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ESTUDIOS / *RESEARCH STUDIES*

An analytical framework for the study of geographical places in the scientific literature

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Abstract: Scientometrics has traditionally examined place in terms of author affiliations and, as such, has tended to overlook the more detailed use of geographical data in scholarly publications to design indicators of the scientific literature. This study constructs a comprehensive framework to formalize and unify the Scientometrics analysis of places (Spatial Framework to identify Bibliographic Relationships or SFBR), constituting three main stages: identification, description, and measurement. We present five descriptive dimensions and a set of 57 core metrics for scrutinizing the place-related features of science. These metrics encompass author-, publication-, and place-level parameters, categorized according to the specific section (zone) containing the geographical information (i.e., citing author affiliation, the body of the text, and cited author affiliation). The SFBR serves as an innovative tool for unraveling the significance and influence of place in scientific literature. By considering place a fundamental element in Scientometrics studies, it extends the boundaries of spatial bibliometrics and provides a more holistic understanding of place as research object.

Keywords: institutional affiliation, scientific collaboration, author-level metrics, article-level metrics, place-level metrics, geographical information, Scientometrics, spatial bibliometrics.

Marco analítico para el estudio de lugares geográficos en la literatura científica

Resumen: La Cienciometría tradicionalmente ha examinado los lugares principalmente a través de las afiliaciones de las personas autoras, pasando por alto a menudo la utilización exhaustiva de datos geográficos dentro de publicaciones académicas para diseñar indicadores científicos. Este estudio presenta un marco integral para formalizar y unificar el

análisis cienciométrico de lugares (SFBR), que comprende tres fases clave: identificación, descripción y medición de lugares. En este contexto, se presentan cinco dimensiones descriptivas y un conjunto de 57 métricas centrales para examinar aspectos relacionados con el lugar en la literatura científica. Estas métricas abarcan parámetros a nivel de autor, de publicación y de lugar, y quedan categorizadas según la sección donde se encuentra la información geográfica (afiliación autoría citante, el cuerpo del texto y afiliación de la autoría citada). El SFBR sirve como una herramienta innovadora para desentrañar la importancia y la influencia de los lugares en la literatura científica. Al posicionar los lugares como un elemento fundamental en los estudios cienciométricos, se amplían los límites de la Bibliometría espacial, ofreciendo una comprensión más holística de los lugares como objeto de investigación.

Palabras clave: afiliación académica, colaboración científica, métricas de autor, métricas de artículo, métricas de lugar, información geográfica, cienciometría, bibliometría espacial.

1. INTRODUCTION

Place is a complex concept that can be evoked in many ways, from a physical space (real or imaginary) to a place of understanding or even a social place (Lefebvre, 1991; Pillet Capdepón, 2004), through a multitude of quasi-synonymous terms (e.g., space, territory, location, area, site, landscape). The concept of place can differ significantly depending on the academic domain in which it is handled, be it geography, politics, history, law, sociology, psychology, etc. For this reason, and despite advances in technology and the development of geographic information systems (GIS) and their use in science (Longley et al., 2005), some authors have posited the lack of an overarching theory of place (Sui and Goodchild, 2011; Cresswell, 2014).

However, various attempts have been made to define place based on a consideration of its different uses. Agnew (1987), for example, identifies three fundamental components of the concept: i) location, i.e., an element with fixed objective coordinates about a given point; ii) locale, i.e., the material settings for social relations; and iii) sense of place, i.e., the subjective, emotional attachments people have to a place.

In the science of science, a pluralist sensibility towards the nature of science emerged with the publication of Thomas Kuhn's seminal work (1962). From that date, the geographical perspective of science grew significantly, showing that "science is indelibly marked by the local and the spatial circumstances of its making" (Shapin, 1998), promoting the undertaking of studies that sought to determine the local or regional impact that science organizations (e.g., universities) have on development, thus linking science and location (Grossetti, 1995; Grossetti et al., 2007; Sterlacchini, 2008; Belenzon and Schankerman, 2013).

Subsequently, the development of pioneering bibliographic databases has enabled us to study different spatial aspects of science (Frenken et al., 2009) and represent science spatially through maps of science (Small and Garfield, 1985). The development of GIS, in turn, has made it possible to explore the intersection between bibliometrics and geographic information in greater depth (Xuemei et al., 2014) in what has become known as spatial bibliometrics (Frenken et al., 2009).

Spatial bibliometrics has facilitated the study of: i) the geographical distribution of scientists (Gaillard, 1991); ii) the geographical distribution of disciplines (Carvalho and Batty, 2006); iii) scientific productivity by place, including country-level (e.g., Zhou and Leydesdorff, 2006), city-level (Van Noorden, 2010; Eckert et al., 2013; Bornmann and De Moya-Anegón, 2019), institutional-level (Leydesdorff and Persson, 2010), and group-level (Cuyala, 2013; Maisonobe, 2013) analyses; iv) citation-based impact by place (Batty, 2003; Wuestman et al., 2019); v) research excellence (Bornmann et al., 2011; Bornmann and Waltman, 2011); vi) scientific collaboration, including conceptual (Cronin, 2008), methodological (Katz, 1994), and applied (Gazni et al., 2012; Hoekman et al., 2009) studies; vii) proximity, including its concept (Frenken et al., 2009) and effects (Ponds et al., 2007; Pan et al., 2012); viii) scientific mobility (Laudel, 2003; Robinson-Garcia et al., 2019), including the brain drain phenomenon (Laudel, 2003); ix) the geographical location of research funders (Grassano et al., 2017); x) the geopolitics of university rankings (Pietrucha, 2018); xi) attendance at scientific events (Van Dijk and Maier, 2006); xii) local and regional scholarly studies (Tijssen et al., 2006); xiii) science maps (Borner, 2010); and xiv) the multi-affiliation of authors (Halevi et al., 2023).

