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A Landscape of Open Science Policies Research

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Abstract

This literature review aims to examine the approach given to open science policy in the different studies. The main findings are that the approach given to open science has different aspects: policy framing and its geopolitical aspects are described as an asymmetries replication and epistemic governance tool. The main geopolitical aspects of open science policies described in the literature are the relations between international, regional, and national policies. There are also different components of open science covered in the literature: open data seems much discussed in the works in the English language, while open access is the main component discussed in the Portuguese and Spanish speaking papers. Finally, the relationship between open science policies and the science policy is framed by highlighting the innovation and transparency that open science can bring into it.

Keywords

open science, open science policies, Europe, Latin America

Introduction

Open science implies the opening of all phases of scientific research. Furthermore, Open Science is a participatory process for determining the scientific and research agenda in relation to "the public and their concerns" in society (Miedema, 2022). Garcia Aristegui and Rendueles (2014) consider open science is often framed as apolitical, but these authors believe this is not the case. Instead, they agree that openness (and the open movement) ultimately lies within the economic inequalities already existing in the neoliberal framework.

There are also divergent opinions about the globality of the value of open science. It is argued openness is usually progressive and differentiated (Fressoli & Arza, 2017) or that openness is not an intrinsic positive goal of science and needs to be promoted and rewarded at every step of the research process (Levin & Leonelli, 2017). Moreover, European governments have recognized the open science movement since the turn of the century (Gong, 2022). More specifically, the EU has made a significant effort to embrace Open Science as the standard for science and research in Europe since 2015 (Miedema, 2022).

Numerous reviews debate what open science is and what it encompasses. Several definitions have been proposed. For instance, Fecher and Friesike (2014) understand the term open science as an umbrella term that involves different understandings and viewpoints. Similarly, Abadal and Anglada (2020) argue that open science is not yet a well-delimited concept; its development depends on the advancements of each of its components. According to Vicente-Saez and Martinez-Fuentes (2018), open science is transparent and accessible knowledge shared and developed through collaborative networks. Furthermore, some reviews focus on particular subjects or publications on open science in specific countries. Fell (2019) carried out a rapid evidence assessment on the economic advantages of open science and identifies two ways in which open science makes an economic impact: efficiency, which refers to costs savings and productivity enhancement, and enablement, the creation of new products, services, companies, and collaborations. Another review from Ramírez-Montoya and García-Peñalvo (2018) concludes that most papers on open

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innovation focus on a business environment and academic environment. Moreover, it is argued that open Science has been shown to help bridge the evidence-policy divide, with assertions that it can increase policymakers' use of publicly available scientific discoveries and data (Reichmann & Wieser, 2022). Nevertheless, there is still a literature review gap on open science policies. The main objective of this article is to review a variety of research works that explore open science policies or touch upon this subject, and mainly explore the approach given to open science policy in these studies.

Methodology

To carry out this literature review we selected papers discussing open science policies as the main subject of study or articles that touch the subject tangentially. The results of this literature review were obtained reading and coding all of these articles in different stages:

(a) The document corpus was constructed searching Google Scholar, Semantic Scholar, and Scopus.

(b) The searches were made using keywords such as open science and open science policy and its translations to the different languages used in this review: English, Spanish, Portuguese, and French. Figure 1 presents a flowchart for the search and selection process of articles, alternatively, the specific search strings and their results are available in Appendix A. The final list of documents and its sources used in this review is available in Appendix B (Manco, 2022).

Finally, (c) The coding process was made using an inductive category development approach using the software Nvivo 12.

The specific research questions addressed are:

Which is the approach given to open science policy in the different studies?

Which components of open science are these papers covering?

Which are the main geopolitical aspects of open science policies?

How open science policies are framed in relation to science policy?

The selected articles have several interesting characteristics. The majority of the papers are written in English and come from countries from the global north (North America and Europe), then there is a major cluster of publications written in Portuguese from Brazil and the minority of papers are written in Spanish coming from Argentina and Spain and in French coming from France and Belgium. A regional approach of the papers can be seen in Figure 2.

Building upon the papers abstract, we constructed a word cloud of the keywords from the articles. It is evident that open data and their related issues, such as data repository public data, research data etc. are the most prevalent issues after open science itself (Figure 3).

The selected papers came from different sources, such as journals, conferences, and repositories. PLOS Biology is the source of four papers, LIBER Quaterly is the source of three papers while the conference ELPUB 2018 and the journals of Medicine, Health Care and Philosophy and Transinformação are the sources of two papers each. The rest of the sources have one selected paper. The complete list of sources used in this review is also available at Appendix B.

The selected works were published between 2007 and 2021 (Figure 4). Two distinctive periods are observable in this interval: a first period of conceptualization of open science and their policies until before 2015 and a second period, which starts around 2016 and coincides with the surge and establishment of the open science movement. Moreover, starting from 2017 a sharp increase in studies on open science policy is observable, which correspond with the formulation and implementation of open science policy in various environments.

Results

This section focuses on how different articles handle the notion of open science policy and its relationships. It is organized as follows: it begins with a section on the various studies' approaches to open science policy, followed by a description of the essential components of open science covered in the publications. The key geopolitical features of open science guidelines are then explored, followed by a discussion of how open science policies are presented in terms of science policy. Additionally, Table 1 presents the classified findings and their references by research question.

Approach to Open Science Policy

Back in 2010, Stodden (2010) argued that due to technological changes, the scale of rapid results has changed, so it is necessary to adopt policy countermeasures. According to this author (Stodden, 2010), these response measures should mainly include standards aimed at increasing transparency, as well as policy changes related to citizen scientists to increase their contributions; changes to data and code reuse. Advances in information and communication technology, as well as the growth of different kinds of digital platforms, are steadily changing open science policies and practices. (Vicente-Saez et al., 2020). Therefore, initiatives to develop and promote open science have been developed over the last decade (De Filippo & D'Onofrio, 2019). As for the perspective of open science, the trend toward openness will consolidate at a global level. Moreover, training and capacity

