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# Open science-related policies in Europe

Shima Moradi
*University of St. Augustine for Health Sciences*, smoradi@usa.edu

Sajede Abdi
*National Research Institute for Science Policy (NRISP)*, abdi@nrisp.ac.ir

Author(s) ORCID Identifier:

Shima Moradi: 🆔 0000-0001-5556-4098

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# Open science–related policies in Europe

**Sh. Moradi** [1,*] **and S. Abdi** [2]

[1]Library, University of St. Augustine for Health Sciences, 700 Windy Point Dr, San Marcos, CA 92069, USA and [2]Policy Evaluation and Science, Technology and Innovation Monitoring Department, National Research Institute for Science Policy (NRISP) Tehran, Iran

*Corresponding author. E-mail: smoradi@usa.edu

## Abstract

This study aims to review the open science (OS) policy documents, identify their subject areas, and distinguish the topics of OS support policies in seven European countries, providing a platform for practical cooperation between countries in science popularization. With a qualitative–inductive approach, all pertinent policy documents in OS were collected through documentary study, and thematic analysis was conducted to identify OS policies for each country. Finally, forty-six policy documents extracted up to December 2020 were thematically analyzed through a qualitative–inductive case study. All selected countries had developed OS policies, and these supportive policies were generally related to the three dimensions of 'open input, open process, and open output'. In 'open input', recommendations for the performance of research data repositories, as well as management criteria, are considered. Most countries adopted 'open output' protectionist policies. Multiple policies in the 'open process' indicate the need for an appropriate OS platform.

**Key words:** open scholarship; open access; open data; open scholarly communication; open scientific communication; European countries; policy assessment.

## 1. Introduction

In the past, scientists had to work within the boundaries of geography and their specialties, while new ways of communication and information have provided more mobility to scientists and provided further opportunities these days. In other words, the science production mode has changed so that it can be termed an 'evolving communication system' (Gibbons et al. 1994). In the scientific community, the concept of 'open science' (OS) is a novel approach to science and the process of its generation, monitoring, and dissemination, covering the three components of open research data, open scholarly communication, and open access (Moradi 2020, 2021). In the OS ecosystem, data, methods, peer review, software, tools, research results, curricula, and pamphlets should be as accessible and reusable as possible (Moradi and Abdi 2020). In multiple international organizations such as United Nations (UN), World Bank, European Commission, European Parliament, and Organisation for Economic Co-operation and Development, OS has been mentioned to solve significant societal challenges (Vicente-Sáez and Martínez-Fuentes, 2018). UNESCO (2020) is also developing an OS handbook to formulate a coherent perspective, general principles, and common OS values for all countries.

Like any other innovation or action, the shift toward OS demands a review of budgeting, relevant regulations, procedures, policies, and standards; therefore, redefining governance structures, including reviewing or formulating policies that are critical drivers of OS implementation, is on the agenda of many countries (Kunst and Degkwitz 2018). OS is no exception to this rule, and it is evident that policy-making at a national level is essential for openness.

Having different levels that complement each other hierarchically, policy-making is a set of actions that are determined based on specific principles or rules to guide decisions and achieve reasonable outcomes (Arnold 2004; Hill and Varone 2016). Policy-making is usually addressed through directives assuming complete rationality (Soltani and Tabatabaeian 2019) and includes the following items: (1) principles, rules, and guidelines, (2) goals and missions, (3) processes, (4) decisions, and (5) official documents. Not all societies agree on policy-making in a particular area, and policies are formulated based on features of each country; therefore, the understanding, formulation, and analysis of policies, especially in a country's science and technology system, requires a comprehensive perception of the components of policies, including goals, tools, target groups, implementers, and rationale for a policy program (Rothmayr and Varone 2002). On the other hand, there are different preferences in implementing policies that are not executed properly due to multiple reasons such as uncertainty, incomplete information, problems of policy interpretation, contradictory perceptions, and various societies' capacities.

Despite the willingness of countries toward openness of science and its processes as well as various programs and parties sharing scientific achievements, the available science support policies and their subject matters in selected countries have not been specified. The presentation of a platform for OS policies in the European Union (Lagvik and Nolin 2017) and the development of programs to increase and facilitate access to research results in government agencies like the National Academies of Sciences, Engineering, and Medicine (2018: 88) are examples of such expected support.

Also, "researchers may be less willing to try to support OS policy implementation despite the fact that OS policies are motivated by the desire to enhance the excellence and quality of research. The findings address how the incentive problems lie not only in the research evaluation and academic credit systems but also in the policy–practice divide. These problems

need to be solved in terms of participation in policy-making and in the knowledge production of 'openness' itself" (Lilja 2020).

This paper intends to examine different countries' policies in OS and issues related to these policies. Identification of policy-making in OS can be a valuable idea for other countries, providing a platform for practical cooperation between countries in science's popularization.

## 2. Literature review

Several studies on OS policies have been conducted in the past, based on a search of previous literature, most of which have focused on a specific dimension of it, like 'open access'. It is also worth mentioning that there were some literature studies in the purview of open innovation and policies like Silva et al. (2020), Vlaisavljevic et al. (2020), and Hashim et al. (2021). Open innovation accelerates the development of the fruits and outcomes of OS (Chesbrough 2015) by providing a platform to implement in the ecosystem of science, technology, and innovation. As for our concerns, the following literature contains those studies that are thematically relevant to OS policy studies.

