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<https://doi.org/10.1057/s41599-022-01189-2>

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Dispersion of ICT-related subject terms in information and knowledge management publications: A Bradford analysis

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The application of information and communication technologies (ICTs) in information and knowledge management (IKM) has attracted the attention of library and information Science (LIS) scholars in the recent past. The multidisciplinary and interdisciplinary nature of ICTs means that the ICT literature is published in several fields of knowledge. Although Bradford's law of dispersion is commonly used to determine the core journals in a given field or discipline or topic of study, this study attempts to use the principles of the law to determine the core concepts of ICTs within the information and knowledge management literature. Data was obtained from EBSCO Discovery's Library, Information Science and Technology Abstracts (LISTA) and the Library and Information Science Source (LISS) databases using a variety of keywords as search terms. The procedures of conducting a Bradford analysis were followed to determine the core subject terms in ICTs as reflected in the IKM group of articles published between 1998 and 2017. The results indicate that the application of ICTs in IKM largely occurs in the fields medicine, business and commerce, education and training (higher education and training), decision sciences, and industrial management. It was also noted that the core subjects varied from one study period to another; technology-associated subject terms were largely visible; and the dispersion of subject terms fits the Bradford's dispersion. We however noted that the dispersion of articles according to Bradford's zones is not accurately representative of the principles of the Law. The study has implications for collection development, searching and retrieval practices, and the application of Bradford's law beyond the analysis of core journals or publications in not only IKM but also in the field of library and information science.

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Introduction

One of the areas that have received considerable attention from bibliometricians are studies seeking to determine core areas of study, research, competencies, subject terms, and journals. Diverse methods and techniques have been employed to make such determinations. Among the most common ones are:

- Core/periphery model, mostly used to identify core terms in a text, journal or subject area (e.g. Borgatti and Everett, 1999; Onyancha and Ocholla, 2009a; Ocholla et al., 2010; Onyancha and Mokwatlo, 2012).
- Subject specialization index, mostly used to assess the concentration of research in given topics, fields, or disciplines (e.g. UNESCO, 2015; Davis, 1983; Pouris and Pouris, 2009; Onyancha, 2018).
- Bradford's Law of scattering, commonly used to identify core journals in a subject area or field (e.g. Singh and Bebi, 2014).

This study focuses on the possible use of Bradford's law to determine the core subject terms of *information and communication technologies* (ICTs) as reflected in the published articles on the sub-field of information and knowledge management (IKM). The application of information and communication technologies (ICTs) in diverse sectors has resulted in many scientific investigations and scholarly outputs throughout the world. The trend of research on ICTs has accelerated in the recent past, and more particularly in the latter part of the 2011–2020 decade. For instance, a study conducted by Onyancha (2018) noted that ICTs has emerged as one of the leading topics of research in the library and information science field. Onyancha's (2018) study revealed that research on different ICTs has continued to dominate LIS research. Knowledge management, too, has emerged as a hot research topic having emerged from nowhere so to speak to rank the 2nd in the top 20 author supplied keywords in 2011–2015 (see Onyancha 2018). A study to assess the application of ICTs in IKM, an emerging sub-field of LIS, as well as to identify the core subject terms in the sub-field, is therefore timely, especially in view of the fact that knowledge management is increasingly becoming reliant on ICTs for effective and successful execution (López et al., 2009). A content analysis of the literature to identify the core concepts within a given subject domain serves many purposes, including delineating subject terms, topics or disciplines, establishing the level of interest in a subject field, ascertaining the quality of organization of information resources through indexing and abstracting of the literature, determining the growth of a discipline or subject area, and aiding searching and retrieval of relevant information for information seekers and users, as well as gauging the level of interest and adoption of specific terms to describe a subject domain or discipline (see Onyancha and Ocholla, 2009b; Girap et al., 2014). The current study uses Bradford's to determine the core ICTs subject terms as reflected in the IKM literature.

