Article

Digital Government Transformation and Sustainable Development Goals: To What Extent Are They Interconnected? Bibliometric Analysis Results

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Abstract: The increasing prevalence of digital technologies has sparked interest in the relationship between digital transformation and sustainable development, leading to a surge in theoretical and practical research on this topic. This study conducts a bibliometric analysis of publications in the Web of Science database to examine the extent to which sustainable development goals are integrated into digital government transformation discourses. Using statistical properties of the citation network and the main path approach to identify key publication clusters, the analysis reveals limited research explicitly focusing on the link between digital government transformation and sustainable development goals. Furthermore, articles exploring this interconnection are notably scarce in public administration journals, indicating a significant gap in the literature that requires further investigation.

Keywords: digital government transformation; sustainable development; sustainable development goals; bibliometric studies

1. Introduction

In recent decades, digital transformation (DT) has become an important dimension of development in many spheres of economic and social life. Digital technologies, artificial intelligence, and data analysis have already become common instruments to support decision-making in business, government, and society. Digital technologies have proven their effectiveness in healthcare [1], education [2], transport [3], and environmental protection [4] among many other human activities. The majority of national governments have introduced digital government agendas to improve service provision, citizen communication, and other related areas of public concern. Governments and businesses seek to increase capacities in these fields as parts of strategies to be internationally competitive [5].

Digital transformation goes alongside furthering efforts towards sustainable development [6]. Digital public administration and digital governance are seen, for example, amongst instruments to support the achievement of the Sustainable Development Goals or SDGs [7,8]. Concepts like digital sustainability [9] or digital sustainable development [10] further support this interpenetration and interdependence of sustainable and digital transformations. Digital government promises to contribute to efficient resource management (including management of natural resources) and promote sustainable and inclusive economic growth, social development, and environmental protection.

Despite the growing sense that digital government transformation can benefit sustainable development, the nature, scope, and intensity of these fields' interconnections have not been thoroughly analyzed. Furthermore, the role of the SDGs in the actual practice of digital government transformation appears to be less central than some discourses have suggested.

This was something that emerged from our previous study. The study conducted 42 expert interviews across the world in 2021 which were concerned with assembling expert-led empirical definitions for digital government transformation (DGT). One of the surprising findings was that the respondents did not make explicit connections between DGT and the SDGs. They mostly named political and economic efficiency, financial effectiveness, transparency of government, better citizen–government communication, and better public service as the goals of DGT. Unlike these other goals, the SDGs and sustainable development more generally maintained a rather marginal position.

The goal of better understanding the reasons behind this contradiction has motivated us to initiate this present study. Based on an extensive bibliometric analysis, we seek to address the following research questions:

RQ1 How are the concepts of the SDGs and DGT connected in academic journals?

RQ2 What are the most significant publications?

RQ3 Which SDGs are supported by DGT?

RQ4 Which SDGs are less supported by DGT?

To this end, our analysis explored publications from the Web of Science database. The research used the statistical properties of the citation network and identified the most significant publications in the research areas concerned. Through further content analysis of these publications, we were able to identify their key themes and connections with the SDGs. Overall, our analysis confirms that little published research has so far directly linked DGT to the SDGs. Our study thus highlights that the nexus of DGT and the SDGs remains rather nascent in the literature and has not matured into a solid research agenda. Moreover, extant literature is published in journals concerned with environmental sustainability and very much in journals on public administration that more directly target civil servants, government consultants, and public managers and raise awareness through that body of scholarship. This calls for a new agenda of research in public administration.

2. Digital Government Transformation and Sustainable Development

Digital government transformation (DGT) is discussed in the literature in many ways: as a complex process [11], as mainly technological changes [12], as organizational changes [13], as a socio-cultural transformation [14], or as communication changes to meet the expectations of citizens [12]. Digital transformation is a process that leads to changes in different parts of public life, and it should lead to the creation of a new government-and-society ecosystem. The concept of digital transformation emphasizes cultural, organizational, and communicative changes in all public institutions, which should, in theory at least, lead to better governance and a better society.

DGT is often considered as a synonym for *e-governance* (or *e-government*) [15]. Less often, but still significantly, the DGT concept is accompanied by terms such as *open data, big data, artificial intelligence, Internet of Things, self-service technology, data management, electronic government service, and digitized government service* [11,13,16,17]. Still, *digital government transformation* is the most general umbrella term reflecting the significant changes in government and society and new ways to address some of the most critical issues of contemporary world development [11,12,18,19].

One such issue is certainly sustainable development and the achievement of sustainable development goals (SDGs). Conceptually, there are several reasons why digital transformation should support the SDGs.

First, digital technologies address environmental problems, providing an opportunity to develop unique models focused on the preservation and improvement of the environment [20] as well as providing resource efficiency and accelerating the spread of sustainable innovations [21].

Second, DGT transforms governance into *smart governance* focused on innovation and technological development to achieve better conditions for peoples' lives. That includes addressing problems of social inequality, unemployment, poverty, environmental pollution, and disease [22,23]. E-government systems of less-developed countries may still not be

sufficiently advanced for concerted sustainable development efforts. However, with the improvement of macroeconomic conditions, and the export of information and communications technology (ICT), it could be possible to bridge the digital divide and build a sustainable and developed society in such countries [23].

Third, DGT contributes to the transparency of citizen–government relationships [24]. One of the most important conditions for the success of digital and socio-economic transformation is the effective and consistent interaction of government agencies, business communities, and social institutions in the development of the SDGs [25].

