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Review

A Survey of Digital Government: Science Mapping Approach, Application Areas, and Future Directions

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Abstract: With the rapid development of digital technologies, digital transformation reshapes the functioning of governments. Digital government (DG) aims to leverage technology to enhance the delivery of public services, improve efficiency, and foster transparency. Embracing DG is a strategic imperative for governments looking to provide effective, transparent, and citizen-centric services in the 21st century. Therefore, many government organizations have intensified their DG efforts in response to its necessity. However, there is little clarity in the previous literature and a lack of uniform understanding among government employees, policymakers, and citizens regarding the concept of DG. Therefore, this study aims to analyze current DG research with science mapping, classify the research areas, and propose future directions for upcoming studies. A search was conducted on Web of Science and Scopus databases since the year 2000. VOSViewer software was used for visualizing and exploring bibliometric networks. This study is one of the first attempts to examine the DG area using the science mapping approach. Selected publications were categorized into research areas, and future directions were presented to bridge the identified research gaps. According to our results, the five main research areas are DG transformation, cybersecurity, public participation and social media, open government data and transparency, and e-Government adoption models. This study guides practitioners, academics, policymakers, and public employees in planning their future studies.

Keywords: digital government; e-Government; digital transformation; systematic literature review; science mapping

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1. Introduction

Digital technologies are no doubt transforming societies. The McKinsey Global Institute highlighted digital technology adoption as the most critical factor for future economic growth, accounting for about sixty percent of potential productivity growth by 2030. Digital technologies support governments in engaging with their stakeholders (e.g., citizens, businesses, and government agencies) and improve government legitimacy by operating more transparently, giving governments win–win opportunities through technology and automation [1]. Electronic Government (e-Government) initiatives are also becoming increasingly popular [2]. The "e-Government" concept is evolving into the idea of "digital government" (DG) over time with the utilization of new technologies (e.g., mobile applications, data analytics, social media, open data, and the Internet of Things (IoT)) [3]. The four types of DG interactions are studied in the related literature: (1) government-to-citizens (G2C) (the government intends to interact with citizens); (2) government-to-business (G2B) (the government intends to interact with business enterprises); (3) government-to-government (G2G) (the government intends to make services more friendly, transparent, convenient, and inexpensive); (4) government-to-employee (G2E) (the government intends to empower employees to help citizens in the most appropriate and fastest way, speed up administrative processes, and optimize governmental solutions) [4]. Based on the existing research [5,6], we define DG as a government that is organized progressively in terms of virtual agencies, cross-agency, and public-private networks to deliver improved public services and advance

its relationships with citizens, the private sector, and civil society by improving service delivery modes and creating public value.

In the late 1990s to early 2000s, DG operated by one-way government-oriented operations at a national level; paper transactions were replaced by Worldwide Web (i.e., www) technologies, and key information and communication technology (ICT) areas were infrastructure management. In the late 2000s to early 2010s, DG operations focused on citizen-oriented operations, collaborative governance was aimed, Web 2.0 technologies and open-source computing power were driving technologies, and key ICT areas were people and data. Since the mid-2010s, DG has focused on individual-oriented operations, data, and evidence-based decision making as a management tool, providing that public services anytime and anywhere are achievable. Key ICT areas have been cloud computing, machine learning, and IoT. In late 2010–2019, smart ubiquitous infrastructure was implemented where user-driven public services with personalized access to real-time interactions were employed. Key ICT areas were cognitive systems and advanced analytics. From 2020 to the present, citizen-managed relationships were achieved by implementing whole-of-life services with seamless interaction with the public sector, and key ICT areas were digital twinning [7]. Despite considerable investments in the last three decades, there is still a need to transform governments. Although this transformation is on the agenda of the public sector itself, government employees, policymakers, citizens, and businesses are not all actors understanding the same under a DG. People's and businesses' expectations and interactions with governments change continuously. Meeting such new expectations constitutes a great challenge for governments [8].

Many recently published studies have discussed DG. Some reviews examined local governments in specific regions or countries [9,10]. Others studied the DG architecture by examining the challenges and problems in investigating the research agenda [11–13]. Other review papers focused on knowledge management in the public sector and open government data (OGD) [14,15]. None of these studies about DG so far have applied science mapping to capture the literature by examining their key terms. Science mapping applies visualization methods to ensure a novel approach to dynamically discover new frontiers [16].

The complex structure of these studies indicates a need to progress the research in the DG field by classifying the existing studies. This study presents a systematic literature review with science mapping about DG. Our literature review aims to answer the following research problem about future studies' construction on the concept of DG based on existing research. We have further developed the following RQs for this research problem:

- RQ1: what is the state of the art of DG?
- RQ2: what are the research fields (i.e., article type, applied methods, technology, and country) of the research on DG?
- RQ3: what are the popular research areas of DG?
- RQ4: what are the limitations of the existing research on DG?
- RQ5: what are the future research directions of DG?

The main contributions of this review can be listed as follows:

(1) We present the preliminaries of DG, such as the definitions and the research fields, and summarize the existing research on DG.

(2) Based on the existing literature, we utilize VOSviewer [17], an instrument for text mining, to perform bibliometric analysis for following the latest developments and illustrating the main areas of DG.

(3) According to the analysis of the existing research, we point out the limitations of the present research concerning DG and present the potential future research directions.

Our critical academic and practical contribution lies in classifying the selected publications into five distinct research areas with science mapping to support researchers in discussing new literature-related findings. Constructing the co-occurrence, bibliographic coupling, and co-citation networks can allow us to find proximate research areas, author collaboration, sources with the most citations, and the most examined countries. At the

very least, such a map can help trace the relationship changes as discoveries are made over time [16]. This study uses bibliometric maps to handle the limitations of subjective human judgments. Although the interpretation of the bibliometric maps is based on subjective reviews, this technique can significantly decrease the impact of human factors. In other words, this technique offers an objective perspective for analyzing DG research. Therefore, integrating subjective and objective analyses improves the quality of our literature review. This paper may inspire other academics, practitioners, policymakers, and public employees to better comprehend the subject, set up a theoretical framework, discover research gaps, and identify future directions in the field of DG.

The overall framework of the study is illustrated in Figure 1. The study has the following structure: Section 2 summarizes the methodology of the literature review; Section 3 provides the current situation of the literature; the science mapping based on keyword co-occurrence analysis, bibliographic coupling, and co-citation analysis is provided in Section 4; the research gaps, potential study directions, and concluding remarks are presented in Section 5.

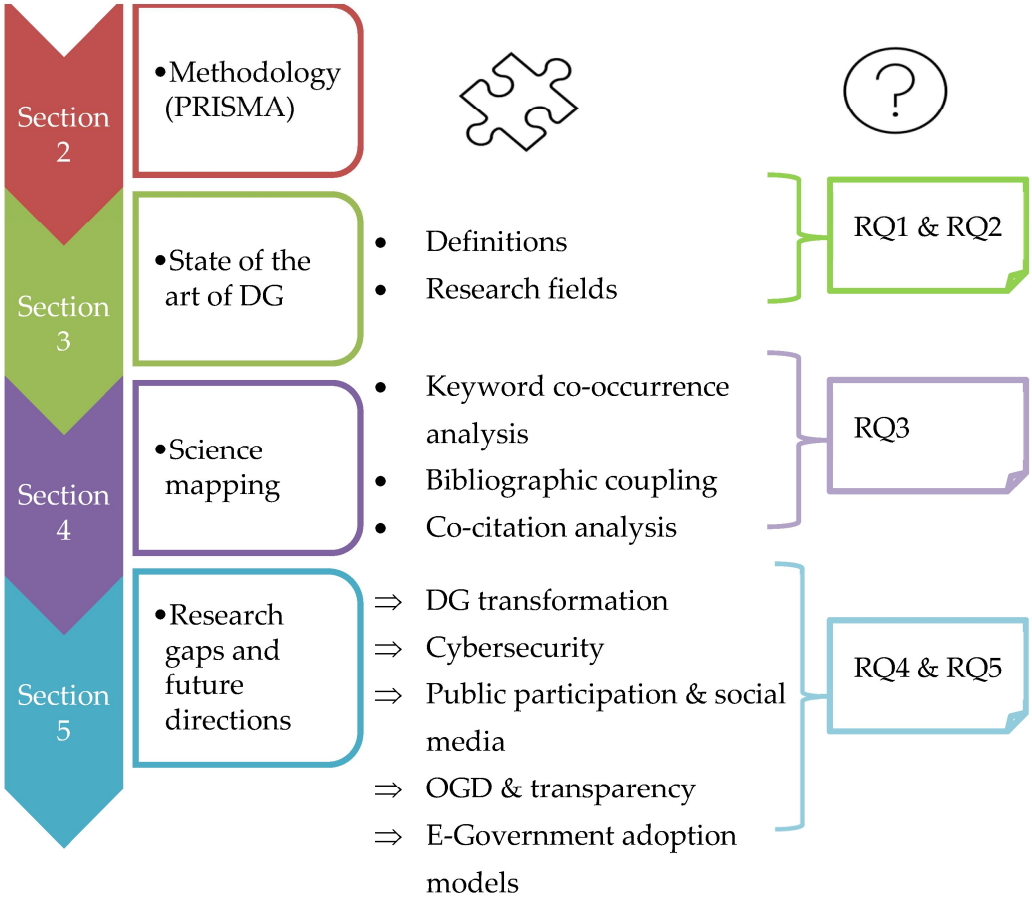

Figure 1. The overall survey framework.

2. Methodology

This study presents a systematic review using PRISMA (preferred reporting items for systematic reviews and meta-analyses) guidelines for searching activities, as illustrated in Figure 2 [18]. At the very start, we collected data from the WoS and Scopus databases, the details of which are provided in Section 2.1. Then, we pre-processed the data to remove duplications.