Bradford's law: a brief overview

Bradford's law, formulated in 1934 by Samuel C Bradford, states that "if scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same number of articles as the nucleus, when the numbers of periodicals in the nucleus and succeeding zones will be as $1:n:n^2:n^3$, where n is a multiplier" (Bailón-Moreno et al., 2005, p. 213). Simply stated, the law states that in a given subject field over a given period of time, (a) a few journals publish a relatively high percent of articles

in a field; and (b) there are many journals that publish only a few articles each (Diodato, 1994). Diodato (1994) argues that a Bradford analysis may be used to test how well Bradford's law applies to a collection of items and sources (usually articles and journals) or to identify the core of journals in a field. As Yatsko (2012) observes, a number of authors have offered suggestions to (a) clarify the law (e.g. Brookes, 1968; Bailón-Moreno et al., 2005); (b) offer its interpretation; (c) analyse its conformity with the other laws; and/or (d) to demonstrate the possibilities of its application for the analysis of various kinds of data (e.g. Drott et al., 1979; Girap et al., 2014). It is on the basis of point (d) that this study was conducted. It is worth noting however that there are some scholars who have criticized the law, especially the formula, (e.g. Brookes, 1968; Urquhart, 1981; Heine, 1998, all as cited in Shenton and Hay-Gibson, 2009). Criticism of this nature is not unexpected in scholarship. Despite the criticisms, Bradford's law remains a subject of much discussion as witnessed in recent studies.

Related studies

Most studies that have been conducted on Bradford's law have sought to determine the dispersion of articles in journals in order to identify core journals in a subject field or discipline (Andrés, 2009; Hjørland and Nicolaisen, 2005; Yatsko, 2012). Recent studies that have been conducted, using the Bradford analysis, to assess journal productivity so as to identify core journals in a subject field include Desai et al. (2018), Wahid and Idrees (2017), and Neelamma and Gavissiddappa (2016), Yang et al. (2016), and Singh and Bebi (2014). The law has also been applied to study the citations in a given journal in order to find out the list of core journals cited by authors publishing their works in a journal (Wahid and Idrees, 2017). For example, Singh and Bebi (2014) used Bradford's law to study the cited references in Ph.D. theses in social sciences of the University of Delhi and found that Bradford's law fitted the study. Lately, however, there have been attempts to study the application of the law beyond its original focus in assessing journal productivity. Tsay (2008) conducted a study, by employing bibliometrics techniques and more particularly the Bradford's Law, to analyse the scattering and subject changes between the citing and cited literature in digital libraries. The author noted that while the citing core journals were devoted to the subject of the "application of computer and information technology to library implication", the cited core journals addressed four main subject areas namely *digital library orientation*, *general library and information science*, *new development in librarianship* and *library technology* (Tsay, 2008, p. 713). It would have been interesting to find out if the aforementioned subject areas constituted the core subjects in the citing and cited literature respectively.

Bradford's Law has also been applied to examine how well the distribution of 'sitations' fits a Bradford-type distribution. In their study titled "situation" distributions and Bradford's law in a closed Web space, Faba-Pérez et al. (2003, p. 558) found that although the situation distributions were coherent with those in previous experiments, the "plots of accumulated clusters of situations [i.e. plotting the accumulated situations against accumulated targets] and targets did not fit the typical Bradford distribution".

Girap et al. (2014) study on the application of Bradford's law to the evaluation of book collection of the library of Bhabha Atomic Research Centre is perhaps the closest to the current study. Using the Universal Decimal Classification class numbers, the authors identified 27 main subject headings in which a total of 94,450 books at the library belonged. The authors then ranked the subject headings according to the number of books in Bradford-

type zones and noted that the subject headings formed three zones with Bradford’s nucleus (core zone) comprising two subject headings, the next zone consisting five subject headings while the last zone consisted of twenty (20) subject headings. When expressed according to the Bradford’s distribution, the pattern of the distribution of subject headings, according to Girap et al. (2014), was 2:5:20, which was close to 1:2¹:2², and in the Bradford-type distribution of 1:n¹:n². Apparently, the dispersion pattern reported by Girap et al. (2014), in their study, does not perfectly fit Bradford’s law but is close, as the 3rd zone in their study consists of far more subject headings (i.e. 20) than the Bradford law suggests (i.e. 8).

