

The Prospect of 5th Industrial Revolution and Academic Library Services: Exploring the role of Data Science in the Post Pandemic Period

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Abstract-Background and objective: *The 5th industrial revolution provides many opportunities for the industrial and commercial sectors, researchers, educationists, information specialists, librarians and health managers to address communication challenges facing the systems using wireless devices through 5G. The literature review examines studies focusing on the prospect of the 5th industrial revolution and academic library services by exploring the role of data science in the post-pandemic period. The purpose is to identify knowledge gaps in the literature to make recommendations for future research.*

Approach: *The review analysis focuses on data science, academic library services and post-pandemic recovery in the 5th industrial revolution. A literature search was conducted on the Scopus database as a peer-reviewed and scientific source and for document analysis of the extracted literature, while the result was analysed based on the objectives set for the study.*

Result: *Out of 307 documents identified, 19 documents were included in the review analysis. The highest number of documents were published in 2020 with 11(57.9%). The trend of research outputs between 2019 and 2020 reveals a prospect of better turnout of literature focusing on data science and academic library services efficiently utilizing 5G resources in the post-pandemic period.*

Implication/Limitation: *Academic libraries in developing countries could benefit from the interdependent connection with data science and the field of information science using digital technologies. The review analysis is limited to documents identified in the Scopus database with search strategies such as “5th Industrial Revolution”, “Data science” AND libraries, “Post-pandemic” AND libraries, “Post pandemic recovery ”AND 5th industrial revolution, “5th Industrial revolution” AND libraries “5th Industrial revolution” AND data science, Wireless Technologies Communication Health AND services.*

Originality: *This literature analysis built on the expected role of data librarians and data science in bridging the knowledge gap among African researchers in the post-pandemic recovery period.*

Conclusion: It is envisaged that the prospect of 5G will enhance the use of data science and academic library services

using wireless communication technologies promoted in the post-pandemic recovery period.

Keyword: *Data science, 5th industrial revolution, academic library services, post-pandemic recovery*

I. Introduction

The continuous demand for highly modified products with flexibility in the production lines, informs the need for data science skills and literacy with expertise in data-intensive domains in academic libraries which comes with the 5th Industrial Revolution (5IR) [1]. Information and communication technology (ICT) development began from the 60s progressing towards many opportunities for capturing, processing and storing information in many contexts [2]. ICT was invented to overcome many challenges including distance, communication difficulties and many other constraints in the 80s. As time went by, the world economy changed based on the new opportunities offered by ICT activities on a global scale as sometimes called the "2nd industrial revolution" [2]. Currently, research shows that the 5th IR emerged with improvement in various activities developed in the 4th Industrial Revolution (4th IR). The 4th IR comprises many digital technologies such as “artificial intelligence (AI), robotics, Internet of Things (IoT) cloud computing, big data, 3D printing among others [3]. The 5th IR is marked with advance improvement in activities such as digital technologies artificial intelligence (AI), robotics, Internet of Things (IoT) cloud computing, big data, 3D printing [3], based on the need for higher flexibility to support new information communication devices such as moving robots or drones. The 5th IR includes applications of mechanical and digital machines to communication devices for information transfer over the network [4] including the IoT (Prajapati, *et al.*, 2019). The applications of wireless technologies of 5G help to improve the flexibility use of 4G robots and drones [2]. The 4G technologies are used to guide 5G mobile networks (5G), to gain flexibility, efficiency, QoS- and energy-aware solutions, for a sustainable economy [5] The 5G provides opportunities for researchers to address the challenges facing communication systems using wireless devices through 5G, including education and health challenges. In the health arena, research shows that Machine learning (ML) and Big data analytics (BDA) were developed

to provide promising solutions to biomedical communities, to solve healthcare problems, and to provide patient care as well as predict and interpret early signs of chronic diseases such as heart disease, diabetes, and kidney disease [6; 7; 8].

