

Exploratory Analysis of Nigeria's Computer Science Production From 1996 to 2014

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ABSTRACT

Vast amount of Computer Science scientific production analysis have been conducted in emerging countries around the world but not particularly in Nigeria. In this paper we study Nigeria's Computer Science production in comparison with other African countries from 1996 to 2014 using indicators such as the total numbers of Computer Science productions, the distribution of Computer Science production among Computer Science sub-areas and the distribution of Computer Science specialists available in the country. In order to do this, we used publication data from Scopus database and profiles of Computer Science academics with doctorate degrees in tertiary institutions in Nigeria, Egypt and South Africa. The results shows that; (1) Nigeria is part of the top 6 countries with the majority of Computer Science productions in Africa (2) Nigeria's production growth rate is marked by two non-linear phases of growth and decline (3) Nigeria's Computer Science specialists seem to be geared towards more general and practical themed Computer Science as oppose to defined and theoretical Computer Science.

Keywords- Scientific Production; Computer Science; Research Performances; ACM classification system

1. INTRODUCTION

Many scientific production analysis have been conducted in fast growing economies over the past few years, mostly in the BRIC countries; Brazil, Russia, India and China [1] [2] with focus on a wide range of areas such as medical and biological sciences [3] [4] [5] [6], Physics [7], Biochemistry [8], Tribology [9], Economics [10], Mathematics [11], Computer Science [12] [13] [1] etc. It will be interesting to conduct the same type of analysis in the Nigeria's Computer Science community as Nigeria is also categorised among the emerging economies of the World.

The goal of this paper is to study Nigeria's Computer Science production for the period of 1996 to 2014. Here, we focus on the comparisons between Nigeria and other African countries (such as South Africa, Egypt, Algeria, Morocco and Tunisia). What are Nigeria's strengths? Where are they lagging behind? How does Nigeria compare generally to the others? How can Nigeria improve if she needs to? These are some of the questions we want to answer. These countries are selected in comparison with Nigeria because they all have higher Computer Science production than Nigeria in the Africa section of the SCImago Journal and Country Rank. The SCImago Journal and Country Rank use data and the indicators information from the Scopus database to develop a ranking portal [14].

This analysis is done based on the distribution of Computer Science publications for the period of 1996 to 2014, the distribution of Computer Science publications divided into Computer Science research sub-areas and the distributions of academic specialisations.

In section 2, how scientific production can be measured and the importance of scientific production analysis to Nigeria and the Computer Science community is reviewed; in section 3 the two methods used for the analysis is described; in section 4 our findings are presented; and section 5 our findings are discussed and recommendations provided.

2. LITERATURE REVIEW

Scientific production research is uncommon in the Computer Science domain [1]. This is because the standard methodologies for such analysis (using data from the Institute for Scientific Information or Web of Science) [15] is inappropriate in the Computer Science domain because not every Computer Science production is published in journals [1]. They are usually published in a combination of journals, conferences and workshops and the Institute for Scientific Information do not index a majority of conference proceedings and workshops. The alternative is the use of databases like Scopus, Google Scholar etc. Using a combination of databases such as Scopus and Google Scholar will provide a clearer picture of the Computer Science domain but this could be a potential data duplication issue. This may be the reason why recent scientific production analysis like [16] and [17] used Scopus as their single data gathering database. The Scopus database is an online international multidisciplinary indexing database with over 18,000 international peer-reviewed journals and conference proceedings [2] [16]

Analysing the scientific production of a country is vital. It could provide evidence into the concentrations of researchers and also point to the need for strategies and encouragement for research financing in areas not appropriately developed [18] [3]. Also, it identifies the number of publications in the area over a period of time [3]. It could provide evidence of gender differences in the country and the domain [19]. Lastly, it could be used to characterise the phases of a country's scientific development [20].

Recent scientific production research have measured a wide range of indicators. [1] measured scientific production by the total number of publications, the sub-areas distribution and the distribution of publications according to the impact factors of the journals [3] measured scientific production by accessing the impact of the production in professional practice. [16] measured scientific production using the number of hard working authors and their publication H-index. [10] measured the impact of the publications and tested the importance of author's collaboration.

