission reduction efficiency Threshold model Spatial Durbin model IV estimation DID
	(Ding et al. 2022)	Digital Economy, Technological Innovation and High-Quality Economic Development: Based on Spatial Effect and Mediation Effect.	2022	Digital economy Green total factor productivity Industrial structure
	(Beck et al. 2010)	Big bad banks? The winners and losers from bank deregulation in the United States	2010	-
	(Chen 2020)	Improving market performance in the digital economy	2020	Digital economy Digitization platforms Search innovation Data protection Privacy

Table A1. *Cont.*

Cluster	Ref.	Title	Year	Author Keywords
Blue	(Tapscott 2016)	The digital economy: Promise and peril in the age of networked intelligence	1996	-
	(Li and Wang 2022)	The dynamic impact of digital economy on carbon emission reduction: Evidence city-level empirical data in China	2022	Digital economy Carbon emission reduction Spatial spillover effect SDM
	(Ma et al. 2022)	The nexus between digital economy and carbon dioxide emissions in China: The moderating role of investments in research and development	2022	Carbon emission Digital economy Research and development Technological innovation Carbon-neutrality China
	(Wu et al. 2021b)	Does internet development improve green total factor energy efficiency? Evidence from China	2021	Internet development Green total factor energy efficiency Spatial Durbin model Dynamic threshold model
	(Pan et al. 2022)	Digital economy: An innovation driver for total factor productivity	2022	Digital economy Total factor productivity Principal component analysis Nonlinear relationship Regional diversity
	(Su et al. 2021)	Does the digital economy promote industrial structural upgrading? A test of mediating effects based on heterogeneous technological innovation	2021	Digital economy Industrial structure upgrading Technological innovation Mediating effect
	(Acemoglu and Restrepo 2018)	The race between man and machine: Implications of technology for growth, factor shares, and employment	2018	-
	(Zhang et al. 2022a)	Digital economy: An innovation driving factor for low-carbon development	2022	Digital economy Low-carbon development Intermediary effect model
	(Yi et al. 2022)	Effects of digital economy on carbon emission reduction: New evidence from China	2022	Digital economy Carbon emission reduction Energy structure Spatial spillover effect Regional heterogeneity
	(Li et al. 2022)	Innovation and Optimization Logic of Grassroots Digital Governance in China under Digital Empowerment and Digital Sustainability	2022	Digital economy Carbon emissions Logistics industry
	(Ren et al. 2021)	Digitalization and energy: How does internet development affect China's energy consumption?	2021	Digitalization Internet development Energy Consumption China
	(Zhu et al. 2022)	Effects of the digital economy on carbon emissions: Evidence from China	2022	Digital economy Carbon emissions Sustainable development Spatial spillover China

References

Abramo, Giovanni, Ciriaco Andrea D'angelo, and Flavia Di Costa. 2023. Correlating article citedness and journal impact: An empirical investigation by field on a large-scale dataset. *Scientometrics* 128: 1877–94. [CrossRef]

Acemoglu, Daron, and Pascual Restrepo. 2018. The Race between Man and Machine: Implications of Technology for Growth, Factor Shares, and Employment. *The American Economic Review* 108: 1488–542. [CrossRef]

Agbozo, Ebenezer. 2020. A Bibliometric Perspective of Digital Economy Research in Russia. In *Digital Transformation and New Challenges*. Edited by Evgeny Zaramenskikh and Alena Fedorova. Cham: Springer International Publishing, pp. 25–36.

Aparicio, Gloria, Txomin Iturralde, and Ana Vilma Rodríguez. 2023. Developments in the knowledge-based economy research field: A bibliometric literature review. *Management Review Quarterly* 73: 317–52. [CrossRef]

Baas, Jeroen, Michiel Schotten, Andrew Plume, Grégoire Côté, and Reza Karimi. 2020. Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies. *Quantitative Science Studies* 1: 377–86. [CrossRef]

Beck, Thorsten, Ross Levine, and Alexey Levkov. 2010. American Finance Association Big Bad Banks? The Winners and Losers from Bank Deregulation in the United States. *Journal of Finance* 65: 1637–67. [CrossRef]

Bornmann, Lutz, and Loet Leydesdorff. 2014. Scientometrics in a changing research landscape. *Embo Reports* 15: 1228–32. [CrossRef]

Bujang, Mohamad Adam, and Tassha Hilda Adnan. 2016. Requirements for Minimum Sample Size for Sensitivity and Specificity Analysis. *Journal of Clinical and Diagnostic Research* 10: YE01–YE06. [CrossRef]