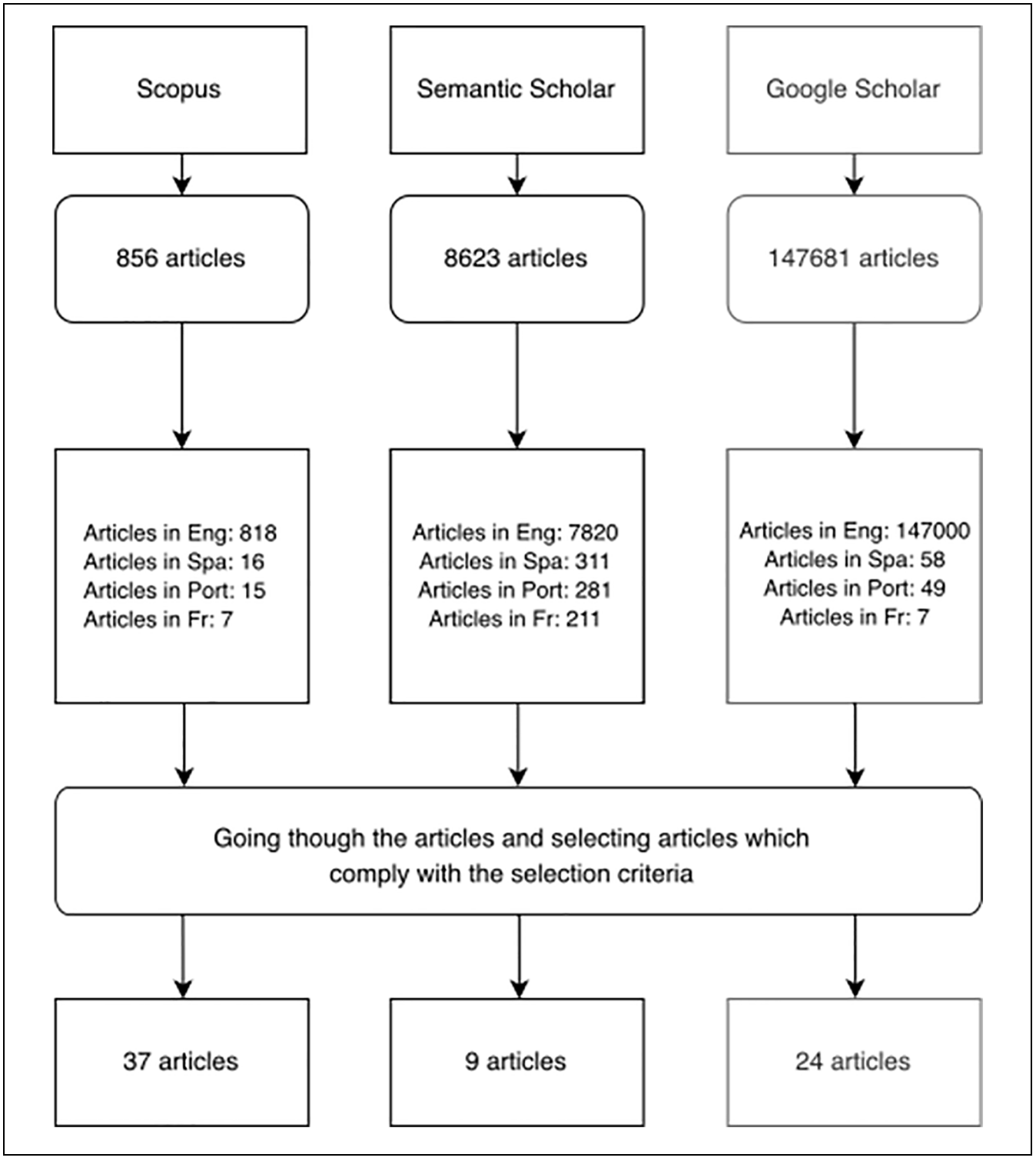

Figure 1. Flowchart for the search and selection process of articles.