Fourth, there are close relationships between localization, digital transformation, and sustainable development. Localization allows a government to effectively adapt the SDGs at the local level. The ideas of smart cities and smart sustainable cities are a case in point [26]. They stress the importance of leveraging the advancements in ICT technologies for improving living conditions and sustainable credentials of cities and communities.

Thus, it can be argued that the use of digital technologies and digitalization in general is interconnected with the sustainable development of society. According to van Gils and Weigand, digital transformation projects are in a unique position to realize the sustainable development agenda [27] (p. 104). Our research approach is based on the assumption of the utility of the interconnection of DGT and the SDGs. This interconnection can be exhibited in different ways because DGT-related concepts are rather ambiguous and can have variations in definition. Following this logic, the schematic presentation of the research approach can look like Figure 1.
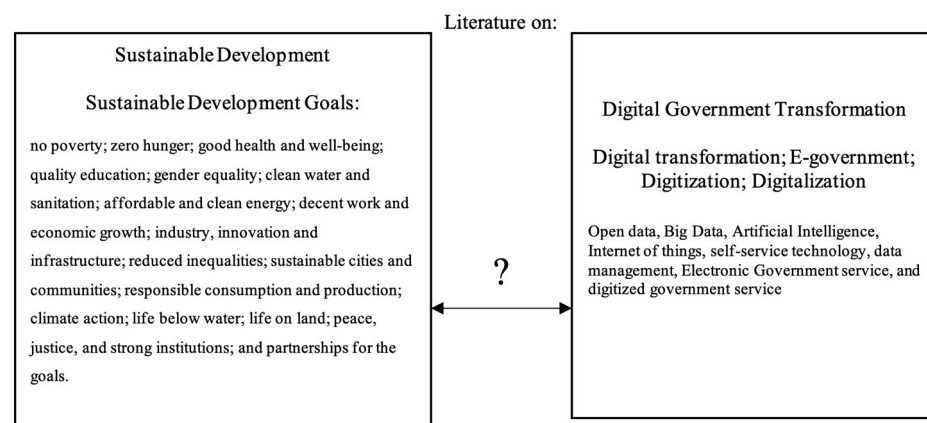
Figure 1. The theoretical model.

3. Methodology

To answer our research questions, we used a series of bibliometric methods (including social network analysis (SNA), citation analysis, keyword analysis, and main path analysis) and visualization techniques to assess the co-evolution of the two research fields and identify links between them. We identify trends in the development of articles focused on both the SDGs and digital government transformation (DGT) over the period of 1900–2022; that is the widest available range of the citation network of publications from *the Web of Science* database. It uses the statistical properties of the citation network and the groups of key publications extracted using the main path approach (as explained in the subsections below).

3.1. Data Collection

The *Web of Science*, or *WoS*, is Clarivate Analytics's multidisciplinary databases of bibliographic information. Even though there are other sources for obtaining bibliometric data (e.g., *Scopus*, *Google Scholar*), *WoS* provides greater temporary coverage and contains descriptions including references (*CR* field). Several iterations were made to construct the dataset that would be appropriate to answer the research question. We examined the network connections between the topics of sustainable development and digital government transformation. The keywords were explored in different combinations together with

OR/AND logical operators. We gradually broadened the search query and obtained the results summarized in Figure 2.
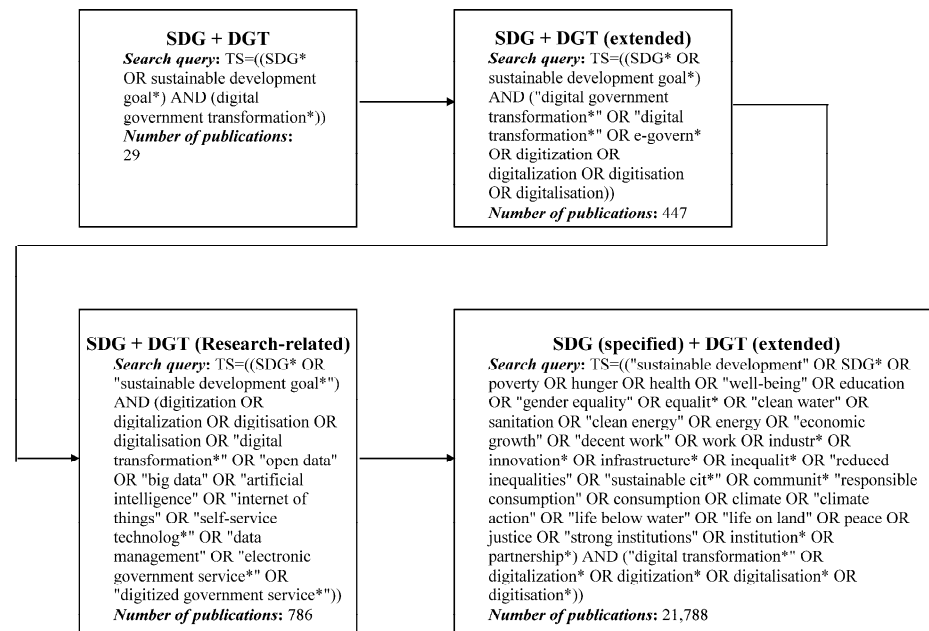

SDG + DGT
Search query: TS=((SDG* OR sustainable development goal*) AND (digital government transformation*))
Number of publications:
29

SDG + DGT (extended)
Search query: TS=((SDG* OR sustainable development goal*) AND ("digital government transformation*" OR "digital transformation*" OR e-govern* OR digitization OR digitalization OR digitisation OR digitalisation))
Number of publications: 447