Although spatial bibliometrics has provided metascience with a geographical perspective, the view is limited because its geographical information is extracted exclusively from an author's institutional affiliation. However, scholarly publications con-

tain other relevant geographical information in the metadata fields of their bibliographic records (Castro-Torres and Alburez-Gutiérrez, 2022; Miguel et al., 2024 and the main body of their texts (Acheson and Purves, 2021) that can provide insights into the place where a particular study has been conducted, the specific location where samples have been taken or analyzed, the area in which fieldwork has been performed, or the city where a study's subjects have been interviewed or surveyed. Hence, the design of new Scientometrics indicators based on place mentions would allow researchers to measuring and gain insights into other aspects related to the influence of place on research and vice versa.

Publications concerned with the extraction of geographical information from scientific publications - beyond, that is, the authors' affiliations - have garnered limited attention. Nevertheless, this body of literature exhibits a solid technical and experimental nature, and has occupied itself with a range of disciplines or scientific domains rich in such information, including orchards and cancer genetics (Acheson and Purves, 2021), food packaging (Lentschat, 2020), phylogeography (Weissenbacher et al., 2015; 2017; 2019), the life and earth sciences (Karl, 2019), geology (Leveling, 2015; Kmoch, 2018), biology (Scott et al., 2021), and ecology (Tamames and De Lorenzo, 2010; Martin et al., 2012; Karl et al., 2013). Among studies taking an information science (and bibliometric) approach, local science-oriented publications stand out at both national (Chinchilla-Rodríguez et al., 2015; Miguel et al., 2015; González et al., 2019; Miguel et al., 2023) and regional (Arias and González, 2021) levels. Unlike publications based on authors' affiliations, however, most of this body of literature lacks a scientometric conceptual basis, especially as regards the measurement of places using quantitative indicators.

A few attempts have been made to conceptualize place-mention analysis from a bibliometric perspective (Page, 2010; Eckert et al., 2013; Cascón-Katchadourian et al., 2023); however, these works generally employ basic metrics (e.g., the number of publications mentioning a place) and do not exhaustively exploit all extant place metrics. Thus, a general Scientometrics-inspired framework is necessary to situate the concept within quantitative science studies, integrating, in this way, traditional studies of authors' affiliation and scientific collaboration with modern studies of place mentions.

Therefore, the present paper's main objective is to propose and define a Scientometrics framework for the study of place mentions in the scientific literature that can serve as a baseline for future conceptual, methodological, or descriptive studies.

2. METHODS

The framework employed herein was developed systematically from the study of the scientific literature, on the one hand, and from a review undertaken by experts and the authors of this paper, on the other. It was, moreover, constructed by exploiting a sequential point of view obtained in the following three stages: the identification of a place (through place mentions), the description of a place (in terms of its essential characteristics), and the measurement of a place (using bibliometric indicators).

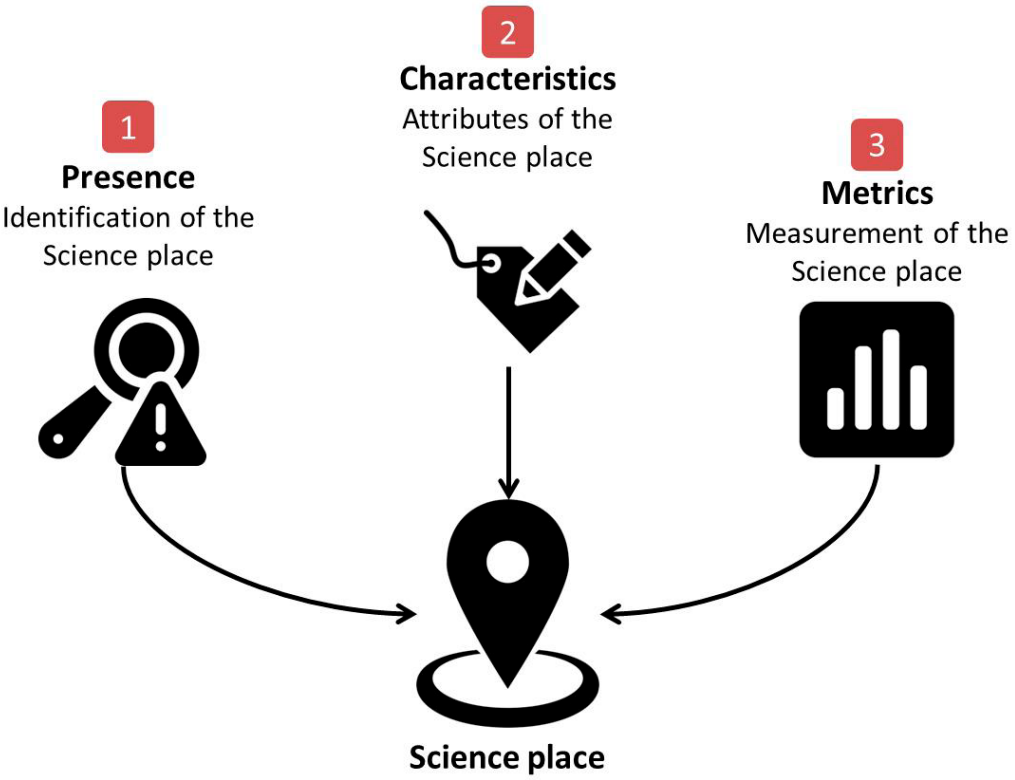
In the identification stage, the scientific literature dedicated to the geoparsing of scholarly publications was taken into consideration - above all, the work of Acheson and Purves (2021) - as well as the literature oriented towards highlighting inconsistencies in authors' institutional affiliations, e.g., Taşkın and Al (2014). Second, the description stage was concerned with identifying the attributes of a place. To this end, a brainstorming session was conducted among the authors of this paper - all of whom have extensive experience in publishing and reviewing scholarly publications - aimed at identifying these attributes and agreeing on classes for each attribute. The first author distilled all this information, which the other four debated, discussed, and edited. Finally, the measurement stage involved identifying areas based on geographical information (i.e., place mentions), establishing bibliographic relationships between authors, publications, and places (e.g., mentions, citations, co-citations, and bibliographic couplings), and assigning geographical relationships between places (e.g., local, national, regional, and international), via physical and institutional proximity estimations (Frenken et al., 2009).