Using a focus group, Moradi (2020, 2021) proposed a model for facilitating OS policies in Iran based on six areas: environmental, technological, social (cultural), economic, political (legal), and value (STEEP (V)). She believed that the OS ecosystem in any country could be attained by identifying the capacities and challenges of that country, and policy-making in the following five categories is necessary to implement OS nationwide: determining the nature of science, removing barriers to OS, distinguishing thematic areas of OS, motivating for its implementation, and separating performance levels. Moreover, conducting a thematic analysis of the twenty-five UN-commissioned reports and cultural heritage policy documents, Koya and Chowdhury (2020) identified fourteen broad cultural heritage information, of which information platforms, information sharing, information broadcast, information quality, information usage training, information access, information collection, and contribution appear. This demonstrated that a thematic analysis of such documents can explore the key themes for cultural informatics education and research, which leads to sustainable development. Also, by studying topics such as budgeting, dissemination methods, and influential research indicators, Heuritsch (2020) showed how the effectiveness of knowledge in society, as well as the advancement and development of science, can be helped by setting qualitative criteria for knowledge utilization and OS policies and presented policy recommendations in this regard. Olesk et al. (2019), in their study titled 'open science facilities for transfer of knowledge in science-politics', pointed to the possible role of OS in the passage of knowledge between research and politics which members of the Scientific Council used at Estonian ministries. Qualitative interviews with these members showed that they perform as intermediaries between research and policy and significantly impact the ministry's research quality. This process involved using academic papers and datasets that funders in the industrial sector could use.

Besides, through documentation and content analysis, Tirado and Ochoa (2018) examined the status of OS and national policy planning in Colombia and identified relevant challenges and perspectives in national policy, projects,

and innovations. Zuiderwijk et al. (2014: 24–8) also implemented open data from an institutional perspective (relying on governance and government) and detected seven main legal, political, social, economic, institutional, operational, and technical areas to achieve transparent government. In their view, the implementation of open data required attention to three general considerations in open data theory and development and its policies and infrastructure. In this regard, the study by Nosek et al. (2015) mentioned the need for accessibility of scientific data for society by researchers and set eight standards for guiding actors in science with particular emphasis on accessibility, the openness of science, and attention to science assessment. By studying the policy implications of OS implementation in creating change and innovation in the science ecosystem, Stodden (2010) found that public engagement with the scientific community is directly related to the available knowledge for the general public and the generalization of science and that the formulation of proper policies in this regard contributes to citizen science, which is a welfare theme of the society. Also, Lilja (2020) applies the policy alienation perspective to understand researchers' perceptions of OS policy implementation. Analysis of survey responses indicates that researchers have difficulties in coping with the OS policy and that they feel policy alienation from OS policy. Researchers expressed feelings and perceptions of ambivalence, pointlessness, and disengagement when dealing with OS policy implementation. Their perceptions of the added value of OS policy to scientifically-relevant goals indicate that researchers also feel scientific meaninglessness. Armeni et al. (2021) realized that, despite the increasing availability of OS infrastructure and the rise in policies to change behavior, OS practices are not yet the norm. While pioneering researchers are developing OS practices, the majority stick to the status quo. In this transition, OS communities (OSCs) play a key role. OSCs are bottom-up learning groups of scholars who discuss OS within and across disciplines. They make OS knowledge more accessible and facilitate communication among scholars and policymakers. They emphasize that, despite the grassroots character of OSCs, support from universities is critical for OSCs to be viable, effective, and sustainable. Wide-scale adoption of OS practices requires a culture change that leads to normalization among members of the scientific community. Also, three challenges identified that stand in the way of wide-scale adoption of OS practices: (1) reaching a critical mass, (2) the perceived cost of change, and (3) disciplinary differences that a network of local OSCs can overcome these challenges. OSCs play a central role in identifying obstacles that hinder scholars from opening their workflows.

Moreover, Ballestar et al. (2019) conducted a study on the research motivations, and relevant elements were examined. By studying new policies such as financial incentives, a multi-level machine learning model was designed to evaluate public policies related to academic researchers' scientific performance. Regarding these empirical two-stage models, the financial incentives have a more significant impact on tenure-track researchers, and gender plays an important role in academia.

On the other hand, a bibliographic study of policy documents in nuclear energy by Huang et al. (2021) reckoned that policy documents reveal valuable policymakers' intentions, behaviors, and governmental economic or social goals.

The background of OS shows a particular focus on models and frameworks meant for describing this field. Previous studies have concentrated on the benefits, consequences, strengths, and weaknesses of OS policy-making and the formulation of policies; therefore, the content of OS policies has not been studied so far. Therefore, the purpose of this study is to review OS policy documents in seven European countries, identify their subject areas, and distinguish the topics of OS support policies.

## 3. Methodology

All the policy documents extracted up to December 2020 were examined in terms of relevance to the subject of OS and its various components, and finally, forty-six policy documents were selected as the final community as follows (Table 1).

The approach of the present study is a qualitative–inductive case study through thematic analysis, which involves a process used to extract categories or themes from raw data based on valid inference and interpretation, which is the most common technique for the content analysis of documents that is often implicit in search of topics (Sandelowski 1995; Wimmer and Dominick 2005). In the present study, seven European countries (UK, Germany, France, Italy, the Netherlands, Sweden, and Spain) were selected, which had the highest *H*-index in SCImago among other European countries at the time of this study. *H*-indices are therefore used to select countries based on their scientific and productivity accomplishments, as evidenced by their policy documents. First, the OS policy documents in the mentioned countries were collected through documentary research and a review of available documents. Then, forty-six policy documents were reviewed in the OS field; finally, OS policies were thematically analyzed, and their thematic dimensions were extracted, grouped, and compared by country and dimensions (Fig. 1).