SDG + DGT (Research-related)
Search query: TS=((SDG* OR "sustainable development goal*") AND (digitization OR digitalization OR digitisation OR digitalisation OR "digital transformation*" OR "open data" OR "big data" OR "artificial intelligence" OR "internet of things" OR "self-service technolog*" OR "data management" OR "electronic government service*" OR "digitized government service*"))
Number of publications: 786

SDG (specified) + DGT (extended)
Search query: TS=(("sustainable development" OR SDG* OR poverty OR hunger OR health OR "well-being" OR education OR "gender equality" OR equalit* OR "clean water" OR sanitation OR "clean energy" OR energy OR "economic growth" OR "decent work" OR work OR industr* OR innovation* OR infrastructure* OR inequalit* OR "reduced inequalities" OR "sustainable cit*" OR communit* "responsible consumption" OR consumption OR climate OR "climate action" OR "life below water" OR "life on land" OR peace OR justice OR "strong institutions" OR institution* OR partnership*) AND ("digital transformation*" OR digitalization* OR digitization* OR digitalisation* OR digitisation*))
Number of publications: 21,788

Figure 2. Search query broadening. The asterisk (*) is a wildcard that represents any group of characters, including no character. Source: https://images.webofknowledge.com/images/help/WOS/hs_wildcards.html (accessed on 2 July 2024).

To decide which dataset to use in the further analysis, keyword co-occurrence visualizations were made with VOSviewer 1.6.18 [28]. We assume that keywords are important markers that not only highlight the focus of one's research but also indicate central areas that the researchers pursue and study to generate new data and information. They help researchers in locating and retrieving publications. The keyword analysis highlights important research areas and explains interlinking in different research areas [29].

In the visualizations provided by the software, the distance between two nodes approximately indicates the relatedness of the nodes. After a network has been constructed, the next step is to position the nodes in the network in a two-dimensional space in such a way that strongly related nodes are located close to each other while weakly related nodes are located far away from each other. VOSviewer also assigns the nodes in a network to clusters by default. A cluster is a set of closely related nodes. Each node in a network is assigned to exactly one cluster. The number of clusters is determined by a resolution parameter. The higher the value of this parameter, the larger the number of clusters. In the visualization of a bibliometric network, VOSviewer uses colors to indicate the cluster to which a node has been assigned. The clustering technique used by VOSviewer is the smart local moving algorithm introduced by Waltman and Van Eck [28].

The analysis shows the most frequently used keywords in the publications related to both the SDGs and DGT (Figure 3). The number of articles in the first dataset was relatively small; we suppose that some relevant publications were not presented. The algorithm identified four clusters: red is mainly connected to governance (*digital transformation*, *e-governance*, *e-government*, *artificial intelligence*, *digital economy*), which is unsurprising. It is more interesting that sustainable development and sustainable development goals terms ended up in different clusters.
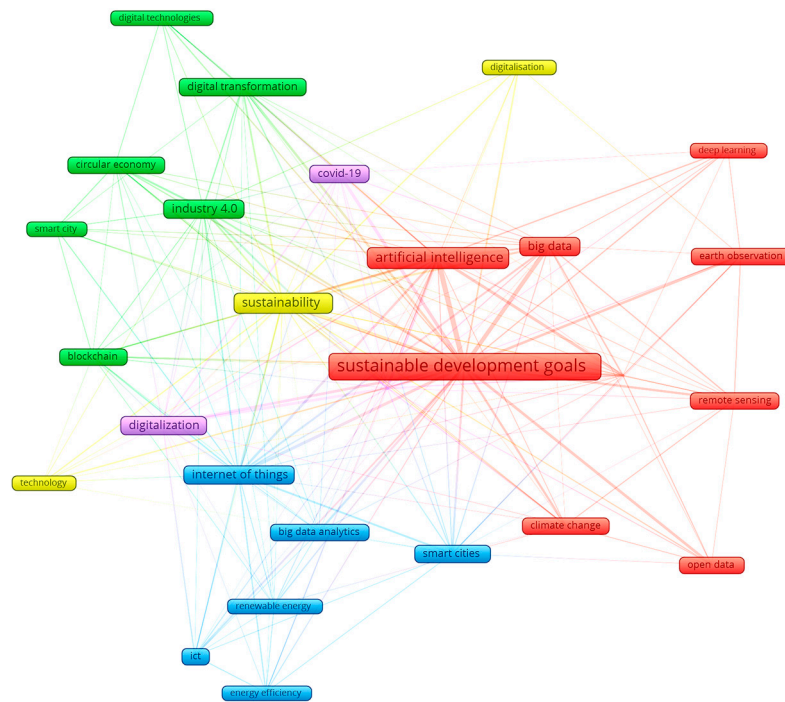
Figure 3. SDGs and DGT keyword co-occurrence analysis visualization.

In the second dataset, keywords are evenly distributed between two concepts. Terms traditionally associated with the SDGs are associated not only with specific digital technologies but also with terms from the field of governance (Figure 4). The keywords in the identified clusters are difficult to combine into meaningful subgroups. The terms traditionally associated with digital transformation (*digitization*, *digitalization*, *e-government*) are in different clusters, just like the terms associated with the SDGs (*sustainability*, *sustainable development*). Only in the green cluster can the partial homogeneity of concepts be observed (*AI*, *big data*, *ICT*, *smart city*, *energy efficiency*, *renewable energy*).

