5 The digital disruption of science

Governments and scientists toward an “Open Science”

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1. Introduction: Open Science, a new era for science?

The digitalization is a key element in the evolution of public policies and governments' activities. It is an important tool to foster efficiency and a better consideration for users' needs. It is an opportunity to foster the creation of “digital governments” (OECD, 2016), characterized by a greater implication of citizens and businesses in the agenda-setting, the elaboration but also in the making of public welfare policies. It is an opportunity to foster the creation of “digital governments” (OECD, 2016), characterized by a greater implication of citizens and businesses in the agenda-setting, the elaboration but also in the making of public welfare policies. Science is at the forefront of this evolution, being recognized as a strategic issue in new knowledge-based economies.

In science, digitalization comes from the availability of new technologies and tools that enable the emergence of innovative research practices. It does not only concern the use of digital technologies in the daily work of scientists: It also provokes an important evolution in the very activity of research from agenda-setting to the publication of results. The disruption provoked by digitalization in science is often summed up with the buzzwords “science 2.0”, “science in transition”, “digital science”, “e-Science” or more generally with the concept of “Open Science” (Millerand, 2015). If nuances exist between those concepts, they all stress the idea of a transition from one type of research to another, based on collaborative work, transparency and efficiency allowed by the digitalization of scientific activities. The concept of “Open Science” will be used in this chapter, as it is the one used by governments and European institutions when they refer to this evolution (European Commission, 2015).

1.1. Digitalization and science: what is at stake?

The digitalization refers to the use of tools coming from the web 2.0 in research activities (Teif, 2013). It is sometimes referred as the basis of a second revolution in science (Bartling and Friesike, 2014). The first revolution was based on the professionalization of research activities, and on the continuous build-up of new

knowledge based on the work of other scientists. The second revolution would be based on digital technologies. It would lead to a more collaborative science, a new mode of creation of scientific knowledge; complex, non-linear, heterogeneous and transdisciplinary (Szkuta and Osimo, 2016). Thus, digitalization is commonly seen as a way to go toward a “better science” (Millerand, 2015), a potential solution to the challenges that modern science is facing, that is an increasing number of authors, of publications and of data available (Burgelman, Osimo and Bogdanowicz, 2010). They are creating new opportunities to develop more complex and more collaborative approaches, where interdisciplinary is crucial, to solve wicked problems (Bly and Ginanni, 2012).

The evolution generated by digitalization can be summed up with five main characteristics (Fecher and Friesike, 2014):

- The democratization of science: It stresses the ability of digitalization to facilitate the diffusion of the scientific results across all spheres of society, from governments to NGOs, from big businesses to small and medium enterprises. This expectation is closely associated with the “Open Access movement”;
- An improvement of scientific processes: the way research is done and on how digitalization will strengthen its efficiency. It emphasizes the increasing collaboration between scientists that this movement will promote;
- The development of innovative infrastructure: The new tools available in this digital age will enable scientists to deal with an increasing amount of data and to develop a data-based culture;
- The diversification of the actors involved in the making of science: Citizens and civil society’s organizations can now be involved from the funding of research, through crowdfunding for example, to the processing and analysis of data. It is sometimes summed up with the nickname “citizen science”;
- The emergence of new measurement tools, new type of impact measures, sometimes called “alt-metrics”. It will allow to better understand the influence and impact of science over the rest of the society.

To sum up, the disruptive effect of digitalization in science is seen as a major opportunity to foster the emergence of a new mode of production of scientific knowledge, called “Open Science”. It is a tool to promote a better science and to increase its efficiency and impact.

1.2. Digitalization of science from a governmental perspective

For government, the move toward Open Science is an opportunity to foster the efficiency of public investments in science and to further increase the competitiveness of their economy (OECD, 2016). Three stakes explain governments’ interest in Open Science and why they are framing new policies to foster this movement. For government, the move toward Open Science is an opportunity to foster the efficiency of public investments in science and to further increase the

competitiveness of their economy (OECD, 2016). Three stakes explain governments' interest in Open Science and why they are framing new policies to foster this movement.

First, digitalization is a tool to limit the differences between heavily-funded research centers and small research centers and the polarization of the scientific field (Breivik, Hovland and From, 2010). It should allow small research centers to be more competitive, with fewer investments required, in particular if such centers do not have to devote an increasing amount of money to pay for subscriptions to research journals.

