

Drivers and barriers in the transition to open science: the perspective of stakeholders in the Spanish scientific community

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Abstract

This paper presents the results of a research study whose objective was to identify the facilitating factors and barriers that, in the opinion of representatives of the Spanish scientific community, impact the implementation of the new open science model in four areas: open access, open research data, research assessment and open peer review. A qualitative study was designed in which information was obtained through interviews with researchers, editors of scientific journals, representatives of assessment agencies and vice-chancellors, and through a focus group of librarians with expertise in aspects of open science. The enabling factors and barriers identified were related to the researcher and the fruit of their research, as well as to the scientific ecosystem, which provides direct institutional support and backing (universities/research centres), the regulatory framework (management of the science system) and the science communication system (media). The results indicate that a shift in scientific practices toward the open science model can only be achieved if there is a policy framework that integrates all initiatives and links into the scientific assessment and reward system, and if the necessary funding is in place to support this transition.

Keywords

Open science; Open access; Open research data; Research assessment; Open peer review; Scientific system; Legislation; Research funding; Feasibility; Spain.

1. Introduction

It has now been 20 years since the Budapest conference that led to the *Budapest Open Access Initiative*. This manifesto showed that, at last, new technologies could change scientific communication by speeding up dissemination and facilitating access to publications (Abadal, 2017). At that time, the Internet was already starting to transform multiple processes in the areas of research, administration and education. Meanwhile, open access was opening up through scientific policy, from promotion to obligation, activism to legislation, and raising expectations about what could be shared. From that point, there were no further technological excuses to bar collaboration, and an increasing number of repositories and platforms were created to share content of various kinds (Ferreira *et al.*, 2008). Thus the foundations of what we now know as open science (OS) gradually began to take shape. The Foster project (2018) defined it as

“the practice of science in such a way that others can collaborate and contribute, where research data, lab notes and other research processes are freely available, under terms that enable reuse, redistribution and reproduction of the research and its underlying data and methods”.

For Anglada and Abadal (2018), OS introduces an open vision both in the design and the collection of data, peer review and the dissemination of research results. This change, rather than representing a rupture, is a social and cultural shift in scientific research, formalised, *inter alia*, by the *European Commission*, especially in its document *Digital Science in Horizon 2020* (European Commission, 2013). Thus, the concept of OS signifies a step forward in assuming a global and strategic vision of the way science and research are approached (Bartling; Friesike, 2014), promoting and covering parallel and multidisciplinary initiatives related to open access, the sharing of research data, educational resources, citizen science and the open review of scientific articles. On the other hand, Fecher and Friesike (2013) identify five perspectives in the literature on the cross-cutting approach to these dimensions of OS. They consist of the focus on its technological infrastructure, the right of access to knowledge, efficiency in the generation of this knowledge through collaboration, the extension of the audience that accesses it to include interested non-experts and, finally, the search for alternative standards to determine scientific impact.

It should be noted that, unlike the open access movement, the other OS fields have been promoted by public actors, the *European Commission* (2016; 2018; 2019) in particular. Proof of this can be seen in the progressive incorporation of the obligation to publish research articles and data in open access, pioneered by European public funding projects (e.g. The *Horizon* programme), but also by private funding projects (e.g. the *Wellcome Trust* and the *Bill & Melinda Gates Foundation*). However, while this has given a boost to OS from a science policy perspective, it does not mean that it enjoys the buy-in of all actors involved. As in any process of profound transformation such as that represented by the transition to OS, while the main structures are in place, it is also necessary for the actors involved to embrace the cultural and social change that this transformation implies. For this, even today, it is necessary to assess how the various OS initiatives are being implemented and to understand the barriers and reluctance that these initiatives may generate. Understanding science as a rational academic whole, but also as the sum of multiple individual visions. With logic, but also with emotion, habits, doubts and need for support and backing.

The *European Commission's* Science 2.0 survey (European Commission, 2014) identified some early barriers to the adoption of an OS model. They included a lack of incentives and financial resources (e.g. APCs or article processing charges), doubts about quality in open review processes, or issues related to intellectual property. In the same vein, Levin *et al.* (2016) identified others such as competitiveness among researchers, the diversity of repositories for all types of data and publications, and the academic remuneration

“ Open science is a social and cultural turn in scientific research ”

system. In addition, in recent years, a number of survey-based research studies have been carried out, such as the annual report by **Hahnel et al.** (2020) focusing on research data, as well as the systematic review by **Zuiderwijk, Shinde and Wei** (2020) on the facilitators or inhibitors of sharing research data. Moreover, other studies have addressed the determinants for the adoption of OS globally, such as the work of **Gagliardi, Cox and Li** (2015), **Cabello-Valdés et al.** (2017), **Pardo-Martínez and Cotte-Poveda** (2018), **Allen and Mehler** (2019), and **Heise and Pearce** (2020).

“ We need to understand the barriers to the implementation of open science ”

However, despite the abundant literature on the process of dissemination of OS in all its aspects, what **Fry, Schroeder and Besten** (2009) call a shortfall in research governance between micro-practices at the level of the researcher and research projects, and macro-policies at the institutional level can still be observed, resulting in an environment of uncertainty despite the impetus given to OS by the institutions. In this regard, it is especially relevant to examine these aspects with respect to open access, which is the earlier extended dimension and which can help us understand how to promote the remaining initiatives more efficiently. It is enough to see how the recent public health crisis brought about by Covid-19 has afforded a huge step forward in terms of data sharing and almost immediate dissemination of articles between the laboratory and the public (**Méndez**, 2021).

In the case of this particular research, it has been carried out in Spain where, back in 2011, the Science, Technology and Innovation Act established the legal obligation to deposit a copy of the articles published in an open access repository in the framework of its state R&D&I projects. Some studies have found that the level of compliance with this mandate is quite low (**Borrego**, 2016; **Fecyt**, 2016; **Abad-García; González-Teruel; González-Llinares**, 2018; **Melero; Melero-Fuentes; Rodríguez-Gairín**, 2018). It seems appropriate then, ten years on, to acquire an in-depth understanding of the perspectives on OS of the actors involved in the Spanish scientific community. All the more so, when the only known approaches to the issue of OS in Spain have focused on a single actor (usually researchers) (**Segado-Boj; Martín-Quevedo; Prieto-Gutiérrez**, 2018); a single dimension, mainly open access (**Abadal et al.**, 2019; **Ferreras-Fernández**, 2021) and generally through surveys (e.g. **Ruiz-Pérez; Delgado-López-Cózar**, 2017; **Rodríguez-Bravo; Nicholas**, 2020) which, while they provide representative results, do not contribute to an in-depth understanding of the phenomenon under study.