Thematic analysis was helpful in this study given the lack of a comprehensive theoretical framework to explain the mentioned issue, and the four steps of this study are discussed in the next subsections based on Braun and Clarke's (2006) analysis.

### 3.1 The first stage
The first stage (familiarity with data) included 'frequent re-reading of data' and actively reading them. In this research, texts and printed and electronic documents in the webspace were reviewed for all eight selected countries.

### 3.2 The second stage
The second stage involved the production of initial codes from the data. By creating the first codes, the data features that were attractive to the analyst were introduced and referred to as 'the most basic segment, or element, of the raw data or information that could be assessed in a meaningful way regarding the phenomenon' (Boyatzis 1998: 63). The coded data are different from analysis units (themes) (Boyatzis 1998). In this study, the first codes were subject areas of documents determined through the research of particular texts. The coding of the subject areas in this paper was performed manually by assigning an exclusive code to each of the policy documents' subject areas from different countries. Thus, the data were

coded by writing notes on the texts that were being analyzed, using highlighting and punctuation.

### 3.3 The third stage
The third stage was the search for and designation of themes. The first analysis codes and each set of equivalent codes were combined to create a general theme. Several of the primary codes formed the main themes, some formed the sub-themes, and the rest were removed. Following the first coding of 'thematic domains of OS policy documents', this study examined relationships between codes, between themes, and between different levels of themes (i.e. major overarching themes and sub-themes within them). Various codes were categorized into main themes and sub-themes. OS is considered an ecosystem, and like any other dynamic system, it consists of inputs, outputs, and processes. Therefore, to better understand the nature of themes, the above classification of input, output, and process was applied. This means that in this stage, a title was assigned for the main themes and sub-themes, indicating the nature of metrics discussed by that theme determining which aspect of the criteria the theme contained.

### 3.4 A final report
The final report was presented on the main and secondary thematic areas of OS policy metrics and OS support policies in selected countries in the fourth stage. Data within themes should cohere together meaningfully, while there should be clear and identifiable distinctions between themes. This phase concludes with a set of candidate themes, sub-themes, and all data extracts coded (ST1–ST11, where ST is secondary theme) concerning them.

## 4. Data analysis

In the first stage, the policy documents extracted up to December 2020 were examined in terms of relevance to the subject of OS and its various components, which finally resulted in national and institutional policy documents (Table 1). The institutional policies address inside the organization, while the scope of national policies is nationwide.

In the second stage, through the study of policy documents, the thematic areas of OS support policy documents in each country were identified (first codes). Analyzing and identifying the general pattern of policy documents in the selected countries, a code was assigned to each of the subject areas of policy documents (Table 2). The UK, for example, created a specific repository for uploading and sharing research data in the policy text entitled 'Guidance on best practice in the management of research data'. Accordingly, a topic entitled 'The need for a repository to load and share research data' as an EIA7 code was assigned to this country.

In the third stage, an attempt was made to extract and categorize equivalent subject areas with similar characteristics into sub-themes (Table 3). Besides, the sub-themes have been designated to reflect the nature and index of the subject areas they contain. For example, 'The process of self-archiving and citation of open access scientific works' with ITIA5 code is the only subject created by the ST5 sub-theme entitled 'Researchers' approach to open access', or the creation of the sub-theme 'Researchers' approach to free access' (ST9) 'originates from subjects such as 'Making research data available in

