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## The role of South African researchers in intercontinental collaboration<sup>1</sup>

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### Introduction

In the recent decades, scientific collaboration has been a significant part of the emerging research communities as, by 2016, 60% of the totally scientific publications are internationally co-authored (UNESCO, 2010; NSB, 2016). The relation between organizations, authors and/or governing bodies can be manifested in multiple ways. Even though collaborative research gains more and more value among researchers across the world, the evaluation of these relations is still ill-understood (Klein, 2008; Yegros-Yegros, Rafols, & D'Este, 2015). The discussion about the possible quality and quantity of collaboration has been scattered over several forums, which makes it essential to trigger overarching interaction and evaluation about the ongoing research collaboration across and within continents (Klein, 2008; Mâsse et al., 2008; Yegros-Yegros, Rafols, & D'Este, 2015). In our analysis, we use co-authorship as an indicator of collaboration. The measurement of co-authorship comes with certain issues, such as double and over-counting (Kahn, 2017). In addition, it is important to consider co-authorship relatively scaled to the specific field the publications belong (Ronda-Pupo and Katz, 2016). In regard of quantification of co-authorship, we chose this correction and focused on the field-based counts of co-authored publications.

In order to analyse scientific collaboration, some fundamental principles are introduced here. Starting with the variability of goals, the process of integration or transcendence of certain

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field can be viewed as an epistemological investment to produce a wider and more accurate set of knowledge on the investigated phenomenon (Klein, 2008). This endeavour is based on the collection and reformation of theoretical attributes, procedures and skills as well (Sonnenwald, 2007; Ynalvez, & Shrum, 2011). The collaboration occurs on the level of researchers and the institution is taking to secondary but vital role of supporter for the realisation of the connection between the particular authors (Sooryamoorthy, 2013b). In addition, there is a high emphasis on methodological interdisciplinarity as it provides the integrating medium that can capitalize on the different theoretical approaches (Mâsse et al., 2008; Sonnenwald, 2007). Scientific collaboration builds up from the delicate interaction of social relations involving different contributors of knowledge (Ynalvez, & Shrum, 2011). Research projects that reach successfully results in return generate new foundations and resources aiding social actions, which can be manifested in discussion and presentations at conferences and publications in journals (Ynalvez, & Shrum, 2011).

Researchers are usually evaluated and judged based on the field specific metrics that are barely compatible across different scientific areas. Besides the field specific differences, it is crucial to highlight that the amount of interaction and its promotion has been distorted by certain geographic biases. However Sooryamoorthy, & Shrum, (2007) found that, specifically in South Africa, the introduction of Internet technology reduced the amount of hindrances that fuel geographic biases and deny the possibility of international cooperation.

Parallel to the sheer quantity of scientific collaboration, the underlying funding organizations, as well, have been specifically tailored to western researchers (Mâsse et al., 2008). With this in mind, we need to be careful how to evaluate the indicators of collaborative research in the current scientific world. Furthermore, it is necessary to focus on not just the outcome but the process of the integrative research and provide transparent description of everyone`s capabilities and background knowledge, so then the emerging project can maximize the effectiveness of the collaboration (Sonnenwald, 2007; OECD, 2016; Sooryamoorthy, 2013b). In addition, the importance of social and cognitive aspects of collaboration can smooth out the process of interaction between cooperating researchers in order to gain sufficiently effective product (Mâsse et al., 2008; Sonnenwald, 2007). The continuous and systematic interaction of collaborators and subgroups of the project diminish the potential possibility of failure of the project (Klein, 2008; Evans, Lambiotte, & Panzarasa, 2011). It is important to engage into clear and effective management and coaching of the common project (Sonnenwald, 2007). To make this happen, the members need to introduce common boundary objects, integrated decision-making platforms and consensus building processes (Klein, 2008). Finally, scientific

collaboration needs to be built on transparent feedback system between involved researchers and outside of their circle. The dynamic evaluation of each-other's work as well as the relative contribution and the overarching progress of the project needs to be clearly interpretable by all of the involved parties (Roper, 2002; Sooryamoorthy, & Shrum, 2007).

