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Scientific Research in West Africa and the Impact of International Collaboration: An Analysis in Scopus Database, 1997-2017

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Abstract

This study analysed the trend of West African research output, the effect of population size and its relative global share during the period 1997 - 2017. The patterns and impact of intra-regional and inter-regional research collaboration on West Africa research output were also assessed. Results show that all West African countries have generated noticeable growth. The West African share of global research has continued to increase over the years. However, West African volume of research output remains small if its global share is to be realised for the benefit of its population. Results show that the research output through collaborative research among West African countries is minimal. The impact of inter-regional collaboration in West African research output is higher than that of intra-regional collaboration. The findings presented in this study suggest that West African countries must invest more in research and improve their research production abilities through a collaborative effort.

Keywords: West Africa, Research Output, Collaboration, Population Size

Introduction

Scientific research in West Africa has been transforming over the last decades. One of the major indicators of scientific research is the research output, which contributes to the existing body of knowledge. Research outputs are the avenue for the determination of the cumulative research area of institutions and are measured by the number of articles published by these institutions (Okagbue, Atayero, Oguntunde, Opanuga, Adamu, and Adebayo, 2018). A reliable approach to study scientific research output is to examine the scientific publications contained in bibliometric databases (Blom et al. 2015). Bibliometrics has been known as a tool for assessing and mapping the state of science in institutions, countries, and regions.

So far, there have not been too many bibliometric studies analysing science in West Africa. Most of the studies carried out focused on Africa as a whole (Narvaez-Berthelemot, Russel, Arvanitis, Waast, and Gaillard, 2002); Tijssen 2007; Pouris and Pouris, 2009; Pouris and Ho (2014); Confraria and Godinho 2015; Blom, Lan, and Adil, 2015; Sooryamoorthy, 2018). Although few studies have focused on West Africa such as Mêgnigbêto (2013a), who examined the scientific research in West Africa from 2001-2010, using data from the Web of Science database. Defor, Kwamie, and Agyepong (2017) examined the pattern and trend of peer-reviewed Health Policy and Systems Research (HPSR) publications in West African countries. Other studies on West Africa are those of Aaron, Wilson and Brown (2010) and Nwagwu (2016). There have also been bilometric studies on specific countries in West Africa such as (Eniayejuni, 2018; and Odeyemi, Bamidele, and Adebisi, 2019.)

Despite that, a few studies have highlighted the development of science in West Africa to the best my knowledge, no study has provided an overall analysis of West African research output over time, the effect of population size, and its relative global

share. In addition, no study has been conducted to assess the patterns and impact of intra-regional and inter-regional research collaboration on West African research output. Thus, this study seeks to conduct an overall analysis of the trend of West African research output, the effect of population size and its relative global share during the period 1997 - 2017. The patterns and impact of intra-regional and inter-regional research collaboration on West Africa *research output* were also assessed. The study seeks to answer the following research questions:

- What is the trend of West African research output
- What is the West African share of global research
- How does population size affect the research output in West Africa?
- How does intra-regional and inter-regional collaboration affect West Africa's research output?
- What are the current scientific research areas in West Africa?

Methods

The study focuses on West Africa, a sub-region comprising fifteen countries, with an estimated population of about 367 million (Worldometers, 2017). West Africa is one of the five regions in the continent of Africa. It consists of fifteen countries who are members of a regional economic organization, ECOWAS. Out of the fifteen countries, four (Nigeria, Sierra Leone, Ghana, and Gambia) are former British colonies, Eight (Benin, Burkina Faso, Cote d'Ivoire, Guinea, Mali, Niger, Senegal, and Togo) are former French colonies, two (Guinea-Bissau and Cape Verde) are former Portuguese colonies, and Liberia was created by citizens of the United States of America for free black slaves. Hence, three international languages are distinguished in the region: English, Portuguese and French (African Union, 2019).

Given that, there is no citation database in West Africa, this study opted to use the Scopus database as the source of data. Scopus database was used due to its comprehensiveness. Scopus is the largest abstract and citations database that tracks and analyses peer-reviewed literature. It has strong coverage with citation data and bibliographic data. Scopus covers more than 49 million records including several journals, books, proceedings, covering research topics across all scientific and technical disciplines (Aghaei et al., 2013; Scopus, 2018; Barrot, 2017; Bornmann and Marx, 2014).

The data for this study was gathered from the Scopus database on June 17, 2019. Documents that are classified as articles published between 1997 and 2017 were downloaded for all West African countries. Firstly, Data for West Africa was retrieved using the Boolean operators. Then Data for each West African country was sourced individually for their research output, co-authorship, and scientific research area. The data gathered from the Scopus database was processed using the data management software program, SPSS, and Excel spreadsheets.

Population data were retrieved from worldometers (Worldometers, 2017).

Findings

The findings are reported in the following categories: The trend of research output, the share of global research, effect of population size on West African research output, the intra-regional and inter-regional collaboration of West Africa research output and current scientific research areas in West Africa.

The Trend of West African Research Output

Table 1 shows the research output from the fifteen West African countries in alphabetical order. To capture the trends in West African research output, data were presented in an aggregate manner for the entire study period of 1997-2017. Data was further segregated into a seven- year period, under three periods of 1997-2003, 2004-2010, and 2011-2017.