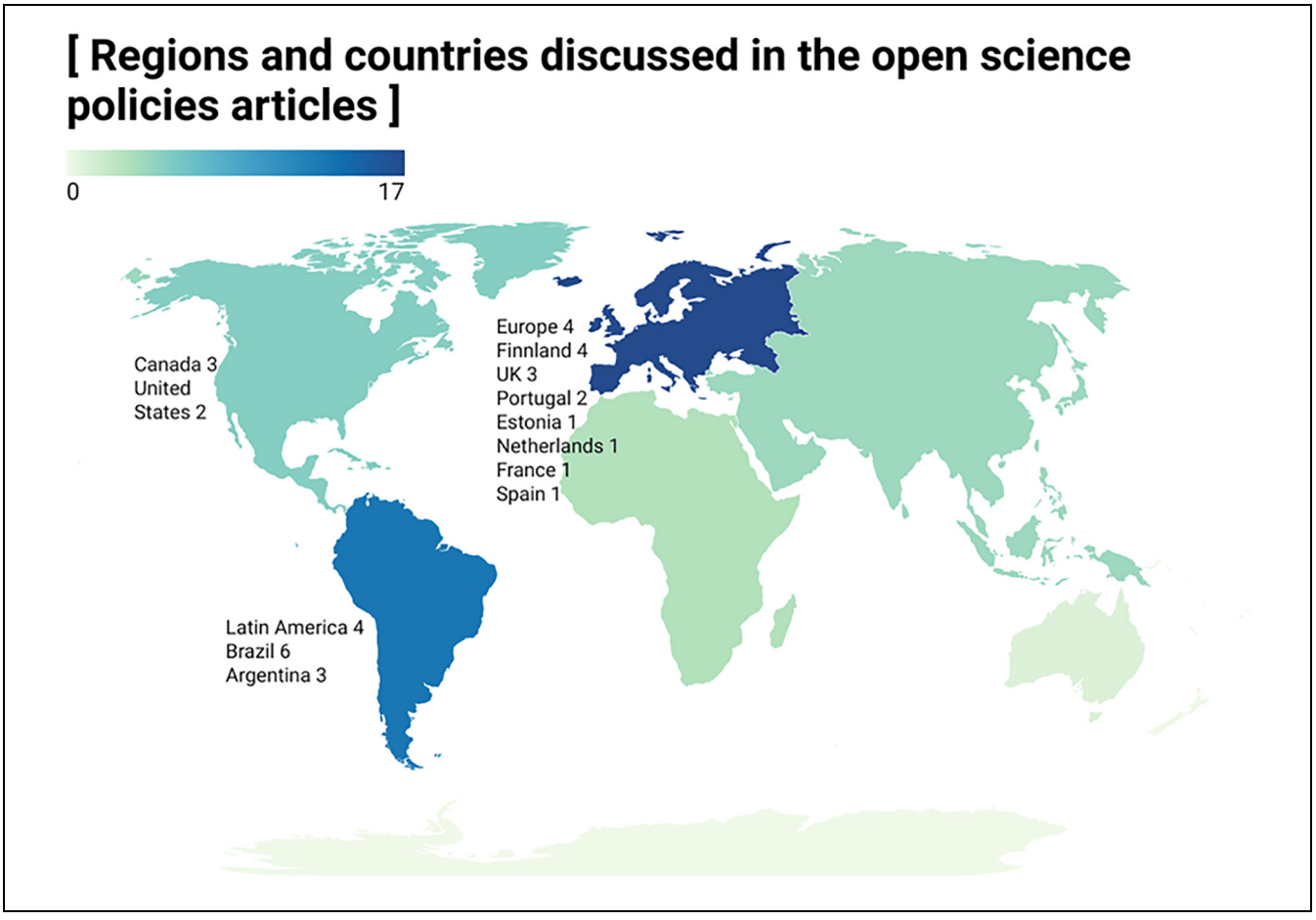

Figure 2. Regions and countries discussed in the reviewed open science policies articles.

building plans around the fields and practices of innovation and openness are very much needed to not be left behind (Fressoli & Arza, 2018).

Another important issue discussed in the literature is policy framing and its geopolitical aspects. In this regard, the geopolitics of open science is a complex issue as asymmetries in knowledge production and consumption are also replicated in policies (Chartron, 2018). Moreover, Albornoz et al. (2018) propose that policies are tools of epistemic governance. These researchers examined at how open science is framed in policy: (1) open access and open data as key facilitators of open science; (2) open science as a means of enhancing scientific efficiency; (3) research infrastructures and data repositories as enablers of open science; (4) open science as a strategic advantage in a knowledge-based society and their competitiveness; (5) the private sector as a facilitator of scientific funding and expenditure; (6) the key beneficiaries of open science as researchers whose efficiency will be increased by open science; (7) open science as a catalyst of creativity and socioeconomic progress, or as a response to global development challenges; and finally; and (8) open science is also envisioned as a model for reducing dependency on today's subscription-based journal structure.

An innovation frame is also observable. For instance, Vicente-Saez et al. (2020) argue that open science policies and practices are expanding the university's scientific and innovative spirit. Furthermore, Caulfield et al. (2012) argue for integration and compatibility between innovation and open science policies. These authors argue that a fluid and streamlined approach to innovation is needed (Caulfield et al., 2012). Moreover, investment in open science is presented as a means to prevent the outflow of innovation and to gain the capabilities needed to maintain international competitiveness (Albornoz et al., 2018). Moreover, Ali-Khan et al. (2017) argue that open science should not impose an additional burden on researchers, policies must make sharing easy, and structures should be built to enhance the competitiveness of researchers, research plans, and partnerships with patients and industry.

Open science also has negative facets such as threads, conflicts, and contradictions. A contradiction identified

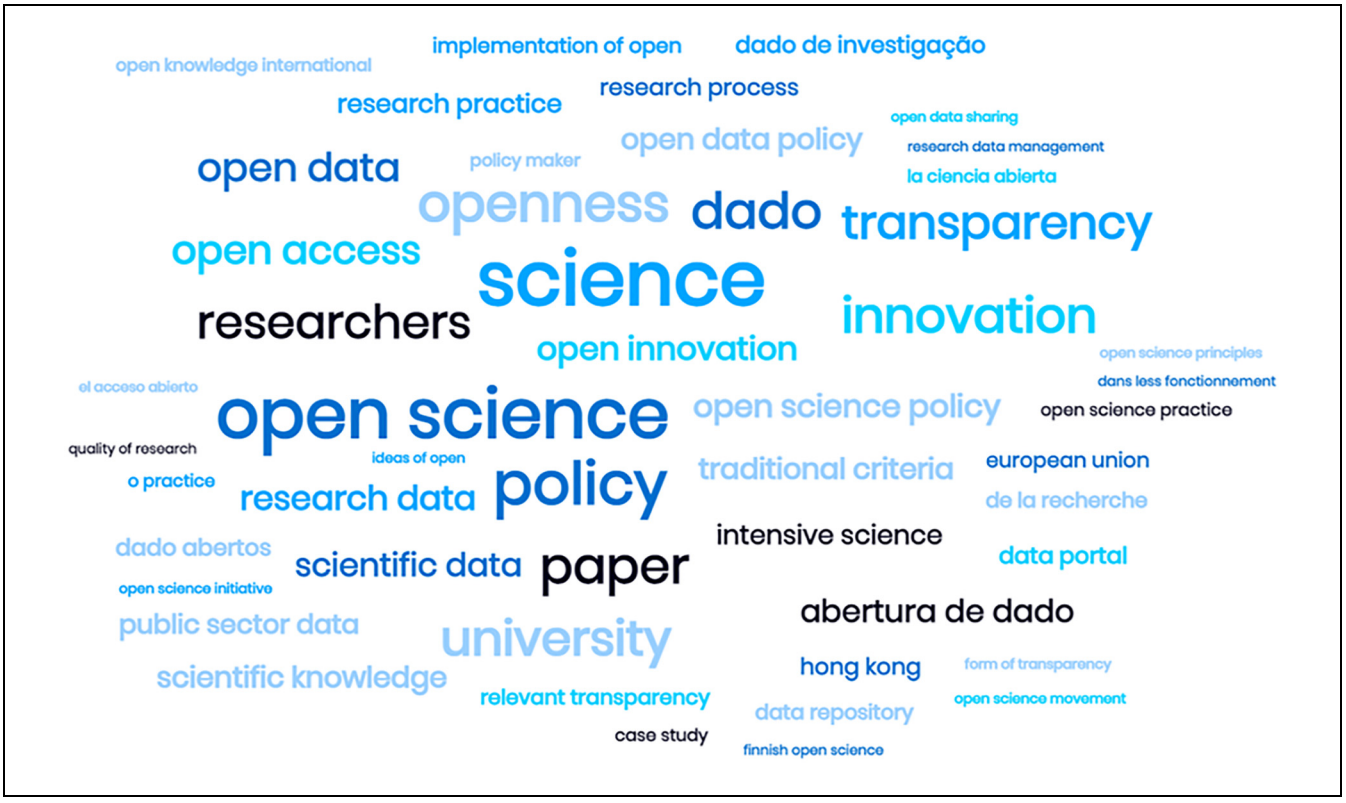

Figure 3. Word cloud generated from articles' abstracts.