*Specific issues regarding international collaboration within Africa*

It is important to clarify how collaborative research can circumvent emerging power imbalances introduced and reinforced by colonialism in regard of the evaluation of African scientific contribution (Briggs, & Weathers, 2016). As Nhemachena et al. (2016) argues: *‘African culture since the colonial era originated from methodological practices that took Africa as a “field” without organic cultivators. Such conceptualization of Africa merely as a field for mining “raw data” has legitimized centuries-old (neo-) colonial epistemic and methodological experiments on the people of the continent.’* (see pp. 15). This detrimental epistemological approach to African scientific contribution invites the rigorous evaluation of the current intercontinental influence on African research collaboration.

In addition, the nature of relationship between collaborators tends to be biased, which is why diminishing personal gain to specifically the lead contributors as well as the involvement of an independent advisory board is crucial (Parry, 2014). In the case of African scientific communities, it is vital to establish a balanced partnership with researchers and institutions located in Africa and making sure that the quantity and quality of involvement is equally discussed and agreed upon (Dodsworth, & Cheeseman, 2017).

Even though there is a general rise in the number of research publications from African countries, the number of researchers who contribute to these publications and live on the continent decreased (Dodsworth, & Cheeseman, 2017). In regard of collaboration specifically among African researchers, it is typical that across different sectors they collaborate with researchers mostly within their own institute (Beaudry, & Mouton, 2017). The exceptions are the researchers who are employed by international organizations even though they collaborate less outside of Africa than members of non-international institutes (Beaudry & Mouton, 2017). Across all the different fields, researchers tend to collaborate more with others within their countries than in their own organization but still less with people from other African countries (Beaudry, & Mouton, 2017). Scientists who focus on specifically research work

usually show a higher frequency and intensity of collaboration too (Sooryamoorthy, 2013b). Generally, research institutes prefer within-country- while universities capitalize more frequently on international collaboration (Sooryamoorthy, 2013a).

In parallel to the prior described cooperative trends, it is important to clarify that international cooperation is frequently present in the case of publications that are produced by authors with the highest scientific impact, claimed by African Observatory of Science, Technology and Innovation (AOSTI). According to AOSTI, the top 500 most cited African researchers *'have more than 50% of their publications co-authored, primarily with researchers outside Africa'* (AOSTI 2014: 38).

#### *International and domestic funding*

Finally, it is necessary to mention the impact of the source and nature of funding that allows the financial support for each publication from any scientific field. The evaluation regarding the involvement of international and domestic funding organizations is significant in order to determine the goals and challenges of each publication (Beaudry & Mouton, 2017; OECD, 2016). The influence of these institutions, besides providing fund for the publication, mainly effects the continuity in research programs in African countries (Beaudry & Mouton, 2017), act as donors for R&D projects, work as the integrating body for international and/or intercontinental collaboration (Sonnenwald, 2007; OECD, 2016). In addition, it is a potential provider of employment for local scientists and provider of facilities and technology that are, currently, not accessible in the involved countries (Beaudry & Mouton, 2017).

The aforementioned attributes of integrative scientific research collaboration are fundamental; each research community has its own features that potentially vary based on the involved fields, geographic location, underlying organizations, institutes, and funding (Evans, Lambiotte, & Panzarasa, 2011; Sonnenwald, 2007). The analysis presented here is specifically focusing on mapping up, based on publication output, the scientific collaborating activity of African authors and the role of the South African research community as a channel for intercontinental collaborations.

