Informetric Growth Analysis of Engineering Research in Nigerian Universities: 2007 - 2016 Survey

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Abstract

Purpose: *The purpose of this informetrics study was to conduct an analysis of the research productivity and scholarly impact of trends and patterns of engineering research in Nigeria universities for a period of 10 years from 2007-2016.*

Design/methodology/approach: *The data was quantitatively obtained using SCOPUS which is one of the largest information database that gives researchers visibility and citation, the collation yielded 1227 different articles.*

Findings: *The findings indicate that constant increase in research productivity within the years under review, ten leading journals indexed by SCOPUS where Nigerian engineering reseachers published and communicate their research finding within the time frame covered by this research were confirmed,The findings also revealed the list of most prolific and visible authors within the space of 10 years in engineering research in Nigeria. The finding of the study reaveled the trend of research in Engineering among Nigerian Universities,trend of collaboration between countries, sources of research communications and trend of publications in different subjects areas. This study also reveals the citation index and impact of research productivities in engineering among Nigerian scholars within the timeframe of ten years.*

Keywords: *Informetrics, Engineering Research, and Nigerian Universities*.

Introduction

If there is any benefit that emanated from evolution of information and communication technology in the twentieth century; it is the internet. Uzuegbu (2012) points out that the development of Internet technology has provided academic and research institutions with a very high level of visibility on the web. As a result, teaching, learning and research is widely improved in the global society today. The intellectual knowledge and information dissemination by countless organisations and educational meetings has given birth to a terminology called open access. According to Brinkley, (2008) "higher education, and especially academic research, has become the focus of intense policy and geo-political interest around the world as its role as the engine of economic growth and innovation has soared. Successful economies are deemed to be those which can develop and exploit new knowledge for 'competitive advantage and performance ... through investment in knowledge-based and intellectual assets – research and development (R&D), software, design new process innovation, and human and organizational capital".

The origin of engineering education in Nigeria can be traced from two different distinct institutions. First is the trade apprenticeship education where the trainees of the local trade program studied to advance their practical and theoretical knowledge of their various trades. The second root can be traced through the college or university that recognises natural science which serves as a key point for specialization to an application in engineering (Booth, 2004 cited Rajuddin & Idris, 2012). Late George King (in Maillardet, 2004) described engineering as 'a three legged stool' that relies on science, mathematics and techne. He referred the word techne as the creative abilities that distinguish an engineer from scientist; to design, to make, to conceive and to actually bring into fruition. It is important to recognise that engineering is more than to simply understands the rudiments of science; it is basically a vocational subject which depends on the sound understanding of scientific principles as well as appropriate mathematics facility, the modeling language and vital communication.

Furthermore, Nigeria as a developing nation and indeed of other nation does not depend on its enormous natural resources possessed but the specialised engineering skills, competence and

the ability of its populace to harness and utilize the resources. Engineering is the bedrock and propeller of economic, social and technological development of any nation because of its connection to all aspect of human activity (Kofoworola, 2003). The quality of engineering graduates from universities and polytechnics in Nigeria will depend on the quality of the teaching and research materials that are consulted for good quality engineering graduates that are been turned out periodically. This will only be possible if such information resources are made visible in a knowledge society where there is free access to all kinds of information and learning material using the internet and ICT tools. The library plays an important role in sustaining the open access initiative (Das, 2008 cited in Uzuegbu, 2012). Librarians who ensure the organisation and dissemination of full-text content of knowledge materials to online communities are the digital librarians.

Therefore, it is imperative to know that the visibility of research productivity of engineering scholars would boast knowledge development in an information society where such information is disseminated by countless organizations and educational meetings which has given birth to a terminology called open access. According to Pinfield (2005), open access to knowledge is free, immediate, and unrestricted availability of content. Prosser (2003) defines open access as "free and unrestricted access on the internet to literature that scholars provide without expectation of direct payment". He stated that the reasons for open access are to accelerate research, enrich education, and share learning across rich and poor nations. It is from this perspective that this study visibility and impact of research productivity of engineering scholars in Nigeria between the year 2007 and 2016 is being carried out. The essence is to understudy some data generated within this period, through survey analysis and findings to give us an in-road into the visibility impact of research productivity of engineering scholars. It is also an opportunity to elaborate the acknowledgement of open access in the global society, Bhaf (2010) records that, presently, there are 1,451 of open access repositories registered in Open DOAR (http://www.opendoar.org/).