**Table 1.** Types of policy documents of different countries in the field of OS.

| Country | Issued by | Policy document |
| --- | --- | --- |
| UK | UK Research and Innovation | RCUK Policy on Open Access and Supporting Guidance |
| | UK Government Investment Association | Research Excellence Framework |
| | Wellcome Trust | Charity Open Access Fund |
| | Academy of Medical Science | Policy document |
| | Royal Society | Policy document |
| | Marie Curie Cancer Care | Policy document |
| | Arts and Humanities Research Council | Policy document |
| | UK Research and Innovation | Concordant on Open Research Data |
| | UK Research and Innovation | Guidance on best practices in the management of research data |
| | Department for International Development (DFID) | DFID Research Open and Enhanced Access Policy |
| | Natural Environment Research Council | Policy document |
| | UK Research and Innovation | RCUK Policy and Guidelines on Governance of Good Research Conduct |
| | UK Research and Innovation | Guidance on best practices in the management of research data |
| France | Ministry of National Education, Higher Education, and Research | National Plan for Open Science |
| | French National Center for Scientific Research | Feuille de route du CNRS pour la science ouverte (CNRS Roadmap for OS) |
| | Agence Nationale de la Recherche | Policy document |
| | National Institute of Health and Medical Research | Policy document |
| | European Marine Research Network | Policy document |
| Germany | Berlin Declaration | Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities |
| | The Federal Ministry for Education and Research | Open Access in Germany |
| | Leibniz Association | Open Access Guidelines |
| | Research Foundation (German Research Foundation) | Guidelines for the Use of Funds |
| | Helmholtz Association | Open Access Publications Popularization |
| | Fraunhofer | Open Access Publications Popularization |
| | German Research Foundation | German Research Foundation Document |
| | Max Planck Society | Principles for the Handling of Research Data |
| Italy | Decreto-Legge | Urgent provisions for the protection, enhancement, and revitalization of cultural heritage and activities and tourism |
| | Telethon | Policy document |
| | Fondazione Cariplo | Scientific Research Grants—Open Access Policy |
| Sweden | Swedish Research Council | Proposal for National Guidelines for Open Access to Scientific Information |
| | Forte | Swedish Research Council for Health, Working Life and Welfare (Forte) |
| | Formas | Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) |
| | Knut and Alice Wallenberg Foundation | Policy document |
| | Ministry of Education, Culture and Science | New procedure for handling alleged research misconduct |
| | Stockholm University | Good practice and misconduct in research |
| Spain | Scientific and Technical Research and Innovation | National Plan for Scientific and Technical Research and Innovation |
| | The Ministry of Science and Innovation | Consolidated Legislation/Science, Technology and Innovation |
| | Spanish National Research Council (CSIC) | CSIC Institutional Open Access Mandate |
| | CSIC | Code of Good Scientific Practices of CSIC |
| | Obra Social 'La Caixa' | La Caixa |
| | Asturias | Principality of Asturias |
| The Netherlands | Sweden Government | Amsterdam Call for Action on Open Science |
| | Ministry of Education, Culture and Science | National Plan for Open Science |
| | Netherlands Organization for Scientific Research | Policy document |
| | Royal Netherlands Academy of Arts and Sciences | Policy document |
| | General Board of the Association of Universities (Algemeen Bestuur van de Vereniging van Universiteiten) | Netherlands Code of Conduct for Scientific Practice |

the shortest possible time' with EIA12 code and also 'Voluntary and spontaneous data sharing' with GIA11, which belong to UK and Germany, respectively.

In the fourth step, to give a better representation of thematic areas of OS policy indicators from the studied countries, the extraction of the main themes of OS policy support
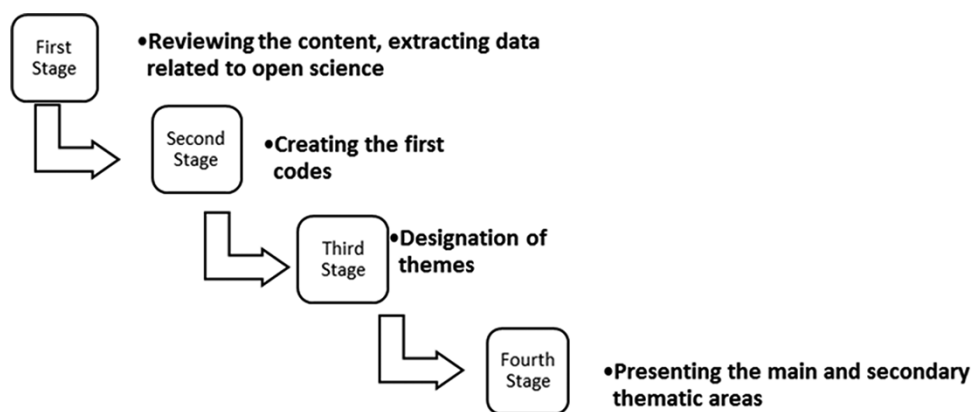
**Figure 1.** Stages of research methods of thematic analysis.

documents based on each category of valuable sub-themes was on the agenda. Thus, the main themes were categorized in the form of Table 4.

According to Table 4, a complete map of the main themes and sub-themes from subject areas of policy documents in countries under study in the field of OS is presented in Fig. 2, which shows that the policies adopted in the OS ecosystem of countries in various relevant subjects have been developed in the form of input, output, and open process. In this ecosystem, 'open input' is related to the sharing of raw data, analytics, pamphlets, and any input created in a scientific process such as papers, designs, and books, as well as issues related to their storage, including repository. The open process involves the platforms, infrastructures, and activities developed to generalize and share science at all levels and steps. The open output is related to unlocking the findings and outputs of science that encompasses all alternative methods for disseminating research results, platforms accelerating the release of search results (e.g. preprint), and corrections resulting from plagiarism. It is worth mentioning that open peer review concerns effective scholarly communication through peer reviewing; however, this can be the indicator of open output when it comes to publishing the findings.

Finally, Table 4 is devoted to a comparative study of countries and OS support policies of three main themes. Policies are presented separately for institutional and national policies. The researchers' approach to open access (ST5) is categorized in the open process as it naturally gets the route in the research process instead of output. It is worth mentioning that a document could contain multiple policies; therefore, a single document could be counted multiple times in this study.

## 5. Findings

Analysis of research findings based on research objectives is presented in the next subsection.

### 5.1 Comparative study of selected countries in terms of approved OS policies

According to Fig. 3 and Table 5, the selected countries did not have the same status in various OS components, and among the three areas identified in OS, 'open access publications' were discussed more than others. The findings displayed that

twenty-nine national and fifteen foundation documents have been developed to make the publications accessible in selected countries. Publication open access has been the most prominent and controversial dimension of OS, after which scientific achievements are freely available to the public. Thus, fifteen national and fourteen institutional documents were related to data sharing in all countries. Indeed, in OS activities, open access to publications and data is closely interrelated (Laakso et al. 2011), and access to 'open research data' was concerned only a short while later to 'open access' issues and was supported by various countries.