Overall, West Africa produced 109, 878 articles during the 21 years of 1997-2017. There was an average of 7,550 articles per country in West Africa within a range of 0 to 66403 publications. Six countries made the most significant contributions to West Africa's research output. Nigeria led all other West African countries by producing more than half (60.43%) of all articles from West Africa. Ghana follows but not very closely, with a 12.54% share of all articles from the region. Senegal had the third-

highest articles with 6.96%. Burkina Faso, Cote d'Ivoire, and Benin had 4.82%, 4.67%, and 3.83% share respectively. Apart from the six most prolific countries that together contributed approximately 93% of the total research output from West Africa, all other countries contributed below a 3% share of the total West African research output.

The delineated period analysis shows that during the first period (1997-2003) 15,668 articles originated from West Africa. Nigeria was the prominent producer, producing more than half (54.36%) of research output during this period. The remaining major contributors were Senegal (9.86%), Ghana (9.29%), Cote d'Ivoire (6.78%), Guinea (4.82%), Burkina Faso (4.61%), and Benin (3.42%), who jointly contributed another 33.97% of the total research output in West Africa. Gambia, Mali, Niger, and Togo contributed 2.76%, 2.48%, 2.29% and 1.87% respectively. All remaining countries (Sierra Leone, Guinea-Bissau, Liberia, and Cape Verde) contributed less than 1% of the total research output in the region.

Table 1: Research output of West African countries, 1997-2017

Country	Overall 1997-2017		3rd Period 2011-2017		2nd Period 2004-2010		1st Period 1997-2003	
	N	%	N	%	N	%	N	%
Benin	4322	3.93	2577	4.26	1209	3.58	536	3.42
Burkina Faso	5293	4.82	3039	5.03	1532	4.54	722	4.61
Cape Verde	243	0.22	184	0.30	47	0.14	12	0.08
Cote d'Ivoire	5131	4.67	2415	4.00	1653	4.89	1063	6.78
Gambia	1948	1.77	905	1.50	611	1.81	432	2.76
Ghana	13774	12.54	9267	15.34	3051	9.03	1456	9.29
Guinea	3139	2.86	1514	2.51	870	2.58	755	4.82
Guinea-Bissau	506	0.46	285	0.47	140	0.41	81	0.52
Liberia	362	0.33	301	0.50	45	0.13	16	0.10
Mali	2744	2.50	1513	2.50	843	2.50	388	2.48
Niger	1748	1.59	886	1.47	503	1.49	359	2.29
Nigeria	66403	60.43	36022	59.61	21861	64.72	8520	54.38
Senegal	7646	6.96	3978	6.58	2123	6.28	1545	9.86
Sierra Leone	760	0.69	538	0.89	129	0.38	93	0.59
Togo	1617	1.47	905	1.50	419	1.24	293	1.87
Total West Africa	**109878**		**60430**		**33780**		**15668**	

By the second period (2004-2010), research output in West Africa more than doubled from the previous period (1997-2003), showing significant growth. This growth is in line with the growth in research output for most West African countries. Countries such as Benin, Burkina Faso, Cape Verde, Ghana, Liberia, Mali, and Nigeria more than doubled their research output from the previous period. The second-period analysis also shows that Nigeria contributed the largest share of West African research output with a 64.72% share followed by Ghana (9.03%), Senegal (6.28%), Cote d'Ivoire (4.89%), Burkina Faso (4.54%), and Benin (3.58%).

The recent years of 2011-2017 recorded a dramatic growth in West Africa research output. Research output in West Africa grew to 60, 430 showing a percentage increase of 79% and 286% from the second and first periods. All West African countries showed a significant increase in their research output from the first and second periods. The major contributors in this period were Nigeria (59.61%), Ghana (15.34%), Senegal (6.58%), Burkina Faso (5.03%), Benin (4.26%), and Cote d'Ivoire (4.00%). Mali, Guinea, Gambia, Togo, and Niger contributed 2.5%, 2.5%, 1.5%, 1.5%, and 1.47% respectively. The rest countries contributed less than 1% of the total research output in West Africa.

West African Share of Global Research

Figure 1 presents the world and West African research output, 1997-2017. The evolution in Figure 1 shows a rising trend in both world and West African research output. West African research output more than quadrupled between 1997 and 2017, with more than 80% of articles published after 2005.