Although, what might be a decade of existence of open access movement, scholarly publishing in Nigerian is yet to reach such an appreciable level among some higher institutions, some of their publications are not visible and put in the open access for people to consult and make use of them. Abrahams, Burke & Mouton (2010) argued that some African universities are emerging from a period of sustained neglect over several decades, during which they operated with limited academic freedoms within the context of the region's various political dispensations. Assie-Lumumba (2005) points to the historical failure to invest in research facilities and dissemination channels. Investment in electronic networks, and the changes in research and scholarly communications practice that are set in motion by the introduction of these networks, has been slow to take root on the continent. For instance, some of the recent initiatives, such as the African Union's plan of action on the Second Decade of Education for Africa 2006-2015 recognize the 'link between high-level human resources, knowledge production and sustainable development' (African Union, 2006). This plan prioritized the promotion of sustainable development, quality assurance and advocacy for increased funding.

Aims

The aim of this study is to quantify, enumerate and assess the research trend in engineering by investigating the research productivity during a period of ten years (2007 to 2016) using informetrics analysis.

Research Objectives:

i. To identify the most productive research year among engineering scholars in Nigeria Universities and their publication output per year.
ii. To measure growth rate of research productivity of engineering researchers in Nigeria Universities.
iii. To examine the preferred source of publication among engineering scholars in Nigerian Universities.
iv. To identify the visibility of engineering researchers in Nigerian Universities.
v. To establish trend of collaborations of engineering researchers in Nigeria with other countries.
vi. To examine type of publications among engineering researchers in Nigeria.
vii. vii. To identify areas of research communication by subjects areas and level of productivityengineering researchers in Nigeria.

viii. To explore citation trends and h-index of publications among engineering researchers in Nigeria Universities.

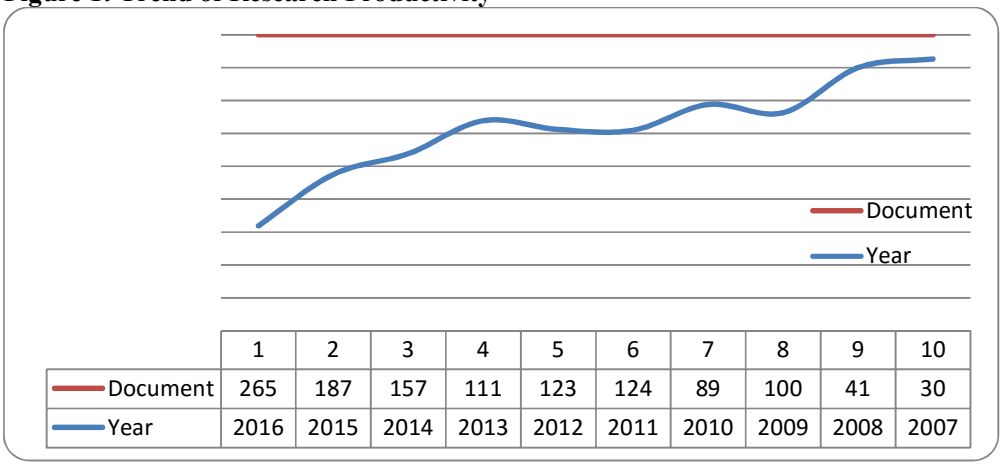
Methodology

This studies pertain to the informetric evaluation and analysis of research productivity of engineering researchers in Nigeria within the space of ten years (2007 – 2016), the data was quantitatively gathered using SCOPUS which is one of the largest information database that gives researchers visibility and citation, the collation yielded 1227 different articles. This research is based on peculiar philosophical foundation that sets out to measure scholastic productivity, by studying researchers output, journal publications, collaboration with institution of higher learning within and outside the country, extent of collaboration, degree of teamwork and acceptability of research work through citation by Professional colleagues.

Data Collation

This segment provides the findings of the study under the following subheadings: most productive research year; preferred source of publication; research visibility; trend of collaborations; type of publications; research communication by subjects' areas; level of research productivity and citation trends and h-index of publications among engineering researchers in Nigeria universities.

Figure 1: Trend of Research Productivity



	1	2	3	4	5	6	7	8	9	10
Document	265	187	157	111	123	124	89	100	41	30
Year	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007

Figure 1 above present explicit disclosure of research productivity in engineering from year 2007 to 2016 in SCOPUS, it reveal systematic increase in engineering research among top ten Universities in Nigeria. Out of the 1227 research publications within the space of ten years, the researh output of year 2016 remain the highest which is 265 publications representing 21.6%, 2015 (15.2%), 2014 (12.8%), 2013 (9.04%), 2012 (10.02%), 2011 (10.11%), 2010 (7.25%), 2009 (8.15%), 2008 (3.34%) and 2007 (2.44%). Regardless of the constant increase in research productivity, the research output in 2012 was slightly lower than 2011.