The scientific literature on spatial bibliometrics (see Frenken et al., 2009) integrates affiliation-related indicators within this framework. Additionally, the concept of 'heterogeneous couplings' (Costas et al., 2021) was adopted to refer to the relationships between scholarly and non-scholarly publications when establishing the spatial relationship between two publications mentioning places.

3. RESULTS

The study of place in scholarly literature can be structured into three main blocks (Figure 1). The first block - *presence*, detected by place identification - is concerned with accurately identifying a place in a scholarly publication, paying particular

Figure 1. General framework for the study of place in the scholarly literature.



attention to linguistic uses. The second block - that is, description, with a specific concern for the *characteristics* of place - is concerned with defining a place previously identified by employing a distinct set of attributes. Based on metrics, the third block establishes indicators that reflect other uses of a place in the scientific literature.

The three blocks making up this study of place (as depicted in Figure 1) are described in greater depth in the following subsections.

3.1. Presence of science places

When considering the places mentioned in the authors' affiliation fields, the inherent lack of spatial precision in the information supplied must be borne in mind (Eckert et al., 2013). Such inaccuracies may arise from typographical errors, different degrees of geographical detail (i.e., where the same place may be described with varying levels of information), topographic variations, or insufficient data (e.g., identical place names within the same country). All these factors constitute a substantial challenge to efforts to assign a specific geographical location with any degree of accuracy based on the addresses provided by authors in their publications. This challenge is exacerbated when seeking to set a place in an aggregate space, such as a scientific area (Bornmann and De Moya-Anegón, 2019), given that it requires complex, time-consuming data-cleaning processes.

In the case of places mentioned in the body of the text, the challenge is even more significant. Here, the study of places requires the precise identification and recognition of toponyms (Bensalem and Kholladi, 2010), a process referred to as geoparsing (Leidner and Lieberman, 2011). However, this is frequently hindered by several critical technical limitations attributable to the authors' linguistic uses, making the identification task more complex. Table I shows the main obstacles to the accurate recognition of place names.

The complexity of this task also depends on the purpose or nature of the analysis. A closed analysis (i.e., identifying all mentions of one place or region) is more straightforward than an open analysis (i.e., identifying all place names mentioned). Likewise, a monolingual analysis (i.e., a corpus of documents written in a single language) is more accessible than a multilingual analysis (i.e., a corpus of publications in different languages). Similarly, a

Table I. Recognition of place names.

Limitation	Example
Polysemy	Dakota (US district and a personal name); Granada (a Spanish city, fruit, and car model).
Synonymy	Córdoba (city in Spain and city in Argentina).
Equivalence- intra language	Pampasia, Pampa, Pampeana (different terms referring to the same Argentinean region).
Equivalence- inter language	London, Londres, Londra, Londyn, Lontoo, ロンドン, etc.
Typographical errors	Buenoz Aires; Vallencia, New Tork.
Ambiguity	Alcalá (i.e., Alcalá de Henares; Alcalá de Guadaira; Alcalá del Río).
Informal uses	La ciudad del Turia (i.e., Valencia, in Spain); CABA or Baires (i.e. Buenos Aires, in Argentina); Ciudad de la luz or Ciudad Luz (i.e. Paris, in France).
Demonyms	French (France); Spanish (Spain).
Geographical rename	Terra de Santa Cruz (Brazil); Persia (Iran).

metadata-level analysis (i.e., an analysis of publications based on specific descriptive fields, such as the title, abstract, or keywords) can be completed more readily than a full-text analysis; however, the former is insufficient for identifying all the places that may have been mentioned in a single publication.

Whole-part relationships constitute an additional element of complexity. For example, if a publication mentions the city of Madrid, we can infer that Spain has been indirectly mentioned since Madrid is located in Spain. For this reason, in some studies, whole-part relationships need to be established between places to offer results at different levels of aggregation.

The toponym resolution is the relationship between the place mentioned and the unambiguous spatial footprint of that same place (e.g., latitude/longitude coordinates). However, the toponym resolution can be a further element of complexity in identifying a place name, especially in studies that visualize places on 2D or 3D maps. The resolution can be critical when the original place is incompletely or ambiguously mentioned.

Identifying place names may also be influenced by the scientific traditions that typify different research disciplines and which operate distinct representation mechanisms and rules when mentioning places.