Next, digitalization is also a tool to strengthen the efficiency of national scientific communities, and to take more benefits of a huge public investment (Buhr, 2014). It asks the question of the competitiveness of a scientific community in an increasingly competitive scientific world. Moving toward Open Science is a solution to this challenge as it should increase the efficiency of the research process.

The final stake for governments is that digitalization is seen as a tool to close the gap between science, businesses and other actors, strengthening the impact of science on society (Hetland, 2011). Behind this preoccupation lies the question of how to improve the efficiency of an economy. Digitalization of science is a tool to use, as it allows scientific results to be more quickly and easily spread among businesses and among the rest of the society.

1.3. Barriers in moving toward digitalization of science

If this portrait emphasizes the advantages and hopes that digitalization is creating in science, some difficulties remain on the way. One of the characteristics of the Open Science movement is the fact that it implies the evolution of how scientists are doing research. Such evolution is already noticed with the increasing number of publications being open access or with the growing importance of research social networks (Millerand, 2015). The ability of researchers to use those new tools and the evolution of their practices are one way to move toward Open Science. It could be described as a bottom-up phenomenon, researchers experimenting directly new tools, new technic and new collaboration strategies in their daily activity (Vignoli, Kraker and Sevault, 2015). However, there are also barriers in moving toward an Open Science.

Surveys on this question show that researchers have, for an overall majority, a positive image of Open Science. When asked (Schöpfel et al., 2016), researchers mentioned several potential changes that digitalization should foster: a broader diffusion of results and publications, more collaboration, the breaking-down of discipline barriers, the ability to involve non-usual actors in the research process, but also an opportunity to better meet societal needs and public demands. Nevertheless, this positive opinion does not necessarily translate into practices. In 2015, the European Commission has commissioned a survey to better understand researchers' perceptions about what was called at the time "Science 2.0" (European Commission, 2015). When asked about the barriers in moving toward Open Science, researchers mention a limited awareness about the benefits of such a

move, a lack of incentives given to Open Science in their career, a lack of infrastructure and of financial supports. All those elements, combined with a cultural resistance to change, show that a bottom-up approach is not sufficient to move toward Open Science. It shows that this evolution also needs to be encompassed and furthered by a top-down approach, in other words, by public policies (Vignoli, Kraker and Sevault, 2015; European Commission, 2015; Schöpfel et al., 2016).

The debate about the digitalization of science usually takes place within the broader debate of the digitalization of government activities and public policies, creating a discussion between researchers, experts, policymakers and citizens. However, most scientific work done on the subject is devoted to Open Science as a concept and not as a new object of public policies. Due to that, this chapter will study the evolution of emerging public policies that must foster digitalization in science and a move toward Open Science.

2. Methods

2.1. Theoretical framework

From a theoretical perspective, the problem studied is specific because the inclusion of Open Science in public policies does not come from the need to solve a specific problem. It rather comes from the perception that an opportunity should be taken. Thus, the question here is not how to solve a problem but rather how to promote a specific approach on a relatively new and unknown subject. Within this perspective, this chapter will be based on the “advocacy coalition framework” (ACF) (Sabatier and Weible, 2007). This theoretical approach assumes that policy making is so complex nowadays that public policies are elaborated in subsystems made up of experts, legislators, bureaucrats, lobbyists, researchers, experts, journalists and activists. Within such subsystems, it is argued that actors are joining and progressively establishing a “coalition of causes” to influence policy making according to their own objectives and beliefs. To understand a given policy, the ACF framework argues that it is necessary to identify a “coalition of causes” within the subsystem of public policy making. Compared to other approaches, the ACF framework has the advantage of not having to focus on whether or not to make a particular decision, but rather on issues requiring long-term policies.

2.2. Survey methodology

To apply this approach on the making of public policies toward Open Science, a comparative approach will be used with two case studies: the European policy and the French policy toward Open Science. Those two cases should lead to a better understanding of the disruptive effect of digitalization on research activities. In both cases, the ACF framework will be applied. It will lead to the identification of action subsystems of the public policy toward Open Science. It will also identify core beliefs of involved actors, to better understand why they are pushing in favor of such policies and what causes they are supporting. Finally, it will identify

coordination mechanisms established within those coalitions to progressively go toward a kind of institutionalization of such gatherings.