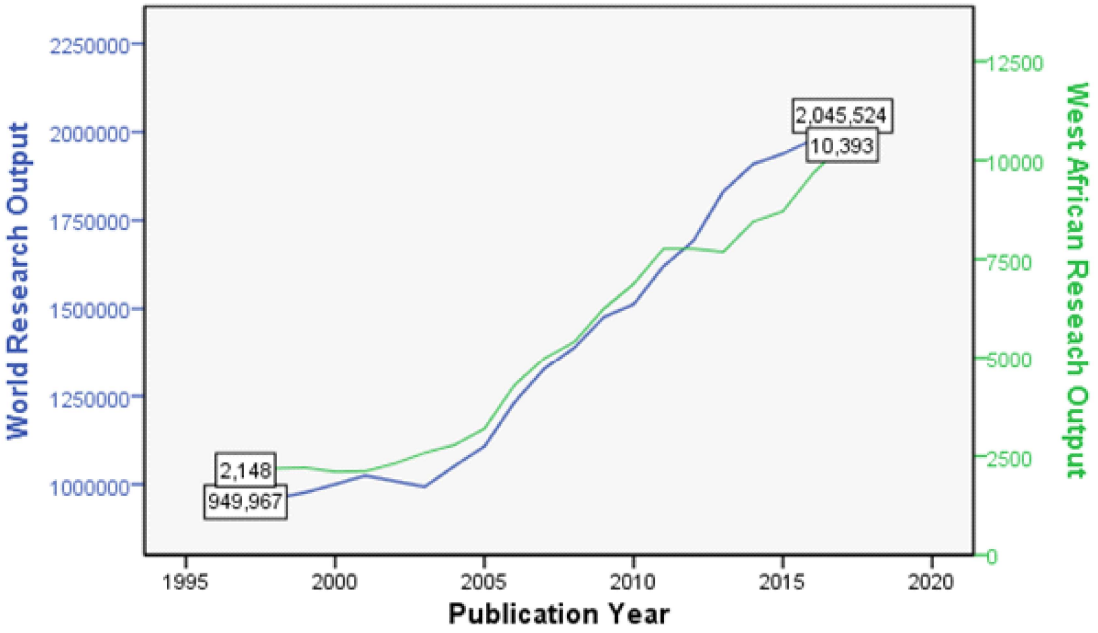

Figure 1: World and West Africa research output

Figure 2 presents the percentage of the West African share of global research. As shown in Figure 2 West African share of the world's article count has continued to increase with a mixed growth pattern. West African global share of published articles grew from 0.23% in 1997 to 0.51% in 2017.

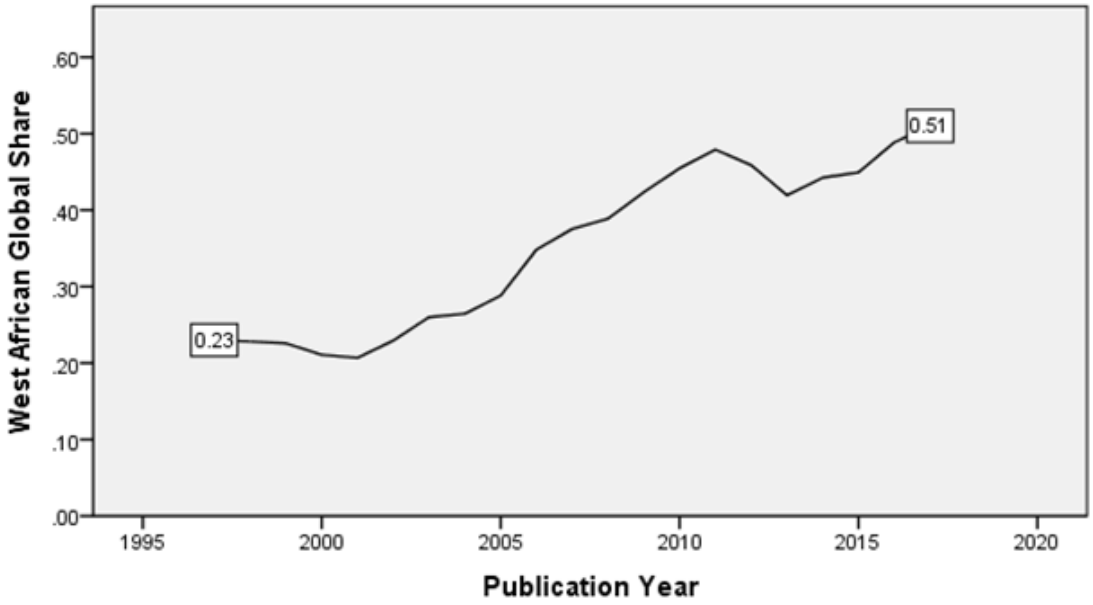

Figure 2: West African share of global research

Effect of Population Size on West Africa Research Output

Table 2 shows the research output, population size and the relative regional share (RS) and global share (GS) of West African countries in alphabetical order.

Table 2: West African Research output, Population size, and its Relative Regional and Global Share

Country	Research Output 1997 -2017			Population Size 2017		
	N	RS	GS	N	RS	GS
Benin	4322	3.93	0.01	11175692	3.04	0.15
Burkina Faso	5293	4.82	0.02	19193382	5.22	0.25
Cape Verde	243	0.22	0.00	546388	0.15	0.01
Cote d'Ivoire	5131	4.67	0.02	24294750	6.61	0.32
Gambia	1948	1.77	0.01	2100568	0.57	0.03
Ghana	13774	12.54	0.05	28833629	7.84	0.38
Guinea	3139	2.86	0.00	12717176	3.46	0.17
Guinea-Bissau	506	0.46	0.00	1861283	0.51	0.02
Liberia	362	0.33	0.00	4731906	1.29	0.06
Mali	2744	2.50	0.01	18541980	5.04	0.25
Niger	1748	1.59	0.01	21477348	5.84	0.28
Nigeria	66403	60.43	0.23	190886311	51.93	2.53
Senegal	7646	6.96	0.03	15850567	4.31	0.21
Sierra Leone	760	0.69	0.00	7557212	2.06	0.10
Togo	1617	1.47	0.01	7797694	2.12	0.10
Total West Africa	**109878**		**0.38**	**367565886**	**100.00**	**4.87**
Total World	**29026436**		**100.00**	**7550262101**		**100.00**

Regional Share (RS),
Global Share (GS)

The global and regional share analysis shows that Nigeria maintained its dominance among West African countries in terms of both research output and population size. Nigeria produced more than half (60.43%) of the total research output and comprised more than half (51.93%) the total population size of West Africa. Approximately 33% of research output in West Africa comes from five other countries: Ghana, Senegal, Burkina Faso, Cote d'Ivoire, and Benin who jointly comprised 27% of the total West African population.