Table 1: Growth rate of research productivity of engineering researchers in Nigeria universities

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.537115	0.181026	19.53928	0.0000
T	0.200846	0.029175	6.884173	0.0001
R-squared	0.855574	Mean dependent var		4.641766
Adjusted R-squared	0.837521	S.D. dependent var		0.657414
S.E. of regression	0.264995	Akaike info criterion		0.358643
Sum squared resid	0.561778	Schwarz criterion		0.419160
Log likelihood	0.206783	Hannan-Quinn criter.		0.292256
F-statistic	47.39183	Durbin-Watson stat		1.400867
Prob(F-statistic)	0.000127			

Table 1 presents the growth rate of research productivity of engineering researchers in Nigeria within 2007 and 2016. The result showed that growth rate of research productivity is 20.4% as indicated by the T value of 0.200846. The probability value of 0.0001 showed that research

productivity of engineering scholars in Nigeria have significantly increased within the space of ten years. The growth rate was found to be statistically significant at 5% level of significance. Therefore, we are ninety-five percent confident that the growth rate of research productivity of engineering researchers in Nigeria is sacrosanct. The F-Statistic (F=47.39183, p=000127) showed that the model obtained is considered useful and worthwhile to predict future growth of research productivity of engineering researchers. This result indicates that engineering researchers in Nigeria have proliferated the research environment over the period under consideration. Nonetheless, quality of any research work is beyond research production, number of citation recieved in past, current and future journals and impact criteria occupies higher precedence than research copiousness.

Time series analysis requires strict compliance to certain assumptions. Key infometric assumptions considered were tests of Breusch-Godfrey Serial Correlation, Breusch-Pagan-Godfrey,heteroskedasticity and Jarque-Bera statistics. This assumption is required in order to avoid spurious and incorrect result. Breusch-Godfrey Serial Correlation LM Test of 0.888911, (p=0.641) indicates that there is no serial correlation, Breusch-Pagan-Godfrey test of 0.888911 (p=0.641) indicates that this model does not have heteroskedasticity and Jarque-Bera statistics of 0.570395 (p=0.752) indicates that the residual of this model is normally distributed. The correlogram-Q-statistics shown in Table 2 below showed that the residual is stationary. Conclusively, there is no serial correlation, heteroskedasticity and the residual is normally distributed and stationary, which means that all the assumptions have been passed. So we can accept this model as being valuable.

Table 2: Correlogram-Q-statistics

Autocorrelation (AC)	Partial correlation (PAC)	Q-Stat	Prob.
0.198	0.198	0.5206	0.471
-0.174	-0.222	0.9737	0.615
-0.276	-0.208	2.2803	0.516
-0.464	-0.456	6.5869	0.159
-0.034	0.019	6.6146	0.251
0.090	-0.196	6.8574	0.334
0.126	-0.079	7.4964	0.379
0.054	-0.283	7.6741	0.466
-0.020	-0.050	7.7244	0.562

The correlogram-Q-statistics shown in Table 2 above showed that the residual is stationary. Conclusively, there is no serial correlation, heteroskedasticity and the residual is normally distributed and stationary, which means that the Generalized Linear Model (GLM) met all the informetric requirements for an appropriate and useful model. So we can accept this model as being valuable.

