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MAPPING OUT THE RESEARCH ON "BIG DATA" A CASE STUDY OF BRICS NATIONS

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ABSTRACT

Every day, large amount of data is produced at an enormous rate, handling of which through conventional tools and technologies is difficult, a phenomenon called as "Big Data", thus requiring innovative information analytics for exacerbated decision making. "Big Data" era has garnered global eyeballs and is a research focus for many disciplines. In view of its popularity over the past few years, the study is an attempt to map out the research output on "Big Data" by BRICS nations during 2010–2015. The comparison among the nations has been visualized on the parameters including total research output, growth of research output, top articles and contributing sources along with their impact, top contributing authors, and the nature of articles (open access or closed access). The paper is an extensive one and shows the productive competition among the BRICS nations on "Big Data" research.

KEYWORDS :*Big Data research, BRICS, Computing, Scientometrics, Bibliometrics.*

INTRODUCTION

The universe of data is expanding since technological revolution and every entity associated with it is contributing to make what can be visualized as planets of data, if not, properly managed the

"Data Bang" is inevitable. We are always adding to the universe of data either passively or by logging onto our PC's and surfing the net and is estimated to reach *40ZB by 2020 or 5,247 GB* per person (Prabhu & Arpitha, 2014). The contributions also pour in from sensors used to gather climate, traffic and flight information, posts to social media sites, digital pictures and videos, transaction records, etc (Infographic, 2015) (as cited in Bello-Orgaz, Jung, & Camacho, 2015). The concept of "Big Data" has its roots in the field of computing since times immemorial, however in the present times it has become much more hyped due to its ubiquitous presence and eternal value for enhanced decision making. Despite the references to the mid-nineties, the *term became widespread as recently as in 2011* due to the promotional initiatives by IBM and other innovation driving organizations (Diebold, 2012). "Big Data" derives its name from the fact that the datasets are large enough that typical database frameworks cannot capture, save, and analyze these datasets (Manyika et al., 2011). However, Kaisler, Armour, Espinosa and Money (2013) refers "Big Data" as data that is in the *range of exabytes (10^{18}) and beyond;* exceed the capacity of current on-line storage systems and is beyond technology's capability to store, manage and process efficiently. In particular, "Big Data" and "Knowledge Discovery" can be used to reduce information asymmetries between organizations holding the data and the data sources and is increasingly used to create value in many different settings (O'Leary, 2015). The "Big Data" sounds to be related to the area of data science only, but is a subject of attention from *corporate leaders to municipal planners and academicians* and plays an important role in *healthcare research, including emergency medicine and cancer care* (Gandomi & Haider, 2015; Wong et al., 2015; Hudis, 2015). "Big Data" holds importance for both, public and private sector, as every aspect of their business involves huge amount of data– information about their products and services, about their buyers and suppliers and about consumer preferences and intent (Big Data, 2011). Other areas where "Big Data" finds its highest use are astronomy, oceanography, and engineering among many others (Halevi, 2012).

Nations across the world have realized the potential of "Big Data" research and instituted special national programs and initiatives on "Big Data" research (Singh, Banshal, Singha & Uddin, 2015). Among the emerging countries, the role of Brazil, Russia, India, China, and South Africa (BRICS) is particularly relevant. These five countries are among the major emerging national economies, distinguished by their fast growth and as such deserve to be studied in all their peculiar features (Finardi, 2015). However, academic journals in numerous disciplines, which will benefit from a relevant discussion of "Big Data", have yet to cover the topic (Gandomi & Haider , 2015); if *"Big Data" is truly to be liberated from bottlenecks, it must be exposed and explored in an intuitive, user-friendly way* (Prabhu & Arpitha, 2014). In view of this, the current study tries to make a comparative analysis of BRICS nations in terms of scientific production on "Big Data" and its characteristics.

DATA COLLECTION AND METHODOLOGY

This study is based on publications produced on "Big Data" by BRICS nations. The data was extracted from *Web of Science (WoS), one of the largest citation and abstract database*. The records were retrieved by entering a search query [TS= ("Big Data"), Timespan= 2010-2015, Database= Web of Science Core Collection, Indexes= SCI-EXPANDED, SSCI, A&HCI]. No variations of the term were used in order to capture only the use of this specific phrase. The country filter was used to restrict the publication output from a particular nation and each records meta-data such as paper title, authors etc. were recorded and analyzed in Microsoft excel. The impact of papers was measured by the number of citations and journals by journal impact factor (JCR-2014).