## Methods

The analysis presented here is based on a quantitative analysis of scientific publications in journals processed on the CWTS in-house version of the Web of Science (WoS) database (Science Citation Index Expanded, Social Sciences Citation Index, and Arts & Humanities Citation Index) of Clarivate Analytics. WoS is a bibliographic database that covers the publications of about 12,000 journals in the sciences, the social sciences, and the arts and humanities.

Above we present the different steps followed for the selection of the dataset and the analysis.

### *Selected Scientific Fields*

As a first step we have selected three scientific fields that serve as an indicator to map up the scientific cooperation involving the African continent and identifying South Africa as a beacon in this process. These fields are *Agriculture and Food Sciences*, *Biomedical Sciences* and *Psychology*. The first two fields were singled out as partnerships among African researchers and development organizations have long tradition to become more prominent in technical fields (Beaudry & Mouton, 2017). In addition, the field of Psychology was selected based on the idea to get samples from a field with different perspective and impact on the research communities.

### *Selection of Authors*

In these selected fields we have selected those authors that published between 2000 and 2017. In addition, we have created three specific groups based on the registered location of institution of the researchers. The first group included researchers that have published mainly under an address in a South African institution, another group where researchers have published mainly under an address in any African country besides South Africa, and the last group where researchers that have published mainly under an address outside of Africa. Additionally we filter out those researchers that published at least the amount that equals to the mean of the distribution regarding the number of publications in the aforementioned fields (see Table 1). We have used the mean value as a cut off limit as it has been established as a standard (size independent) indicator of individual productivity (Ruiz-Castillo, & Costas, 2014).

Table 1. Mean, Standard Error (SE) and Standard Deviation (SD) of distributions across the number of publications in selected scientific fields in South Africa (ZA), rest of African continent (AF) and non-African countries (NA).

<b>Field</b>	<b>Mean</b>	<b>SE</b>	<b>SD</b>
Psychology (ZA)	14,115	0,668	40,903
Psychology (AF)	25,846	1,248	45,032
Psychology (NA)	14,732	0,057	49,896
Biomedical Sciences (ZA)	18,000	0,398	42,983
Biomedical Sciences (AF)	17,118	0,190	28,536
Biomedical Sciences (NA)	70,294	0,100	87,269
Agricultural and Food Sciences (ZA)	20,606	0,646	47,819
Agricultural and Food Sciences (AF)	15,480	0,248	27,635
Agricultural and Food Sciences (NA)	15,705	0,049	49,448

### *Co-authorship maps*

Based on this data we have created co-authorship matrices between the researchers selected. In order to visualize the co-publications between the authors we created co-authorship maps based on the prior mention matrices in *VosViewer 1.6.6* (Van Eck, & Waltman, 2010; Ranjbar-Sahraei, & Negenborn, 2017) (see Figure 1-3 in Results).

### *Locate the most influential sub-community in each field*

In order to find out which sub-communities had the highest influence on specific field in regard of cooperation between the three aforementioned groups, we calculated the centrality measures in the cooperation networks. We have selected the three most frequently used centrality indicators, namely betweenness, degree and closeness (Wasserman, & Faust, 2016). To gain these measurements we have used the software *Pajek64 5.03* (Batagelj, & Mrvar, 2003). The converted network files from *VosViewer* were transferred to *Pajek* to calculate the centrality measurements. As an example, we selected out the 10 most influential researchers who have the highest scores in each of the centrality measurement and listed the belonging countries in order to gain a picture of the influence of South African research collaboration in the selected fields (Table 3-5 in Results). Furthermore, we have run *Louvain Modularity* analysis, using *Pajek*, on each of the networks, that depict the collaboration between African and non-African researchers in each field, to identify the more exact sub communities that collaborate with high frequency. This method is based on the density of connecting edges inside the community and outside the defined community in the network (see Figure 1-3(B)) (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008).

*Authorship position*

Furthermore, we have taken a look at the number of authors for each publication and focused on the first position of authorship of the researchers that have mainly South African address, that were involved in the publication. We have counted the number of authors that take first authorship position in publications in the selected fields. This step helps to get a more accurate picture about the role of South African research community in the scientific collaborative process.