Figure 2: Distribution of Documents by Source

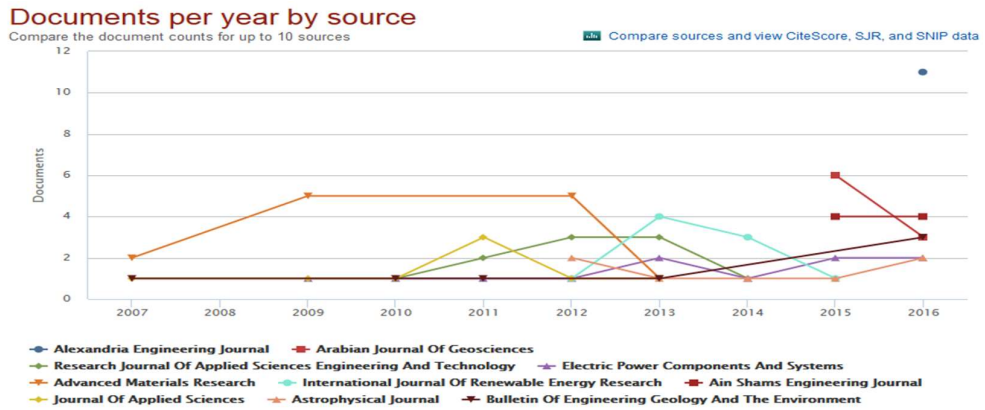


Figure 2. Evaluate sources where researchers in engineering publish, the above listed academic journals serves as an avenue to communicate and exchange view relating to research finding. According to the information available in SCOPUS between the space of 10 years (2007 - 2016), the research out put of engineering researchers in Nigeria universities are mostly published and became visible in the Advance Materials Research with 13 publications representing 1.1% of the research output, followed by Alexandra Engineering Journal and Electric power components and systems with 11 publications each representing 1.09 %, followed by Research journal of applied science which is 10 (0.81%), Arabic Journal of Geosciences and International Journal of Renewable Energy research have 9 publications from Nigerian engineering researchers each which represent 0.7%, followed by Aln shams Engineering Journal and Journal of Applied Sciences with 8 each which stand for 0.65% each, with Astrophysical Journal and Bulletin of Engineering Geology and the Environment with 7 each which represents 0.57%. The above sources of publication also represents the ten leading journals indexed by SCOPUS where Nigerian engineering reseachers published and communicate their research finding within the time frame covered by this research.

Figure 3: Distribution of Document by Author

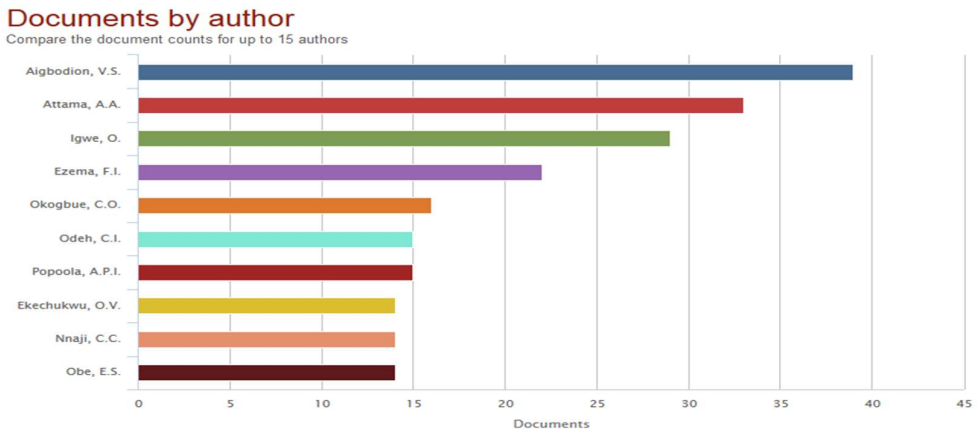


Figure 3, shows the list of the most prolific and visible authors within the space of 10 years in engineering research in Nigeria. Based on the available evidence of the top ten researchers, Aigbodion V. S has 39 research publications which represent 3.18% of the total research output, followed by Attama, A.A 33 (2.69%), Igwe, O. 29 (2.36%), Ezema, F.I, 22 (1.79%), Okogbue, C.O, 16 (1.30%), Odeh, C.I, 15 (1.22%), Popoola, A.P.I 15 (1.22%), others are Ekechukwu, O.V, Nnaji, C. C. and Obe, E.S with 14 publication each which represent (1.14%) publication output in SCOPUS.

Figure 4: Distribution of Documents by Affiliation

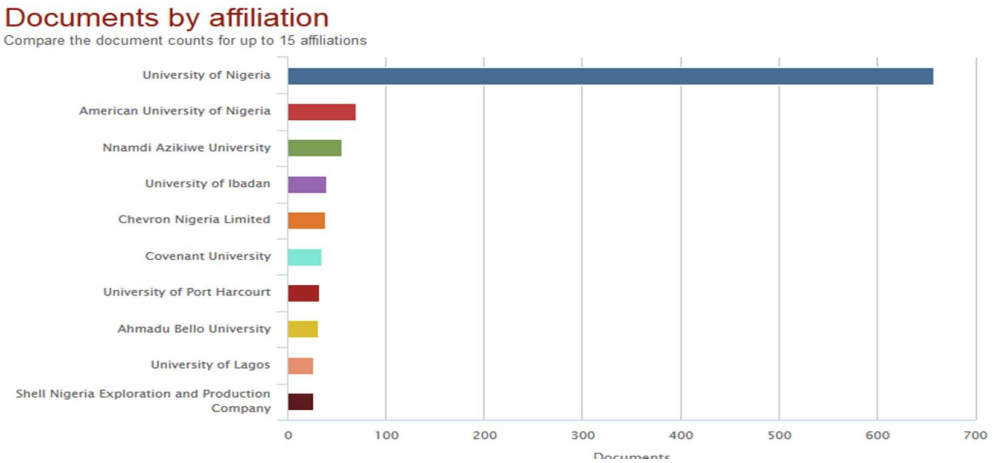


Figure 4 above revealed the visibility of research done by ten leading institutions in Nigeria within the space of ten years among all the publications indexed by SCOPUS, University of Nigeria leading with 658 publications, which represent 53.6% output, American University of Nigeria with 70 publications representing 5.70%, Nnamdi Azikiwe University with 55 research publications which representing 4.48%, University of Ibadan with 40 publications representing 3.26%, Covenant University with 35 publications which represents 2.85%, University of Port Harcourt with 33 publications, which represents 2.69%, Ahmadu Bello University with 31 research publications, representing 2.53%, University of Lagos with 27 research publications, representing 2.20%.

