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Factors Affecting Computer Science Research Productivity and Impact in Nigeria: A Bibliometric Evidence

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Abstract

Computer science is a burgeoning research field and has the potential to accelerate the rate of industrialisation and subsequently, economic development. Using bibliometric data obtained from Scopus, this study employed a 15-year bibliometric analysis to highlight Nigeria's productivity and impact trends in the computer science research landscape. Our findings are summarised as follows: First, Nigeria's computer science research contribution and citations are meager in comparison to the global output. Secondly, international collaboration is generally weak as most collaborations are national in scope. Third, Nigeria's computer science-related research is published in low-quality outlets, as Scopus has discontinued the indexing of most of the outlets. Although, the publication growth trend is encouraging, the volume and impact of computer science-related research can improve significantly with the conduct of more quality researches that facilitated by strong international collaborations, and published in very high-quality outlets.

Keywords: Computer Science research, Bibliometrics, Scientometrics, Informetrics, publication, research, Scopus

1. Introduction

The field of Computer science is a broad field concerned with the study of computation and information. This burgeoning field can be classified into theoretical computer science, computer systems, computer applications and software engineering. Theoretical computer science is further classified into Theory of computation, Information and coding theory, Data structures and algorithms, Programming language theory, and Formal methods. An inexhaustive list of the sub-feeds in Computer Science are as follows: computer architecture, Concurrent, parallel and distributed systems, Computer security and cryptography, Databases, Computer graphics and visualisation, Human-computer interactions, Artificial intelligence, Machine learning, Computer vision and image processing, Data mining, science and analytics, Natural language processing and Software engineering (Bird et al., 2009).

In general, science as a discipline is developing permanently (Vinkler, 2019), and there has been rapid development of scientific knowledge globally as well as in the field of computing.

However, global contributions to scientific knowledge have not been evenly distributed as Africa generally still lags in the quantity and impact of scientific contributions (Duermeijer et al., 2018; Okeke et al., 2017). Although Africa contributes less than 1% to global scientific knowledge, this contribution can be attributed to only a few countries in the region; one of such countries is Nigeria (Kpolovie & Dorgu, 2020; Okoro & Umagba, 2016; Unesco, 2018; Uthman & Uthman, 2007).

Informetrics studies the quantitative aspects of information (Tague-Sutcliffe, 1992). Informetrics as a discipline encompasses fields such as scientometrics and bibliometrics, and can help situate significant research impact, by analysing research trends through the use of bibliometrics indicators that evaluate authors, research teams, institutions, countries or specific papers and publication outlets (Vinkler, 2019). Using bibliometric analysis, Okoro et al. explored Nigeria's Computer Science Production from 1996 to 2014 within the context of other African countries and reported that Nigeria is among the top 6 countries on the continent (Okoro & Umagba, 2016). Against this backdrop, we performed a 15-year in-depth bibliometrics analysis of the computer science-related research outputs from the leading institutions in Nigeria.

Consequently, the main aim of this study is two-fold, first to gain deeper insights into the productivity and citations trends of these institutions, as well as to uncover the underlaying factors that affecting these trends benchmarked against global trends. To achieve the aim, we first identified the leading institutions in Nigeria that have contributed to the computer science-related research domain and then analysed their annual productivity and citation trends. After that, we uncovered their top national and international collaborators, publication types and the quality of the publications' outlets.

2. Materials and Methods

The bibliometric data on computer science-related corpus was downloaded from the Scopus database. Scopus is the largest abstract and citation database of peer-reviewed literature (Elsevier, 2016). Expressly, the search query was framed as follows: [AFFILCOUNTRY (Nigeria) AND SUBJAREA (COMP) AND PUBYEAR AFT 2003 AND PUBYEAR BEF 2019]. The query was formulated to retrieve all the records relating to the field of "Computer Science" from the Scopus Database. We defined the period as from 2004 to 2018 and the author(s) must be affiliated to institutions in Nigeria. The year 2018 was selected because as at the date of data retrieval (August 14, 2020, 4:31 PM) some documents for 2019 may not

yet be indexed in the Scopus database. We choose 2018 to ascertain the completeness of the bibliometric data that was retrieved from Scopus. Global Universities ranking bodies, such as the Times Higher Education (THE) usually make such consideration since they also use the Scopus database as a data source (THE, 2018). The query returned a total 4,971 documents. To enable a comparison with the global trends, we modified the query to remove the national limit to Nigeria as follows: [SUBJAREA (COMP) AND PUBYEAR AFT 2003 AND PUBYEAR BEF 2019].

