BRAZILIAN REGIONS AND INTERNATIONAL SCIENTIFIC COLLABORATION[1]

Concepta McManus[2]
Abilio Afonso Baeta Neves[3]
Felipe Pimentel[4]
Daniel Pimentel[5]
Timothy Finan[6]

There is little information on the differences between Brazilian regions regarding the quantity and quality of North-South and South-South scientific collaboration. Data from 2012 to 2021 was collected in InCites. Variance, principal components, discriminant and canonical analyses were carried out. Regional differences for publishing indicators are highly variable. Brazilian first, last or corresponding authors tend to publish in journals in quartiles 3 or 4 (poorer quality). These tend to be poorly cited, have a lower percentage of documents cited and have fewer publications in hybrid journals. Collaborations with industry tend to have higher citation impact. While the percentage of documents in open access journals positively affected the impact of North-South collaboration (NSC), it negatively affected South-South collaboration (SSC). Publishing in hybrid journals was important for increasing the impact factor in SSC. Factors such as article processing charges and open access should be considered when financing international collaboration. The inequalities between Brazilian regions for international collaborations tend to be numerical and not necessarily qualitative.

Keywords: impact of scientific publications; quality of publications; quantity of publications; South-South scientific cooperation; North-South scientific cooperation.

REGIÕES BRASILEIRAS E COLABORAÇÃO CIENTÍFICA INTERNACIONAL

Há poucas informações sobre as diferenças entre as regiões brasileiras quanto à quantidade e à qualidade da colaboração científica Norte-Sul e Sul-Sul. Os dados de 2012 a 2021 foram coletados no InCites. Análises de variância, componentes principais, discriminante e canônica foram realizadas. As diferenças regionais para a publicação de indicadores são altamente variáveis. Primeiros, últimos ou correspondentes autores brasileiros tendem a publicar em periódicos nos quartis três ou quarto (qualidade pior). Estes tendem a ser pouco citados, possuem

1. The authors acknowledge the Coordination for the Improvement of Higher-Level Personnel (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Capes) and the Brazilian National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq).

2. Professor at the University of Brasilia (Universidade de Brasília – UnB); and PhD in philosophy at the University of Oxford. Orcid: <https://orcid.org/0000-0002-1106-8962>. E-mail: <conniemmcmanus@gmail.com>.

3. Advisor at the Pontifical Catholic University of Rio Grande do Sul (Pontifícia Universidade Católica do Rio Grande do Sul – PUCRS); and PhD in political science at the Westfälische Wilhelms Universität. Orcid: <https://orcid.org/0000-0002-4684-2479>. E-mail: <abiliobneves@gmail.com>.

4. Student at the University Center of Brasilia (Centro Universitário de Brasília – Ceub). Orcid: <https://orcid.org/0000-0001-7016-5255>. E-mail: <felix1996@hotmail.com>.

5. Student at the UnB. Orcid: <https://orcid.org/0000-0002-1105-4720>. E-mail: <danielmcpimentel@gmail.com>.

6. Professor and PhD in cultural anthropology at the University of Arizona. Orcid: <https://orcid.org/0000-0003-0172-6607>. E-mail: <finan@email.arizona.edu>.

menor percentual de documentos citados e possuem menos publicações em periódicos híbridos. As colaborações com a indústria tendem a ter um impacto de citação mais alto. Enquanto a porcentagem de documentos em periódicos de acesso aberto afetou positivamente o impacto do Norte-Sul (North-South collaboration – NSC), afetou negativamente a colaboração Sul-Sul (South-South collaboration – SSC). Publicar em periódicos híbridos foi importante para aumentar o fator de impacto no SSC. Fatores como taxas de processamento de artigos e acesso aberto devem ser considerados ao financiar a colaboração internacional. As desigualdades entre regiões brasileiras para colaborações internacionais tendem a ser numéricas e não necessariamente qualitativas.

Palavras-chave: impacto das publicações científicas; qualidade das publicações; quantidade de publicações; cooperação científica Sul-Sul; cooperação científica Norte-Sul.

REGIONES BRASILEÑAS Y COLABORACIÓN CIENTÍFICA INTERNACIONAL

Existe poca información sobre las diferencias entre las distintas regiones brasileñas en cuanto a la cantidad y calidad de las colaboraciones científicas Norte-Sur y Sur-Sur. Se recopilaron los datos de 2012 a 2021 a través de InCites y se realizaron análisis de varianza, de componentes principales, discriminante y de correlación canónica. Las diferencias regionales para la publicación de indicadores son muy variables. Los autores brasileños que se desempeñan como primeros, últimos o corresponsales tienden a publicar en revistas de los cuartiles 3 o 4 (de peor calidad). Estos tienden a ser poco citados, poseen menor porcentaje de documentos citados y menos publicaciones en revistas híbridas. Las colaboraciones con empresas/el sector privado, tienden a producir mayor impacto en las citaciones. Aunque el porcentaje de documentos en revistas de acceso abierto afectó positivamente el impacto de Norte-Sur (North-South collaboration – NSC), el resultado para la colaboración Sur-Sur (South-South collaboration – SSC) fue negativo. Publicar en revistas híbridas fue importante para aumentar el factor de impacto en SSC. Al financiar la colaboración internacional se deben considerar factores como los costos para envío de artículos y el acceso abierto. Se concluye que las desigualdades entre regiones brasileñas para colaboraciones internacionales tienden a ser numéricas y no necesariamente cualitativas.

Palabras clave: impacto de publicaciones científicas; calidad de publicaciones; cantidad de publicaciones; cooperación científica Sur-Sur; cooperación científica Norte-Sur.

JEL: O32.

DOI: http://dx.doi.org/10.38116/rtm31art6

Data de envio do artigo: 31/3/2023. Data de aceite: 13/6/2023.

1 INTRODUCTION

Scientific and academic international collaboration refers to the collaboration between researchers, scientists, and scholars from different countries who work together on a joint research project or academic endeavour (Gui, Liu and Du, 2019). This type of collaboration can involve various activities, including sharing data and research findings, joint authorship of publications, and exchange of personnel. Freeman (2010) states that collaboration benefits advanced and developing countries. South-South international scientific collaboration refers to scientific and academic collaborations between countries in the global South, including countries in Africa, Latin America, and Asia (Gray and Gills, 2016).

International collaboration is increasingly important in science and academia because it allows researchers to access resources and expertise that may not be available in their own countries (McManus et al., 2020), and to explore different perspectives and approaches to research problems. It can also promote cultural understanding and help to build relationships between institutions and countries. South-South collaboration (SSC) is important because it can help to address common challenges faced by countries in the global South, such as poverty, inequality, and health disparities. By sharing resources, expertise, and knowledge, researchers and scholars from different countries in the global South can collaborate to develop innovative solutions to these challenges (Teferra, Sirat and Beneitone, 2022). International collaboration can take many forms, including formal partnerships between institutions, joint research projects, and collaborations between individual researchers or research teams. These collaborations often require significant coordination and communication to ensure that all parties work towards a common goal and that the research is conducted rigorously and ethically (Minasny et al., 2020).

Overall, SSC is an important aspect of international scientific and academic collaboration, as it can help promote scientific and technological development in the global South and contribute to advancing knowledge and understanding on a global scale. Nevertheless, Brazilian cooperation tends to focus on North-South relationships (McManus et al., 2020). Significant heterogeneity can exist between countries regarding their research and development (R&D) infrastructure, fields of knowledge, language and publication profiles, so comparisons should be made with caution (Gonzalez-Brambila et al., 2016).

Most science in Brazil is carried out within the postgraduate system, which has rapidly expanded in the last 12 years (McManus et al., 2023a). McManus et al. (2022) showed that the age of the postgraduate system affected the grade received by postgraduate programs in Brazil, and expansion used the need to form qualified human resources to impulse development in the country's interior. Within Brazil, regional differences exist in the quantity and quality of research being produced, but little is known about the different impacts of science from different regions in international cooperation. McManus et al. (2023b) suggested clustering analyses and examining differences between these using other qualitative and qualitative measures could help understand different publishing behaviours. This paper aims to address in part this question.

2 MATERIAL AND METHODS

Data on postgraduate programs was taken from the Sucupira database.[7] International collaboration of Brazilian research was then examined.

7. Available at: www.capes.gov.br.

Information was collected from InCites based on web of science data from clarivate analytics. Years included 2012 to 2021 (last complete year). Information was separated by Brazilian region (North, Northeast, South, Southeast and Center-West) and the collaborating country, which was then designated at global North (North-South collaboration – NSC) or global South (SSC).[8]

TABLE 1
Data included in analyses from InCites

Abbreviation	Variable
WoS	Number of documents in web of science for the Brazilian region in question from 2012 to 2021.
%Docs_Cited	Percentage of documents that received at least one citation.
CI	Citation_Impact – Number of citations per paper.
CNCI	Category Normalised Citation Impact – takes into account the average citation rate of papers in the same research category or field and is calculated by dividing the number of citations received by a paper by the expected number of citations for papers in the same category, given the year of publication and publication type. The expected number of citations is estimated using a reference set of papers in the same category and published in the same year. A score of 1 indicates that the paper has the same impact as the average paper in the category.
% First, % Last, % Corresponding	Percentage of first, last or corresponding authors from the Brazilian region.
% Top1% and %Top10%	Percentage of papers in the top 1% and top 10% of citations.
%Industry	Percentage of papers with industry collaboration. An industry collaborative publication lists its organisation type as "corporate" or "global corporate" for one or more of the co-author's affiliations.
Average_Percentile	A citation frequency distribution is created for all publications in the same year, subject category, and document type (arranging the papers in ascending order of citation count), and determining the percentage of papers at each citation level. If a paper has a percentile value of 99, then 99% of the papers in the same subject category, year, and document type have a lower citation count.
%High	The number of Essential Science Indicators (ESI) highly cited papers for an entity (paper, author, institution, country, journal and field) divided by the total number of documents produced by the given entity, represented as a percentage. It is a measure of excellence and can show what percentage of an institution's output is among the most impactful papers in the world.
% Hot	Percentage of publications assigned as hot papers in ESI; the top 0.1% by citations for field and age.
IRW	Impact Relative to the World – Citation impact of the set of publications as a ratio to the world average. The world average is always equal to one.
Citations from Patents	Number of citations from patents.
%Q1, %Q2, %Q3, %Q4	Percentage of documents that appear in a journal in a particular Journal Impact Factor (JIF) quartile in a given year. For example, if a value displays 10%, it indicates that 10% of the documents in the set were published in journals of the specified JIF quartile in that year. Formula: % of documents in Q1 Journals = (Count of Documents in Q1 Journals) / (Count of Documents in JIF Journals)
%OA	Percentage of articles published as open access as defined by https://ourresearch.org/.
%Gold	Percentage of articles published in journals listed on the Directory of Open Access Journals (DOAJ).
%Hybrid	Percentage of articles published in journals other gold open access articles are identified as having a Creative Commons (CC) license by our research but are not in journals listed on the DOAJ. Most of these articles are from hybrid journals.