LITERATURE REVIEW

The *"Big Data" era is in full force today because* the world is changing and is witnessing exponential growth and we are able to add intelligence to almost everything (Zikopoulos, Eaton, DeRoos, Deutsch & Lapis, 2005, P. no. 4). It had been *coined to describe the era of data deluge* (Emani, Cullot & Nicolle, 2015) and includes structured data i.e data that is formatted for use in a database management system, *semi-structured* and *un-structured data*. Semi-structured and un-structured data include all types of unformatted data including multimedia and social media content (Purcell, nd).The "Big Data" revolution is evolving and organizations should embrace it in order to build superior capabilities which can become a decisive competitive advantage (Wamba et al, 2015). There will be rapid, widespread implementation and use of "Big Data" analytics across the healthcare organization and the healthcare industry (Raghupathi & Raghupathi, 2014). "Big Data" *has no big brother: it's ready, but still young* (Zikopoulos, Eaton, DeRoos, Deutsch & Lapis, 2005). Although in its young stage, a number of studies from the past few years are revolving around the "Big Data" phenomenon, its features, opportunities, applications and challenges. Kum, Stewart, Rose and Duncan (2015) discuss the frameworks for utilizing the "Big Data" for governance in child welfare. In view of its characteristics *(5 Vs) - volume, variety, velocity, veracity and value* (Wamba et al, 2015; Jin et al, 2015), the National Science Foundation, the National Institutes of Health, the U.S. Geological Survey, the Departments of Defense and Energy, and the Defense Advanced Research Projects Agency announced a joint R&D initiative in March 2012. Its goal is to advance our "…understanding of the technologies needed to manipulate and mine massive amounts of information; apply that knowledge to other scientific fields "as well as address the national goals in the areas of health energy defense, education and researcher" (Felten, 2010). At the same time, "Big Data's" characteristics are *tightly linked to privacy, security, effects on consumer welfare, complex data sharing and accessibility-related issues.* Moreover, the existing non-big data security solutions are not designed to handle the scale, speed, variety and complexity of "Big Data" (Kshetri, 2014). Halevi (2012) analyzed the emergence of "Big Data" as a research topic and views it is on a growing path. Strong (2014) discusses the challenges of "Big Data" from the view of qualitative research. Bello-Orgaz, Jung and Camacho (2015) analyzed the recent achievements and new challenges of social "Big Data". Storage issues, management issues, and processing issues have been seen fundamental issue areas that need to be addressed in dealing with "Big Data" (Kaisler, Armour, Espinosa & Money, 2013). Hashem, et al. (2015) reviewed the rise of "Big Data" in cloud computing and its research challenges. whileas, Li, Cao and Yao (2015) investigated the "Big Data" of smart cities and problems and challenges caused by it. Some see *"Big Data" as the beginning of the problem* because technology evolution and placement guarantee that in a few years more data will be available in a year than has been collected since the dawn of man (Gupta & Chaudhari, 2015).

Although, a number of studies exist on "Big Data" research, however we haven't found any work that maps out literature or performs a bibliometric analysis of "Big Data" contributed by the BRICS nations.

ANALYSIS

Research output and share of BRICS nations

The BRICS countries contribute a total of 589 (20%) publications to the global share of 2,927 for the period of 2010-2015. China stood at rank second in the global contribution on "Big Data" and is holding rank first among BRICS nations with a remarkable contribution of 499 papers (84.7%) and the remaining 90 publications (15.3%) is shared by other four countries (Table-1). India is at second position

with a contributions of 43 publications (7.3%) followed by Brazil 23 (3.9%). Russia is at bottom by contributing 11 (1.9%) publications. China has highest H-index value (12) among BRICS nations, whileas in average citation per paper, it is after South Africa and Brazil. South Africa stands at top in average citation per paper (3.31), ahead of global average (2.27) and is after China in H-index value. The position of BRICS nations varies according to Total Publications (TP), Average Citation Per Paper (ACPP) and H-index. The Table 2 presents the year-wise research output from BRICS nations, indexed in Web of Science (WoS). As it is evident that maximum research on "Big Data" in BRICS countries has happened in the year 2015 (343 papers) followed by 2014 (179 papers). Moreover, the research on "Big Data" started in 2010 in China, quite earlier than other nations; India in 2012, followed by other nations in 2013. The growth of "Big Data" is on exponential path with highest indications from China.