Figure 4. SDGs and DGT (extended) keyword co-occurrence analysis visualization.

We found that the emphasis in the third dataset shifted toward the specific digital transformation technologies (Figure 5). There seems to be three major clusters, one in green, one in red, and one in blue. The red cluster contains terms related to the SDGs and digital technologies (*AI*, *big data*, *deep learning*, etc.), the blue cluster contains terms related to particular digital technologies and the economy, and the green cluster is connected with both digital transformation and the circular economy.

Figure 5. SDGs and DGT (research related) keyword co-occurrence analysis visualization.

In the fourth dataset (Figure 6), there were a large number of irrelevant articles not capturing DGT. Even though specific countries and regions (*Ghana*, *Africa*, *China*, *India*, *Nigeria*) and agendas (*human rights*, *global health*, *equality*) are among the keywords, very few terms related to digital government transformation were found. Since cross-country differences in the context of sustainable development are not the purpose of this study, we assumed that the data were not suitable.
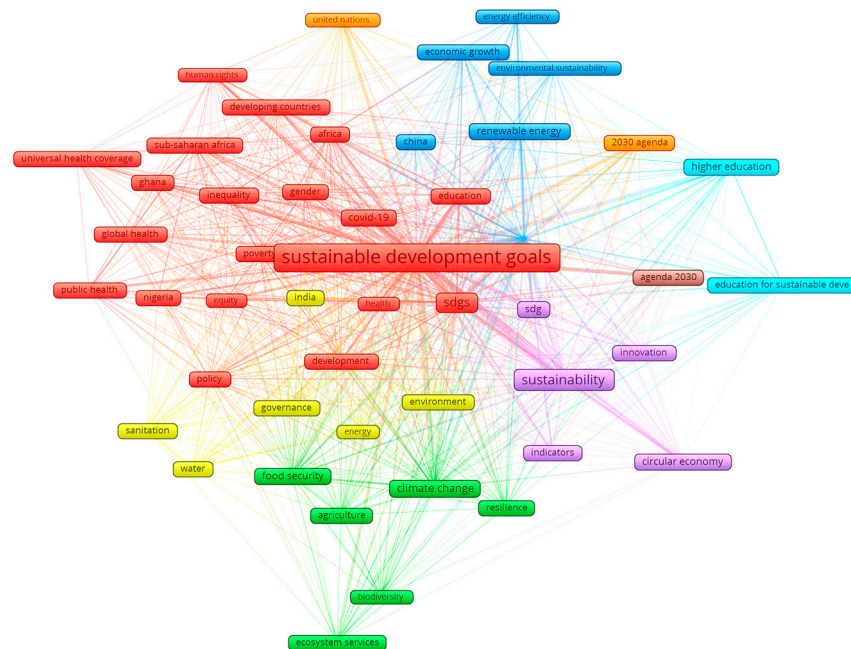
Figure 6. SDG (specified) and DGT (extended) keyword co-occurrence analysis visualization.

To conclude, the second dataset was considered the most preferable for a further analysis. It presents a certain cross-section of articles in which both the SDGs and DT concepts are almost equally represented. This dataset implements a comprehensive approach for the

identification of the main trends in the development of both concepts, with a representation of various connected terms.

3.2. Data Cleaning

The data collection, cleaning, and basic network construction were based on the research of Maltseva and Batagelj [30]. Obtained descriptions of the publications can be two types: hits (with full publication description) and *terminal*, listed only in the *CR* field of a work description in WoS (cited only). Based on the search query presented above, the original hits and additional articles citing those hits were obtained. We retrieved bibliographic description and full-text articles. The final dataset contains 447 publications with full description (hits) and cited-only works (*terminal*).

Using computer program WoS2Pajek 1.5 [31], the dataset was transformed into a collection of basic networks: a one-mode citation network Cite on works (from the field CR of the WoS file description) and two-mode networks, the authorship network WA on works × authors (from the field AU), and the keyword network WJ on works × journals (from the fields *CR*, *J9*). After data cleaning, from 447 hits we created networks with sets of the following sizes: works |W| = 24,876, authors |A| = 18,837, journals |J| = 4453. We further replaced multiple lines with simple lines and deleted loops. It is important to note that for the terminal works, only partial information is provided: the name of the first author, journal, publication year, journal issue, and the first page number. In this paper, we analyze these three basic networks.

A two-mode network can be split into two one-mode networks by multiplication. The resulting derived networks may have some deficiencies, which is why a fractional approach was applied [30]. It deals with overrepresentation, normalizing the weight of bibliographic entities (works and authors in our case), so that their input to the resulting network is equal to 1. Detailed information about the network-construction process is presented in Maltseva and Batagelj [30].

3.3. Most Significant Publications and Main Path Analysis

The number of citations is widely used as an indicator of the impact of the article. If other scientists often cite the article, it may be a research hotspot. Contributors to such a publication may provide updated insights in a particular field of research.

Main path analysis is a powerful tool that can identify chains of significant links in an acyclic directed network, thereby extracting the skeleton of a large and complicated directed network. By simplifying the network, it reveals the important knowledge flows in the citation network and tracks the development path of the research field. The two most important contributions to the main path analysis were made by Hummon and Dereian [32]. They proposed the method, and Batagelj [33] designed efficient algorithms that make the method applicable for large datasets.