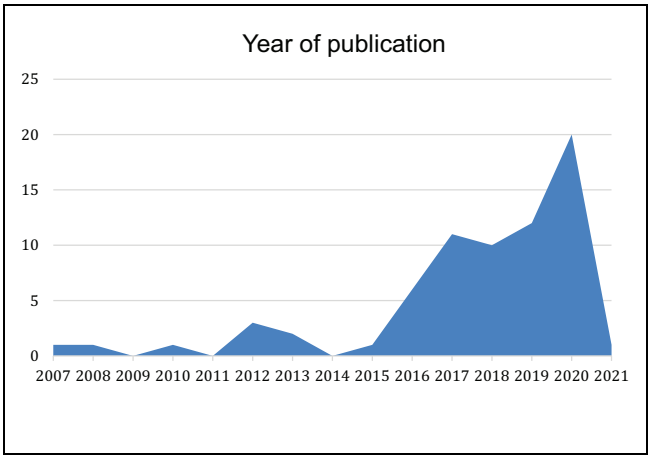

Figure 4. Year of publication.

by Levin and Leonelli (2017) is the fact that open science policies are generally formulated in a general way with general principles (more often than not revolve around economic value and data commodification) without taking into account particular differences in individuals, contexts, or social processes. In addition, Elliott and Resnik (2019) find that open science policies can create asymmetries between academic scientists who are forced to share their data and industry scientists who are not obligated to comply with such policies and are not required to follow such policies. Furthermore, Open science policies can also suppress social accountability by aiding special interest groups in distorting scientific findings and misleading the public.

A conflict between commercialization and open science is also presented in the literature. Caulfield et al. (2012) argue that there is a resisting and conflicting coexistence between commercialization policies and open science policies. Moreover, there is a further contradiction in the formulation of research policies: they encourage openness while continuing to promote scientific production through intellectual property and patents. This issue may create difficult tensions (Fressoli & Arza, 2018).

Actors, Stakeholders, and Their Institutional Policies

Among various institutions and scholars, openness is gaining traction (Smart et al., 2019). In the research environment, there are a variety of players. This section will highlight some of the stakeholders listed in the literature and their key roles in the implementation of open science policies. Researchers are crucial actors in this type of environment. In this regard, Chataway et al. (2017) argue that open science is consistent with many researchers' beliefs about the importance of knowledge exchange and

Table 1. Classified Findings and Their References by Research Question.

Approach given to open science policy	Technological changes	De Filippo and D'Onofrio (2019) Fressoli and Arza (2018) Stodden (2010) Vicente-Saez et al. (2020)
	Asymmetries and epistemic governance	Albornoz et al. (2018) Chartron (2018)
	Innovation	Albornoz et al. (2018) Ali-Khan et al. (2017) Caulfield et al. (2012) Vicente-Saez et al. (2020)
	Negative aspects	Levin and Leonelli (2017) Elliott and Resnik (2019)
	Commercialization	Caulfield et al. (2012)
	Actors and stakeholders	Beck et al. (2020) Chataway et al. (2017) De Filippo and D'Onofrio (2019) Funamori (2017) Hormia-Poutanen and Forsström (2016) Smart et al. (2019)
	Institutional policies	Ali-Khan et al. (2017) Caulfield et al. (2012) Kretser et al. (2019) Lyon (2016) Margoni et al. (2016) Schmidt et al. (2018)
Components of open science	Open access	Biesenbender et al. (2019) Chataway et al. (2017) De Filippo and D'Onofrio (2019) De Filippo et al. (2019) Margoni et al. (2018) Piwowar et al. (2018)
	Open data	Burgelman et al. (2019) Gabrielsen (2020) Hormia-Poutanen and Forsström (2016) Joly et al. (2012) Kwon and Motohashi (2020) Maijala (2016) Mancini et al. (2020) Rockhold et al. (2019) Roman et al. (2018) Timmermann (2019) Xafis and Labude (2019)
Geopolitical aspects	International policies	Babini and Rovelli (2020) Albornoz et al. (2018) Araujo et al. (2020) De Filippo and D'Onofrio (2019) Fressoli and Arza (2017) Oliveira and Silva (2016) Rentier (2018)
	Regional and national policies: Europe	Abadal and Anglada (2021) Bardi (2018) Biesenbender et al. (2019) Burgelman et al. (2019) Chartron (2018) Chataway et al. (2017) Maijala (2016) Olesk et al. (2019) Schöpfel and Fabre (2019) Vanholsbeeck (2017)

(continued)

Table 1. (continued)

	Regional and national policies: Latin America	Albornoz et al. (2018) Araujo et al. (2020) Arza et al. (2017) Babini and Rovelli (2020) Bertin et al. (2019) Clinio (2019) Costa (2020) De Filippo and D'Onofrio (2019) Rezende and Abadal (2020)
Relation to science policy	Transparency	Elliott and Resnik (2019) Gabrielsen (2020) Lyon (2016)
	Legal and intellectual property systems	Kelty (2012) Oliveira and Silva (2016) Wong et al. (2018)
	Policy implementation	Aguinis et al. (2020) Armeni et al. (2020) Bardi (2018) Fressoli and Arza (2018) Kretser et al. (2019) Levin et al. (2016) Rockhold et al. (2019) Santos (2017) Saraite Sariene et al. (2020) Schmidt et al. (2018) Vicente-Saez et a. (2020)
	Rewards' system	Abadal and Anglada (2021) Armeni et al. (2021) Burgelman et al. (2019) Chataway et al. (2017) Fressoli and Arza (2018) Funamori (2017) Heise and Pearce (2020) Howe et al. (2017) Kamoun et al. (2019) Kittrie et al. (2017) Kraker et al. (2012) Krishna (2020) Levin et al. (2016) Moher et al. (2020) Mukherjee and Stern (2009) Rentier (2018) Rice et al. (2020) Robinson-Garcia et al. (2020) Schöpfel and Fabre (2019) Walsh and Huang (2014)

collaboration. Therefore, universities should also develop policies and infrastructure to support open research programs (Smart et al., 2019). Moreover, Funamori (2017) concludes that academic institutions should adopt proposals for changing research strategies, faculty review, and research support structures, believing that these proposals will bring competitive advantages over peer institutions.