According to the amount of coverage in Fig. 1, countries have paid less attention to 'open scholarly communication' than the other two components. In general, there are five national policy documents and three institutional policy documents in this regard. The lower attention to this component is probably due to the relative recentness of the topic of open scholarly communication relative to the two issues of open access and data sharing because although there have been detailed discussions about the advantages and importance of opening the scientific findings, publications, and research data, there are still ambiguities on the benefits of utilizing the indicators associated with open scholarly communication.

On the other hand, most data-sharing policies do not present specific guidance on measures that should be taken to ensure that maximum data are available and utilizable, and the importance and benefits of data sharing are usually published in the context of discussion for public access to research findings, especially papers. Germany, meanwhile, was the only country to pay almost equal attention to all three main issues, while Italy was less focused on all three main issues generally.

On the other hand, France, Germany, the UK, and Italy are members of the G8 group, and all have signed the 2013 Declaration of the UK Ministry of Science that emphasizes the creation of global research infrastructure, open research data, and open access to peer-reviewed research resources. Hence, the high number of policy documents in these countries will not be unexpected. Among G8 countries, however, Italy has the most minor policy documents. It should be noted that the presence of national open access policies for Italy has been the concern of many researchers in this country, which means that many reports over time have aimed at encouraging the ministries and organizations supporting Italian research to formulate a strong policy document to implement open

**Table 2.** Thematic first codes of policy documents in the field of OS.

| Countries | First codes |
| --- | --- |
| UK | Researchers' progress requirements for producing sound research (EIA1); use of Twitter account to benefit from the ideas and feedback of people working in the field of humanities (EIA2); research data sharing (EIA3); open sharing of all research data within legal, ethical, and scientific framework (EIA4); open research and improved accessibility policies (EIA5); unrestrained, free, and fast access policy (EIA6); the need for a repository to load and share research data (EIA7); use of a special resource for loading research (EIA8); International Development Organization promoting open access (EIA9); free access by Academy of Medical Sciences (EIA10); data sharing (EIA11); making research data available in the shortest possible time (EIA12); peer review of research works produced by researchers (EIA13); open access policies by Higher Research Framework Organization (EIA14); free and open publication of scientific achievements from the Open Access Charity Investment Center (EIA15); full sharing of research data (EIA16); and archiving and retrieving research data (EIA17) |
| France | Establishment of a repository for data storage (FIA1); the importance of increasing communication of scientific content users and taking advantage of their feedback (FIA2); uploading research data freely (FIA3); open access to research papers upon publication (FIA5); access to all research findings freely in the research network (FIA6); developing a culture of managing and sharing data between different types of users (FIA7); complete insertion of all scientific data in Hall repository (FIA8); new methods of publishing scientific achievements such as equivalence (FIA9); 100% free access to scientific resources (FIA10); financial support for research projects in various subject areas (FIA4); expansion of open access activities using digital facilities (FIA11); attention to and investment in prepublication of papers in the form of short essays (FIA12); and establishment of prepublication servers (similar to archive) (FIA13) |
| Germany | Increasing retrievability and visibility and facilitating the process of citing scientific works (GIA1); the importance of open access to papers by the organization (GIA2); providing institutional data-sharing policies (GIA3); organizational focus on open and public data dissemination (GIA4); publication of research data by the Helmholtz Association (GIA5); declaration on open access to knowledge in the German Science and Humanities (GIA6); ability to measure open access publications (GIA7); implementing innovative approaches and new business models to enhance scientific communication (GIA8); principles of 'good researcher' behavior (GIA9); public access to science publications by the Helmholtz Association (GIA10); voluntary and spontaneous data sharing (GIA11); support for open access to publications (GIA12); and establishment of an active working group to prepare a research data repository (GIA13) |
| Italy | 'Open access policies' by institutions (ITIA1); the importance of data sharing (ITIA2); publication of government research in open access journals (ITIA3); having a repository for publishing papers (ITIA4); and the process of self-archiving and citation of open access scientific works (ITIA5) |
| The Netherlands | Five principles of prudence, credibility, reliability, impartiality, and independence of Code of Scientific Conduct (NIA1); availability of all organizational scientific content (NIA2); the need to open alternative methods of publishing research results (NIA3); full access to publications (NIA4); the need to measure the impact of research and facilitate the introduction of people's knowledge in the research process (NIA5); special attention to organizational data sharing (NIA6); availability of research data through a university repository (NIA7); academic open access policies (NIA8); and full access to scientific research in Amsterdam Declaration of Open Science (NIA9) |
| Spain | Retraction of papers because of scientific misconduct (SPIA1); the importance of open access in increasing and improving visibility and impact of scientific achievements in the Spanish National Research Center (SPIA2); sharing research data to improve the impact of scientific works (SPIA3); publication of the results of all research studies under the title of 'Code of Good Scientific Research Approach' (SPIA4); free publication of scientific research and data sharing (SPIA5); the importance of data access and public use of results (SPIA6); production of science from projects provided by the organization (SPIA7) subject to open access to the text of 'Constitution of Science and Technology' (SPIA8); and providing a research repository for public sharing of research achievements (SPIA9) |
| Sweden | 'Appropriate Approach to Research and Immorality' Guidelines (SWIA6); national guidelines for open access to scientific information (SWIA1); new approach to dealing with scientific misconduct (SWIA2); access to research data (SWIA3); Knut and Alice Wallenberg Open Access Policy (SWIA4); and Swedish Medical Research Council's Research Achievement Sharing Policy (SWIA5) |

access activities, execute national declarations, and explain the importance of open access for progress in the country's research and economic field. Only some of the policy's content associated with the data-sharing policy mentions the need for a specific repository for this purpose, including the Hall Repository in France, Dance Archive Network, Riculta Repository in Spain, and Operetac in Turkey.