The present 5IR information communication technologies rely on wire-line technologies to connect sensors and which informs the reason why the present technological connections need to be replaced by wireless technologies to support the emergence of 5IR. In the LIS domain, information specialists can apply the 5IR wireless communications to enhance service provisions for their clients which in turn requires the need for further training in the specific areas of demand. Oliver, *et al.*, [9] noted that “data science is a rapidly growing field with applications across all scientific domains”. Also, research by Hatzivasilis, *et al.*, [5] found out that “Smart interconnected devices, including Cyber-Physical Systems (CPS), permeate our lives and are now as an integral part of our daily activities, paving the way towards the Internet of Things (IoT)”. In the industrial domain, these devices interact with their surroundings and system operators, while often also integrating industrial cloud applications. According to Hammad [10], the internet of thing (IoT) enable machines to be connected and communicate, whereas the Internet of Everything (IoE) makes the connection more relevant between all smart devices, machines and also people with huge data, high speed and high security. The new wireless communication technologies were proposed to solve communication problems, to meet the increasingly high demand as well as improve the performances of bandwidth connectivity [3; 4; 10].

A. The Link between 5th IR, Data Science and Academic Libraries

Data librarians in academic libraries must understand how data science skills and techniques could be jointly utilised to improve data management services in academic libraries. Scholars examined the importance of data science, the various branches and the emerging trends of use in academic libraries [11; 12; 13; 14]. According to Chiware, [13], “academic and research libraries in Africa remains an important aspect of higher education and the national systems of research and innovation. As such, the provision of data management services is one of the important roles of academic and research libraries [13]. Kaur [14] regarded data science as “a blanket term for machine learning, artificial intelligence (AI) and big data (BD)” because the knowledge of data science is being used to provide services to users both “in commercial and noncommercial organizations” including institutions of higher learning such as universities and academic libraries to improve research and learning experiences. Shah, *et al.*, [12] sums up the six roles of data science managers such as “data archivist, data curator, data librarian, data analyst, data engineer, and data journalist” using the latest and highly cited research studies through the search on Google-scholar. Tella and Kadri [11] examined an aspect of data science such as big data and the importance to users in academic libraries but found out that “big data is indeed very big in academic libraries given the pieces of evidence of its adoption and best practices and use in

academic libraries across the world”. Tzanova [15] examine some changes in academic libraries in the era of Open Science, but found out that “academic libraries face challenges regarding accommodating and providing support for open big data, the expansion of library services, and adoption of new roles and responsibilities” which includes the “development of the supporting models for research data management, providing data management plan assistance, expanding the qualifications of library personnel toward data science literacy, integration of the library services into research and educational process and among others.

The link between 5IR, data science and library services relates to the prospect of using wireless technologies to solve the problem of communication as earlier stated especially in the libraries [16]. Data are used to facilitate learning methodology for students or lecturers as well as provide easy access and use of information resources by every category of users (undergraduate, post-graduates, facilitators and corporate organisation). The analysis aspect of data is used by librarians to calculate the use of resources by library clients using different approaches [17; 14]. According to Shah, *et al.*, [12], data librarians provides access to data sources and repositories such as files, print and electronic assortments to facilitate an exciting learning environment for scholars. However, provisions of free access to data sources require wireless technologies to enhance the use of resources. The use of wireless technologies promoted in 5th IR can be used to better improve the role of data science in supporting data librarianship especially in the aspect of service delivery. Many libraries in the developed and under-developed countries have embraced the opportunities provided by new technologies to improve their library services [University of Toronto, Canada; [16], National Network of Libraries of Medicine; [16]. Although in some countries such as in United State, data librarians still value the role of traditional librarians such as reference services, collection management, literature searching more than the emerging role of expertise such as data science skills, grant experience, and research impact assessment” [18]. In that situation, one would be tempted to ask what step would be taken at the period of a pandemic such as covid-19 whereby physical movement is restricted?. Data scientists in the 5IR “employs techniques and theories drawn from many fields within the broad areas of mathematics, statistics, information science, computer science as well as other domain such as machine learning, classification, cluster analysis, data mining” and among others [19]. Data scientist promotes data science literacy, data science integration into the library services, and the educational process by taking part in the research grants and many others’ [15]. Successful integration of data science into library services no doubt requires new skills and collaboration among library staff to work with both researchers and end-users as they manage data going forward” [10].

Academic libraries must embrace the services of a data scientist to improve the LIS curriculum at the faculty level to prepare data librarians for the unexpected shift in circumstances such as during an outbreak of epidemic to cope with challenges facing research data management [15; 16; 17]. It is equally important to note that universities in developed and developing countries are advance towards a

new “data-informed, intra-institutional collaboration paradigm, and new services ... added to academic library routines” [20]. Regarding open big data as a branch of data science, a Study by Tzanova [15]) argues that “academic libraries face challenges of accommodating and providing support for open big data composed from existing raw data sets and new massive sets generated from data-driven research”. Interestingly, the problems of open big data “trigger not only more development of traditional library services, but also leads to the adoption of a set of new roles and responsibilities” which includes the “development of the supporting models for research data management, providing data management plan assistance, expanding the qualifications of library personnel toward data science literacy, integration of the library services into research and the educational process by taking part in research grants and many others” [15].