The importance of studies of this kind lies in the insight they can provide, beyond merely quantitative metrics, into practices, habits and attitudes related to aspects requiring a regulatory framework which, as mentioned above in relation to OA, has proven ineffective. At a time when various public initiatives are seeking to promote a fully open vision of science, does the academic community understand the need for and advantages of OS? How successful might other regulatory actions be, such as making data sharing and reuse compulsory? And above all, are the current scientific assessment systems, most of which are based on individual reputation (citations and impact) and competition for resources, ready to assimilate OS values such as the notion of collective benefit? And in the process of assimilating these values, can and should assessment agencies encourage publication in open peer review journals given the conflicting views on the effects of maintaining open identities (**Thelwall et al.**, 2021)? Answering these kinds of questions could help us to take the necessary steps towards truly open science, provided that the scientific ecosystem is ready for it.

In this context, the aim of this research was to expose the facilitating factors and barriers that, in the opinion of representatives of the Spanish scientific community, affect the implementation of the new open science model in four areas: open access (OA), open research data (ORD), research assessment (RA) and open peer review (OPR).

2. Method

A qualitative study was designed in order to gain an in-depth understanding of the perspectives of all actors involved in the transition to OS in the studied environment. The results obtained were to be the basis for a subsequent survey study that would also provide representative results of the entire population. This population consisted of all stakeholders in the Spanish public science community. Specifically, researchers, editors of scientific journals, vice-chancellors of universities with responsibilities in aspects of OS, heads of research assessment agencies and university librarians responsible for repositories or other areas related to OS. The selection of informants for the qualitative study was done through purposive sampling, including key informants or key knowledgeable (**Patton**, 2002), because of their role in the scientific system and therefore their ability to contribute relevant information to the research. All stakeholders with whom the members of the research team had had prior contact were invited to participate, and 31 informants expressed their availability.

Initially, data collection was to be carried out by means of focus groups with each interest group, with a view to obtaining information not only from each informant, but also from their interaction. However, the March-May 2020 lockdown period made necessary by the Covid-19 pandemic prevented this and online interviews were conducted instead, except in the case of librarians with whom a focus group was conducted. A total of 23 interviews were conducted with editors of university scientific journals (9 interviews), researchers (9), vice-chancellors (3), and assessment agency managers (2). With the exception of one vice-chancellor [03VR3], all of them, regardless of their post at the time of the interview, were researchers in different scientific fields. Eight librarians from university libraries participated in a focus group. Table 1 lists the make-up of the 31 informants who are assigned a code, as referenced in the presentation of the results (Table

1). Additional details on the informants are provided as supplementary material for the purposes of further contextualization of the results (see Appendix 1).

Table 1. Informants

Vice-chancellor/ Area of research (3 interviews)	Researchers/ Area of research (9 interviews)	Editors/ Area of the journal (9 interviews)	Librarians/ Responsibility (1 focus group)	Agencies (2 interviews)
01VR1 - Medicine	04INV1 - Economics	13ED1 - Documentation	23BIB1 - Repository	31AG1 - Mathematics
02VR2 - Anthropology	05INV2 - Engineering	14ED2 - Pharmacy	24BIB2 - Training	32AG2 - Engineering
03VR3	06INV3 - Psychology	15ED3 - Education	25BIB3 - Repository	
	07INV4 - Biomedicine	16ED4 - Biology	26BIB4 - Repository	
	08INV5 - History	17ED5 - Biology	27BIB5 - Repository	
	09INV6 - Medicine	18ED6 - Economics	28BIB6 - Repository	
	10INV7 - IT	19ED7 - Inform. science	29BIB7 - Repository	
	11INV8 - Sociology	20ED8 - Medicine	30BIB8 - Research	
	12INV9 - Economic	21ED9 - Medicine		

The interviews were conducted using a script that included different questions related to OS (Table 2 and Appendix 2). Each of the agents were asked only about the areas of OS over which they had decision-making power. This paper contains the analysis of the results of the questions regarding the barriers and facilitating factors. In the context of this research, barriers were considered to be any factor that could obstruct or hinder the implementation of OS policies, procedures or strategies. Conversely, enabling factors were considered to be those that could facilitate such actions.

Table 2. Informants, data collection technique and barriers/drivers for each dimension of OS observed for each group

Informants	Data collection	Dimensions of open science			
		Open access (OA)	Open research data (ORD)	Research assessment (RA)	Open peer review (OPR)
Vice Chancellors	Interviews	*	*	*	
Researchers	Interviews	*	*		*
Editors	Interviews	*	*		*
Librarians	Focus group	*	*		
Assessment agencies	Interviews			*	

The interviews and focus groups were conducted between March and May 2020 and lasted an average of one hour. In all cases, data collection was conducted via video conference, which was recorded for later transcription and analysis. This analysis took the form of qualitative content analysis in two phases. In the first phase, the interviewers themselves carried out a full manual analysis only of the interviews they had conducted. This first analysis started by reading the transcripts, line by line, underlining the relevant fragments according to the research question and assigning them a code, i.e., a word or phrase reflecting the content of the fragment. In the second phase, a single researcher carried out a second analysis based on the transcripts and the results of the previous analysis. For this second phase, an open coding process was used using *Atlas.ti* software. As prescribed by Boeije (2010), this process started with a complete reading of each transcript. Subsequently, the fragments that were significant for this research (enabling factors and barriers) were coded. Finally, these codes were compared with each other and with those obtained by the interviewers and grouped into two general categories. In the first, the factors related to the researcher and the research outputs were grouped together. In the second, the factors related to the scientific ecosystem responsible for providing direct institutional support and backing (universities/research centres), the regulatory framework (management of the science system) and the science communication system (media) were grouped together. In addition, the two analysis phases were used as peer debriefing, which, together with the thick description of the research process and the implementation of an audit trail in the software used for the data analysis, shaped the procedures to ensure the trustworthiness of the research (Lincoln; Guba, 1985). In this regard, it is worth mentioning that the interviews were conducted in Spanish or Catalan, although the fragments of the transcripts included in the results were translated into English.

Finally, the data collection process followed the ethical standards of social research, with each informant having to sign or verbally grant their informed consent on the template provided by the *University of Barcelona*, the

“Lecturers want to have everything in open access but are reluctant to deposit their own work in open”

institution hosting the project. This document included information about the research (objectives, methods, funding and the team), the voluntary nature of the participation, the destination of the data collected and the commitment to confidentiality and anonymity in the management of these data. In view of this commitment, any identifying information of the informants was disassociated from the responses, and they were identified only by a code during the analysis of the information.

3. Results

3.1. Open access to publications

All informants, apart from the representatives of the assessment agencies, were considered as actors involved in this dimension of OS (Table 3).