Purpose and objectives of the study

In view of the above and despite the arguments that Bradford’s law can be adopted to assess the distribution of literature according to subject terms (see Yatsko, 2012), less has been explored in the subject of investigation of this paper. The purpose of this study therefore is to investigate the possibility of applying Bradford’s law of dispersion to determine core subject terms of information and communication technologies (ICTs) as reflected in the information and knowledge management (IKM) literature. Specific objectives of the study are:

- To determine the nature of dispersion of ICT-related subject terms and publications as reflected in the IKM literature using Bradford’s law of scattering, from 1998 to 2017.
- To identify the core subject terms in ICTs in the IKM literature, from 1998 to 2017.
- To determine the applicability of Bradford’s law in the dispersion of the ICTs literature, from 1998 to 2017.

Methods

We used EBSCO Discovery and EBOSCO-HOST’s Library, Information Science and Technology Abstracts (LISTA) and the Library and Information Science Source (LISS) databases to extract relevant data for the study. The former hosts many internationally popular databases and was therefore found most desirable. The latter two focus on LIS, a discipline within which knowledge management is considered as a sub-field. An advance search platform was used to conduct searches for articles published on ICTs, by combining the search terms “Information and Communication Technologies” and “information technologies” and their variations, on the one hand, and “information management” and “knowledge management” terms, on the other hand. The search was conducted within the subject fields so as to obtain results with high specificity and reliability. The search was limited to articles published in peer-reviewed and scholarly publications between 1998 and 2017, all inclusive. The exact search query that was used to search for relevant data was: (SU (“information technology” OR “information technologies” OR

“information systems” OR “information communication technologies” OR “information and communication technologies” OR “information & communication technology” OR “information & communication technologies”)) AND SU (“information management” OR “information resources management” OR “information services management” OR “knowledge management” OR “knowledge organization”). The search yielded a total of 9479 articles, which were considered adequate for analysis.

The extracted data (i.e. subject terms) for each record was saved in text format to meet the requirements of the Bibexcel Software which was used to analyse the data in order to generate frequencies of term occurrence. As explained in the section above on literature review, the core subject terms constituted those terms that formed the Bradford’s nucleus. In order to determine the core subject terms, we followed the procedures outlined in Andrés (2009) and Singh and Bebi (2014) regarding the application of Bradford’s Law.

We ranked the subject terms and corresponding articles as reflected in Appendixes A–D. Each of the tables in the appendixes consists of the number of subject terms (column 1) appearing in how many number of documents (column 2), cumulative subject terms (column 3), cumulative documents (column 4) and the log (*ln*) of cumulative subjects (column 5). Secondly, we calculated the value of Bradford’s constant (*k*) for each time period of study (i.e. 1998–2002, 2003–2007, 2008–2012, and 2013–2017) as follows:

$$\kappa = (e^\gamma \times Y_m)^{1/p}$$

where γ is Euler’s number (i.e. $\gamma = 0.5772$), Y_m is the maximum number of records for the highest ranked subject term, and p is the number of zones or Bradford’s groups. Given that the number of subject terms was big, the number of zones was set at four (i.e. $p = 4$) for each year period. Consequently, Bradford’s constant κ for each period of study was calculated as follows:

- 1988–2002: $\kappa = (1.781 \times 283)^{1/4} = 4.738191$
- 2003–2007: $\kappa = (1.781 \times 122)^{1/4} = 3.839334$
- 2008–2012: $\kappa = (1.781 \times 59)^{1/4} = 3.201688$
- 2013–2017: $\kappa = (1.781 \times 135)^{1/4} = 3.937762$