In the literature review (i.e., the left side of Figure 2), the abstracts and full texts were first screened to identify those articles that would be included in the detailed analysis. Only publications in the related areas were included. Dissertation theses and industry papers about DG were added to the selected articles. In science mapping (i.e., the right side of Figure 2), the pre-processed data (n = 11,917) were transferred to VOSViewer. Then,

the keyword co-occurrence analysis, bibliographic coupling, and co-citation analysis were applied to create bibliometric networks. The clusters were determined, and the research on the DG subject was visualized through maps.

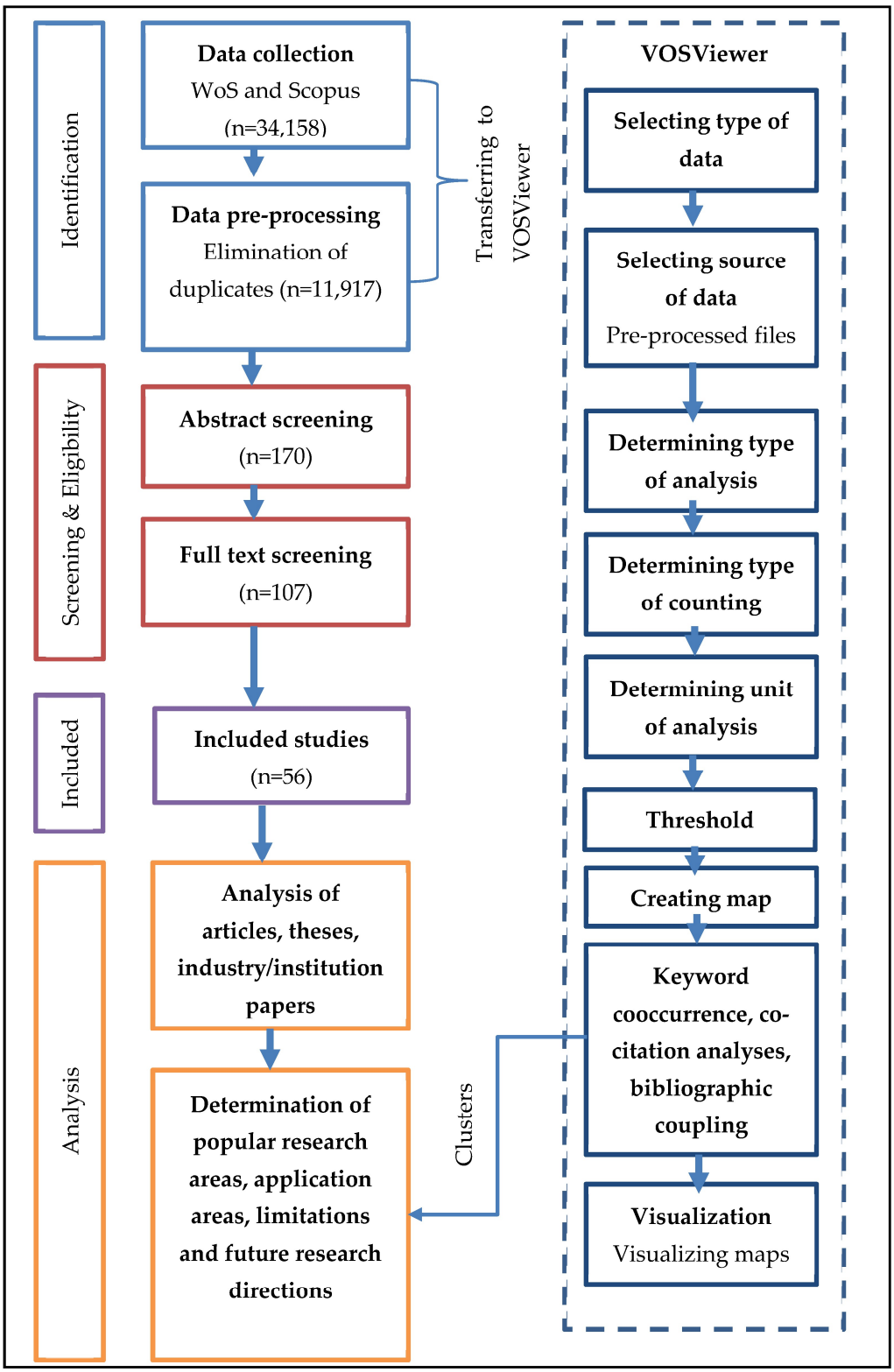

Figure 2. The PRISMA flow guiding the review methodology.

2.1. Data Collection and Data Extraction

The first step of bibliometric analysis is to gather the required metadata (e.g., references, authors, citations, and countries). The two largest databases are Scopus from Elsevier and the Web of Science (WoS) from Clarivate Analytics. In this paper, data were collected from these two databases. The search strings were used for the "topic" field in the WoS core collection. This ensured that the results included the selected keyword in the documents' titles, abstracts, and author keywords. In Scopus, the search strings were used for the "article title, abstract, keywords" field. The databases were searched with the following keywords with 6 queries:

"digital government"; "e-Government"; "digital technology" AND "government"; "digital transformation" AND "government"; "platform" AND "government"; "ICT" AND "government".

The search was restricted to the criteria given in Table 1. Then, restraints were applied to the year (documents published after 2000), language (English), and document type (articles) [19]. Following this, duplicates within and between WoS and Scopus search results, first within the same database and then between both databases, were eliminated by removing articles with identical DOIs, ending up with 11,917 records.

Table 1. The number of papers on data extraction phases (source: authors' own elaboration).

Search Keywords	1. Initial Search		2. Year (2000–2023)		3. Language (English)		4. Document Type (Article)	
	WoS	**Scopus**	**WoS**	**Scopus**	**WoS**	**Scopus**	**WoS**	**Scopus**
1. "digital government"	687	1184	686	1183	657	1145	387	404
2. "e-Government"	10,724	17,766	10,717	17,761	10,289	16,570	5514	5237
3. "digital technology" AND "government"	555	2110	550	2087	532	1997	407	972
4. "digital transformation" AND "government"	782	1298	782	1298	722	1226	466	497
5. "platform" AND "government"	17,727	14,834	11,009	17,202	10,388	16,261	6661	7928
6. "ICT" AND "government"	5032	7420	5021	7393	4755	7190	2732	2953
Total	35,507	44,612	28,765	46,924	27,343	44,389	16,167	17,991

After duplications were eliminated, 170 abstracts were screened and examined based on their aims, methods, and findings. Then, 107 full texts were examined regarding their contents, originality, methods, and findings. To analyze the DG subject, 56 articles were included, and these articles were examined in detail.

2.2. Data Analysis with Science Mapping

Science mapping aims to build bibliometric maps defining how research areas, scientific fields, or disciplines are socially, conceptually, and intellectually formed [20].

In this paper, we selected VOSViewer version 1.6.15., since it is a powerful and efficient tool for the graphical illustration of bibliometric maps. It is compelling to introduce large bibliometric maps in an efficiently interpretable way [17]. VOSviewer provides the main functions needed for generating, visualizing, and discovering bibliometric networks.

The terminology should be clear to better make sense of the maps created by the software. Items are the objects of interest (e.g., researchers, publications, or terms), and a link is a relationship or a connection between two items. A network is a set of items together with the links between the items. A cluster is a set of items grouped in a map. In VOSViewer, clusters are non-overlapping [17].

Natural language processing algorithms are used to determine the terms in the text data. Bibliographic data can be used in VOSviewer for WoS, Scopus, PubMed, RIS, or Crossref JSON files. For further details, the work of Van Eck and Valtman [17] can be consulted.

3. State of the Art of DG

3.1. Definitions of DG

In the related literature, there is no proper agreement on the definition of DG, and different conceptualizations contain and focus on various aspects [21]. In this section, different definitions of "DG"; "e-Government"; "Government 4.0"; "m-Government", "t-Government", and "GaaP" from different sources are presented. Figure 3 illustrates these definitions [4,5,22–26].

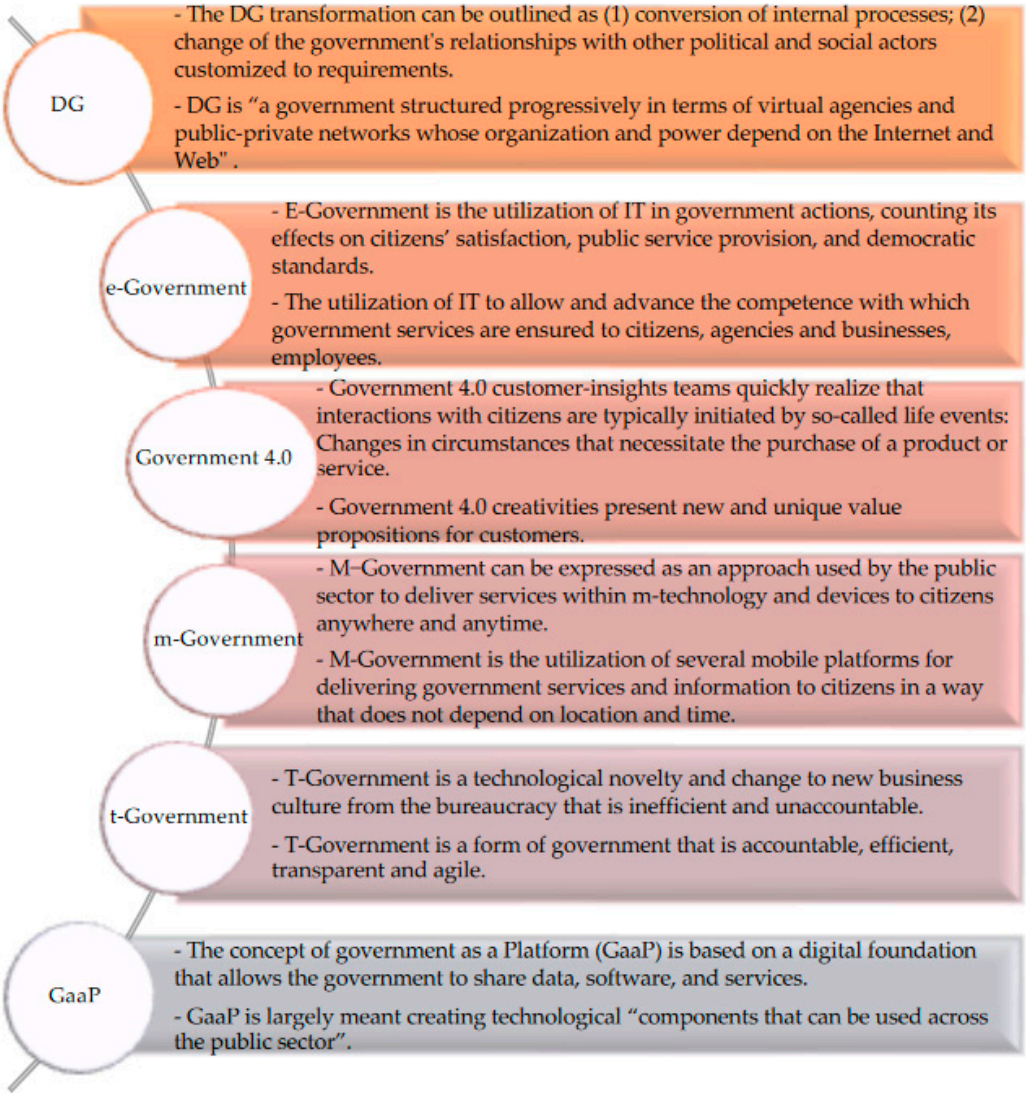

Figure 3. Definitions of concepts [4,5,22–26].

