



# Relationship between collaboration and normalized scientific impact in South American public universities

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## Abstract

The relationship between international collaboration and scientific impact is studied in the context of South American universities. This study aims to comprehensively analyze the strength of this relationship using nonparametric statistical methods. The records are the 244,300 papers published in journals indexed in Scopus (2011–2020) by researchers affiliated to 10 South American public universities and extracted with Scival support. There is a marked trend of collaborative work, since 93% of publications were collaborative at institutional, national or international level, with a higher percentage of international collaboration. A refined analysis of the geographic collaboration of publications in Q1 journals further evidences the frequency of international collaboration. In the top 4 collaborating partner institutions for each university, the presence of the Centre National de la Recherche Scientifique of France (CNRS) is observed, followed by the National Council for Scientific and Technical Research of Argentina (Conicet). It is proven that there is a statistically significant relationship ( $p < .01$ ) in each of the 10 universities between collaboration (number of countries) and normalized impact (FWCI). The results confirmed the hypothesis of this study and the authors provide practical recommendations for science policy makers and researchers, including the promotion of strategic collaboration between different institutional sectors of society to increase the impact of publications.

**Keywords** Scientific collaboration · Universities · South America · FWCI · Normalized impact · Scientometrics

## Introduction

### Scientific policies in South America and the context in universities

The exchange of knowledge, lifelong learning and the possibility of access to resources or equipment not available in one or another institution, in addition to the possibility of obtaining greater funding, favor the improvement of research results and the

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promotion of interdisciplinary and institutional growth. Under this context, universities play a fundamental role in the social, economic and technological development of a country through the production of scientific knowledge (Fernández et al., 2021), which implies generating and sharing knowledge; thus, giving way to scientific collaboration (González & Gómez, 2014). Science, technology and innovation (STI) policies are transcendental, since they allow the development of guidelines that orient the most appropriate objectives, fields and strategies for the development of research at the university level. In South America, these policies have materialized in various countries such as Peru, through the enactment of Law No. 30220 in 2014, which involved the creation of entities such as the National Superintendence of University Higher Education (Sunedu); or in the case of Ecuador through the Organic Law of Higher Education (LOES) in 2010 and the creation of the Prometeo "Viejos Sabios" program (Limaymanta et al., 2020). Likewise, in 2012 in Argentina, the Ministry of Science, Technology and Productive Innovation (MINCyT) launched the National Plan for Science, Technology and Innovation: Argentina Innovadora 2020, which is composed of six strategic areas (agribusiness; energy; environment and sustainable development; health; industry and social development) and three general purpose technologies (GPT): biotechnologies, information and communication technology (ICT) and nanotechnologies (UNESCO, 2018).

Similarly, Moreno-López et al. (2022) note that in Colombia between 2010 and 2014, the Administrative Department of Science, Technology and Innovation (currently Minciencias), established various strategies for STI policies. These were materialized, for example, through Vision 2025, which aims to position Colombia as one of the three most innovative countries in Latin America by 2025. In this work developed by the Colombian government, it is necessary to mention Decree 1279 of 2002, responsible for the regulation of the incentive policy derived from scientific production in public universities, related to the creation of the journal evaluation model (Publindex), which, despite limitations and criticisms, has brought order to the national research system. In addition, the individual efforts of universities in strengthening the processes of scientific production and generation of new knowledge are important (Uribe-Tirado, 2017). For Bolivia, the design of STI policies was in charge of the Ministry of Education since 2010 (UNESCO, 2018). In them, a set of programs were proposed under the Institutional Strategic Plan 2010–2014, including the Bolivian Scientific and Technological Information System (Sibicyt) and the Bolivian Innovation System. In addition, UNESCO (2018) noted that, for the Chilean case, a Presidential Commission composed of 35 experts called "Science for the development of Chile" was created in January 2015 that prepared a proposal on the promotion of STI as a scientific practice and culture.

The above policies and regulations have improved the scientific activity of South American countries and institutions. For example, the set of countries whose universities are selected in the present research went from publishing 79,334 documents in 2010 to 146,293 in 2020 with a growth of 184% documents in the last 10 years in Scopus (Turpo-Gebera et al., 2021). However, many aspects of this research ecosystem need to be strengthened, given the existence of asymmetries in regional production, the unequal allocation of resources and other problems. Indeed, they should be analyzed in the light of a variety of indicators that help to understand the influence of different variables and have more precise descriptions of this South American context.

## Collaboration and scientific impact

Scientific production is considered as the materialization of the resulting knowledge, in which several agents may participate through scientific collaboration (Lancho-Barrantes & Cantú-Ortiz, 2019). However, the production of scientific knowledge alone does not represent an indicator of the quality of research results; rather, several variables of the activities carried out by institutions must be taken into account, in order to have a broad view that leads to better decision making. In recent decades, knowledge production has undergone radical changes. Research collaboration has become a necessity due to the enormous pressure researchers and institutions face in meeting publication requirements. As a result, the number of internationally co-authored articles is increasing considerably. An intensification of scientific collaboration is observed at all levels of aggregation (Glänzel et al., 1999; Katz & Martin, 1997) and even at the level of emerging disciplines (Heinze & Kuhlmann, 2008), where knowledge sharing should be more efficient. However, differences remain between research fields in terms of the volume and impact of collaboration (Glänzel & Schubert, 2001).

Scientometrics, as an instrumental metric discipline of scientific activity (Nalimov & Mulchenko, 1969), is a fundamental tool for the study of the evaluation of research activity in institutions (Moed et al., 2005; Turpo-Gebera et al., 2021). Among the main scientometric indicators used for evaluation purposes are investment in R&D&I, human resources, productivity, impact, collaboration and structural analysis at the multivariate level (social, thematic and intellectual).

As a standard practice, the concept of scientific collaboration is translated as joint work between two or more authors that is consolidated in a scientific publication (Larivière et al., 2015; Olivera-Batista et al., 2018). Co-authorship serves as a vehicle for the integration of knowledge, efforts and capabilities, whose levels in the frequency of collaboration have increased since the 1980s in all areas of research (Bermeo-Andrade et al., 2009; Glänzel, 2002). For example, technological development, the interdisciplinarity existing in current science for the solution of a problem, the saving of resources and even the possibility of publishing in better positioned journals are some of the reasons why collaborative practices have increased. As a common activity in the process of scientific communication, its potential will depend on the type of collaboration, the discipline and the geographical area involved (Leimu & Koricheva, 2005). For example, several studies consider that international collaboration increases citation rates more than institutional or national collaboration (Asubiaro, 2019; Katz & Hicks, 1997). Additionally, Adams (2013) argues that international collaboration is the fourth era of research and that institutions that do not foster it run the risk of falling progressively behind in their performance in terms of visibility and scientific impact.

For their part, impact indicators make it possible to measure the scope of published documents in terms of citations and their derivatives (Peralta-González et al., 2015). This typology of indicators, despite their limitations and criticisms (Haustein & Larivière, 2015), play a prominent role in the evaluation of scientific research. Their use has increased during the last decades, a behavior that is reflected in the corpus of scientific literature (Bornmann & Daniel, 2008; Persson et al., 2004; Waltman, 2016). More than 90 years ago, Gross and Gross (1927) were the first to use citation counting to evaluate the importance of scientific papers. From there, several citation-based impact indicators have been proposed, such as the impact factor, average number of citations per publication, number and proportion of highly cited publications, the H-index, among others (Waltman,

2016) and normalized impact indicators that are born from the ratio between the observed impact and the expected impact, according to the proposals of CWTS (Centre for Science and Technology Studies, Leiden University) and the Karolinska Institute (Lundberg, 2007; Moed et al., 1995; Torres-Salinas et al., 2018); useful indicators in the science planning and evaluation process.