Finally, the names of territories may change because of political conflicts and war. Thus, cities or countries may have changed their name (e.g., Madras became Chennai; Byzantium became Constantinople and later Istanbul), disappeared (e.g., Ctesiphon, the ancient Persian capital city), been disaggregated (e.g., Yugoslavia was broken down into Bosnia and Herzegovina, Croatia, Montenegro, North Macedonia, Serbia, and Slovenia), changed their geographical limits (e.g., the Roman empire), changed ownership (e.g., Strasbourg has belonged to both France and Germany), or ended up sharing the same border (e.g., the twin cities of Nova Gorica in Slovenia and Gorizia in Italy).

3.2. Characteristics of science places

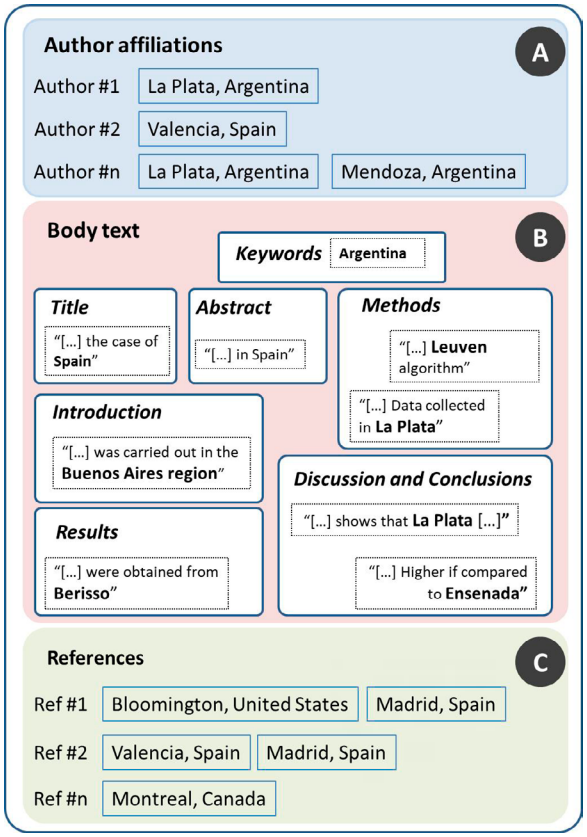
After identifying a place, the next step is to describe it. The following attributes must be defined to make this description:

Position

This attribute refers to the actual location where the mention of a place appears. Here, we propose breaking a publication down into three zones: A (affiliation), B (body of text, including title, abstract, and keywords), and C (references), in which the mentions of a place can occur (Figure 2).

While zones A and C have been extensively addressed in the literature and focus on the authors' institutional affiliations, zone B has been barely explored. The appearance of mentions in this area does not necessarily respond to affiliations but to places used explicitly in the research.

Figure 2. Zones of a scholarly publication containing mentions of location.



Within zone B, mentions can be distinguished according to the specific section of the article in which they appear: i.e., title, abstract, keywords, introduction, method, results, discussion, conclusions, acknowledgments, or supplementary material (with each discipline/document type potentially introducing variants in the names afforded these sections).

Nomenclature

This attribute captures how the place is mentioned in the publication. An author might use a place name, its geographic coordinates, an image, or a geocode, among other options.

Method

The method employed when mentioning a place may be either direct (e.g., the sample was collected in "La Plata") or indirect (e.g., the samples were analyzed at the "Instituto Médico Platense" [La Plata Medical Institute]). In the first instance, the place (La Plata, an Argentine city) is explicitly mentioned, while in the second, the place can be inferred from the mention of a hospital located in the city of La Plata.

Geographical category

This attribute refers to the class of the place, as used in geographical nomenclators. Thus, we can distinguish between administrative divisions, populated places and buildings, hydrography, orography, and transportation infrastructure.

Geographical scope

This attribute refers to the breadth of the mention, which might range from a specific space (e.g., a mountain, a bridge, or a building) to a city (e.g., Jeddah), a region (Mecca), a country (Saudi Arabia), a supranational area (Arabia) or a continent (Asia). It applies above all to places categorized as administrative divisions.

Role

This attribute indicates the specific function a mention has in a scholarly publication. Depending on the mention, a place can be categorized as playing either an endogenous (i.e., a mention directly related to the research conducted) or exogenous (i.e., a mention unrelated to the study carried out) role (see Table II). It should be borne in mind that the same place can take on different roles in the same publication depending on the mention it receives.

3.3. Place metrics

Once the places have been identified and described, their use in the scholarly literature is quantified in the next stage. The term "place metrics" has been specifically coined in the present study to embrace all the metrics related to mentioning places, regardless of their geographical scope, role, method, and nomenclature.

Figure 3 depicts the conceptual framework devised - a Spatial Framework to identify Bibliographic Relationships (SFBR) - in which all "place metrics" are identified. Here, a "cited scholarly publication" is taken as a baseline. This publication can either be cited by another scholarly publication (referred to as "citing scholarly publication") or a non-scholarly publication (referred to as "citing non-scholarly publication"). The cited scholarly publication can, in turn, cite other publications that appear in their zone C (see Figure 2) as cited references. Finally, users may consume the cited scholarly publication (e.g., read, download) in different places. Since citing (active, oriented to productivity)

Table II. Roles related to the mention of a place in a scholarly publication.