Rank	Country	Number of Papers				
		TP	%*	TC	ACPP	H-index
1	China	499	84.7	793	1.59	12
2	India	43	7.3	40	0.93	4
3	Brazil	23	3.9	38	1.65	3
4	South Africa	13	2.2	43	3.31	5
5	Russia	11	1.9	5	0.45	2
	World	2, 927		6,645	2.27	28

Table-1 Contribution and citation impact of BRICS countries.
* Percentage of contribution w.r.t. total 589 publications; TP=Total Publications; TC=Total Citations; ACPP= Average citations per paper.

Country	2010	2011	2012	2013	2014	2015
Brazil				1	9	13
Russia				1	2	8
India			1	3	10	29
China	1		6	49	157	286
South Africa				5	1	7
Total	1		7	59	179	343

Table-2 Research output (Year wise) of BRICS countries in "Big Data" research.

MEDIA OF COMMUNICATION OF BRICS NATIONS

Journals publishing the research on "Big Data" from BRICS (Top-5) are shown in Table-3. All the BRICS nations are publishing the research in well reputed journals as indicated by their impact factor. The emerging countries on "Big Data" publishing like Brazil, Russia, India and South Africa have published the articles in highly reputed journals as in some cases the impact factor of journals is over 3 & 4, (3.77, Vaccine, Brazil); (3.539, Expert opinion on drug discovery, Russia); (4.038, Information sciences, India) and IEEE transactions on smart grid (4.252, South Africa). Information science and IBM journal of research and development are leading journals from Indian sub continent with 3 publications each, having an impact factor of 4.038 & 0.688 respectively. However, the China has a good number of top articles in journals having impact factor in the range of 0.665-2.786 with highest contribution in International journal of distributed sensor networks (18) and IEEE networks (13).

Brazil			Russia			India		
Name of the journal	No. of papers	IF-2014	Name of the journal	No. of papers	IF-2014	Name of the journal	No. of papers	IF-2014
Scandinavian journal of immunology	2	1.739	Automatic documentation and mathematical linguistics	2	0	Information sciences	3	4.038
Pattern recognition letters	2	1.551	Acta naturae	2	0.872	IBM journal of research and development	3	0.688
Vaccine	1	3.77	Expert opinion on drug discovery	1	3.539	Scientometrics	2	2.183
Transportation research part c emerging technologies	1	2.818	Digital investigation	1	1.648	Sadhana academy proceedings in engineering sciences	2	0.587
Sensors	1	2.245	Biodata mining	1	2.024	Pattern recognition letters	2	1.551

China			South Africa		
Name of the journal	No. of papers	IF-2014	Name of the journal	No. of papers	IF-2014
International journal of distributed sensor networks	18	0.665	OMICS a journal of integrative biology	2	2.362
IEEE network	13	2.54	International journal of production economics	1	2.752
Mathematical problems in engineering	12	0.762	IEEE transactions on smart grid	1	4.252
Cluster computing the journal of networks software tools and applications	12	1.51	Ecosphere	1	2.255
Future generation computer systems the international journal of grid computing and escience	11	2.786	Ecology and evolution	1	2.32

Table-3 Media of communication (Top-5) of BRICS nations for "Big Data research", 2010–2015

Analysis of highly cited papers on "Big Data"

The highly cited articles along with source and average citation per year are shown (Table-4). It is to mention that most of the research articles are highly nascent as published in 2015, so a higher citation rate shall not be expected. Nevertheless, the top article of the BRICS countries is sharing 9 to 12 citations except China where it is 47. Also the articles from China are having higher citation count and average citations per year in comparison to other countries, due to the fact that China is quite active in "Big Data" research for a long time. The highest citation credit 47 (ACPY=23.5) is to "Data mining with

Big Data" published in IEEE Transactions on knowledge and data engineering from China. It is to mention that the citation rate and average citations are poor in case of other nations and in some countries the articles with just one, two, three citations or yet to be cited have made their presence in the top 5 cited articles.