Following the results of the initial query, we identified the top institutions in Nigeria using a threshold of 100 publications. Institutions with publications volume below 100 were not considered in this study. These 14 institutions met the criteria – Covenant University, University of Ibadan, University of Lagos, Obafemi Awolowo University, University of Nigeria, Federal University of Technology, Akure, Federal University of Technology, Minna, University of Ilorin, Ahmadu Bello University, Bayero University, Delta State University, Rivers State University of Science and Technology, University of Benin, and the Federal University of Technology, Owerri.

We then modified the query by filtering the initial results, limiting the bibliometric retrieval to the 14 institutions selected. This process yielded the bibliometric data for the analysis undertaken in this study. The modified query returned an aggregate of 3,137 publications, which is 63% of the original records (4,971) that was returned.

We downloaded the bibliometric data in Comma Separated Version (CSV) Format and performed the bibliometrics and statistical analysis to achieve the aim of this research. All the analyses were carried out in Microsoft Excel, 2016 Version.

3. Results

3.1. Profile of the top 14 Institutions

We present in Table 1 the summary of the profiles of the top 14 institutions in Nigeria's computer science-related research landscape. From Table 1, Covenant University (CU) emerged as the only private University in the list. The classifications of other universities in this list are as follows, 11 Federal Universities (78.6%) and two State-owned universities (14.3%). Figure 2 shows that majority of the shortlisted Universities are located in the south-western region of Nigeria (35.71%), followed by the south-south area (28.57%). Two Universities are located in each of the North-East, North-Central and South-East regions of

the Country. When considering the year of establishment, the oldest University on the list is the University of Ibadan, and it was established in 1948 (72 years ago), while the youngest is CU, established in 2002 (18 years ago).

Table 1: Profile of Top Productive 14 Institutions in Computer Science-related Research in Nigeria

#	Institution	State Located	Proprietors	Region of the Country	Est.	Age (Years)
1	CU	Ogun	Private	South-West	2002	18
2	UI	Oyo	Federal	South-West	1948	72
3	UNIL	Lagos	Federal	South-West	1962	58
4	OAU	Osun	Federal	South-West	1961	59
5	UNN	Enugu	Federal	South-East	1955	65
6	FUTA	Ondo	Federal	South-West	1981	39
7	FUTM	Niger	Federal	North-Central	1983	37
8	UNII	Kwara	Federal	North-Central	1975	45
9	ABU	Kaduna	Federal	North West	1962	58
10	BUK	Kano	Federal	North West	1962	58
11	DSU	Delta	State	South-South	1992	28
12	RUST	Rivers	State	South-South	1980	40
13	UNIB	Edo	Federal	South-South	1970	50
14	FUTO	Imo	Federal	South-East	1980	40

CU = Covenant University; **UI** = University of Ibadan; **UNIL** = University of Lagos; **OAU** = Obafemi Awolowo University; **UNN** = University of Nigeria; **FUTA** = Federal University of Technology, Akure; **FUTM** = Federal University of Technology, Minna; **UNII** = University of Ilorin; **ABU** = Ahmadu Bello University; **BUK** = Bayero University; **DSU** = Delta State University; **RUST** = Rivers State University of Science and Technology; **UNIB** = University of Benin; **FUTO** = Federal University of Technology, Owerri;