Table 3. Enabling factors and barriers to the adoption of OA

Enables	I	E	R	V	Barriers	I	E	R	V
Researchers and their research									
Greater impact and visibility		*	*		Increased workload				*
Increasing accessibility		*	*		Age of the researcher			*	
					Contradictory attitude	*	*	*	
Scientific ecosystem									
Institutional support									
OA promotion/mandatory policies	*	*	*		Putting OA into practice				*
Training and deposit campaigns	*		*		Lack of OA funding		*		
Existence of an institutional repository			*		Lack of OA plans and policies	*			*
Information tailored to each researcher			*		Unclear institutional procedures			*	
Curricular incentives	*	*			Lack of incentives and support for publishing	*		*	
Economic incentives	*		*		Lack of visibility of the institutional repository			*	
					Repository usability			*	
Regulatory framework									
Requirement/obligation of the call for proposals	*	*	*	*	Current assessment system	*	*	*	*
					Private indices as the basis of the system		*		
Scientific communication system									
Commitment to OA for publishers		*			Confusion/lack of awareness of the transfer of rights	*	*	*	*
Early transition to an electronic format		*			OA publication costs - APCs	*		*	
Agreements with major publishing groups		*			Lack of prestige OA journals			*	
					Predatory magazines			*	
					Sustainability of the journal in an OA environment		*		

L: librarians; E: editors; R: researchers; V: vice-chancellors

3.1.1. Researchers and the dissemination of their research

There were two enabling factors directly related to the researcher and the fruit of their research. The first is the belief that both open publication and the use of document repositories increase the impact and visibility of the work. Derived in part from this, the second is the fact that accessibility to and therefore dissemination of the publications has been made easier:

“If it is open, it is more accessible to everybody. In other words, the main motivation that, let’s say, what you publish or contribute [to] becomes accessible to everybody and that [...] people [...] don’t have to pay for anything. In the end, for research that, in many cases, has already been funded with public money, the results should be accessible to the public, who, when all is said and done, have funded the whole process.” [11INV8]

There were three barriers directly related to the researcher. The first is the increased workload involved with document repositories and the second is the greater reluctance to change among the older generation of researchers. The third barrier is the contradictory attitude of some researchers mentioned by librarians, editors and researchers alike:

“Lecturers want to have everything in open access so that they can have these materials, but [...] they are more reluctant to make their own work available in open access.” [27BIB5]

3.1.2. Scientific ecosystem

Enabling factors

The enabling factors related to the scientific ecosystem had three main aspects. The first relates to the role of the university and/or research centre as the most immediate point of support in the field of OA. Therefore, institutional policy and strategies for the promotion and/or enforcement of OA and, specifically, campaigns to promote the deposit of work on open access repositories were mentioned as favourable factors:

“Nowadays, the institution requires the author’s version from the researcher. And then it is the library that checks the rights. What has happened as a result? In a few years we have gone from 60% to over 95%. Because sooner or later we get an open version, thanks to what? Thanks to research policy.” [28BIB7]

In addition, at the institutional level, the existence of an institutional repository and the adaptation of the information disseminated on OA to each researcher or area, as well as the existence of curricular and economic incentives, were also mentioned as favourable factors:

“...the grass roots movement [...] around the importance of open access is perhaps the biggest driver of change. Obviously, it helps if the institution joins this movement and there are initiatives, firstly to provide information and secondly to encourage this type of publication.” [04INV1]

The second group of factors with a driving effect on OA within the scientific ecosystem involve the regulatory framework and, in particular, the deposit or open publication requirement in calls for proposals for research funding, something mentioned by informants from all groups:

“I think Europe has done more, ...all the papers that come out have to be open. I don’t really mind where, but a science law with an article that, I believe [...], many institutions fail to comply with and nothing happens as a result.” [03VR3]

Finally, the remaining enabling factors within the scientific ecosystem are related to the scientific communication system and were contributed by editors only. Thus, from this point of view, the commitment of publishers to OA, the early transition to an electronic format and the possibility of establishing agreements with large publishing groups favour OA at the editorial level:

“...in terms of costs and contribution, as a editor, it is much more profitable for me to be in a publishing group like this..., as opposed to the university, since the university is not a publishing house and does not have the same clout as publishers such as Springer, not to mention the marketing and dissemination systems as their disposal.” [15ED3]

Barriers

The barriers related to the scientific ecosystem also spanned three aspects. First, from the institutional point of view, while vice-chancellors see the barriers as a lack of plans and policy and their translation into practice, the rest of the actors attribute these barriers to the university itself (Table 4).

Table 4. Barriers to OA adoption attributed to the university by editors, researchers and librarians

Group	Barrier	Example from interviews
Editors	Lack of funding for open publishing by universities.	“Of course, as a editor I thought, when all these things were happening, that there were only two ways to do it and one was that my university supported all this and economically speaking, I was told [no], no way!... And the other, which is the first [the quickest] way that I explored was to look for co-publications.” [15ED3]
Librarians and researchers	Lack of openness plans and policies, as well as incentives and support for open publishing.	“We intend to publish in the top impact Q1 journal and it’s open, but will the [university] help us? I don’t think so, and it’s going to cost \$2,500. Ah, no, go to open, but pay for it out of your project.” [12INV9]
Researchers	Lack of clarity in institutional procedures related to OA.	“We have wasted weeks on absurd discussions and the worst thing is that each periodic assessment of the project leads to the same discussion [...] at the institutional level, surely the message was clear that there was an obligation, an interest in promoting this form of publication. But at the level of monitoring, the whole thing is still quite green after a year and a bit.” [05INV2]
Researchers	Problems with repositories for depositing document (e.g. visibility or usability).	“At the technical level, it is also true that the repositories where you can put all this type of information are sometimes not especially usable, or easy to go to to deposit the data.” [10INV7]

Beyond the institution itself, from the point of view of the regulatory framework, it is the current science assessment system that is conditioning the adoption of OA, an aspect on which all four groups of informants agree, and which translates into incoherence between what should be done in the spirit of OA and the reality of a system that promotes impact as an assessment criterion:

“...I think it is a pioneering factor in this avalanche of inconsistencies, in other words, publish in open but you won’t receive a penny, publish in open [...] but it is worthless since the repositories that are worthwhile are the international ones, where there is much more [...] visibility and publish in open and then I will assess you through the impact.” [12INV9]

Finally, there were five barriers related to the scientific communication system. One barrier mentioned by informants from all four groups is the lack of knowledge or confusion around publishing policy with regard to usage rights:

“The editorial policies, that some [journals] implement for publications, copyrights, etc., mean that they sometimes don’t know exactly what the copyrights are, or because explicitly in some publishers the publishing contracts give very limited exclusivity.” [02VR2]

In addition to the previous barrier, there is another identified by librarians and researchers. This consists of the unaffordable cost per publication imposed by many journals. From the researcher’s point of view, there is also the lack of prestige of some OA journals with a short history, which are therefore not included in the impact indices, together with the existence of predatory journals that confuse the researcher:

“The bad press that many of these journals have attracted, as open access requirements are often confused with predatory journals, is due to the fact that in many cases, in order to justify charging fees, these journals argue that the article will be in open access. I therefore think that much more information is needed here to allow authors to distinguish between the two.” [04INV1]

In addition, a final barrier was mentioned by the editors alone: the curtailing of the sustainability of their journal caused by the competition posed by other journals included in the main impact indices in attracting good manuscripts, given that an OA journal enjoys little or no institutional funding:

“Is that sustainable? Well, these doubts come up regularly at editorial board meetingsif our journal does not enter *WoS* or *Scopus* indexes in a reasonably short period of time, we are forced to conclude that it has no prospect for life, not because of open access, but because of the fierce competition to be in this league of indexed journals. A journal that is not currently indexed, without the support of the university itself, [...] is therefore condemned to self-publication, which is not useful for the department either, since publishing in your own university does not score points in accreditations and you have no great capacity for change.” [19ED7]

3.2. Open research data (ORD)

All stakeholders, with the exception of representatives of assessment agencies, were asked about the factors related to ORD (Table 5).