3.2. Research Fields of DG

The number of publications with the "digital government" keyword published from 2000 to 2023 November is illustrated in Figure 4. In the first 17 years, the number of journal articles grew steadily. Our research shows a solid increasing trend from 2018 to 2020. The number of journal articles increased from 28 in 2018 to 55 in 2020. In 2021, 53 articles were published. In 2022, 83 publications showed the growing attention to studies related to the DG subject. Until November 2023, there were 101 studies, and the increasing trend is expected to continue until the end of 2023.

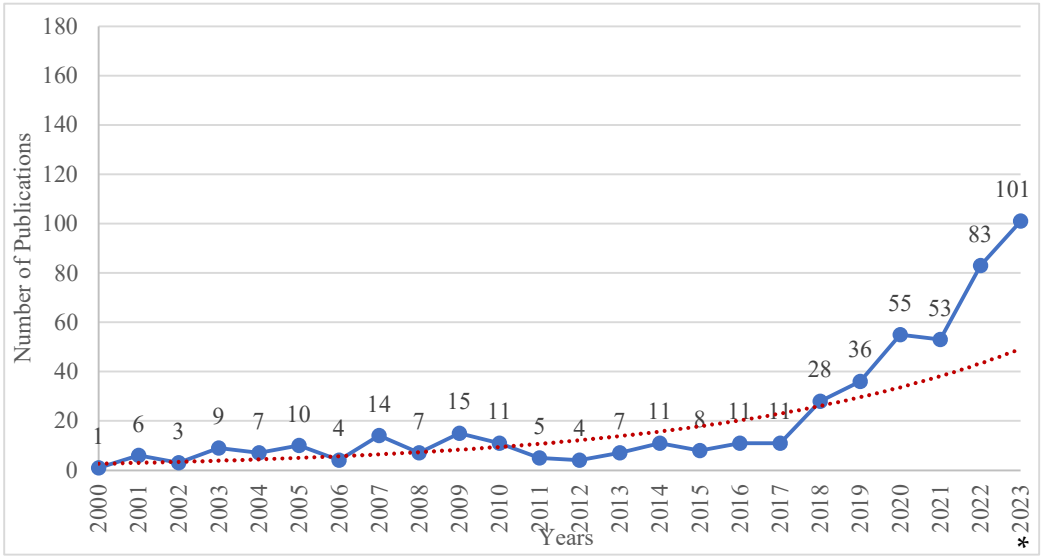

Figure 4. The number of publications published 2000–2023 (Source: Scopus, November 2023). * This number indicates the publications until November 2023.

The selected 56 articles were examined according to year, author(s), article type, system, applied methods, technology, and country, as shown in Appendix A, Table A1. Our examination by article type aimed to distinguish research articles from review articles. As seen in Figure 5, 71.43% of the examined documents were research articles, while 28.57% were review articles. The applied methods were examined to find the literature gaps from an analytical perspective. Technologies and countries were examined to see which country was studied for which technology in the related literature.

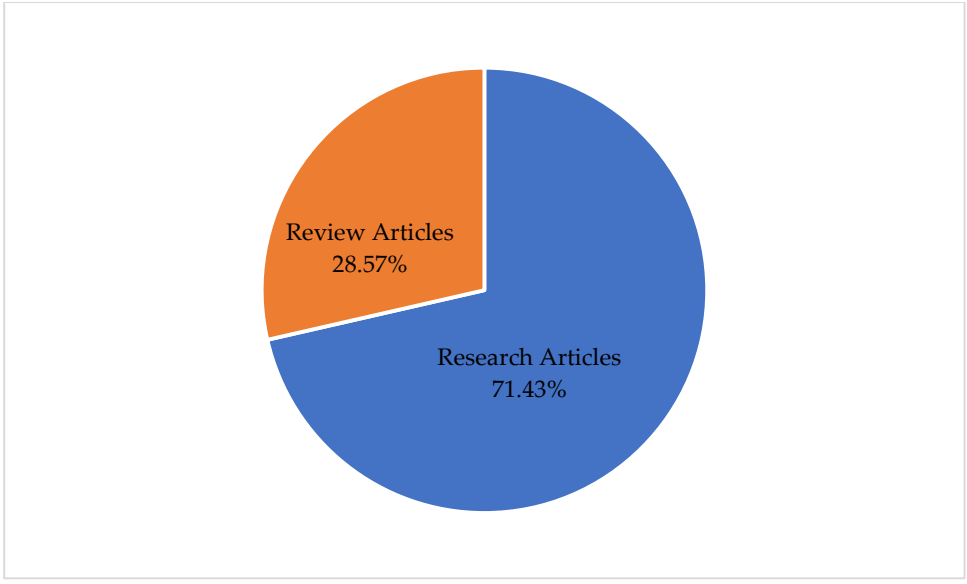

Figure 5. The percentages of article types in examined articles.

The chronological evolution of the examined technologies in DG research between 2004 and 2023 is, respectively, IT, IS, ICT, government websites, e-services, e-voting, e-procurement, online tax filing, OGD, e-Government, social media, DG platform, and digital technologies (i.e., IoT, machine learning, blockchain, and artificial intelligence). Table 2 provides the percentage of technologies used in the examined articles. ICT is the most examined technology at 26.68%; digital technologies are the second at 16.66%; OGD is the third at 13.33%; websites and e-services have an equal percentage (10%).

Table 2. The percentages of the examined technologies in academic articles.

Technology	Percentage
IT, IS, and ICT	26.68%
Digital technologies	16.66%
OGD	13.33%
Websites	10%
e-services	10%
e-voting	6.67%
DG platform	6.67%
e-procurement	3.33%
Online tax filing	3.33%
IoT	3.33%

Our findings reveal that DG, e-Government, e-Government services, OGD, and GaaP are the most frequently examined systems, as seen in Figure 6. The countries investigated in the articles provided in Table A1 can be listed according to their frequency in descending order: UK, USA, China, Turkey, Denmark, Mexico, Republic of Korea, Australia, Austria, Bahrain, Belgium, Cyprus, Estonia, Greece, Kuwait, Malaysia, Pakistan, Peru, Russia, Saudi Arabia, South Africa, Switzerland, and Thailand. The methods in the research articles provided in Table A1 can be listed according to their frequency in descending order: case study, hypothesis testing, descriptive analysis, qualitative analysis, comparative analysis, design science research, interpretative structural modeling (ISM), application development, ANOVA, classification and regression tree (CART), data envelopment analysis (DEA), frequency analysis, fuzzy cognitive map, online survey, and simulation. Review articles applied analysis methods such as systematic review, interviews, conceptual analysis, content analysis method, meta-analysis, science mapping approach, thematic analysis, and weight analysis.

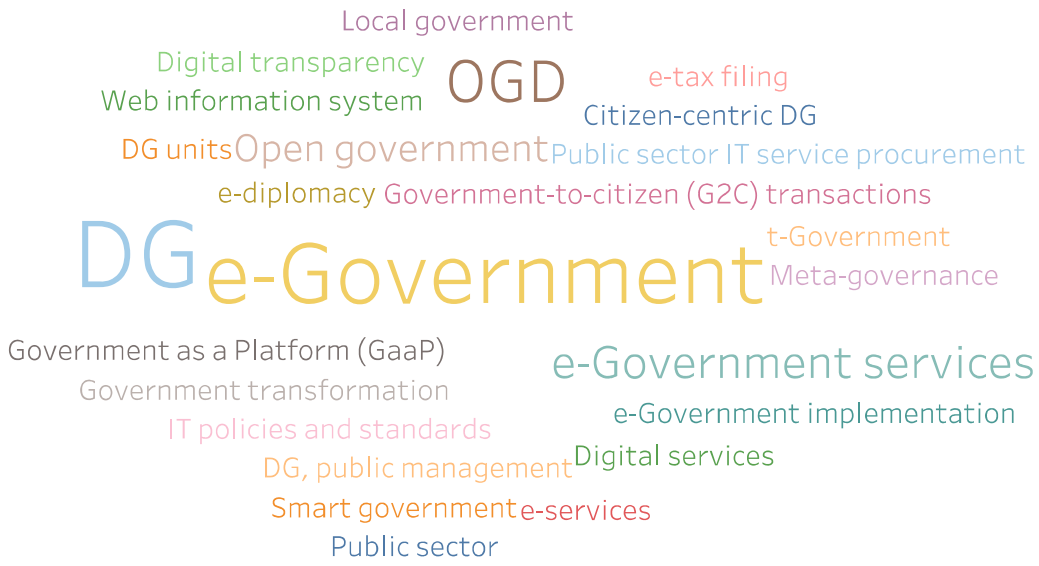

Figure 6. The word cloud based on systems in examined articles.