(Continues)

8. Available at: https://worldpopulationreview.com/country-rankings/global-south-countries.

(Continued)

Abbreviation	Variable
%Free	The licensing for these articles is either unclear or identified by our research as non-CC license articles. These are free-to-read or public access articles located on a publisher's site.
%Green	Publications that only have a green open access status and do not have an additional gold or free to read status.

Source: InCites. Available at: https://incites.help.clarivate.com/Content/Indicators-Handbook/ih-about.htm.

Analysis of variance (PROC GLM and PROC PLM) was carried out to determine differences between regions of Brazil and global regions (global South and global North) and their interaction. Data residuals were tested for normality using Shapiro-Wilk tests, and non-normal data were transformed using Box-Cox transformations (PROC TRANSREG).

Clusters were formed (PROC FASTCLUS) according to the volume of documents, Impact, author and journal characteristics, as in table 1. A discriminate analysis was then carried out (PROC CANDISC, PROC STEPDISC) to see which variables distinguished between clusters. This analysis was carried out by type of collaboration (NSC or SSC) and only with countries with more than 100 documents. Regressions on CNCI by SSC or NSC were carried out using the other variables. Indicators were removed sequentially from the model if the Variance Inflation Factor (VIF) was > 10. Principal component (PROC PRINCOMP) analyses were also carried out by global region collaboration. Statistical analyses were considered only for countries where Brazil published > 100 papers in 10 years. Data were analysed in SAS v9.4.[9]

3 RESULTS

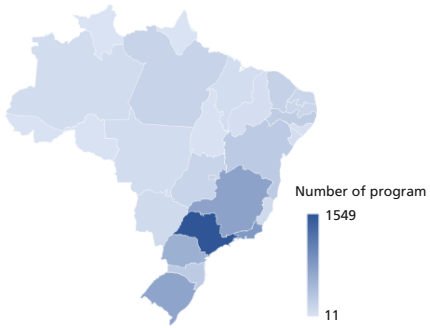
There are more postgraduate programs in the south and southeast of Brazil (figure 1A), with more recent programs being created in the North and Center-West of the country (figure 1B).

Looking at the mean grades by state (figure 2), we observe that even though programs may be recent in some poorer developed regions, some states show grades equivalent to the more developed and older regions. This is true for Ceará in exact sciences or Pará, Rio Grande do Norte and Pernambuco in social sciences and humanities. This suggests that there may be groups in these regions that would be suitable partners for international collaboration.

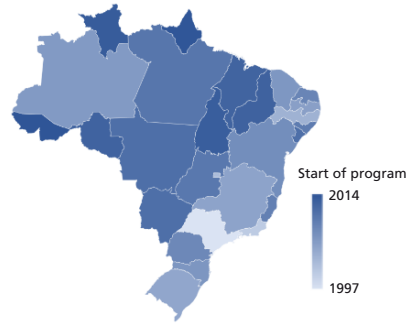
9. Statistical Analysis System Institute (Cary, North Carolina).

FIGURE 1
Start of postgraduate programs in Brazil

1A – Number of postgraduate programs



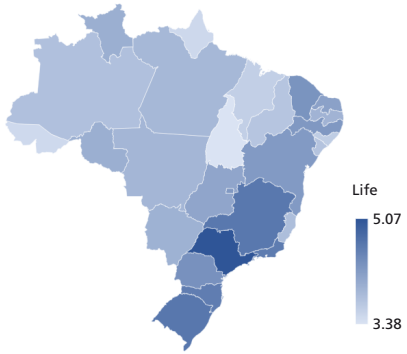
1B – Mean date of start of program



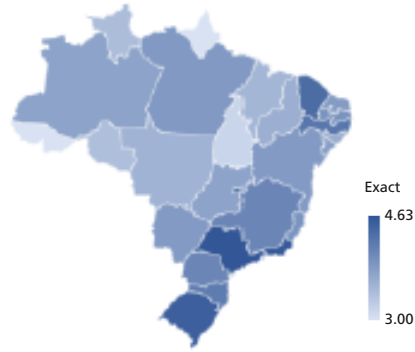
Authors' elaboration.
Obs.: Figure whose layout and texts could not be formatted due to the technical characteristics of the original files (Publisher's note).

FIGURE 2
Mean grades by state for postgraduate programs in Brazil

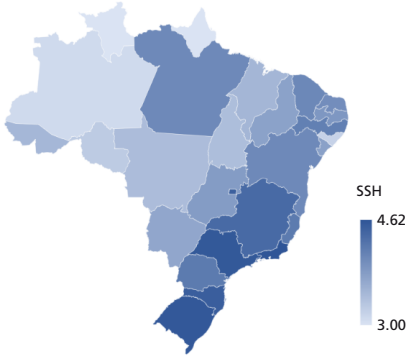
2A – For life



2B – For exact sciences



2C – For social sciences and humanities



Authors' elaboration.
Obs.: Figure whose layout and texts could not be formatted due to the technical characteristics of the original files (Publisher's note).

Most indicators did not show a signification interaction between the Brazilian region and NSC, indicating that, in general, Brazilian regions showed similar characteristics independent from the global collaborating region (table 1). As such, we will discuss the Brazilian region and global region separately. In most cases, coefficients of determination (R^2) were low and coefficients of variation (CV) were high, indicating high variation in the response of the Brazilian regions to international collaboration. Results from analyses of variance showed that there were significant differences between Brazilian regions for all variables examined. This was also the case for global regional collaboration, but some indicators, especially journal characteristics, were not significant ($P > 0.05$).

TABLE 2
Summary of analysis of variance for Brazilian international collaboration in scientific publishing

Indicator	R^2	CV	Brazilian region	North or South (N/S) collaboration	Interaction Brazilian region* N/S
			Volume		
WoS	0.20	227.47	***	***	***
Times_Cited	0.29	120.81	***	***	***
Citations from Patents	0.33	113.09	***	***	***
			Citation impact		
% Docs_Cited	0.04	4.90	*	ns	ns
Citation_Impact	0.18	73.79	***	***	ns
%Top1%	0.15	56.17	***	***	ns
%Top10%	0.11	32.74	***	***	ns
Average_Percentile	0.05	12.91	*	*	ns
% High	0.16	63.97	***	***	ns
% Hot	0.20	92.59	***	***	*
IRW	0.18	73.79	***	***	ns
CNCI	0.20	73.00	***	***	ns
			Author information		
% First	0.05	74.64	***	ns	ns
% Last	0.17	74.12	***	***	ns
% Corresp	0.09	77.16	***	***	ns
% Industry	0.05	56.52	*	ns	ns
			Journal characteristics		
% Q1	0.10	13.82	***	***	ns
% Q2	0.14	20.97	***	ns	***
% Q3	0.11	42.77	***	***	ns
% Q4	0.08	71.68	***	*	ns

(Continues)

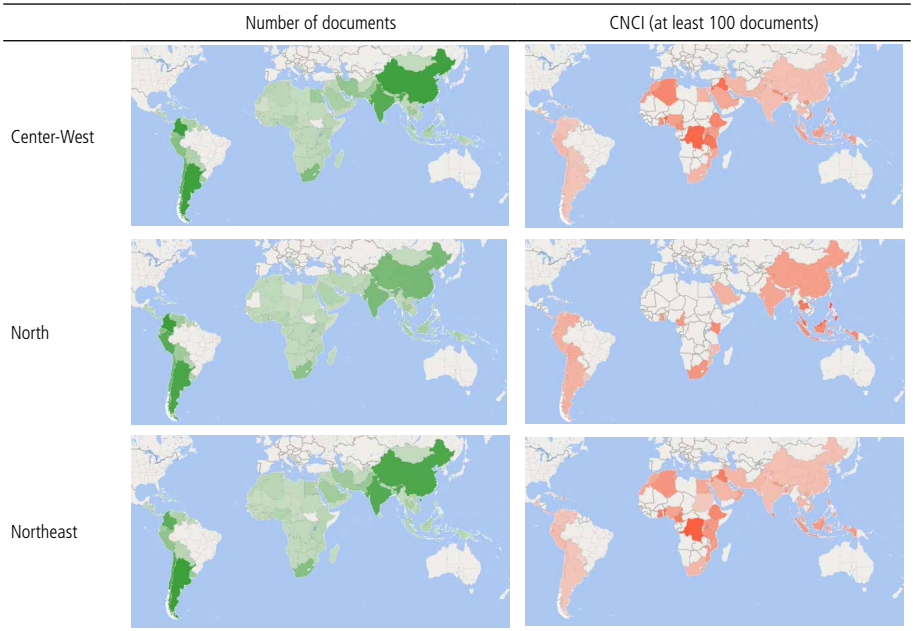
(Continued)

Indicator	R^2	CV	Brazilian region	North or South (N/S) collaboration	Interaction Brazilian region* N/S
			Journal characteristics		
% Hybrid	0.17	43.31	***	*	***
% Free	0.18	39.79	***	ns	***
% Green	0.12	24.79	***	ns	ns
% OA	0.09	15.30	***	ns	ns
% Gold	0.21	33.83	***	*	***

Authors' elaboration.
Obs.: R^2 – coefficient of determination; CV – coefficient of variation; *P < 0,05; *** P < 0,001; ns – not significant (see Material and Methods for abbreviations).