Thirdly, we calculated the number of subject terms that would constitute the core or Bradford’s nucleus using the following formula:

$$r_0 = \frac{T(\kappa - 1)}{(\kappa^p - 1)}$$

where T is the total number of subject terms which are the subject of research in the ICT documents, κ is Bradford’s constant and p is the number of zones or Bradford’s groups. The value of the core subject terms (i.e. r_0), as obtained using the above formula, for each time zone, is provided in column three of Table 1.

The number of subject terms that would constitute the subsequent zones of Bradford’s groups were calculated based on the number that constituted the core zone and Bradford’s constant κ

Table 1 Bradford zones for publications in ICTs research within the IKM context, 1998–2017.

Year of publication		Core (r_0)	Zone 1 (r_1)	Zone 2 (r_2)	Zone 3 (r_3)
1998–2002	No. of subject terms	7	34	160	759
	No. of articles	776	572	728	857
2003–2007	No. of subject terms	36	139	532	2043
	No. of articles	1380	1237	1592	2160
2008–2012	No. of subject terms	86	274	878	2811
	No. of articles	1902	1898	2255	2819
2013–2017	No. of subject terms	39	151	595	2344
	No. of articles	959	1295	1728	2509

Table 2 Core subject terms in ICT research, 1998–2002 (N = 1143).

	Frequency	%
1 Technology—Information Services	283	24.76
2 Information Technology	263	23.01
3 Information Society	58	5.07
4 Internet	53	4.64
5 Libraries	50	4.37
6 Library Science	39	3.41
7 Electronic Publications	30	2.62

as follows:

$$r_1 = r_0 \times \kappa^1$$

$$r_2 = r_0 \times \kappa^2$$

$$r_3 = r_0 \times \kappa^3$$

This process of determining the number of subject terms that constituted each zone was repeated for each time zone. The results are presented in Table 1. Once the number of the core subject terms was generated, we identified the subject terms from the ranked list of the terms in each time zone and plotted them in Tables 2–5).

Results and discussion

Nature of dispersion of ICT-related subject terms and publications within the IKM context using Bradford’s law of scattering. Table 1, which is drawn from the data presented in Appendices A–D, provides the results of the study according to Bradford’s zones or groups. It reveals that, in 1998–2002, the core or nucleus consisted of seven subject terms, which were the subject of investigation or discussion in 776 articles while the core in 2003–2007 comprised a total of 36 subject terms, which posted a total of 1380 articles. In 2008–2012 and 2013–2017, there were 86 and 39 subject terms, with some 1902 and 959 articles in Bradford’s core or nucleus, respectively. The other zones, which can be termed as peripheral, produced a pattern that was similar to the core but with a higher volume of subject terms and articles as reflected in columns 4–6 in Table 1. The Table further reveals that the number of subject terms that form the core in each time period varies, just as the subsequent zones. Appendices A–D demonstrate that the cumulative number of subject terms rose rapidly from 960 spread across 2933 articles in 1998–2002 to 4049 subject terms which spread across 8874 articles 2008–2012, only for it to fall to 3129 in 653 articles in 2013–2017. The least number of subject terms witnessed in the 2013–2017 time period can be attributed to retrospective indexing, where indexing time lag is a factor that influences the capturing of a record’s metadata and/or bibliographic information in a database. Another observation that can be made based on the data in Appendices A–D is that most subject terms appeared once (see column 1 in each Table) in the articles. In summary, Table 1 shows that Bradford’s core consisted of the smallest number of subject terms when compared to the other three zones. The core can be said to consist of the key subject terms in a field.