The global share (GS) analysis in Table 2 shows that West Africa comprises approximately 5% of the world's population and contributed 0.38% of the total article in Scopus, 1997-2017. It is evident from this that the West African global research share is ten times lower than its global population share.

The regional share analysis in Table 2 shows an interesting observation with respect to the dimension of West African research output and population size. The research output of West African countries is very much in line with their population size. Countries with high population size produce more research output.

The Intra-Regional and Inter-Regional Collaboration of West Africa Research Output

In assessing the intra-regional research collaboration of West African research output, Table 3 provides country X's contributions to country Y's research output. There has been a significant level of research collaboration among most West African countries. Nigeria and Ghana had the highest level of collaborations with 650 research collaborations. Other countries with a high level of collaborations are Burkina Faso and Senegal with 437 collaborations, Burkina Faso and Mali with 297 collaborations. Despite the high level of collaborations between these countries, the influence of their collaboration on each country's research output differs. For instance, Nigeria contributed 4.7% of Ghana's total research output while Ghana contributed only 1% of Nigeria's total research output. Burkina Faso contributed 5.7% of Senegal's total research output while Senegal contributed 8.3% of Burkina Faso's total research output. Burkina Faso contributed 10.8% of Mali's total research output while Mali contributed 5.6% of Burkina Faso's total research output.

Countries with a high level of influence on other countries' research output include the Gambia, which contributed 16.2% of Guinea-Bissau's total research output. Benin contributed 12.3% of Togo's total research output; Burkina Faso contributed 11.6% of Togo's and 10.8% of Mali's total research output. Senegal contributed 10.6% of Niger's and 10% of Guinea-Bissau's total research output. All other countries contributed less than 10.5% to other country's research output.

In assessing the inter-regional research collaboration of West Africa research output, as observed in Table 3, collaboration with countries outside West Africa have greatly influenced West Africa's research output. The first collaborator for all West African countries falls outside the West African region. Gambia had the highest influence from a foreign collaborator, with 67% contribution from the United Kingdom (UK). This was followed by Guinea-Bissau with 66% from Denmark and Liberia with 57% from the United States (US). Except for Nigeria who had 6% influence from its first foreign collaborator. All other West African countries had 19% and above influence from their first foreign collaborator.

Table 3: West African countries' contributing to one another's research output, 1997 -2017

	X	BJ	BF	CV	CI	GM	GH	GN	GW	LR	ML	NE	NG	SN	SL	TG
	N		233	0	196	31	216	57	15	3	140	75	293	212	8	199
Benin (BJ)	%		5.4	0.0	4.5	0.7	5.0	1.3	0.3	0.1	3.2	1.7	6.8	4.9	0.2	4.6
	N	233		0	283	87	284	88	28	6	295	168	168	437	19	188
Burkina Faso (BF)	%	4.4		0.0	5.3	1.6	5.4	1.7	0.5	0.1	5.6	3.2	3.2	8.3	0.4	3.6
	N	0	0		1	0	3	3	0	0	2	1	3	5	0	0
Cape Verde (CV)	%	0.0	0.0		0.4	0.0	1.2	1.2	0.0	0.0	0.8	0.4	1.2	2.1	0.0	0.0
	N	196	283	1		40	153	65	19	9	120	46	145	205	10	105
Cote d'Ivoire (CI)	%	3.8	5.5	0.0		0.8	3.0	1.3	0.4	0.2	2.3	0.9	2.8	4.0	0.2	2.0
	N	31	87	0	40		100	26	82	2	102	14	119	115	9	11
Gambia (GM)	%	1.6	4.5	0.0	2.1		5.1	1.3	4.2	0.1	5.2	0.7	6.1	5.9	0.5	0.6
	N	216	284	3	153	100		61	26	17	146	72	650	166	30	76
Ghana (GH)	%	1.6	2.1	0.0	1.1	0.7		0.4	0.2	0.1	1.1	0.5	4.7	1.2	0.2	0.6
	N	57	88	3	65	26	61		15	13	58	23	56	99	29	23
Guinea (GN)	%	1.8	2.8	0.1	2.1	0.8	1.9		0.5	0.4	1.8	0.7	1.8	3.2	0.9	0.7
Guinea-Bissau	N	15	28	0	19	82	26	15		1	19	2	21	50	1	14
(GW)	%	3.0	5.5	0.0	3.8	16.2	5.1	3.0		0.2	3.8	0.4	4.2	9.9	0.2	2.8
	N	3	6	0	9	2	17	13	1		5	2	27	9	18	1
Liberia (LR)	%	0.8	1.7	0.0	2.5	0.6	4.7	3.6	0.3		1.4	0.6	7.5	2.5	5.0	0.3
	N	140	295	2	120	102	146	58	19	5		137	131	251	8	58
Mali (ML)	%	5.1	10.8	0.1	4.4	3.7	5.3	2.1	0.7	0.2		5.0	4.8	9.2	0.3	2.1
	N	75	168	1	46	14	72	23	2	2	137		112	182	4	31
Niger (NE)	%	4.3	9.6	0.1	2.6	0.8	4.1	1.3	0.1	0.1	7.9		6.4	10.4	0.2	1.8
	N	293	168	3	145	119	650	56	21	27	131	112		158	61	73
Nigeria (NG)	%	0.4	0.3	0.0	0.2	0.2	1.0	0.1	0.0	0.0	0.2	0.2		0.2	0.1	0.1
	N	212	437	5	205	115	166	99	50	9	251	182	158		26	92
Senegal (SN)	%	2.8	5.7	0.1	2.7	1.5	2.2	1.3	0.7	0.1	3.3	2.4	2.1		0.3	1.2
	N	8	19	0	10	9	30	29	1	18	8	4	61	26		8
Sierra Leone (SL)	%	1.1	2.5	0.0	1.3	1.2	3.9	3.8	0.1	2.4	1.1	0.5	8.0	3.4		1.1
	N	199	188	0	105	11	76	23	14	1	58	31	73	92	8	
Togo (TG)	%	12.3	11.6	0.0	6.5	0.7	4.7	1.4	0.9	0.1	3.6	1.9	4.5	5.7	0.5	