2.3. *Materials and data*

The case studies will be analyzed through primary sources, such as reports, decisions and presentations made by the actors involved in this process. The documents allow for a proposal that seeks to outline various policies aimed toward promoting Open Science. However, they do not say much about the debates that such policies have faced. To know more about them, a third step in this research has used semi-directive interviews with key actors involved in the implementation of such policies.

3. Open Science in Europe and in France, assessment of two case studies

3.1. *The European impetus for “Open Science”*

3.1.1. *The elaboration of a European policy toward Open Science*

The European Union (EU) has been among the first institutions to push for Open Science. Its ambition was to strengthen the competitiveness of European research and more broadly the competitiveness of the European economy. This emphasis is relatively recent and the timeline of European actions shows an increasing globalization of European institutions' policies. A sequential approach allows the identification of four main kinds of actions. They are related, in a chronological order, to Open Access, Open Data, the development of new infrastructure and next to Open Science, an encompassing concept recently adopted by EU institutions.

As for Open Access, the EU has played a key role in fostering Open Access, seen as a strategic stake in the establishment of a European Research Area (ERA). The EU has followed a gradual approach. In 2006, the European Research Council (ERC) published a statement about the importance of Open Access for all publications receiving public funds (European Research Council – Scientific Council, 2016). This first move led to the creation of a Pilot project for Open Access in the frame of the implementation of the seventh framework program for science (European Commission, 2007). This pilot project has defined two ways to develop Open Access publishing. The “golden way” provides a reimbursement of the publications costs by European funds. The “green way” allows a publication in open archives for 6 or 12 months (for social sciences) after the first publication. This policy echoes the two strategies already mentioned for Open Access in the Budapest declaration of 2002 (Chan et al., 2002). This orientation was later confirmed by the European Commission in July 2012 with a recommendation on access and preservation of scientific information (European Commission, 2012b), updated in April 2018 to give more concrete orientations to Member States (European Commission, 2018f), and a communication entitled, “Towards better access

to scientific information: boosting the benefits of public investment in research” (European Commission, 2012a). This commitment in favor of Open Access has been confirmed and strengthened in the FP8 – H2020 program (European Commission, 2014a). Since 2014, all scientific publications receiving European funding should be made available through Open Access, following either the “golden” or the “green way”. Ultimately, the objective is to achieve 100% of Open Access publications in Europe from 2020.

Regarding data, following the adoption of the Reda report by the European Parliament in 2015 (European Parliament, 2015), a revision of the directives related to copyrights is under review. Its objectives are to ease the move toward Open Access and to allow the development of innovative research methods such as text and data mining. The process followed is similar to the one used for Open Access. The recommendation published by the European Commission in 2012 has encouraged Member States to adopt Open Data policies (European Commission, 2012b). The debate and policies cover both the access to research data, as well as access to public data. Thus, the FP8 – H2020 has done research data open by default for all project implemented within the program. It has also imposed the adoption of a data management plan. In the data management, the European Commission is pushing for a “FAIR” approach, meaning that data should be Findable, Accessible, Interoperable and Reusable (European Commission, 2016b).

The Open Access and Open Data objectives have led the European Commission to develop innovative infrastructure needed to support both moves. The main project is the European Open Science Cloud (EOSC). Its ambition is to build an infrastructure that would enable European researchers to stock and to exploit their data in a common infrastructure (EOSC Summit, 2017). It will also connect existing scientific data infrastructure built by Member States. A pilot has been launched in 2018 (European Commission, 2018b) and the objective is to implement the project from 2020. The other infrastructure project developed by the European Commission, called OpenAIRE for Open Access Infrastructure for Research in Europe (European Commission, 2018e), is dedicated to Open Access and to foster interactions between researchers.