Table 5. Enabling factors and barriers to the adoption of open research data

Enablers	L	E	R	V	Barriers	L	E	R	V
Researchers and the data they generate and use									
Perception of the benefit of sharing			*		Lack of perception of the benefit of sharing			*	*
Curricular benefits or reputation			*		Competitiveness among researchers		*	*	
Trust in the sharer		*	*	*	Differences between disciplines		*	*	*
Disciplines with a tradition in ORD		*			Decontextualisation			*	
Competition between researchers		*			Fear of being questioned			*	
					Increased workload		*	*	
					Reluctance to relinquish/share		*		*
Scientific ecosystem									
Institutional support									
Involvement/conviction of all stakeholders	*		*	*	Lack of data policies at the university		*	*	
Existence of a data plan			*		Need for coordination with other universities				*
Backing/support of university services			*	*	Uncertain financing				*
					Infrastructure for the repository				*
					Lack of practical data management knowledge	*		*	*
					Differing criteria depending on the project institution			*	
					Excessive bureaucracy			*	
					Lack of incentives and recognition			*	
Regulatory framework									
Existence of regulatory framework		*	*		Uncertain legal/ethical framework		*	*	*
Obligatory nature (or merit) in funded projects	*	*	*		Economic interests	*	*		
Scientific communication system									
Obligatory nature of the journal		*	*		Doubts about integration into the publishing process		*		
It is seen as a reflection of reliability		*							

L: librarians; E: editors; R: researchers; V: vice-chancellors

3.2.1. Researchers and the data they generate and use

Enabling factors

The ORD enabling factors directly related to researchers identified by these are: the perceived benefit of sharing the researcher's data, the existence of curricular or academic reputational benefits associated with sharing data and having confidence in the sharer. This last factor was also mentioned by editors and vice-chancellors:

"You can't make a generalised policy, because everyone is different. I think the best thing a university can do [is] to say that those in the know, i.e. their researchers, should establish their own rules. For the sake of science and also based more on trust than on a rule." [09INV6]

Only two factors were highlighted by journal editors, namely, the existence of disciplines where sharing and opening up data is already seen as a natural process, and encouraging this openness so that competition between researchers comes into play to encourage the implementation of this practice:

"If they see what others are doing, they would say 'hey, I want to do this too and I want to improve.'" [17ED5]

Barriers

There are four barriers on the other side of the coin of factors cited as enabling factors. These are the lack of perception of the benefit of sharing data, competition between researchers, in this case to disseminate these data before others, the differences between disciplines that require detailed processing and the fact that the decontextualisation of the data makes them useless for anyone who has not generated them:

"...to be usable, of course, they would have to know that in such and such a layer of semiconductors we made I don't know how many. Because, of course, then these metadata, you put it there [...], in other words, for the data to be usable you need a great deal of knowledge about the data itself and I have that knowledge [...] because I think it is very unlikely that through pure data you can come to understand something more, if you don't have the context." [05INV2]

Other barriers referred to researcher attitudes and perceptions such as fear of being questioned, increased workload and, in general, researcher reluctance to give and share data:

"We came up against reticence on the part of the first doctoral author who is just beginning the process of publishing and using the material of their thesis and who, when you tell them [...], put all this data in open access, they say: but I intend to make use of this thesis over the next few years [...]. I don't want to have my material in open access as it entails a very high cost for me and I want it to be my letter of introduction for the next three or four years." [20ED8]

3.2.2. Scientific ecosystem

Enabling factors

The enabling factors associated with the role of universities were the involvement and buy-in of all actors into ORD, the existence of prior data plans and backing and support from university services:

"There was already a strong base in academia that believed in it and a team from the libraries, also very specialised and committed to it, so that has made it much easier to have an open knowledge plan today, without doubt." [03VR3]

On the other hand, from the point of view of the regulatory context, the driving factors behind ORD were precisely the fact that a reference framework actually exists and something on which librarians, editors and researchers could agree. This is the merit or obligatory nature of depositing data in research funding calls for proposals as a determining factor for this practice:

"It comes from the fear of not being awarded the project. There is a box that says: it's voluntary, I'm not going to assess you based on this. But you say: oh, you're a good boy, click away. Then you enter the garden of open data." [05INV2]

The mandatory nature of journals is also a key driver of ORD highlighted by editors and researchers, as well as establishing a culture in which this is seen as a reflection of the reliability of the research, as mentioned by the editors.

Barriers

Firstly, the factors cited by informants related to the acceptance of ORD at the institutional level must be placed in a context in which, while appreciating the need to develop an infrastructure to support it, there are still no defined policies or strategies. Therefore, these factors were related to the lack of data policies at the university, the need for coordination with other universities and the still uncertain funding to create a supporting infrastructure:

"This means that beyond the repository that we have open at the [university], where we can basically publish articles and not much else, the data still can't be put in open access and often not even the [university] researchers themselves are sharing data, which is quite surreal, I don't see a, a great... I mean, the philosophy and desire is there, and they intend to put the measures in place, but little else is happening." [10INV7]

These factors point to something mentioned by librarians, researchers and vice-chancellors alike, which is that there is still a lot of theoretical but not practical knowledge on the subject:

“Actually on the subject of data, we have a lot of experts at the theoretical level, but in practice there are very few people who know about it.” [28BIB7]

Along with the above, the researchers mentioned three other barriers to the adoption of ORD. The first is the problem of different data management guidelines in projects involving researchers from different universities. The second is the inefficiency of university support services who increase the bureaucracy required for all ORD-related processes. Finally, there are the limited incentives and recognition in the institutional framework compared to the effort required for project data management.