B Academic Libraries in a Post-Pandemic Period

The impact of the pandemic is marked with social, economic, health and educational influence on the general populace [21], leading to consequences such as “lockdowns, and world-wide reductions in production and consumptions, amplified by cascading impacts through international supply chains that are being felt across the entire world economy” [21]. Other effects of the pandemic include “a mandatory and rapid transition to Work from Home (WFH)” [22]. It was reported that many organisation went through massive changes to adjust very quickly to new working conditions, and many went through different emotional journeys [22]. Eventually many found remote work as an opportunity to realize their competencies and strengths [22], while others provided a “series of best practices with the possibility of running event online [23]. The pandemic left a notable effect on both adult education and “early childhood education and care” given that “young children are in danger of becoming collateral damage in the COVID-19 pandemic”. Consequently, the young children were deprived of necessary social interaction” [24]. For example, an investigation was carried out focusing on “the impact of COVID-19 pandemic on information management research and practice by Dwivedi, *et al.*, [25] found out that “the pandemic has forced many organizations to undergo significant transformation, rethinking key elements of their business processes and also used technology to maintain operations” by changing the landscape of their guidelines and following new procedures. Also, Walsh and Rana, [16] investigated the “continuity of academic library services during the pandemic, found out that the library services were reorganized to meet the need of users through collaboration, transitioning from in-person to online service delivery. The study noted how libraries provided online access, modifications and expansion to support teaching and learning, supporting researchers through remote research support without compromising efficacy and social distancing [16]. During the post-pandemic recovery era, online learning became more popular for the education of both young and

adult learners, including medical providers [26]. Consequently, many researchers suggested “a broader shift within digital libraries community by moving events online during a novel pandemic [23]. Many experts in the business and education sector moved to “online learning” [25; 16]. Researchers maintained that during the pandemic, many academic libraries provided improved access to existing physical collections through digitization to make access to materials more convenient to consult [16].

Given the emerging prospects that 5IR presents in the aspects of digital technologies, wireless communication technologies, increase in bandwidth connectivity, artificial intelligence (AI), robotics, Internet of Things (IoT) cloud computing, big data, 3D printing [3]), this literature review aim to explore the emerging role of data science to inform a suitable area of applications in academic library services, adding to the improved and the existing infrastructure in the African context. The purpose of this literature review is to identify knowledge gaps in the literature on the 5th industrial revolution and academic library services: exploring the role of data science in the post-pandemic recovery era to make recommendations for future research (Peters, *et al.*, 2015:141).

II. Aim of the Review

The broad aim of this review is to identify knowledge gaps in the literature on the 5th IR and the role of data scientists in supporting academic library services during the post-pandemic recovery era, to make recommendations for future research [28]. The research questions are as follows:

- ❖ What are the characteristics of data science documents contributing to the role of data librarians in the 5IR?
- ❖ What method of investigations are used in data science documents written in the post-pandemic period?
- ❖ What emerging technologies and the area of applications are featured in the documents highlighting the 5th IR?
- ❖ What are the implications of applying data science to library services in the post-pandemic recovery period?

III. Methodology

The methodology used for this review includes a literature analysis approach to explore studies conducted on the 5th industrial revolution and academic library services: exploring the role of data science in the post-pandemic recovery era. A literature survey was conducted on the Scopus database as a peer-reviewed and scientific source and for document analysis for the extracted literature. Thematic analysis approach was also used to explore the themes based on documents identifying the subject of the review. The literature searches conducted in the Scopus database focused on four thematic areas such as “5th industrial revolution, academic library services, data science and post-pandemic recovery. The limit was set to identify open access journals and conference proceedings, as well as articles published in the English Language. To avoid bias, only literature that featured the 5th industrial revolution, academic libraries, data science and post-pandemic were included. The search strategies identify a total of 306 documents. The breakdown of the searched documents is illustrated in table 1 of this paper.