The question of Open Access, Open Data and the need of affiliated infrastructure has led to the birth of a debate about the consequences of digitalization for scientific activities. It is based on the assessment that digital technologies are not only making access to research and data easier but rather that they radically change the way scientific knowledge is produced. Confronted with this challenge and based on initial reflections about the influence of digitalization in science (European Commission, 2013), the European Commission has led a public consultation on the impact of digitalization on science between July and September 2014 (European Commission, 2014b). The results have been published in February 2015 (European Commission, 2015). They show the preference of researchers for the term “Open Science” rather than “Science 2.0” previously used by European institutions, and a consensus about the benefits of Open Science as a means to foster the impact of science and to promote more collaborative and multidisciplinary projects. It has also identified a lack of awareness of the

European research community about the meaning and implications of this digital evolution.

Based on the results of this consultation, the new European commissioner, Carlos Moedas has made of Open Science one of its three strategic priorities with Open Innovation and Openness to the World (Moedas, 2015). From this new impetus, the European Commission has drafted a European Open Science agenda published in February 2016 by the Directorate General for Research and Innovation (European Commission, 2016a). Five main policy actions are identified: (1) fostering Open Science; (2) removing the barriers to Open Science; (3) developing research infrastructure for Open Science; (4) mainstreaming Open Access to research results; (5) embedding Open Science in society. Those policy actions must be translated into concrete measures to be taken by European institutions and Member States.

One of the main measures is the creation in 2014 of an advisory body in charge of co-designing and co-developing policies implemented to foster Open Science (European Commission, 2018c). Named the Open Science Policy Platform (OSPP), it is placed under the authority of the Directorate General for Research and Innovation. Apart from this assignment, the OSPP is also in charge of the education and training of the European research community to Open Science. The European Commission has thus financed a project under the nickname FOSTER, which stands for “Facilitate Open Science Training for European Researcher” (European Commission, 2018c) in February 2014. It includes a website offering free training courses, toolkits, and an Open Science training book. The ambition of this project is to tackle one of the main difficulties in the evolution toward Open Science, the need of a change in researchers’ behavior.

The creation of the OSPP represents an important evolution because it should play a key role in the elaboration of a new European policy toward Open Science. It gives the EU the ability to encompass all the aspects of Open Science. The work already done by the platform is proof. Working groups have been established and have produced reports (European Commission, 2018c) on alt-metrics, citizen science, on how to provide researchers with the skills they need for Open Science, on the evaluation of research careers fully acknowledging Open Science practices or on the awards, incentives and recognition for researchers practicing Open Science. This work comes in parallel with the ignition of the process leading to the elaboration of the next Framework Program, FP9, which will follow H2020. The advance report already published under the leadership of Pascal Lamy strongly emphasized the need to go further on Open Science. It argues that Europe now needs to “*embrace the transformative power of Open Science*” (Lamy, 2017, p. 8).

If actions were taken by the Commission, it was also the case at the intergovernmental level. In particular, Open Science has been promoted under the Dutch presidency of the European Union Council in the first half of 2016. The Dutch government, jointly with the European Commission, organized an important international conference on Open Science in Amsterdam in April 2016 entitled “Open Science, from vision to action.” It was based on the assessment that the transition toward an Open Science needs to be accompanied by governmental

actions. It has led to the adoption of the Amsterdam Call for Action on Open Science (Ministry of Education, Culture and Science, 2016) that identified five main areas of actions: (1) removing the barriers to Open Science; (2) developing research infrastructure; (3) fostering and creating incentives for Open Science; (4) mainstreaming and further promoting Open Science policies; and (5) stimulating and embedding Open Science in science and society. This call was later used to push for the adoption of a common position between the Member States regarding Open Science during the competitiveness council of May 2016 (European Union Council, 2016). Its adoption has not faced any opposition from Member States, all being aware of the importance of the topic. This common position has validated the orientation of the Commission on Open Science. It is also a testimony of the desire of all Member States to work for the emergence of an Open Science.

3.1.2. Analysis of the elaboration of the European policy

The analysis of the emergence of a European policy according to the ACF framework allows for a better understanding of the dynamics and logic behind the increasing role played by European institutions in the field of Open Science. The subsystem is the one in which the science policy of the European Union is framed. The central actor within this move is the European Commission. Compared to other subjects, the Commission has been a frontrunner on the topic of Open Access and Open Data, but also regarding the financing of the infrastructure needed to support the move. The action of the Commission precedes the ones implemented by Member States, even the most advanced ones such as the Netherlands and Germany. The Commission can be considered a frontrunner in this evolution because its commitment was a deliberate one. It comes first from the attention given to Open Access and Open Data and later to the formalization of a more comprehensive policy toward Open Science, which followed the survey commissioned in 2014. It was implemented under the orientation of the commissioner and the responsibility of this policy is divided between two directorates: A and B. The first directorate is in charge of the policy development and coordination and the second one of Open Innovation and Open Science.