From a regulatory point of view, the barriers, which may be considered critical for the implementation of ORD, are related to the ethical aspects that need to be considered (e.g. anonymisation of data) and/or legal aspects. They reflect a lack of a regulatory framework that regulates various aspects such as data ownership, or a specific legal environment in projects with partners from different backgrounds and which, in short, has to do with the existence of differing criteria depending on the institutions participating in a research project, as mentioned above:

“Yes, we trusted and relied on one another, but all the institutions were asked to talk to their legal departments to see, to get an ok that what they were doing... that they were doing it right. So, even though we had a legal partner, when we had the documents, how the data could and could not be handled and what data we could share among us, became a matter for our legal departments, [...] and then they told us that we cannot agree to this, but we could agree with that and so on. The law lacks substance, but it says this and we want to position ourselves in that way...” [10INV7]

In addition to the above, another factor that could be considered critical and which, in part, has to do with the legal and also economic aspects, is the existence of private funding that derives from patents which are therefore governed by confidentiality and data usage agreements:

“Just as there are the economic interests of publishers, there are also individual interests in universities. There are the famous indirect ones of course, i.e. patents. And especially with regard to the current trend, with research data, there is a lot of fear, not so much of plagiarism as of the appropriation or theft of data.” [28BIB7]

Finally, with regard to the scientific communication system, a barrier to the adoption of ORD is the uncertainty that still exists as to how to integrate it into the publishing process:

“What we have, as we mentioned before, is a lack of knowledge. We still don’t have well-defined pathways. People ask you how and where to upload it, to the institutional repository itself.” [19ED7]

3.3. Research assessment

Vice-chancellors and heads of assessment agencies were asked about research assessment in an OS environment (Table 6). In general, these groups provided more barriers than enabling factors vis-à-vis a change in the research assessment criteria.

Table 6. Enabling factors and barriers to change in assessment criteria in an OS environment

Enablers	V	A	Barriers	V	A
Researcher as evaluator					
Cultural change	*	*	Disciplinary differences	*	
Involvement of researchers	*		Reward/recognition of evaluators		*
			Commitment of established researchers		*
Scientific ecosystem					
Institutional support/Policy framework					
Involvement and policy decisions at all levels	*	*	Inconsistencies with the traditional/alternative system	*	*
Global approach from OS	*		Undefined alternatives	*	*
			Economic cost assessments	*	*
			Longer assessment time and greater subjectivity	*	*
			Media vs. scientific impact	*	
			Coordination with other universities	*	
			Possibility of cheating		*
			Immobile administrative criteria		*
Scientific communication system					
			High degree of consolidation of the current publication/assessment system	*	

V: vice-chancellors; A: assessment agencies

3.3.1. The researcher as evaluator

Informants from both the vice-chancellor and assessment agency groups agreed that the change of culture that will come with new generations of researchers who are pursuing their careers with OS standards and values is a strong factor that favours the transition to an OS-orientated assessment system:

“I think we are talking about a generational change.... We are going to need an open science native, and to have an open science native [...], we have to start bringing them into being. At least for the time being. And when that native born into open science arrives at the top, we will have achieved it, but that will imply a generational change, and we have to start changing the chip.” [30AG1]

In addition, the vice-chancellors mentioned that bringing researchers into the debate could help bring about the necessary change:

“...The new models [...], we want them to come out after a debate with academics, because for me, it is key that the researchers are present. However much we are able to decide how to do this, it has to be discussed, it has to be opened up, there has to be reflection and we have to take advantage of the path to do pedagogy.” [03VR3]

On the other hand, only the vice-chancellors mentioned the difference between areas of knowledge requiring specific criteria as a barrier to the adoption of new assessment models. For their part, the agency managers cited barriers such as the low recognition of evaluators, but also a lack of commitment of some to the necessary shift in the assessment culture:

“ Curricular benefits and trust in the sharer favour data-sharing ”

“Let’s apply the concept of open science in the call for proposals for pre-doctoral grants [...] Well, let the poor people who want to have a pre-doctoral grant fight it out, and I will continue to publish where I publish, because it makes no difference to me. If those top researchers, who are the ones who end up deciding [...] because they are the ministry’s own advisors...” [30AG1]

3.3.2. Scientific ecosystem

Only two enabling factors were mentioned. The first, mentioned by both the vice-chancellors and the heads of assessment agencies, relates to the policy decisions that are necessary at all levels and which support OS. The second, mentioned only by one vice-chancellor, was the need to address the different dimensions of OS in a holistic way, not only from an assessment point of view. However, in contrast to the few enabling factors, the number of different barriers mentioned by informants is striking.

The vice-chancellors and agency heads agreed on four barriers. Of these, two highlight the difficulty of having two assessment systems, one traditional and the other alternative, which generate conflicts between what is asked of the researcher according to OS criteria and what is assessed according to traditional criteria. Meanwhile, the idea of assessment with criteria adjusted to a new scientific ecosystem remains an unresolved issue due to a lack of clear guidelines:

“...in this whole debate on how we conduct our assessment, there is a lot of discussion, some progress is being made, but what is clear is that [...] as things stand, there is no alternative. This is what a great many managers are asking for:

- OK! So tell me, which index? Altmetrics?
- No, it’s just that each thing measures something different.
- And how do I do that...?” [03VR3]

The other two barriers that the vice-chancellors and assessment agency managers agreed upon are related to operational issues within the assessment processes, such as the increased costs of the processes, in terms of money and time, as well as increased subjectivity in the criteria applied:

“Who wants to evaluate 3,000 files when they can rely on statistical indicators, perhaps changing them, so why go for the qualitative version? Subjectivity has these problems. The cost as well as the subjectivity.” [31AG2]

On the other hand, the barriers mentioned only by vice-chancellors or agency heads are closely related to their field of decision-making. In the case of vice-chancellors, it is the scope of their own university and the way in which they have to apply assessment criteria in this context. A barrier for them is the difficulty of differentiating between scientific and media impact when assessing research, and the need for coordination with other universities to ensure that no one benefits and/or is disadvantaged. In the case of the agency managers, the factors mentioned by them alone are tied into two aspects. The first relates to the lack of robustness of a system that relies on popularity in the easily manipulated social media environment:

“I don’t know much about it, but I am concerned about how this could be cheated, not by the researcher, but by the journal itself. In other words, it’s easy to get bots to give you lots of likes. That worries me.” [30AG1]

“ The open culture of the new generations will favour the transition towards an open science-oriented evaluation system ”

The second is related to the public administration's priority of avoiding potential administrative appeals rather than developing assessment systems based on scientific criteria:

"We are often very constrained, so to speak, by the Administrative Procedure Act. We have a tendency to reproduce this in any call for proposals and this poses a problem not only with using open science, but of using any assessment model, whereby we try to ensure that assessment is shielded from an administrative procedural point of view." [30AG1]

Competition among researchers is a barrier to data sharing

Finally, the vice-chancellors mentioned a barrier related to the science communication system and its high degree of consolidation which hinders the necessary change:

"We publish in publishing houses as if we were in the 19th century, when nowadays technologies undoubtedly afford us other ways of communicating our science. The fact that this is the basis not only for promotion, but also for funding, on the back of which the group will be able to do more research, well, the circle has already been drawn." [03VR3]

3.4. Open peer review (OPR)

Both journal editors and researchers were asked about the factors involved in the adoption of OPR and, as with the other OS dimensions, they referred to the researcher, in this case also in the role of reviewer, and to the scientific ecosystem (Table 7).