Table 4: Foreign countries contribution to West African countries research output, 1997-2017

Country	1st Collaborator	2nd Collaborator	3rd Collaborator	4th Collaborator	5th Collaborator
Benin	France (1252, 29%)	Belgium (512, 12%)	US (455, 11%)	UK (376, 9%)	Germany (345, 8%)
Burkina Faso	France (1733, 33%)	US (709, 13%)	UK (633, 12%)	Germany (459, 9%)	Belgium (434, 8%)
Cape Verde	Portugal (104, 43%)	Spain (57, 23%)	UK (37, 15%)	US (29, 12%)	Brazil (27, 11%)
Cote d'Ivoire	France (1738, 34%)	US (566, 11%)	Switzerland (457, 9%)	UK (345, 7%)	Germany (304, 6%)
Gambia	UK (1312, 67%)	US (557, 29%)	Belgium (270, 14%)	Netherlands (204, 10%)	Switzerland (178, 9%)
Ghana	US (2634, 19%)	UK (2228, 16%)	South Africa (928, 7%)	Germany (882, 6%)	Netherlands (748, 5%)
Guinea	Australia (1012, 32%)	US (706, 22%)	UK (473, 15%)	France (357, 11%)	Spain (263, 8%)
Guinea-Bissau	Denmark (331, 66%)	Sweden (122, 24%)	UK (108, 21%)	Gambia (81, 16%)	US (80, 16%)
Liberia	US (206, 57%)	UK (58, 16%)	France (32, 9%)	Canada (30, 8%)	Switzerland (28, 8%)
Mali	US (872, 32%)	France (724, 26%)	UK (361, 13%)	Kenya (240, 9%)	Switzerland (210, 8%)
Niger	France (577, 33%)	US (384, 22%)	UK (174, 10%)	Belgium (127, 7%)	Germany (104, 6%)
Nigeria	US (4231, 6%)	UK (3574, 5%)	South Africa (2979, 4%)	Malaysia (1672, 3%)	Germany (1412, 2%)
Senegal	France (2858, 37%)	US (1039, 14%)	UK (513, 7%)	Belgium (367, 5%)	Cameroon (276, 4%)
Sierra Leone	US (274, 36%)	UK (223, 29%)	China (100, 13%)	Germany (52, 7%)	Switzerland (46, 6%)
Togo	France (465, 29%)	US (162, 10%)	Germany (100, 6%)	Belgium (65, 4%)	Switzerland (62, 4%)

An interesting observation emerged when comparing the intra-regional collaboration (Table 3) and inter-regional collaboration (Table 4). It was observed that West African countries contribute only a small percentage to each other's research output as compared to the contributions made by foreign countries. For instance, despite Nigeria's huge volume of research output, contributions of other West African countries to Nigeria's research output were below 0.5%, while the US contributed 6%, and the UK contributed 5%. Gambia who had the highest influence from a foreign collaborator, with a 67% contribution from the UK had its highest regional contribution from Senegal with a 5.9% contribution. Others with high contributions from foreign countries include Guinea-Bissau, which had 66% from Denmark (foreign) but 16.2% from Gambia (regional). Liberia had 57% from US (foreign) but 7.5% from Nigeria (regional). Even countries with high regional influence had their highest influence from foreign collaborators. For instance, Togo had 12.3% from Benin but 29% from France (foreign). The influence of foreign countries on West African countries is higher than the influence of West Africa countries on each other's research output.

Current Scientific Research Areas in West Africa

The current scientific research foci of West Africa during the study period are presented in Table 5. Most West African countries had published in the 27 research areas (according to Scopus database classification). Research areas that had a minimum of 7,000 publications were considered. Seven research areas had more than 7,000 publications.

Medicine topped the list with 43,318 article publications. The others were Agricultural and Biological Sciences (26,414), Biochemistry, Genetics and Molecular Biology (12,236), Social Sciences (12,080), Environmental Science (10,673), Immunology and Microbiology (9,981) and Engineering (7,238).