The European Commission is convinced of the necessity to deal with digitalization as it changes the whole life cycle of the research project. This conviction is supported by the results of the 2014 public consultation that have shown a strong appetite of the research community for Open Science. Thus, one of the ambitions of the European Commission is to give a voice to the research community and to progressively translate its aspiration into policy actions. This should lead Member States to take into account this perspective and this new orientation. Besides this aspiration, the core beliefs of the initiators of such policies, in particular of European commissioners, is to strengthen the efficiency of the European investment in public research. Therefore, the Commission considers that moving toward Open Science is critical to maintain a dominant position for Europe in the field of Science. Moreover, the scientific policy of the European Union is often

criticized due to its lack of ambition, in part because it is difficult for the EU to bypass the specificity and isolation of each Member State's scientific policies, many of them being reluctant to give up parts of their sovereignty in this strategic field. The adoption of a European policy for Open Science allows the Commission to go beyond this compartmentalization. It can promote an encompassing concept that could foster the efficiency of scientific research and that offer the occasion to promote the connectivity and the interoperability of Member States' scientific policies. The mutual learning exercise organized by the Commission in 2017 in an example of this ambition (Miedema et al., 2018).

This ambition is also related to one of the most important objectives of the European Commission: the creation of a common European Research Area (ERA), a key objective of the former Lisbon Strategy (European Council, 2000). The objective is for the ERA to do for scientific research what the Common Market did for economic exchanges. In this perspective, Open Science is a tool to further the integration of national research initiatives. This objective clearly appears in the directorate general's organizational chart as the unit in charge of Open Science is also in charge of the ERA (European Commission, 2018a). The European Open Science Cloud is another symbol of how Open Science is used by the Commission to promote a unified European Research Area.

Within this perspective, the European Commission appears to be at the center of the advocacy coalition pushing toward a more active policy for Open Science. The creation of a European Open Science Platform strengthens the coordination within the coalition and is a tool to gather and exchange for supportive actors. The European Open Science Platform actually recommends the creation of similar administrative structures in each Member States to enable them to develop a comprehensive policy on the subject (Open Science Policy Platform, 2018d). The key element for this coalition is to convince the Member States to support this orientation and more importantly to translate it at a national level. The common position adopted by the Member States regarding Open Science during the competitiveness council of May 2016 is thus an important milestone. It has given legitimacy to the European Commission to go further on this topic. It has also marked the commitment of Member States to engage in this endeavor.

3.2. Open Science in the French context

3.2.1. The elaboration of a French policy toward Open Science

The study of the French case shows several differences with the European case studied before. The appropriation of Open Science, as a concept, is relatively recent. Because of that, key documents regarding the orientation of French science policy forgot to mention the concept as an objective or a reference. For example, the French national strategy for research, published in 2015, never mentioned Open Science (Ministry of National Education Teaching and Research, 2015). More recently, the French white paper for research and higher education mentions the concept of Open Science but only on a vague perspective (Ministry

of National Education Teaching and Research, 2017), in a sidebar saying that some debates exist at the European and national level about Open Science. It also mentions that the French ministry for higher education and research is working on new International Strategy for Research, Innovation and Higher Education. Its purpose is to provide strategic guidance for French stakeholders, ensuring that France establishes relevant and efficient partnerships and endowing France with a strong decision-making capacity in international bodies (Ministry of National Education Teaching and Research, 2017). This new strategy is supposed to take into account the European dimension of research and in particular the European impetus regarding Open Science. This approach tends to resume Open Science to an EU initiative, an element that the French international science policy should take into account, and not to a bottom-up phenomenon associated with the disruption of scientific activities created by the digitalization. Nonetheless, if Open Science is not directly mentioned, the question of the digitalization of scientific and teaching activities is a major concern in all those texts. The white paper insists on the disruptive effect of digitalization and on the need for research to better understand the consequences of such evolution on scientific activities. The concept of Open Science is also supposed to appear more clearly in the next French national strategy for research.