Table 7. Enabling factors and barriers to the adoption of open peer review

Enablers	E	R	Barriers	E	R
Researcher as reviewer					
Curricular or reputational incentives	*	*	Public scrutiny	*	*
			Conflicts between peers	*	*
			Coercive effect	*	*
			Biases by gender, nationality or age		*
Scientific ecosystem					
Scientific communication system					
Access or publication incentives		*	Lack of rigour	*	*
Classic PR malfunctioning		*	Managing the process	*	*
Transparency/visibility of the process	*		Reluctance for change	*	
Synonymous with quality	*				

E: editors; R: researchers

3.4.1. Researcher as reviewer

Researchers and editors were largely in agreement on factors related to the role of the researcher in the review process. In terms of favourable factors, informants from both groups mentioned the possibility that an open review could be a means to enhancing academic reputation or could be incentivised with curricular benefits:

"Publishing reviews also with the names and surnames of the reviewer increases your recognition. And if it is also [recognised] by the institution or the state agency that assesses you as a researcher, then these are aspects that could indeed be valued. In addition to the scientific article itself, the quality of the reviews you do and how much you contribute to the scientific world as a reviewer can also be valued." [06INV3]

In terms of barriers, researchers and editors agreed on three factors. Firstly, the fear of public scrutiny by giving up reviewer and researcher anonymity. This opens up the possibility of these processes generating conflicts and enmity between peers or a possible coercive effect, which will especially affect those who will have to undergo assessment or promotion processes in the future:

"I see more dangers than advantages. For example, one of the great dangers that I can see is especially in young people who, as has been demonstrated, tend to be the best reviewers [...], who have an entire promotional career ahead of them that can be filled with uncertainty and who don't know who is going to assess their projects. The fact of exposing your name in a peer review that is trying to be fair may be construed as criticising, albeit in a constructive way, your future peer [competitor] in a project..." [06INV3]

In addition, in the case of researchers, possible barriers due to gender, nationality or age bias in a review process without the refuge of anonymity was mentioned:

"To what extent are open peer reviews biased or unbiased...? For example, in seeing that it is a woman [the reviewer] could tend towards a particular opinion or vice versa. In seeing that the author is a man, [the reviewer]

may tend towards another assessment, or the fact that they are researchers from the United States, [the reviewer] may start the review with a more biased view, perhaps, than if they were researchers from other less powerful countries in terms of research.” [06INV3]

3.4.2 Scientific ecosystem

As for the factors related to the scientific ecosystem, these referred only to the scientific communication system, as would be expected. The enabling factors mentioned by researchers alone were, firstly, the fact that journals provide reviewers who publish their work with benefits in the form of free access to their content or at reduced cost per publication. Secondly, there is the fact that the very dissatisfaction with the reviews currently received, in a system where the reviewer is anonymous, could encourage the introduction of alternative systems:

“...is that the peer review system works so badly that it won’t do much harm. I mean, in the end, peer review responses that are sometimes indolent, sometimes insolent, sometimes vindictive, so if this is exposed [...]. There’s nothing wrong with people having a little shame or being careful either.” [05INV2]

On the other hand, the two identified by editors alone as favouring factors were the perceived link between OPR and the transparency and visibility of editorial work, as well as the link to a culture of quality of the process and even that OPR be taken as a mechanism for improving the quality of publications:

“I personally like it because I find that you see the entire life cycle of the article [...] As a editor, I see it every day. In other words, I already see it, and what’s more, I don’t just see it, I make decisions about it. Now it’s my turn to play the worst role. But instead you say, if that could be open and everyone could see it, everyone would realise how complex it is. And what’s more, I think that in the end the article would be better off for it.” [15ED3]

In terms of barriers, researchers and editors agreed that the coercive and conditioning effect of the loss of anonymity could result in a decrease in the rigour with which reviews are conducted. In addition, both groups also shared the conviction that OPR would complicate the process:

“...it’s the management of it. We currently have 800 articles that we receive, but in truth only about 200 are actually in the process of being reviewed, so managing this with an open peer review is complex [...]. I think that it would lengthen the work processes and I find it difficult above all because I don’t have the people who can do it.” [15ED3]

Finally, the barrier that was mentioned by editors only was the reluctance to change into a consolidated review system:

“I believe that open peer review is about changing things and changing them in a positive sense. Of course, but when you change it, it means that you are changing mentalities, you are changing resistance and therefore it will be slower.” [15ED3]

4. Discussion

This research offers an in-depth picture of the factors that may facilitate and/or hinder the adoption of open science (OS) in the Spanish scientific system, including four of its dimensions and collating the perspectives of the different stakeholders to whom this transformation will fall. It has therefore been possible to identify factors related to the attitudes, values or beliefs of researchers and factors that form part of what is considered the scientific ecosystem, which are the environmental variables that can modify scientific practices in a process of profound change.

As regards the barriers related to the researcher, it has been possible to identify most of those already put forward in the previous literature on the subject. These include the need for a clear scientific assessment procedure and the consideration of qualitative criteria (Cabello-Valdés *et al.*, 2017), the discrepancy between the interest and understanding of OS and open research methods actually applied (Heise; Pearce, 2020), the need for a shift in attitudes and productivity of both academics and funders (Allen; Mehler, 2019), institutional inertia and the inadequacy of current funding priorities to develop research activities following the OS approach (Gagliardi; Cox; Li, 2015) and the lack of resources to carry out research activities within the OS approach (Pardo-Martínez; Cotte-Poveda, 2018). In the area of research data, perhaps the area of OS with the least progress to date, it has also been shown that trust in the parties with whom the data is shared greatly conditions this practice, a point also highlighted by Zuiderwijk, Shinde and Wei (2020), and that the curricular and academic reputational benefits are an aspect that could lend impetus to the sharing of research data, in line with what has already been highlighted by Stieglitz *et al.* (2020).

However, despite the time that has elapsed since the first OA-related initiatives, the barriers to the full acceptance of an open environment in science do not appear to have been pulled down, despite being well known. In the light of the results obtained, it will only be possible to change the culture and habits of researchers from a traditional model to the model proposed by OS if the conditions for this to happen exist in the environment in which they carry out their work. These favourable conditions are related to three areas of the scientific ecosystem: the existence of a regulatory framework that integrates the different OS initiatives of all the institutions of the Spanish Science, Technology and Innovation System (Secti), the linking of this regu-

“ The current lack of harmony between scientific practices and institutional policies creates a context of uncertainty ”

latory framework to the system in place to assess and reward researchers, and finally, the existence of financial planning that facilitates the transition to this new model. In this respect, it is worth highlighting the *Center for Open Science's* (COS) strategy for culture change (Nosek,

2019), which suggests that this change needs to be comprehensive, starting with the infrastructure necessary to make it possible, and followed by its integration into workflows to make it easier, the development of norms that show the desired behaviour to make it normative, and finally, the introduction of incentives to make it rewarding and policies that turn it into a mandate. The *European Commission* (2021) has also presented a recent report in which proposes a coordinated approach based on principles and actions that could be agreed upon by a coalition of research funding and research performing organisations committed to implement changes.