## Literature review

Many studies have shown that scientific collaboration provides visibility and increases impact, measured by the number of citations that published papers receive. They demonstrate the correlation between collaboration in papers and scientific impact (Abramo et al., 2009; Benavent-Pérez et al., 2012; Glänzel, 2002). That is, the more contributors to a publication, the greater the scientific impact and vice versa. However, unlike production, the progression of the increase in impact is not linear and has a fluctuating behavior. The authors pointed out that the impact of citations varies among different fields with specific characteristics. In addition, they emphasize the need to support policies in favor of creating networks and collaborations since they help to disseminate knowledge and research results in a rapid and generalized manner. The influence and contribution of scientific collaboration on the impact of published papers has also been demonstrated (Bermeo-Andrade et al., 2009; Larivière et al., 2015; Leydesdorff et al., 2019). In their conclusions, they emphasize that one of the many reasons for collaborative scientific work is that the most important scientific problems are complex and can only be solved by a team of researchers with complementary expertise. In addition, several studies have also pointed out that multiple authorship leads to an increase in citations as a positive effect of scientific collaboration (Hsu & Huang, 2011; Abramo & D'Angelo, 2015; Liao 2011). Even, effect was demonstrated at the level of subject areas such as Medicine (Cañedo-Andalia et al., 2016), ecology (Leimu & Koricheva, 2005) and in specific topics such as difficult airway (García-Aroca et al., 2017). Similarly, collaboration between institutions has been documented; either from an institutional management approach in order to improve relationships between researchers from the same institution (Huang & Brown, 2019), or from a bibliometric approach between institutions from different countries (Liu et al., 2021) examining patterns of co-authorship in cross-border research collaboration. In addition, the progressive generation of collaborative networks between accredited institutions considered of high quality (Perutz et al., 2020) is a phenomenon that has been energized, despite being an incipient aspect in the Latin American context, and collaboration between universities and companies is developing (González-Suarez et al., 2017; Orduña-Malea, 2020).

It should also be noted that the influence on research impact depends largely on the type of collaboration, since not all of them have the same effect on research impact in terms of citations (Gorraiz et al., 2012; Persson et al., 2004). For example, it has been shown that authors from the same institution produce lower impact research compared to smaller teams, but from different institutions that produce higher impact research (Jones, 2008).

In this context, measuring the relationship between collaboration and the impact of scientific results is necessary for better research planning and science policy management. This study is oriented to the South American context given the lack of studies on the behavior of collaboration and impact in South American universities, which allows a clear understanding of the behavior and joint trends of the results derived from these indicators. For example, how the normalized impact varies according to the type of collaboration or how the types of geographical collaboration are distributed according to publications in

Q1 journals, among other relevant aspects for evaluation and management. This behavior at the univariate and bivariate level, based on the analysis of 10 universities in each South American country, provides relevant information to understand the collaboration-impact relationship and propose inputs for planning and improving research in similar contexts. The research hypothesis of this study is that there is a relationship between collaboration and normalized impact in publications of South American universities (2011–2020). The specific objectives are: (1) To identify the behavior of collaboration and scientific impact present in the publications of South American universities, (2) To show the characteristics of collaboration-impact according to research areas and main collaborating partners of South American universities and, (3) To determine the correlation between collaboration and normalized scientific impact in the publications of South American universities. The achievement of these objectives can be a referential framework for the work of both the universities under study and others for the planning of research in their institutional policies. These aspects would allow an increase in prestige, visibility or recognition, in addition to improving collective research capabilities.

### Methodology

This research with a quantitative approach and scientometric methodology was carried out using data from Scival, Elsevier’s analytical solution that provides complete access to the research performance of authors, journals, institutions, countries and regions from Scopus data (Elsevier, 2022). It comprises the 244,300 papers published in the period 2011–2020 by researchers affiliated to South American public universities. A group of 10 South American universities were selected that were different from each other with respect to their normalized impact and number of publications, as well as belonging to 10 different South American countries (Table 1). This makes it possible to have an integrative view

**Table 1** Public universities in each selected South American country

No	Country	University	Abbreviations	Normal-ized impact (2011–2020)	Output (2011–2020)
1	Argentina	Universidad de Buenos Aires	UBA	1.04	34,079
2	Brazil	Universidad de São Paulo	USP	1.11	143,170
3	Chile	Universidad de Chile	UCh	1.15	28,032
4	Colombia	Universidad Nacional de Colombia	UNAL	0.97	20,443
5	Bolivia	Universidad Mayor de San Andres	UMSA	1.24	939
6	Ecuador	Universidad Central del Ecuador	UCE	0.82	1001
7	Paraguay	Universidad Nacional de Asunción	UNA	1.55	1188
8	Perú	Universidad Nacional Agraria La Molina	UNALM	0.87	913
9	Uruguay	Universidad de la República	Udelar	1.31	10,962
10	Venezuela	Universidad Central de Venezuela	UCV	1.05	4234

of the scientometric profile of South American universities that allows us to describe the different contexts of the results of research activities. This selection also helped to have a representation of the most visible public universities in their countries according to the Scimago Institutions Ranking 2021 (<https://www.scimagoir.com>). Scientometric indicators independent of the size of the universities were systematized (Waltman, 2016; Abramo & D'Angelo, 2016). That is, the indicators analyzed are not conditioned by population size or by the number of publications of the universities (Table 2). The results serve as inputs for decision making and research planning for universities with different research behaviors and outcomes.

Metadata collection was performed in January 2022. Data was obtained on the types of geographical collaboration (without collaboration, institutional, national and international collaboration), the normalized impact (Field Weighted Citation Impact-FWCI), the number of countries that make up a document, the journal quartile of a publication according to SJR, the main subject areas and the main collaborative partners of each university. The units of analysis taken into account were documents published in journals indexed in Scopus where at least one author is affiliated with a university that is part of the sample. There was no restriction on the language of publication or the type of document. The dimensions and indicators used are shown in Table 2. Excel 2019, R Studio Package Manager 1.2.0 and SPSS v22 were used for data analysis. The graphical representation of the correlation between collaboration and impact was given through the scatter diagram (point cloud), and the Pearson or Spearman coefficient was used to determine the correlation according to the behavior of the statistical distribution of the variables.

**Table 2** Description of dimensions and size-independent scientometric indicators

Analyzed dimensions	Indicators/variables: description
Scientific collaboration	<p>Proportion of institutional collaboration: When authors from the same institution collaborate</p> <p>Proportion of national collaboration: This is when authors from different institutions belonging to the same country collaborate</p> <p>Proportion of international collaboration: Here, authors from institutions belonging to different countries collaborate</p> <p>Proportion of collaboration in Q1: Type of geographical collaboration of publications in Q1 journals</p> <p>International collaboration by number of countries: This is the count of the number of countries that appear in a publication based on an author's affiliation information</p>
Scientific impact	<p>Normalized impact (Field Weighted Citation Impact -FWCI). It compares the number of citations received by publications with the average number of citations received by all other similar publications</p> <p>Proportion of publications according to SJR quartile of journals: It is the position of the journal where the researchers publish according to the SJR indicator</p>
<b>Bivariate analysis</b>	<b>Statistical technique</b>
Scatterplot and correlation	<p>Scatterplot: A point cloud that identifies the relationship between two quantitative variables</p> <p>Correlation coefficient: Value ranging from -1 to 1, whose magnitude indicates the strength and direction of the relationship between two quantitative variables</p>

## Results

### Distribution of publications by type of geographical collaboration

Figure 1 shows the percentage distribution of publications by each university according to the four types of geographical collaboration. There is a clear predominance of publications with international collaboration (IC onwards) in all the universities, with the exception of USP of Brazil whose national collaboration (NC onwards) is more frequent in its publications with 38.8%. Among the three universities with the highest IC are UMSA (88.2%), UCE (66.3%) and UNA (65.4%), while single publications are the ones with the lowest percentages in most universities. These dynamics of geographic collaboration show the trends of its growth in the last decades, specifically impacted by the NC or IC.