The advantage of the main path analysis lies in considering the direct and indirect influence of the article simultaneously, emphasizing the connection between the citing and the cited paper. Therefore, compared to the traditional "citation counting" method, which only considers direct influence, main path analysis reveals a more accurate path of knowledge transmission. This method is widely used in recent bibliometrics research [34], and its effectiveness has been verified in many previous studies. This study conducted the global main path analysis to identify the major themes of the SDGs and DGT research and describe how these themes have evolved over time. To reveal how two concepts have developed over time, we used the SPC (search path count) algorithm to identify the main path of the citation network Cite. The main path is obtained by the Critical Path Method (CPM), borrowed from the Operations research, which determines the path with the largest sum of weights [35] (pp. 135–139).

4. Results

4.1. Distribution of Works and Main Publications in the Resulting Citation Network

Figure 7 represents the distributions of the number of works per year. Panel (a) shows how many works from the set of hits are published per year. The data show constant and fast growth in the number of articles on SNA topics starting from 2018, when there were 28 articles published. In 2021 and 2022, there were 109 and 141 articles published, respectively. Starting from 2018, average annual growth was more than 83 percent. We may explain such a big number by the general interest of researchers in the SDGs and digital transformation, which also manifested itself in the increase in the number of journals on these topics.

(a)

(b)
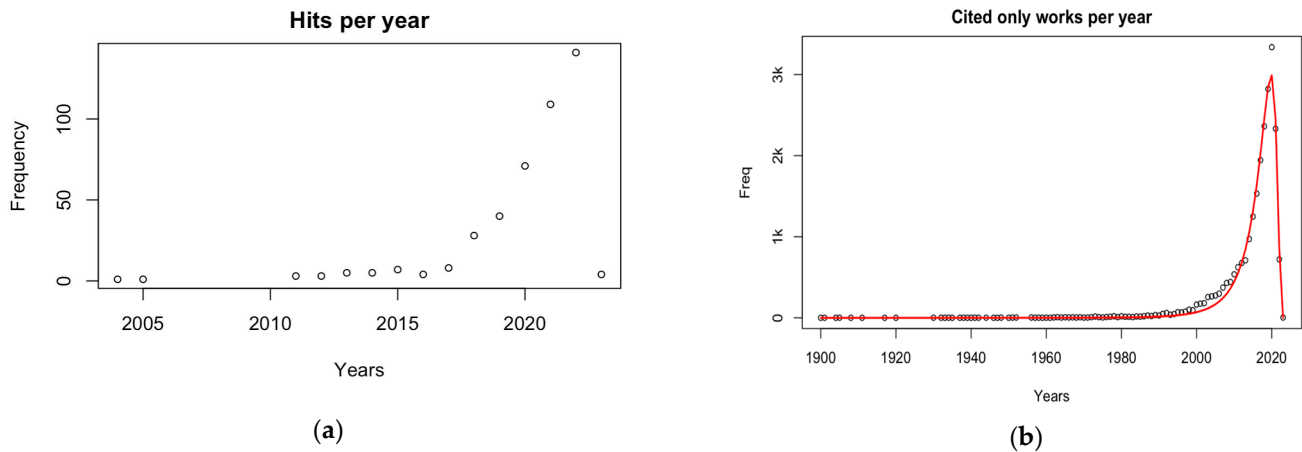
Figure 7. Cite network: the distribution of hits (**a**) and terminal works (**b**) by year. The dots in the pictures are observations, the red line shows that the cited only distribution obeys the lognormal distribution.

Panel (b) of Figure 7 shows the publication years for the terminal works that are cited only. The majority of works cited were published recently: 2362 works published in 2018, 2822 in 2019, and 3338 in 2020. The amount of cited works published after 2020 is decreasing, which simply means that works published very recently could not yet receive the large number of citations. However, the presence of the newest works shows that representatives of the field have already seen and cited it. The distribution of works for the whole available period (from 1900 to 2023) fits the log normal distribution.

4.2. The Most Significant Publications

Table 1 presents the 20 most cited publications (based on indegree centrality in Cite network). Only two of these works were published before 2015. Among the most cited works, more than half [11] are reports of large international organizations (United Nations, European Commission, World Bank), which means that the authors often refer to them as those who formulated and promoted the SDGs. There are no books among the most cited publications, as researchers mainly tend to cite research articles. The most cited publication is the report compiled by the United Nations (2015), in which the 2030 agenda for sustainable development was formulated. We assume that this report forms the prism for the modern research in both the SDGs and DGT fields, being an impetus for research. The most cited scientific article is "*Industry 4.0, digitization, and opportunities for sustainability*" [36]. This study contributes to the sustainability literature by systematically identifying the sustainability functions of Industry 4.0.

Table 1. Cite network: The most cited works (based on indegree centrality).

N	Frequency	Id
1	23	UNITED_N(2015):
2	20	EUROPEAN_C(2020):
3	17	UNITED_N(2017):
4	16	UNITED_N(2016):
5	15	GHOBAKHLOO_M(2020)252:119869
6	14	EUROPEAN_C(2017)
7	12	UNITED_N(2018):
8	12	VIAL_G(2019)28:118
9	12	EUROPEAN_C(2021):
10	12	TRANFIEL_D(2003)14:207
11	12	ELMASSAH_S(2020)169:106490
12	12	WORLD_B(2020):
13	12	ABBOUR_A(2018)132:18
14	11	CASTRO_G(2021)280:122204
15	11	DALENOGA_L(2018)204:383
16	10	UNITED_N(2020):
17	10	UNITED_N(2015):157180910X12665776638740
18	10	BEIER_G(2020)259:120856
19	10	EUROPEAN_C(2015):
20	9	KIRCHHER_J(2017)127:221

If we take a more meaningful look at the most quoted *hits*, however, from the initial dataset that contains 447 publications, a total of 20 highly cited articles were identified, subsequently analyzed, and classified according to the journal's main scope, article type, digital government transformation focus, sustainable development focus, and area focus of the studies. Table 2 represents key articles at the intersection of DGT and the SDGs and a summary of the main results of each study.