In Table A2, the selected 12 theses were categorized according to their subject, system, and country. Their subject and system were included to discover the DG terminology and research fields within the theses. Generally, the theses realized in the DG concept were based on implementation and adoption models. Developing countries (i.e., Nigeria, Tanzania, Egypt, Bangladesh, and Kosovo) were examined in an essential part of the thesis, with case studies about e-Government, smart government, DG, and m-Government systems (please refer to Appendix A).

The selected 19 reports from international organizations (e.g., WEF, OECD, and the European Commission) and top-tier advisory companies (e.g., Deloitte, McKinsey, and

PwC) are provided in Table A3, Appendix A. These reports' source, system, and country were analyzed. The systems examined in these reports included smart nation, DG, DG transformation, future of work, e-Government, digital economy and society index, DG 5.0, and digital transition framework. The countries examined in these reports were Canada, China, EU27+, Singapore, Spain, Italy, UK, Belgium, Poland, and Thailand.

The reports usually investigated best practices, examined successful implementations, and made valuable recommendations for other countries. McKinsey [1] highlighted three challenges for digital technologies' utilization in governments' operations: (1) workers' skills are usually insufficient; (2) future works are less inclusive and more unequal without reforms; (3) resistance to automation. According to WEF [27], collaboration is more essential than ever to achieve the successful digital transformation goal for governments.

Based on the report of OECD [28], the main dimensions of DG are illustrated in Figure 7. They were designed in the DG policy instrument of OECD to ensure effective digital transformation of the public sector.

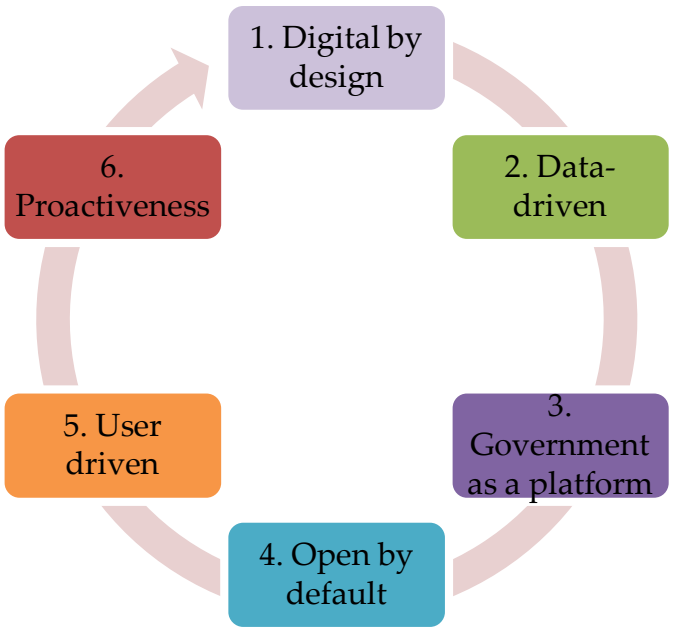

Figure 7. Dimensions of DG (source: [28]).

The majority of such reports discussed DG initiatives of several countries and various case studies about digital technology implementation of governments and presented key recommendations for governments to meet their citizens' expectations and solve challenges related to digital technology implementation.

4. Science Mapping

4.1. Keyword Co-Occurrence Analysis

VOSviewer is used for a keyword co-occurrence analysis to create a visualization based on clustering. Keywords characterize the focused topics of a scientific field. Keyword networks can show how a knowledge body is constructed by studying the interrelationships of research fields [17].

The different clusters of the most common keywords in the articles (n = 11,917) are displayed in Figure 8, and the keywords in each of the clusters are listed in Table A4, Appendix A. Different colors make the most featured topics in the literature more visible. The sizes of the circles in Figure 8 represent the occurrences of the keywords. The larger the size of the circles, the higher the frequency of occurrence of keywords in the articles.

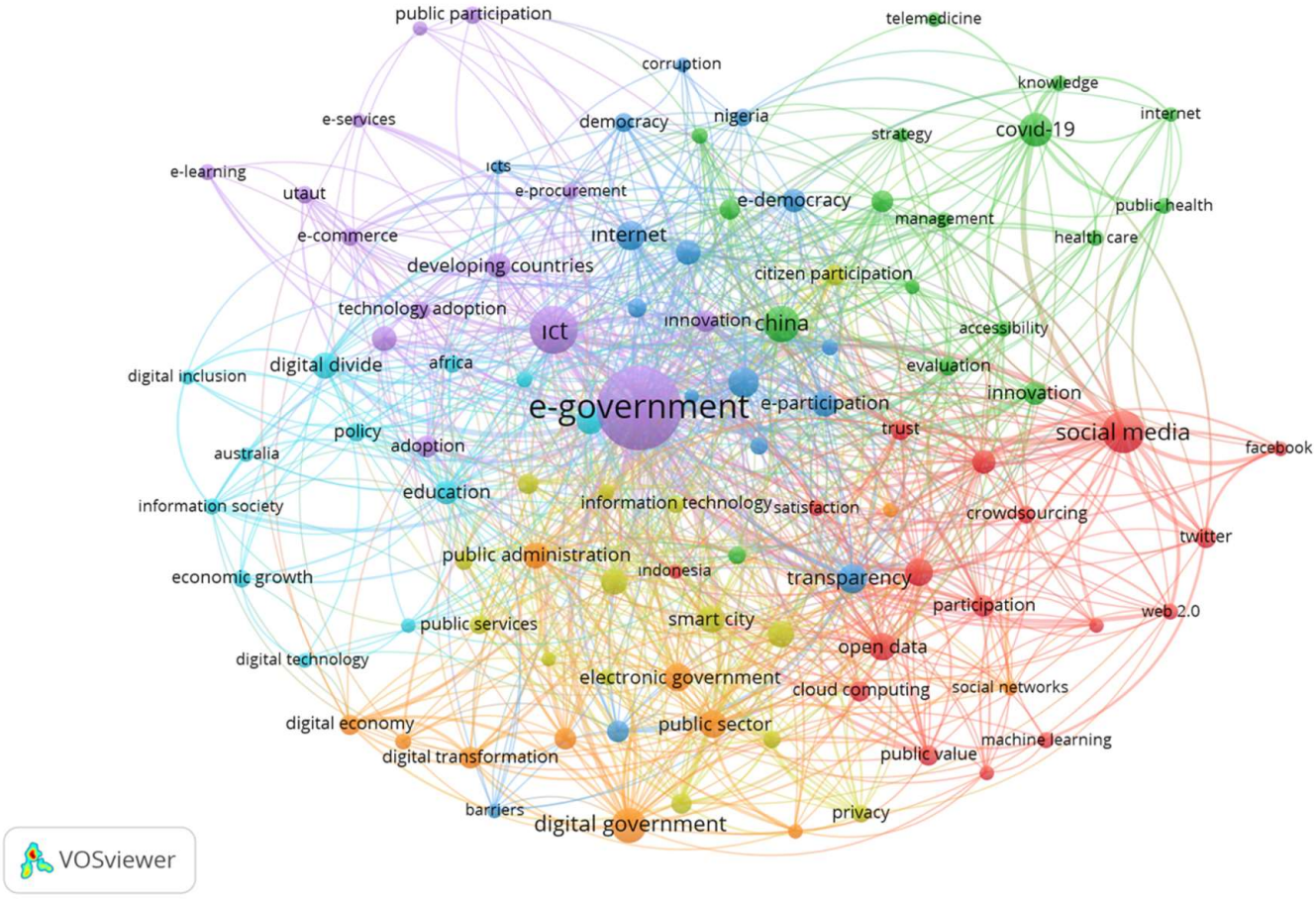

Figure 8. Network visualization of keyword co-occurrence analysis.

This analysis found 101 items, 7 clusters, and 942 links, with a total length strength of 1596. Full counting was used as the counting method. The author keyword was selected as the unit of analysis, the threshold value was determined as 10, and 101 keywords met the threshold. The keyword "e-Government" was found as the most frequent keyword, with 330 occurrences and a total link strength of 354.

From the keyword co-occurrence analysis, we grouped clusters into five research areas:

- Research Area 1: DG transformation from clusters 4, 6, and 7

"Digital government", "digital transformation" and "digitalization" were the most frequently studied keywords from cluster 7. Other key research topics from clusters 4, 6, and 7 involved "government", "smart city", and "smart cities". Furthermore, "sustainability", "sustainable development", "security" "digital divide", and "education" concepts have also been frequently studied in the DG literature. In the acceleration of DG transformation, data exchanges across the "public sector" should be expanded by technologies to construct an integrated and sustainable system [29]. The most promising "digital technologies" for governments were found as "artificial intelligence", "blockchain", and "big data".

- Research Area 2: cybersecurity from clusters 1 and 4

Cybersecurity as a general concept has been gaining relevance because of its strategic importance for society, citizens, companies, and countries. To solve "trust", "privacy", and "security" issues on "information technologies" and "information and communication technologies", cybersecurity practices are implied. Moreover, the utilization of digital technologies such as "blockchain" and "artificial intelligence" in government applications necessitates secure and efficient end-to-end processing capabilities, avoiding fraud and rising "transparency" and "trust" between stakeholders.

- Research Area 3: public participation and social media from cluster 1

"Social media", especially "Twitter" and "Facebook", has an important utilization rate for the public sector. These technologies can be used for: (1) information transmission from the government to the public; (2) information transmission from the public to the government; and (3) building and supporting networks between the government and the public and within the public at large [30]. In the studies about public participation and social media, "participation", "public value", "local government", "trust", "satisfaction", and "e-democracy" were the most frequently used keywords.

- Research Area 4: OGD and transparency from clusters 1 and 3

OGD programs have been applied in several countries, political systems, and cultures at sub-national and municipal levels. The social and political benefits of "open government" comprise greater "transparency" and "accountability" [31]. Generally, the absence of transparency in government actions and decision-making practices causes "corruption" scandals [32]. The success of OGD programs necessitates an integrated use of complementary tools for "collaboration" with citizens and "stakeholders" [33].