A comparative analysis between the dispersion of international and national collaboration is shown in Fig. 2 by means of the box plot. UBA, Udelar, UNAL and UCh are the universities that present the greatest homogeneity in the dispersion of the values of international and national collaboration, i.e., the behavior of the dynamics of their collaborations remains stable during the study period. While UCE, UCV and UNALM have heterogeneous behaviors in both types of collaboration in comparison with other universities. This could be a product of changes in their national scientific policies that influence the universities. UCE, UMSA, Udelar, UNA and UNALM present a greater difference between international and national collaboration.

### International collaboration trend (2011–2020)

It can be seen that UMSA, with stable behavior throughout the study period, is the institution with the highest percentage of publications in IC, with values ranging from 84% t– 95% of IC (Fig. 3). At the other extreme is USP, whose values range from 27% – 42% of its publications in IC. UCE, in 2012 had a higher percentage of IC compared to the other universities in the region, as it registered 90.9% of its publications in IC, in the following

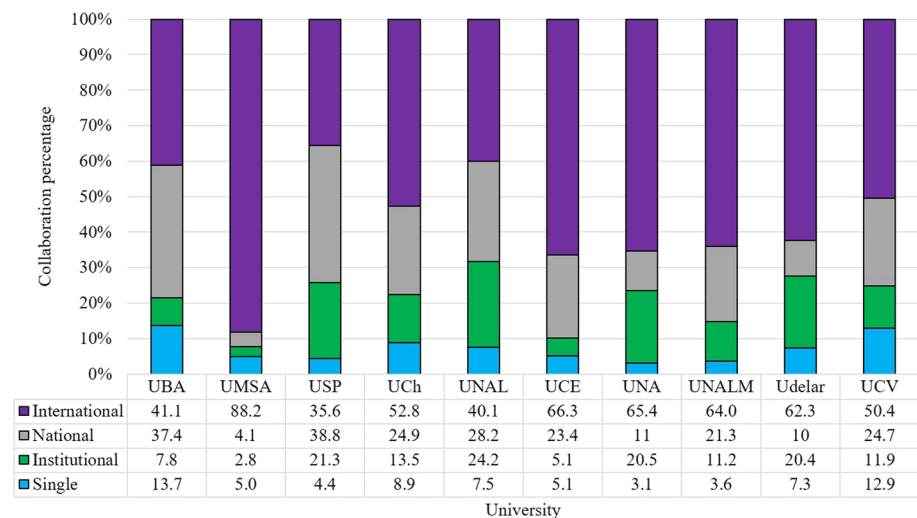
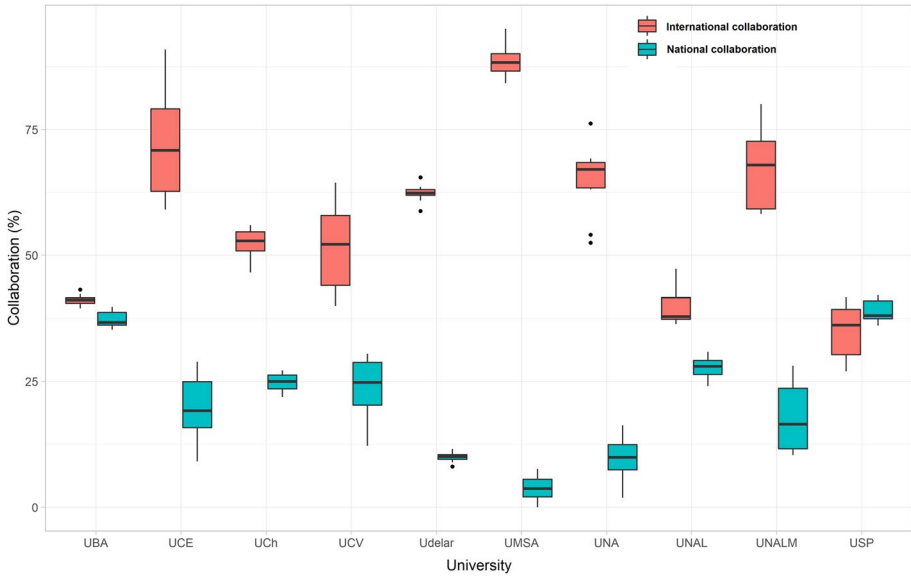
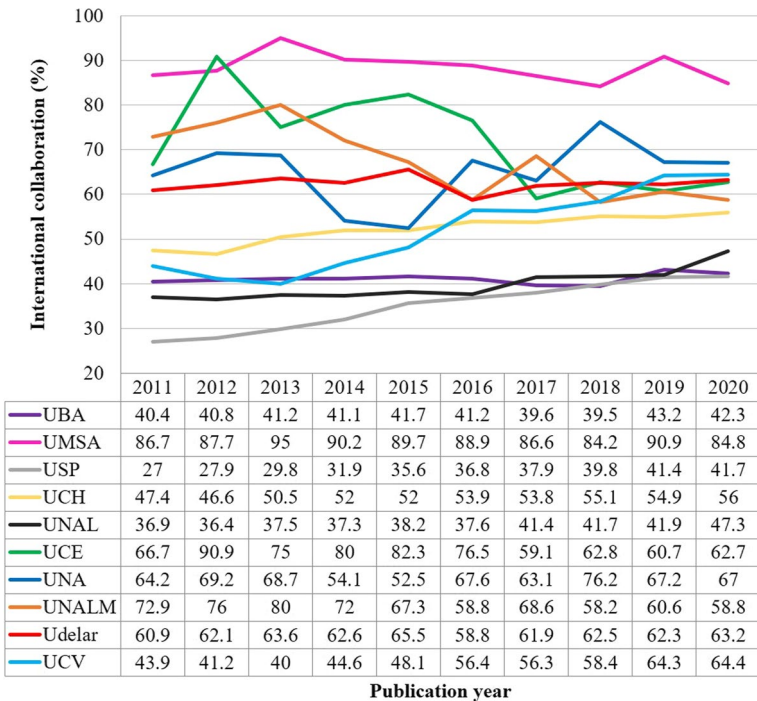


Fig. 1 Distribution of publications according to type of collaboration by university