Policymakers are other key stakeholders in the research environment. These actors traditionally participate in scientific research by formulating science and innovation policies. However, with the advancement of open science, their role changes to that of active co-creators of scientific research through open and collaborative policymaking practices (Beck et al., 2020). Funamori (2017) argues that policymakers should meet the needs of researchers and support the researcher's point on view of openness.

Furthermore, aside from policymakers and managers, coordinating bodies of higher education institutions such as rectors' councils and other institutions should also be

aware of open science practices (De Filippo & D'onofrio, 2019). Similarly, research councils must also determine their requirements to fund new research streams and coordinate open methods in collaboration with the public, private, and third sectors (Smart et al., 2019). Furthermore, Hormia-Poutanen and Forsström (2016) argue that collaboration at different levels (national, disciplinary, and role-related) is fundamental for the advancement of open science.

Institutional Policies

This section discusses different implications for open science policies at an institutional level.

Many institutions have started the development, adoption, and implementation of open science policies, mostly during the last 10 years (Kretser et al., 2019; Schmidt et al., 2018). Furthermore, organizations must formulate policies, procedures, and practices that address scientific integrity, provide personnel training, and continue to work hard to maintain awareness of and advocate for these practices (Kretser et al., 2019). In addition, it is argued that open science should be established as the standard operating procedure of the entire scientific enterprise (Kretser et al., 2019).

Many academic institutions have research policies or research codes of practice that clarify the principles, ethical basis, and expectations for the behavior of researchers in the institution. Seldom open science policies such as open access and open data are included in these research policies (Lyon, 2016).

Institutional open science policies have many characteristics in the way they ought to be constructed. For instance, Caulfield et al. (2012) assert that there must be a balance between funding and institutional policies, research guidelines, and project agreements as they must all recognize dualism and allow locals to choose courses that best meet the needs of the public. Similarly, rather than adopting a sole open science policy, departments at the institution should consider providing a disciplinary approach (Schmidt et al., 2018).

About the discussion of top-down and bottom-up policies approaches. Ali-Khan et al. (2017) argue that institutional open science policies can only be successfully formulated in close cooperation with researchers, rather than in a top-down manner. Similarly, Margoni et al. (2016) argue that bottom-up interventions in open science policies seem more effective than the usual top-down approach to regulation.

Components of Open Science Covered in the Literature

Within the openness discussion, open access to publications has already reached consensus, and open data is on the brink of doing so (Chataway et al., 2017). Furthermore, open data is one of the most critical facets of open science's progress (Burgelman et al., 2019). This is why, particularly in English-speaking countries, open data policies tend to be more evolved than the other components of open science.

Open access, on the other hand, is a more established term in the realm of open science for Spanish and Portuguese journals than open data or altmetrics (De Filippo et al., 2019). The Latin American area is experiencing the same phenomenon.

For example, De Filippo and D'Onofrio (2019) argue that countries in the area should work hard to establish and enforce national policies that support various open science activities in a comprehensive and organized manner since, although open access is a well-known problem, the other facets of open science are not. The next section will highlight the main aspects of open data mentioned in the literature.

Open Data

Open science has many aspects, as it is used as an umbrella term. However, the aspect that is more studied concerning its policies is open data. This section will highlight the major issues within this concept.

It is argued that there are multiple benefits of open data. Open data contributes to the growth of new research that is unexpected (Maijala, 2016). Moreover, open data can contribute to open innovation. A change in focus from a sole open science data obligation to the identification of fundamental opportunities and the advancement of business models to capture them through open science initiatives is proposed by Roman et al. (2018).

There is much discussion about open data policies at an institutional level. Joly et al. (2012) analyze various data retention policies and publication moratoria. These authors observed that the rapid development of genomics research and biobanking has led to increasingly complex policies seeking to balance the interests of various stakeholders.

At a university level, Helsinki University started a research data policy back in 2015. This data policy states that the university will provide infrastructure, legal aid, and training on related issues to research data management to scientists. In turn, researchers would have to draft and carry out a data management plan for their research projects. University libraries would also help with policy implementation and research support (Hormia-Poutanen & Forsström, 2016).

Open data policies have several implications as well. The application of the principles of unrestricted access to data and the vastly extended provision of software

services has resulted in the implementation of a fully open data policy on the creation of databases (Mancini et al., 2020). Xafis and Labude (2019) debate about data repositories and their ethics in health research and how the issue can be introduced in policies to promote trustworthiness and transparency. Science Europe has collaborated with other research partners in recent years to facilitate a more harmonized approach to data sharing policies (Timmermann, 2019). Moreover, Rockhold et al. (2019) studies guidelines for clinical data sharing, and argues that open data policy implementation should be done in phases.

Data policies have several actors. Kwon and Motohashi (2020) argue that policies on research data should institutionalize the legal protection of research data ownership and mandate research data disclosure. Gabrielsen (2020) argues that data policies should include digital curator communities, which would give them more focus and jurisdiction, as well as frameworks to build and preserve trust. Curators should be included in the infrastructure for data-intensive research that is being developed.

Open Access

Institutional policies in the open access realm have been thoroughly studied. For instance, the institutional policies in the UK stipulate a specific funding mechanism for OA publications, as these institutional policies are part of the legal system that encourages the publishing of gold OA (Margoni et al., 2016). In the same regard, research funders constantly require their grantees to disseminate using open access materials (Piwowar et al., 2018). Additionally, Biesenbender et al. (2019) observed that reputation and institutional incentives may severely hinder the motivation of researchers to publish papers in OA journals or provide publications through OA. Moreover, at a regional level, according to De Filippo and D'Onofrio (2019), Latin American countries have been pioneers and active in reference to open access infrastructures and normative.

Geopolitical Aspects of Open Science Policies

Open science public policy refers to national strategies and actions of organizations responsible for formulating and coordinating science and technology policies, funding agencies, and national research councils to promote their principles and practices (De Filippo & D'Onofrio, 2019). This section refers to the international, regional, and national policies of the European and Latin American regions.