Brazil			Russia			India		
Title	TC	ACPY	Title	TC	ACPY	Title	TC	ACPY
Big data in biomedicine	12	6	Chemical Data Visualization and Analysis with Incremental Generative Topographic Mapping: Big Data Challenge	2	2	Crowd-Funded Micro-Grants for Genomics and Big Data: An Actionable Idea Connecting Small (Artisan) Science, Infrastructure Science, and Citizen Philanthropy	9	3
Advancing biomarker research: utilizing 'Big Data' approaches for the characterization and prevention of bipolar disorder	10	5	Semantic Web and Big Data meets Applied Ontology The Ontology Summit 2014	2	1	Sweat, Skepticism, and Uncharted Territory: A Qualitative Study of Opinions on Data Sharing Among Public Health Researchers and Research Participants in Mumbai, India	7	7
A framework for selection and fusion of pattern classifiers in multimedia recognition	5	2.5	Progress in visual representations of chemical space	1	1	Vegetation ecology meets ecosystem science: Permanent grasslands as a functional biogeography case study	4	4
A path- and label-cost propagation approach to speed up the training of the optimum-path forest classifier	3	1.5	Life Sciences in Russia: Priorities in 2014-2020	0	0	Open Source Software and Web Services for Designing Therapeutic Molecules	4	1.33
Addressing Big Data Time Series: Mining Trillions of Time Series Subsequences Under Dynamic Time Warping	2	0.67	Experimental Study of the Cloud Architecture Selection for Effective Big Data Processing	0	0	CANDO and the infinite drug discovery frontier	3	1.5

China			South Africa		
Title	TC	ACPY	Title	TC	ACPY
Data Mining with Big Data	47	23.5	Prevention and management of non-communicable disease: the IOC consensus statement, Lausanne 2013	10	3.33
Next-generation Digital Earth	38	9.5	Crowd-Funded Micro-Grants for Genomics and Big Data: An Actionable Idea Connecting Small (Artisan) Science, Infrastructure Science, and Citizen Philanthropy	9	3
Data-intensive applications, challenges, techniques and technologies: A survey on Big Data	34	17	The compadre Plant Matrix Database: an open online repository for plant demography	8	8
Big Data: A Survey	28	14	Dynamic occupancy models for analyzing species' range dynamics across large geographic scales	7	2.33
Trends in extreme learning machines: A review	24	24	Prevention and management of non-communicable disease: the IOC consensus statement, lausanne 2013	5	1.67

Table-4 Top 5 highly cited papers on "Big Data" from BRICS
TC= Total Citations; ACPY= Average Citations per Year.

Productive authors and authorship pattern

Table-5 shows the most productive authors (Top 5) from BRICS nations with their TP & TC values identified for the six year studied period. As it can be seen, no author has contributed over 4 research articles except China, where Wang, LZ is at lead with 14 articles. It can also be observed that top authors from Brazil and Russia have failed to be cited and citation rate of top authors in India in comparison to China and South Africa is poor. The trend of multi authored papers 557 (94.6%) is quite evident in all BRICS nations with a high share of papers having more than 3 authors 391 (70.2%) (Table-6)

Brazil			**Russia**			**India**			**China**			**South Africa**		
Author name	**TP**	**TC**	**Author name**	**TP**	**TC**	**Author name**	**TP**	**TC**	**Author name**	**TP**	**TC**	**Author name**	**TP**	**TC**
Valim V	2	0	Lisitsa AV	2	0	Pal SK	4	2	Wang LZ	14	44	Van Mechelen W	3	17
Solans R	2	0	Shevel AE	1	0	Ozdemir V	3	12	Ranjan R	13	38	Sundberg CJ	3	17
Quartuccio	2	0	Sharnin MM	1	0	Kundu S	3	2	Chen JJ	11	46	Steffen K	3	17
Kruize A	2	0	Schneider T	1	2	Simmhan Y	2	0	Liu Y	11	27	Soligard T	3	17
Kostov BA	2	0	Sadov OL	1	0	Rogers B	2	0	Li Y	11	12	Shultz R	3	17

Table-5 Most productive authors.TP= Total Publications; TC= Total Citations.