Figure 5: Distribution of Documents by Countries

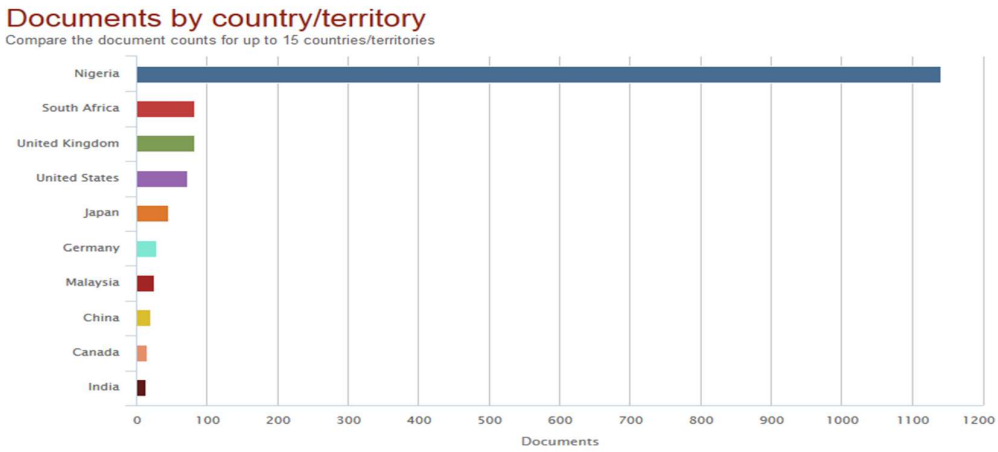


Figure 5 above, reveals the extent of inter continental research collaboration of Nigerian engineering researchers with scholars from other part of the world, this shows the trends of academic cooperation and mutual aids among researchers. For instance within the space of ten years (2007 - 2016) the research output of Nigerian engineering scholars is 1,227, these are academic research output that are visible on SCOPUS, the amount produced wholly by Nigerian scholars was 1,141, signifying 93% of the research productivity. The countries that have the highest collarbolative research efforts with Nigeria researchers are South Africa and United Kingdom with 83 research publications each representing 6.8%. Another Country where there is research collaboration with Nigerian engineering scholars is United States of America with 73 research output which represents 5.9% publications. Other countries with joint initiative in research with Nigeria was Japan with 46 research publications which represents 3.7%, Germany with 29 research publications, representing 2.4%, Malaysia with 26 research output which stand at 2.11%, China shows 20 research output which repesent 1.6% and Canada with 15 research output which represent 1.2%.

Figure 6: Distribution of Documents by Types of Publication.

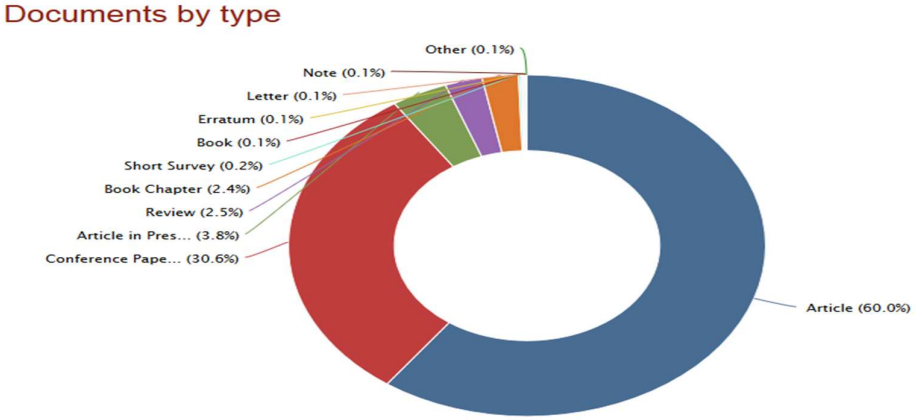


Figure 6: above, shows the trend of research communication among engineering scholars in Nigeria within the space ten years (2007 to 2016) which are visible in SCOPUS electronic database, this research communication shows where engineering scholars disemminate their research findings by making their result and scientific reports accessible to wider audience. The above result shows that most of the researchers in engineering communicate their findings by publishing in peer-review scientific articles, 736 articles which represents 60% of the total research output for the selected years were published, followed by 376 conference papers which represents 31% of the output, articles which are in press waiting for publications were 47 representing 3.8%, review were 31 scientific research which stands at 2.53%, others are book chapters with 30 representing 2.4% and short survey was 2 output which stands at 0.2%. Other areas where scientific research output were communicated in engineering were Books, Erratum, Letter, Note and Retracted with just 1 research output each representing negligible ratio of 0.08%.