Cao, Shaopeng, Liang Nie, Huaping Sun, Weifeng Sun, and Farhad Taghizadeh-Hesary. 2021. Digital finance, green technological innovation and energy-environmental performance: Evidence from China's regional economies. *Journal of Cleaner Production* 327: 129458. [CrossRef]

Cardona, Melisande, Thomas Kretschmer, and Tobias Strobel. 2013. ICT and productivity: Conclusions from the empirical literature. *Information Economics and Policy* 25: 109–25. [CrossRef]

Chen, Guifu, Jing Han, and Hongwei Yuan. 2022. Urban digital economy development, enterprise innovation, and ESG performance in China. *Frontiers in Environmental Science* 10: 955055. [CrossRef]

Chen, Guo, and Lu Xiao. 2016. Selecting publication keywords for domain analysis in bibliometrics: A comparison of three methods. *Journal of Informetrics* 10: 212–23. [CrossRef]

Chen, Yongmin. 2020. Improving market performance in the digital economy. *China Economic Review* 62: 101482. [CrossRef]

Cobo, Martín, Manuel Jesús, Björn Jürgens, V. Herrero-Solana, M.A. Martínez, and Enrique Herrera-Viedma. 2018. Industry 4.0: A perspective based on bibliometric analysis. *Procedia Computer Science* 139: 364–71. [CrossRef]

Cuéllar-Rojas, Oscar-Andrés, Mauricio Hincapié-Montoya, Manuel Contero, and David Güemes-Castorena. 2022. Bibliometric analysis and systematic literature review of the intelligent tutoring systems. *Frontiers in Education* 7: 1047853. [CrossRef]

da Rosa, Luciana Aparecida Barbieri, Marcos Cohen, Waleska Yone Yamakawa Zavatti Campos, Lucas Veiga Ávila, and Maria Carolina Martins Rodrigues. 2023. Circular economy and sustainable development goals: Main research trends. *Revista de Administração da UFSM* 16: e9. [CrossRef]

Dai, Debao, Yaodong Fan, Guangyu Wang, and Jiaping Xie. 2022. Digital Economy, R&D Investment, and Regional Green Innovation—Analysis Based on Provincial Panel Data in China. *Sustainability* 14: 6508. [CrossRef]

Ding, Chenhui, Chao Liu, Chuiyong Zheng, and Feng Li. 2022. Digital Economy, Technological Innovation and High-Quality Economic Development: Based on Spatial Effect and Mediation Effect. *Sustainability* 14: 216. [CrossRef]

Ellegaard, Ole, and Johan A. Wallin. 2015. The bibliometric analysis of scholarly production: How great is the impact? *Scientometrics* 105: 1809–31. [CrossRef]

Filho, Walter Leal, Anabela Marisa Azul, Tony Wall, Claudio Ruy Portela de Vasconcelos, Amanda Lange Salvia, Arminda Do Paço, Kalterina Shulla, Vanessa Levesque, Federica Doni, Lorena Alvarez-Castañón, and et al. 2021. COVID-19: The impact of a global crisis on sustainable development research. *Sustainability Science* 16: 85–99. [CrossRef]

Fu, Yihang, Yuxiang Mao, Shuangyan Jiang, Sheng Luo, Xiaoyun Chen, and Wei Xiao. 2023. A bibliometric analysis of systematic reviews and meta-analyses in ophthalmology. *Frontiers in Medicine* 10: 1135592. [CrossRef]

Galais, Virginie, Holly Fleming, Niamh Nic Daéid, and Hervé Ménard. 2022. Scientometric analysis of the forensic science literature for fibre as an evidence type: Access and data availability. *Forensic Science International: Synergy* 5: 100269. [CrossRef] [PubMed]

Goldfarb, Avi, and Catherine Tucker. 2019. Digital Economics. *Journal of Economic Literature* 57: 3–43. [CrossRef]

Grau-Sarabia, Mónica, and Mayo Fuster-Morell. 2021. Gender approaches in the study of the digital economy: A systematic literature review. *Humanities and Social Sciences Communications* 8: 201. [CrossRef]

Hanna, Nagy K. 2020. Assessing the digital economy: Aims, frameworks, pilots, results, and lessons. *Journal of Innovation and Entrepreneurship* 9: 16. [CrossRef]

Hermundsdottir, Fanny, Dag Håkon Haneberg, and Arild Aspelund. 2022. Analyzing the impact of COVID-19 on environmental innovations in manufacturing firms. *Technology in Society* 68: 101918–101918. [CrossRef]

Hui, Ning, Qian Yu, and Yu Gu. 2023. Does the Digital Economy Improve the Innovation Efficiency of the Manufacturing Industry? Evidence in Provincial Data from China. *Sustainability* 15: 10615. [CrossRef]