- Research Area 5: E-Government adoption models from clusters 2, 3, and 5

In this analysis, "e-Government" was the most frequently studied keyword; it has been an evolving trend in recent years, attracting the interest of policymakers, citizens, bureaucrats, and "public administration" researchers. In the "adoption" of "e-services", "e-democracy", "e-governance", and "e-participation", their "accountability" should be considered [4,6,32]. "Governance" is the key to government systems, and "e-governance" defines the responsibility of an organization's online presence and who has the power to make decisions [29]. In "China", e-Government research focuses on "public health". In this context, the "COVID-19" keyword is included in the majority of the studies, since it has an accelerating effect using "digital technologies" such as "telemedicine" [27,34].

4.2. Bibliographic Coupling

Bibliographic coupling can group thematically parallel documents into clusters. Two documents can have a citation link between them if one document comprises a cited reference that has a matching key consistent with one of the match keys representing the other document. In the bibliography, the number of bibliographic coupling links between two publications equals the number of pairs of cited references in the two publications. Bibliographic coupling maps can be constructed for the level of documents, sources, authors, organizations, or countries [17].

In this analysis, the counting method was selected as full counting, the unit of analysis was selected as countries, and the maximum country number for each document was selected as 25 in order to ignore those publications that were co-authored by many countries. The minimum number of documents in a country was set to 5. Out of the 134 countries, 78 countries met the threshold. Table 3 provides the top 10 countries; Figure 9 displays the bibliographic coupling.

Table 3. Top 10 countries resulting from bibliographic coupling.

Rank	Countries	Total Link Strength
1	United States	154,856
2	United Kingdom	60,938
3	China	60,193
4	Spain	52,452
5	Australia	49,109
6	India	44,454
7	Netherlands	35,359
8	Canada	34,610
9	South Korea	34,031
10	Malaysia	30,097

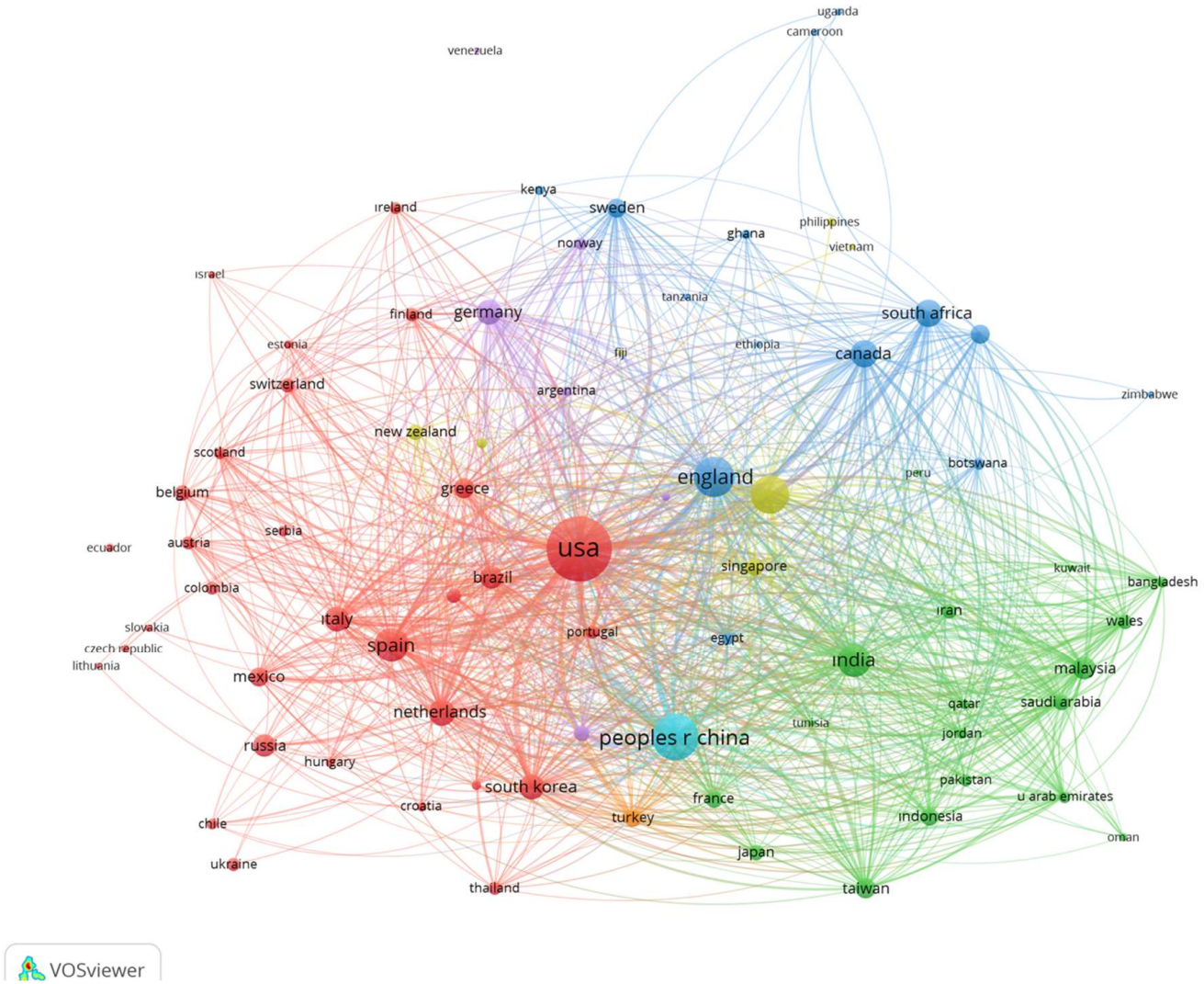

Figure 9. Overlay visualization of bibliographic coupling regarding countries.

The bibliographic coupling analysis shown in Figure 9 and Table 3 indicates that the United States had the highest total link strength. The United Kingdom and China were ranked as the second- and the third-ranked countries, respectively. Therefore, this bibliographic coupling analysis showed that the themes of the documents published in the United States, the United Kingdom, and China showed great similarities.

4.3. Co-Citation Analysis

The connection between journals in terms of co-citation links are represented by the distance between them in the visualization. The citation attribute shows the number of citations made to a cited source, a cited reference, or a cited author [17].

In this analysis, the counting method was selected as full counting, the unit of analysis was selected as cited sources, the minimum number of citations of a source was selected as 50, and 263 sources met the threshold. Figure 10 displays the document co-citation analysis regarding sources. Figure 10 illustrates the clusters' colors that indicate the similar types of journals having common co-citation links.

The analysis shows that the most-cited journal was *Government Information Quarterly*, followed by *Public Administration Review* and *Management Information Systems Quarterly*.

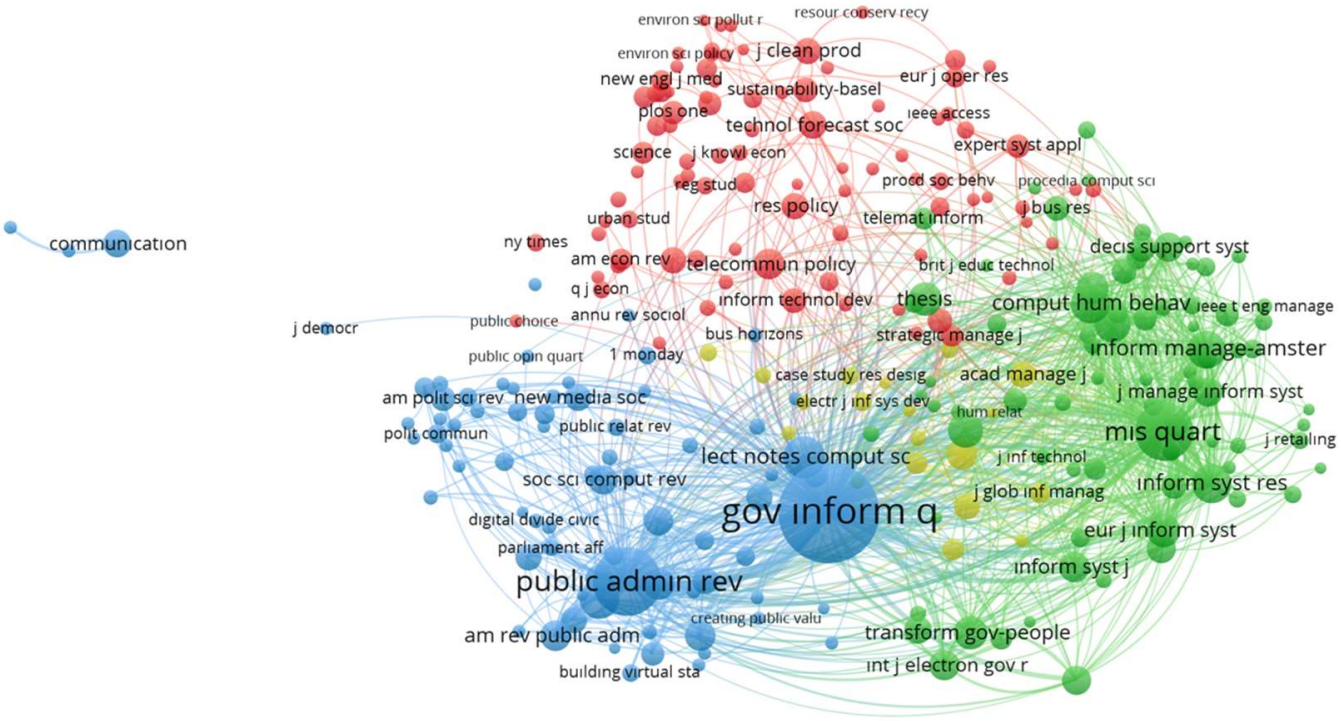

Figure 10. Document co-citation analysis (sources).