## 5.2 Thematic analysis of OS policies in selected countries

As mentioned, the OS ecosystem covers a variety of topics. Therefore, supportive policies should encompass all OS components. In this study, OS policy documents were classified according to main themes and sub-themes. The sub-theme showed the thematic areas of policy documents in the field of OS, which were classified into eleven items based on their nature. Research data repository (ST1), open access publications (ST2), research supporter policies for open access publication (ST3), journal policies for open access (ST4), prepublications (ST4), researchers' approach to open access (ST5), alternative dissemination platforms (ST67), research-related policies for data sharing (ST7), correction and retraction of papers (ST8), researchers' approach to data sharing (ST9), open peer review (ST10), and the use of Altmetrics platform for assessment (ST11) indicate thematic areas in sub-theme. Subsequently, the main themes of OS support policy documents in selected countries were extracted and separated based on open input, open process, and open output. Besides, based on the findings, all the countries had developed policies

**Table 3.** Extraction of sub-themes of OS policy documents.

| Countries | First codes | ST |
|---|---|---|
| UK, Italy, Germany, Spain, and France | The need for a repository for uploading and sharing research data (EIA7); archiving and retrieval of research data (EIA17); use of special resources for loading research (EIA8); providing a repository for publishing papers (ITIA4); establishment of an active working group to prepare a research data repository (GIA13); providing a research repository for public sharing of research achievements (SPIA9); complete repositioning of all scientific data (FIA8); and establishment of a repository for data storage (FIA1) | Research data repositories (ST1) |
| UK, France, Germany, Italy, the Netherlands, Spain, and Sweden | Unlimited, free, and fast access policy (EIA6); publication of government research in open access journals (ITIA3); declaration on open access to knowledge in the German Science and Humanities (GIA6); increasing retrievability and visibility and facilitating the process of citing scientific works (GIA1); support for open access to publications (GIA12); the importance of data access and public use of results (SPIA6); the subject of open access in the text of 'Constitution of Science and Technology' (SPIA8); the importance of open access in increasing and improving visibility and the impact of scientific achievements (SPIA2); publication of the results of all research entitled 'Code of Good Scientific Research Approach' (SPIA4); national guidelines for open access to scientific information (SWIA1); expansion of open access activities using digital facilities (FIA11); 100% free access to scientific resources (FIA10); full access to scientific research (NIA9); and full access to publications (NIA4) | Open access publications (ST2) |
| UK, France, Germany, Italy, the Netherlands, Spain, and Sweden | Open access policies by Higher Research Framework Organization (EIA14); free and open publication of the scientific achievements of the Open Access Charity Investment Center (EIA15); international development organization supporting open access (EIA9); Open Access by the Academy of Medical Sciences (EIA10); 'Open Access Policies' by the organization (ITIA1); the importance of open access to papers by the organization (GIA2); public access to scientific publications by the association (GIA10); free publication of scientific research and data sharing (SPIA5); production of knowledge from projects provided by the organization (SPIA7); Knut and Alice Wallenberg Open Access Policy (SWIA4); Medical and Health Research Council's Research Achievement Sharing Policy (SWIA5); access to all research findings freely in the research network (FIA6); financial support for research projects in various subject areas (FIA4); free access to research papers upon publication (FIA5); availability of all organizational scientific content (NIA2); and Academic Open Access Policies (NIA8) | Research-related policies for open access publication (ST3) |
| France | Establishment of prepublication servers (similar to archive) (FIA13) and attention to and investment in prepublication of papers in the form of short essays (FIA12) | Prepublication (ST4) |
| Italy | Process of self-archiving and citation of open access scientific works (ITIA5) | Researchers' approach to open access (ST5) |
| UK | Use of Twitter account to benefit from the ideas and feedback of people working in the field of humanities (EIA2) | Alternative dissemination platforms (ST6) |
| UK, Italy, Germany, Spain, Sweden, France, and the Netherlands | Sharing of research data (EIA3); data sharing (EIA11); open sharing of all research data within the legal, ethical, and scientific framework (EIA4); full sharing of research data (EIA16); Open Research and Accessibility Policies (EIA5); the importance of data sharing (ITIA2); publication of research data by the Helmholtz Association (GIA5); organizational focus on free and public data dissemination (GIA4); development of institutional data-sharing policies (GIA3); sharing research data to improve the impact of scientific works (SPIA3); access to research data (SWIA3); Medical and Health Research Council's Research Achievement Sharing Policy (SWIA5); financial support for research projects in various subject areas (FIA4); development of a culture of managing and sharing data between different types of users (FIA7); free upload of research data (FIA3); special attention to organizational data sharing (NIA6); and availability of research data through the university repository (NIA7) | Research-related policies for free access (ST7) |
| UK, Germany, Spain, Sweden, and the Netherlands | Researchers' progress requirements for producing sound research (EIA1); principles of 'good researcher' behavior (GIA9); ability to measure open access publications (GIA7); rejection of papers due to scientific misconduct (SPIA1); guidance on appropriate research and ethics approach (SWIA6); new approach to dealing with scientific misconduct (SWIA2); and five principles of discipline, validity, reliability, impartiality, and independence of scientific conduct code (NIA1) | Correction and retraction of papers (ST8) |