**Results**

The analysis shows that out of the three prior selected fields, only the collaboration in Biomedical Sciences has a clear indication of the role of South African research communities as prominent beacons for intercontinental scientific collaboration (see Table 3-5).

Table 3. Agricultural and Food Sciences centrality measurements

<b>Agricultural and Food Sciences</b>						
<b>Position</b>	<b>Betweenness</b>	<b>Countries</b>	<b>Closeness</b>	<b>Countries</b>	<b>Degree</b>	<b>Countries</b>
1	0.013441	TN	0.068926	ZA	63	KY
2	0.012072	ZA	0.066174	TN	56	EG
3	0.00957	CR	0.065388	GH	52	EG
4	0.008402	CR	0.065315	CR	50	EG
5	0.007468	TN	0.065012	NI	42	TN
6	0.007207	EG	0.064554	GH	41	NI
7	0.006832	TN	0.06394	TN	39	TN
8	0.006503	SN	0.063685	ZA	31	UG
9	0.005258	TN	0.06349	TN	30	TN
10	0.005208	TN	0.063412	CR	28	TN

Table 4. Biomedical Sciences centrality measurements

<b>Biomedical Sciences</b>						
<b>Position</b>	<b>Betweenness</b>	<b>Countries</b>	<b>Closeness</b>	<b>Countries</b>	<b>Degree</b>	<b>Countries</b>
1	0.01715250	ZA	0.143026	ZA	184	ZA
2	0.01495173	ZA	0.142693	ZA	176	ZA
3	0.01130580	ZA	0.139629	ZA	153	ZA
4	0.01089066	ZA	0.138049	ZA	149	ZA
5	0.00993138	ZA	0.137564	SN	148	ZA
6	0.00915612	ZA	0.137187	ZA	132	ZA
7	0.00826083	EG	0.135456	ZA	130	ZA
8	0.00825255	BW	0.135252	UG	128	ZA
9	0.00779423	ZA	0.134919	KY	122	ZA
10	0.00736965	ZA	0.134809	ZA	119	ZA

Table 5. Psychology centrality measurements

Position	Psychology					
	Betweenness	Countries	Closeness	Countries	Degree	Countries
1	0.001641	ZA	0.015359	ZA	25	NI
2	0.001479	UG	0.014233	UG	19	NI
3	0.001079	UG	0.013194	GH	17	UG
4	0.000446	ZA	0.013185	GH	15	NI
5	0.000309	NI	0.012752	ZA	15	ZA
6	0.000159	UG	0.012735	UG	13	UG
7	0.000120	ZA	0.012622	UG	11	ZA
8	0.000104	NI	0.012289	UG	11	ZA
9	0.000100	UG	0.012289	UG	11	UG
10	0.000061	KY	0.012185	NI	11	ZA

We have also seen that the more technical fields, especially Biomedical Sciences show a higher impact on scientific contribution of African authors to the intercontinental research communities. It is clearly visible in Table 4 that in regard of the degree centrality measurement of the Biomedical Sciences collaboration network, 10 out of the 10 highest scores are contributed by South African authors. The perfect depiction of the sheer difference in numbers of co-publication is visible on Figure 1-3(A).

Figure 1(A). Collaboration between African and non-African research institutes in the field of Agricultural and Food Sciences