Core ICT-related subject terms in the IKM literature, according to Bradford’s nucleus. Having established the number of subject terms in each zone, according to Bradford’s Law, we sought to identify and present the core subjects per the publication time period as shown in Tables 2–5. The analysis was also meant to identify the core areas in which ICTs are applied in IKM. Table 2 presents the seven subject terms, which comprised

Table 3 Core subject terms in ICT research, 2003–2007 (N = 2813).

Subject term	F	%	Subject term	F	%
Technology	122	4.34	Decision Making	29	1.03
High Technology	106	3.77	Enterprise Resource Planning	28	1.00
Management	83	2.95	Public Institutions	27	0.96
Information Systems					
Business Enterprises	75	2.67	Higher Education	26	0.92
Management	72	2.56	Teaching	26	0.92
Electronic Commerce	55	1.96	Educational Innovations	24	0.85
Medical Care	40	1.42	Work Environment	23	0.82
Industrial Management	39	1.39	Organizational Learning	22	0.78
Intellectual Capital	33	1.17	Management Science	21	0.75
Public Administration	32	1.14	Teacher Training	20	0.71
Information Technology	31	1.10	Economic Development	20	0.71
Business Planning	31	1.10	Personnel Management	19	0.68
Corporate Culture	30	1.07	Instructional Systems	19	0.68
Globalization	29	1.03	Investments	18	0.64
Organization	29	1.03	College Teachers	18	0.64

the core of Bradford’s distribution for the period 1998–2002. Leading the pack is *Technology—Information Services* with 283 (24.76%) articles, followed closely by *Information Technology*, which was mentioned in 263 (23.01%) articles. It is evident that the core areas of research during this period were associated with the application of information technology (as opposed to ICTs, in its broad term) in the provision of information services in libraries. The occurrence of information society among the core subject terms is testimony of the hyping of the concept ‘information society’ in the 1990s (Technopolitics Working Group, 2015). It should be acknowledged that one of the characteristics of an information society is the presence and application of information technology as an enabler of accessing, processing or organizing, storing, dissemination or transfer and manipulation of information (Balan, 2013). The presence of electronic publications among the seven core subject terms is not surprising as the e-publications are products of ICTs. The Internet seems to be the main enabler for library services during the 1998–2002 period of study, given the prominence it received during the 1998–2002 study period. Table 2 does not however explicitly reveal how the said ICTs were applied in KM but we can conjure that the ICTs available in libraries during this period were largely used to provide Internet services to patrons as well as for the automation of services (see Bowers, 2018).

The 2003–2007 period saw the number of the core subject terms not only increase to 36 but also the dropping out of some of the core terms that existed in Bradford’s core in 1998–2002. Table 3 provides the top 30 out of the 36 core subject terms, for purposes of data presentation. All but one subject term in Table 2 were dropped from the list of core subject terms in 2003–2007, implying that out of the 36 subject terms that constituted Bradford’s core in 2003–2007, 35 were new. The core subject terms in 2003–2007 are largely associated with business/trade/commerce and the management of organizations. We further note that no specific ICT is mentioned among the core subject terms. This may imply that all articles on ICTs were indexed under the headings Technology or Information Technology or that no ICT-specific subject term was core in the period of study. Nevertheless, we note that Management Information Systems, defined as a “set of procedures that collects (or retrieves),

Table 4 Core subject terms in ICT research, 2008–2012 (N = 3265).

Subject term	F	%	Subject term	F	%
Management Information Systems	52	1.59	Educational Innovations	25	0.77
Decision Making	49	1.50	College Teachers	25	0.77
Online Social Networks	48	1.47	Information Technology	24	0.74
Electronic Commerce	44	1.35	Public Administration	24	0.74
Business Enterprises	42	1.29	Technology & Society	22	0.67
Social Networks	42	1.29	Project Management	22	0.67
Industrial Management	39	1.19	Technology Acceptance Model	21	0.64
High Technology	35	1.07	Organizational Change	21	0.64
Corporate Culture	32	0.98	Knowledge Management Research	19	0.58
Technology	31	0.95	Globalization	18	0.55
Data Security	28	0.86	Business Communication	19	0.58
Management	27	0.83	Organizational Behaviour	17	0.52
Organizational Learning	27	0.83	Diffusion of Innovations	17	0.52
Theory of Knowledge	26	0.80	Social Interaction	17	0.52
Intellectual Capital	25	0.77	Innovation Management	16	0.49

Table 5 Core subject terms in ICT research, 2013–2017.