5. Findings and Discussion

Since DG transformation plays a vital role in the public sector's agenda, this study aimed to analyze current DG research by applying a science mapping approach. The selected publications were grouped into five distinct research areas to support scholars in discussing new literature-related findings as a theoretical contribution of this research. As a practical contribution, the practitioners, academics, policymakers, and public employees can be inspired and guided by this paper to better comprehend the subject, set up a theoretical framework, discover research gaps, and identify future directions in the field of DG.

Because government employees, policymakers, citizens, and businesses are not all actors who understand the same under a DG, the DG terminology is clarified in RQ1. The literature was analyzed by examining the articles, industry reports, and theses in RQ2 to identify the research fields in DG. VOSViewer software was utilized for creating bibliometric maps based on clustering, and the research areas are determined in RQ3. The limitations of the existing research are identified in RQ4, and the future research directions are proposed in RQ5. The findings of the RQs are detailed in the following sections.

5.1. RQ1: What Is the State of the Art of DG?

The terminology of DG is divided into six concepts: "digital government", "e-Government", "government 4.0", "mobile government", "t-Government", and "GaaP". These concepts have distinguishing features; however, they can be used interchangeably with each other.

To summarize, DG is a government structured progressively in terms of virtual agencies whose organization and power depend on the Internet. E-Government is IT utilization in government services, counting its effects on citizens' satisfaction, public service provision, and democratic standards. Government 4.0 focuses on whole-of-government alignment for citizens. Several mobile platforms are used in m-Government for delivering government services and information to citizens. The t-Government concept aims to achieve an accountable, efficient, transparent, and agile government. The main objective of the GaaP concept is to create technological components that can be used across the public sector [4,5,22–25].

5.2. RQ2: What Are the Research Fields (i.e., Article Type, Applied Methods, Technology, and Country) of the Research on DG?

Our findings from the academic literature reveal the research fields of the DG literature as follows:

- Article type: 71.43% of the examined articles are research articles, while 28.57% are review articles.
- Applied methods: In the research articles, case study, hypothesis testing, descriptive analysis, qualitative analysis, comparative analysis, design science research, interpretative structural modeling (ISM), application development, ANOVA, classification and regression tree (CART), data envelopment analysis (DEA), frequency analysis, fuzzy cognitive map, online survey, and simulation are used. In the review articles, analysis methods such as systematic review, interviews, conceptual analysis, content analysis method, meta-analysis, science mapping approach, thematic analysis, and weight analysis are used.
- Technology: ICT is the most examined technology; digital technologies are the second. Other technologies include IT, IS, ICT, government websites, e-services, e-voting, e-procurement, online tax filing, OGD, e-Government, social media, DG platform, and digital technologies (i.e., IoT, machine learning, blockchain, and artificial intelligence).
- Country: the countries investigated in the articles are UK, USA, China, Turkey, Denmark, Mexico, South Korea, Australia, Austria, Bahrain, Belgium, Cyprus, Estonia, Greece, Kuwait, Malaysia, Pakistan, Peru, Russia, Saudi Arabia, South Africa, Switzerland, and Thailand.

Our findings from the industry reports reveal the research fields of the DG literature as follows:

- System: the systems examined in these reports include smart nation, DG, DG transformation, future of work, e-Government, digital economy and society index, DG 5.0, and digital transition framework.
- Country: the countries examined in the reports are Canada, China, EU27+, Singapore, Spain, Italy, the U.K., Belgium, Poland, and Thailand.

5.3. RQ3: What Are the Popular Research Areas of DG?

The science mapping approach was used for determining the popular research areas of DG. Keyword co-occurrence analysis was conducted on VOSviewer. A bibliometric map based on clustering was achieved at the end of the analysis. Five popular research areas of DG are determined as follows:

- Research Area 1: DG transformation;
- Research Area 2: cybersecurity;
- Research Area 3: public participation and social media;
- Research Area 4: OGD and transparency;
- Research Area 5: e-Government adoption models.

Due to the increase in the number of articles in 2018, the time horizon was divided into three sub-periods: 2004–2017, 2018–2020, and 2021–2023. The keywords in the clusters provided in Figure 8 were examined based on these sub-periods, as shown in Figure 11. According to Figure 11, research area 1 was mainly extended in 2021–2023 with keywords such as DG, digital transformation, digitalization, and digital technology. Research area 2 was mainly discussed in the 2018–2020 time period with security keywords, while trust and privacy keywords were popular research trends between 2004 and 2017. Research area 3 was popular in the 2018–2020 period with social media keywords. While some social media platform keywords (i.e., Facebook) were popular in those years, others (i.e., Twitter) were popular in 2021–2023. Open government and transparency keywords in research area 4 were popular in 2004–2017, while open data were popular in 2018–2020. Research area 5 was mainly popular in the 2004–2017 time period.

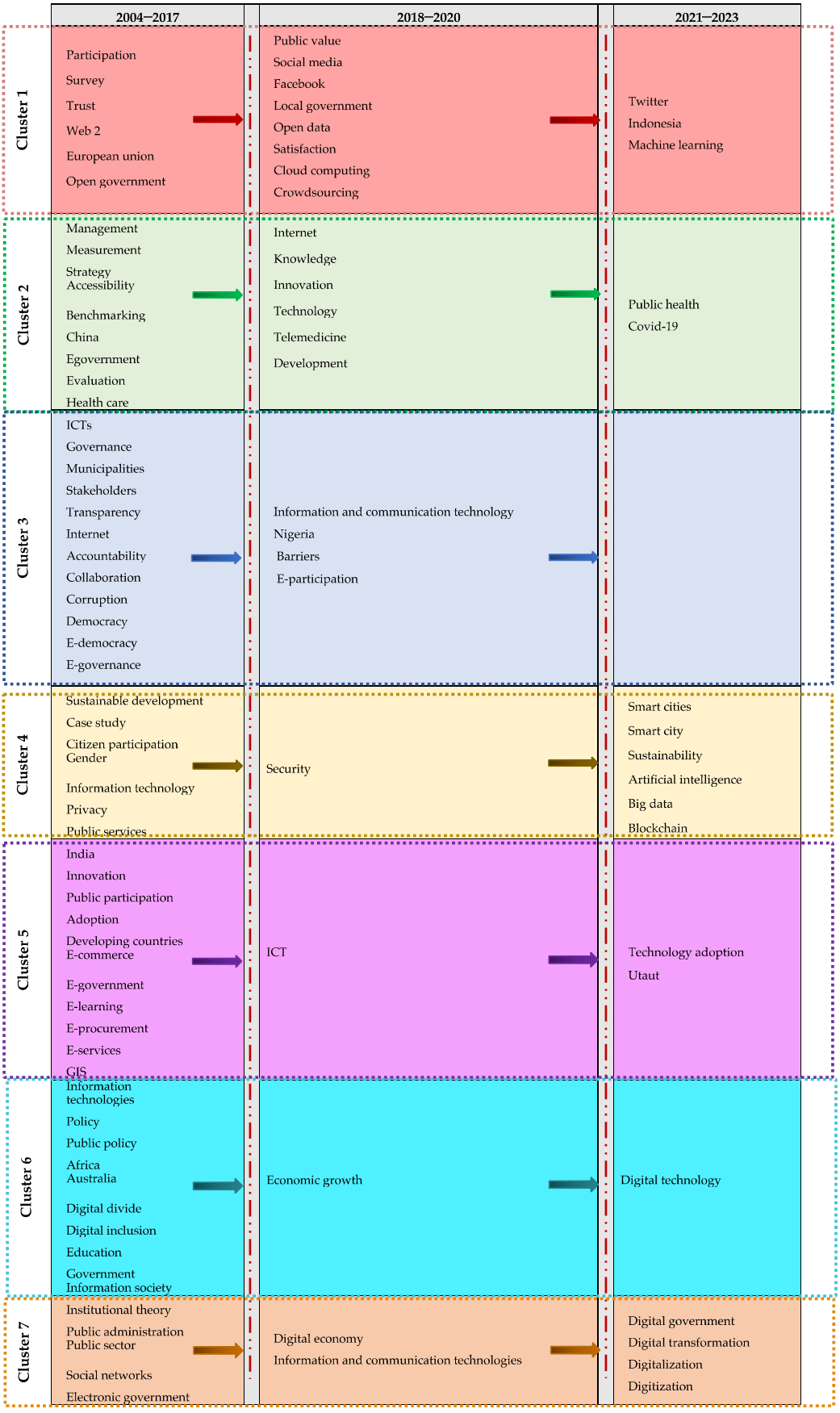

Figure 11. Thematic evolution of DG based on the keywords.

5.4. RQ4: What Are the Limitations of the Existing Research on DG?

The limitations of the existing research on DG according to the five research areas can be summarized as follows:

- DG transformation: The DG literature is mainly based on qualitative research, therefore quantitative research on the subject can be developed. One of the most significant research gaps in the DG transformation literature is frameworks examining seamless service delivery and adaptive workplaces in governments [35–37].
- Cybersecurity: Our findings reveal a lack of studies developing practices for governments to enhance citizens' security. Therefore, government cybersecurity systems and sustaining trust in public services are the major research gaps in the literature [38–40].
- Public participation and social media: The literature lacks in discussing e-participation in comprehending citizens' expectations of public participation [16,41–44]. The security, privacy, and nepotism problems should be addressed in the literature to successfully implement social media utilization and e-voting systems [40,45,46].
- OGD and transparency: The factors that influence the performance of OGD programs should be analyzed. The analysis of data generation at local, national, and regional levels is essential for the body of research on OGD and transparency [47,48].
- E-Government adoption models: In the adoption of e-Government, citizens' perceptions of trust should be analyzed. The literature lacks studies about blockchain technology utilization in e-Government for effective and safe processing capabilities [35,49–52].