Ichhpujani, Parul, Gagan Kalra, Rishemjit Kaur, Rutvi Chahal, and Suresh Kumar. 2021. COVID-19 and ophthalmology: A scientometric analysis. *Indian Journal of Ophthalmology* 69: 1234–40. [CrossRef]

Imamov, Marsel M., and Natalia B. Semenikhina. 2019. Digitalization of Russian Economy within the Framework of the National Innovation Policy. *Journal of Advanced Research in Law and Economics* 10: 1274–80. [CrossRef]
Jangjarat, Kris, and Chanchai Jewjinda. 2023. Impact of the digital economy and innovation on the businesses of small and medium enterprises. *Corporate and Business Strategy Review* 4: 102–10. [CrossRef]
Kirby, Andrew. 2023. Exploratory Bibliometrics: Using VOSviewer as a Preliminary Research Tool. *Publications* 11: 10. [CrossRef]
Kumar, Suchetan, and Md Safiqur Rahaman. 2019. Research Performance in the Field of Big Data in India: A Scientometric Analysis Based on Scopus Database. Available online: https://digitalcommons.unl.edu/libphilprac/3736 (accessed on 1 September 2023).
Kumpulainen, Miika, and Marko Seppänen. 2022. Combining Web of Science and Scopus datasets in citation-based literature study. *Scientometrics* 127: 5613–31. [CrossRef]
Lazović, Vujica, Milorad Jovović, Tamara Backović, Tamara Djuričković, and Biljana Rondović. 2022. Is Digital Economy a Good Samaritan to Developing Countries? *Sustainability* 14: 8471. [CrossRef]
Lee, Chung-Shing. 2001. An analytical framework for evaluating e-commerce business models and strategies. *Internet Research* 11: 349–59. [CrossRef]
Leitão, João, Pereira Dina, Ângela Gonçalve, and Tiago Oliveira. 2023. Digitalizing the pillars of Hybrid Civic Universities: A bibliometric analysis and new taxonomy proposal. *Journal of Open Innovation: Technology, Market, and Complexity* 9: 100026. [CrossRef]
Li, Feng. 2020. The digital transformation of business models in the creative industries: A holistic framework and emerging trends. *Technovation* 92–93: 102012. [CrossRef]
Li, Junjie, Guohui Zhan, Xin Dai, Meng Qi, and Bangfan Liu. 2022. Innovation and Optimization Logic of Grassroots Digital Governance in China under Digital Empowerment and Digital Sustainability. *Sustainability* 14: 16470. [CrossRef]
Li, Yan, Xiaodong Yang, Qiying Ran, Haitao Wu, Muhammad Irfan, and Munir Ahmad. 2021a. Energy structure, digital economy, and carbon emissions: Evidence from China. *Environmental Science and Pollution Research* 28: 64606–29. [CrossRef]
Li, Zhiguo, and Jie Wang. 2022. The Dynamic Impact of Digital Economy on Carbon Emission Reduction: Evidence City-level Empirical Data in China. *Journal of Cleaner Production* 351: 131570. [CrossRef]
Li, Zihanxin, Nuoyan Li, and Huwei Wen. 2021b. Digital Economy and Environmental Quality: Evidence from 217 Cities in China. *Sustainability* 13: 8058. [CrossRef]
Linnenluecke, Martina K., Mauricio Marrone, and Abhay K. Singh. 2020. Conducting systematic literature reviews and bibliometric analyses. *Australian Journal of Management* 45: 175–94. [CrossRef]