Subject term	F	%	Subject term	F	%
Information Technology in Medicine	135	5.98	Electronic Commerce	21	0.93
Decision Making	45	1.99	Social Networks	21	0.93
Diffusion of Innovations	43	1.90	Competitive Advantage In Business	20	0.89
Higher Education	41	1.82	Organizational Change	19	0.84
Information Technology Industry	32	1.42	Knowledge Management Research	19	0.84
Organizational Performance	30	1.33	Online Social Networks	19	0.84
Medical Care	30	1.33	Technology	18	0.80
Telemedicine	26	1.15	Data Analysis Software	17	0.75
Business Enterprises	26	1.15	Industrial Management	17	0.75
Structural Equation Modelling	25	1.11	Theory Of Knowledge	16	0.71
Financing of Research	23	1.02	Learning Strategies	16	0.71
Public Sector	23	1.02	Information Technology Periodicals	16	0.71
Public Administration	22	0.97	Cell Phones	15	0.66
Mathematical Models	21	0.93	Data Security	15	0.66
Project Management	21	0.93	Medical Communication	15	0.66

processes, stores, and disseminates information to support decision making and control” (Laudon and Laudon, 2003), is the only ICT-oriented term that appears in the core during the 2003–2007 period. Its presence explains the occurrence of the other terms which are largely associated with the management of and decision making processes in organizations and public institutions. Other information system-oriented terms that appear in Table 3 include ‘electronic commerce’, ‘educational innovations’ and ‘Instructional Systems’ which are closely linked with business and education.

In terms of the application of ICTs in IKM between 2003 and 2007, the focus of research was centred around management information systems and management (including industrial management, public administration, enterprise resource planning, business planning, organizational learning, and personnel management). Organizational or corporate culture and globalization are two terms that have become commonly visible in IKM literature (see for example, Rocha, 2021; Srinibash and Mohapatra, 2018).

Table 4 provides 30 of the 86 subject terms in the Bradford nucleus for the period 2008–2012. Like the previous time period (i.e. 2003–2007), this period witnessed some new additions while other subject terms dropped out. Out of the 36 subject terms that formed the core in 2003–2007, six did not feature in 2008–2012. These are: Organization, Enterprise Resource Planning, Public Institutions, Business, and Management Science. The rest of the subject terms, numbering 29, featured

in the 2008–2012 Bradford’s core. The implication therefore is that, of the 86 core subject terms in Bradford’s core of 2008–2012, 57 were new. Unlike the previous years, no one subject term was highly dominant in 2008–2012. The top ranking terms appeared in articles that were close in terms of their (i.e. subject terms) frequency of occurrence in the databases. The period represented in Table 4 saw the dominance of issues revolving around management science, trade, education and medicine, which may also reflect the areas in which ICTs were applied in relation to IKM. The top ranking subject terms during the 2008–2012 time period were similar to those occurring in the previous time period, albeit the slight differences in terms of their frequencies of occurrence. Management Information Systems, Electronic Commerce, Business Enterprises, Industrial Management, and Organizational Learning were among the top ranking terms that co-occurred in the two core zones of 2003–2007 and 2008–2012. Information Technology-based terms popped up in the latter period with Management Information Systems, Online Social Networks, Social Networks, High Technology, Technology, Information Technology, Technology & Society, and User-Centred System Design appearing frequently in the ICT literature. Furthermore, the occurrence of Technology Acceptance Model and Diffusion of Innovations may reveal the studies’ orientation, namely the acceptance and diffusion of ICTs in management, education, trade, organizational learning, knowledge management and medical care, among others.