Apart from this assessment, the formalization of the debate has followed in France approximately the same process as at the European level. It has started with Open Access, moving to Open Data before leading to the progressive elaboration of an encompassing policy toward Open Science. The necessity of Open Access has been pushed in France by activists since the beginning of the 2000s. They have built upon the global movement for Open Science with the three declarations of Budapest in 2002 (Chan et al., 2002) and Bethesda (Brown et al., 2003) and Berlin in 2003 (Chan et al., 2003). Local initiatives have been implemented through COUPERIN, Open Edition or through the establishment of an archive which allows researchers to safely store their works, *Hyper Articles en Ligne* [Eng: Hyper Article Online] (HAL). Those initiatives show the progressive emergence and structuration of a coalition of actors pushing in favor of Open Access. For them, science is a global common to which everyone should have access (Chartron, 2016).

As for Open Data, the French initiative has also to be understood within a broader context, international and European. The Sebastopol meeting held in California in 2007 has affirmed the principles related to Open Data (Malamud et al., 2007). In France, the implementation of an open data policy has followed an initiative pushed by the new French President, François Hollande, for the opening of administrative data. It has led to the reform of “Etalab”. Initially designed to build a public portal of administrative data (Government Bill, 2011), it is now described as an “administrative start-up” in charge of supervising the opening of public data. Besides this mission, Etalab is also in charge of fostering scientific practices based on a culture of data. It has also pushed for the French adhesion to the Open Government Partnership in 2014, later used to elaborate a first French policy toward Open Science.

The different aspects of Open Science have been highly debated in France on the occasion of the adoption of the new law, “Towards a Digital Republic”, in 2015–2016 (Government Bill, 2016). On Open Access, the law allows researchers to make their articles freely accessible 6 months after the publication and 12 months for humanities and social sciences, following the European recommendations. On Open Data, the law is also making public data open by default. It is opening the way for text and data mining, even though the application decree still needs to be adopted. The debate surrounding this application decree is symptomatic of the controversy that opposed the research sphere and the publishing sphere. Publishers are usual opponents of Open Access, arguing that it threatens their economic model and the viability of their industry. In the French context, this debate is important because it indirectly touches the “cultural exception” that France is claiming. Transposed to the European debate surrounding copyright, it explains the difficulties faced by the Commission to change the directives related to copyright to allow the development of text- and data-mining practices.

Moreover, the innovative and collaborative method used to shape the law has allowed many actors, individual and institutional to publish recommendations in the frame of the elaboration of the law. For example, the French National Council for Scientific Research (CNRS) has published a white paper (CNRS, 2016) and strategic guide (CNRS, 2017) arguing in favor of moving toward Open Science in the broader context of the construction of the so-called new “digital republic”. This debate is structuring because it has allowed the progressive acceptance and recognition of Open Science as a concept in France.¹

This growing interest for Open Science has later led to the definition of a French embryonic strategy for Open Science. Practical decisions have been made, such as the creation of a special position within the Ministry of Higher Education, Research and Innovation dedicated to Open Science. It has also led to the adoption of a full engagement on Open Science in the frame of the Open Government Partnership (State Secretariat in charge of Digital Affairs, 2018). This international initiative was supposed to focus on the opening and the transparency of governmental activities. However, France has pushed to include an engagement bearing the objective of building an “Open Science ecosystem” in France. This engagement, “number 18”, can be considered the first French embryonic strategy toward Open Science. It has been translated into a national plan for Open Science in July 2018 (Ministry of Higher Education, Research and Innovation, 2018b).

Apart from further investments in existing infrastructure such as the archive HAL, the ScanR search engine, or the Isidore platform, the main evolution proposed by this strategy is the creation of a special committee dedicated to Open Science (Ministry of Higher Education, Research and Innovation, 2018a). Under the leadership of the Directorate General to research and innovation of the Ministry of Higher Education, Research and Innovation, it will gather experts who will recommend policy orientations and concrete actions to foster Open Science. Its main mission will be to define a French policy for Open Science and to oversee its implementation. It will also play a role in the diffusion of knowledge related

to Open Science in the scientific communities and in the gathering of potential remarks and ideas in a bottom-up approach.