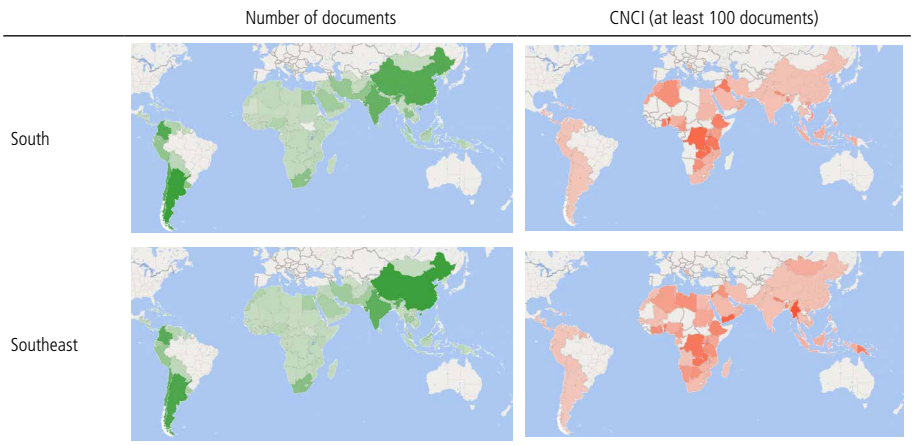
While a higher number of documents tend to be published with Chinese, Indian and South American countries, the impact is higher with African countries (figure 3). This impact is triangulated with Northern cooperation, as the percentage of first, last and corresponding authors is low (table 2). Argentina and Colombia are the most important South American collaborations for all Brazilian regions. The Northern regions show the lowest number of collaborations with > 100 documents per year, with collaboration centred in South America.

FIGURE 3
Heat map for number of documents and category normalised citation impact for Brazilian SSC



(Continues)

(Continued)



Authors' elaboration.
Obs.: Figure whose layout and texts could not be formatted due to the technical characteristics of the original files (Publisher's note).

The regression analyses show the important indicators affecting CNCI for NSC (Equation 1) and SSC (Equation 2). While the percentage of open access had a positive effect on CNCI for NSC, it had a negative effect for CNCI in SSC. Publishing in hybrid journals was important to increase CNCI in SSC.

$$CNCI_{NSC} = 4.90 - 0.06*\%Docs\ Cited + 0.06*CI + 0.69*Hot + 0.01\%OA \quad (1)$$
$$(R^2 = 0.99, CV = 7.31)$$

$$CNCI_{SSC} = 2.22 + 0.06*CI + 0.40*\%Hot + 0.01\%Q1 + 0.09*\%Hybrid - 0.03*\%OA \quad (2)$$
$$(R^2 = 0.99, CV = 5.73)$$

Table 2 shows comparisons between indicators for Brazilian regions and for Brazil between global regions. There are significantly fewer papers with the global south compared to the global north, for the SE region of Brazil, but not for the other regions. %DocsCited does not differ between global or Brazilian region. CNCI is higher for SSC than NSC, except for the Northern region of Brazil. Nevertheless, CNCI for NSC is not significantly different for North, South and Southeast regions. Brazil shows relatively low first, last and corresponding author percentages, and it is lower for SSC than NSC. Industry collaboration is higher in SSC for South and Southeast regions. For types of publications, there is little difference between regions for percentage quartile of the journal, or type of open access publishing, although SSC shows higher percentage of publishing in hybrid journals for the N region. This region also shows less hybrid and more free-to-read than other Brazilian regions. The Southern region shows more open acess gold publishing, while the Southeast shows less ($P < 0.05$).

TABLE 3
Indicators for type of scientific collaboration and Brazilian region

Indicator	Global North collaboration					Global South collaboration				
	Center-West	North	Northeast	South	Southeast	Center-West	North	Northeast	South	Southeast
WoS	39700^{a}	16588^{a}	60119^{a}	114963^{a}	387881^{Ab}	12897	5282	19190	33686	96618^{B}
Times_Cited	3729547^{bc}	997060^{c}	4792671^{bc}	7348070^{Ab}	19496384^{Aa}	2751114	421138	3119602	4501875^{B}	7794649^{B}
% Docs_Cited	91.71	95.60	92.19	92.43	92.17	91.03	94.24	93.43	89.47	91.83
Citation_Impact	210.76^{A}	113.99	183.58^{A}	134.21^{A}	91.34^{A}	348.12^{Bab}	89.00^{c}	281.26^{Ba}	350.87^{Ba}	196.47^{Bbc}
CNCI	13.25^{Aa}	7.44^{b}	12.22^{Aa}	8.81^{Aab}	6.08^{Ab}	23.47^{Bab}	6.01^{c}	19.53^{Ba}	22.28^{Ba}	12.58^{Bbc}
% First	11.38^{ab}	10.43^{b}	11.66^{ab}	10.63^{b}	9.81^{b}	6.40	9.44	9.21	9.59	8.57
% Last	9.76^{Ab}	12.43^{Aa}	13.74^{Aa}	11.49^{Ab}	10.39^{Ab}	4.72^{B}	7.42^{B}	6.58^{B}	7.15^{B}	5.81^{B}
% Corresp	10.24^{b}	11.02^{Aa}	11.99^{ab}	10.41^{b}	9.12^{b}	4.56	8.26^{B}	7.87	7.82	6.46
%Top1%	20.33^{Aab}	18.78^{ab}	20.72^{Aa}	14.61^{Ab}	13.70^{Ab}	30.59^{B}	20.26	31.13^{B}	29.31^{B}	22.53^{B}
%Top10%	44.43^{Aa}	51.21^{ab}	45.78^{a}	37.06^{Ab}	37.51^{Ab}	56.53^{Bab}	54.18^{ab}	56.48^{a}	50.17^{Bab}	47.41^{Bb}
% Industry	17.46	19.35	12.51	10.55^{A}	11.03^{A}	21.31^{a}	11.91^{b}	13.20^{ab}	18.13^{Bab}	13.08^{Bab}
Average_Percentile	70.65	76.60	72.56	68.27	69.17	75.62	77.01	76.80	71.63	72.08
% High	18.55^{A}	17.47	19.29^{A}	12.09^{A}	9.87^{A}	28.23^{B}	17.32	27.72^{B}	26.32^{B}	18.51^{B}
% Hot	0.69^{a}	0.02^{b}	0.61^{Aa}	0.69^{Aa}	0.53^{Aab}	0.76^{b}	0.01^{c}	1.70^{Aa}	1.77^{Aa}	0.89^{Ab}
IRW	18.29^{A}	9.89	15.93^{A}	11.65^{A}	7.93^{A}	30.22^{Bab}	7.73c	24.41^{Ba}	30.46^{Ba}	17.05^{Bbc}
Citations_From_Patents	419.55^{b}	8.06^{c}	395.90^{Ab}	629.63^{Ab}	1043.03^{Aa}	86.02	1.89	83.56^{B}	95.93^{B}	131.10^{B}
% Q1	69.20^{ab}	70.46^{a}	67.52^{b}	69.90^{a}	71.52^{a}	72.11	68.19	71.55	74.43	71.89
% Q2	18.30^{a}	16.60^{b}	19.82^{Aa}	20.11^{Aa}	16.11^{b}	15.36^{ab}	16.05^{a}	15.15B^{b}	12.63^{Bb}	14.94^{b}
% Q3	8.12^{Ac}	10.37^{a}	9.43^{ab}	7.24^{Ac}	8.33^{Abc}	7.97^{B}	11.67	8.26	7.54^{B}	8.37^{B}
% Q4	4.38^{a}	2.57^{b}	3.23^{ab}	2.75^{b}	2.65^{Ab}	4.56	3.18	3.42	3.80	4.80^{B}

(Continues)

(Continued)

Indicator	Global North collaboration					Global South collaboration				
	Center-West	North	Northeast	South	Southeast	Center-West	North	Northeast	South	Southeast
% Hybrid	27.70[a]	12.98[c]	21.61[Ab]	25.49[ab]	25.14[ab]	30.77[a]	13.64[b]	31.76[Ba]	28.51[a]	22.95[a]
% Free	8.76[Aa]	16.05[a]	9.69[Aa]	8.04[b]	7.11[b]	7.18[Bb]	13.87[a]	8.09[Bb]	7.96[b]	7.64[b]
% Green	68.54	55.18	56.56	69.24[A]	65.34	68.96	65.10	67.83	66.68[B]	64.03
% OA	81.86[a]	78.91[b]	74.20[b]	80.19[Aa]	79.96[Aa]	79.34	81.44	81.99	81.32[B]	78.19[B]
% Gold	28.86[b]	24.85[bc]	20.75[c]	34.46[Aa]	33.11[b]	24.82	31.68	25.59	28.35[B]	28.93

Authors' elaboration.

Obs.: 1. Brazilian regions in the same line and global region followed by the same small letter are not significantly different by Tukey test ($P > 0.05$).

2. Global regions followed by the same capital letter in the same line and Brazilian region are not significantly different by Tukey test ($P > 0.05$) (abbreviations are in table 1).