Type	Role	Description	Example.
Exogenous	**Informative**	The mention of the place does not respond to scientific interests. It is entirely trivial in the context of the study.	The service was acquired by X, a company based in Basel.
	Disambiguation	The mention is included to disambiguate the meaning of one term, but it is not related to the study.	Valence (in Spanish, this name also refers to the name of a city).
	Circumstantial	The mention of the place appears as part of a proper name (company, organization, brand, event, etc.), but does not necessarily imply a place related to the research.	The Budapest Declaration. *Cervecería y Maltería Quilmes.*
	Affiliation	The mention is made to indicate the place of professional affiliation of the author.	Universidad Complutense (Madrid, Spain).
Endogenous	**Origin**	The mention indicates where information was obtained for the study (e.g., place where samples were collected, area where interviews were conducted, place where fieldwork was conducted, etc.).	Place of sample collection. Place of interviews or surveys. Location of fieldwork.
	Author location	The mention is made to indicate the place where the author was when collecting information. This place may not coincide with the place where the analyzed data were located or processed.	Location where the user collects data online from a website.
	Object location	The mention indicates the place where the object of study was analyzed. It does not necessarily have to coincide with where the data were obtained.	Patients treated in a hospital. Food processed in a specific orchard.
	Effect	The mention indicates where an effect, or a direct or indirect consequence, of the study findings occurred.	Disaster zones. Economic consequences.
	Target	The mention indicates a place that was the object of study, either directly or indirectly.	Direct: The goal is to analyze the Paris riots. Indirect: results from the University of Berlin were collected.

and being cited (passive, oriented to impact) acts lead to different indicators, they have been separated in the model to illustrate the bibliographic relationships in greater detail. However, they reflect reflexive actions (A cites B and B is cited by A).

The different place metrics identified in Figure 3 (letters A to Q) are defined below. For clarity, we assume just one author per citing or cited publication. However, geographic relationships must be computed for each citing/cited author pair.

A. Multi-affiliation

The author might have one or more institutional affiliations, including a city, region, and country. In this case, a relationship is established between all the author's affiliations.

B. Collaboration

The author might collaborate with other authors, co-authoring a publication. In this case, a relationship is established between the affiliations of the co-authors.

C. Place mention (from author's affiliation)

The author might mention a place in the publication. In this case, a relationship is established between the author's affiliation and the place mentioned.

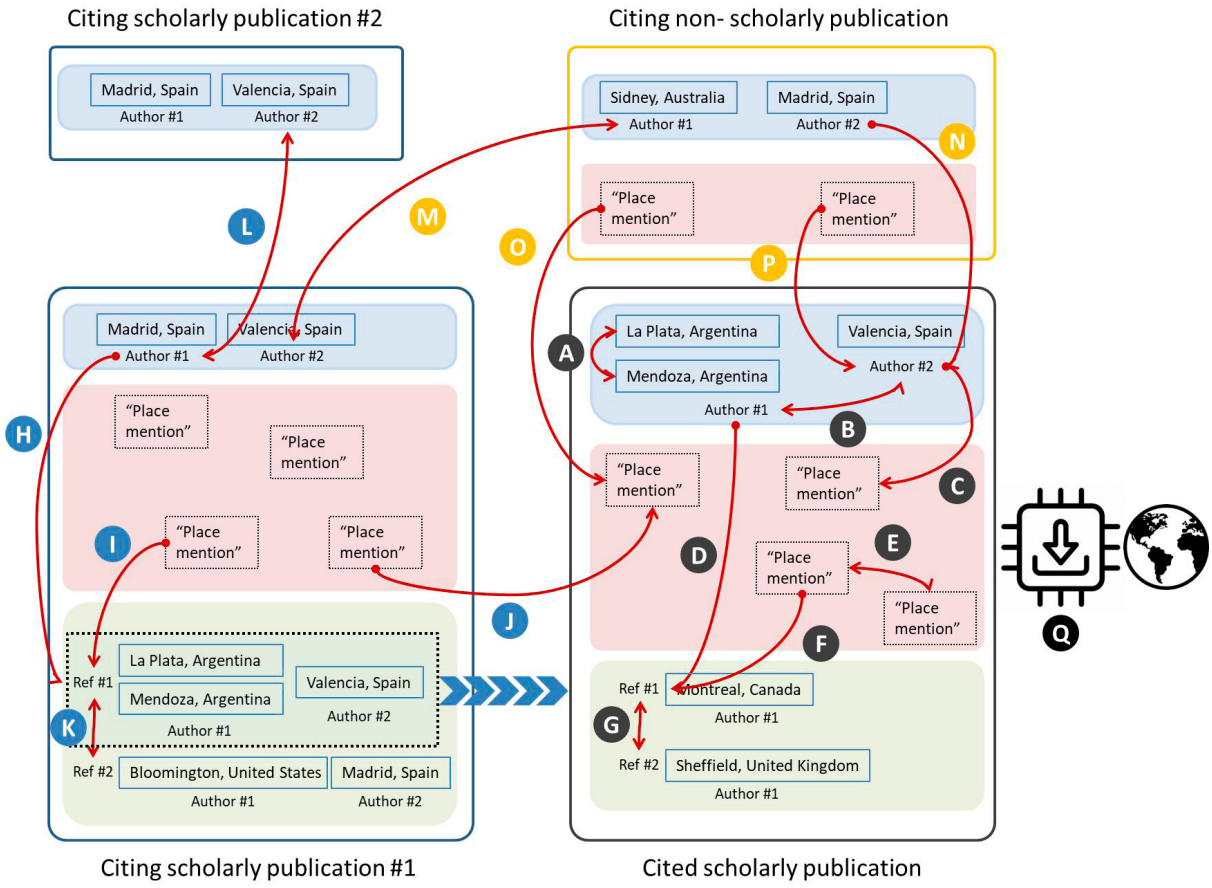
D. Cited affiliation

The author might include a citation to another publication, which will be described in the references. In this case, a relationship is established between the citing author's and the cited author's affiliations.

