Knowledge Mapping of Open Government Data Studies: A Bibliometric Analysis Based on Keyword Structure

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Abstract: As few studies have systematically reviewed Open Government Data (OGD) research, the present study conducts an overall bibliometric analysis to propose main themes, spatial structure, specific research paradigms, keyword evolution trends, and noteworthy future themes in the OGD field. Specifically, we employ the top 116 keywords as research data collected from 602 publications in the Web of Science database (WOS) from 2010 to 2022. In this research, We find that existing literature mainly focuses on five main research themes: (1) OGD participants, (2) OGD technologies, (3) OGD theories and methodologies, (4) OGD values, and (5) OGD management. Furthermore, we conclude with the specific research paradigms of the five main themes, respectively. In addition, we conclude notable themes and propose three well-studied perspectives (i.e., bureaucratic, technological, and political) and one under-studied perspective (i.e., economic) in the domain of OGD research. Our findings provide scholars guidance in conducting OGD research comprehensively.

Keywords: Bibliometric analysis; Knowledge map; Open government data

1   Introduction

In the past decade, a large number of scholars have entered the field of OGD research. For example, Wang and Lo[1] have explored the drivers of OGD adoption; Gottfried, Hartmann and Yates[2] have found the role of OGD in business intelligence. Due to the complexity of OGD connotation and composition, research in the field of OGD is characterized by diversity, which leads to the emergence of new research topics or research hotspots. However, critical research questions still exist. Most of the literature reviewes focused on one aspect of OGD management or application, such as citizen engagement with OGD[3], assessing OGD initiatives[4], and OGD utilization[5]. Despite Tai[6] have conducted comprehensive reviews of OGD research by bibliometric,what form is OGD research distributed? What are the trends in OGD research from its

emergence to the present day, and what are the potential opportunities for the future development of OGD research? What are the basic research paradigms that are now included in OGD research?

In order to address these gaps, we create a knowledge map of OGD research based on the top 116 keywords collected from 602 publications in the Wos database from 2010 to 2022. Through a bibliometric analysis with k-core, co-word, and multidimensional scaling (MDS), we identify five categories of research themes, including (1) OGD participants, (2) OGD technologies, (3) OGD theories and methodologies, (4) OGD values, and (5) OGD management. Next, we summarize the specific research paradigms of each research theme. Finally, we conclude three well-studied themes and one under-studied theme in the domain of OGD research and provide several noteworthy topics for the future.

2   Data resource

We used "Open Government Data" or "OGD" as keywords to search literature in the Web of Science (WoS) from 2010 to 2022 (April). We obtained 663 articles, of which 57 papers lacked source, abstracts, or keywords. Next, we carried out the deletion and selection of duplicate documents. In the third step, we eliminated 4 editorials and letters. Therefore, these incomplete articles were removed, and 602 papers were finally selected as our research sample. The Fig. 1 shows the literature screening process of this study.

After setting our research sample, we collected three items - Year, Keywords, and Abstract – to establish our dataset. We extracted keywords frequencies, selecting keywords with a frequency no less than 3. Finally, we obtained 116 keywords. An example with the frequency of keywords no less than 5 are illustrated in Table 1, "open government data" is the most frequent keyword with 324 occurrences, which is the core keyword of this research area. Keywords such as "open data," "open government," "e-government," also appeared with large frequency, which are closely related to "open government data."
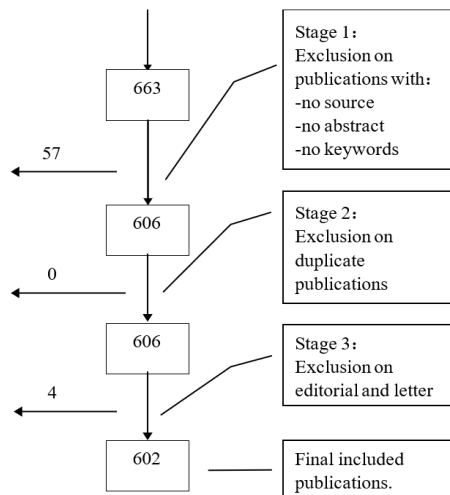

Fig. 1. Literature Screening Process

Table 1. Frequency of keywords.