No. of Authors	Brazil	Russia	India	China	South Africa	Total
Single	1	1	7	22	1	32
Double	2	1	9	57		69
Triple	2	1	7	86	1	97
>3	18	8	20	334	11	391
Single Authorship						**32 (5.4%)**
Joint Authorship						**557 (94.6%)**

Table-6 Authorship Pattern

DISCIPLINE WISE OUTPUT ANALYSIS:

Many disciplines are contributing to "Big Data" research from different perspectives. The top contributing disciplines include Medical sciences, Physical sciences, Material sciences etc. Table 7 presents the number of research publications from different broader disciplines (Top 5) indexed in WoS for the six year period from BRICS nations. As it is clear Computer science is leading with maximum number of contributions in all countries except South Africa wherein Sports science (23%) is leading. It is also evident a good number of contributions are also from the Engineering sector. The percentage values calculated are changing around 100% as it is based on total publications for each country and also research publications belong to more than one discipline (due to interdisciplinary outputs).

Brazil			Russia			India		
Discipline	Publications		Discipline	Publications		Discipline	Publications	
	No	%*		No	%*		No	%*
Computer science	6	26.1	Computer science	6	54.5	Computer science	23	53.5
Immunology	3	13	Pharmacology pharmacy	2	18.2	Engineering	4	9.3
Mathematics	2	8.7	Cell biology	2	18.2	Telecommunications	3	7
Environmental sciences ecology	2	8.7	Biochemistry molecular biology	2	18.2	Pharmacology pharmacy	3	7
Chemistry	2	8.7	Materials science	1	9.1	Biotechnology applied microbiology	3	7

China			South Africa		
Discipline	Publications		Discipline	Publications	
	No	% *		No	%*
Computer science	290	58	Sport sciences	3	23
Engineering	121	24	Environmental sciences ecology	3	15
Telecommunications	85	17	Genetics heredity	2	15
Science technology other topics	26	5	Engineering	2	15
Mathematics	26	5	Biotechnology applied microbiology	2	15

Table-7 Discipline-wise distribution of research output (Top-5). * Percentage of contribution w.r.t. total publications for each country.

Nature of Access

Majority of the articles from BRICS nations are published in subscription/closed access journals 454 (77%). However, it is contrary in India, where open access mode is quite prevalent (Table-8).

	Brazil	Russia	India	China	South Africa	Total
Closed Access	20	9	6	409	10	**454 (77%)**
Open Access	3	2	37	90	3	**135 (23%)**

Table-8 Nature of Access

SUMMARY AND CONCLUSION

"Big Data" is emerging a strong research topic due to its potentiality in wide array of disciplines and areas of human advancement. The use of "Big Data" analytics provides unparalleled competitive advantage. Whoever explores it more deeply and aggressively will have greater insight into its commercial, social, and scientific potential and will be able to make decisions that change the course of our lives; Whoever hesitates will be left behind (Prabhu & Arpitha, 2014). The BRICS nations are also making efforts for its exploration on different fronts by contributing a total of 589 (20%) publications to the global share of 2,927 for the period of 2010-2015. Among the BRICS countries, China is quite active from 2010 and is contributing a huge corpus of literature on the "Big Data" research. It holds first place among BRICS nations with a remarkable contribution of 499 papers (84.7%) and leaving the remaining 90 publications (15.3%) to other four countries. China is succeeded by India and Brazil but with a marked difference and is also having the highest H-index value. The research on "Big Data" is in beginning stage as the articles have started appearing frequently in 2012 with impressive growth rate in 2015. The high distribution in the recent years is aligning with the study by Wamba et al, 2015. China is also leading in citation counts and average citations per year, the top article acquiring 47 citations with average citations of 23.5 per year. The citation count of other nations is dismal with top articles sharing citation count in the range of 9-12. The publication count of top five authors in Brazil, Russia, India and South Africa ranges 2-4; whereas in China it ranges 11-14 with maximum contribution of 14 credits to Wang, LZ. The articles publishing on "Big Data" research are highly collaborative in nature and accounts to over 94.6% of the total. The "Big Data" research has garnered the global eye balls of academicians, healthcare researchers, etc with maximum contributions from computer science discipline in all countries, except South Africa wherein sports science is leading. The maximum research output from BRICS nations 454 (77%) is available on subscription basis with the exceptions from India, where much research on "Big Data" phenomenon is available in open access mode.

The study showed the extra ordinary lead of China in comparison to other nations of BRICS group. The other countries in the group need to gear up for improving the research account on "Big Data" particularly in India, where digital India is a dream of nation. More studies need to be carried out on a global level for bringing into lime light the contributions of the developed nations. The present study leaves the room for bibliometric/scientometric analysis of "Big Data" research on a large time frame, so that actual growth and other characteristics of the phenomenon shall be known.

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