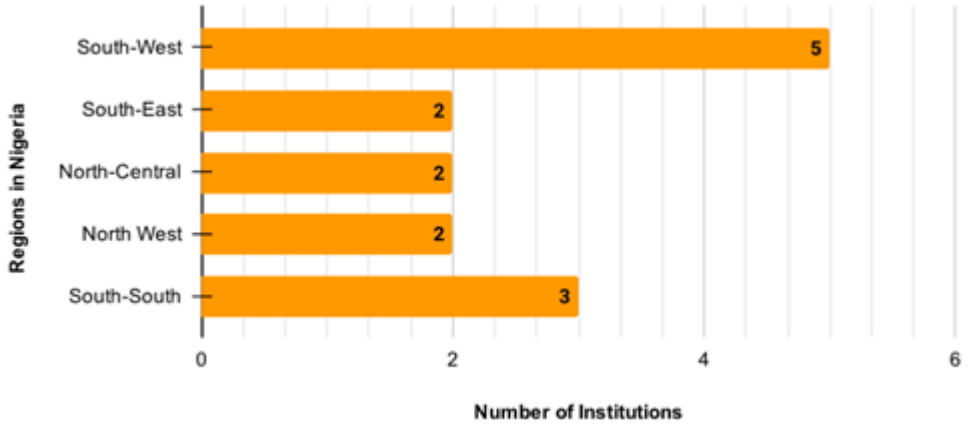

Figure 1: Regional Distribution of the Top 14 Institutions in Nigeria:
The South-west had the highest concentration of the 14 leading Institutions in the Country

3.2. General Bibliometric Analysis

The 3,137 publications have been cited 12,740 times with an h-index of 36. Figure 3 shows the citation trends of the documents, while the annual publication volume is also shown in Figure 4. From Figures 3 and 4, it is clear that the volume of publication and citation is on the increase, with the highest publication and citation counts at 602 and 2,459 respectively in 2018, which is the terminal year period of this study.

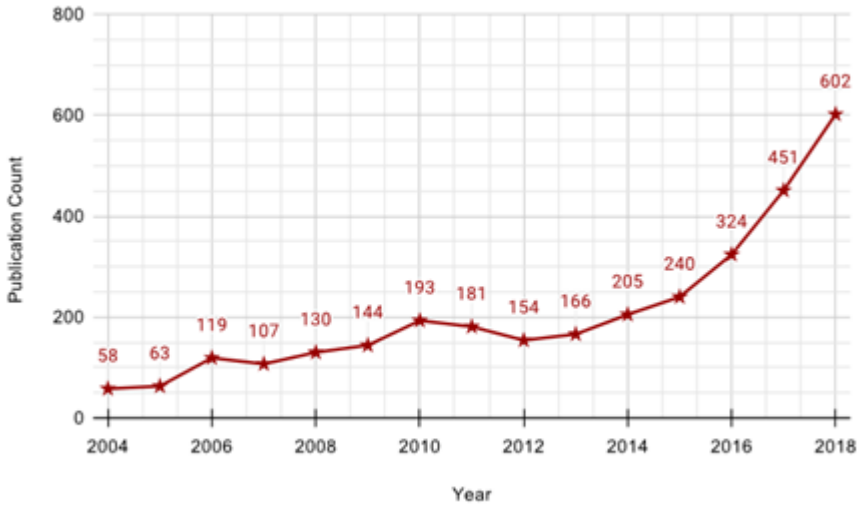

Figure 2: Annual Publication Volume Trend for 3,137 Publications by the 14 leading Institutions in Nigeria

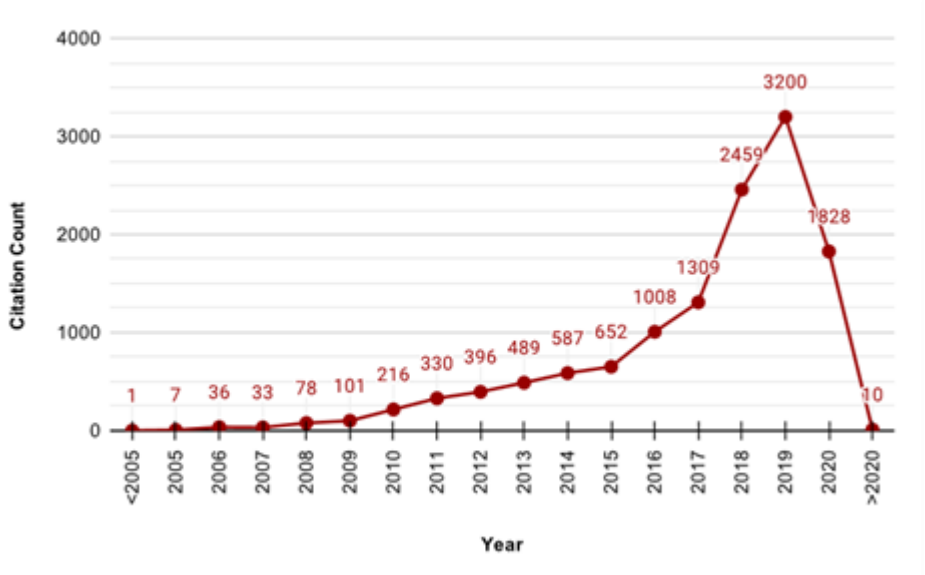

Figure 3: Annual Citation Trend for 3,137 Publications by the 14 leading Institutions in Nigeria