| No	Keyword	Count	No	Keyword	Count
1	open government data	324	27	usability	8
2	open data	224	28	big data	8
3	open government	70	29	adoption	8
4	e-government	54	30	visualization	8
5	transparency	46	31	re-use	8
6	linked data	34	32	health data	8
7	accountability	20	33	ontology	8
8	data quality	20	34	metadata	8
9	smart city	18	35	data portal	7
10	ecosystem	15	36	use	7
11	open data portal	14	37	citizens	7
12	local government	14	38	framework	7
13	linked open data	14	39	literature review	7
14	public sector	12	40	participation	7
15	government	12	41	dataset	7
16	semantic web	11	42	case study	7
17	public sector information (PSI)	11	43	open data ecosystem	7
18	evaluation	11	44	data analysis	6
19	barriers	11	45	digital government	6
20	benefits	11	46	openness	6
21	innovation	10	47	privacy	6
22	citizen engagement	10	48	interoperability	6
23	government data	10	49	publishing	6
24	freedom of information (FoI)	9	50	public administration	6
25	challenges	9	51	open innovation	6
26	electronic government	9	52	data visualization	6

3   Data analysis

Keyword-based knowledge maps reflect forward-looking knowledge structures[7]. We employed co-word analysis to develop our research framework as a method for assessing thematic relationships. We defined the structure of OGD research by analyzing trends in keywords or vocabulary that frequently occur in the same paper.

This research extracted the co-occurrences of the top 116 keywords from 602 publications in the WoS and used CO_CO10.6 to build a keyword co-occurrence matrix A, where $A \in R116 \times 116$. An example of six keywords with the highest co-occurrence frequency is illustrated in Table 2. Each data in Matrix A reflects the frequency of simultaneous occurrences of each keyword pair in the same literature. For example, the number of 90 at the cross of row 2 and column 1 in Table 2 means that the keywords "open government data" and "open data" occurred 90 times in the same literature[8].

Social network analysis (SNA), multidimensional scaling (MDS), and k-core analysis are widely applied to analyze the "technological foresight" of a specific research area[7]. First, SNA is a computable analytical method that helps us to explore the formation and development of relationships among keywords. We employed SNA to classify the 116 keywords into five sub-groups according to the node degrees. In addition, we employed MDS to identify the spatial location of the 116 keywords, classify research themes and summarize research paradigms. We then used NetDraw software to present the results of MDS and k-core analysis by visualizing the keyword-based knowledge map. See details in Fig.2.

Table 2. Keywords co-occurrence matrix A.

	1	2	3	4	5	6
1.open government data		90	28	29	23	20
2.open data	90		42	21	20	6
3.open government	28	42		16	9	1
4.transparency	29	21	16		8	2
5.e-government	23	20	9	8		1
6.linked data	20	6	1	2	1	
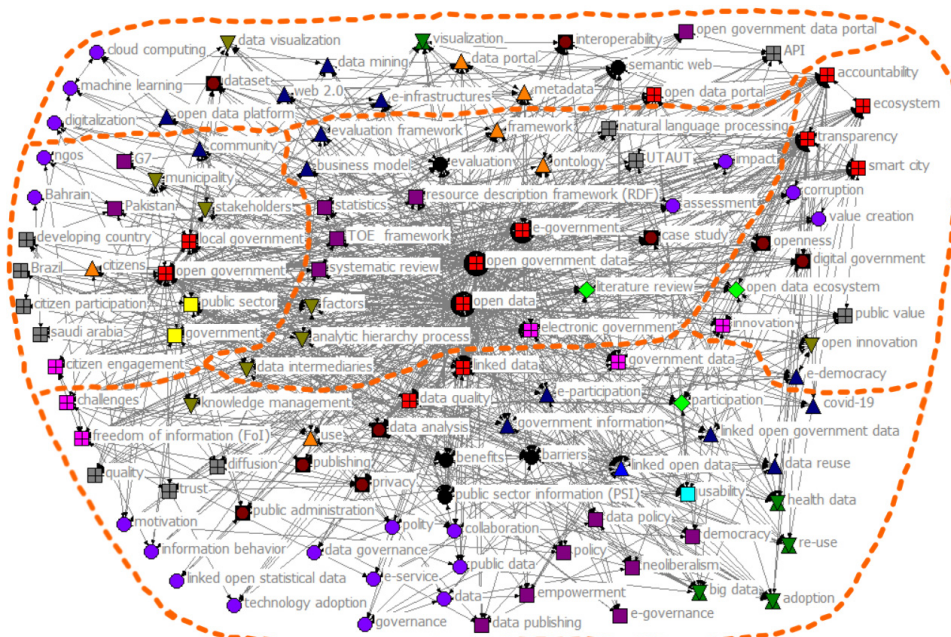
Notes: Purple circles indicate keywords with a degree of node 6; dark purple squares indicate keywords with a degree of node 7; equilateral triangle of dark blue indicate keywords with a degree of node 8; the gray boxes indicate keywords with a degree of node 9; earth-colored inverted triangles indicates a node degree of 10 for the keyword; dark red circle-in-black-boxes indicate indicates a node degree of 11 for the keyword; green rhombus indicate keywords with a degree of node 12; orange up triangles indicate indicates a node degree of 13 for the keyword; dark green superimposed triangles indicateindicates a node degree of 14 for the keyword; light blue squares indicate keywords with a degree of node 15; pink box indicate keywords with a degree of node 16; black circles indicate keywords with a degree of node 17; yellow squares indicate keywords with a degree of node 18; equilateral triangle of dark blue indicate keywords with a degree of node 19; red box indicate keywords with a degree higher than node 20.