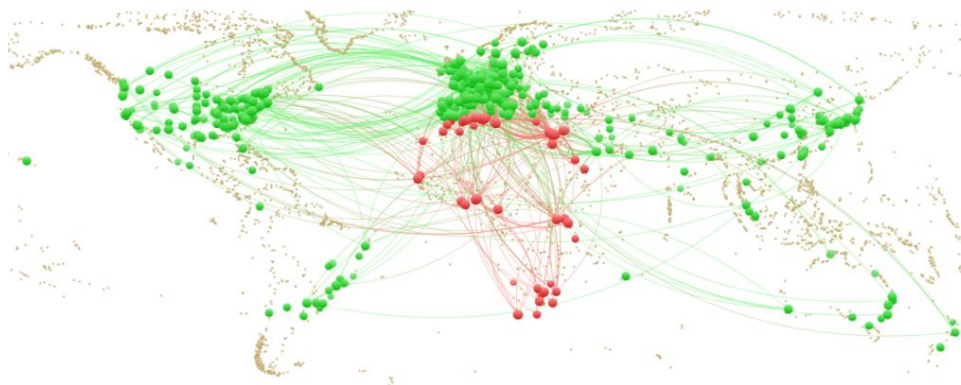
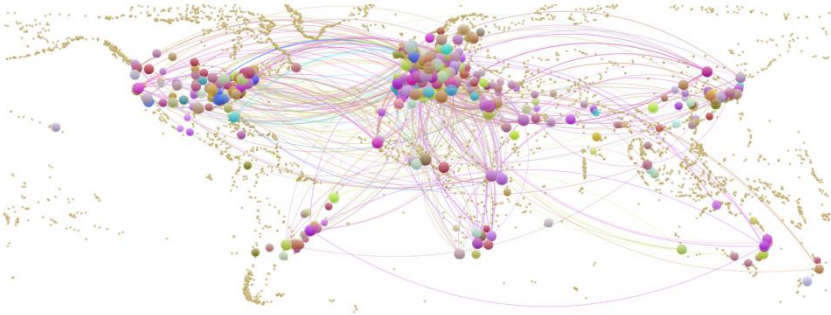


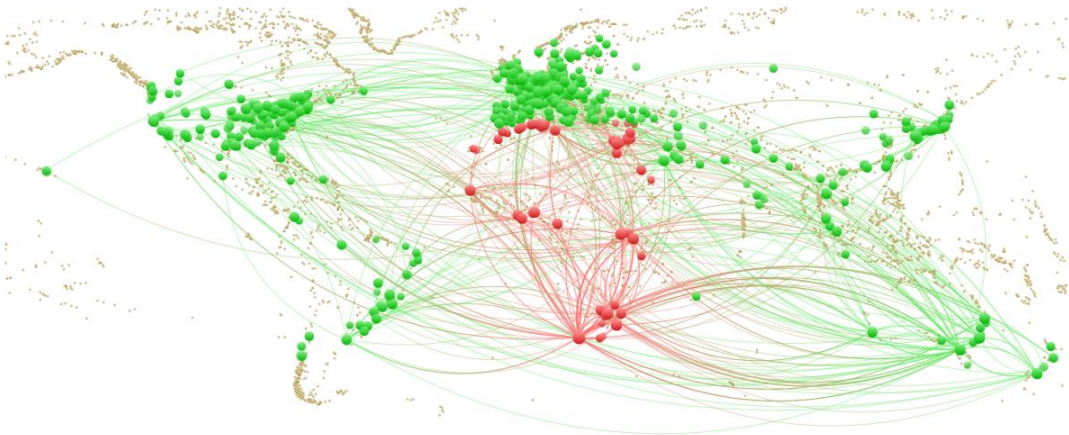
Figure 1(B). Collaboration split to communities between African and non-African research institutes in the field of Agricultural and Food Sciences (Louvain Modularity)



VOSviewer

Each colour represents different communities based on the density of edges (representing collaboration) connecting the institutions.

Figure 2 (A). Collaboration between African and non-African research institutes in the field of Biomedical Sciences



VOSviewer

Figure 2 (B). Collaboration split to communities between African and non-African research institutes in the field of Biomedical Sciences (Louvain Modularity)



Each colour represents different communities based on the density of edges (representing collaboration) connecting the institutions.