3.3. Institutional Bibliometric Analysis

Figure 5 shows the top 14 institutions in Nigeria based on the bibliometric dataset. The institution with the highest number of publications is CU with 807 publications (25.73%), followed by the University of Ibadan with 342 publications (10.1%). The publication volume of other institutions in the list includes University of Lagos (284 publications), Obafemi Awolowo University (274 publications), University of Nigeria (233 publications), Federal University of Technology, Akure (230 publications), Federal University of Technology, Minna (228 publications), University of Ilorin (214 publications), Ahmadu Bello University (198 publications), Bayero University (129 publications), Delta State University Nigeria (129 publications), Rivers State University of Science and Technology (122 publications), University of Benin (116 publications), Federal University of Technology, Owerri (110 publications).

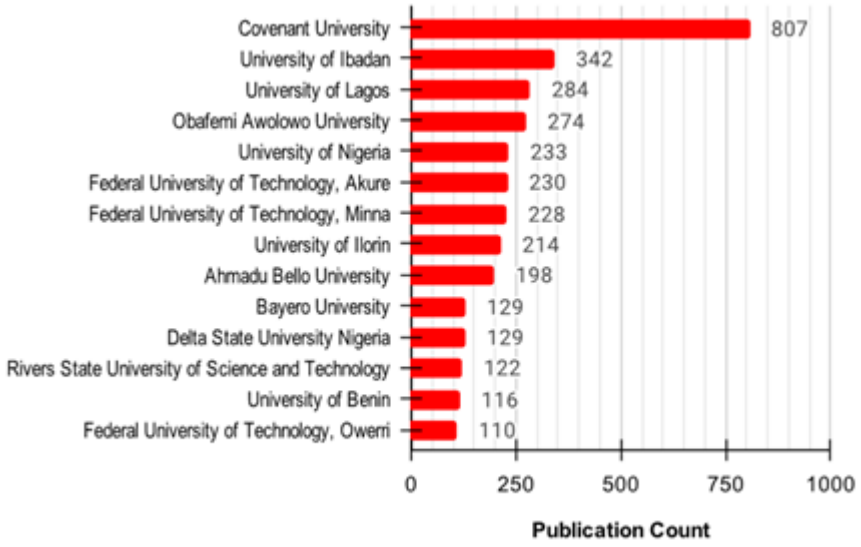

Figure 4: Profile of Top Productive 14 Institutions in Computer Science-related Research in Nigeria

3.4. Annual Research Productivity Trends

We grouped the number of publications into a three-year interval for visual and statistical convenience (See Table 2). in Figure 6 shows the annual publication growth rate for each institution. Covenant University had the highest growth rate of 42.45% in the period under review, followed by Bayero University (38.26%). The University of Nigeria had an annual publication growth rate of 31.13%, while Ahmadu Bello University had a growth rate of 29.71%. The yearly productivity trends of the University of Lagos, University of Benin and

the University of Ilorin were at 20.19%, 20.58% and 19.94% respectively. Other institutions' annual publications growth rate are as follows: The Federal University of Technology, Akure (18.96%), University of Ibadan (18.44%), Obafemi Awolowo University (16.42%), Federal University of Technology, Minna (16.52%), Federal University of Technology, Owerri (13.72%), River State University of Science and Technology (12.48%). The institution with the least growth rate is Delta State University at 4.78%.

Table 2: Publication Volume in Three-year Interval from 2004 to 2018

Institution	Year Interval					Total
	2004-2006	2007-2009	2010-2012	2013-2015	2016-2018	
CU	4	13	34	157	599	807
UI	27	81	86	50	98	342
UNIL	18	47	64	34	121	284
OAU	28	42	58	51	95	274
UNN	4	21	49	57	102	233
FUTA	17	16	37	74	86	230
FUTM	23	6	22	57	120	228
UNII	14	30	43	36	91	214
ABU	4	24	52	39	79	198
BUK	1	10	25	31	62	129
DSU	64	22	24	14	5	129
RUST	21	53	28	10	10	122
UNIB	7	24	31	23	31	116
FUTO	16	11	12	22	49	110
Global	495,126	801,374	955,646	983,391	1,213,164	4,448,701