**Table 3.** (Continued)

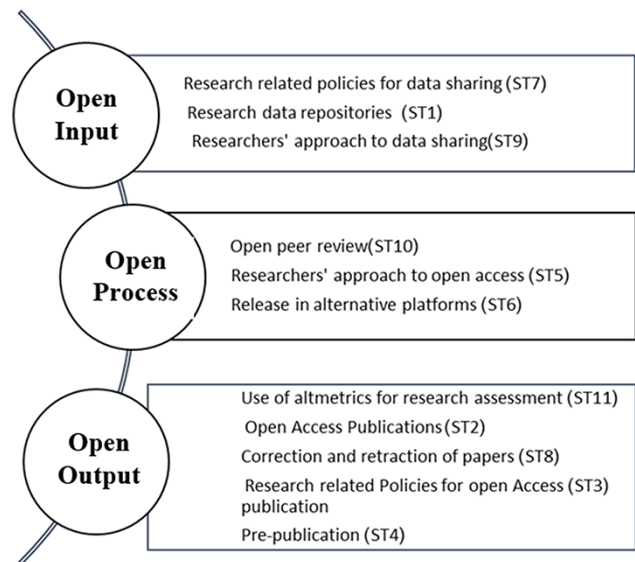| Countries | First codes | ST |
|---|---|---|
| UK and Germany | Making research data available in the shortest possible time (EIA12) and voluntary and spontaneous data sharing (GIA11) | Researchers' approach to free access (ST9) |
| UK, Germany, France, and the Netherlands | Peer review of research works obtained from researchers (EIA13) and implementing innovative approaches and new business models to enhance scientific communication (GIA8); new methods of publishing scientific achievements such as equivalence (FIA9); the importance of augmenting the communication of scientific content users and taking advantage of their feedback (FIA2); and the need to introduce alternative methods of publishing research results (NIA3) | Open peer review (ST10) |
| The Netherlands | The need to measure the impact of research and facilitate the introduction of people's knowledge to the research process (NIA5) | Use of Altmetric platform for research assessment (ST11) |

**Table 4.** Extraction of the main themes of policy documents in the field of OS.

| Main theme | ST |
|---|---|
| Open input | Research-related policies for data sharing (ST7) |
|  | Research data repositories (ST1) |
|  | Researchers' approach to data sharing (ST9) |
| Open process | Open peer review (ST10) |
|  | Alternative dissemination platforms (ST6) |
|  | Researchers' approach to free access (ST5) |
| Open output | Use of Altmetrics platform for research assessment (ST11) |
|  | Publications with an open access approach (ST2) |
|  | Correction and retraction of papers (ST8) |
|  | Research-related policies for open access publication (ST3) |
|  | Prepublication (ST4) |



**Figure 2.** Subject areas of OS policy documents in the countries under study.

related to OS, but each country focused on a specific component of OS and policies the most according to its capacities and strategies.

Open peer review and its policies among the subject areas of OS are mainly observed in European countries, and recent research has shown that European countries have played a decisive role in open peer review (Wolfram et al. 2020). Moreover, the small number of OS policies in developing countries compared to developed countries can be rooted in their ignorance of the subject of OS. Researchers in European countries seem to have devoted more efforts to increasing awareness of the importance of OS (McKiernan et al. 2016). An example of negligence of open access in a developing country was a study conducted in 2006, which found that only 23 per cent of active researchers were aware of the existence of open access journals and that others did not use vast resources that were freely accessible to them (Papin-Ramcharan and Dawe, 2006). On the other hand, the absence of proper Internet infrastructure can influence policymakers' lack of attention to OS. Because most open access resources are web-based, taking advantage of all the features and benefits of open access requires a good and acceptable Internet connection (Chan and Kirsop 2001).

In the meantime, the policy plan or tool should not be ignored, which is a kind of policy implementation defined in the form of several activities, actions, projects, or plans such as the OS working group established by the Helmholtz Association to develop a research data repository to present recommendations for the performance of repositories, as well as management criteria, for golden publications. TUBITAK has also established a repository called 'Aperta' to store and publish researchers' research data (TUBITAK 2019).