IV. Findings

Table 1. Search Strategies

S.N	Search Strategies	
1.	5 th Industrial Revolution	13
2.	5 th Industrial Revolution AND libraries	0
3.	“5 th industrial revolution” data science AND libraries	0
4.	“5 th Industrial revolution” AND data science	0
5.	“5 th Industrial revolution” AND libraries	0
6.	“Post pandemic recovery” AND 5 th industrial revolution	0
7.	“Data science” AND libraries	286
8.	“Post-pandemic” AND libraries	7
	Total Documents	306

TABLE 2. A SUMMARY OF THE SELECTED ARTICLES INCLUDED IN REVIEWED LITERATURE.

Source: Generated by the researcher from findings from the literature.

Source: Search strategies generated by the researcher.

Table 1 above shows the total of 306 documents searched and identified in the Scopus database. The documents comprise of articles, conference papers, book series and books from various subject areas of specialisation were identified, however, after a thorough scanning through the abstracts and full texts documents, only 19 articles including conference papers were extracted from the identified documents. Articles not discussing 5th IR, data science applications in the libraries during the post-pandemic period were not selected. A search “5th industrial revolution” produced 13 documents. However, a search for “5th Industrial Revolution” AND libraries; “5th industrial revolution” data science AND libraries; “5th Industrial revolution” AND data science; “5th Industrial revolution” AND libraries and “Post pandemic recovery” AND 5th industrial revolution did not yield any result. Besides, the search for “Data science” AND libraries yielded 286 results while the search for “Post-pandemic” AND libraries also yielded only 7 documents, eventually, no document was selected from among the 7 documents identified from the search. The reason was that none of the articles focused on the subject of the study. The 7 documents focused on irrelevant subjects such as Agaric and biology (2), biochemistry (2), medicine (2), and social sciences (2). The 2 articles published in the social science subject area focused on building community at a distance: a datathon during COVID-19 by Fritz, *et al.*, [23] in the Journal of Digital Library Perspectives, while the second article by Wasmuth [24] focusing on early childhood education and care in a post-pandemic world” and published in Journal of Knowledge and Culture, and affiliated to Art and Humanities subject area. The 19 extracted documents were summarized in table 2 of this document.

Summary of the Reviewed Literature

The summary of the reviewed literature was analysed based on the research questions. Meanwhile, the summary of the included articles was organised according to the literature characteristics.

S/N	Author	Country	Methodology	Subject specialization	Area of Applications	Findings
1	Tella & Kadri [11].	Nigeria	A conceptual and review analysis.	Big data and academic libraries.	Big data in academic libraries.	Although big data is indeed very big in academic libraries based on best practices in its use in academic libraries across the world, however, challenges can render it big for nothing.
2	Shao, et al., [29].	USA	Content analysis.	Academic libraries supporting data science education curriculum.	Applying computer science skills, statistics, data management, data ethics, and data communications.	Academic libraries can enrich data science education by supporting credit courses, certificate programs, to provide learning opportunities to all students.
3	Shibly, et al., [30].	Singapore	The descriptive analysis method used Twitter as the social networking Web site	Classifying and measuring hate speech	Machine learning libraries incorporated with Python program to design and develop a model to classify and measure hate speech.	Researchers have found that the majority of the tweets are based on racist, ethnicity, sex and religion-based.
4	Satpathy, et al., [3].	Germany	Qualitative	Digital technologies i. Artificial intelligence (AI), robotics, Internet of Things (IoT) cloud computing, big data, 3D printing.	English language development, communication, personality development, leadership, critical thinking, problem-solving and team-building skills to meet employers expectations.	The study provides valuable insights on the problems faced by the 5th semester students related to language acquisition and their readiness for future industrial demands.
5	Bonati, et al., [31].	United States	Compendium of recent open-source software and 4 frameworks for 5G cellular networks.	Open, programmable, and virtualized 5G networks.	Applications of wireless devices, communication techniques in a wireless environment through several heterogeneous city-scale testbeds.	Findings revealed that despite the efforts of operators, vendors and scientists, the system is not ready for prime time on commercial 5G networks just yet.