International Policies

Several international organizations are currently working on open science recommendations and policies. Moreover, the expansion of open science through the broadening of platforms where researchers share data, publications, experiments, and equipment is driven by international and regional organizations (Babini & Rovelli, 2020). In addition, several international organizations and scientific institutions around the world have started to issue recommendations and policies for the implementation of open science practices. This fact may have serious implications since, as Albornoz et al. (2018) argue the various mechanisms of knowledge transfer and consensus-building among international participants are not neutral; rather, they include negotiations that reflect unequal power relations in the global and local arenas.

This list includes multilateral organizations such as UNESCO, the Group of Seven, European Commission, the European Research Council and OECD, as well as international scientific societies, associations, and industry publishing organizations, such as the International Science Council, the International Science Association and the STM Publishing International Association (Albornoz et al., 2018; Fressoli & Arza, 2017; Rentier, 2018).

In addition, Oliveira and Silva (2016) observe that concerning the proposal of open science policies there is a soft law that refers to rules that are not strictly binding, do not contain legal meaning, but can be used as principles to guide behavior. In this regard, as maintained by Albornoz et al. (2018) some international and European stakeholders have contributed to open science policies and projects in Latin America and Africa by funding and establishing partnerships. For instance, there is the significant influence of the European Commission, the Organization for Economic Cooperation and Development (OECD) and other government agencies have had a significant impact on policy guidelines in improving government transparency and public participation (De Filippo & D'Onofrio, 2019).

At a practical implementation level, this trend is observable for instance at La Referencia. Araujo et al. (2020) assert that it has established a series of interoperability guidelines. Participating countries must ensure its compliance, and recommends that the repositories that make up the network adopt these guidelines. The guidelines agreed on at the regional level are based on the

OpenAIRE documentation adopted by the European Union.

Regional and National Policies: Europe

Open science policies have been developed and implemented in Europe for over 10 years.

The European Commission has been fundamental in the promotion of open science throughout the years openly and comprehensively, covering all aspects of the research cycle from scientific discovery and review to knowledge sharing, publication, and promotion (Abadal & Anglada, 2021; Burgelman et al., 2019). Moreover, open science is one of the three main priority areas of the European Commission's science, research, and innovation policy (Chataway et al., 2017).

Open access became the first area of European regulations in the realm of open science, originally called "Science 2.0" (Vanholsbeeck, 2017). The Committee's communications and recommendations on access to scientific information put European open science in the context of the exoterization research trend (Vanholsbeeck, 2017). European open science regulations are a way to overcome the intensifying trend of ERA research. However, the trend of European open science and research management also has more management relations (Vanholsbeeck, 2017). In this regional realm, open science objectives are rather clear in all the reviewed policies, but the pending issues are located in the transition and the implementation of these policies into reality (Abadal & Anglada, 2021). Moreover, Chartron (2018) argues that open science harmonization in the European Union will be difficult to achieve since every country does not have the same priorities or the same funding for open science policy implementation.

National plans for open science from Finland, Slovenia, the Netherlands, and France were published between 2014 and 2018 (Abadal & Anglada, 2021). Finland's roadmap on open science dates back to 2014 (Maijala, 2016). Open science is defined as the unrestricted dissemination of research publications and data, based on the opportunities presented by digital transformation in France's national plan for open science (Schöpfel & Fabre, 2019).

The national plan also commits to ensuring that the results of scientific research will not be delayed, and will not be hindered by all payment to personnel, researchers, companies and citizens (Schöpfel & Fabre, 2019). Moreover, this commitment mobilizes all higher education and research participants whose projects, initiatives and strategies create a dynamic and complex ecosystem that plays an important role in the evolution of publishers' strategic choices and their business models (Schöpfel & Fabre, 2019).

There are also practical applications provided by the literature. Biesenbender et al. (2019) study three country-specific implementation cases in Italy, the Netherlands and Germany. They identify that through institutionalized Current Research Information Systems (CRIS) infrastructure, open access repositories can be integrated into CRIS. Additionally, Bardi (2018) presents the OpenAIRE service, which fosters transparent evaluation of results and facilitates reproducibility of science for research communities by providing the open science infrastructure to do so. Finally, a further application of open science is in the creation of evidence-based policymaking. Open Science can make contributions to knowledge transfer from studies to policymaking (Olesk et al., 2019).

Regional and National Policies: Latin America

Thus far, there are currently several studies about open science and related issues in the Latin American region. De Filippo and D'Onofrio (2019) identify and analyze the main public policies supporting open science in Latin America. These authors examine the scientific achievements of the region in open science and analyze its main characteristics. They point out that in most Latin American countries, governmental science and technology policy entities promote open infrastructure, open access, open data, and open science policies. Moreover, the governmental offices of science, technology, and innovation of countries such as Colombia, Mexico, and Chile have issued their national policies on open science (Albornoz et al., 2018).

It is argued that in this region, the current evolution of open science is built on the open access movement (Babini & Rovelli, 2020; Bertin et al., 2019).

Policies on open science in the region have some characteristics. For instance, in several statements in the region, knowledge is introduced as a concept as a common good (Babini & Rovelli, 2020). Likewise, some researchers suspect that hegemonic open science can reproduce the colonial view of science, as if unregulated, it could leave to extract data from Latin America through the different capabilities developed countries exploit to distinguish, process, and extract knowledge (Clinio, 2019). By doing so, open science can reproduce existing inequalities in science.

Currently, there is no formal open science policy in Brazil. However, there are many initiatives by public education and research institutions that are motivated by the need to respond to the new demands of development agents—especially foreign agents—and scientific journals (Clinio, 2019). Similarly, Costa (2020) argues that those policies need to establish some kind of guarantee to achieve international collaboration, rather than

dependence for researchers in Brazil. A Brazilian overview of regulatory frameworks that directly influence the practice of open science, considering the sphere of government, institutions, funding agencies, and institutions providing information products and services. Most frameworks in this country are related to open data and open access (Rezende & Abadal, 2020).

Concerning the Argentinian case, Arza et al. (2017) emphasized open science practices. They argue the country's policy should include new tools and incentive schemes to encourage collaboration at all stages of scientific knowledge production and more open and collaborative practices.

There are also practical examples of open science infrastructure in the region. The Latin American repository network La Referencia has also produced their policy on open scientific infrastructure (Albornoz et al., 2018). According to the statement of research outputs as a public good, La Referencia Network promotes the national open access strategies of member countries using a platform with interoperability standards (Araujo et al., 2020).