E. Place co-mention

The author might mention more than one place in the publication. In this case, a relationship between these places is established.

Figure 3. Spatial Framework to identify Bibliographic Relationships (SFBR).



F. Place explicitly cited (in the cited document)

A place might be mentioned with a bibliographic reference, indicating a direct relationship between the place and said reference. For example, we might find in the cited document a sentence such as "… previous results have shown that productivity in the Netherlands has increased in the last decade (AuthorName, year)". In this case, a connection is established between the place (i.e., the Netherlands) and the cited author's affiliation (i.e., the affiliation of AuthorName).

G. Co-cited affiliation (in the cited document)

The author might include citations to different publications, which are all described in the references. In this case, a relationship is established between the affiliation of the cited author of one cited reference and the affiliation of the cited author of another.

H. Citing affiliation

Another scholarly publication might cite the author's publication. In this case, a relationship is established between the cited author's and the citing author's affiliations.

I. Place explicitly cited (in the citing document)

A place might be mentioned in a publication accompanied by a bibliographic citation. For example, in a document authored by AuthorName1, we might find a sentence such as "The literature has shown that the riots in Paris are related to […] (AuthorName2, year)". In this case, a relationship is established between the place (i.e., Paris) and the citing author's affiliation (i.e., the affiliation of AuthorName1).

J. Place coupling

A place might be mentioned in two different publications. In this case, a relationship is establi-

shed between the documents mentioning the same place.

K. Co-citation of affiliations (in the citing document)

The author's publication might be cited by other scholarly publications, which may include other cited references. In this case, a relationship is established between the authors' affiliations of each cited reference.

L. Affiliation coupling

Two different scholarly publications might mention the same place. In this case, a relationship is established between the affiliation of the author of the first publication and that of the author of the second publication.

M. Heterogeneous affiliation coupling

Two publications might mention a place, a scholarly publication, and a non-scholarly publication (e.g., Facebook post, tweet, unpublished report, presentation). In this case, a relationship is established between the affiliation of the author of the scholarly publication and that of the author of the non-scholarly publication.

N. Heterogeneous citing affiliation

A non-scholarly publication might cite the author's publication. In this case, a relationship is established between the cited author's and the citing author's affiliations.

O. Heterogeneous place coupling

A place might be mentioned in two different publications: a scholarly publication and a non-scholarly publication. In this case, a relationship is established between the two publications mentioning the same place.

P. Heterogeneous place explicitly cited (in the citing document)

A non-scholarly document might cite the author's publication, including a place mention. In this case, a relationship is established between the place and the citing author's affiliation.

Q. Place usage

Users can use the author's publication (e.g., read, download) in different places. In this case, a relationship between the author's affiliation and the user's location is established.

From the 17 types of geographical relationships, 57 place metrics are proposed (Table III). The definition of each metric, along with illustrative examples, is included in Annexes I (author-level), II (place-level), and III (publication-level). The annexes are presented as supplementary material (see section 9).

Places in zones A and C are based exclusively on the institutional affiliation of the publication's authors. In contrast, places in zone B are based solely on the places explicitly mentioned by the publication's authors elsewhere. However, note that the metrics of the AB intersection are related to the quantitative study of the places mentioned based on the authors' affiliation, whereas those of the AC intersection are related to the relationship between the institutional affiliation of the publication's authors and the institutional affiliation of the cited references' authors. Finally, those of the BC intersection are related to the relationship between the places mentioned and the affiliations of the cited references' authors.

Three main types of indicator have been considered to generate metrics. First, "count indicators" gauge the frequency of a place's mention (i.e., how often an author mentions a place: for example, author A mentions Place 1 five times). Second, "breadth indicators" measure the number of elements generating or receiving mentions (i.e., unique authors mentioning a place or being mentioned from a place: for example, five authors mention Place 1). Third, "profile indicators" determine the scope of the geographical relationship between an author's affiliation and other places, including those mentioned by the author or the affiliations of collaborating or cited authors (for example, Place 1 and Place 2 have a regional relationship).

While other cross-cutting indicators exist - most notably, the h-index, g-index, and i10-index (each calculated using identical procedures across various bibliographic databases and employing different parameters, that is, places, authors, and publications) - they have not been included here for the sake of clarity. However, they could be applied, expanding the range of possible indicators based on the bibliographic relationships established in Figure 3.

All metrics presented can be computed in absolute and disaggregated forms, depending on the attributes associated with the place, author, or document under analysis. Thus, these counts can be refined by taking into consideration such factors as the location of the mention (e.g., introduction, methods, results), the nomenclature employed (e.g., coordinates, textual mention), the purpose of the reference (e.g., informative, target, affiliation), the document type generating or receiving the mention (e.g., journal articles, conference papers, books, chapters, reports, posts), the publication year of the document generating or receiving the mention, the

Table III. Summary of science places metrics by level (author, place, and publication) and zone of publication (A, B, and C).