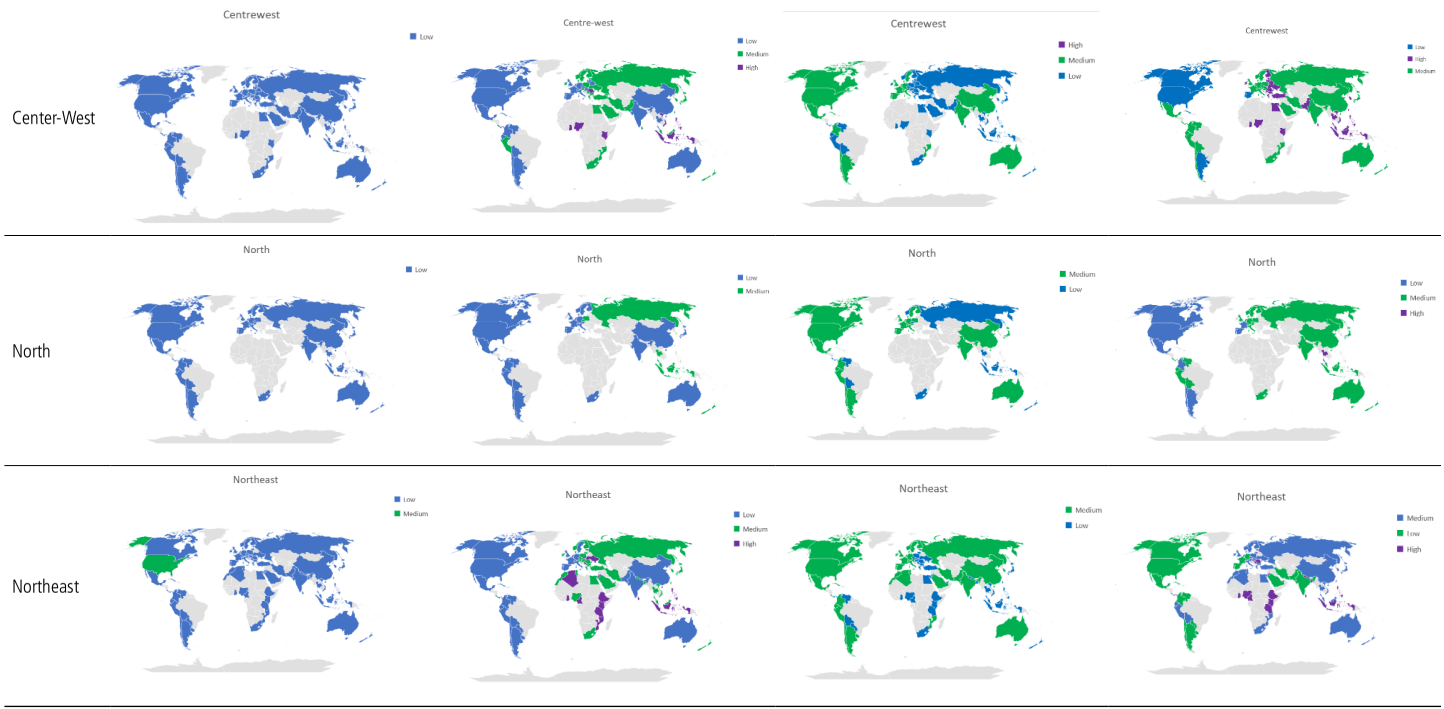
Clusters of countries by Brazilian and global region are shown in supplementary figure 2 and figure 4. The means for clusters are in table 4. The Northern region shows collaboration with fewer global North and global South countries. Regarding volume, only the southeast is in the high cluster, mainly with North America and Western European countries. Nevertheless, these tend to be the low-impact group for collaboration for all Brazilian regions. The higher impact is seen for all regions, except North, for some African countries. In this case, Brazil has a low percentage of first, last and corresponding authorship with these high-impact countries. The only country with which Brazil has high first and corresponding authorship is Armenia, in the region Center-West and South.

TABLE 4
Mean values per cluster for major indicators on the quality of international collaboration by Brazilian scientists

Volume	Cluster	WoS	Times cited	Cite patent						
	High	21610.17	928839.67	3369.33						
	Medium	7780.44	414011.84	1707.31						
	Low	872.67	79276.51	357.61						
Impact	Cluster	%Docs_Cited	Citation Impact	CNCI	%Top1%	%Top10%	AVP	IRW	%High	%Hot
	High	96.21	573.35	37.77	46.20	68.84	84.42	49.77	43.49	1.93
	Medium	93.17	279.14	18.57	26.98	53.81	76.08	24.23	24.50	1.00
	Low	89.12	68.38	4.61	9.70	30.95	63.06	5.94	7.45	0.28
Authorship	Cluster	%First	%Last	%Corresp	%Industry					
	High	71.90	0.07	71.78	3.76					
	Medium	20.48	13.15	17.10	8.42					
	Low	7.06	6.44	6.14	13.64					
Publishing	Cluster	%OA	%Gold	%Hybrid	%Free	%Green	%Q1	%Q2	%Q3	%Q4
	High	88.13	35.13	33.98	6.94	79.01	76.26	14.99	6.01	2.73
	Medium	72.94	25.66	18.89	10.38	55.87	65.97	19.70	10.14	4.19
	Low	57.55	25.47	9.69	8.47	39.74	51.82	24.10	14.87	9.21

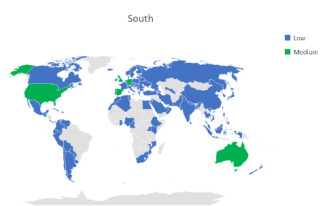
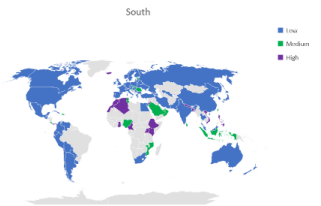
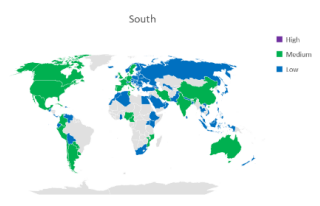
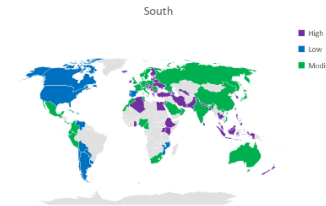
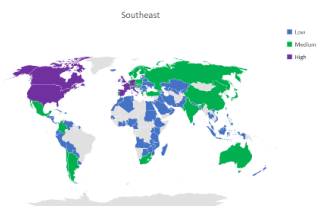
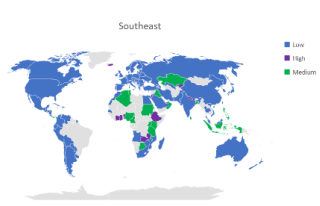
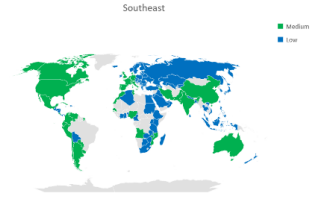
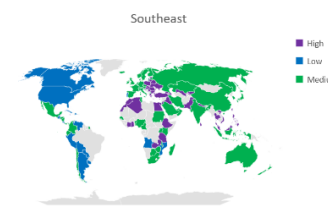
Authors' elaboration.

FIGURE 4
Clusters by Brazilian region for volume of publications, their impact, authorship and type of publishing



(Continues)

(Continued)

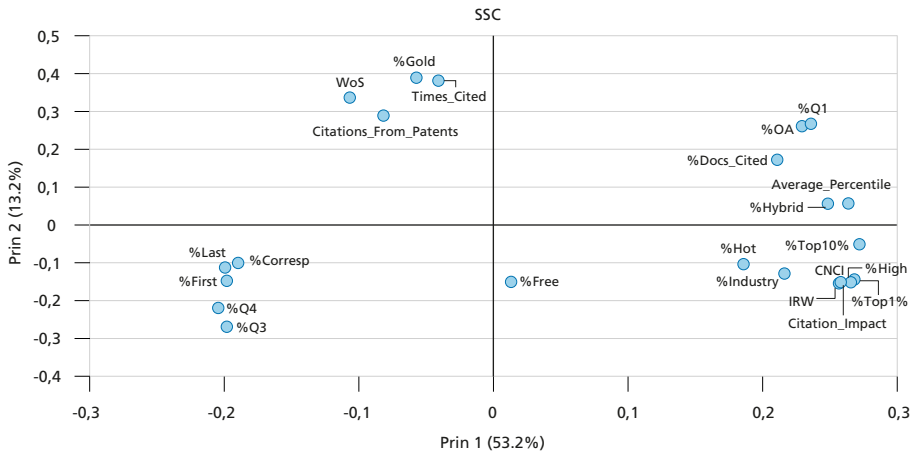
	Volume	Impact	Authors	Publishing
South				
Southeast				

Authors' elaboration.
Obs.: 1. See table 1 for details.
2. Figure whose layout and texts could not be formatted due to the technical characteristics of the original files (Publisher's note).

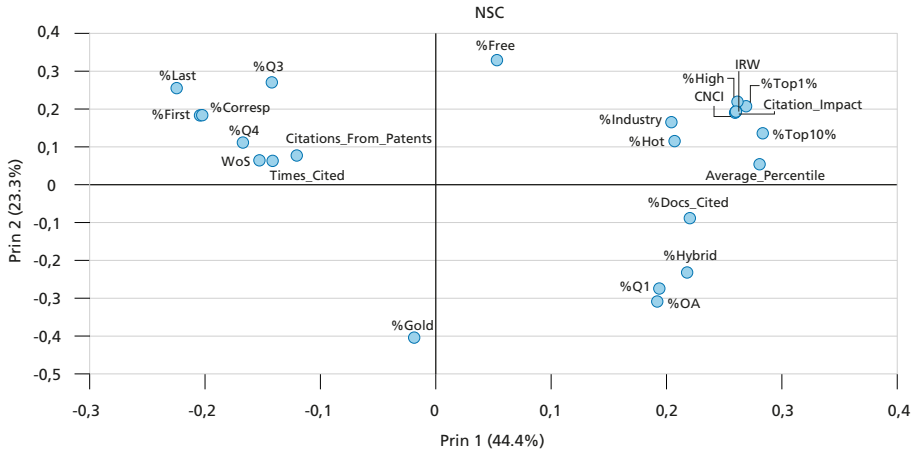
The principal component analyses (figure 5) show different collaboration behaviours of Brazilian publishing depending on the global region. Brazilian first, last or corresponding authors tend to publish in Q3 and Q4 journals. These tend to be poorly cited, have fewer %Docs cited and fewer hybrid journals. Collaborations with industry tend to have higher CNCI. For NSC, % Gold Access is not a determinant factor for high impact, while in SSC, this has a positive relationship with the number of WoS documents and citations.