Open Science Framed in Relation to Science Policy

This section examines the relationship between open science and science policies, focusing on the legal implications of open science policies, compliance challenges, and potential changes to the rewards system in the research structure to achieve open science.

The literature on open science has highlighted several issues, such as its relationship to innovation and transparency, and how it can contribute to science policy. It is argued that open science and their policies' implementation have many perceived benefits. For instance, Krishna (2020) argues that in crisis contexts open science policies can remove barriers to the free flow of research data and ideas, thereby accelerating the pace of research critical to disease prevention. Another advantage noted in the literature is the issue of transparency (and its principles), which has been included in the open science policy (Lyon, 2016). The motivations for addressing transparency as a concept have been articulated and the development of open science policy, which embraces transparency principles, has been described. Open science strategies pursuing socially relevant transparency are also mentioned as a basis for effective science translation, science communication, and public engagement with it (Elliott & Resnik, 2019).

Open science policy implementation has some implications that may collide with current legal and intellectual property systems. Historically, secrecy in science is encouraged prior to patenting and maintained after patenting, making research communication difficult. Moreover, Gabrielsen (2020) argues that in the current science policy, the importance of trust has decreased, and there is a tendency toward openness and transparency. The lack of consensus on the establishment of grace periods (as an exception, allowing inventions to be disclosed before patent applications) has created legal uncertainty (Wong et al., 2018). Additionally, Kelty (2012) argues that openness is opposed by the fact that certain fields, such as biotechnology and pharmaceuticals, are dominated by patents to enhance competitive markets. Furthermore, Kelty (2012) argues that a strong intellectual property system requires that all concepts, technologies, claims, or results generated be owned separately, rather than collectively owned concepts and technologies that lead to a combination of collaboration and competition. Moreover, open science is located between two ethical-cultural-legal spectra, according to Oliveira and Silva (2016): (1) the transition from a proprietary economic paradigm that reinforces private intellectual property rights to the paradigm of sharing and (2) the emphasis of the new scientific paradigm based on research data and the culture of commons.

Open Science Policies Implementation

Despite the multiple perceived benefits of open science, such as achieving more productive, democratic, and egalitarian research practices, there are still issues in policy implementation (Levin et al., 2016). Previous research has established that there is a gap in the implementation and adoption of open science policies (Armeni et al., 2020; Kretser et al., 2019). Moreover, Schmidt, et al. (2018) argue there is a challenge on communication and implementation of institutional policies on open science. In addition, in the open access field the same phenomenon occurs: Saraite Sariene et al. (2020) in their study about open access policies in higher education conclude that despite different policies, so far the implementation of open access policies is still at a moderate level.

Strategies in different dimensions, such as new metrics for science evaluation, the development of infrastructures and legal frameworks, are essential for open science policy implementation (Santos, 2017).

A scientific communication ecosystem as an enabler of transparency and reproducibility is a main infrastructure of open science. This open science ecosystem implementation will need to provide tools and policies related to sharing, interlinking, and reusability of research artefacts (Bardi, 2018). Similarly, Rockhold et al. (2019) study guidelines for clinical data sharing, they argue that open data policy implementation should be done in phases.

There are several recognized reasons for this gap. For instance, Aguinis et al. (2020) argue there is a gap

between practice and theory in open science due to disagreements between different science stakeholders. Similarly, Levin et al. (2016) state that the implementation of open science requires a number of shifting prospects for multiple stakeholders. Furthermore, Armeni et al. (2020) identify three main reasons for this gap: the difficulty of reaching a critical mass, the perceived cost of change, and several disciplinary differences. In the same way, Levin et al. (2016) argue that one of the issues is that policies seem to refer to all research stages in different fields without any differentiation. Moreover, Saraite Sariene et al. (2020) assert that the reputation of the university seems to influence the university's better adoption of open access policies.

Capacity building is needed argue Fressoli and Arza (2018) as implementing open scientific practice involves learning new skills that are not always available to researchers. Finally, Vicente-Saez et al. (2020) argue that there is already a shift toward openness in the research process. This conveyance is focusing more on the procedures such as open sharing practices, open protocols, open data sharing, or open repositories, and open invitation practices while the current policies at the national, regional, and international level tend to focus on the openness of research outputs such as open access or open data. Therefore, there is currently an imbalance between open scientific practices and open science policies.

Changes the Rewards' System in the Research Environment to Achieve Open Science

Several studies suggest that there is a lack of incentives for open science in the current research assessment. Despite the fact that the vast majority of scientists support open science, few actually practice it (Heise & Pearce, 2020). For instance, academic incentive structures should be adjusted and restructured to align with open science policies and allow for some level of response (Armeni et al., 2021).

The current incentive mechanism of contemporary academia does not promote data sharing before publication (Kamoun et al., 2019). Moreover, a recognition system different to the "publish or perish" approach is needed to improve the adoption of open science (Howe et al., 2017). In this regard, Robinson-Garcia et al. (2020) assert that science policies should introduce metrics of openness.

In the policy debate on the impact of competitiveness, the issue of the university's agenda and commercialization policy should be based on an understanding of the specific institutional context under consideration (Walsh & Huang, 2014). Furthermore, the commercialization of research has become an indispensable portion of academic policy (Krishna, 2020).

Previous research has established that open science feasibility is based on incentives (Kraker et al., 2012; Mukherjee & Stern, 2009). Current local incentive programs do not promote these open science practices but prevent them by incurring opportunity costs of using the time to conduct activities that are not valued by the evaluation program (Fressoli & Arza, 2018). This is the reason why various authors discuss the need to implement a change in the reward's system for open science mainstreaming. For example, Funamori (2017) argues and proposes an integral reform of research evaluation. Specific to the open data realm, Levin et al. (2016) recommend that due to the current conflict between transparency and commercialization, a reform of promotion and tenure policies is required to achieve open science and, in particular, open data principles. Similarly, at a university level, it is argued that these institutions should also develop infrastructure and training to support, measure, and reward work that fulfils open science principles (Howe et al., 2017).