In the next section we discuss the methods of data gathering.

3. METHOD

Two methods were adopted for data gathering. The first method used data from the Scopus database and the second used data from profiles of Computer Science academics with doctorate degrees in Nigeria, Egypt and South Africa's tertiary institutions.

3.1 Method 1: Scopus database

The Scopus data was downloaded through the ScImago Journal and Country Rank website in March 2016 with the following parameters:

SUBJECT AREA= Computer Science,
SUBJECT CATEGORY= All categories of selected Area,
REGION= Africa,
ORDER BY= Documents,
YEAR= 1996-2014.

3.2 Method 2: Academic profiles

The Computer Science profiles of academics with doctorate degrees were collected from the websites of 13 Nigerian tertiary institutions, 10 South African tertiary institutions and 10 Egyptian tertiary institutions.

The following were collected; academic titles (Dr. or Prof.), gender, tertiary institution and specialisations (research interests). We did not include academics conducting their doctorate degrees (Dr in views) at the point of this data gathering exercise. A total of 93 academics from 13 Nigerian tertiary institutions, 130 academics from 10 Egyptian tertiary institutions and 70 academics from 10 South African tertiary institutions were used (See table 1). These tertiary institutions were not selected at random. They were selected using the For International Colleges and Universities (4ICU) higher education search engine and directory. 4ICU is a non-profit organisation that ranks tertiary institutions based on web popularity. We reviewed tertiary institutions for the selected countries from the top of the list downwards and stopped when we have achieved the number of tertiary institutions we needed for analysis (See table 2 for the list of tertiary institutions used). The tertiary institutions were reviewed to acquire the profiles of academics in the Computer Science department with doctorate degrees and their specialisations or research interests. The tertiary institutions that did not provide their Computer Science academic profiles were not included in the data gathering process.

Table 1. Countries and the numbers of tertiary institutions analysed and the total number of academic profiles collected

	Nigeria	Egypt	South Africa
<i>Number of tertiary institutions</i>	13	10	10
<i>Total number of academic profiles collected</i>	93	130	70

Table 2. The tertiary institutions which were used in the data gathering exercise

Nigeria	Egypt	South Africa
Adekunle Ajasin University	Ains Shams University	Cape Peninsula University of Technology
Babcock University	Assuit	Nelson Mandela Metropolitan University
Bayero University	Benha University	Rhodos University
Covenant University	Cairo University	Universiteit Stellenbosch
Federal University Ndufu-Alike Ikwo	Damietta University	University of Cape Town
Lagos State University	Egypt-Japan University of Science and Technology	University of KwaZulu-Natal
Obafemi Awolowo University	Fayoum University	University of Pretoria
Ondo State University of Science & Technology	MSA University	University of the Western Cape
Tai Solarin University of Education	Sinai University	University of Zululand
University of Agriculture	The British University of Egypt	Vaal University of Technology
University of Benin		
University of Ibadan		
University of Nigeria		

The specialisations of the Computer Science academics were classified using the American Computing Machinery (ACM) 2012 classification system. The ACM classification system is one of the most recognised Computer Science classification systems available. It classifies Computer Science into 14 categories. For the purpose of this paper, 12 categories were used; hardware, computer system organisation, networks, software and its engineering, theory of computation, mathematics of computing, information systems, security and privacy, human-centred computing, computing methodologies, applied computing, social and professional topics.

4. FINDINGS

In this section, we present the findings from the methods; the Scopus database and that of the profiles of Computer Science academic specialisation.

4.1 Scopus database

The Scopus database was used to download the data needed for the analysis. Here we show findings for the total number of Computer Science productions, the trend of Computer Science productions in Nigeria and Nigeria's Computer Science production divided into Computer Science sub-areas.

4.1.1 Total numbers of Computer Science production

Nigeria belongs to the top 6 African countries that have the majority of Computer Science productions in Africa produced between 1996 and 2014. Egypt has a production majority with 22%, South Africa 21%, Tunisia 19%, Algeria 16%, Morocco 8% and Nigeria 5% of the total Africa Computer Science publications from 1996 to 2014 (See figure 1). Egypt, South Africa, Tunisia, Algeria and Morocco form "the big five" of Africa's Computer Science productions.