FIGURE 5
Principal component analyses

5A – For SSC with Brazilian scientists



5B – For NSC with Brazilian scientists

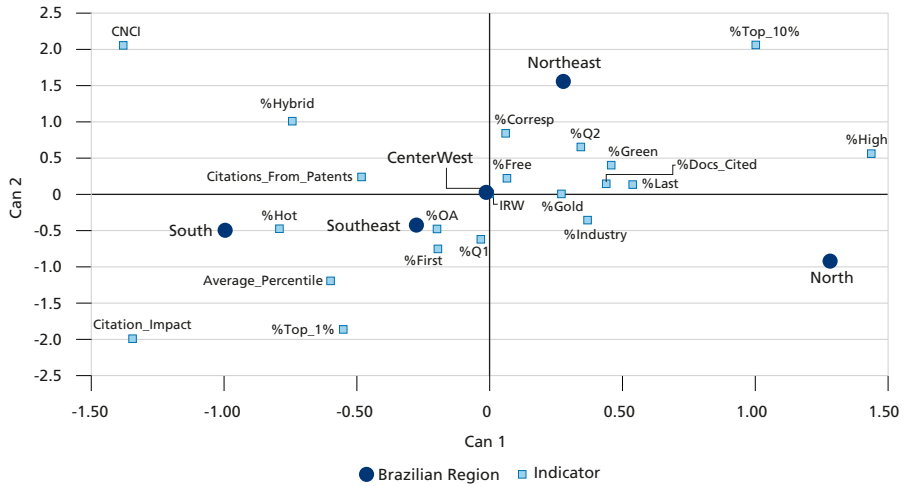


Authors' elaboration.

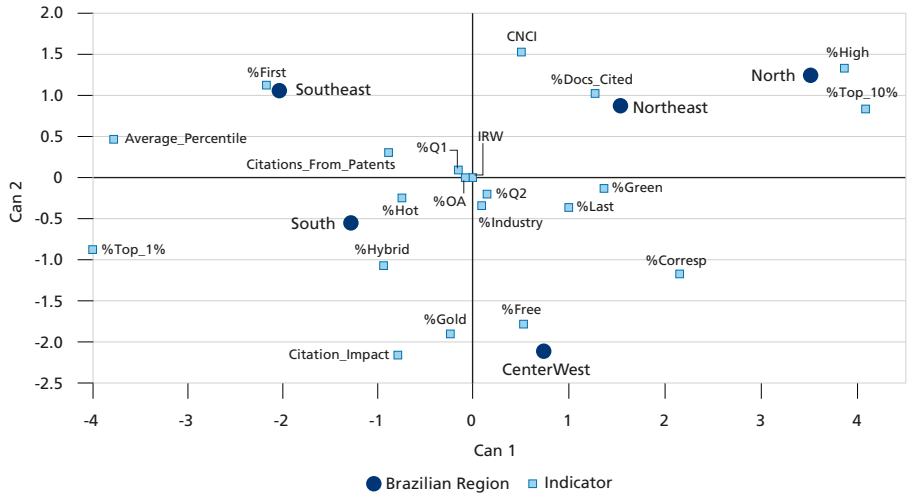
In SSC (figure 6), Northeast Brazilian region is linked to more papers in %Top10% of papers cited, while the South and Southeast have more papers in open acess, more citations per paper and first authorship. The Northern region is important for %high papers in both NSC and SSC and %Top10% in NSC. In NSC, the Northeast has higher %Docs cited, the South has more hybrid papers and higher citation impact, while the Southeast has a higher first authorship.

FIGURE 6
Regional canonical analysis

6A – for SSC with Brazilian scientists



6B – for NSC with Brazilian scientists



Authors' elaboration.

The discriminant analysis (table 5) shows the important indicators separating Brazilian regions depending on the type of collaboration (NSC or SSC). Differences exist between regions. For SSC, the percentage of documents in open access is important, but not for NSC. For NSC, indicators such as green access and % of papers in the top 1 and 10% separate Brazilian regions, as do the number of citations per paper.

TABLE 5
Indicators separating Brazilian regions depending on the type of collaboration

Entered	Partial R^2	F Value	Pr > F	Wilks' Lambda	Pr < Lambda	ASCC	Pr > ASCC
			South-South				
%Hot	0.16	9.42	< .0001	0.84	< .0001	0.04	< .0001
%Top10%	0.14	7.81	< .0001	0.72	< .0001	0.07	< .0001
%Q2	0.21	12.66	< .0001	0.57	< .0001	0.12	< .0001
%Hybrid	0.21	12.66	< .0001	0.45	< .0001	0.17	< .0001
%Last	0.10	5.11	0.00	0.41	< .0001	0.19	< .0001
IRW	0.09	4.80	0.00	0.37	< .0001	0.21	< .0001
%High	0.14	7.73	< .0001	0.32	< .0001	0.23	< .0001
CNCI	0.10	5.40	0.00	0.28	< .0001	0.25	< .0001
%Q4	0.09	4.39	0.00	0.26	< .0001	0.26	< .0001
Citations_From_Patents	0.12	6.11	0.00	0.23	< .0001	0.28	< .0001
%Industry	0.06	2.90	0.02	0.22	< .0001	0.30	< .0001
%Gold	0.09	4.72	0.00	0.20	< .0001	0.31	< .0001
%OA	0.06	2.99	0.02	0.18	< .0001	0.33	< .0001
			North-South				
%Gold	0.24	16.25	< .0001	0.76	< .0001	0.06	< .0001
Citations_From_Patents	0.34	26.99	< .0001	0.50	< .0001	0.14	< .0001
%Hot	0.36	29.41	< .0001	0.32	< .0001	0.20	< .0001
%Hybrid	0.23	14.99	< .0001	0.25	< .0001	0.25	< .0001
%Q4	0.30	21.45	< .0001	0.17	< .0001	0.32	< .0001
%Free	0.27	18.98	< .0001	0.13	< .0001	0.37	< .0001
%Docs_Cited	0.22	14.26	<.0001	0.10	<.0001	0.40	<.0001
CNCI	0.23	14.81	< .0001	0.08	< .0001	0.43	< .0001
%High	0.12	7.16	< .0001	0.07	< .0001	0.45	< .0001
Average_Percentile	0.10	5.47	0.00	0.06	< .0001	0.46	< .0001
Citation_Impact	0.10	5.31	0.00	0.05	< .0001	0.48	< .0001
%Green	0.09	4.61	0.00	0.05	< .0001	0.49	< .0001
%Q2	0.09	4.69	0.00	0.05	< .0001	0.51	< .0001

(Continues)

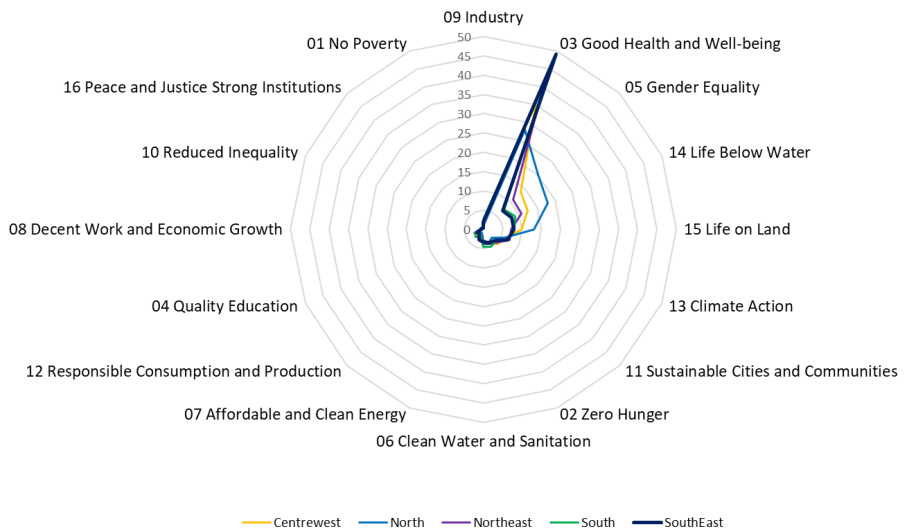
(Continued)

Entered	Partial R^2	F Value	Pr > F	Wilks' Lambda	Pr < Lambda	ASCC	Pr > ASCC
			North-South				
%Top10%	0.05	2.76	0.03	0.04	< .0001	0.51	< .0001
%Top1%	0.08	4.50	0.00	0.04	< .0001	0.52	< .0001
%Industry	0.07	3.83	0.01	0.04	< .0001	0.53	< .0001
%Last	0.08	4.11	0.00	0.03	< .0001	0.53	< .0001

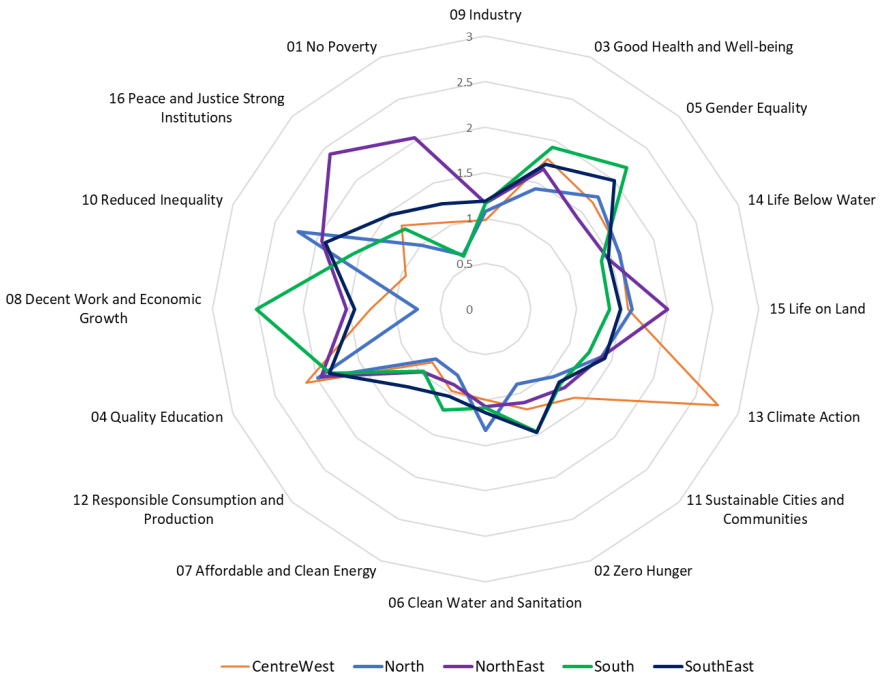
Authors' elaboration.
Obs.: ASCC – Average Squared Canonical Correlation.