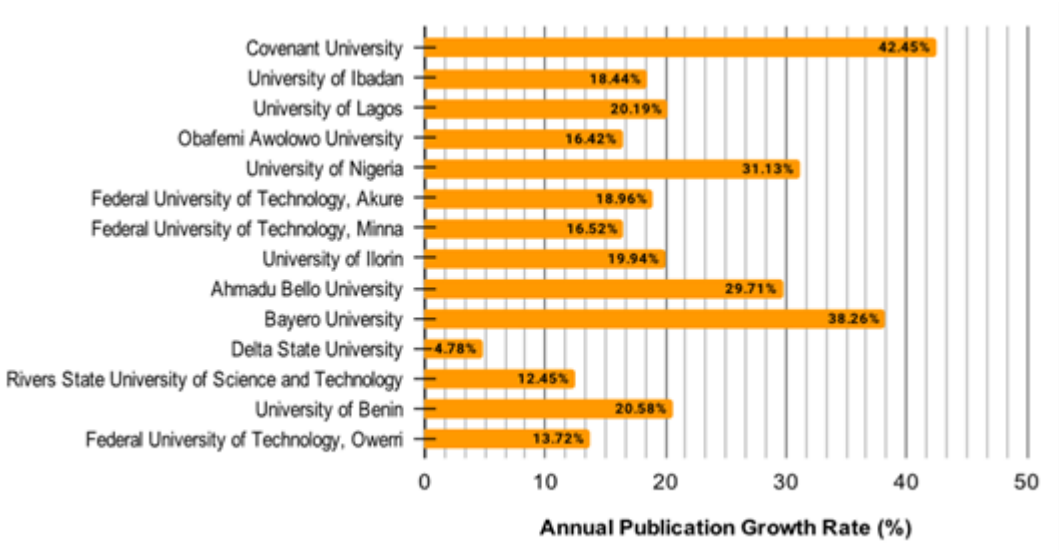

Figure 5: Annual Growth Rate for 14 Leading Institutions in Computer Sciences-related Research publications in Nigeria

3.5. Analysis of the Top Collaborators Per Institution

An analysis of top inter-institutional collaborators shows that Covenant University was the highest collaborator of most of the other leading institutions in Nigeria (5 out of 13 institutions, i.e. 38.5 %). Meanwhile, University of Lagos was Covenant University's highest collaborator with 46 documents. Most of the 14 institutions had top national collaborators (10 out of 14, 71.43%), while four of the institutions, i.e. FUTA, FUTM, ABU, and BUK, had top international collaborators, mainly from Malaysia and South Africa. Details of the Analysis of the principal collaborators for each institution is shown in Table 3.

Table 3: Analysis of Top Collaborators Per Institution

#	Institution	Principal Collaborator	Region	Publication Count
1	CU	University of Lagos	National	46
2	UI	Covenant University	National	15
3	UNIL	Covenant University	National	46
4	OAU	Covenant University	National	18
5	UNN	Nnamdi Azikiwe University	National	15
6	FUTA	Tshwane University of Technology, South Africa	International	8
7	FUTM	International Islamic University, Malaysia	International	17
8	UNII	Covenant University	National	37
9	ABU	Universiti Teknologi Malaysia, Malaysia	International	12
10	BUK	University of Malaya, Malaysia	International	25
11	DSU	Niger Delta University	National	4
12	RUST	Niger Delta University	National	10
13	UNIB	Covenant University	National	7

14	FUTO	University of Nigeria	National	10

3.6. Institutional Citation Analysis

The citation analysis of the top 14 institutions shows that CU had the highest citation count, with a total of 3001 citations, and an h-index of 19, at 3.72 citations per publication, a ratio that is ranked ninth in Table 5. However, CU had the highest h-index of 19. Although ABU had the fourth-highest citation count of 1,379, it had the second-highest h-index of 18 and the highest citations per publication ratio of 6.96 citations per publication). FUTA has the second-highest citation count of 1,476 and third-highest h-index of 17. FUTO consistent ranked the lowest in citation count (172 citations), citation per publication (1.56) and h-index (6). Table 4 shows a citation analysis for the other institutions under review.