Liu, Yang, Yanlin Yang, Huihui Li, and Kaiyang Zhong. 2022. Digital Economy Development, Industrial Structure Upgrading and Green Total Factor Productivity: Empirical Evidence from China's Cities. *International Journal of Environmental Research and Public Health* 19: 2414. [CrossRef] [PubMed]
Ma, Dan, and Qing Zhu. 2022. Innovation in emerging economies: Research on the digital economy driving high-quality green development. *Journal of Business Research* 145: 801–13. [CrossRef]
Ma, Qiang, Muhammad Tariq, Haider Mahmood, and Zeeshan Khan. 2022. The nexus between digital economy and carbon dioxide emissions in China: The moderating role of investments in research and development. *Technology in Society* 68: 101910. [CrossRef]
Mejia, Cristian, Mengjia Wu, Yi Zhang, and Yuya Kajikawa. 2021. Exploring Topics in Bibliometric Research Through Citation Networks and Semantic Analysis. *Frontiers in Research Metrics and Analytics* 6: 742311. [CrossRef]
Moher, David, Alessandro Liberati, Jennifer Tetzlaff, and Douglas G. Altman. 2010. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *International Journal of Surgery* 8: 336–41. [CrossRef] [PubMed]
Mozelius, Peter, and Niklas Humble. 2022. Content Analysis or Thematic Analysis-Similarities, Differences and Applications in Qualitative Research. [Online]. Available online: https://www.researchgate.net/publication/361063562 (accessed on 1 September 2023).
Nambisan, Satish, Mike Wright, and Maryann Feldman. 2019. The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes. *Research Policy* 48: 103773. [CrossRef]
Nightingale, Julie M., and Gill Marshall. 2012. Citation analysis as a measure of article quality, journal influence and individual researcher performance. *Radiography* 18: 60–67. [CrossRef]
Nunn, Nathan, and Nancy Qian. 2014. US Food Aid and Civil Conflict. *The American Economic Review* 104: 1630–66. [CrossRef]
Oyewola, David Opeoluwa, and Emmanuel Gbenga Dada. 2022. Exploring machine learning: A scientometrics approach using bibliometrix and VOSviewer. *SN Applied Sciences* 4: 143. [CrossRef]
Pan, Wenrong, Tao Xie, Zhuwang Wang, and Lisha Ma. 2022. Digital economy: An innovation driver for total factor productivity. *Journal of Business Research* 139: 303–11. [CrossRef]
Parlina, Anne, Kalamullah Ramli, and Hendri Murfi. 2020. Theme Mapping and Bibliometrics Analysis of One Decade of Big Data Research in the Scopus Database. *Information* 11: 69. [CrossRef]
Patra, Swapan Kumar, and Mammo Muchie. 2021. Scientific and Technical Productivity of African Countries: What Scopus and WIPO Patentscope Data Tell Us? *Journal of Scientometric Research* 10: 355–65. [CrossRef]
Peng, Yongfang, Yingying Fan, and Yi Liang. 2021. A Green Technological Innovation Efficiency Evaluation of Technology-Based SMEs Based on the Undesirable SBM and the Malmquist Index: A Case of Hebei Province in China. *Sustainability* 13: 11079. [CrossRef]
Rejeb, Abderahman, Karim Rejeb, and Horst Treiblmaier. 2023. Mapping Metaverse Research: Identifying Future Research Areas Based on Bibliometric and Topic Modeling Techniques. *Information* 14: 356. [CrossRef]