**Fig. 2** Distribution of publications by percentage and type of collaboration by university



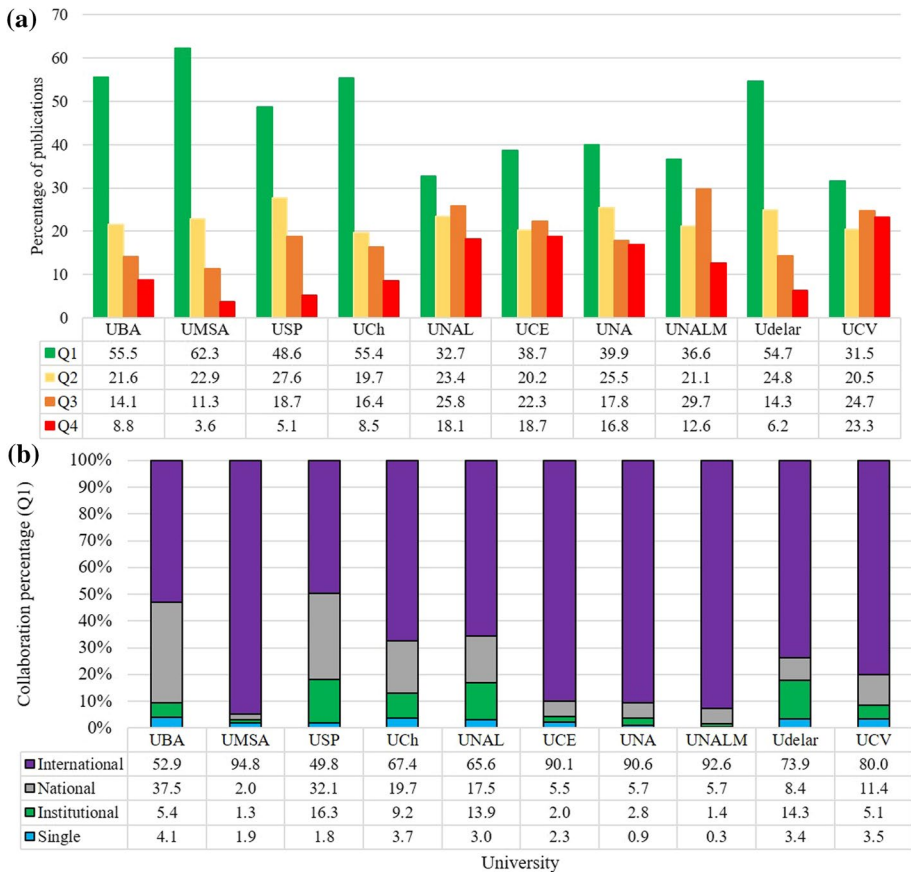
**Fig. 3** Behavior of international collaboration in the universities. (2011–2020)



years it had a decreasing trend to 60.7% of publications in IC. For their part, UCV and USP had a growth trend from 41.2% in 2012 to 64.4% in 2020 and from 27% in 2012 to 41.7% in 2020, respectively. Udelar and UBA had a constant trend during the study period in the percentage of publications in IC.

**Publications according to SJR quartile (2011–2020) and collaboration in Q1 journal papers**

An analysis of the impact according to the quartile of the journals where university researchers publish is presented in Fig. 4a by means of the comparative bars. Indeed, all the universities in the study have a higher percentage of publications in journals indexed in Scopus that are classified in quartile 1 (Q1) according to the SJR indicator. The universities that exceed one third of their publications in Q1 journals are UBA, UMSA, UCh, Udelar and USP, despite the latter despite the lowest percentage of IC throughout the study period compared to the other universities that do register a higher percentage of publications in IC (Figs. 2 and 3). UNAL (32.7%) and UCV (31.5%) are the universities with the



**Fig. 4** a Impact of scientific production according to SJR journal quartiles, b Geographical collaboration of publications in Q1

lowest percentage of documents in Q1 journals. Regarding the behavior of publications in Q4 journals, with the exception of UCV, all the universities have a lower percentage of publications in Q4 journals compared to the other quartiles (Q1, Q2 and Q3).

Figure 4b was constructed to identify the behavior of geographic collaboration of publications in Q1 journals according to SJR. It can be seen that in all universities the IC increased compared to Fig. 1. The universities with the highest percentage of publications in IC are UMSA (94.8%) and UNALM (92.6%). These results show that publications in Q1 journals have a higher IC component compared to the total number of publications (Fig. 1). As for single publications, their percentage is reduced, the maximum value of which is found at UBA with 4.1%. Consequently, from Fig. 4b it can be deduced that very few papers published in Q1 journals were written alone.

### Collaboration and scientific impact according to main subject areas

An analysis of the behavior of the thematic areas with the highest percentage of IC, NC and normalized impact (FWCI) is shown in Table 3. The top 3 for each indicator by university is shown, which for each institution identifies a specific behavior of its thematic areas. Thus, for UBA, USP and UCh the thematic area that is in the top 3 of both the IC and the FWCI is Physics and Astronomy. Meanwhile, UCE, UNA, Udelar and UCV have the Multidisciplinary area with the highest IC values. The other areas that stand out within the top 3 for both the IC and the FWCI are Decision Sciences at UBA, Dentistry and Health Professions at UMSA, Earth and Planetary Sciences at UCh, Psychology at UNALM and Nursing at Udelar. It should be noted that the thematic area that represents a university is not necessarily related to the existence of a professional career, since the results are sometimes the product of collaborations with other universities in a multidisciplinary manner. Proof of this, the areas of Psychology Arts and Humanities that appear in the UNALM are products of research in IC. Another aspect to highlight is that, with the exception of Arts and Humanities at UNALM, no other university has within the top 3 the same thematic area in both the NC and the FWCI. That is to say, no area that is in the top 3 of the NC, appears at the same time in the top 3 of the highest value of the normalized impact FWCI, which allows us to conclude that the areas that have the highest IC also present the highest normalized impact (FWCI). The particular reason for the Arts and Humanities is that it has a component of interest that is mostly national rather than international and that its production is not always published in journals indexed in citation databases, since its means of dissemination is not always the scientific article.

### Top 4 collaborative partners of each South American University

Within the behavior of the top 4 institutions with which each university collaborates, the French Centre National de la Recherche Scientifique (CNRS) plays a leading role. It is the institution from the old continent that appears most frequently in the analysis, since it is a collaborating partner of seven South American universities within the top 4 (Table 4). This shows the important role of the French institution in joint scientific production with South American universities, which is a consequence of its multidisciplinary character and leadership in research at the French and global level. Another aspect to highlight is the participation of the National Council for Scientific and Technical Research of Argentina (Conicet) and its collaboration with several universities such as UBA, UMSA, UNA and Udelar. On the other hand, an analysis for each university shows that the four institutions

**Table 3** Publications according to thematic areas with the highest IC, FWCI and NC by university

University	N°	IC (%)	FWCI	NC (%)
UBA	1	Physics and Astronomy (66.1%)	Physics and Astronomy (2.08)	Agricultural and Biological Sciences (54%)
	2	Decision Sciences (59.8%)	Engineering (1.58)	Environmental Science (53.8%)
	3	Computer Science (55.6%)	Decision Sciences (1.12)	Immunology and Microbiology (51.4%)
UMSA	1	Dentistry, Health Professions, Business, Management and Accounting, Chemical Engineering, Neuroscience, Psychology, Decision Sciences (100%)	Multidisciplinary (2.54)	Materials Science (8.7%)
	2		Dentistry (1.95)	Veterinary (8.3%)
	3		Health Professions (1.74)	Engineering (7.7%)
USP	1	Earth and Planetary Sciences (56.8%)	Medicine (1.39)	Veterinary (60.3%)
	2	Physics and Astronomy (55.3%)	Physics and Astronomy (1.37)	Dentistry (47.7%)
	3	Multidisciplinary (50.3%)	Earth and Planetary Sciences (1.17)	Nursing (46%)
UCh	1	Earth and Planetary Sciences (80.7%)	Earth and Planetary Sciences (1.49)	Medicine (36%)
	2	Physics and Astronomy (78.5%)	Dentistry (1.46)	Chemical Engineering (33.9%)
	3	Multidisciplinary (72.5%)	Physics and Astronomy (1.45)	Veterinary (32.8%)
UNAL	1	Dentistry (62.3%)	Medicine (2.21)	Veterinary (40.7%)
	2	Physics and Astronomy (56.1%)	Health Professions (1.65)	Decision Sciences (40.1%)
	3	Neuroscience (52.9%)	Environmental Science (1.11)	Immunology and Microbiology (39.9%)
UCE	1	Chemistry (87.9%)	Multidisciplinary (2.45)	Decision Sciences (50%)
	2	Multidisciplinary (86.5%)	Arts and Humanities (1.26%)	Health Professions (45.5%)
	3	Chemical Engineering (85.7%)	Veterinary (1.21)	Neuroscience (42.9%)
UNA	1	Multidisciplinary (100%)	Multidisciplinary (5.73)	Immunology and Microbiology (22%)
	2	Chemistry (95.2%)	Economics, Econometrics and Finance (2.59)	Decision Sciences (20%)
	3	Biochemistry, Genetics and Molecular Biology (91.5%)	Medicine (2.23)	Business, Management and Accounting (18.8%)