Table 4: Summary of the Citation Analysis: Citation Count, Average Citation Per Publication (ACPP), institutional h-index of the top 14 Institutions

#	Institution	Pub. Volume	Citation Count	Avg. CPP	Inst. h-index
1	CU	807	3001	3.72	19
2	UI	342	1415	4.14	15
3	UNIL	284	1126	3.96	15
4	OAU	273	864	3.16	14
5	UNN	233	1084	4.65	15
6	FUTA	230	1476	6.42	17
7	FUTM	228	1037	4.55	13
8	UNII	214	1146	5.36	16
9	ABU	198	1379	6.96	18
10	BUK	129	606	4.70	14
11	DSU	129	380	2.95	11
12	RUST	122	208	1.70	7
13	UNIB	116	362	3.12	10
14	FUTO	110	172	1.56	6

3.7. Analysis of the Publication Document Type

We grouped the document types retrieved from the bibliometric dataset into four categories: Journal articles, conference papers, book chapters. Other publication types (e.g. review, editorials, letters, etc.) were groups under a general term – others (See Table 5 and Figure 7).

An analysis of the document types shows that Covenant university has the highest number of publications in all the categories with 261 journal articles, 470 conference papers, 34 book chapters and 42 others. All the 14 institutions except CU and FUTM had the largest percentage of their publications in a journal article form, while CU and FUTM's highest publication form was in conference papers. Generally, book Chapter and other document types accounted as low percentages of the institutional volume, except for DSU, whose percentage of a book chapter and other document types exceeded that of conference papers.

Table 5: Document Type Analysis Per Institution

#	Institution	Inst. Volume	Document Type			
			Journal Article	Conference	Book Chapter	Others
1	CU	807	261	470	34	42
2	UI	342	223	76	14	19
3	UNIL	284	147	123	5	9
4	OAU	273	159	92	15	7
5	UNN	233	153	70	6	4
6	FUTA	230	120	98	8	4
7	FUTM	228	81	135	7	5
8	UNII	214	136	69	4	5
9	ABU	198	133	54	7	4
10	BUK	129	62	52	5	10
11	DSU	129	80	7	29	13
12	RUST	122	109	11	1	1
13	UNIB	116	74	38	3	1
14	FUTO	110	57	50	2	1
15	Global	4,448,701	2,765,744	1,402,451	76,525	203,981

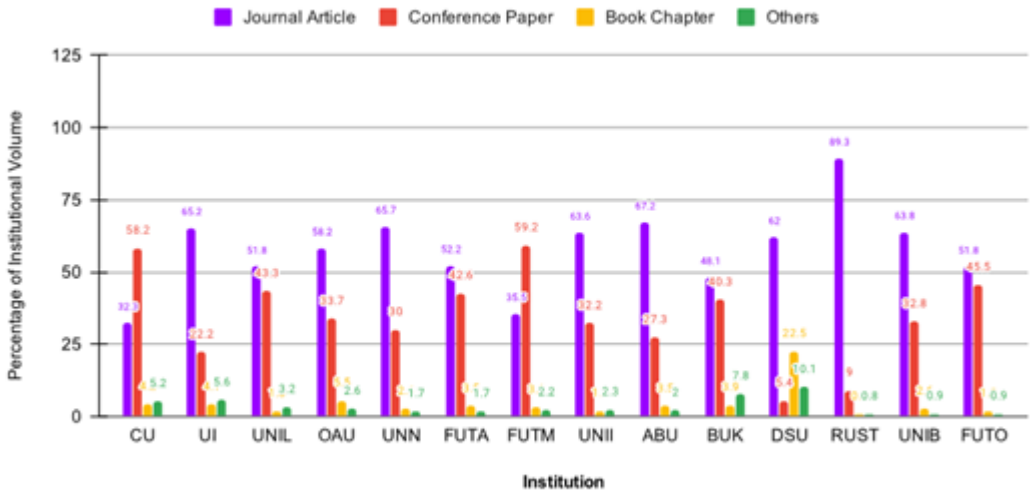

Figure 6: Document Type Per Percentage of Institutional Volume

3.8. Publication Outlet Analysis

The SCImago Journal Rank (SJR) measures weighted citations received by the publication outlet. The citation weighting depends on subject field and prestige (SJR) of the citing source (SCImago, n.d.). Therefore, the SJR is a measure of the quality of the Journal or publication outlet. From Table 7, we observed that 9 out of 14 institutions (i.e. 64.28%) had the institution's highest publications in one Journal titled "European Journal of Scientific Research". However, CU, the leading University had its highest publication in the Journal titled "International Journal of Civil Engineering and Technology". Other top outlets include, Lecture Notes in Engineering and Computer Science, CEUR Workshop Proceedings, Research Journal of Applied Sciences Engineering and Technology and Modelling Measurement and Control C. Table 6 shows the distribution of these sources per institution and the percentage of each institutional publication volume in those sources.