Figure 7: Distribution of Documents by Subject Area

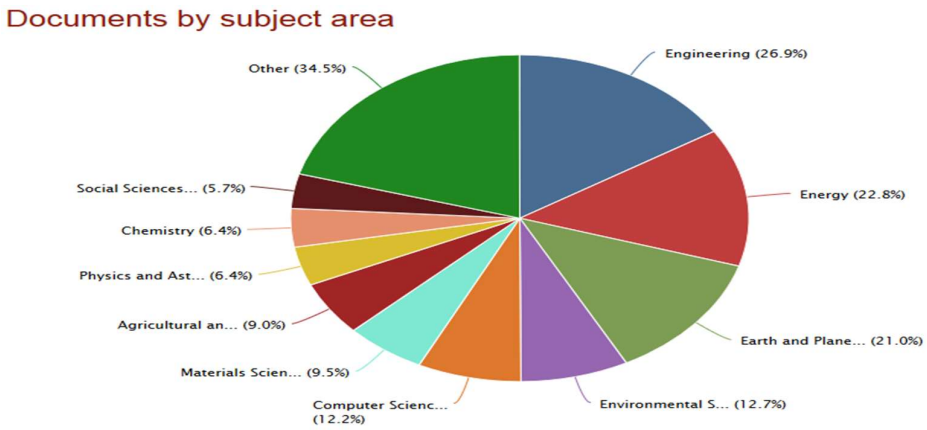


Figure 7 revealed the most researched subject areas in Engineering and related discipline and related areas of collaboration. The most prolific department by publication count was Engineering, which yielded a total research output of 330 (26.9%), followed by Energy research 280 (22.8%), Earth and planetary 258 (21.0%), Environmental science 156 (12.7%), Computer science 150 (12.2%), Material science 117 (9.53%), Agricultural science and Biological Sciences 110 (8.96%), Physics and Astronomy 79 (6.43%), Chemistry 78 (6.35%) and Social sciences 70 (5.70%).

Figure 8: Distribution by Trend of Citation

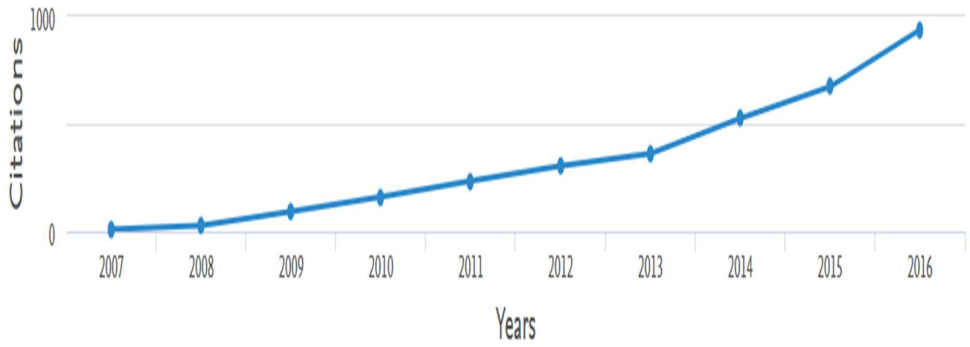
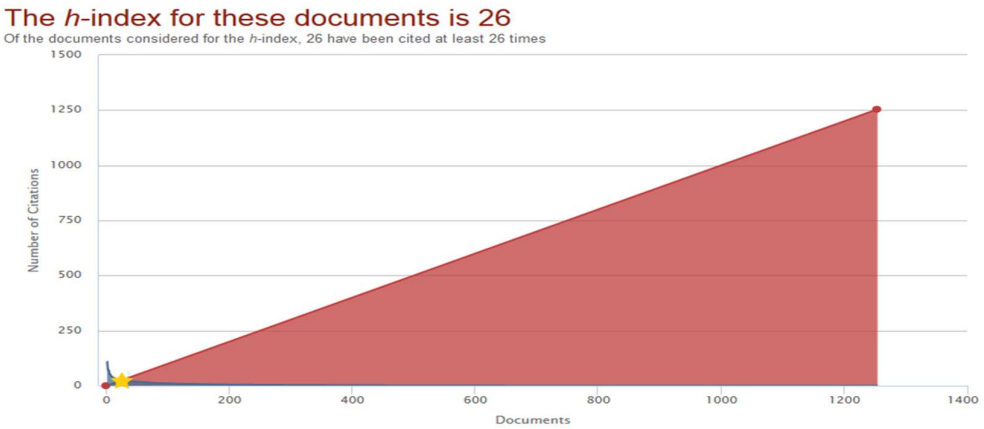