Scientific research in Medicine was centralized in Nigeria with 55.16% of the total publications. Other important countries in this regard were Ghana (11.93%), Senegal (8.54%), Burkina Faso (6.0%), and Cote d'Ivoire (5.49%). In Agricultural and Biological Sciences, Nigeria topped with (58.14%), Ghana (11.66%), Benin (6.98%), Senegal (6.74%), and Burkina Faso (5.64%) were ahead of other countries in the region.

In Biochemistry, Genetics and Molecular Biology research, West African relied mostly on Nigeria with 59.67%. Other countries in this regard include Ghana (10.87%), Senegal (6.42%), Burkina Faso (5.33%), Cote d'Ivoire (4.72%), and Benin (4.59%). Other countries had less than 3.6%. Nigeria and Ghana led West Africa in Social Sciences with 61.35% and 21.22% respectively. In Environmental Science, Nigeria had 58.03% and Ghana 17.24%. Other countries had less than 6%. The leading countries in Immunology and Microbiology were Nigeria (40.01%), Senegal (12.59%), Ghana (12.39%), Burkina Faso (9.98%), Cote d'Ivoire (6.91%), and Gambia (6.23%).

In Engineering West Africa relied mainly on Nigeria with 75.31%. Apart from Ghana with 11.04%, other countries had less than 4%.

Table 5: Research Area of West African countries, 1997 - 2017

	Medicine		Agricultural and Biological Sciences		Biochemistry, Genetics and Molecular Biology		Social Sciences		Environmental Science		Immunology and Microbiology		Engineering	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Benin	1454	3.36	1843	6.98	562	4.59	290	2.40	521	4.88	495	4.96	119	1.64
Burkina Faso	2598	6.00	1489	5.64	652	5.33	376	3.11	546	5.12	996	9.98	139	1.92
Cape Verde	42	0.10	86	0.33	17	0.14	34	0.28	52	0.49	11	0.11	12	0.17
Cote d'Ivore	2377	5.49	1416	5.36	578	4.72	266	2.20	369	3.46	690	6.91	288	3.98
Gambia	1419	3.28	293	1.11	430	3.51	66	0.55	47	0.44	622	6.23	8	0.11
Ghana	5170	11.93	3081	11.66	1330	10.87	2563	21.22	1840	17.24	1237	12.39	799	11.04
Guinea	1533	3.54	871	3.30	419	3.42	253	2.09	268	2.51	487	4.88	91	1.26
Guinea-Bissau	400	0.92	77	0.29	92	0.75	15	0.12	17	0.16	169	1.69	2	0.03
Liberia	229	0.53	45	0.17	29	0.24	72	0.60	34	0.32	35	0.35	10	0.14
Mali	1442	3.33	831	3.15	396	3.24	197	1.63	253	2.37	526	5.27	38	0.53
Niger	578	1.33	646	2.45	231	1.89	157	1.30	278	2.60	191	1.91	57	0.79
Nigeria	23894	55.16	15356	58.14	7301	59.67	7411	61.35	6194	58.03	3993	40.01	5451	75.31
Senegal	3699	8.54	1780	6.74	785	6.42	498	4.12	639	5.99	1257	12.59	246	3.40
Sierra Leone	422	0.97	154	0.58	73	0.60	113	0.94	53	0.50	83	0.83	19	0.26
Togo	898	2.07	363	1.37	127	1.04	73	0.60	91	0.85	131	1.31	55	0.76
Total	**43318**	**100.00**	**26414**	**100.00**	**12236**	**100.00**	**12080**	**100.00**	**10673**	**100.00**	**9981**	**100.00**	**7238**	**100.00**

Discussion

The findings on the research output in West African countries reveal a noticeable growth from the years 1997 to 2017. By the second period of analysis, the total research output in West Africa more than doubled from the previous period. Eight of the fifteen countries increased their research output by more than 100%. This trend continued to the third period where the total research output in West Africa increased by 79% from the second period and 286% from the first period. This trend indicates that West Africa's research outputs are increasing over the years.

An analysis of the research output in West African countries reveals that the research output in West African countries is relative to its population size. The research output of West African countries strongly correlates with its population size. Countries with high population size were found to produce more research output. This is evident from previous studies (Luo, Liang, Gong, Bao, Huang, and Jia, 2015). 2015; Cheng and Zhang 2013), where it was found population size strongly correlated with research output.

West Africa represents almost 5% of the world's population, despite West African's vast population; it only contributes 0.38% of the total research article in Scopus, 1997- 2017 indicating that West African global research share is ten times lower than its global population share. Despite the noticeable growth in West African's research output, West African global research share is well below the world average. Though West African contribution to global knowledge has increased quite dramatically from 0.23% share in 1997 to 0.51% in 2017; however, the share of West African research output at the global level remains low. West Africa's share of the world's scientific output remained below the world average. This low share can be attributed to insufficient research funding as similarly noted by Tijssen (2007), and Megnigbeto (2016).

Scientific research output in West Africa as noted in the study is more concentrated in Medicine. Similarly, Mêgnigbêto (2013a) also noted that research in West Africa is produced mainly in medical and health sciences. This can be attributed to the study of Nwagwu, (2016), who noted that Medicine is a local discipline, often addressing challenges that exist in the immediate environment and that researchers are naturally responding to the needs of the local and immediate community.