Table 2. Cite network: The most quoted hits.

Reference	Journal's Main Scope	Article Type	DGT Focus	SD Focus	Area Focus	Key Findings
Adjei-Bamfo et al., 2019 [37]	Sustainable production and consumption improvement	Systematic literature review	E-government	Sustainable Public Procurement	Developing countries	E-government facilitates various kinds of processes devoted to the building and evaluation of an integrated e-procurement system and Sustainable Public Procurement practices.
ElMassah and Mohieldin, 2020 [38]	Understanding the interfaces and interplay between ecosystems and the economy	Research article (comparative case studies, several countries)	E-government and big data	SD goals	Developing countries (7)	Digital transformation supports localization, allowing governments to tailor sustainable development strategies at the local level.
Garde Sánchez et al., 2013 [39]	Understanding of environmental and sustainability education	Research article (quantitative research, one country)	ICT	Education, social responsibility	Developed countries (1)	University policies do not contribute to ICT development to promote social responsibility.
Bican and Brem, 2020 [40]	An advanced forum for studies related to sustainability and sustainable development	Systematic literature review + Case study, one country	Digitalization, Digital Entrepreneurship	SD goals	Developed countries (1)	A conceptual framework on sustainable relations of Digital Entrepreneurship to Innovation, moderated by a Digital Transformation Process, is developed.

Table 2. *Cont.*

Reference	Journal's Main Scope	Article Type	DGT Focus	SD Focus	Area Focus	Key Findings
Abad-Segura et al., 2020 [41]	An advanced forum for studies related to sustainability and sustainable development	Systematic literature review	ICT, digital learning technologies	SDG 4: Quality education (Higher education)	Worldwide	Digital transformation helps to achieve a model of an open, innovative, networked higher education institution.
Bertola and Teunissen, 2018 [42]	Worldwide research dealing with textile and apparel systems	Research article (expert positioning essays, descriptive case studies)	Industry 4.0, smart manufacturing	Sustainable industrial systems	Developed countries	Digital transformation could reshape the fashion industry into a more sustainable and truly customer-driven business.
Ghobakhloo et al., 2021 [43]	Cleaner production, environmental, and sustainability research	Systematic literature review	Industry 4.0, digital industrial transformation	Sustainable manufacturing	Worldwide	Industry 4.0 transformation could address issues of sustainable development goals, particularly concerning manufacturing economic development.
Elavarasan, et al., 2021 [44]	Energy conservation, use of energy resources and optimal energy processes, sustainable energy systems	Research article (qualitative research, SWOT-AHP and quantitative, correlation analysis)	Digitalization	SDG 7: Energy sustainability	Worldwide	To achieve SDG 7, a parallel approach is needed from the vision of renewable energy, digital transformation, and energy affordability.
Mondejar et al., 2021 [45]	Research on the total environment	Review article	Digitalization and smart technologies	Food-water-energy, industry and citizen wellbeing, climate and biodiversity	Worldwide	Sustainable development in years to come will capitalize greatly on digitalization.
Castro et al., 2021 [46]	Cleaner production, environmental, and sustainability research	Systematic literature review	ICT, big data, and artificial intelligence	SD goals	Worldwide	There are growing expectations about the added value of digitalization for pursuing the SDGs through data sources, analytical capacities, and digital ecosystems.
Beier et al., 2018 [47]	All aspects of applied natural sciences	Research article (case study, 1 country)	Digitalization, Industry 4.0, Industrial Internet of Things	Sustainable development of industries	Developing countries (1)	Transparency, resource efficiency, and sustainable energy are three possible starting points for linking digitalization and a sustainable development of industries.
Janowski, 2016 [48]	The intersection of policy, information technology, government, and the public	Research article (quantitative research)	Digital Government	SD goals	Worldwide	Digital Government should play a key role in the implementation of the SDGs but, at present, there is a gap between the SDGs and Digital Government.
Xiao et al., 2018 [49]	Photogrammetry, remote sensing, spatial information systems, and computer vision	Research article (case studies, 3 countries)	Geoinformatics technologies	Cultural heritage (SDG 11.4), sustainable tourism (SDG 8.9)	Developing (2) and developed countries (1)	The contribution of geoinformatics to the achievement of cultural heritage the SDGs is necessary, significant, and evident.
Schuette, 2018 [50]	Covers all areas of biotechnology	Review article	Digitalization	SD goals	Developed countries (1)	The Sustainable Development Goals can be achieved through digital technologies, new policies and strategies, and international cooperation.
Meng et al., 2018 [51]	Sustainability and sustainable development	Review article	Smart manufacturing, big data	Sustainable manufacturing	N/A	The use of big data has great potential in manufacturing to achieve smart and sustainable development. However, smart and sustainable production is only possible with international cooperation.
Ahmad et al., 2021 [52]	Focus on cleaner production, environmental, and sustainability research and practice	Review article	Digitalization, artificial intelligence (AI), big data	Renewable energy	Worldwide	The use of artificial intelligence is essential to achieving sustainable energy goals.