5.5. RQ5: What Are the Future Research Directions of DG?

According to the results of our study, the future research directions of DG are identified as follows:

- Integrating the DG field with operation research, data mining, and multi-criteria decision-making techniques;
- Proposing cybersecurity frameworks to analyze governments' cybersecurity capabilities;
- Examining citizens' incentives in e-participation;
- Analyzing e-voting systems and increasing public trust;
- Examining factors that influence the performance of OGD programs;
- Developing an ecosystem approach for OGD planning;
- Implementing blockchain technology to enhance transparency and trust in the DG ecosystem;
- Comparing citizens' perception of trust for similar public services in traditional means and their e-Government versions.

6. Future Directions for Research Areas

Our literature review and science mapping analysis show that the most prevalent topics in the field of DG can be grouped into five research areas: public participation and social media, OGD and transparency, e-Government adoption models, cybersecurity, and DG transformation. The recommendations for future research according to gaps in the research areas are discussed in the following sections.

6.1. DG Transformation

One key focus of research has been successful DG transformation. For example, Ashaye and Irani [2] examined the influencing factors and the relationships with stakeholders on successful DG implementation. Mahundu [53] studied the socio-technical effects of DG implementation. Almamari [54] investigated organizational culture's role in DG transformation. Hussain [22] constructed a mobile-based DG implementation framework and applied this model to two countries.

Seamless service delivery (personalized, frictionless, and anticipatory), adaptive workplaces in government, and generating greater public value from governments and agile governments present the biggest research gaps in DG transformation [55]. The DG litera-

ture is mainly based on qualitative research. Although quantitative research is appropriate for evaluating DG, few studies have combined the subject with analytical techniques. For this reason, integrating the study of DG with operational research, data mining, and multi-criteria decision-making techniques can prove helpful. The research integrating the subject with those techniques will certainly gain from further diverse perspectives and be closer to real-life problems [35–37].

6.2. Cybersecurity

In the related literature, security and trust issues among different stakeholders are investigated. Weerakkody et al. [56] found in their literature review article that trust was one of DG's most widely explored keywords. Weerakkody et al. [52] investigated the impact of trust on user satisfaction with e-Government services, where it was identified as a significant factor. Hasan et al. [6] aimed to determine critical success factors for citizen-centric DG, and the authors found trust to be one of the determinants of success. Mahmood et al. [57] examined government transformation's influence on citizen trust and confidence. Kam et al. [39] analyzed the effect of self-motivation of public employees on cybersecurity training.

Our review shows a lack of studies providing practices for governments to increase citizens' trust and security. Government cybersecurity systems and sustaining public trust in government are the major research gaps in the literature [38]. Cybersecurity can potentially enhance the trust and security of citizens by protecting against unauthorized access to data centers and other computerized systems. Thus, cybersecurity can help governments adopt DG services by preventing mistrust. In future studies, different cybersecurity frameworks can be constructed to analyze governments' cybersecurity capabilities in different dimensions.

6.3. Public Participation and Social Media

Alarabiat et al. [41] searched citizens' motivations for e-participation through Facebook and found that e-participation via social media platforms was not necessarily beneficial without citizens' awareness. Another study by Weerakkody et al. [24] revealed that the exchange and collaboration between stakeholders was an important barrier for government systems.

The Internet can help construct a democratic and inclusive framework. Further research is necessary to shed light on the context essential to facilitate citizens' participation in public affairs and the e-participation actions mobilized by citizens in various social media contexts [42]. The issues of security, privacy, and nepotism were to be addressed in successful e-voting systems to increase public trust [40,45,46]. However, the literature fails to sufficiently discuss e-participation in comprehending citizens' expectations from such participation [16,41–44].

6.4. OGD and Transparency

Generating value from OGD implies a rise in data quantities and the enhancement of the capacity to detect high-value data geared to increasing use. Governments have a key role in data publishing to provide open data and spur collaboration [28]. Bright et al. [58] described usage patterns in OGD with hypothesis testing. Dawes et al. [31] developed an OGD ecosystem model for planning and design, while Srimuang et al. [59] presented an assessment model for OGD by conducting an online survey. Matheus and Janssen [15] constructed a comprehensive model for OGD, and Porumbescu et al. [33] proposed a framework for open government in their literature review article.

OGD literature can be further expanded by examining those factors that influence the performance of OGD programs, as well as by investigating data generation at local, national, and regional levels [47,48]. An ecosystem approach can be used for OGD planning [31,60], system quality, data quality, and organizational characteristics. Individual characteristics have a crucial impact on OGD [15], which can benefit from more attention from government managers, policymakers, and researchers.

6.5. E-Government Adoption Models

In the e-Government concept, people trust the government and its ability to deliver services, solve problems as promised, and safeguard personal information. Therefore, e-services will require the assurance that citizens' privacy and security are protected. Weerakkody et al. [52] examined the impact of trust on user satisfaction of e-Government services, where it was identified as a significant factor. Hasan et al. [6] aimed to determine critical success factors of citizen-centric DG, with trust being found to be one of the determinants of success. Pérez-Morote et al. [61] analyzed e-Government usage in European countries, and the authors found that communication and promotion strategies are essential in the citizen-centric e-Government policy. Li and Shang [62] revealed that service quality, satisfaction, and value are the main reasons for continuously utilizing e-Government platforms. Patergiannaki and Pollalis [63] assessed the e-Government maturity of Greek municipalities, where population, ideology, and budget were found to have a limited influence.

In future studies, comparing citizens' perceptions of trust for similar public services in traditional means and their digital versions would be possible. In addition, researchers will be implored to examine blockchain technology for more effective and safe processing capabilities, such as fraud prevention, transparency, and confidence enhancing the DG [35,49–52]. The opinions of government employees against citizens' perceptions, habits, trust, self-efficacy, and social influences can be examined in future studies. Furthermore, citizens can be sampled randomly as potential users and non-users to investigate their opinions [10,45,50,52].

7. Concluding Remarks

Governments implement various projects to promote DG. The subject has caught the attention of academics, industrial practitioners, government agencies, and advisory companies. A significant number of papers have committed to the study of DG since 2000. This paper introduces a structured literature review of DG leveraged by the science mapping approach, especially for 2000–2023. In this context, the state of the art of DG, the research fields and the popular research areas of DG, the limitations in the existing research on DG, and potential future research directions are determined. Our findings show that there exists an evolutionary trend in the DG field.

Articles, theses, and reports were examined to investigate the research fields of DG. We utilized the VOSviewer software for advanced bibliometric analysis, with a visual presentation of the results. Raw bibliographic records collected from Scopus and WoS databases were pre-processed to eliminate duplicates. The maps were created using keyword co-occurrence, bibliographic coupling, and co-citation networks. With the keyword co-occurrence analysis, the articles' most important keywords were determined and clustered. Then, the following five main popular research areas were identified: (1) DG transformation, (2) cybersecurity, (3) public participation and social media, (4) OGD and transparency, and (5) e-Government adoption models.

To our knowledge, this study is the first attempt to examine the DG literature using the science mapping methodology and contributes to the literature in several ways.

State-of-the-art DG was presented, and the publications were classified with science mapping using a practical and illustrative approach. Science mapping allowed us to discover the most frequently examined keywords, the most collaborative countries, and the most cited sources.

Possible subjective evaluations were avoided by using bibliometric maps in the science mapping approach. In this way, a more objective literature analysis was presented compared with previous review studies in the literature. This analysis allowed us to present today's research areas and future directions.

From a managerial standpoint, the findings from this paper may serve as an anchor for academicians, practitioners, policymakers, and public employees. The following trends for future research were identified: citizens' incentives in e-participation, e-voting systems increasing public trust, examining factors that influence the performance of OGD programs, an ecosystem approach for OGD planning, blockchain technology to enhance transparency

and trust in the DG ecosystem, comparing citizens' perception of trust for similar public services in traditional means and their e-Government versions, cybersecurity frameworks to analyze governments' cybersecurity capabilities, and integrating the DG field with operation research, data mining, and multi-criteria decision-making techniques.

In this study, only English-language articles were included; conference papers and publications in other languages have yet to be incorporated. This paper primarily relied on data from Scopus and WoS databases. Nevertheless, other databases and grey literature sources may contain relevant information not covered by Scopus and WoS. Extending this analysis by containing more research in future review studies would enhance the generalizability of the findings. While this study focused on articles, theses, and reports, it may underrepresent practical insights from industry practitioners. In future extensions, incorporating more perspectives from professionals involved in DG implementation could provide a more balanced view.

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Appendix A

Table A1. Articles concerning DG subject.

Year	Author (s)	Type	System	Applied Methods	Technology	Country
2004	Gil-Garcia [64]	Review Article	IT policies and standards	Comparative Review	Information technology (IT)	-
2008	Kim et al. [65]	Research Article	Web information system	Data Mining	Information systems (IS)	Republic of Korea
2010	Magoutas and Mentzas [66]	Research Article	e-Government services	Case Study	e-services	Austria
2011	Andersen et al. [67]	Research Article	e-Government	Case Study	IS	Denmark
2014	Osman et al. [35]	Research Article	e-Government services	The Proposed COBRA (Cost, Benefit, Risk, Opportunity) Model	e-services	Turkey
2014	Weerakkody et al. [56]	Review Article	e-Government	Weight Analysis, Meta-Analysis	-	-
2015	Bright et al. [58]	Research Article	OGD	Hypothesis Testing	Websites	UK
2015	Weerakkody et al. [68]	Review Article	e-Government	Systematic Review	-	-
2016	Dawes et al. [31]	Research Article	OGD	Case Study	OGD programs	USA and Russia
2016	Weerakkody et al. [52]	Research Article	e-Government	Hypothesis Testing, Descriptive Analysis, Structural Model Testing	-	UK
2017	Alcaide–Muñoz et al. [16]	Review Article	e-Government	Science Mapping Approach	-	-
2017	Margetts and Naumann [26]	Research Article	Government as a Platform (GaaP)	Comparative Analysis	-	Estonia and UK
2018	Al-Muftah et al. [37]	Research Article	e-diplomacy	Interpretative Structural Modeling (ISM)	ICT	USA, UK, and Qatar