Scientific research output in West Africa is largely dependent on a few countries. Nigeria, Ghana, Senegal, Burkina-Faso, and Cote d'Ivoire. Nigeria alone contributed more than half of the publications. The second major contributor was Ghana but it was far lower than the percentage share of Nigeria. The leadership demonstrated by Nigeria has both demographic and economic roots. Nigeria contributes the largest share of West African total research output and population size. This is evident from the study of Megnigbeto (2013a) who reported that Nigeria is the leader of knowledge production in West Africa, as Nigeria accounts for more than half of West African research output and demography.

It is also significant that the level of research collaboration among most West African countries has impacted greatly by boosting the research output of other West African countries. This analysis is in line with that of Onyancha and Maluleka (2011); Hoekman, Frenken and Tijssen (2010); Onyancha and Ocholla (2007) which found that a country's total research output is greatly boosted by its neighbours. A different scenario emerged when assessing the research collaboration of West African countries with non-West African countries. It was observed that foreign collaboration plays a big role in the production of knowledge in West Africa. The research output through collaborative research among West African countries is minimal as compared to foreign collaboration. This implies that collaboration with researchers from other parts of the world helps increase West Africa's research output. This illustrates the remark of Mêgnigbêto, (2013c) that collaboration within West African countries is weak or negligible. However, this is in contrast to the report of Adam, King, and Ma (2010) which revealed that countries belonging to the same geographical region tend to collaborate more with each other than they did with countries outside their region.

Collaborative research has drastically increased international co-authorship in scientific publications, resulting in a rapid increase in the number of international co-authored articles in all fields and disciplines (Low, Ng, Kabir., Koh and Sinnasamy, 2014; Pouris and Ho, 2014). Prathap (2013) explained that scientific collaboration has brought about greater co-authored articles, which has

increased the overall number of research output. An increase in research output tends to advance scientific knowledge. As noted by Eniayejuni (2018) "researchers need to collaborate and publish more to yield impactful research and to advance scientific knowledge which will be assessed for national science policies and development".

Conclusion

Over the years, West African contribution to global knowledge has increased quite dramatically. Although all West African countries have made gains in the last decade. Only a few countries were responsible for the growth and development of the bulk of knowledge production in West Africa. The regional top six countries were Nigeria, Ghana, Senegal, Burkina Faso, Cote d'Ivoire and Benin. The combined share of these countries is about 88% of the total West Africa research output and about 80% of total West Africa population.

The research output of West African countries is very much in line with its population size. Countries with high population size were found to be more productive than countries with lower population size. The share of West African research output at the global level remains low as compared to their global population share.

Research preferences and specialisation in all research areas were dominated by Nigeria. Other prolific countries were Ghana, Senegal, Burkina Faso, Cote d'Ivoire, and Benin. The key research areas were Medicine, Agricultural and Biological Sciences, Biochemistry, Genetics, and Molecular Biology, Social Sciences, Environmental Science, Immunology and Microbiology and Engineering.

West African research appears to be more dependent on inter-regional collaboration than intra-regional collaboration. The impact of foreign collaboration in West African research output is higher than that of regional collaboration. Since knowledge-creation is increasingly dependent on collaborative efforts and research is known as a driver of economic growth and political development, West Africa must increase their collaborative effort to increase their research output, West African countries must invest more in research and improve their research production abilities to further strengthen socio-economic development in the sub-region.

References

Aaron, G. J., Wilson, S. E., and Brown, K. H. (2010). Bibliographic Analysis of Scientific Research on Selected Topics in Public Health Nutrition in West Africa: Review of Articles Published from 1998 to 2008. *Global Public Health*, *5* (S1), S42-S57.

Abbas, A., Avdic, A., Xiaobao, P., Hasan, M. M., and Ming, W. (2019). University-Government Collaboration for the Generation and Commercialization of New Knowledge for Use in Industry. *Journal of Innovation and Knowledge*, *4* (1), 23-31.

Adams, J., King, C., and Ma, N. (2010). Global Research Report. *Africa. Leeds, UK: Evidence, a Thomson Reuters business*.

African Union, Member States, (2019). Retrieved 15th June 2019, <https://au.int/en/member_states/countryprofiles2>

Aghaei, Chadegani, A., Salehi, H., Yunus, M., Farhadi, H., Fooladi, M., Farhadi, M., and Ale Ebrahim, N. (2013). A Comparison between Two Main Academic Literature Collections: Web of Science and Scopus Databases. *Asian Social Science*, *9* (5), 18-26.

Barrot, J. S. (2017). Research Impact and Productivity of Southeast Asian Countries in Language and Linguistics. *Scientometrics*, *110* (1), 1-15.

Baskaran, A. (2017). UNESCO Science Report: Towards 2030. *Institutions and Economies*, 125-127.

Blom, A., Lan, G., and Adil, M. (2015). *Sub-Saharan African Science, Technology, Engineering, and Mathematics Research: A Decade of Development*. The World Bank.

Bornmann, L. and Marx, W. (2014). How to Evaluate Individual Researchers Working in the Natural and Life Sciences Meaningfully? A Proposal of Methods Based on Percentiles of Citations. *Scientometrics*, *98* (1), 487-509.

Cheng, T., and Zhang, G. (2013). Worldwide Research Productivity in the Field Of

Rheumatology from 1996 to 2010: A Bibliometric Analysis. *Rheumatology*, *52*(9), 1630-1634.