AREA	Author-level	Place-level	Publication-level
A	Collaboration profile. Affiliation profile. Affiliation output. Collaboration breadth. Collaboration (%).	Output. Collaboration breadth. Collaboration count.	Collaboration profile. Affiliations breadth.
AB	Mentioned places profile. Mentioned places breadth. Mentioned places count.	Author mentions breadth. Author mentions count.	Place mention profile.
AC	Cited affiliations profile. Cited affiliations breadth. Cited affiliations count. Citing affiliations profile. Citing affiliations breadth. Citing affiliations count. Heterogeneous citing affiliations breadth Heterogeneo.us citing affiliations count.	Cited affiliations breadth. Cited affiliations count. Citing references breadth. Citing references count. Heterogeneous citing references breadth. Heterogeneous citing references count.	Cited affiliations profile. Cited affiliations breadth. Cited affiliations count. Citing affiliations profile. Citing affiliations breadth. Citing affiliations count. Heterogeneous citing affiliations breadth. Heterogeneous citing affiliations count.
B	AEP mentions count. AEP citations count.	Mentions count. Average intensity. Co-citation.	Mentioned places breadth. Mentioned places count.
BC	PEC mentions breadth. PEC citations count.	PEC mentions output. PEC mentions count.	PEC mentions breadth. PEC mentions count.
C	Neighborhood breadth. Neighborhood count.	Neighborhood breadth. Neighborhood count.	Neighborhood breadth. Neighborhood count.

Note: A: Author Affiliation; B: Body Text; C: References; AB: metric based on the relation between zones A and B; AC: metric based on the relation between zones A and C; BC: metric based on the relation between zones B and C. AEP = authority explicitly placed and PEC = place explicitly cited. See supplementary material for a detailed description of each indicator.

position of the author generating or receiving the reference, or even the disciplinary focus of the journal generating or receiving the mention.

Moreover, metrics implying a connection between two places (e.g., places cited by an author affiliated with an institution in a specific location) can be further dissected based on the scale of the geographical relationship between these places (e.g., local, regional, national, and international).

Furthermore, all these metrics can be computed based on the geographical scope assigned to the place, ranging from that of a specific area, municipality, region, or country to that of a supranational region, continent, or even an entire planet. This scope may be explicitly mentioned in the publication (e.g., the Netherlands is mentioned directly) or inherited (e.g., Amsterdam is referenced and is additionally attributed to the Netherlands due to the geographical association between the two references).

The number of place-related indicators expands significantly when the various data disaggregation parameters and geographical coverage units are taken into consideration. Annexes I, II, and III provide illustrative examples for each metric, breaking them down into multiple parameters and providing instances for places of varying geographical scope.

4. DISCUSSION

The above framework comprises three consecutive stages of identifying, describing, and measuring science places. To the best of our knowledge, this is the first attempt to formally and comprehensively define the use of place in scientific publications (i.e., integrating studies based on author affiliations, on the one hand, with studies based on the identification of place names in the text, on the other), and to propose specific indicators where place is explicitly measured as an independent entity (place-level metrics), thus expanding the notion of spatial bibliometrics (Frenken et al., 2009) and integrating the concept of heterogeneous couplings to consider place mentions between scholarly (including peer-reviewed publications and patents) and non-scholarly (e.g., press releases, clinical guidelines, policy reports, working papers) documents (Costas et al., 2021).

Although other place-mention roles or place metrics might be identified, our primary objective here is not to be exhaustive in the lists we have drawn up but rather to structure the different components on which the study of places is based and to situate them cognitively under the umbrella of Scientometrics. In so doing, observation, bibliographic review, and expert review have been carried out. Consequently, the findings need to be expanded and improved by undertaking further empirical and theoretical studies.

In the case of the place metrics proposed here, the following issues must be considered. First, to facilitate calculation, most of the indicators are based only on the primary affiliation of each author; however, there is a clear need to expand their coverage by considering the multiple affiliations of each co-author. Second, the problems created by institutions with numerous headquarters (in some instances located in different regions and cities) must be addressed since this adds considerable complexity to the computation of some indicators. Third, we have included author-, publication-, and place-level metrics; however, other aggregations, including journals, groups, or universities, should also be studied. Fourth, the indicators address content explicitly mentioned within a publication (zones A, B, and C); however, metadata containing other geographical information (e.g., a publisher's location) may be equally interesting. Fifth, usage metrics (e.g., downloads from specific locations) are not included in the proposal (see supplementary material) and should be specifically developed in future research.

However, the calculation of some place-related indicators is computationally complex, entailing not only the collection of multiple affiliations but also the establishment of a geographical relationship (e.g., affiliation with affiliation, affiliation with place-mention, and place-mention with place-mention) both for cited and citing publications, and for scholarly and non-scholarly publications. To this, we should add the complexity of correctly identifying each place name, which can be challenging even for formatted data included in the authors' affiliations (Eckert et al., 2013).

Meta-researchers and geographers interested in determining the role played by place in scientific activity; researchers seeking to identify key locations in their disciplines; research evaluators wishing to gain insights into the local/international role of authors, publications and journals; and, practitioners and librarians involved in developing bibliographic products may all have an interest in consulting place metrics and can fruitfully exploit the model proposed in this work. To obtain these place-related metrics, their first source of information is the publication itself, with mentions of place appearing explicitly and implicitly throughout the publication in zones A, B, and C (Figure 2). In this way, they can identify the places that refer to the authors' affiliations as well as those that might appear in the title, abstract, keywords, body of the work, notes, acknowledgments, and annexes. Their second source of information is the metadata of each publication, curated by publishers, repositories, or bibliographic databases. Mentions of places might appear primarily as toponyms (e.g., Norway) and demonyms (e.g., Norwegian), independently or as part of proper names (e.g., Norwegian University of Science and Technology).