6	Shah and Naeem, [12].	Pakistan	Summary of reviews.	Data Science, Librarians Duties.	Applications of data science to the duties of data librarians regarding data use.	There is a need to educate librarians, library science researchers, and students regarding understanding, utility, and management of data to meet the requirements of data science librarians.
7	Federer, et al., [32].	USA	Literature review.	Data Services Competency	Health and biomedical libraries use and provision of data services.	Librarians have a unique opportunity to provide valuable support and assistance in data science and open science but may need to add to their expertise and skillset to have the most impact.
8	Salleras, & Daza, [33].	Spain	SANS: Self-Sovereign Authentication for Network Slices	Internet of Things (IoT). 5G Radio Access Network (RAN), wireless networks and services.	Using 5G Internet of Things (IoT) devices to assist users to have full control over their information.	The paper provided benchmarks demonstrating non-linkable protection for information, preventing an SO or an eavesdropper from tracking users' activity and relating it to their real identities.
9	Petcu, et al., [27].	Romania	Exploratory-Analysis	Digital technologies (Artificial Intelligence)	Business activities, educational system and society	The study recorded up-to-date public services, increased quality of products and services provided by companies, and a better quality of life for citizens.
10	Pico-Valencia, et al., [34].	Spain	Machine Learning (ML) model applications for predictive behaviour.	Machine Learning tools i.e Python, Matlab, R Suite, and libraries, to enhance decision making.	Applying ML software to predict future behaviours to help in the decision-making process.	ML requires extensive knowledge of statistics, artificial intelligence, algorithms and computer programming that generally only computer engineers are skilled at.
11	Washington Durr [35].	USA	A latent semantic analysis of over 1,600 job postings and iSchool course documentation	Data Science and Library and Information Science.	Exploring the role of library and information science and data science. Searching for guiding future directions for library and information science professionals into data science-driven roles.	The study envisaged that the study will guide future directions for LIS professionals into data science-driven roles.

12	Morriello, [36].	Italy	A systematic exploration of data librarianship and the role of data librarian.	Research data management (RDM).	Data Librarianship.	The study encourages the data librarian to figure out what is needed to be built on the subject .still to be built and defined
13	Virkus, & Garoufallou, [37].	Not available	Content analysis/web of science search for data science.	Content analysis of data science publications	Applying data science to health sciences, data science education and training and knowledge and skills of the data professional.	Findings show that several publications fell into several categories because the topics were closely related.
14	Ramon-Cortes, et al., [38].	Spain	Building complex Data Science workflows with different approaches	Hybrid-workflow: Combining task-based workflows and data flows all-in-one	Using task-based management systems to support input and output data to combine task-based workflows and dataflows in a single programming model.	The library can be easily integrated with existing task-based frameworks to provide support for dataflow.
15	Hammad, et al., [10].	Jordan	Using the questionnaire was to collect data from 21 academic libraries in Jordan	Research data management and academic library services.	Applying RDM to library services.	Awareness, partnership and RMD skills are needed between the research community and academic libraries.
16	Hassan, et al., [4].	Malaysia	UsTng The Internet of Thing (IIOT) to solve Communication problems, meet environmental demand, enhance the performances of the system and to overcome	Application of mechanical and digital machines to communication devices for information transfer over the network.	Connecting new wireless communication technologies to meet the demand and performance of the system to overcome bandwidth limitations.	Li-Fi technology is a complement to Wi-Fi for 5G technology, safer in the use of petrol pumps, hospitals, no license is needed and it is a green technology by using light instead of the radio wave.

			bandwidth limitations.			
17	Prajapati, et al., [39].	USA	Self-corrective maintenance (SCM) paradigm as a hybrid.	IOT	Internet of Things (IIoT) for industrial power systems.	This hybrid proposal could be a significant gear shift in maintenance direction for general industry as well as power systems
18	Gundall, et al., [1].	Germany	Analysing, identification, modification and integration of various radio access technologies (RATs).	Applications of wireless technologies of 5G to improve the flexibility use of 4G robots and Drones.	Applications of German Tactile Internet 4.0 (TACNET 4.0) research project to address the challenges and requirements of communication industries 4.0 using wireless communication system 5G.	While 4G provides the key for flexible, efficient and adaptable industrial automation, 5G provides the tools to realize the industry 4.0 vision and expand the use landscape significantly.
19	Hatzivasilis, et al., [5].	France	Hy-LP - a novel hybrid protocol and development framework for Industrial IoT (IIoT) systems.	Adopting 4G technologies to guide 5th Generation Mobile Networks (5G), to gain flexibility, efficiency, QoS- and energy-aware solutions, for the sustainable economy.	Applications of Hy-LP to enable seamless communication of IIoT sensors and actuators, within and across domains, facilitating the integration of the Industrial Cloud.	The proposed system is around 10 times faster for the same CPU usage level while consuming 7 times less memory.