Firstly, in terms of the regulatory framework, the recent *Unesco* project (2021) in OS recommends that member states adopt simultaneous measures and create an enabling policy environment

“through a multi-stakeholder, participatory and transparent process with the scientific community and other actors” (Unesco, 2021).

In the case of Spain, in addition to the numerous specific policies in favour of OA from different funding institutions (Melibe, 2010), there is a higher-level regulation known as the *Science Act* of 2011 that requires the deposit of documents resulting from publicly funded calls for proposals. In view of our results, the existence of this regulatory framework is seen as a favourable factor for the adoption of OS. However, it is possible to affirm that its application is deficient, as evidenced by the fact that only 58.4% of articles resulting from publicly funded research had at least one open access copy available, two years after the entry into force of the Spanish *Science Act* (Borrego, 2016) or 62% in the case of articles in the area of biomedicine (Abad-García; González-Teruel; González-Llinares, 2018).

This poor implementation of a regulation that was supposed to be sufficient for the adoption of OS practices may be down to two reasons. Firstly, the regulation does not include the requirement for the depositing of data in the framework of European project funding. Secondly, it does not determine explicit procedures for assessing and monitoring compliance. In this respect, it is worth mentioning that “it is not enough to enact a law for policies to change” (Cosce, 2021) and that lack of oversight makes this law more of a declaration of intent than an OS-enabling instrument. In this regard, *Unesco* (2021), in addition to recommending an enabling policy environment, urges governments to establish adequate oversight and assessment mechanisms to measure the implementation of OS-related policies and incentives. Fortunately, it seems that work is currently being done in this direction through the Spanish science, technology and innovation strategy for 2021-2027 by promoting OS and boosting Spain's contribution to the *European Open Science Cloud* (Secretaría General de Investigación, 2021).

Furthermore, with regard to the assessment system, and in line with other studies such as Cabello-Valdés *et al.* (2017), the adoption of a new assessment model is emerging as one of the major challenges, as the traditional system conflicts with the values of OS. This lack of harmonisation is a barrier pointed to by all stakeholders and can be seen in two areas. The first is of a conceptual nature, related to the entrenched use of citation- and impact-based metrics and the limited penetration of alternative metrics that are more aligned with the spirit of OS. Despite the various proposals put forward thus far (e.g. Wilsdon, 2017; Tahamtan; Bornmann, 2020), consensus is still far from being reached on the use of new metrics that are more reliable, transparent and adaptable to all disciplines that enable an assessment based on the quality, integrity, reproducibility and social impact of science, thus replacing the current model of citation-based indicators.

On the other hand, a second area in which the lack of harmonisation between a traditional assessment system and the values of OS has been highlighted by the representatives of the assessment agencies participating in this study. This boils down to the operational consequences, such as the need for greater investment in human and financial resources and possible legal-administrative risks due to the application of more subjective and specific criteria for each scientific area. These are issues that the *European University Association* report (Saenen *et al.*, 2019) has already addressed, highlighting the complexity of this transformation, in addition to the lack of autonomy to develop and implement assessment approaches specific to each funding institution or science policy manager. As several informants in this study have pointed out, there is a need for policy decisions at all levels and a concerted approach that allows for inter-university dialogue and engagement between key actors.

However, despite the potential difficulties, some European countries have developed initiatives to foster the transition from a traditional assessment model to one that is more in line with OS. One example of this is the Dutch national assessment framework based on a new system of recognition and rewards that classifies university work, called the *Job Classification System* (UFO) or the German *Excellence Initiative*, in which universities are evaluated according to cooperation projects, which favours a collaborative scientific community and the openness of science, or the various European initiatives for global promotion of OS, such as those deployed in Portugal, France, Finland, Switzerland and Ireland (Méendez, 2021). While there are no similar

“ Librarians best perceive the dissonance between researchers' practices and institutional mandates ”

“ Costs, in terms of money and time, and subjectivity make difficult the implementation of a new evaluation system ”

initiatives at a global level in Spain, something seems to be changing, particularly in view of the individual adherence of certain assessment agencies and universities to the *DORA* declaration and the calls made by researchers for real change in line with this declaration (Delgado-López-Cózar; Ràfols; Abadal, 2021).

Change in attitudes towards open science is possible, but it can only happen if there is an institutional will to change

The third area of the scientific ecosystem on which, according to our results, efforts for a transition towards OS should be focused is research funding. Indeed, the barrier posed by the lack of resources to develop research activities within an OS approach has already been highlighted in previous studies (Pardo-Martínez; Cotte-Poveda, 2018). Moreover, this complaint has also been expressed by editors in terms of the need for universities to commit to open funding to ensure the sustainability of their scientific journals, by vice-chancellors in relation to the uncertain funding of the technological infrastructure that supports data sharing, by the increase in the economic cost of assessments, which is currently unaffordable, in the case of the assessment agency representatives and by the need for economic incentives to tackle the increasingly costly payments for open publication, mentioned by researchers and librarians alike. This, moreover, must be seen in the context of poor research funding, which has been dragging on since the 2008 economic crisis, as recently highlighted by representatives of the *Spanish Confederation of Scientific Societies* (Cosce, 2021). However, if there are no *Practical Commitments for Implementation* (PCI), as Méndez (2021) calls them, from the assessment agencies as well, establishing specific lines of funding for a global approach to OS, it will be difficult for the actions of the rest of the actors in the scientific system to be truly effective.

A few clear actions have already been taken, such as the transformative agreements (Borrego; Anglada; Abadal, 2021) that the *Conference of Rectors of Spanish Universities* (CRUE) and the *Spanish National Research Higher Council* (CSIC) have signed recently with various academic publishers for journal subscription and the option to publish their researchers' work in open access at no additional cost, under a single contract with each publisher. These are clear changes to the policies of funding agencies that are transforming the rules of play that have governed until now and resolving various questions (such as how much it costs, what the cost covers, and who has to pay for it), which could favour OA in the long term. However, for initiatives like these to have the desired effect, a firm commitment is also needed in terms of assessment policies, so that adherence to initiatives like *DORA* can have real, evident effects on researchers. An example of this kind of commitment is the recent announcement by the *National Agency for Quality Assessment and Accreditation* (Aneca) that it will be including activities related to open science in its assessment criteria.

If the regulatory framework, the change in research assessment criteria and funding are important, then the support at the grassroots level, i.e. librarians, should not be neglected either. Of all the actors in this study who reported on the drivers and barriers to the transition to OS, they are the ones who are best placed to perceive the frequent dissonance between researchers' practices and institutions' mandates, given their responses. In this sense, research support units in today's libraries tend to focus on the management of the infrastructures needed for OA (institutional repositories), support for the publication and dissemination of research (OA journals) and bibliometric services (Iribarren-Maestro et al., 2015). However, the *League of European Research Universities* (LERU, 2018) goes further and proposes that one of the challenges for academic libraries should be the creation of OA-oriented services, as also proposed by the *Ligue des Bibliothèques Européennes de Recherche* (Liber, 2018).