Ren, Siyu, Yu Hao, Lu Xu, Haitao Wu, and Ning Ba. 2021. Digitalization and energy: How does internet development affect China's energy consumption? *Energy Economics* 98: 105220. [CrossRef]
Rogers, Gordon, Martin Szomszor, and Jonathan Adams. 2020. Sample size in bibliometric analysis. *Scientometrics* 125: 777–94. [CrossRef]
Rojas-Sánchez, Mario A., Pedro R. Palos-Sánchez, and José A. Folgado-Fernández. 2023. Systematic literature review and bibliometric analysis on virtual reality and education. *Education and Information Technologies* 28: 155–92. [CrossRef]
Scuotto, Veronica, Alberto Ferraris, and Stefano Bresciani. 2016. Internet of Things: Applications and challenges in smart cities: A case study of IBM smart city projects. *Business Process Management Journal* 22: 357–67. [CrossRef]
Shushanyan, Ruzanna, and Maria Ohanyan. 2021. How to Perform a Bibliometric Analysis of Journals for Specific Scientific Fields. *Proceedings Metallurgy Material Science Mining Engineering* 2: 9–22. [CrossRef]
Sorescu, Alina, and Martin Schreier. 2021. Innovation in the digital economy: A broader view of its scope, antecedents, and consequences. *Journal of the Academy of Marketing Science* 49: 627–31. [CrossRef]
Soto-Acosta, Pedro. 2020. COVID-19 Pandemic: Shifting Digital Transformation to a High-Speed Gear. *Information Systems Management* 37: 260–66. [CrossRef]
Su, Chao-Ton, Yung-Hsin Chen, and D. Y. Sha. 2006. Linking innovative product development with customer knowledge: A data-mining approach. *Technovation* 26: 784–95. [CrossRef]
Su, Jinqi, Ke Su, and Shubin Wang. 2021. Does the Digital Economy Promote Industrial Structural Upgrading?—A Test of Mediating Effects Based on Heterogeneous Technological Innovation. *Sustainability* 13: 10105. [CrossRef]
Tapscott, Don. 2016. *The Digital Economy: Promise and Peril in the Age of Networked Intelligence*. New York: MCGraw-Hill.
Teece, David J. 2018. Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world. *Research Policy* 47: 1367–87. [CrossRef]
Teece, David J. 2020. Innovation, governance, and capabilities: Implications for competition policy. *Industrial and Corporate Change* 29: 1075–99. [CrossRef]
Tran, Lam Quynh Trang, Dai Thich Phan, and Manh Tuan Nguyen. 2022. Digital Economy: A Comparative Study in ASEAN. *Theory, Methodology, Practice* 18: 83–92. [CrossRef]
Trusova, Natalia. 2019. Government socio-economic policy under the digital economy in the foreign countries and Russia. *Economic Annals-XXI* 180: 88–96. [CrossRef]
Wu, Guancen, Qian Xu, Xing Niu, and Li Tao. 2022. How Does Government Policy Improve Green Technology Innovation: An Empirical Study in China. *Frontiers in Environmental Science* 9: 799794. [CrossRef]
Wu, Haitao, Yan Xue, Yu Hao, and Siyu Ren. 2021a. How does internet development affect energy-saving and emission reduction? Evidence from China. *Energy Economics* 103: 105577. [CrossRef]
Wu, Haitao, Yu Hao, Siyu Ren, Xiaodong Yang, and Guo Xie. 2021b. Does internet development improve green total factor energy efficiency? Evidence from China. *Energy Policy* 153: 112247. [CrossRef]
Xu, Jianing, and Weidong Li. 2022. The Impact of the Digital Economy on Innovation: New Evidence from Panel Threshold Model. *Sustainability* 14: 15028. [CrossRef]
Yi, Ming, Yafen Liu, Mingyue Selena Sheng, and Le Wen. 2022. Effects of digital economy on carbon emission reduction: New evidence from China. *Energy Policy* 171: 113271. [CrossRef]
Yu, Dejian, and Huchang Liao. 2016. Visualization and quantitative research on intuitionistic fuzzy studies. *Journal of Intelligent & Fuzzy Systems* 30: 3653–63. [CrossRef]
Yu, Dengke, and Hongling Yan. 2021. Relationship Between Knowledge Base and Innovation-Driven Growth: Moderated by Organizational Character. *Frontiers in Psychology* 12: 663317. [CrossRef] [PubMed]
Yu, Wenling, Lipai Zhang, and Chen Yang. 2023. The impact of the digital economy on enterprise innovation behavior: Based on CiteSpace knowledge graph analysis. *Frontiers in Psychology* 14: 1031294. [CrossRef]
Zemtsov, Stepan. 2020. New technologies, potential unemployment and 'nescience economy' during and after the 2020 economic crisis. *Regional Science Policy & Practice* 12: 723–43. [CrossRef]
Zhang, Jinning, Yanwei Lyu, Yutao Li, and Yong Geng. 2022a. Digital economy: An innovation driving factor for low-carbon development. *Environmental Impact Assessment Review* 96: 106821. [CrossRef]
Zhang, Jinzhu, Wenqi Zhao, Baodong Cheng, Aixin Li, Yanzhuo Wang, Ning Yang, and Yuan Tian. 2022b. The Impact of Digital Economy on the Economic Growth and the Development Strategies in the post-COVID-19 Era: Evidence From Countries Along the "Belt and Road". *Frontiers in Public Health* 10: 856142. [CrossRef]
Zhang, Junhua. 2022. A Comprehensive Evaluation of China's Digital Economy: A Comparative Study with the U.K. and the U.S. Available online: https://www.atlantis-press.com/proceedings/esfct-22/125980627 (accessed on 1 September 2023).
Zhang, Wei, Xuemeng Liu, Die Wang, and Jianping Zhou. 2022c. Digital economy and carbon emission performance: Evidence at China's city level. *Energy Policy* 165: 112927. [CrossRef]
Zhang, Xi, Yao Meng, Hui Chen, Jiang Yu, Yongqiang Sun, Patricia Ordóñez de Pablos, and Joy Wei He. 2017. A Bibliometric Analysis of Digital Innovation from 1998 to 2016. *Journal of Management Science and Engineering* 2: 95–115. [CrossRef]

Zhou, Bin, Haoxiang Zhao, Jingyue Yu, Taiyi He, and Jiawei Liu. 2022. Does the growth of the digital economy boost the efficiency of synergistic carbon-haze governance? evidence from China. *Frontiers in Environmental Science* 10: 984591. [CrossRef]
Zhu, Zhichuan, Bo Liu, Zhuoxi Yu, and Jianhong Cao. 2022. Effects of the Digital Economy on Carbon Emissions: Evidence from China. *International Journal of Environmental Research and Public Health* 19: 9450. [CrossRef] [PubMed]