Table 6 Bradford's constant (κ) for each Bradford's and time zones.

Year of publication		Core (r_0)	Zone 1 (r_1)	Zone 2 (r_2)	Zone 3 (r_3)
1998–2002	No. of subjects	7	34	160	759
	κ	–	4.8571	4.7059	4.7438
2003–2007	No. of subjects	36	139	532	2043
	κ	–	3.8611	3.8273	3.8402
2008–2012	No. of subjects	86	274	878	2811
	κ	–	3.1860	3.2044	3.2016
2013–2017	No. of subjects	39	151	595	2344
	κ	–	3.8718	3.9404	3.9395

The Bradford's core concepts or subject terms associated with ICTs in IKM in 2013–2017 totalled 39, but only 30 of the subject terms are presented in Table 5 for data clarity. One-third (that is, 13) of the subject terms were common in the core zones of the two time periods of 2008–2012 and 2013–2017. ICT-based terms included 'information technology in medicine', 'diffusion of innovations', 'information technology industry', 'telemedicine', 'electronic commerce', 'social networks', 'online social networks', 'technology', 'data analysis software' and 'cell phones'. The application of ICTs in the sub-field of knowledge management in this period largely mirrored the preceding period (i.e., 2008–2012) whereby ICTs were used in medicine, decision sciences, business and commerce, and industrial management. This period witnessed the introduction of two types of ICTs, namely the social media and cell phones as the key enablers of IKM.

Does the dispersion of ICTs subject terms in IKM research fit Bradford's law? In this section, we focus our attention on two aspects in order to determine whether or not the data fits Bradford's Law so as to gauge the suitability of the Law in the identification of the core subject terms on ICTs as reflected in the IKM literature indexed in EBSCO's databases. In the first instance, we compute the Bradford multiplier κ in each zone by dividing the number of subject terms in the subsequent zone by the number in the previous zone, i.e.

$$\kappa = \frac{r_n}{r_{n-1}}, \text{ the numerator excludes the nucleus value}$$

If the multiplier is similar to Bradford's constant as provided in the "Methods" section, then the data is said to fit Bradford's Law. A comparison between the Bradford constant (i.e. κ) in Table 6 and Bradford's multiplier (i.e. κ) as shown in the "Methods" section, reveals that the two values are similar across all the zones. For instance, whereas the multiplier for the time zone 1998–2002 is 4.738191 (see the section "Methods"), the constant in the same time zone in Table 6 ranges between 4.7 and 4.9. When the values are rounded off to the nearest whole figure, they all equal to 5.0, therefore registering a perfect semblance.

In the second instance, we determine the ratio of the number of subject terms in one Bradford zone to the number of the subsequent zone to determine whether or not the proportion of the data, in this study, fits Bradford's pattern, i.e. 1:n:n²:n³.... Table 7 provides the proportional distribution of the values, expressed as ratios in the pattern of Bradford's expression of the Law.

The proportional pattern of the distribution of the subject terms for each time period is therefore as follows:

- a. **1998–2002**
1:4.86:22.86:108.43 or 1:5:23:108, which is close to and can be expressed as 1:5¹:5²:5³. The multiplier (n) for the period 1988–2002 is 5.

- b. **2003–2007**
1:3.86:14:78:56.75 or 1:4:15:57, which is close to and can be expressed as 1:4¹:4²:4³. The multiplier (n) for the period 2003–2007 is 4.
- c. **2008–2012**
1:3.19:10.21:32.69 or 1:3:10:33, which is close to and can be expressed as 1:3¹:3²:3³. The multiplier (n) for the period 2008–2012 is 3.
- d. **2013–2017**
1:3.87:15.26:60.10 or 1:4:15:60, which is close to and can be expressed as 1:4¹:4²:4³. The multiplier (n) for the period 2013–2017 is 4.