5. Conclusion

Despite the limitations in terms of the representativeness of the results of a qualitative study, this research has allowed us to deepen our knowledge of the current perceptions of the stakeholder in the Spanish scientific community with respect to Open Access, twenty years after the *Budapest Open Access Initiative* and the first open access initiatives. Therefore, the scientific ecosystem has proved to be dynamic to the extent that informants' responses reflect more knowledge about OS-related aspects, especially in the areas of open access and research data sharing, than in the early years of implementation of institutional policy. The strategies and the outcomes they will bring about are no longer in question, but the focus is on the operational and/or technical level and the way that institutions provide support and develop appropriate policy for their implementation. This is especially significant for research assessment policies, which are still based on traditional academic practices and have limited capacity to respond to the new values proposed by OS.

The plurality of views collated by collecting information from all stakeholders has revealed the constraints perceived by some and the competence of others. It could be said that a change of attitude of researchers toward OS values is possible and that the time is ripe, but it can only happen if there is an institutional will to change. The current lack of harmony that has been detected between scientific practices and the policies and strategies developed by the competent institutions generate a context of uncertainty that will only be overcome with an adequate regulatory framework that includes a break with traditional assessment models and which is accompanied by adequate funding. As Larivière and Sugimoto (2018) put it, when the right structure and incentives are in place, researchers deliver.

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7. Appendix

Appendix 1. Additional characteristics of informants

The data on the size and results of the research are expressed according to the *IUNE* (*Spanish university index*) ranking: <https://iune.es>

Size: average number of teaching and research staff in the past ten years. The biggest number is 3,270 (*Universidad Complutense de Madrid*) and the smallest is 273 (*Universidad de La Rioja*).

Research output: Average number of docs. per average number of profs. in the last ten years. The highest is 3.92 (*Universitat Pompeu Fabra*) and the lowest is 0.10 (*Universitat Abad Oliba*).

Vice-chancellors

Code	Informant		University			
	Area of research	Gender	Type	Size	Research output	Geographical area
01VR1	Medicine	m	Public	2,000-2,500	1.5-2	Valencian Community
02VR2	Anthropology	m	Public	2,000-2,500	2-2.5	Catalonia
03VR3	-	f	Private	<500	0.5-1	Catalonia

Researchers

Code	Informant			University			
	Area of research	Career stage	Gender	Type	Size	Research output	Geographical area
04INV1	Economics	Professor	m	Public	2,000-2,500	2-2.5	Catalonia
05INV2	Engineering	Professor	m	Public	2,000-2,500	2-2.5	Catalonia
06INV3	Psychology	Lecturer	f	Public	2,000-2,500	2-2.5	Catalonia
07INV4	Biomedicine	Researcher	f	Public	2,000-2,500	2-2.5	Catalonia
08INV5	History	Professor	f	Private	500-1,000	1-1.5	Navarre
09INV6	Medicine	Professor	m	Private	500-1,000	1-1.5	Navarre
10INV7	Computer Science	Aggregate	f	Private	<500	0.50-1	Catalonia
11INV8	Sociology	Researcher	m	Private	<500	0.50-1	Catalonia
12INV9	Economics (e-learning)	Aggregate	m	Private	<500	0.50-1	Catalonia

Editors

Code	Informant	Journal		
	Gender	Area	Publisher	Geographical area
13ED1	f	Information science	Research institute	Madrid
14ED2	m	Pharmacy	Scientific society	Canary Islands
15ED3	m	Education	University – Commercial editorial	Catalonia
16ED4	m	Biology	Research institute	Catalonia
17ED5	f	Biology	Research institute	Madrid
18ED6	m	Economics	University – Commercial editorial	Catalonia
19ED7	m	Communication / Information science	University	Catalonia
20ED8	m	Medicine	University	Madrid
21ED9	m	Medicine	Scientific society	Valencian Community

Librarians

Code	Informant		University			
	Responsibility	Gender	Type	Size	Research output	Geographical area
23BIB1	Repository	f	Public	500-1,000	1-1.5	Valencian Community
24BIB2	Training	f	Public	<500	1-1.5	Catalonia
25BIB3	Repository	f	Public	1,500-2,000	2.5-3	Catalonia
26BIB4	Repository	m	Public	2,000-2,500	1.5-2	Valencian Community
27BIB5	Repository	f	Public	<500	1-1.5	Catalonia
28BIB6	Repository	m	Public	1,000-1,500	1-1.5	Catalonia
29BIB7	Repository	m	Public	1,500-2,000	0/5-1	Valencian Community
30BIB8	Research library service	f	Public	1,000-1,500	1-1.5	Catalonia

Agencies

Code	Area of research	Genre	Action area
32AG2	Engineering	m	Regional
31AG1	Mathematics	m	National

Appendix 2. Summary of script for interviews with agents in the Spanish scientific system

Topic	Agents	Interview questions	
		General topics	Additional topics
Open access	Vice-chancellors	Existing barriers to and benefits of the implementation of measures to encourage open access publications.	Existence of an explicit alignment at the university with open science and of incentives to encourage it.
	Researchers	Existing barriers to and/or motivations for open dissemination of your publications.	Existence or absence of strategies or policies at your university that have benefited you when publishing in open access journals.
	Editors	Barriers to and/or motivations for publishing journal articles in open access.	Opinion on the use of reuse licences for articles and the transfer of exploitation rights to authors.
	Librarians	Barriers to and benefits of the expansion of the open science model to research.	Opinion on positioning of institutional repositories in the promotion of open science.
Open research data	Vice-chancellors	Advantages and disadvantages of implementing measures to encourage researchers to deposit research data.	Existence or absence of a policy to recommend, require or provide incentives for the depositing of research data at your institution.
	Researchers	Advantages and disadvantages of depositing and reuse of your research data.	Opinion on whether the strategies at your university related to research data (if any) have benefited you (or not) when sharing or reusing research data.
	Editors	Advantages and disadvantages for authors to include the depositing of research data together with the manuscript and benefits that can be obtained.	Opinion on the level of author acceptance of the requirement related to research data.
	Librarians	Advantages and disadvantages of implementing measures to encourage the depositing of research data.	Opinion on infrastructure for data deposit.
Research assessment	Vice-chancellors	Barriers to and/or motivations for implementing a change to the assessment model.	Model for assessing publications at your institution and opinion on international declarations such as <i>DORA</i> , <i>Leiden</i> , <i>European Commission</i> reports, etc.
	Assessment Agencies	Barriers to and/or motivations for implementing a change to the assessment model.	Model for assessing publications at your institution and opinion on international declarations such as <i>DORA</i> , <i>Leiden</i> , <i>European Commission</i> reports, etc.
Open peer review	Researchers	Potential advantages and disadvantages of revealing author and reviewer identities in the peer review process.	Opinion on open availability of reviewer reports.
	Editors	Potential advantages and disadvantages of revealing author and reviewer identities in the peer review process.	Opinion on open availability of reviewer reports.