In international collaboration, Brazil concentrates on SDG3 (good health and well-being) (figure 7A). The North, Northeast and Center-West areas show higher variation in the percentage of publications by Sustainable Development Goals (SDGs) (> 10%), with significant contributions to SDGs 15, 14 and 13. As can be seen in figure 7B, the different Brazilian regions show a higher impact for varying SDGs. The Center-West region shows the impact of climate action (SDG-13), while the South shows decent work and economic growth (SDG-8). The Northeast shows a higher impact in life on land (SDG-15) and peace, justice and strong institutions (SDG16).

FIGURE 7
Brazilian science with international collaboration by SDG
7A – Documents published (%)



7B – Regional impacts



Authors' elaboration.
Obs.: Figure whose layout and texts could not be formatted due to the technical characteristics of the original files (Publisher's note).

4 DISCUSSION

This paper shows different results for international scientific collaboration with Brazilian and global regions. Considering proximity (both geographically and scientifically) may indicate that the research groups involved share the same information and maintain uniform ways of thinking. At the same time, external influences can generate more disruptive thinking (Buccieri, Javlagi and Cavusgil, 2020). This may indicate that the Northern region, which collaborates primarily within South America, should look further afield for collaboration. Results here show that while there is rhetoric about different understandings of the Brazilian cooperation for development initiatives, including "lusotropical" civilising mission (Cesarino, 2012) or African origins (Cicalo, 2012), Brazil tends to collaborate more with Latin American or Northern countries such as United States and western Europe, independent of the Brazilian region.

It is important to note that collaboration with regions considered less well-developed, such as the North and Northeast, can have a higher impact than that with the South and Southeast. This may have several reasons. Regions such as

the Amazon (North) and Caatinga (Northeast) are biomes of particular interest to international researchers. In the present study, although we only looked at papers published in international collaboration, the percentage of these with the Brazilian author as first, last or corresponding author was low, independent of the Brazilian region. This raises the question of how effective is the collaboration for improving the quality of Brazilian science. This should be taken into account by financing agencies. Adame (2021) looks at helicopter science, whereby local researchers are used as a guise for data collection. These results may also indicate that Brazil is not defining its own research agenda in these areas. Brazil lacks the definition of research priorities (Arbix et al., 2017; Neves, McManus and Carvalho, 2020), which can affect ack a long-term national research strategy and consistent research policy (shared by governments of different political coalitions), thereby generating structural deficiencies of R&D organisations and lower performances (McManus and Neves, 2021).

It is important to note that the international collaboration advantage seems to be region-specific (Breugelmans et al., 2018), with Patel and Kim (2007) showing that research published from low and middle income (LAMI) countries may have authors from high-income countries are responsible for up to 50% of the papers.

Brazilian researchers tend to publish in Q3 and Q4 journals as first, last or corresponding authors, although these journals ay be open access, which may explain some of the results here. Results here are in line with Grácio et al. (2019) who showed a higher citation impact when corresponding authors from high-income countries. McManus, Neves and Maranhão (2020) show that Brazilians tend to publish in Brazilian journals on the Scielo open-access platform. This is, in part, due to lower Article Processing Charges (APCs), which were especially important in recent years with the lack of financing for Brazilian scientific research (McManus et al., 2021; McManus et al., 2022; Pavan and Barbosa, 2018). This can also explain the lack of difference in publication type (open access, gold, green, hybrid). Publishing in hybrid journals was important to increase CNCI in SSC. This was also seen by McManus et al. (2023b) whereby it can be more important to publish as closed access high impact Q1 journals than open access in low impact journals.

The inequalities between Brazilian regions for international collaborations tend to be numerical and not necessarily qualitative. The poorer impact for the Southeast and South regions may be due to the higher number of papers published in collaboration, thereby diluting the higher impact, as seen by Gonzalez-Brambila et al. (2016).

5 CONCLUSION

Significant regional differences were noted for publishing indicators and the impact of Brazilian publications. Brazilian authors tend to publish in poorer quality journals and, as such, these papers tend to have a lower percentage of documents cited and be poorly cited, although they are published open access. Collaborations with industry tend to have higher impact factors. While an increase in the percentage of open access papers positively affected the impact of NSC collaborations, it negatively affected SSC. Publishing in hybrid journals was important for increasing citations in SSC. Factors such as APCs and open access should be considered when financing international collaboration. The inequalities between Brazilian regions for international collaborations tend to be numerical and not necessarily qualitative. As such, results here can be used in constructing specific regional policies for increasing scientific impact and financing international scientific collaboration, both North-South and South-South.

REFERENCES

ADAME, F. Meaningful collaborations can end "helicopter research". **Nature**, 29 June 2021.

ARBIX, G. et al. Brazilian innovation policies: advances, misconception, and instability. **Novos Estudos Cebrap**, v. 36, n. 3, p. 9-27, 2017.

BREUGELMANS, J. G. et al. Scientific impact increases when researchers publish in open access and international collaboration: a bibliometric analysis on poverty-related disease papers. **PLoS One**, v. 13, n. 9, 2018.

BUCCIERI, D.; JAVLAGI, R. G.; CAVUSGIL, E. International new venture performance: role of international entrepreneurial culture, ambidextrous innovation, and dynamic marketing capabilities. **International Business Review**, v. 29, n. 2, 2020.

CESARINO, L. M. C. N. Brazilian postcoloniality and South-South cooperation: a view from anthropology. **Portuguese Cultural Studies**, n. 4, p. 85-113, 2012.

CICALO, A. **Brazil and its African mirror**: discussing "black" approximations in the South Atlantic. Berlin: Desigualdades.net, 2012. (Working Paper Series, n. 24).

FREEMAN, R. B. Globalization of scientific and engineering talent: international mobility of students, workers, and ideas and the world economy. **Economics of Innovation and New Technology**, v. 19, n. 5, p.393-406, 2010.

GONZALEZ-BRAMBILA, C. N. et al. The scientific impact of developing nations. **PLoS One**, v. 11, n. 3, 2016.

GRÁCIO, M. C. C. et al. The influence of corresponding authorship on the impact of collaborative publications: a study on Brazilian institutions (2003-2015). In: INTERNATIONAL CONFERENCE ON SCIENTOMETRICS AND INFORMETRICS, 17., 2019, Rome, Italy. **Proceedings**… Rome: ISSI, 2019. p. 511-522.

GRAY, K.; GILLS, B. K. South–South cooperation and the rise of the global South. **Third World Quarterly**, v. 37, n. 4, p. 557-574, 2016.

GUI, Q.; LIU, C.; DU, D. Globalization of science and international scientific collaboration: a network perspective. **Geoforum**, v. 105, p.1-12, 2019.

MCMANUS, C. M.; BAETA, A. A. N. Funding research in Brazil. **Scientometrics**, v. 126, n. 1, p. 801-823, 2021.

_____. Bibliometric measures in social sciences and humanities from different sources based on Brazilian data. **Collnet**: Journal of Scientometrics and Information Management, v. 16, n. 2, p. 279-304, 2022.

MCMANUS, C. M. et al. International collaboration in Brazilian science: financing and impact. **Scientometrics**, v. 125, p. 2745-2772, 2020. Retrieved from: https://doi.org/10.1007/s11192-020-03728-7.

MCMANUS, C. M. et al. Profiles not metrics: the case of Brazilian universities. **Anais da Academia Brasileira de Ciências**, v. 93, n. 4, 2021.

MCMANUS, C. M. et al. Assessment of the Brazilian postgraduate evaluation system. **Frontiers in Education**, v. 7, 2022.

MCMANUS, C. M. et al. Considerations for continued expansion of the Brazilian post-graduate pystem. **Frontiers in Education**, v. 8, 2023a. Retrieved from: https://doi.org/10.3389/feduc.2023.987200.

MCMANUS, C. M. et al. Funding as a determinant of citation impact in scientific papers in different countries. **Anais da Academia Brasileira de Ciências**, v. 95, n. 1, 2023b. Retrieved from: https://doi.org/10.1590/0001-3765202320220515.

MCMANUS, C. M.; NEVES, A. A. B.; MARANHÃO, A. Q. Brazilian publication profiles: where and how Brazilian authors publish. **Anais da Academia Brasileira de Ciências**, v. 92, n. 2, 2020.

MINASNY, B. et al. Global soil science research collaboration in the 21st century: time to end helicopter research. **Geoderma**, v. 373, 2020.

NEVES, A. A. B.; MCMANUS, C. M.; CARVALHO, C. H. de. The impact of graduate studies and science in Brazil: an analysis in the light of the indicators. **Revista Nupem**, v. 12, n. 27, p. 254-276, 2020.

PATEL, V.; KIM, Y-R. Contribution of low- and middle-income countries to research published in leading general psychiatry journals 2002-2004. **The British Journal of Psychiatry**, v. 190, p. 77-88, 2007.