Table 2. *Cont.*

Reference	Journal's Main Scope	Article Type	DGT Focus	SD Focus	Area Focus	Key Findings
Reuter et al., 2019 [53]	Developments in the field of materials research, including original methodologies, materials phenomena, material systems, and special keynote topics	Review article	Digitalization, big data	SD goals, circular economy	N/A	Integrating product-centric considerations into different types of industries and implementing smart (digital) grid systems support the implementation of the SDGs in practice.
Kristoffersen et al., 2020 [54]	Theoretical and empirical business research	Systematic literature review	Digital technology and big data	SDG 12: Sustainable consumption and production; Smart CE (circular economy) framework	N/A	A Smart CE framework is proposed, which introduces new production technologies reducing structural waste. The relationship between digitalization and SDG 12 is revealed.
Dwivedi et al., 2022 [55]	Analysis and discussion in the field of information management	Opinion paper	Digital technology and IS/IT	SD goals, climate change, education	Developed countries	The measures required to move toward net zero emissions by 2050 and achieve the sustainable development goals include the use of digital technology.
Reuter, 2016 [56]	Processing science and engineering of metals and materials	Review article	Digitalization, metallurgical Internet of Things (m-IoT), big data	SD goals, circular economy	N/A	Digitalization of metallurgy and creation of a digital network of the industry, and digital methods for evaluating resource efficiency, significantly affect the achievement of sustainable development goals.

Taking a closer look at the most cited articles leads us to the following arguments.

First, almost all highly cited articles are in the journals related to sustainable development, sustainability, or, in a broader way, to the topics related to environment, sustainable production, and use of resources. The articles covered several issues. Some of them [51] result in the conclusion that digitalization and the use of advanced technologies have a great potential to achieve smart and sustainable development. However, researchers have not paid enough attention to the actual interconnection of ICT development and sustainability aspects [39]. Another group of articles is in journals that deal with cleaner production [39,43,46,52], sustainable energy [44], industrial systems [42], and sustainable production [37] and shows that digital industrial transformation, the use of big data, and artificial intelligence could address the SDGs.

Thus, articles that are highly cited in a field of the DGT-SDGs interconnection are rare in management journals that would be more accessible for public administrators. The exception to the sustainability scope were three articles presented in private and public sector-related journals. Two articles were published in business and management journals. Kristoffersen et al. [54] proposed a smart circular economy framework, which introduces new production technologies reducing structural waste. Dwivedi et al. [55] expressed the opinion that the use of digital technology is a required measure to achieve sustainable development goals. The work published in the journal related to the public sector by Janowski [48] states that digital government should play a key role in the SDG implementation. It also reveals a gap between current digital government capacity and aspirations to the achievement of sustainable development goals.

Second, most of the highly cited works are review articles [52,55] and systematic literature review articles [36,37,41,46,54] that summarize the current state of understanding on the topic of the relationship between digital transformation and sustainable development. Most of the articles are based on previous research and do not provide new empirical results. Among the research articles, the main research method is a case study, applied to one country [40,47] or several countries [38,42]. An investigation of the real-life examples provides an analysis of the context involved in the process of digital transformation's influence on the implementation of the sustainable development goals.

Third, looking at the digital transformation focus of the highly cited articles, it is clear that most of them focus on the digitalization process [44], the use of information and communication technologies [39,41], and an application of advanced digital technologies such as big data [38,51], artificial intelligence [46,52], geoinformatics technologies, and the Internet of Things [47].

Relating these DGT features and tools to the SDGs, we may divide articles into several large groups. Some explore the pursuit of the specific SDGs [41,44]. Other articles discuss how sustainability can be achieved in a particular industry, or how transforming an industry can help reach the goals [37,39,42,43,47,51,52]. There are SDGs that are highly covered in the literature: poverty (SDG1), higher education (SDG4), hunger (SDG2), and sanitation (SDG6). Some of the SDGs are barely covered: equity (SDG5), peace, justice, and strong institutions (SDG16). Another group of articles looks at accomplishing the SDGs as a whole instead of focusing on one industry or goal, examining the process across the board [21,38,40,48,55].

5. The Main Path Analysis

The use of the main path search algorithm in the resulting network of citations allowed us to build a subnet consisting of four articles that we identify as the most significant from the point of view of the formation of new ideas (Table 3). All publications are from journals related to sustainable development.

Table 3. SPC net: main path (publications).

Id	Title	Authors	Year	Publisher
1	Digital transformation and convergence toward the 2030 agenda's sustainability development goals: Evidence from Italian listed firms	Camodeca, R., and Almici, A. [57]	2021	Sustainability
2	Mindful application of digitalization for sustainable development: The Digitainability Assessment Framework	Gupta, S., and Rhyner, J. [58]	2022	Sustainability
3	Unleashing the convergence amid digitalization and sustainability towards pursuing the Sustainable Development Goals (SDGs): A holistic review	Castro, G. D. R., Fernandez, M. C. G., and Colsa, Á. U. [46]	2021	Journal of Cleaner Production
4	Digital transformation and localizing the sustainable development goals (SDGs)	ElMassah, S., and Mohieldin, M. [38]	2020	Ecological Economics

The first article, *Digital transformation and convergence toward the 2030 agenda's sustainability development goals: Evidence from Italian listed firms* [57], sheds light on whether digital technologies implemented by firms can be used to achieve the SDGs listed in the UN 2030 Agenda. The second article *Mindful application of digitalization for sustainable development: The Digitainability Assessment Framework* [58] introduces a new Digitainability Assessment Framework (DAF) for context-aware practical assessment of the impact of digitalization intervention on the SDG indicators. The third article *Unleashing the convergence amid digitalization and sustainability towards pursuing the Sustainable Development Goals (SDGs): A holistic review* [46] aims at a twofold purpose: categorizing the main SDG research gaps, and a critical exploration of the potential contribution of digital paradigms, particularly big data and artificial intelligence, toward overcoming the aforesaid caveats and pursuing the 2030 Agenda. The fourth article, *Digital transformation and localizing the sustainable development*

goals (SDGs) [38], examines how digital transformation can impact the localization and achievement of the SDGs.