Fig. 2. Keyword-based knowledge map of OGD research.

4 Discussion

4.1 Five categories of OGD research themes

The Fig.2 shows that the 116 top keywords were divided into five groups with different themes. First, we grouped the 17 keywords located in the top left corner into the theme of OGD participants, and we further divided the keywords into two sub-groups: (a) demand-side participants: public sector, citizen engagement, citizens, citizen participation stakeholders, community, NGOs (i.e., non-governmental organizations); (b) supply-side participants: open government, local government, government, municipality, G7, Pakistan, Bahrain, Brazil, and developing country. This theme mainly focuses on the participants in the whole process of OGD implementation and application.

Secondly, 17 keywords at the top of Fig. 2 are grouped into OGD technologies. We further divided this theme into two sub-groups: (a) data technologies: metadata, data visualization, visualization, dataset, digitalization, data mining, could computing, machine learning; (b) platform technologies: e-infrastructures, data portal, API, open (government) data portal, interoperability, web 2.0. This theme aims to illustrate the support for OGD development from a technological perspective.

The third theme we categorized as OGD theories and methodologies, the keywords for this theme are in the middle of Fig. 2, with a total of 21 keywords. We further divided this theme into three sub-groups: (a) OGD definition: open government data, open data, e-government; (b) OGD theories: ontology, UTAUT, TOE framework, resource description framework; (c) OGD methodologies: evaluation, framework, literature review, case study, factors, analytic hierarchy process, natural language processing, business model, evaluation framework, statistics, systematic review, impact, assessment. This theme aims to explain the common theories and methodologies used in OGD research.

The fourth theme is located on the right side of Fig. 2 with 20 keywords. It is categorized as OGD values, where we further divided it into two sub-groups: (a) social values: innovation, value creation, ecosystem, openness, open data ecosystem, public value, open innovation, benefits, barriers, challenges, e-service; (b) political values: accountability, transparency, smart city, corruption, digital government, democracy, e-democracy, neoliberalism, polity. In this theme, we learn about the value that can be brought through the application of OGD.

The final theme is OGD management, a category that includes a total of 41 keywords located at the bottom of Fig. 2. Because of the large range of keywords covered, we have broken it down into three categories: (a) data management: linked data, data quality, linked open data, public sector information (PSI), data, freedom of information (FoI), government data, big data, health data, data analysis, privacy, data intermediaries, quality, government information, linked open government data, data publishing, public data, data governance, linked open statistical data; (b) user management: usability, adoption, re-use use, participation, public administration, trust, diffusion, e-participation, data reuse, information behavior, technology adoption, motivation; (c) process management: knowledge management, policy, data policy, empowerment, governance, e-governance, politics, covid-19, publishing. This theme aims further to reveal potential issues of OGD management in various ways.