Table 6: Analysis of Journal Outlets where the top 14 Institutions Publish

Institution	Source	Pub. Count	PIV (%)	SIS	SJR Metric	
					Year	SJR
CU	IJCET	78	9.67%	Discontinued	2019	0.285
UI	EJSR	109	31.87%	Discontinued	2014	0.123
UNIL	EJSR	41	14.44%	Discontinued	2014	0.123
OAU	EJSR	21	7.69%	Discontinued	2014	0.123

Institution	Source	Pub. Count	PIV (%)	SIS	SJR Metric	
UNN	EJSR	21	9.01%	Discontinued	2014	0.123
FUTA	LNECS	24	10.43%	Current	2019	0.151
FUTM	CEUR	40	17.54%	Current	2019	0.177
UNII	EJSR	32	14.95%	Discontinued	2014	0.123
ABU	RJASET	31	15.66%	Discontinued	2018	0.116
BUK	EJSR	12	9.30%	Discontinued	2014	0.123
DSU	EJSR	37	28.68%	Discontinued	2014	0.123
RUST	EJSR	53	43.44%	Discontinued	2014	0.123
UNIB	EJSR	20	17.24%	Discontinued	2014	0.123
FUTO	MMCC	20	18.18%	Discontinued	2018	0.139

Column Abbreviations

PIV = Percentage of Institutional Volume; **SIS** = Scopus-Indexing Status; **SJR** = SCImago Journal Rank

Outlet Abbreviations

EJSR = European Journal of Scientific Research; **LNECS** = Lecture Notes in Engineering and Computer Science; **IJCET** = International Journal of Civil Engineering and Technology; **RJASET** = Research Journal of Applied Sciences Engineering and Technology; **CEUR** = CEUR Workshop Proceedings; **MMCC** = Modelling Measurement and Control C

4. Discussion

Computer science is a burgeoning research field and has the potential to accelerate the rate of industrialisation and subsequently, economic development as evidenced in the west and east. Africa's, especially Nigeria's, development can be fast-tracked by investment in human capital development, especially in computer science-related education and research (Moyo, 2018; UNCTAD, 2018).

From the results of our analysis, we found that the youngest institution, CU (est. 2002) and the only private University, produced the highest number of publications and has the highest annual growth rate among other institutions in this study, as also confirmed by Oladipupo *et al*. (2020). By comparison, the Federal and State universities, which have access to government funding to acquire human, financial and infrastructural resources to a more

considerable degree, ought to produce more research outputs. Most of these institutions are fraught with corruption, inadequate research funding, academic instability due to incessant strikes by the academic and non-academic unions etc. (Faboyede et al., 2017; Famurewa, 2014).

Furthermore, our analysis revealed that a majority of the top leading institutions in Nigeria are located in the south-western region of the Country (See Figure 2); this is not surprising as the southern part of Nigeria has a higher concentration of universities in the Country (Mogaji, 2019). The south part of Nigeria had benefited more from federal expenditures on education and also had greater access to other benefits that come with educational qualifications (Isumonah & Egwaikhide, 2013). This is without prejudice to the prevalence of education deprivation in the northern part of Nigeria, driven by factors the that discourages formal and western education such as socio-cultural norms, practices, and the insurgency by domestic terrorist groups, like Boko Haram (Afzal, 2020).

The analysis of collaboration patterns showed that the leading institutions in Nigeria had more national collaborators than international. Even the attributed international collaborators are not listed among the elite players in the global computer science research landscape. Some studies have shown that international research collaboration network boosts publication volume and citations (Fang et al., 2020; Khadka & Byers, 2015; Lee & Bozeman, 2005; Wu et al., 2016). Therefore, stronger international research collaboration is highly encouraged to facilitate the production of high-quality computer science research in Nigeria. Through such collaborations, Nigeria's Computer science researchers can leverage resources such as funding, equipment, skills and competence that is otherwise unavailable locally.