Total African Computer Science Production from 1996 to 2014			
Country	Documents Total	Document %	Growth rate
Egypt	9,873	22%	14%
South Africa	9,664	21%	13%
Tunisia	8,626	19%	36%
Algeria	7,100	16%	27%
Morocco	3,746	8%	25%
Nigeria	2,330	5%	21%
Other African countries	4,260	9%	

Figure 1: Total Africa Computer Science production by each country and their growth rate from 1996 to 2014

4.1.2 Trend of Computer Science publication from 1996 to 2014

The trend of Computer Science publications of the top 6 African countries from 1996 to 2014 can be seen in figure 2. In 2014, Nigeria's total Computer Science production was 253 publications, which is 2.2 times less than that of Morocco, 3.6 times less than South Africa, 3.8 times less than Algeria, 4.8 times less than Egypt and 5.3 times less than Tunisia. Nigeria's 2014 production, is similar to what Egypt had in 2005, South Africa in 1996, Morocco in 2009 and Tunisia and Algeria in 2006. Also, Nigeria experienced a 32% negative growth in 2012. This is the highest decline since 1998 where Nigeria had a negative growth of 51%.

Nigeria's Computer Science production over the years can be categorised into two phases based on their growth rate; growth and decline. Nigeria's Computer Science production has visibly three growth phases from 1996 to 1997 (average growth rate of 84%), 1999 to 2011 (average growth rate of 28%) and 2013 to 2014 (average growth rate of 8%). Nigeria Computer Science production has two major decline phase in 1998 (negative growth of 51%) and in 2012 (negative growth of 32%). Nigeria's average growth compared to the big five can be seen in figure 1.

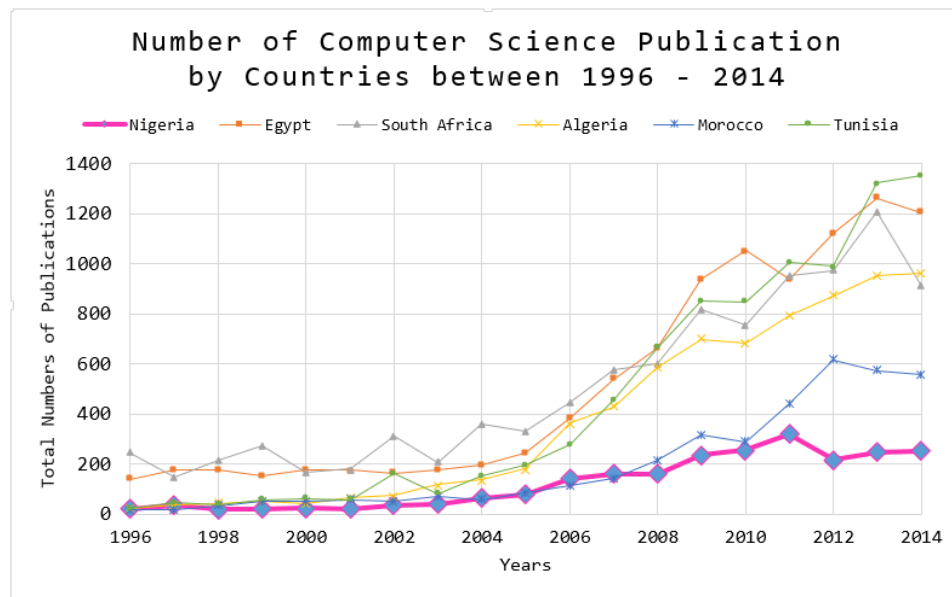


Fig 2: Number of Computer Science publication for Nigeria and the big five from 1996 to 2014

4.1.3 Computer Science sub-areas

Scopus database divides Computer Science into 12 sub-areas. They include; Artificial intelligence, computational theory and mathematics, computer graphics and computer-aided-design, computer networks and communications, computer science (miscellaneous), computer science application, computer vision and pattern recognition, hardware and architecture, human-computer interaction, information systems, signal processing and software. Nigeria and the big five's Computer Science production based on sub-areas can be seen in figure 3.