4.2 Specific research paradigms

Based on the five categories of OGD research themes, we further discussed the specific research paradigms. First, this research focused on the theme of OGD participants. (a) OGD supply-side. The main keywords are "open government" and "local government." We also see from Fig. 2 that the studies focusing on OGD of three countries, including "Pakistan," "Bahrain,"and"Brazil, are relatively rich. In the context of Pakistan, through the disclosure of data by government entities, Saxena and Muhammad[9] noted that OGD improves accountability and transparency. (b) OGD demand-side. Scholars have explored how various demand-side participants use OGD. For example, Kassen[10] pointed out that citizens create themselves data-driven services which they need by using OGD. Thus, research on OGD participants has drawn the attention from scholars.

Next, in terms of the theme of OGD technologies, we divided OGD technologies into data and platform technologies. (a) Data technologies. Heise and Naumann[11] pointed out that the amount of data disclosed by the government is huge, but open data has a large heterogeneity, which is not conducive to retrieval and analysis. When the technology of linking data is immature,data visualization has been employed in the field of OGD to improve the interpretability of data. For example, Gottfried, Hartmann and Yates[2] proposed that with the help of data visualization analysis tools, market opportunities can be more effectively identified. (b) Platform technologies. The platform construction of open data is gradually mature. In addition to the construction of open platforms, a well-operated open data platform is essential[12].

Within the theme of OGD theories and methodologies, scholars are concerned with OGD definition, OGD theories, and OGD methodologies. (a) OGD definition. Gonzalez-Zapata and Heeks[13] identified different perspectives on OGD research by considering three concepts: open government, open data, and government data. The underlying theoretical research provides a solid foundation for methodological and OGD-related follow-up research, including governing corruption[14], improving transparency in government agencies, and encouraging public participation[15]. (b) OGD theories. There are many existing theoretical models that have been applied to OGD research, single theoretical model, such as the UTAUT [16]. Scholars have attempted to combine the UTAUT model with different models and conduct extended research related to usage[19, 20]. The TOE framework was used to explore the drivers of financial transparency[18], and Khurshid, Zakaria, Rashid, Ahmad, Arfeen and Shehzad[19] noted that the TOE framework helps better understanding of organizational adoption of OGD, Mustapa, Nasaruddin, Hamid and Ieee[20] further combine the TOE framework with innovation adoption theory to explain public persistence after OGD adoption from the perspective of a data provider, which provides a new research perspective for researchers. (c) OGD methodologies. Scholars used case studies to focus on co-creation processes[8], the construction of a factor model of OGD firm perceptions.

OGD values can be attributed to political and social contributions. (a) Political values. Transparency is widely recognized as a key contribution of OGD[24]. Scholars have discussed transparency from different perspectives, such as building open data portals[22, 23], improving data usage efficiency[23], and the relationship between freedom of information laws and corruption[15]. Ruijer, Grimmelikhuijsen and Meijer[24] stated that OGD enhanced the democratic process by promoting monitorial, deliberation, and participation. OGD, as part of the digitization of government, promotes a new connection between neoliberalism and data citizenship[25]. (b) Social values. Ruijer and Meijer[26] pointed out that OGD is an innovation in itself and identifies different innovation stages. Moreover, OGD is treated as a data source to facilitate the development of new products and services[1], accelerates the construction of smart cities[27].

In the theme of OGD management, previous studies have discussed almost all possible issues. (a) Data management. Bizer, Heath and Berners-Lee[29] pointed out that linked (open) data is a set of best practices in publishing and linking structured data on the internet. Scholars have conducted research on improving data management through public information sharing[30], and the form of a data completeness ratio[31]. (b) User management. Researchers focus on existing issues such as antecedents of OGD adoption by relevant stakeholders[17] and post-adoption[32]. Literature focusing on citizen engagement dominate almost all of their research in user management. In this context, researchers aim to examine how to increase the participation of other stakeholders[33]. However, these studies ignore a new area that needs to be discussed - the participatory interactions between stakeholders such as citizens, businesses, and civil society organizations. (c) Process management. Knowledge management is the fundamental bridge for the extended development of OGD, scholars have also conducted many studies on OGD-related policies. Chatfield and Reddick[28] noted that data policy plays an important role in predicting ODP capacity.