Conclusion

This study sought to determine the nature of dispersion of the ICT subject terms in the IKM literature using Bradford's law. A total of seven subject terms were considered as core in the period 1998 to 2002 while 2003–2007 yielded 36 subject terms in the core zone. The number of core subject terms for the next two time zones of 2007–2012 and 2013–2017 were 86 and 39, respectively. The subject terms that formed each core, from 1998–2017, have differed both in number and constitution, except the periods 2008–2012 and 2013–2017, which largely consisted of similar concepts. The shifting of the subject terms that constituted the core in each case (see Tables 2–5) may be an indication of an evolving subject domain, change of research focus, interdisciplinary nature of the research areas of ICTs and KM, dynamic application of ICTs in information and knowledge services, or dynamic indexing services. As the ICTs remain relevant and important tools for IKM, among other aspects that affect human life such as health, the pattern of distribution of subject terms in the core zones is likely to persist in research. New concepts will continue emerging while others move from the core to peripheral zones. The application of ICTs in information and knowledge management largely occurs in the fields of medicine, business and commerce, education and training, decision sciences and industrial management as well as information resources management.

The proportional distribution of subject terms reveals that the number of subject terms in each Bradford group is proportional to 1:n:n²:n³. Tables 6 and 7 provide Bradford's constant and multiplier in each time period, respectively. We aver that the data in this study fits the Bradford's Law and therefore the law can be used to not only determine the number of ICTs subject terms that are core IKM research but also identify the core subject terms in a specific research area. It will be however interesting to conduct the same study using different subject domains as case studies to assess the applicability of the law. Such an exploration will provide adequate evidence to make informed conclusions on the application of the law in assessing other units besides the dispersion of the literature in journals.

Table 7 Zones and proportions of ICTs subject terms, 1998–2017.

Year of publication		Core (r_0)	Zone 1 (r_1)	Zone 2 (r_2)	Zone 3 (r_3)	Bradford's multiplier (n)
1998–2002	No. of subjects	7	34	160	759	5
	Proportion	1	4.86	22.86	108.43	
2003–2007	No. of subjects	36	139	532	2043	4
	Proportion	1	3.86	14.78	56.75	
2008–2012	No. of subjects	86	274	878	2811	3
	Proportion	1	3.19	10.21	32.69	
2013–2017	No. of subjects	39	151	595	2344	4
	Proportion	1	3.87	15.26	60.10	

Implications of the study on information practice. The implication of the application of Bradford's law in information practice is well documented. Qiu et al. (2017) have argued that the law has both theoretical and practical applications. The law's application in practice is diverse and includes the determination of core journals, literature search, investigation of monograph distribution, maintenance of dynamic collection, measurement of the integrity of search tools, guiding users to use journals, guiding the work of journal subscription (Qiu et al., 2017) as well as a tool in developing information systems (Von Ungern-Sternberg, 2000).

The current study has demonstrated a possible area and manner in which Bradford's law can be applied in practice. The application of Bradford's law in subject analysis may assist in curriculum development, thesaurus construction, and subject organization and description in the area of ICTs as they relate to IKM. Other areas of application would be the development of an information system as opined by Von Ungern-Sternberg (2000) as well as literature research, and collection development as noted by Qiu et al. (2017).

Received: 6 December 2021; Accepted: 28 April 2022;

Published online: 18 May 2022

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Acknowledgements

A version of this paper was published in the proceedings of the International Society for Scientometrics and Informetrics.

Author contributions

Both authors conceived the project idea and contributed equally to the compilation of the manuscript, leading to its publication in the Journal.

Competing interests

The authors declare no competing interests.

Ethical approval

Ethical approval was not needed for this study. The data was collected from bibliographic databases.

Informed consent

This article does not contain any studies with human participants performed by any of the authors and as such there was no need for authors to seek informed consent.

Additional information

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1057/s41599-022-01189-2>.

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