**Table 3** (continued)

University	N°	IC (%)	FWCI	NC (%)
UNALM	1	Health Professions (100%)	Arts and Humanities (2.77)	Arts and Humanities (50%)
	2	Multidisciplinary (100%)	Psychology (2.75)	Computer Science (59%)
	3	Psychology (100%)	Decision Sciences (1.99)	Pharmacology, Toxicology and Pharmaceutics (50%)
Udelar	1	Dentistry (91.8%)	Medicine (2.73)	Immunology and Microbiology (15.1%)
	2	Nursing (82.1%)	Nursing (1.72)	Biochemistry, Genetics and Molecular Biology; Veterinary; Neuroscience (14.1%)
	3	Multidisciplinary (76.8%)	Multidisciplinary (1.53)	
UCV	1	Multidisciplinary (77.1%)	Medicine (1.62)	Neuroscience (40.6%)
	2	Chemical Engineering (74.1%)	Multidisciplinary (1.51)	Veterinary (36.6%)
	3	Decision Sciences (73.2%)	Biochemistry, Genetics and Molecular Biology (1.18)	Materials Science (35%)

Note: IC: International collaboration; NC: National collaboration

with which UMSA and UNA collaborate most are foreign, while for UCE, the four institutions with which it collaborates most are universities in the same country (Ecuador).

### Relationship of collaboration and scientific impact

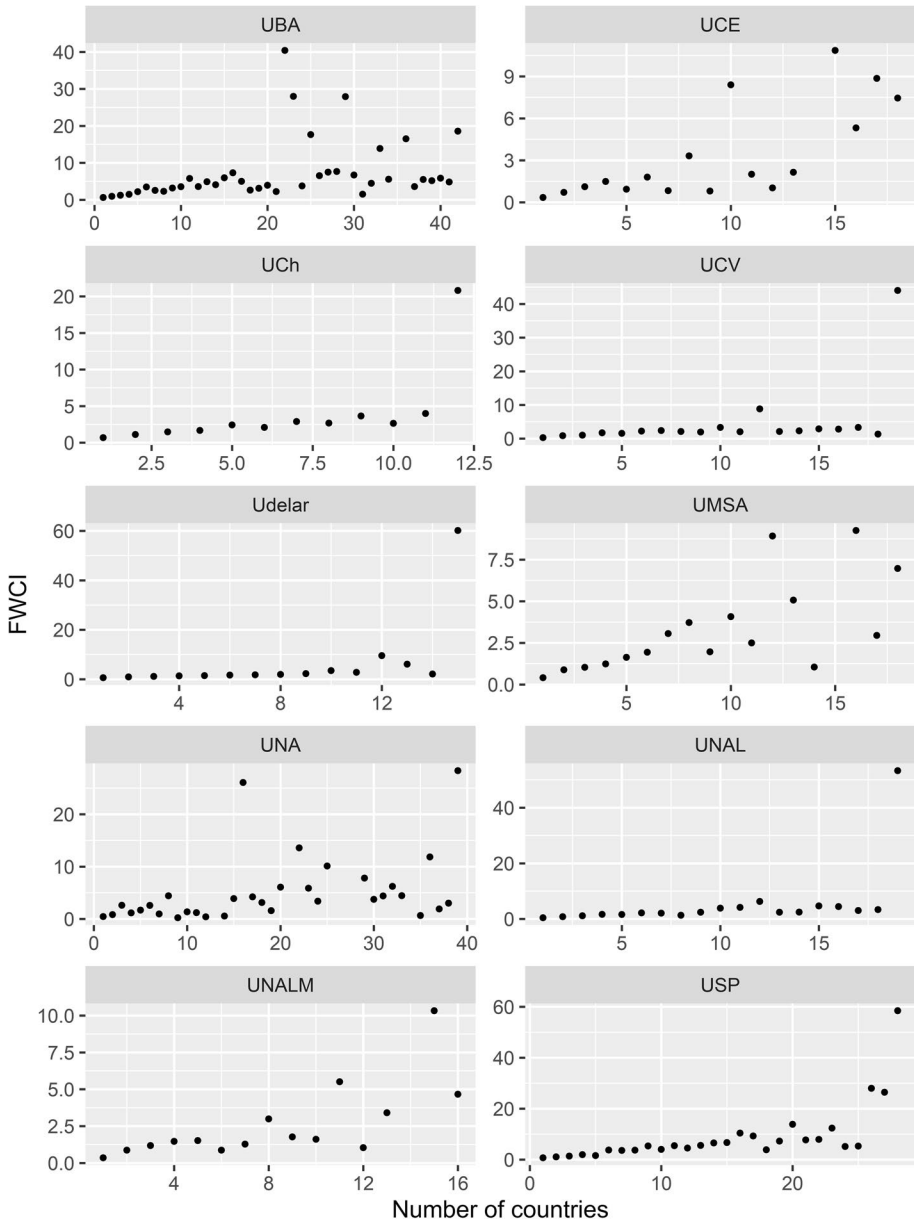
To show the results of the relationship between collaboration (number of countries involved in a publication) and normalized scientific impact (FWCI), the publication records of each South American university were structured. Previously, the publications of each university were organized according to the number of countries. Thus, the groups of publications with the highest number of countries that constituted approximately 1% of all publications were placed in a single group (Excel “summary” sheet available at Zenodo <https://doi.org/10.5281/zenodo.7109033> showing the distribution of publications of each South American university according to number of countries, number and percentage of publications and FWCI). From this, the 10 scatter diagrams were obtained showing that the publications of the universities have a linear relationship between the indicators analyzed (Fig. 5). That is, as the number of countries participating in a registry (publication) increase, the FWCI values increase. For example, Udelar and USP publications show that the greater the number of countries, the greater their FWCI normalized impact, with values around 60.0 (Fig. 5). In this context, to show whether the relationship observed in the scatter diagrams is statistically significant, the research hypothesis H1 was tested using statistical correlation.

**H0 Hypothesis 0**  $\rho_{s(i)} = 0$  (there is no statistically significant relationship between collaboration and the normalized impact of the publications of each of the 10 South American universities).

**Table 4** Top 4 of the institutions with which each South American university collaborates the most  
**Institutions with which it collaborates (number of documents)**

University	1°	2°	3°	4°
<b>UBA</b>	Conicet - Argentina (14786)	Universidad Nacional de la Plata - Argentina (2566)	CNRS - France (2155)	Universidad de Sao Paulo (1520)
<b>UMSA</b>	CNRS – France (156)	Institut de recherche pour le développement – France (135)	Lund University - Sweden (70)	Conicet - Argentina (57)
<b>USP</b>	Universidade Estadual Paulista Júlio de Mesquita Filho (9519)	Universidade Estadual de Campinas (7295)	Universidade Federal de Sao Paulo (6535)	CNRS - France (4307)
<b>UCh</b>	Pontificia Universidad Católica de Chile (2763)	CNRS – France 1680)	Universidad de Santiago de Chile (1202)	Universidad Andrés Bello - Chile (1162)
<b>UNAL</b>	Universidad de Antioquia - Colombia (810)	CNRS - France (640)	Universidad Javeriana - Colombia (600)	Universidad de los Andes Colombia (586)
<b>UCE</b>	Universidad de las Fuerzas Armadas ESPE - Ecuador (82)	Pontificia Universidad Católica del Ecuador (68)	Universidad San Francisco de Quito - Ecuador (60)	Universidad de las Américas - Ecuador (58)
<b>UNA</b>	Universidade de Sao Paulo (57)	Universidad de la República - Uruguay (57)	Conicet - Argentina (49)	Universidad de Talca - Chile (48)
<b>UNALM</b>	Universidad Nacional Mayor de San Marcos - Peru (68)	CNRS - France (44)	Institut de recherche pour le développement - France (42)	Universidad Nacional Autónoma de México (36)
<b>Udelar</b>	Conicet - Argentina (728)	Universidade de Sao Paulo (407)	Instituto de Investigaciones Biológicas Clemente Estable - Uruguay (386)	Universidad de Buenos Aires - Argentina (347)
<b>UCV</b>	Instituto Venezolano de Investigaciones Científicas (478)	Universidad Simón Bolívar - Venezuela (266)	Universidad de Zulia - Venezuela (176)	CNRS - France (175)