Figure 8 above shows the trend of citation of all the research publications within the space of ten years (2007-2016) among engineering researchers in Nigeria. Available information

indicated that all the 1,227 publications within the space of ten years were cited 1,253 times. The figure shows steady and gradual improvement from 2007 and getting to climax by 2016, within this period all the articles, conference papers, article in press, review, book chapters, short survey, books, erratum, letters and note by engineering researchers from Nigeria has been cited 1,253 times by scholars around the world.

Figure 9: The H-index for Document



The h-graph is one approach of demonstrating and evaluating the productivity and impact of published work of scholars. The h-index represents the number citations obtained for each of the articles in descending order. The 45 degree line represents the number of citations equal to the number of articles. Where the author's line meets the 45 degree line marks the h-index, and it can be used to compare different scholars. Therefore the h-index of all the research publication in Engineering within 10 year in Nigeria is 26. Cumulatively all the citation of all the document within the 10 years is where the research focus was 1, 253, the possibility exist that the number of citation will increase. The most cited research article acquired 100 citations while the second most cited got 75, the third was 72, while the fourth was 67, fifth was 52, sixth was 51, seventh 46, eighth 43, ninth 38 and finally the tenth also got 38. The implication of this shows gradual visibility and popularity of intellectual research work of Nigerian engineering researchers in the academic communities around the word.

Discussion of the findings:

Discussion of the findings is based on the research objectives that guided this study. The discussions are done under the following subheadings; identifying the most productive research year among engineering scholars, examine the preferred source of publication among engineering scholars, identifying the visibility of engineering researchers, established the trend of collaborations of engineering researchers, examine type of publications among engineering and identifying areas of research communication by subject areas and level of productivities.

Table 1 has shown the explicit disclosure of research productivity in engineering from year 2017- 2016 in SCOPUS. Where there was systematic increase in engineering research among top ten Universities in Nigeria. The reason for this can be attributed to some factors in which of it is that of availability of research funds among Universities in Nigeria, although universities are among the most important institutions for the development of science and technology (S&T), and they consume a significant amount of natural resources devoted to research (Alo, 1995). The findings is also in agreement with Harneth, cited in Sait et al, (2003), who posited that it is unquestionably the most critical factor in university research, that in Nigeria, the National policy Science and Technology (NPST) has recommended as a policy that 5% of Gross National Product (GNP) be set aside for research, but Nigeria's federal university system is said to spend only 1.3% of its budget on research. Thus this accounted for

the slow rate of research publications as indicated regardless of the constant increase in research productivity. Corroborating this Yusuf (2012) emphasised that research funding is critical to the ability of tertiary instructions to conduct research in the first place and ultimately to the quality and impact of the research.

In examining the preferred sources of publication among the ten leading journals within the specific period as shown in Table 2, where research output of engineering researches are mostly published and became visible in the advanced materials with about 13 publications. This findings is in agreement with Schmoch (2005) who noted that where such publication output as those publications in referred journals and scholarly books through which academics research outcomes and ideas are circulated among peers and subsequently contribute to debates in the relevant field, such publications according to them should be worthy of provoking reactions and throwing up challenges to colleagues. It can be published in such journals because such journals will be better appreciated when explained in the context of its importance to academic institutions, researchers and even to students (Gray, 1998).

Another level of the research study is identifying the visibility of engineering researchers in Nigeria, where Figure 3, has shown list of prolific and visible authors within the space of estimated period of 10 years in engineering research in Nigeria. The findings from this results has contributed to an earlier study which revealed that report of ranking of scientists in the Nigeria Institutions according to their Google Scholar citations of public profiles. Here it was reported that the Google Scholar citation database list 500 scientists in Nigeria, thus this has help our institutional webometrics ranking by making our scientists more visible (Folorunsho, 2015). Figure 4, revealed the visibilty of ten leading institions in Nigeria, such listing would definitely have shown the various levels of individual publications and the name of such institutions in agreement with the Google Scholar as indicated above. Most universities in Nigeria in the past had been rated as number one due to the contribution of their research work from their institutional repository visibility in the public domain such the Google Scholar.