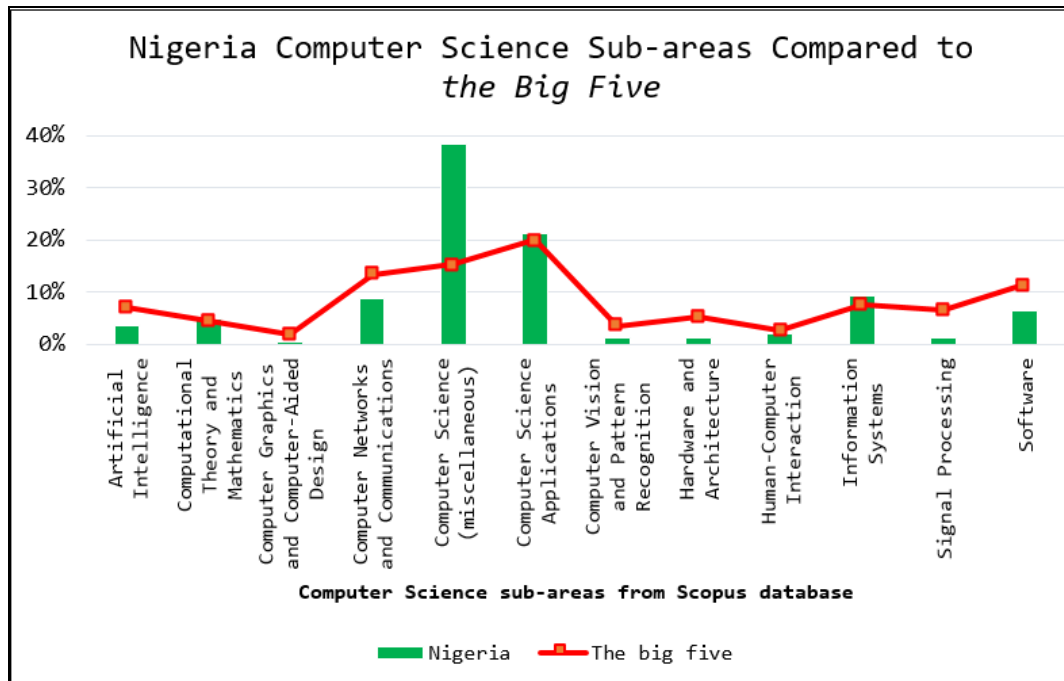


Fig 3. Countries publications divided into Computer Science sub-areas

Here we compare Nigeria and the big five's Computer Science production divided into Computer Science sub-areas. The big five's value here is the average values for Egypt, South Africa, Tunisia, Algeria and Morocco combined. On face value, the selected countries seem to follow the same Computer Science sub-area distribution. However, Nigeria seems to have a larger percentage of their publications in Computer Science (miscellaneous) than the big five.

4.2 Academic Specialisations

A total of 93 academic profiles from 13 Nigerian tertiary institutions, 70 profiles from 10 South African tertiary institutions and 130 profiles from 10 Egyptian tertiary institutions were used for this analysis (see table 1). Here we discuss how the data gathered was analysed and show findings for the academic title and specialisations distribution.

4.2.1 Academic title distribution

From table 3, Nigeria seems to have a 20% to 80% ratio of professors to doctors in the domain compared to South Africa's 37% to 63% and Egypt's 32% to 68% ratio (see table 3).

Table 3: Countries and their academic title percentage distribution

	Nigeria	South Africa	Egypt
Prof.	20%	37%	32%
Dr.	80%	63%	68%

4.2.2 Specialisation Analysis

In order to identify the Computer Science specialisation in Nigeria and other countries part of the big five, a simple binary colour coding scheme (see figure 4) was adopted to represent the academics specialisations using the ACM 2012 Computer Science classification system. Each column represents a specialisation category listed by ACM. When an academic lists a specialisation as part of their specialisation or specialisations, a colour representing the specialisation category and a number one (1) is placed in the corresponding cell. The colour is used to make it easy to distinguish categories and the number one (1) is used so that the analytics application can easily perform basic mathematical operations. If an academics specialisation does not fall into a particular category, it is left blank.