**H1 Hypothesis 1**  $\rho_{s(i)} \neq 0$  (there is statistically significant relationship between collaboration and the normalized impact of the publications of each of the 10 South American universities).



**Fig. 5** Scatterplot between collaboration (number of countries) and normalized impact (FWCI)

Table 5 shows the inferential analysis of the correlation coefficients between collaboration (number of countries) and normalized impact (FWCI). Prior to this, the variable data were subjected to Shapiro–Wilk normality tests in order to decide which correlation coefficient to use, either Pearson’s or Spearman’s correlation. The p-values of the FWCI normality test are significant, which confirm that the FWCI data do not approximate a normal

**Table 5** Normality and correlation tests between collaboration (number of countries) and normalized impact (FWCI)

University	Normality test Shapiro–Wilk ( <i>p</i> value)		Correlation coefficient Spearman’s Rho (A) ↔ (B)
	Number of countries (A)	FWCI (B)	
UBA	.133	.000	.615**
UCE	.639	.001	.767**
UCh	.876	.000	.944**
UCV	.590	.000	.677**
Udelar	.755	.000	.939**
UMSA	.716	.011	.743**
UNA	.086	.000	.558**
UNAL	.590	.000	.856**
UNALM	.849	.001	.776**
USP	.310	.000	.849**

\*\**p* < .01, the correlation is significant at the 0.01 level

distribution. Therefore, the nonparametric Spearman’s Rho coefficient was used because it is less sensitive than Pearson to extreme values of the FWCI.

The results of the analysis of the correlation between collaboration and the FWCI normalized impact show that all the universities present a direct and significant linear relationship (*p* < 0.01). Of these, the five universities with the highest correlation coefficient values are UCh (rho=0.944), Udelar (rho=0.939), UNAL (rho=0.856), USP (rho=0.849) and UNALM (rho=0.776). This means that, as the number of countries participating in a publication increases, the normalized FWCI impact also increases and vice versa. These results indicate that there is a uniform behavior in the dynamics of the relationship between collaboration and normalized impact in the publications of South American public universities, period 2011–2020.

### Discussion and conclusions

The relationship between international collaboration and scientific impact from various perspectives has been addressed in different studies (Abramo et al., 2009; Guerrero-Bote et al., 2013; Leimu & Koricheva, 2005). However, the present research analyzed the relationship of collaboration and scientific impact from the context of a group of South American universities. From there, the results and the following conclusions serve as input for decision makers in institutional and national science policies to improve research management.

There is a marked trend of collaborative work, since collaborations at the institutional, national or international level accumulate 93% of publications, with a higher percentage of international collaboration, whose behavior coincides with the results of Gazni and Didegah (2011) when they studied the publications of Harvard University. The universities that show the highest IC are UMSA of Bolivia, UCE of Ecuador and UNA of Paraguay, which reflect the behavior of IC at the level of publications of the whole country according to Turpo-Gebera et al. (2021), where Bolivia, Paraguay and Ecuador occupy the top 3 countries with the highest IC. The IC percentages increase when analyzing only publications in Q1 journals in each university studied. However, as a line of research for future studies,

this general predominance should be analyzed in the light of the contribution represented by scientific leadership. The existence of a greater number of contributions in indexed journals, mainly in higher quartiles (Q1 and Q2), is a significant result related to the high international collaboration of the universities evaluated, results already found in other studies (Chinchilla-Rodríguez et al., 2015), which evidences that publications in Q1 journals have a greater IC component compared to the total number of publications, sometimes motivated by the relevance of the research and its international nature.

The analysis of the top 3 subject areas according to IC, NC and FWCI values showed heterogeneous behavior in each university. It shows that in some universities, such as UBA, UMSA, UCh and Udelar, the subject areas with the highest IC also have the highest normalized FWCI impact. These areas are Physics and Astronomy, Decision Sciences, Dentistry, Health Professions, Earth and Planetary Sciences, Multidisciplinary, Psychology and Nursing. The most frequent subject areas with the highest IC in several universities are Physics and Astronomy and Multidisciplinary. The most frequent areas with the highest FWCI normalized impact are Multidisciplinary and Medicine. The latter is noteworthy since it is not among those with the highest IC, but it stands out in the FWCI. Finally, the most frequent areas found in the top 3 of the NC are Veterinary and Immunology and Microbiology, which suggests that publications in these areas are of an interinstitutional or national nature. These patterns of behavior reveal different asymmetries within them, where areas of knowledge and disciplines tend to approach collaboration differently. It is evident on the one hand for universities with greater scientific size such as UBA in Argentina, USP in Brazil and UCh in Chile, which have Physics and Astronomy in the top 3 of their thematic areas with the highest percentage of international collaboration and normalized impact. On the other hand, the Udelar of Uruguay, the UCV of Venezuela, the UNA of Paraguay, the UCE of Ecuador and the UMSA of Bolivia have the Multidisciplinary category within the top 3 thematic areas which achieve the highest normalized impact. The latter shows that, in these universities, publishing multidisciplinary topics has a greater impact, which exceeds the world average of citations in their respective category. The policies of support and promotion of research by universities should strengthen scientific collaboration in specific topics and also in multidisciplinary topics that allow solving local or national problems. Larivière et al. (2015) supported this idea since the complex problems of a society can only be solved by a team of researchers in collaboration with complementary knowledge.

In relation to the top 4 institutions collaborating with South American universities, the Centre national de la recherche scientifique (CNRS) of France has a significant presence in the institutions analyzed, since it collaborates with seven of the 10 universities, followed by the Conicet of Argentina, which collaborates with four universities. The CNRS is the main research institution in France in all areas of knowledge and this study shows its high level of collaboration with South American universities. For its part, the Conicet is the main organization for the promotion of science and technology in Argentina, which also shows its capacity to develop collaborative work with South American universities. These institutions are models for South American universities and institutions to take and promote international collaboration practices for the benefit of society. Another result shows that UCE is the only university whose top 4 institutions that maintain scientific collaboration are universities of the same country. At the other extreme is the UNA, whose top 4 collaborating institutions include organizations from other countries. All of the above demonstrates the



diversity of the flow of collaborative behavior, since some universities have already developed the dynamics of international collaborations, while others are still in the process. This can serve to rethink the lines of research according to the local or national problems identified and that the universities have the function of investigating them and proposing alternative solutions.