In the area of intercontinental research collaboration, Table 5 had shown that collaboration has its own benefits most especially in the area of visibility, exchange of ideas, context, methodology, facilities, common objectives or goals, between individual researchers or research teams from different institutions and countries or regions of the world as an exposure on the SCOPUS. These findings support earlier study on research publications. Pouris (2010) reported that South Africa published almost 14 times more publications than second country in the list-Tanzania, with a total of 4184 publications from 1994-2008. Coupled with a recent study reported that Tanzania total publications were 2,354, which was twelve times less publications produced by South African scholars during the 2007 to 2011 (Pouris and Ho, 2014)

The trend of research communication among engineering scholars in Nigeria within the space of ten years (2007-2016) as shown in Table 6 was an indication that not all engineering research study can be published in the same peer-review scientific journals, books chapter, and conference papers. Some of them are in the press waiting to be published. These findings are in tandem with Adebayo, (2012) who posited that Nigeria in particular, that it is not always easy for scholars in developing countries to get articles published in foreign journals because many of their papers address local issues and problems, which are not likely to interest overseas audiences, but with the above findings, it is an indication that our engineering researchers has come a long way in publishing their work most especially in regional publication system. The African Journals Online (AJOL) is a good initiative in this regard and Nigerians seems to be dominating the system as their publications had shown in the SCOPUS. Chiemeke, Longe, Longe and Shaib (2009).

Figure 7 had shown publications by subject areas, the findings from these results has indicated the most research areas in engineering and related discipline coupled with areas of collaboration. The essence of the findings from research subject areas is to boast research productivity as an important criterion for recruitment, promotion, rewards, professional recognition, workload decisions, for allocation of resources and for ranking universities and research institutes. Evaluation of such research publication in subject areas for research productivity can reveal contributions of individual scholars to the advancement of the whole field (Lin, 2006 cited in Sife & Lwoga, 2014).

Finally, Figure 8 had shown the illustration of 1,253 cited documents of all the research publications within the space of ten years covering 2007-2016. The findings here has demonstrated that all the 1, 253 documents cited were researchers in engineering published journal articles, book chapters, conference papers that were visible and all these have contributed to the webometrics of most institutions. Figure 9, has shwon the H-index has shown a steady rise in 2016, these findings support Sife & Lwoga, (2014) report that researchers should publish substantial number in highly cited journals to improve their productivity and impact. This calls for scholars to publish their research papers in journals that are widely visible such as e-journals and, particularly, open access journals. He reiterated further that as scientific research is collaborative in nature, teamwork in research and publication should be encouraged among engineers within and outside the country.

Conclusion

This study has provided insights of the research productivity and scholarly impact of Nigeria engineers research productivity for a period of 10 years from 2007-2016. The findings had indicated the trends and pattern of engineering research in Nigerian universities based on explicit disclosure of research productivity in engineering with substantial number of publications in a particular year totalling 256 publications. It has also shown the evaluation of sources of where engineers published their research journal articles, an opportunity to identify good peer-review journals where researchers can make their work more visible. Beyond this, research productivity and visibility in engineering as an indispensable avenue for finding solutions to Nigeria's social, economic and technology related problems; have an important role to play in higher instutions and the society in general. Progress were also recorded among universities in the area of publications with leading university contributing to their webometrics as a top leading university in a particular year, coupled with these encouraging findings showed that Nigerians were the leading trends of academic cooperation among the various countries. The essence of these research works was to harness the benefits of patterns and trends of engineering research visibility among Nigeria universities in collaborative knowledge sharing with other developed countries in order to boost our intellectual knowledge and information dissemination.

Recommendations

Based on the findings and the implications of the study, the following recommendations are made:

There is need for government policy towards developing an innovation system ties that will exists among universities, research institutes, industries and government for which they can all benefit. These ties of knowledge should flow among these sectors, for which research article outputs would be produced collaboratively among their representatives;

This ultimately will guide the policy makers into apportioning sufficient funds to the science sector, by so doing, there is need for institutions involved with research in science to diversify from relying on a sole source of funds;

Recent global publication output has revealed a trend of rapid growth of articles with authors from the developing world that is the result of collaboration among researchers internationally. This laudable idea should be sustained in order to encourage more engineering researchers' journal articles to be more visible and this will contribute to overall wellbeing of universities' webometrics;

Infrastructural facilities and equipment should be provided for academic libraries where engineering researchers can conveniently do their study with less stress and increase their research productivity; this can only be achieved through provision of alternative power supply for lecturers' offices and their writing rooms.

University should engage in the development of information and communication technology Information (ICT) infrastructure necessary to have them connected to the internet to ensure access to electronic resources which is of utmost important to research and publication output.

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