Serial	Title	University	Specialisation	Hardware	Computer systems organisation	Networks	Software and its engineering	Theory of computation	Mathematics of computing	Information systems	Security and privacy	Human-centered computing	Computing methodologies	Applied computing	Social and professional topics
10	Dr	Adekunle Ajasin University	Computer Networking			1									
11	Dr	Adekunle Ajasin University	Biometrics/informatics											1	
12	Dr	Babcock University	software Engineering				1								
13	Dr	Babcock University	Computation										1		
16	Prof	Babcock University	Artificial Intelligence										1		
17	Prof	Babcock University	Computer engineering and Instrumentation	1											

Fig 4: Colour coding analysis using the ACM 2012 classification system

4.2.3 Academic specialisation distribution

Here we present the findings for the academics Computer Science specialisations analysed in Nigeria, South Africa and Egypt. Figure 5, shows that Nigeria has a wealth of specialists in the fields of Information systems (21%), Applied computing (19%) Software and its engineering (18%) etc. but compared to South Africa and Egypt, we seem to have a weaker concentration of specialists in the areas of computer systems organisation (2%), theory of computation (1%), mathematics of computing (2%), human-centred computing (1%) and computer science social and professional topics (1%).

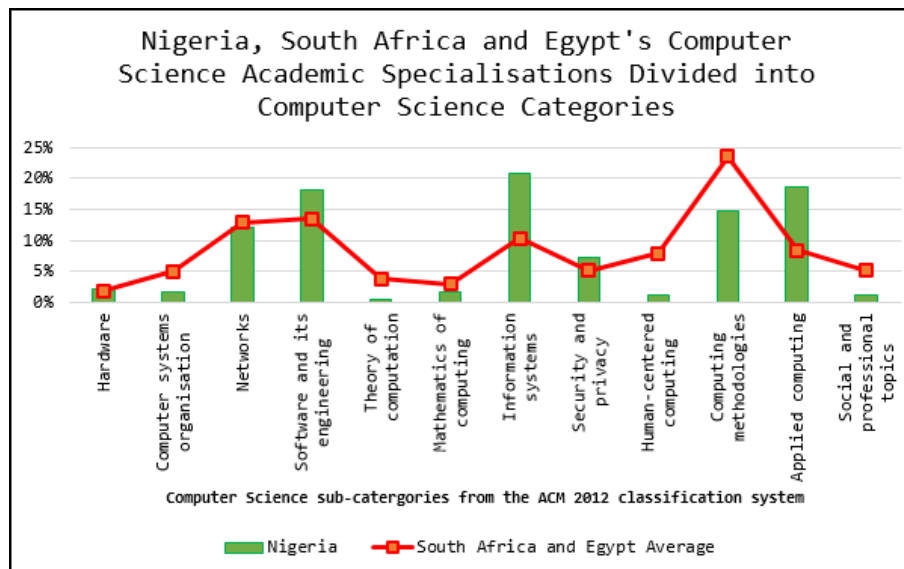


Fig 5: Nigeria academics Computer Science profiles divided into sub-categories compared to that of South Africa and Egypt

5. DISCUSSION AND CONCLUSION

This paper explored Nigeria's Computer Science production from 1996 to 2014 compared to countries that rank higher than Nigeria in the Scopus database. We used publication data from the Scopus database and profiles of Computer Science academics with doctorate degrees in tertiary institutions in Nigeria, South Africa and Egypt for the analysis. Here we highlight the research limitations, discuss our findings and provide suggestions for improvement. This work has some limitations that must be made clear. Using only the Scopus database provides a picture of Computer Science but a combination of indexing databases would provide a clear picture of the Computer Science domain but that also has its limitations as highlighted in the literature review section. Also, this paper does not cover productivity in any sense. Productivity is a function of the production figures divided by the number of Computer Science researchers or the amount of research investments for each country [1]. The reason for this is because, from our findings, this data is not available and the data available is not sub divided into various domains. In addition, we also could not gather the profiles of academics in Algeria, Tunisia and Morocco and this is mainly due to language restrictions.