Having obtained the geographical information, each place can then be identified by parsing the publication's full text and harvesting its bibliographic metadata. The use of place authority lists, gazetteers and thesauri is recommended to merge variants (e.g., London is equal to Londres), establish whole-part relationships (e.g., Paris belongs to France), and to confirm official nomenclature. Likewise, the use of administrative and geodesic place codes (e.g., Mapcode) is also recommended to ensure unique identification of each place. Each place mention should then be characterized. In some instances, this task may be automated (e.g., the section in which the mention appears), but, in others, human intervention is required (e.g., to determine the role of the mention). Each characterized place mention should next be allocated to a citing/cited entity (e.g., author, publication, and place). GIS are needed here to describe places more robustly as well as determine the geographical relationship between two places (e.g., local, regional, national, international). Academic identifiers (e.g., ROR, ORCID, DOI) are also required to assign places to authors, institutions, and publications accurately. OpenAlex natively includes ROR identifiers, and other bibliographic databases are likely to incorporate them gradually.

The following considerations should be taken into account when assigning place mentions to citing/cited agents. Given a work A, published by author B (affiliated in C), which cites a work by author D (affiliated in E), all mentions of places located in zone A will be considered citing affiliations. If there is more than one, the geographical relationship between the different affiliations of the same author will be used to calculate multi-affiliation. In contrast, the geographical relationship between the affiliations of the various authors, if any, will be used to calculate collaboration. On the other hand, all places mentioned in zones B and C will be considered cited places. The citing agent will

be assigned to the publication (i.e., the place is cited by work A), each author (i.e., the place is mentioned by author B), and each citing affiliation (i.e., the place is mentioned by affiliation C). Finally, the affiliations of the authors cited in zone C will be considered cited affiliations, mentioned by the work (i.e., affiliation E is mentioned by work A), each author (i.e., affiliation E is mentioned by author A), and each citing affiliation (i.e., affiliation E is mentioned by affiliation C). In all these cases, the mention date corresponds with work A's publication date.

The metrics can be obtained from ad hoc applications (operating from a collection of full texts imported into the system) or they can be directly provided by bibliographic databases, using their entire coverage of publications, thus facilitating the embedding of this information in publication-level metrics, author/ journal profiles, and new place profiles. While the full model requires the application to access the complete text of each publication, many indicators can be calculated on the basis of the information included in affiliations, titles, abstracts, and keywords, and which is already included in the metadata.

Journals could usefully provide authors with explicit guidelines to ensure places are mentioned in a standardized, unequivocal way and, in this way, help researchers in their studies of place, especially in some specific disciplines (e.g., history, geography, urbanism, zoology, archaeology, geology, and regional studies). Similarly, the inclusion of a section listing uniformly and unambiguously all places referenced in a publication would facilitate the automatic extraction of this information. This task could be further facilitated if HTML versions of manuscripts employed geo meta tags for extracting toponyms and demonyms. Finally, repositories could also request geographic information from authors when depositing their manuscripts as a means of generating geo metadata.

Although applications have already been developed that perform part of these tasks - above all, the identification of toponyms, their resolution and the calculation of basic metrics (Eckert et al., 2013; Acheson and Purves, 2021; Cascón-Katchadourian et al., 2023), there is no application currently available that allows toponyms to be identified accurately without human intervention (Gritta et al., 2018) or that permits all the indicators proposed and defined in the supplementary material of this work to be calculated on a large scale. There is, thus, a pressing need to design and test tools that facilitate the data collection and analysis of the place-related metrics embedded in the conceptual framework proposed in this work.

5. CONCLUSIONS

This work has proposed a Scientometrics-inspired framework for integrating different studies of geographical place in the scientific literature (i.e., extended spatial Bibliometrics). Its primary contributions include the identification and description of the main attributes of a place (e.g., location, nomenclature, method, geographical scope, and, especially, place mention roles) and the bibliographic relationships between elements containing geographical information according to the zone in which they are located in the scholarly work, that is, the SFBR model developed herein. The SFBR allows the integration of geographical and bibliographic information, strengthening the identification, description, and testing of new place-oriented bibliometric indicators. Thus, we have proposed 57 bibliometric place-based indicators, divided into author-, publication-, and place-level metrics.

Some indicators may not be prevalent, relevant in corpora with particular characteristics, or applicable only in specific fields. For this reason, future studies should be devised to test the bibliometric properties of these indicators, especially when we are concerned with determining disciplinary differences in the use of places, the local dimension of an author concerning a process of evaluation, the contribution of a place to scientific endeavor or the use of a place for the development of a particular line of research.

Place-based metrics could be used to assess the spatial profile of authors, institutions, publications, journals, and disciplines; facilitate the development of new bibliographic applications; perform quantitative analyses of places (e.g., studies of infra/supra-analyzed places in the scientific literature); generate new place networks (relationships between locations outside the recognized networks of collaboration), provide place-based search features (i.e., bibliographic products that can track publications by the places they mention); study science traditions (i.e., the use and style of places mentioned depending on the scientific field), unveil the reasons underpinning the mention of each location; support local research (i.e., how particular places have contributed to specific research lines and how research has influenced particular areas); and, facilitate the deployment of public policies seeking territorial development. Specific research is needed to design the most appropriate methods that can address these issues within the spatial framework proposed in this work for identifying bibliographic relationships.

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¡Conceptualization: Enrique Orduña-Malea; fund acquisition: Sandra Miguel and Claudia M. González; methodology: all the authors; supervision: all the authors; visualization: Enrique Orduña-Malea; writing - original draft: Enrique Orduña-Malea; writing: all the authors.

8. DECLARATION OF CONFLICT OF INTEREST

The authors of this article declare that they have no financial, professional or personal conflicts of interest that could have inappropriately influenced this work.

9. SUPPLEMENTARY MATERIAL

Supplementary material is available at: https://www.memoria.fahce.unlp.edu.ar/art_revistas/pr.18098/supplementary-material.pdf

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