This section organised the results of the literature review according to the research questions guiding the study.

❖ **What are the characteristics of data science documents contributing to the role of data librarians in the 5IR?**

The summary of the extracted literature was organised based on characteristics of the study such as author, year of publications in chronological order.

- a) **Country of origin:** Based on the result of the literature search in Scopus, out of 286 documents identified, the majority of the documents were published in the USA (114), followed by the UK (22), Germany (18), and India (18). Others include China (14), Italy (13), Canada (11), Nigeria (2) and Ghana (1). Also, based on the documents included in the reviewed literature, the majority of the articles were published in the USA with 5(26.3%) followed by Spain 3(15.8%), and 2(10.5%) from Germany, other countries like Nigeria had (1) publications each. Table 2 illustrates the summary of the included articles in the review.
- b) **Characteristics based on the subject area and year of publications.** Meanwhile, out of 286 documents produced between 1994 and 2021 focusing on “Data science” and libraries [fig.2], the majority of documents were published in the computer science subject area with 185(64.7%) followed by 65(22.7%) document were

published in the social science with different subjects themes such as data science, machine learning, big data, learning system data mining libraries, data handling and deep learning. Others were published in engineering (48), mathematics (44), decision science (31), medicine (25), and among others (Fig.1). Meanwhile, based on the summary of the documents included in the reviewed literature, the majority of data science and libraries subject was published in the social science subject area were published in LIS source domain such as Journal of Academic Librarianship, Journal of Medical Library Association, Libri Hi-Tech and among others. Out of the 19 documents reviewed, the highest number of documents were published in 2020 with 11(57.9%) out of 19, others were 3(15.8%) were published in 2021, 3(15.8%) were published in 2019 and 2(10.5%) were published in 2018. Fourteen (73.7%) documents were mainly articles out of nineteen (19) full-text, peer-reviewed scientific documents extracted, while five (26.3%) conference papers were full texts, peer-reviewed scientific documents were included in the reviewed documents. On the other hand, 11(57.9%) out of 19 documents focused on data science, while 8(42.1%) documents focused on five 5IR. Figure 1 illustrates te document analysis based on the subject areas.

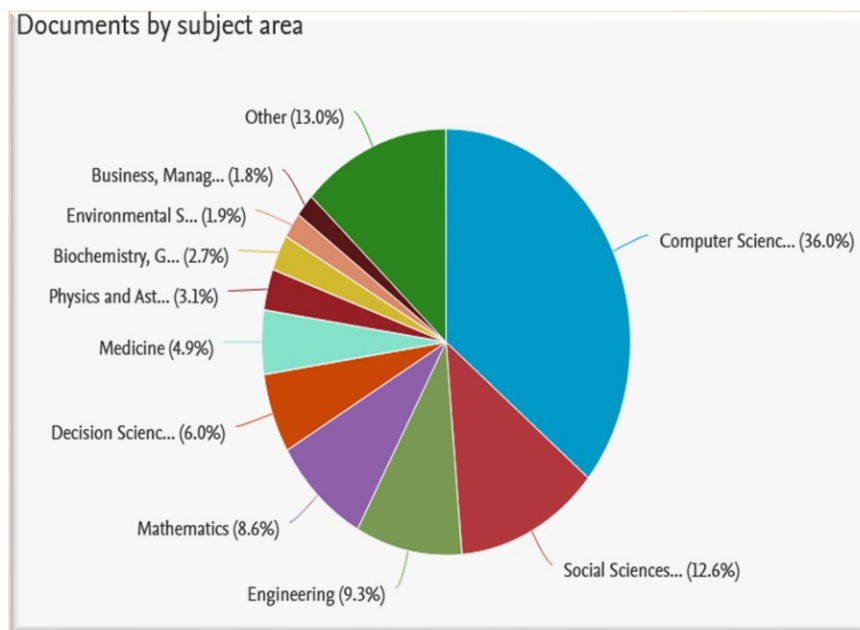


Fig. 1 Document Analysis by Subject Area. Source: *Generated from Scopus by the Researcher.*