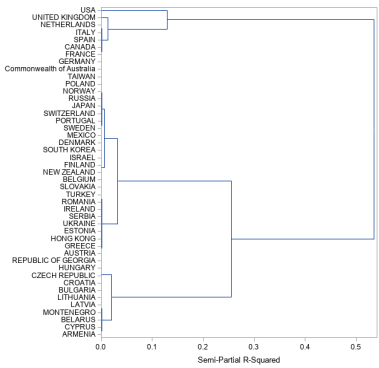
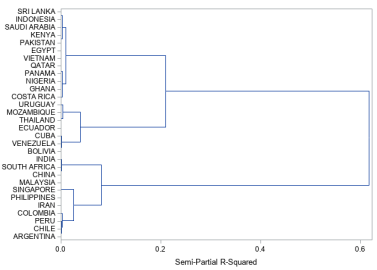
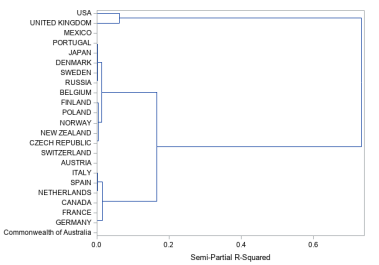
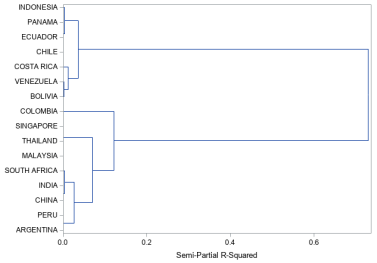
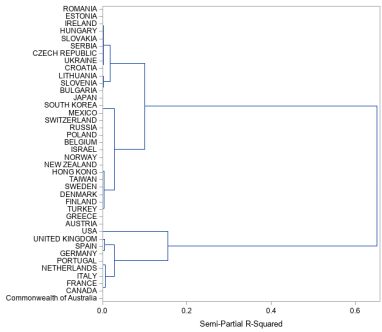
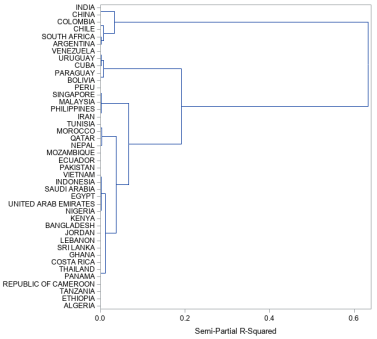
PAVAN, C.; BARBOSA, M. C. Article processing charge (APC) for publishing open access articles: the Brazilian scenario. **Scientometrics**, v. 117, n. 2, p. 805-823, 2018.

TEFERRA, D.; SIRAT, M.; BENEITONE, P. The imperatives of academic collaboration in Africa, Asia and Latin America. **International Journal of African Higher Education**, v. 9, n. 3, p. 13-35, 2022.

APPENDIX

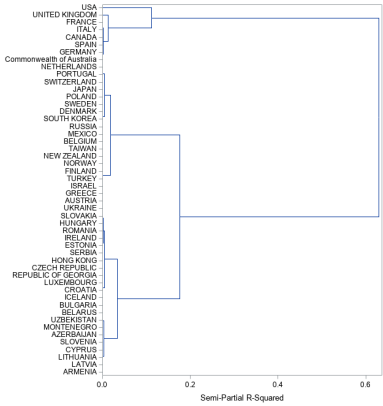
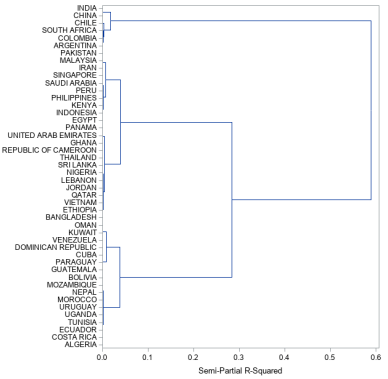
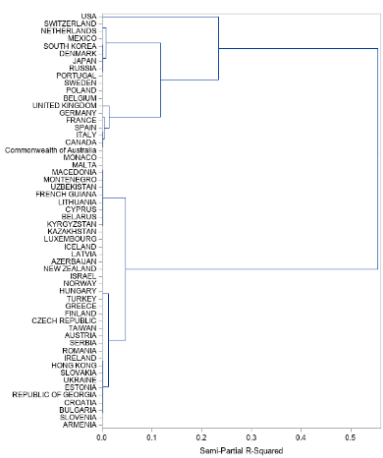
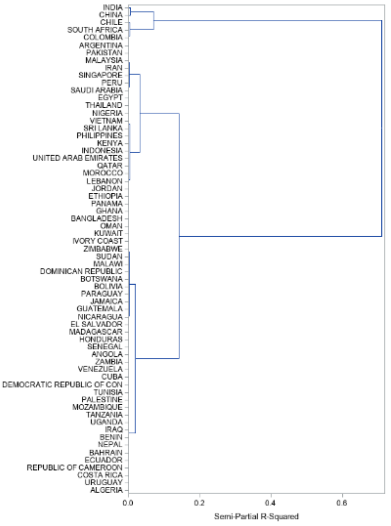
FIGURE A.1
Clusters for North-South and South-South international scientific collaboration by Brazilian researchers: by Brazilian region and type of indicator

Volume

	North	South
Center-West		
North		
Northeast		

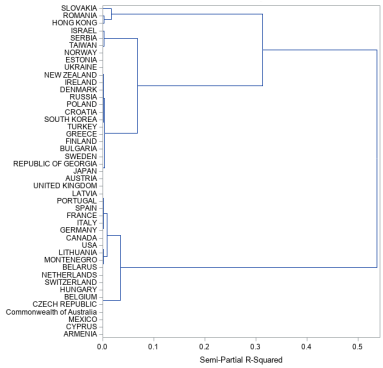
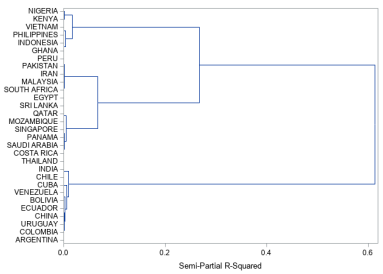
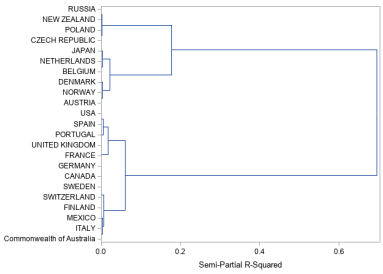
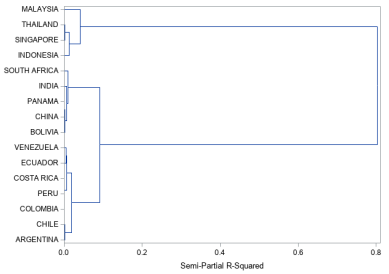
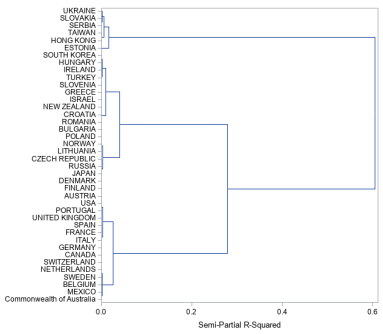
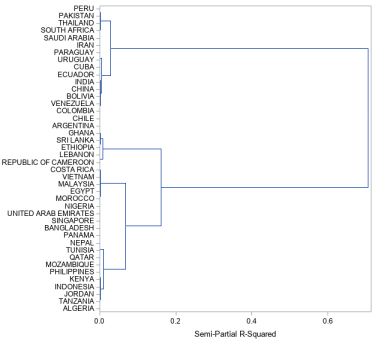
(Continues)

(Continued)

Volume	
North	South
South 	
Southeast 	

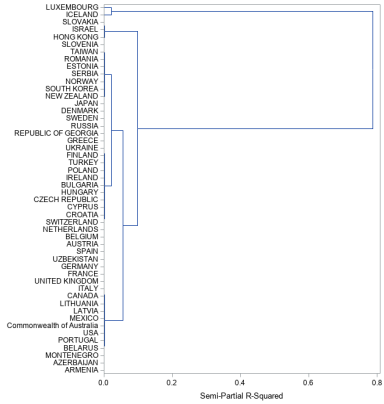
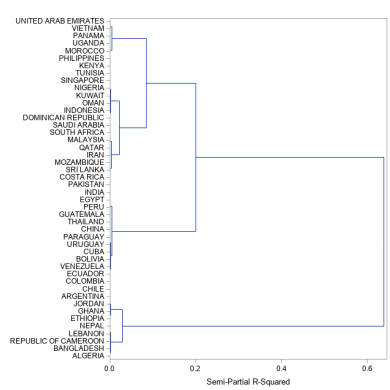
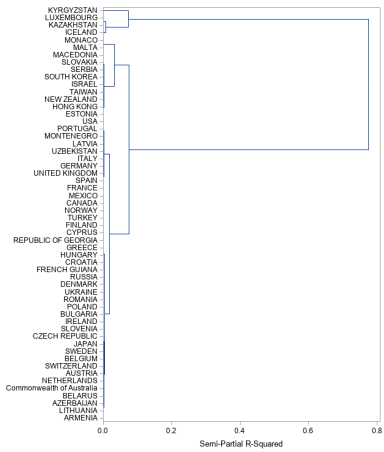
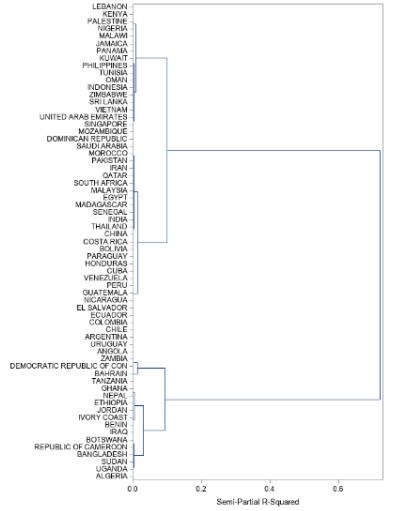
(Continues)

(Continued)