Regarding the research hypothesis of this study, there is a statistically significant positive relationship ( $p < 0.01$ ) between collaboration (number of countries) and normalized impact (FWCI) in the 10 universities. That is, the greater the number of countries participating in a publication, the greater the normalized impact (FWCI). These results are not in agreement with those of Gazni and Didegah (2011), who showed that there is no linear relationship between the number of countries and the mean normalized number of citations in Harvard University publications. However, other studies did show a relationship between the degree of co-authorship and citation impact (Glänzel, 2002), between the degree of collaboration and normalized impact (Benavent-Pérez et al., 2012). In this dynamic of results, it can be concluded that there is a different behavior of collaboration indicators in each geographical context analyzed. The message for science policy makers in the different South American countries and institutions is that they should promote international collaboration through interdisciplinary and interinstitutional projects with or without funding. In addition, they should train their professors and students to participate in research projects at different levels, all with a previously planned and executed budget, whose research results serve to improve society and institutions.

Since collaboration usually has positive effects on research productivity (Lee & Bozeman, 2005), the results of the present research are useful for science policy managers who plan research at different levels of aggregation at both meso (research groups) and macro (universities) levels, as well as being an incentive for collaborative research. However, there are still stereotypes in the institutional organization of modern science, especially within universities (Kronegger et al., 2015), as budget flows are organized by disciplines and this reduces the possibilities for researchers to collaborate across disciplinary boundaries. This should be taken into account by science policy makers so that collaboration is shaped from different research contexts and sectors. In fact, not only should collaboration between universities with their national or international peers be encouraged, but also between universities and research institutes, public and private companies, scientific societies and even basic education institutions. All this will make it possible to propose better research problems, both basic and applied, which will have a greater scientific impact.

Among the limitations of this study are the fact that the relationship between international collaboration and standardized impact according to the different areas has not been tested. Also, only one source of information was taken into account for data collection. Finally, the analysis of other variables that could be related to normalized scientific impact was omitted, for example, funding, scientific disciplines, type of university, scientific and population size of the university, among others. Therefore, it is recommended that future lines of research by institutions and universities cover these topics in order to consolidate scientometric inputs that contribute to better decision making. It is also suggested to analyze the behavior of the scientific leadership of the total number of publications with international collaboration to identify the level of scientific dependence of each university. Likewise, the joint behavior of collaboration and funding and its association with the

impact of South American research should also be analyzed. Indeed, any of these initiatives would complement the results obtained in this work.

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**Data Availability** Data available.

## Declarations

**Conflict of interest** The authors declare that they have no known interests or personal relationships that could have appeared to influence the work reported in this paper.

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## References

- Abramo, G., & D'Angelo, C. A. (2015). The relationship between the number of authors of a publication, its citations and the impact factor of the publishing journal: Evidence from Italy. *Journal of Informetrics*, 9(4), 746–761. <https://doi.org/10.1016/j.joi.2015.07.003>
- Abramo, G., & D'Angelo, C. A. (2016). A farewell to the MNCS and like size-independent indicators. *Journal of Informetrics*, 10(2), 646–651. <https://doi.org/10.1016/j.joi.2016.04.006>
- Abramo, G., D'Angelo, C. A., & Di Costa, F. (2009). Research collaboration and productivity: Is there correlation? *Higher Education*, 57(2), 155–171. <https://doi.org/10.1007/s10734-008-9139-z>
- Adams, J. (2013). The fourth age of research. *Nature*, 497(7451), 557–560. <https://doi.org/10.1038/497557a>
- Andalía, R. C., Rodríguez, M. N., Font, J. C., Hechavarría, I. G., Zaragoza, I. C., & Pupo, J. C. G. (2016). Papel de la colaboración científica en el impacto de la investigación en salud de cuba en el contexto de América Latina. *Revista Cubana De Información En Ciencias De La Salud*, 27(1), 56–74.
- Asubiaro, T. (2019). How collaboration type, publication place, funding and author's role affect citations received by publications from Africa: A bibliometric study of LIS research from 1996 to 2015. *Scientometrics*, 120, 1261–1287. <https://doi.org/10.1007/s11192-019-03157-1>
- Benavent-Pérez, M., Gorraiz, J., Gumpenberger, C., & de Moya-Anegón, F. (2012). The different flavors of research collaboration: A case study of their influence on university excellence in four world regions. *Scientometrics*, 93, 41–58. <https://doi.org/10.1007/s11192-012-0638-4>
- Bermeo-Andrade, H., de los Reyes, L. E., & Bonavia-Martín, T. (2009). Dimensions of scientific collaboration and its contribution to the academic research groups' scientific quality. *Research Evaluation*, 18(4), 301–311. <https://doi.org/10.3152/095820209X451041>
- Bornmann, L., & Daniel, H. (2008). What do citation counts measure? A review of studies on citing behavior. *Journal of Documentation*, 64(1), 45–80. <https://doi.org/10.1108/00220410810844150>
- Chinchilla-Rodríguez, Z., Arencibia-Jorge, R., de Moya-Anegón, F., & Corera-Álvarez, E. (2015). Some patterns of Cuban scientific publication in scopus: The current situation and challenges. *Scientometrics*, 103(3), 779–794. <https://doi.org/10.1007/s11192-015-1568-8>