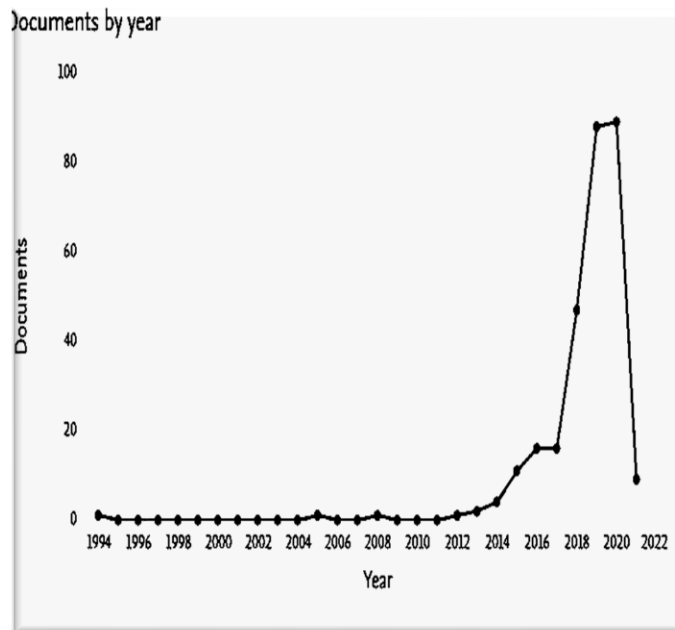


Fig. 2 Document Analysis of Data Science and Libraries by Year of Publications. Source: Generated from Scopus database by the researcher.

What method of investigations are used in data science documents written in the post-pandemic period?

The methodology applied to included literature comprises of varieties of approaches used to examine studies in the documents included in the review. The majority (42.1%) of the study reviewed documents used literature summary, review and content analysis as a method of investigations [11; 29; 31; 12; 32; 37; 36]. Other methods used include the descriptive analysis method [30], qualitative method [3], exploratory analysis and survey questionnaire [27; 10]. Models used also include Machine Learning (ML), Internet of Thing (IIOT) to solve Communication problems [33], meet environmental demand [4], and enhance the performances of the system and to overcome bandwidth limitations Hassan, *et al.*, [4].

What emerging technologies and the area of applications are featured in the documents highlighting the 5th IR?

The emerging technologies include the use of Digital Technologies such as artificial intelligence (AI), robotics, the internet of things (IoT) cloud computing, big data, 3D printing to improve communication and services delivery [3]. Besides, digital technologies enabled “new wireless devices, communication techniques, networks, systems, and services in real wireless environments through several heterogeneous city-scale testbeds” through open, programmable, and virtualized 5G networks [31]. The emerging new technologies using 5G Internet of Things (IoT) devices to assist users to have full control over their information have been tested and proved to be very efficient [33]. Meanwhile, the emerging technologies applicable to library services include applications of Big data to library services [33], digital technologies [3], artificial intelligence (AI) [27], robotics, Internet of Things (IoT) cloud computing [33], 3D printing, Open, programmable, and virtualized 5G networks [3]. Internet of Things (IoT), 5G Radio Access Network (RAN),

wireless networks and services., machine learning (ML) tools such as Python, Matlab, R Suite, and libraries, to enhance decision making. Other applications include the application of mechanical and digital machines to communication devices for information transfer over the network, applications of wireless technologies of 5G to improve the flexibility use of 4G Robots and Drones, and are also applicable to improving communication networks used in the libraries to support speed and efficiency in data management and accessibility and use of resources. Adopting 4G technologies to guide 5th Generation Mobile Networks (5G) also help to gain flexibility and efficiency using QoS- and energy- aware solutions, for sustainable economy [34; 4].

What are the implications of applying data science to library services in the post-pandemic recovery period?

V. IMPLICATIONS: This review has the potential of enriching academic libraries with data science knowledge, supporting credit courses at the departmental level by providing learning opportunities to all students” [29]. It has the implications of improving the services and efficiency level to a mega status, helping organizations to reach a targeted goal. Applications of varieties of data science tools can be used to improve user experience and provide better services to customers by “using appropriate data structure and algorithm. User experience and the better services can also be used to provide effective customer services in the libraries” [29]. According to Virkus and Garoufallou [37], several fields such as the library and information science, information systems, knowledge management and health sciences provided valuable contributions to data science. This review provides the benefits of access to “a wider network of data analysts and specialists”, generating opportunities for librarians to acquire emerging data science and data visualization skills (Reznik-Zellen, *et al.*, 2020).