5.1 Total amount of Computer Science production and countries growth rate

Nigeria currently ranks sixth position in the total number of Computer Science production coming from Africa for the period of 1996 to 2014 with 5% of the total amount of Computer Science productions from Africa. Nigeria Computer Science production over the years can be marked by two phases based on their growth rate; growth phase and the decline phase. Nigeria's growth phase although better than South Africa's (13%) and Egypt's (14%), Nigeria's growth rate at 21% is slower compared to countries like Algeria with 27%, Morocco 27% and Tunisia 36% which are countries who had about the same production as Nigeria in 1996 (in 1996 Nigeria had 19 productions, Algeria 21, Morocco 17 and Tunisia 20). It will be interesting to study what these countries did differently such as their Science and Technology policies etc. Nigeria had two major decline phase in 1998 (-51%) and 2012 (-32%) that reduced its growth rate from 26% to 21%. It will also be interesting to find out what may have happened to Nigeria in those years.

5.2 Computer Science academic titles, specialisations and Computer Science sub-areas

Nigeria has a wide range of Computer Science specialisations. However compared to Egypt and South Africa, Nigeria seem to have less amount of Computer Science professors compared to the others. It will be interesting to see the correlation between countries production against the percentage of Computer Science Doctors to professors ratio they have. Nigeria's Computer Science strength seem to be geared towards more practical sub-areas such as; Software Engineering, Information Systems and Applied Computing. However, Nigeria seem to be lacking in more theoretical sub-areas like computer systems organisation, theory of computation, Human-centred computing and Computer Science Social and Professional topics. In an analysis of the two major Computer Science sub-areas in a country, Nigeria's top two Computer Science sub-areas production are general sub-areas that account for 59% of their total publications (Computer Science Application and Computer Science miscellaneous), compared to the big five with a range of 32% to 39% for their top two sub-areas. Basically, the big five's Computer Science production seem to be distributed among all sub-areas and that of Nigeria seem to focus mainly on those two.

5.3 Recommendations

From the exploratory analysis conducted on Nigeria's Computer Science production for the period of 1996 to 2014, we outline the following recommendations to improve Nigeria's Computer Science production in the near future.

- Studies should be conducted on countries that rank higher than Nigeria in the Computer Science production ranking. Nigeria's Computer Science community should look into how Computer Science research is conducted in those countries that rank above her mostly Algeria, Morocco and Tunisia and should search for data that would allow some analysis to be conducted into the productivity of Computer Science research in Nigeria and those countries. What promoted their high production? Do they have more Computer Science dedicated researchers, how much time is spent on research compared to teaching and administration? Do they have more research funding and grants, better Science and Technology policies? Do they have more researchers that studied abroad? Do they have better acceptance rate in Journals, conferences and workshops? Do they have a better academic environment, etc. these are some interesting questions that should be asked.
- Nigeria's Computer Science community should encourage diversification; this could allow more interests in the defined and theoretical sub-areas of Computer Science such as theory of computation, human-centred computing etc.
- Nigeria Computer Science community should provide measures to continuously monitor her productions; Nigeria's Computer Science community should continue to monitor Nigeria Computer Science production and this can be done by having her indexing database that tracks every production from every Computer Science producer in the country.
- Nigeria Computer Science community should study the period of 1998 and 2012. Data should be gathered to investigate what happened to Nigeria's Computer Science production in 1998 and 2012 where she had her two major declines. Was there a policy change during those times?

In summary, we have explored Nigeria's Computer Science production from the period of 1996 to 2014 in relation to African countries that have more Computer Science production than Nigeria. Both publication data from the Scopus database and the profiles of over 250 academics from Nigeria, South Africa and Egypt was used for the analysis. We have highlighted Nigeria's Computer Science production strengths and also places they may be lagging behind and have provided some recommendations for improvement. The recommendations include; (1) a study of the production decline period, (2) continuous monitoring of the production (3) Diversification encouragement and (4) a study of countries that are ranked better.

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