The analysis of the document types showed that the majority of these leading institutions had published more journal articles than other document types, except for CU and FUTM. In comparison to the global outputs in this domain, conference papers dominated the volume of publications accounting for over 62% of publications in the domain. Compared to other fields, most researchers in the computer science domain consider conferences rather than journals as a final avenue to report a finding or study (Franceschet, 2010; Kim, 2019; Vrettas & Sanderson, 2015). A study had shown that there was no statistical difference in methodological soundness of papers published conference proceedings and journals (Randolph et al., 2007). Leveraging the popularity and quick turn-around time of conference proceedings, we hypothesise that an institutional policy supporting conference participation

could further increase the volume and citations of computer science-related researches from the region (Franceschet, 2010; Kim, 2019; Li & Tang, 2015).

The analysis of the publishing outlets revealed an interesting trend; we observed that most of the indexing of the outlets hosting the computer science-related publications from Nigeria had been discontinued in Scopus. The latest discontinuation was the International Journal of Civil Engineering and Technology, in 2019 (this Journal had its debut in Scopus in 2016). Abstracting and indexing services such as Scopus and Web of Science are relevant for assessing the quality of a journal (Krauskopf, 2018). Using its strict quality and ethics selection criteria, Scopus periodically re-evaluate the quality of sources it indexes (Cortegiani et al., 2020; Elsevier, 2020). Scopus discontinues the indexing of a journal or a source on account of low quality. Besides, we analysed the global SJR of journals relating to the computer science discipline-based on data from SCImago[1]. The highest SJR for a Computer Science journal was 13.637 points out of 4115 sources listed. Based on the data in Table 7, *International Journal of Civil Engineering and Technology* had the highest SJR of 0.285; giving credence to the low impact of Nigeria's computer science research.

We modified the query to obtain insight on the global trends in the volume and impact of computer science-related research. On publication volume, the query returned a total of 4,448,701 records, while only 20,000 of the documents, published in 2018[2], have been cited 69,853 times since 2018. The h-index of the 20,000 documents is 94[3]. In comparison, Nigeria's overall contribution to the global output during the period under review is around 0.1%, while that of the top 14 institutions assessed in the study is 0.07%. Without prejudice to the upward trend in publication volume and citations, this confirms the abysmal contribution of developing countries to new knowledge (Blom et al., 2015; Duermeijer et al., 2018; Fonn et al., 2018; Okeke et al., 2017). On the other hand, the citation count is a measure of the relevance and utilisation of an academic publication, and can also serve as a proxy for the quality of the paper (Aksnes et al., 2019; Atayero et al., 2018; Ezenwoke & Tion, 2020). Consequently, Nigeria's citation performance is also abysmally low compared to the available global citation analysis. Several factors have been attributed to this low research performance including food insecurity, inadequate infrastructure development, poverty,

[1] **SCImago** is a publicly available portal that includes the journals and country scientific indicators developed from the information contained in the Scopus database. It is available at https://www.scimagojr.com.

[2] A total of 443,587 computer science-related publications was published in 2018

[3] Due to the volume of records (over 4 million), Scopus limited the citation data obtainable to the first 20,000 records, all of which were published in 2018.

insufficient energy supply, short life expectancy, of history of mismanagement of communicable/non-communicable disease, and prevalence HIV/AIDS (Duermeijer et al., 2018).

A limitation of the study is that it only included bibliometric data from the Scopus database. A combination of another indexing and abstracting database like Web of Science may have provided more insights into the performance of Nigeria's computer science research output. However, some studies have shown insignificant differences in using a combination of both databases for similar studies, and the Scopus database indexes more sources than Web of science (Archambault et al., 2009; Boshoff & Akanmu, 2018).

5. Conclusion

This study aimed to highlight the pattern of Nigeria's contribution to, and impact in, the computer science research landscape. We summarise our findings as follows: first, computer science research productivity and citations in Nigeria's are very low compared to the global output. However, Covenant University, the youngest and the only private University in the study led the pack in research volume and impact. Secondly, international collaboration is generally weak as most collaborations are national in scope. Third, Nigeria's computer science-related research is published in low-quality outlets, as the Scopus has discontinued the indexing of most of these outlets. Although the publication growth trend is encouraging, the volume and impact of computer science-related research can improve significantly with the conduct of more quality researches that facilitated by strong international collaborations, and published in very high-quality outlets.

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