There are also concerns over the rewards' system in these current regional policies as described in the literature. For instance, Schöpfel and Fabre (2019) state that the open science policies of the European Union, major funding agencies, and major research organizations do not seem to raise questions about the current scientific journal model. On the contrary, they strengthen the function of journals to disseminate research results. Furthermore, Burgelman et al. (2019) argue that necessary changes to the reward and incentive systems for researchers are still missing from various European open science policies. In the same regard, according to Abadal and Anglada (2021), the evaluation model and the need for researchers' habit change seem to be the biggest pitfall for open science.

Research proposes models for research evaluation. For instance, Chataway et al. (2017) propose creating their own monitoring and evaluation approach for open science. Similarly, Kittrie et al. (2017) discuss a prize awarded as a funding model change to incentivize open science. This prize was useful to enhance international collaborations and open digital content. Lastly, the most recent research has focused on open science and its role in research assessment. Moher et al. (2020) outline new research assessment criteria to enhance research integrity and advance open science practices for research institutions and their funding policies. Likewise, Rice et al. (2020) research different research assessment practices. Finally, any type of assessment revision necessitates international coordination and synchronization. Rentier

(2018) makes the case that if this is not done, early adopter researchers will be at a disadvantage.

Discussion

Open science is promptly becoming a mainstream issue, with a wide variety of direct and indirect players and stakeholders in various nations, territories, and at the international level discussing it. In this discussion, two distinct phases can be discerned: the first phase of conceptualization of open science and its policies until before 2015, and a second period, beginning in 2017, with a sharp rise in research on open science policy, which correlates to the formulation and enforcement of open science policy in different settings. This implementation is likely to continue over the upcoming years.

This literature review has brought forward this discussion by pointing out the different approaches to this issue. The approach given to open science in the studies has different frames. On the one side, policy framing and its geopolitical aspects are defined as a mechanism for the reproduction of asymmetries and epistemic governance. On the other hand, open science is framed as an innovation catalyst, and its policies encourage its advancement. Finally, there are also some disadvantages of open science policies: a generalization argument of open science may lead to disparities between researchers and organizations that must follow open science policies and those that do not. There are indeed conflicts between commercialization and open science policies.

The policy literature covers various open science components. However, there are noticeable variations between regions and languages. The subject of open data policy is more developed in English-language works than the other components of open science. Open access, on the other hand, seems to be a well-established subject in Spanish-speaking research. Overall, this corpus seems to rely on these two issues: open data and open access. Therefore, open science policy work seems to focus more on open outputs than on other aspects of the scientific process. Certainly, the fact that open science policies research is mostly written in a particular language and from a particular region or nation brings into doubt the concept's purported universality. Especially, how policies based on this concept could potentially replicate—unintentionally or intentionally—current inequalities in terms of the difficulties of conducting science in different countries and regions, and given the political economy of the different stakeholders in the current research infrastructure.

The major geopolitical dimensions of open science policies described in the literature are first and foremost its various actors and stakeholders, such as academics, universities and research agencies, policymakers, and research councils, and how each of these actors and stakeholders play a unique role in institutional, state, regional, and international open science policies.

Open science recommendations, mandates, and policies are now being developed by some major international organizations. This fact may have significant ramifications, as policymaking may replicate current inequalities on a global scale. At a regional level, the European Commission has been proposing policy recommendations at the regional level for many years. Open science policies have been advocated, debated, and written at the national level in this area, but their adoption is still lacking. The Latin American area also has many policy proposals, but this is not made through international organizations. In particular, in contrast to the European regional situation, Latin American literature focuses more on case studies at the institutional or national level, rather than on large regional organizations supporting regional open science policies. Another significant point to note in this area is that open access is the foundation for open science policy since this topic has been extensively debated, studied, and pursued in the past in this region.

The relationship between open science and science policy is defined by the innovation and transparency that open science will bring to the table. However, the relationship between open science and intellectual property law is still discussed. As the traditional innovation system's ability to produce income and generate social benefit is dwindling. Therefore, Gold (2021) believes that the deterioration of the innovation system could be delayed or reversed by forming an open science collaboration. Finally, there is currently a gap between open science policies and their implementation. Several studies contend that changing the incentive mechanism of the scientific environment is critical to open science deployment.

Conclusions

Unquestionably, the debate over open science policies and their potential implementation among various actors and stakeholders will continue in the next years. This review adds to the conversation by emphasizing what has been stated about this topic in four different languages. We hoped to create a more inclusive and balanced picture of this topic by doing so. However, the study's language choice is likely to be a restriction, given there is likely to be a lot of discussion about open science policies in different languages.

Finally, the fundamental drawback of this literature analysis is that the papers chosen for this paper were mostly science and technology-related. Further research could concentrate on the literature related to open science policy, with a particular focus on works in the humanities and social sciences, which may lead to quite different results.

Appendix A

Search Strings and Their Results.

Database	Search keywords	Results	Selected papers_ policies
Scopus	TITLE-ABS-KEY ("ciencia abierta")	16	2
	TITLE-ABS-KEY ("ciência aberta")	15	1
	TITLE-ABS-KEY ("science ouverte")	7	0
	TITLE-ABS-KEY ("open science") AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (SUBJAREA, "MEDI") OR LIMIT-TO (SUBJAREA, "BIOC") OR LIMIT-TO (SUBJAREA, "NEUR") OR LIMIT-TO (SUBJAREA, "AGRI") OR LIMIT-TO (SUBJAREA, "ENVI") OR LIMIT-TO (SUBJAREA, "PHYS") OR LIMIT-TO (SUBJAREA, "EART") OR LIMIT-TO (SUBJAREA, "PHAR") OR LIMIT-TO (SUBJAREA, "CHEM") OR LIMIT-TO (SUBJAREA, "HEAL") OR LIMIT-TO (SUBJAREA, "CENG") OR LIMIT-TO (SUBJAREA, "MATE"))	818	34
Semantic Scholar	"Ciencia abierta"	311	2
	"Ciência aberta"	281	0
	"Science ouverte"	211	4
	"Open science"	7,820	3
Google Scholar	"Ciencia abierta"	13,000	0
	"Ciência aberta"	3,660	4
	"Science ouverte"	13,700	0
	"Open science"	383,000	3
	"politicas de ciencia abierta"	58	3
	"Open science policies"	567	6
	"open science" policy	147,000	4
	"Políticas de ciência aberta"	49	3
	"Politiques de science ouverte"	7	1

Appendix B

Compiled List of References and Their Characteristics

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Ethical Approval

This work is a literature review, thus an ethics statement for animal and human studies is not applicable.

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