It should be noted that the multiplicity of policies in the 'open process' indicates the need for a suitable platform for the implementation of OS in the scientific community; on the other hand, the diversity of these supportive policies reveals their high importance in OS of the world, and the wide range of subjects suggests the array of the OS ecosystem; therefore, the distinctive features of the scientific community of the country in question should be taken into account. However, it is expected that governments' policies in the field of OS will not be predictably effective as one of the problems in implementing policies in this area occurs when there are legal barriers to the dissemination of data due to privacy concerns, moral issues, and intellectual property rights. Encouraging the idea of open publication demands resolving the fundamental issue of data ownership, responsibility, and control, which has not yet been universally agreed upon (Borgman 2015). Such problems are not limited to developing countries, and implementation problems could arise wherever and whenever fundamental and vital policy implementation factors are lost.
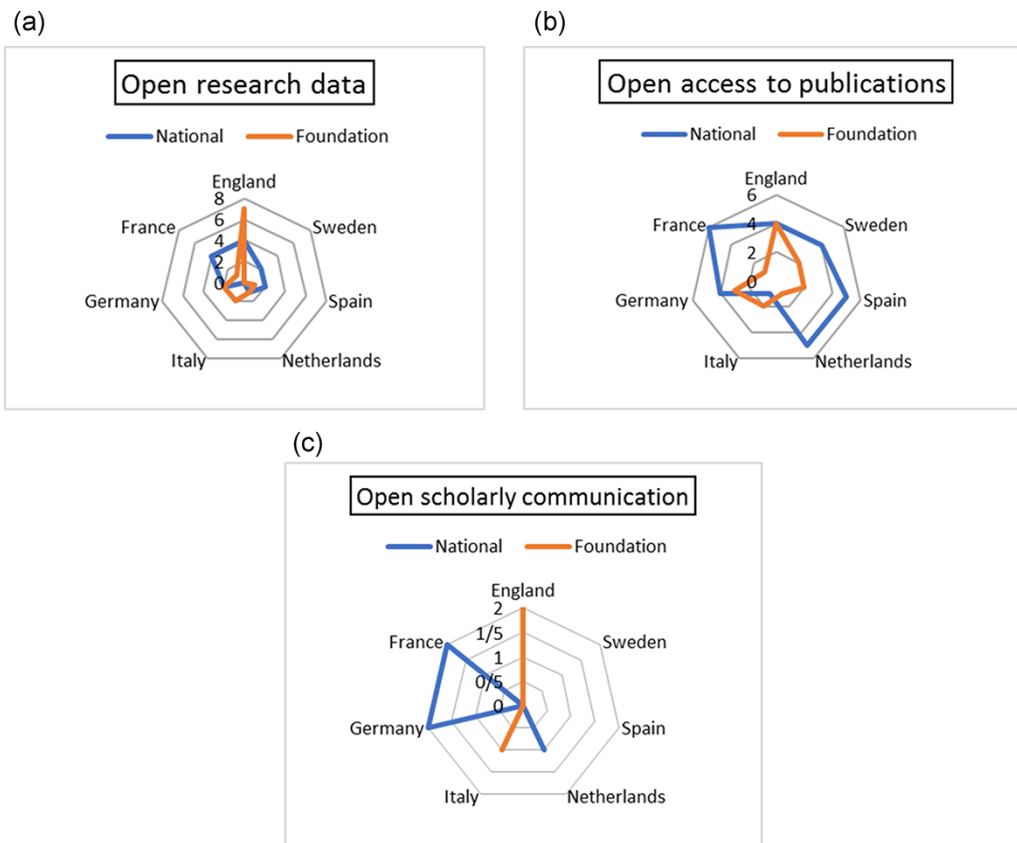
**Figure 3.** Status of selected countries based on OS policy documents.

**Table 5.** Comparison of countries in terms of policy documents based on the components of OS (alphabetically).

|  | Open output | | Open input | | Open process | | Total documents | |
|---|---|---|---|---|---|---|---|---|
| Countries | National | Institutional | National | Institutional | National | Institutional | National | Institutional |
| UK | 4 | 4 | 4 | 7 | 0 | 2 | 8 | 13 |
| France | 6 | 1 | 4 | 1 | 2 | 0 | 12 | 2 |
| Germany | 4 | 3 | 2 | 2 | 2 | 0 | 8 | 5 |
| Italy | 1 | 2 | 0 | 2 | 0 | 1 | 1 | 5 |
| The Netherlands | 5 | 1 | 1 | 1 | 1 | 0 | 7 | 2 |
| Spain | 5 | 2 | 2 | 1 | 0 | 0 | 7 | 3 |
| Sweden | 4 | 2 | 2 | 0 | 0 | 0 | 6 | 2 |
| Total | 29 | 15 | 15 | 14 | 5 | 3 | 49 | 32 |

Furthermore, as a result of the study, it is evident that OS support policies are lacking in each of the countries studied, emphasizing the need to identify and formulate these policies. Although it may be difficult for countries, especially developing ones, to formulate open access policies (Papin-Ramcharan and Dawe 2006), the valuable advantages of such policies will undoubtedly provide sufficient reasons to continue this course of action. Realizing such a systemic change involves an internationally-coordinated effort of researchers, universities, research institutes, publishers, research councils, and policymakers.

### 5.3 Suggestions to fill in the gaps and shortcomings of the OS policy documents

The following suggestions will fill the gaps identified by our findings: the research processes and outputs must be conducted more transparently and accessible to enhance the uptake of results by policy and society at large. Research uptake, communication, and interaction between researchers and policymakers must improve. It is important to encourage local scientific expertise of OS to participate in relevant policy decisions, as well as a broad set of stakeholders and civil society actors to engage in this purview. Last but not least, in order to bridge the evidence–policy gap, scientists need to improve their communication skills.

## 6. Conclusion

To strengthen the ecosystem of OS, all respective actors must be diligent; in this way, the study of the drivers and barriers influencing OS pertinent practices in three dimensions (open input, open process, and open output) is essential. Moreover, it is crucial to provide an international framework for OS

policy and practice and recognize the development and promotion of new methods to incentivize and reward researchers contributing to this purview. On the other hand, investigating the impact of various open scientific policies on the integrated European scientific system, along with identifying factors to strengthen OS policies for the European Union, is highly recommended.

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