4.3   Noteworthy topics in the future

As shown in Figures 2, the previous research paradigm encompasses almost all areas, including technical and modeling studies of OGD, OGD driving influences, OGD values, and OGD management. Researchers have advanced the depth of OGD from different perspectives. Before 2010 OGD research mostly focused on government information disclosure. In 2010, the United States proposed to establish an unprecedented open government, which gave rise to the concept of OGD. After that, scholars in various fields entered into the domain of OGD research, such as healthcare, urban construction, and public administration. Nevertheless, in Fig. 2, we find few keywords in the economic field (e.g., business value creation), which indicates that researchers have not given enough attention to the economic values of OGD. In addition, only several studies have shown that OGD contributes to business value creation [2, 34].

To further investigate potential research points in OGD research, based on the idea of Gonzalez-Zapata and Heeks [13], we divided OGD research into bureaucratic perspective, technological perspectives, political perspectives, and economic perspectives, totally four. The 3D spatial map of OGD research in Fig. 3.The circle area from the projection perpendicular to the practical application and theoretical research is the number of articles on the perspective. We classified the graph into two subgroups according to a compilation of the literature: (1) well-studies perspectives (A, B, and C): Bureaucratic Perspective (39.77%), Political Perspective (30.95%), and Technological Perspective (24.96%); (2) under-studies perspective (D): Economic Perspective (3.67%). This three-dimensional space indicates that existing literature focuses on the bureaucratic, political and technological perspective, and considers the study of economic perspectives to be lacking. However, OGD research from the economic perspective turns more and more important as it brings new insights for users (e.g., individuals and businesses) to create new product and services by employing OGD.
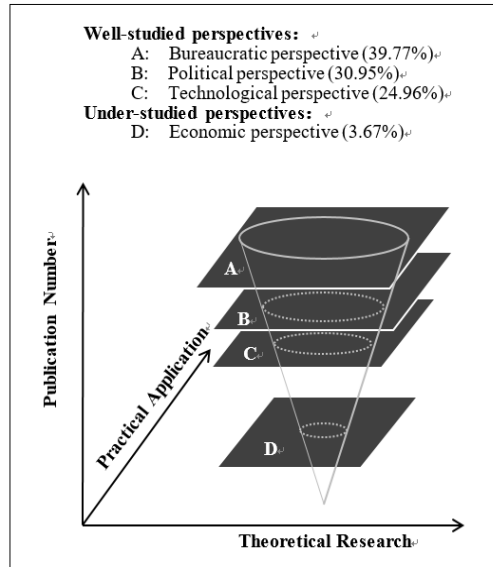
Fig. 3. 3D spatial map of OGD research.

Therefore, we propose that OGD research more notice is taken of the economic perspective in the coming to increase the participation of stakeholders in OGD. For example, how can OGD provide values to the public? How to create new products/services through OGD? How to create new employment opportunities through OGD? Moreover, OGD platforms can create a place to show successful OGD-driven innovation, which provides a pathway for those who have no ideas to employ OGD.

5 Conclusion

By extracting the top 116 keywords from 602 articles on OGD in the WoS database from 2010 to 2022 (March), we perform a systematic literature review on OGD research. Through our research, we have shown that there are five main themes in OGD research, including OGD participants, OGD technologies, OGD theories and methodologies, OGD values, and OGD management. Next, we analyze the specific research paradigms in the five main themes respectively. Finally, we paint the three-dimensional graph of the OGD study, which suggests that there are three well-studied perspectives (e.g., bureaucratic, political, and technological) and one under-studied perspective (e.g., economic).

The present study provides several contributions. First, our keyword-based knowledge map depicts an overall distribution of OGD research. Accordingly, we categorize five main themes of OGD research in the existing literature and analyze the specific research paradigms of the five themes, respectively. The results offer researchers what specific research content corresponds to the keywords under each theme. Finally, the results of our 3D spatial map of OGD research propose noteworthy topics in the future: the economic values of OGD, particularly for the eco-

nomic values of employing OGD for businesses and individuals. Overall, the present study provides scholars with a pathway to clarify the structure of OGD research and understand the keyword-based knowledge map in the field.

As a theoretical review, the current research proposes several valuable insights and and notable topics in the OGD field using various methods, including co-word analysis, social network analysis, multidimensional analysis, keyword evolution analysis et al. However, it is still necessary to further review existing literature of OGD research by introducing emerging bibliometric methods and extending data sources.

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