Confraria, H. and Godinho, M. M. (2015). The Impact of African Science: A Bibliometric Analysis. *Scientometrics*, *102* (2), 1241-1268.

Defor, S., Kwamie, A., and Agyepong, I. A. (2017). Understanding the State of Health Policy and Systems Research in West Africa and Capacity Strengthening Needs: Scoping Of Peer-Reviewed Publications Trends and Patterns 1990–2015. *Health Research Policy And Systems*, *15* (1), 55.

Eniayejuni, A. (2018). Impact of Scientific Productivity and Trend on Publication Output of Nigerian Authors in Web of Science from 2006 to 2016. *African Journal of Library, Archives and Information Science*, *28* (1).

Groboljšek, B., Ferligoj, A., Mali, F., Kronegger, L. and Igliè, H. (2014). The Role and Significance of Scientific Collaboration for the New Emerging Sciences: The Case of Slovenia. *Teorija in praksa*, *51* (5), 864-883.

Hoekman, J., Frenken, K. and Tijssen, R. J. (2010). Research Collaboration at a Distance: Changing Spatial Patterns of Scientific Collaboration within Europe. *Research Policy*, *39* (5), 662-673.

Lan, G., Blom, A., Kamalski, J., Lau, G., Baas, J. and Adil, M. (2014). A Decade of Development in Sub-Saharan African Science, Technology, Engineering, and Mathematics Research. *Elservier., editor. World Bank*.

Low, W. Y., Ng, K. H., Kabir, M. A., Koh, A. P., and Sinnasamy, J. (2014). Trend and Impact of International Collaboration in Clinical Medicine Papers Published in Malaysia. *Scientometrics*, *98* (2), 1521-1533.

Luo, X., Liang, Z., Gong, F., Bao, H., Huang, L. and Jia, Z. (2015). Worldwide Productivity in the Field Of Foot and Ankle Research from 2009–2013: A Bibliometric Analysis of Highly Cited Journals. *Journal of Foot and Ankle Research*, *8* (1), 12.

Megnigbeto, E. (2013a). Scientific Research in West Africa: A Global View (2001–2010). *ISSI Newsletter*, *9*, 6-11.

Mêgnigbêto, E. (2013b). International Collaboration in Scientific Publishing: The Case of West Africa (2001–2010). *Scientometrics*, *96* (3), 761-783.

Mêgnigbêto, E. (2013c). Scientific Publishing in West Africa: Comparing Benin with Ghana and Senegal. *Scientometrics*, *95* (3), 1113-1139.

Narváez-Berthelemot, N., Russell, J. M., Arvanitis, R., Waast, R. and Gaillard, J. (2002). Science in Africa: An Overview of Mainstream Scientific Output. *Scientometrics*, *54* (2), 229-241.

Nwagwu, W. E. (2016). A Decade of Biomedical Research in West Africa (2005–14) A Bibliometric Analysis of the Ten Most Productive Countries in MEDLINE. *Journal of Higher Education in Africa/Revue de l'enseignement supérieur en Afrique*, *14* (1), 43-83.

Odeyemi, O. A., Odeyemi, O. A., Bamidele, F. A., and Adebisi, O. A. (2019). Increased Research Productivity in Nigeria: More to be Done.

Okagbue, H. I., Atayero, A. A., Oguntunde, P. E., Opanuga, A. A., Adamu, P. I., and Adebayo, A. O. (2018). Exploration of Research Areas of Universities in Nigeria based on Scopus Subject Document Classification. *Int. J. Educ. Info. Technol*, *12*, 117-123.

Onyancha, O. B. and Maluleka, J. R. (2011). Knowledge Production Through Collaborative Research in Sub-Saharan Africa: How Much Do Countries Contribute to each other's Knowledge Output and Citation Impact?. *Scientometrics*, *87* (2), 315-336.

Onyancha, O. B. and Ocholla, D. N. (2007). Country-Wise Collaborations in HIV/AIDS Research in Kenya and South Africa, 1980–2005. *Libri*, *57* (4), 239-254.

Pouris, A. and Ho, Y. S. (2014). Research Emphasis and Collaboration in Africa. *Scientometrics*, *98* (3), 2169-2184.

Pouris, A. and Pouris, A. (2009). The State of Science and Technology in Africa (2000–2004): A Scientometric Assessment. *Scientometrics*, *79* (2), 297-309.

Prathap, G. (2013). Second-Order Indicators for Evaluating International Scientific Collaboration. *Scientometrics*, *95* (2), 563-570.

Sooryamoorthy, R. (2018). The Production of Science in Africa: An Analysis of Publications in the Science Disciplines, 2000–2015. *Scientometrics*, *115* (1), 317-349.

Tijssen, R. (2007). Africa's Contribution to the Worldwide Research Literature: New Analytical Perspectives, Trends, and Performance Indicators. *Scientometrics*, *71* (2), 303-327.

Toivanen, H. and Ponomariov, B. (2011). African Regional Innovation Systems: Bibliometric Analysis of Research Collaboration Patterns 2005–2009. *Scientometrics*, *88* (2), 471-493.

Worldmeters, World Population, (2017). Retrieved 15th February 2018, <http://www. worldo meters. info/world-population/western-africa-population/>

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