Figure 3 (A). Collaboration between African and non-African research institutes in the field of Psychology

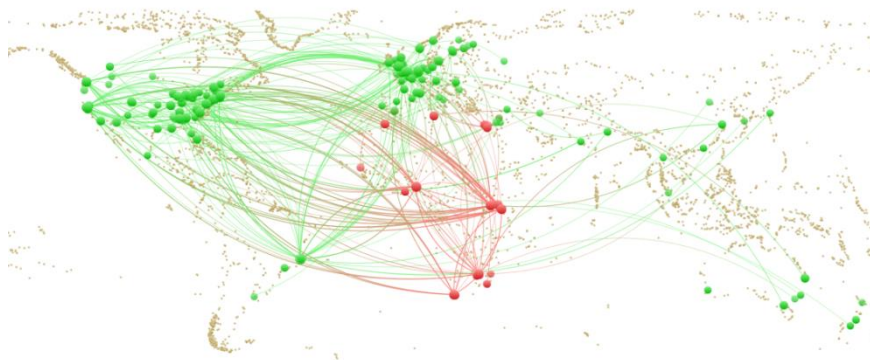


Figure 3 (B). Collaboration split to communities between African and non-African research institutes in the field of Psychology (Louvain Modularity)



Each colour represents different communities based on the density of edges (representing collaboration) connecting the institutions.

Figure 1-3 (A) clearly show that South African collaborative contribution is specifically dominant in Biomedical Sciences that was also depicted by the centrality measures described above. In regard of Agricultural and Food Sciences as well as Psychology (see Figure 1(A) and Figure 3 (A)) show a more scattered involvement of different authors from different countries all around Africa. In addition, regarding the field of Psychology we can see that a trend toward collaboration with non-Asian countries is prominent (see Figure 3 (A)). Figure 3 (B) also shows that there is a large community (magenta colour) that dominates the rest of the communities in strength and number of edges. It is important to clarify that the depiction on Figure 3 (B) can be based on either the generally high number of authors per publication or the high number of publications. The two possibilities have different qualitative value in the perspective of collaboration. On the other hand, the same pattern is not visible in the case of other fields. This difference in diversity of structure in communities of collaboration between fields can be supported by multitude of reasons, for example specific institutional interests, geopolitical underpinnings, or global scientific projects, which are outside of the scope of this paper. Finally, it is important to point out that the colouring on Figure 1-3 (B) highlights that

the specific communities include majorly intercontinental cooperation, that also involve African presence, with field specific geographical biases that are also visible in Figure 1-3 (A). These biases include, among others, a European and Northern-American dominance, higher frequency involvement of Asian communities in Biomedical Sciences and Agricultural and Food Sciences, and significantly less amount of collaboration worldwide in the field of Psychology.

Furthermore, we have found that in publications where a researcher with mainly a South African address in the Agricultural and Food Sciences field, was the first author in 18.4% of the cases based on 18841 publications. In addition, these counts showed that a researcher with mainly a South African address, in the field of Biomedical Sciences, in 15.4% of the cases was first author based on 31889 publications. Finally, a researcher with mainly a South African address, in the field of Psychology, was first author in 52.9% of the cases, based on 4447 publications. For each field we have only selected publications where at least 3 authors were contributing.

## **Conclusion**

Based on the conducted analysis, we can conclude that even though the South African research community does have a major role in intercontinental scientific collaboration, this influence is mainly manifested in Biomedical Sciences. It became visible, through the conducted Louvain Modularity analysis on collaborating communities, that a strong step towards intercontinental collaboration gained dominance. In addition, the analysis about the position of authorship has shown that researchers mainly located in South Africa take first author position more frequently in Psychology compared to Biomedical Sciences and Agricultural and Food Sciences. In order to carry out a more detailed analysis of the role of South African research community in intercontinental collaboration in the future, we are going to conduct more extensive analyses across multitude of different scientific fields, and include defining factors such as the role and prominence of funding organisations in research practices.

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