The result of the main path analysis indicates that publications do not form a unified study approach. This means that there is no so-called skeleton from publications at the intersection of the two concepts. Knowledge flow here formally consists of only four works. The relatively small number of publications also indicates that the agenda in which the nexus of both terms is explored is only being formed.

As stated in the literature, publications identified by the main path analysis are not necessarily the ones with the highest citation counts [59,60]. Fontana et al. [60] state that they may be important at a certain point in time and are thus positioned at a strategic "junction" along the trajectory. Hence, only two articles [38,46] were included both in the list of the most cited articles and in the list of articles formed by the *main path* search algorithm.

6. Conclusions

6.1. Implications

Our analysis demonstrates that the most cited articles in the sphere of DGT and the SDGs interconnection are in journals related to sustainability or environmental issues. These articles mostly support SD in the belief that technologies can be a relevant driver for achieving specific goals, particularly in terms of the 2030 Agenda. The report published by the UN in 2015 [61] put forward such an international agenda, arousing interest in the topic among researchers. More recently, the European Commission has highlighted the role of digital technology within the formulation of a new European growth strategy aimed at creating a climate neutral society by 2050.

Even though many researchers agree that digital transformation can potentially be an effective tool in creating sustainability [57], some studies state that the effects of digital transformation on sustainability remain unclear [46]. A group of studies looks at accomplishing the sustainability goals as a whole, focusing not on one industry or goal but examining the process across the board [38,46,48]. Some authors [38] see the localizing of the SDGs as a way for governments to create effective sustainable development strategies, and argue for using DT as a way to do that. Researchers point out that current integration and vertical diffusion of the social and ecological SDGs remain poorly developed [46]. According to [48], there is a huge gap between aspiration (SDGs) and capacity (Digital Government) in more than 69% of the United Nations Member States.

Some DT technologies are more often considered in terms of the SDGs (blockchain, Internet of Things, AI, cloud technologies, etc.). Thus, the digitalization process can promote the convergence toward the SDGs by enabling connection and communication between people, monitoring the world's activities and ecosystems, analysis of information and the organization of processes and resources, and improvement of human capabilities [46].

Answering the first RQ, it is fair to say that in academic journals the SDGs and DGT are usually connected in different ways. Firstly, some articles explore the pursuit of the specific SDGs [41,44] with DT. Secondly, other articles concern achieving sustainability in particular industries or transformation of the last to reach the SDGs [37,39,42,43,47,51,52]. Thirdly, a big group of articles covers deep analysis of the separate SDGs. A fourth group consists of the articles concerned with accomplishing the SDGs as a whole, examining the process across the board [21,38,40,48,55]. As for RQ2, the most significant publications are in Tables 1 and 2. Considering the SDG support by DGT (RQ3 and RQ4), there is a lack of publications covering DT and equity (SDG5), as well as peace, justice, and strong institutions (SDG16), while others are much better presented in publications.

6.2. Limitations

Despite many potential ways to reach the SDGs, little research has linked digital transformation to the sustainability paradigm. Scholars in developing countries more often study targeted problems (poverty, education, hunger, sanitation), whilst areas such

as justice, equity, and strong institutions are covered only partly. Therefore, in our case political agenda is a limitation.

Following these arguments, we can explain why the DT practitioners we have talked to did not consider SD as a goal of digital transformation. Journals relevant to the respondents' expertise as civil servants, governmental consultants, and public managers do not publish the articles discussing these interconnections. Thus, to maintain concerns about sustainable development in digital transformation projects, we recommend including this in journals for public managers and government experts.

Considering limited numbers of questioned public-management experts, 42 interviews are relevant for the study. However, received results show that wider selection and involvement of SD experts might also be helpful in creating a full picture, and combine SD and DT article with experts of both fields. We limited our data by using only WOS, but it collects more information on the technical and social sciences than Scopus, and publications from these fields were the main subject for our research focus. WOS provides searches back to 1900, which we applied, and that was not possible for other scientific databases. In addition, this limitation helped to reduce the problem of duplication, which is a constant for bibliometric research with several databases.

The English language of the analyzed publications is one more of the current research limits; however, the universal usage of it by scientists made it possible to analyze data from different countries, even those for which English is foreign.

6.3. Further Research

Researchers can overcome mentioned limitations in future studies. Besides combining datasets from different bases (Scopus, Google Academia, and others). Article datasets of WOS showed specific troubles mainly connected to SD and DT research, but using other scientific bases might further validate the results. The English language of the analyzed publications is another of the current research limits, but thanks to this language's universal wide usage, the results are still valuable.

Our bibliometric analysis shows how limited publications are on the matter, so there is a need for additional promotion of such scientific results to practitioners. If journals relevant to practitioners, civil servants, governmental consultants, and public managers will accept more DT and the SDGs interconnection research, it might be strong support for creating more sustainable policy. This is especially true for the connection between digital government and strong institutions, because it is one of the mentioned interconnection aspects which is understandable for practitioners.

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