	Impact	
	North	South
Center-West		
North		
Northeast		

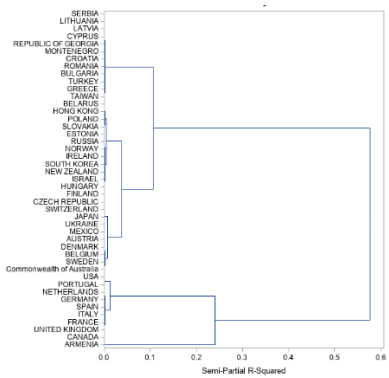
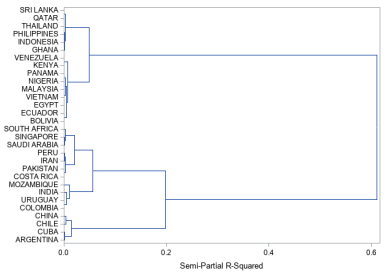
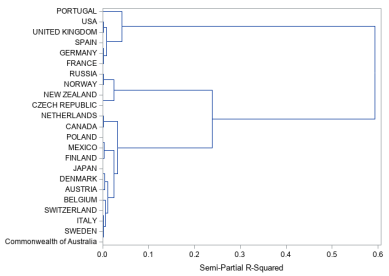
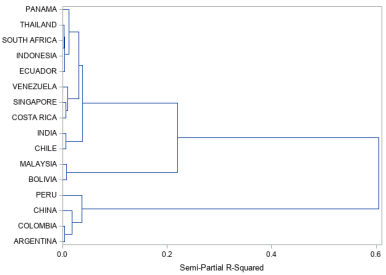
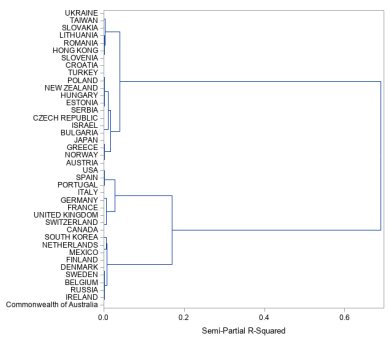
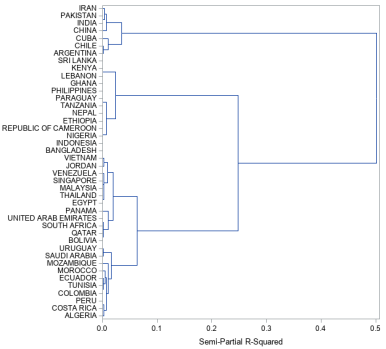
(Continues)

(Continued)

	Impact	
	North	South
South		
Southeast		

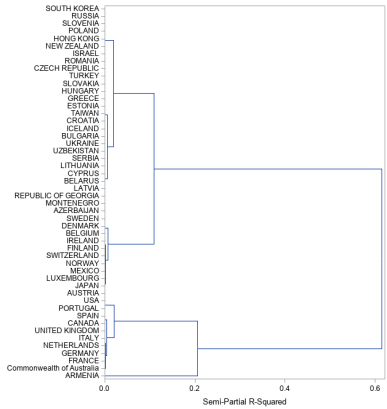
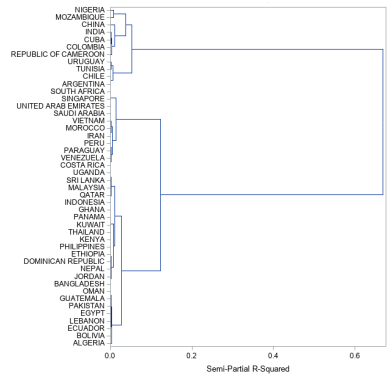
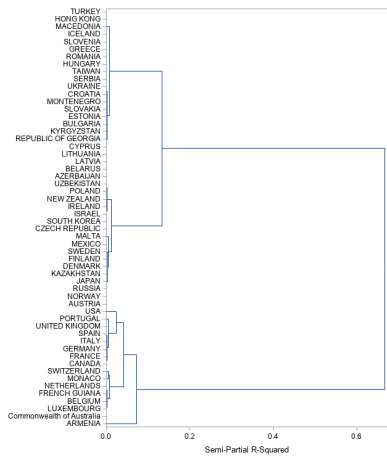
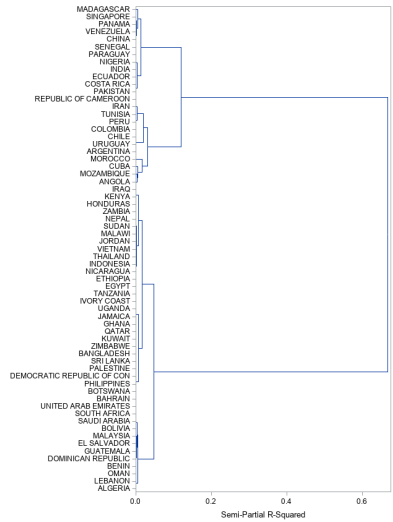
(Continues)

(Continued)

	Author	
	North	South
Center-West		
North		
Northeast		

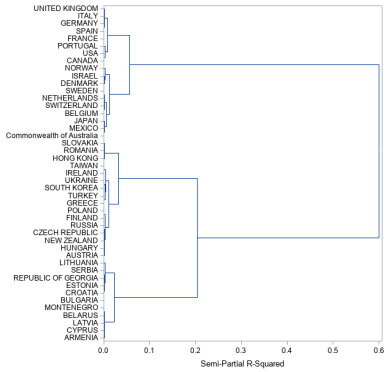
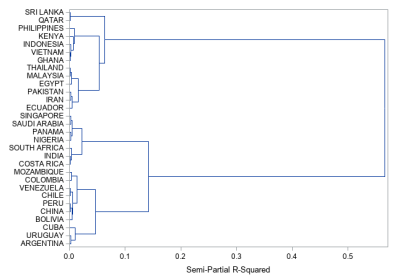
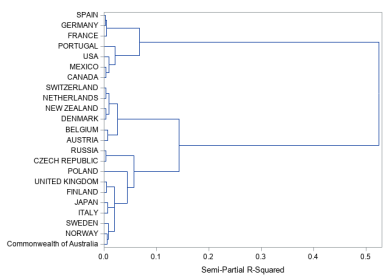
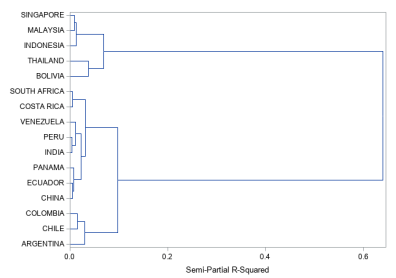
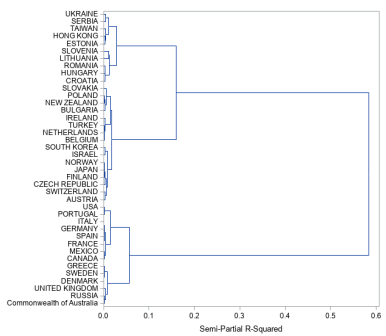
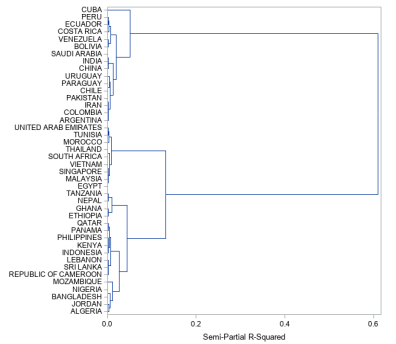
(Continues)

(Continued)

	Author	
	North	South
South		
Southeast		

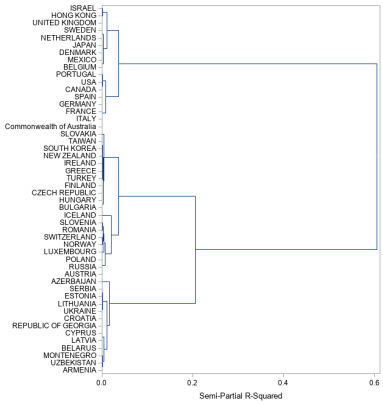
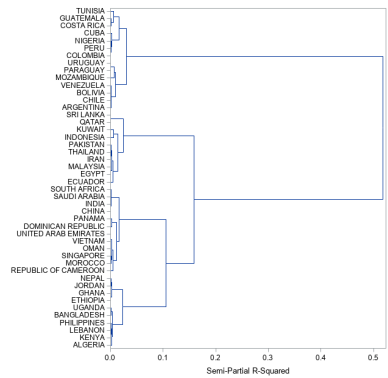
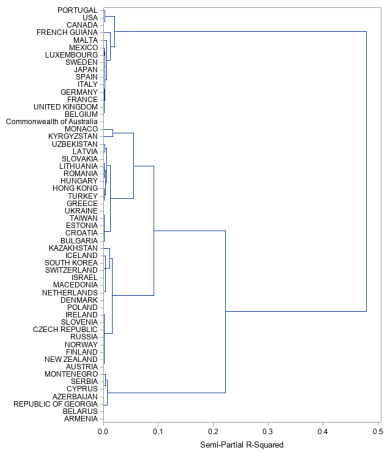
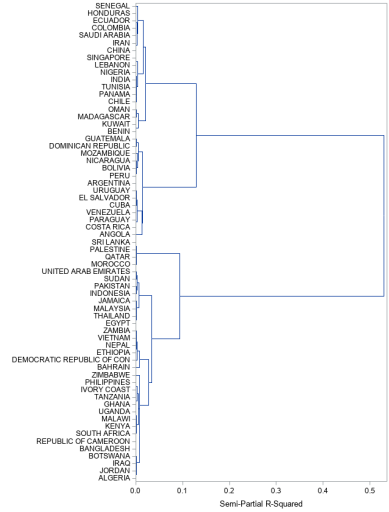
(Continues)

(Continued)

	Publishing	
	North	South
Center-West		
North		
Northeast		

(Continues)

(Continued)

	Publishing	
	North	South
South		
Southeast		

Authors' elaboration.

Obs.: 1. See table 1 for details.

2. Figure whose layout and texts could not be formatted due to the technical characteristics of the original files (Publisher's note).