- Elsevier (2022). See what SciVal can do for you. <https://www.elsevier.com/solutions/scival/features>
- Fernández, A., Ferrándiz, E., & León, M. D. (2021). Are organizational and economic proximity driving factors of scientific collaboration? evidence from Spanish universities, 2001–2010. *Scientometrics*, 126(1), 579–602. <https://doi.org/10.1007/s11192-020-03748-3>
- García-Aroca, M. Á., Pandiella-Dominique, A., Navarro-Suay, R., Alonso-Arroyo, A., Granda-Orive, J. I., Anguita-Rodríguez, F., & López-García, A. (2017). Analysis of production, impact, and scientific collaboration on difficult airway through the web of science and scopus (1981–2013). *Anesthesia and Analgesia*, 124(6), 1886–1896. <https://doi.org/10.1213/ANE.0000000000002058>
- Gazni, A., & Didegah, F. (2011). Investigating different types of research collaboration and citation impact: A case study of harvard university's publications. *Scientometrics*, 87(2), 251–265. <https://doi.org/10.1007/s11192-011-0343-8>
- Glänzel, W. (2002). Coauthorships patterns and trends in the sciences (1980–1998): A bibliometric study with implications for database indexing and search strategies. *Library Trends*, 50(3), 461–473.
- Glänzel, W., & Schubert, A. (2001). Double effort = double impact? A critical view at international co-authorship in chemistry. *Scientometrics*, 50(2), 199–214. <https://doi.org/10.1023/A:1010561321723>
- Glänzel, W., Schubert, A., & Czerwon, H. J. (1999). A bibliometric analysis of international scientific cooperation of the European Union (1985–1995). *Scientometrics*, 45(2), 185–202. <https://doi.org/10.1007/BF02458432>
- González, G., & Gómez, J. (2014). La colaboración científica: Principales líneas de investigación y retos de futuro. *Revista Española De Documentación Científica*, 37(4), e062. <https://doi.org/10.3989/redc.2014.4.1186>
- González-Suárez, E., Miño-Valdés, J. E., & Concepción-Toledo, D. N. (2017). El papel de la colaboración internacional y la vinculación universidad-empresa en la terminación de los resultados científicos. *Revista Universidad y Sociedad*, 9(3), 232–236.
- Gorraiz, J., Reimann, R., & Gumpenberger, C. (2012). Key factors and considerations in the assessment of international collaboration: A case study for Austria and six countries. *Scientometrics*, 91(2), 417–433. <https://doi.org/10.1007/s11192-011-0579-3>
- Gross, P. L., & Gross, E. M. (1927). College libraries and chemical education. *Science (new York NY)*, 66(1713), 385–389. <https://doi.org/10.1126/science.66.1713.385>
- Guerrero-Bote, V. P., Olmeda-Gómez, C., & de Moya-Aneón, F. (2013). Quantifying the benefits of international scientific collaboration. *Journal of the American Society for Information Science and Technology*, 64(2), 392–404. <https://doi.org/10.1002/asi.22754>
- Haustein, S., & Larivière, V. (2015). The Use of Bibliometrics for Assessing Research: Possibilities, Limitations and Adverse Effects. In I. Welpel, J. Wollersheim, S. Ringelhan, & M. Osterloh (Eds.), *In Incentives and Performance*. Cham: Springer International Publishing.
- Heinze, T., & Kuhlmann, S. (2008). Across institutional boundaries? research collaboration in German public sector nanoscience. *Research Policy*, 37(5), 888–899. <https://doi.org/10.1016/j.respol.2008.01.009>
- Hsu, J. W., & Huang, D. W. (2011). Correlation between impact and collaboration. *Scientometrics*, 86(2), 317–324. <https://doi.org/10.1007/s11192-010-0265-x>
- Huang, J. S., & Brown, A. (2019). Enabling collaborative work in higher education: An exploration of enhancing research collaborations within an institution. *Journal of Research Administration*, 50(3), 63–89.
- Jones, B. F., Wuchty, S., & Uzzi, B. (2008). Multi-university research teams: Shifting impact, geography, and stratification in science. *Science*, 322(5905), 1259–1262. <https://doi.org/10.1126/science.1158357>
- Katz, J., & Hicks, D. (1997). How much is a collaboration worth? A calibrated bibliometric model. *Scientometrics*, 40(3), 541–554. <https://doi.org/10.1007/bf02459299>
- Katz, J. S., & Martin, B. R. (1997). What is research collaboration? *Research Policy*, 26(1), 1–18. [https://doi.org/10.1016/S0048-7333\(96\)00917-1](https://doi.org/10.1016/S0048-7333(96)00917-1)
- Kronegger, L., Mali, F., Ferligoj, A., & Doreian, P. (2015). Classifying scientific disciplines in Slovenia: A study of the evolution of collaboration structures. *Journal of the Association for Information Science and Technology*, 66(2), 321–339. <https://doi.org/10.1002/ASI.23171>
- Lancho-Barrantes, B. S., & Cantú-Ortiz, F. J. (2019). Science in Mexico: A bibliometric analysis. *Scientometrics*, 118(2), 499–517. <https://doi.org/10.1007/s11192-018-2985-2>
- Larivière, V., Gingras, Y., Sugimoto, C. R., & Tsou, A. (2015). Team size matters: Collaboration and scientific impact since 1900. *Journal of the Association for Information Science and Technology*, 66(7), 1323–1332. <https://doi.org/10.1002/asi.23266>
- Lee, S., & Bozeman, B. (2005). The impact of research collaboration on scientific productivity. *Social Studies of Science*, 35(5), 673–702. <https://doi.org/10.1177/0306312705052359>
- Leimu, R., & Koricheva, J. (2005). Does scientific collaboration increase the impact of ecological articles? *BioScience*, 55(5), 438–443. [https://doi.org/10.1641/0006-3568\(2005\)055\[0438:DSCITI\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2005)055[0438:DSCITI]2.0.CO;2)

- Leydesdorff, L., Bornmann, L., & Wagner, C. S. (2019). The relative influences of government funding and international collaboration on citation impact. *Journal of the Association for Information Science and Technology*, 70(2), 198–201. <https://doi.org/10.1002/asi.24109>
- Limaymanta, C. H., Zulueta-Rafael, H., Restrepo-Arango, C., & ÁlvarezMuñoz, P. (2020). Análisis bibliométrico y cuantitativo de la producción científica de Perú y Ecuador desde web of science (2009–2018). *Información Cultura y Sociedad*, 43, 31–52. <https://doi.org/10.34096/ICS.143.7926>
- Liu, Y., Ma, J., Song, H., Qian, Z., & Lin, X. (2021). Chinese universities' cross-border research collaboration in the social sciences and its impact. *Sustainability*, 13(18), 10378. <https://doi.org/10.3390/su131810378>
- Lundberg, J. (2007). Lifting the crown—citation z-score. *Journal of Informetrics*, 1(2), 145–154. <https://doi.org/10.1016/j.joi.2006.09.007>
- Moed, H. F., De Bruin, R. E., & Van Leeuwen, T. N. (1995). New bibliometric tools for the assessment of national research performance: Database description, overview of indicators and first applications. *Scientometrics*, 33(3), 381–422. <https://doi.org/10.1007/BF02017338>
- Moed, H. F., Glänzel, W., & Schmoch, U. (Eds.). (2005). *Handbook of Quantitative Science and Technology Research*. New York: Kluwer.
- MorenoLópez, G., Marín, L. M. G., GómezBayona, L., & Mora, J. M. R. (2022). Knowledge production in universities: An analysis based on human capital theory, a case of accredited HEIs in Colombia. In Á. Rocha, C. F. HernanTorro, & J. M. R. Rodríguez (Eds.), *In Smart Innovation Systems and Technologies* (pp. 529–539). Singapore: Springer.
- Nalimov, V. V., & Mulchenko, Z. M. (1969). *Naukometriya Izuchenie Razvitiya Nauki kak Informatsionnogo Protsessa. Scientometrics. Study of the Development of Science as an Information Process*. Moscow: Nauka.
- Olivera Batista, D., PeraltaGonzález, M. J., & García García, O. (2018). Co authorship as expression of collaboration in the scientific production of Camagüey Biblios. *Journal of Librarianship and Information Science*, 70, 1–16.
- Orduña-Malea, E. (2020). Do Latin American universities engage industry in the scientific publication? a bibliometrics approach through Scopus. *Palabra Clave (la Plata)*, 10(1), e100. <https://doi.org/10.24215/18539912e100>
- Peralta-González, M. J., Frías-Guzmán, M., & Gregorio-Chaviano, O. (2015). Criterios, clasificaciones y tendencias de los indicadores bibliométricos en la evaluación de la ciencia. *Revista Cubana De Información En Ciencias De La Salud*, 26(3), 290–309.
- Persson, O., Glänzel, W., & Danell, R. (2004). Inflationary bibliometric values: The role of scientific collaboration and the need for relative indicators in evaluative studies. *Scientometrics*, 60(3), 421–432. <https://doi.org/10.1023/B:SCIE.0000034384.35498.7d>
- Pertuz, V., Pérez, A., Vega, A., & Aguilar-Ávila, J. (2020). Análisis de las redes de colaboración entre las instituciones de educación superior en Colombia de acuerdo con researchgate. *Revista Española De Documentación Científica*, 43(2), e265. <https://doi.org/10.3989/redc.2020.2.1686>
- Torres-Salinas, D., Robinson-García, N., Herrera-Viedma, E., & Jiménez-Contreras, E. (2018). Consideraciones metodológicas sobre uso del impacto normalizado en convocatorias Severo Ochoa y María de Maetzu. *Profesional De La Información*, 27(2), 367–374. <https://doi.org/10.3145/epi.2018.mar.15>
- Turpo-Gebera, O., Limaymanta, C. H., & Sanz-casado, E. (2021). Producción científica y tecnológica de Perú en el contexto sudamericano: Un análisis cuantitativo. *Profesional De La Información*, 30(5), 1–17. <https://doi.org/10.3145/epi.2021.sep.15>
- UNESCO (2018). Informe de la UNESCO sobre la ciencia, hacia 2030: informe regional de América Latina y el Caribe. <https://bit.ly/3K4P5ju>
- Uribe-Tirado, A. (2017). PUBLINDEX se usa como no se debe. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3489246>
- Waltman, L. (2016). A review of the literature on citation impact indicators. *Journal of Informetrics*, 10(2), 365–391. <https://doi.org/10.1016/j.joi.2016.02.007>

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