Table A1. *Cont.*

Year	Author (s)	Type	System	Applied Methods	Technology	Country
2018	Choi et al. [69]	Research Article	Public sector IT service procurement	Fuzzy Cognitive Map, Simulation	IT services	Russia
2018	Gil-Garcia et al. [70]	Review Article	DG, public management	Systematic Review	-	-
2018	Guenduez et al. [71]	Review Article	Smart government	Qualitative Analysis	-	Switzerland
2018	Hasan et al. [6]	Research Article	Citizen-centric DG	Frequency Analysis	Digital technologies	Malaysia
2018	Srimuang [59]	Research Article	OGD	Survey, Online Assessment	OGD web-based application	Thailand
2019	Akram et al. [50]	Research Article	e-tax filing	Hypothesis testing, ANOVA	Online tax filing	Pakistan
2019	Ashaye and Irani [2]	Research Article	e-Government implementation	Qualitative Analysis	-	-
2019	Khatib et al. [72]	Research Article	Government-to-citizen (G2C) transactions	Hypothetic Deductive Approach	-	Kuwait
2019	Mahmood et al. [57]	Research Article	Government transformation	Hypothesis Testing	-	Bahrain
2019	Osman et al. [73]	Research Article	e-Government services	Data Envelopment Analysis (DEA), Classification and Regression Tree (CART)	e-services	Turkey
2019	Weerakkody et al. [24]	Research Article	e-Government services	Case Study	e- services	UK
2020	Chen et al. [74]	Research Article	e-Government	Hypothesis Testing	-	-
2020	Clarke [12]	Review Article	DG units	Interviews, Document Analysis	-	-
2020a	Gil-Garcia et al. [75]	Review Article	Public sector	Conceptual Analysis	IoT	-
2020b	Gil-Garcia et al. [76]	Research Article	Open government	Randomized Survey Experiment, ANOVA	-	USA
2020c	Gil-Garcia and Flores-Zúñiga [21]	Review Article	DG	Hypothesis Testing	-	Mexico
2020	Gjaltema et al. [77]	Review Article	Meta-governance	Systematic Review	-	-
2020	Gong et al. [78]	Review Article	DG	Case Study	-	China
2020a	Kaya et al. [45]	Research Article	e-Government	Qualitative Analysis	e-voting	Turkey
2020b	Kaya et al. [46]	Research Article	e-Government	Descriptive Analysis	e-voting	Cyprus
2020	Long and Gil-Garcia [79]	Research Article	e-Government	Online Survey	Online services, websites	China
2020	Matheus and Janssen [15]	Review Article	OGD	Content Analysis Method	-	-
2020	Omar et al. [80]	Review Article	t-Government	Descriptive Analysis, Thematic Analysis	-	-
2020	Porumbescu et al. [33]	Review Article	Open government	Randomized Survey Experiment	IT	-
2021	Luna-Reyes et al. [81]	Research Article	DG	Case Study, System Dynamics	-	USA
2021	Matheus et al. [32]	Research Article	Digital transparency	Design Science Research	-	-
2022	Alshallaqi [82]	Research Article	e-Government	Case Study	Digital technologies, AI-enabled solutions	-

Table A1. *Cont.*

Year	Author (s)	Type	System	Applied Methods	Technology	Country
2022	Chen et al. [83]	Research Article	Local government	Survey, Hypothesis Testing	e-procurement	-
2022	Choi et al. [84]	Research Article	DG	Comparative Analysis	ICT, portal-based platform, OGD	Republic of Korea and Denmark
2022	Makki and Alqahtani [29]	Research Article	DG	ISM	-	Saudi Arabia
2022	Ndlovu et al. [85]	Research Article	DG	Hypothesis Testing	DG platform	South Africa
2022	Newman et al. [86]	Review Article	DG	Systematic Review	Digital technologies, AI	-
2022	Puron-Cid et al. [87]	Research Article	DG	Principal Component Analysis	Digital technologies, ICT, government websites	Mexico
2022	Shen et al. [36]	Research Article	DG	Case Study	DG platform	China
2022	Simonofski et al. [88]	Research Article	OGD	Design Science Research	OGD portals	Belgium
2022	Wilson et al. [13]	Review Article	DG	Literature Review, Interviews	-	USA
2022	Young [30]	Research Article	Digital services	Survival Analysis	ICT, social media, smartphone	-
2023	Castilla et al. [43]	Research Article	DG	Application Development	Digital technologies	Peru
2023	Li et al. [10]	Research Article	DG	Hypothesis Testing	Websites	China
2023	Patergiannaki and Pollalis [63]	Research Article	e-Government	Regression	-	Greece
2023	Sterrenberg et al. [89]	Research Article	e-Government	Case Study	-	Australia

Table A2. Theses concerning DG subject.

Year	Author	Subject	System	Country
2008	AL-Shehry [90]	E-Government Adoption Model	e-Government	Saudi Arabia
2010	Re [91]	Quality of Digital Services in E-Government	e-Government	-
2014	Ashaye [92]	E-Government Implementation	e-Government	Nigeria
2015	Mahundu [53]	Higher Education Institutions' Service Provision and Quality Assurance	e-Government	Tanzania
2016	Almamari [54]	DG Implementation	DG	Oman
2016	ElKheshin [4]	E-Government Service Adoption Model	e-Government	Egypt
2017	Hussain [22]	Mobile-Based Government (M-Government) Implementation	m-Government	Bangladesh and Australia
2017	Nikaj [93]	Technology-Enabled State Building	e-Government	Kosovo
2019	Meijer [94]	E-Government Innovation Platform	e-Government	Netherlands
2021	Ekinci [95]	Smart Government Transformation	smart government	Estonia and Singapore
2022	McDaniel [96]	E-Governance in Urban Planning	e-Government	USA
2023	Sapraz [97]	E-Government and Environmental Sustainability	e-Government	Sri Lanka

Table A3. Industry reports on DG subject.

Year	Source	System	Country
2018	CLC [98]	Smart Nation	Singapore
2018	Microsoft [99]	DG Transformation	-
2018	OPDC [100]	Government Innovation Lab	Thailand
2019	Deloitte [101]	DG Transformation	-
2019	European Commission [7]	DG Transformation	Belgium, Italy, Poland, Spain, and UK
2019	Merics [102]	DG	China
2020	McKinsey [1]	Future of Work	-
2020	OECD [28]	DG Policy Framework	-
2020	United Nations [103]	E-Government	Several countries
2021	Deloitte [34]	DG Transformation	-
2021	Institute for Government [25]	DG	UK
2021	PwC [104]	DG	Canada
2022	Deloitte [38]	DG Trends	-
2022	European Commission [105]	E-Government Benchmark	EU27+
2022	European Commission [106]	Digital Economy and Society Index (DESI)	EU27+
2022	The World Bank [107]	DG Transformation-GovTech	Several countries
2022	McKinsey [108]	DG Transformation	Several countries
2022	PwC [109]	DG 5.0	-
2023	WEF [27]	Digital Transition Framework	-

Table A4. Keywords for co-occurrence analysis.

Clusters (Colors)	Number of Items	Items and Their Occurrences
Cluster 1 (red)	17	1. Cloud computing (21) 2. Crowdsourcing (16) 3. European Union (10) 4. Facebook (11) 5. Indonesia (10) 6. Local government (27) 7. Machine learning (12) 8. Open data (35) 9. Open government (36) 10. Participation (23) 11. Public value (19) 12. Satisfaction (13) 13. **Social media (85) *** 14. Survey (10) 15. Trust (20) 16. Twitter (21) 17. Web 2.0 (12)
Cluster 2 (green)	16	1. Accessibility (13) 2. Benchmarking (11) 3. **China (60) *** 4. COVID-19 (52) 5. Development (20) 6. E-Government (15) 7. Evaluation (17) 8. Health care (12) 9. Innovation (25) 10. Internet (10) 11. Knowledge (13) 12. Management (11) 13. Measurement (12) 14. Public health (13) 15. Strategy (10) 16. Technology (22) 17. Telemedicine (10)

Table A4. *Cont.*

Clusters (Colors)	Number of Items	Items and Their Occurrences
Cluster 3 (blue)	16	1. Accountability (23) 2. Barriers (10) 3. Collaboration (16) 4. Corruption (10) 5. Democracy (17) 6. E-democracy (27) 7. E-governance (30) 8. E-participation (31) 9. **Governance (43) *** 10. ICTs (10) 11. Information and communication technology (17) 12. Internet (41) 13. Municipalities (12) 14. Nigeria (16) 15. Stakeholders (10) 16. Transparency (40)
Cluster 4 (yellow)	14	1. Artificial intelligence (12) 2. Big data (21) 3. Blockchain (10) 4. Case study (16) 5. Citizen participation (21) 6. Gender (12) 7. Information technology (16) 8. Privacy (15) 9. Public services (17) 10. Security (31) 11. Smart cities (31) 12. **Smart city (37) *** 13. Sustainability (33) 14. Sustainable development (21)
Cluster 5 (purple)	14	1. Adoption (24) 2. Developing countries (28) 3. E-commerce (15) 4. **E-Government (330) *** 5. E-learning (13) 6. E-procurement (13) 7. E-services (11) 8. GIS (10) 9. ICT (108) 10. India (29) 11. Innovation (23) 12. Public participation (14) 13. Technology adoption (14) 14. Utaut (14)
Cluster 6 (light blue)	12	1. Africa (14) 2. Australia (10) 3. Digital divide (34) 4. Digital inclusion (10) 5. Digital technology (11) 6. Economic growth (16) 7. Education (26) 8. **Government (37) *** 9. Information society (13) 10. Information technologies (10) 11. Policy (17) 12. Public policy (12)

Table A4. *Cont.*

Clusters (Colors)	Number of Items	Items and Their Occurrences
Cluster 7 (orange)	11	1. Digital economy (20) 2. **Digital government (56) *** 3. Digital transformation (22) 4. Digitalization (22) 5. Digitization (11) 6. Electronic government (35) 7. Information and communication technologies (12) 8. Institutional theory (11) 9. Public administration (34) 10. Public sector (35) 11. Social networks (10)

* The keywords with the highest occurrences within clusters are highlighted in bold characters.

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