VI. LIMITATIONS: The review analysis is limited to only the documents recorded in the Scopus database and identified with the search strategies such as “5th Industrial Revolution”, “Data science ”AND libraries, “Post-pandemic” AND libraries, “Post pandemic recovery ”AND 5th industrial revolution, “5th Industrial revolution” AND libraries “5th Industrial revolution” AND data science, Wireless Technologies Communication Health AND services. Theoretical applications have not yet been applied.

VII. DISCUSSION

The literature analysis aimed to identify knowledge gaps in the literature on the 5th IR and the role of data science in supporting academic library services during the post-pandemic recovery era, to make recommendations for future research. Based on the findings from the review of the literature, the highest number of documents were published between 2016 and 2020 with 256(89.5%), while the trend of research out between 2008 and 2014 on the subject was very low. The literature review identified a wide gap between the low level of research outputs experienced between 1994 and 2014. However, the gap was bridged with an increase in research productivity between 2015 and 2020. Perhaps the factors responsible for the increase might be influenced by the new shift in the paradigm of the wide acceptance of technological development, using information communication technological devices to influence information communication technologies in the libraries, promoting information sharing, data management and use. Secondly, about (22.7%) of identified documents from the Scopus database were produced by social science researchers. In the real sense, such a percentage of output needs to be improved. The contributions of library and information scientists are very important in this aspect. It is equally important for data librarians to acquire relevant digital technology skills to meet the demand of their clients. Thirdly, findings show that the majority of the documents were published in developed countries such as the USA (114), followed by UK (22), Germany (18), and India (18), while countries in the developing region have very low research outputs specifically in the African region (Nigeria and Ghana). It is hoped that social scientist and library and information scientists will improve their research productivities in the African region. Data science has a lot of potentials in the developed countries. According to Washington Durr (2020:270), the prospects of data science is enormous because it has potentials for offering a wealth of jobs to prospective employees. In the LIS domain, Oliver, *et al.*, (2019:241) noted how “academic library is uniquely positioned to provide training and guidance in a number of areas relevant to data science”. In another development, findings shows that the majority (42.1%) of the articles reviewed used literature summary, review and content analysis as a method of investigations (Tella & Kadri, 2021; Shao, *et al.*, 2021; Bonati, *et al.*, 2020; Shah and Naeem, 2020; Federer, *et al.*, 2020; Virkus, & Garoufallou, 2020; Morriello, 2020). The reason is that the use of methodological

approaches for investigations is very important in social science research as well as in the LIS discipline to identify gaps in knowledge or research is very important. Besides, emerging technologies have many areas of compatibilities with the role of academic in providing services for library clients. Areas of applications include Big data (Tella & Kadri, 2021), artificial intelligence (AI) (Petcu, *et al.*, 2020), robotics, Internet of Things (IoT) cloud computing (Salleras, & Daza, 2020), 3D printing, Open, programmable, and virtualized 5G networks (Satpathy, *et al.*, 2020), Internet of Things (IoT), 5G Radio Access Network (RAN), wireless networks and services., machine learning (ML) tools such as Python, Matlab, R Suite, are used to enhance data management as part of library services and decision making.

VIII. CONCLUSION AND SUGGESTIONS

Conclusively, based on the increase in research productivity between 2015 and 2020, and 2021 already produced 9 documents related to the subject, this indicates that there is a prospect of more increase in research outputs on data science and libraries in the years to come. On the other hand, academic libraries in developing countries can benefit from the interdependent relationship between data science and the field of information science, researchers in information science and other social science-related fields must utilize the data to bring out more research outputs. The result of this literature analysis can guide the future directions of academic librarians collaborating with data scientists in the possibilities for the future corporation. The adoption of digital technologies (Artificial Intelligence) in the library services will help to increased the quality of products and services provision, with the prospect of contributing to a better quality of life for citizens [27]. It is suggested that “academic libraries should enrich data science education efforts, by supporting credit courses, certificate programs, and other co-curricular activities to provide learning opportunities to all students” [12]. Therefore, it is envisaged that utilizing data science skills and techniques in the post-pandemic period will guide future directions for library and information science professionals into data science role (Digital technologies), while also examining and highlighting the data-science techniques currently driven by the education of LIS curriculum and professional skills. This literature review is limited to Scopus database search. The authors suggested that further review could make use of Web of Science or more.

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