3.2.2. Analysis of the French policy toward Open Science

The application of the ACF framework allows for better understanding of the progressive elaboration of a French policy toward Open Science. The sequential approach that led to the formulation of a French policy toward Open Science is similar to the phenomenon observed at the European level. It started with Open Access and Open Data, with a support to needed infrastructure and it has later ended up with the formalization of a comprehensive policy toward Open Science.

Compared to the European case, the French subsystem of action appears to be mainly dominated by actors involved in the technical aspects of digitalization. Two of the milestones in the elaboration of a French policy toward Open Science have been promoted directly and indirectly by the Secretariat of State in charge of Digital Affairs: the adoption of the law, “Towards a Digital Republic”, and the French commitment to the Open Government Partnership. It is also true for the National Center for Scientific Research, since the white paper on Open Science published in 2016 was produced by the directorate for scientific and technical information (CNRS, 2016). On the contrary, the Ministry of Higher Education, Research and Innovation plays a secondary role in this evolution as the absence of Open Science in strategic documents is a testimony. The creation of an advisory position in charge of Open Science within the ministry is, however, changing the dynamic and should allow the ministry to better take into consideration Open Science in the future.

As for the advocacy coalition framework, the French case shows an interesting convergence of two different advocacy coalitions. The first one structured itself around the promotion of Open Access to scientific publications. It is mainly composed of activists who believed that science is a common good for which no one should have to pay. Their core beliefs were a bit different than the one previously mentioned for the European case. Access to science results is seen as a principle when it was mainly seen by European institutions as a tool to reinforce the efficiency of the money invested in research. The main challenge this coalition has to face is an advocacy coalition organized around publishers. The recommendations published in 2012 by the European Commission have thus played a key role in strengthening the position of the Open Access advocacy coalition within the French system. It has demonstrated that Open Access is not only a utopian concept but also a matter of economic efficiency and scientific competitiveness.

The second advocacy coalition which merged in this trend toward Open Science is related to the opening of data. It was mainly structured around entrepreneurs. They have pushed in favor of the opening of public data arguing that the private sector has now access to enough calculus power to offer innovative services to the public. Its theoretical basis is “Government as a platform” described by O’Reilly (O’Reilly, 2011) and translated in the French context by Colin and Verdier (Colin and Verdier, 2015). In this perspective, opening public data should

allow citizens and businesses to do more with those data and to develop innovative services, science not being an exception. The coalition has strongly pushed in favor of the opening of public data and has succeeded in making the “Government as a platform” a new objective for the French government (State Secretariat in charge of the Modernization of Public Action, 2018).

The collaboration between those two advocacy coalitions has played a crucial role in the elaboration of a new French policy toward Open Science. It was the symbol, in a way, of the alliance between a scientific and technological perspective. The modernization of government has offered an occasion to those two coalitions to meet and collaborate through inter-ministerial consultations to frame those new policies. The law, “Towards a Digital Republic”, and the commitment in the Open Government Partnership are good examples of such consultations. The success of these advocacy coalitions is linked to the ability of some of their members to access public positions, enabling them to act directly within the administrative structure. For the Open Data coalition, Henri Verdier has been appointed in 2013 director of Etalab and later inter-ministerial director in charge of digital, information and communication systems as well as administrator general in charge of data. For the Open Access, Marin Dacos has been appointed in 2017 as an advisor in charge of Open Science in the French Ministry of Higher Education, Research and Innovation.

However, despite the convergence between those two advocacy coalitions, the emergence of a comprehensive coalition arguing in favor of Open Science is still in the making. The call of Jussieu signed by many actors of the sector in October 2017 is a good illustration, both of the composition of this advocacy coalition and of the central role it played within the French debate. Entitled “Jussieu Call for Open Science and Bibliodiversity” (Bauin et al., 2017), it illustrates the central role played by the Open Access movement in the elaboration and structuration of a new advocacy coalition in favor of Open Science. The creation of the future Committee for Open Science should also play a key role in the coordination of this coalition of actors to push for Open Science. It presents a lot of similarities with the European Open Science Platform previously mentioned.

4. Discussion of the results

This study shows that the digitalization of science is still in an emerging phase. The process that led to the formulation of new policies toward Open Science is reflecting a convergence between different dynamics, Open Access and Open Data being the most prominent ones. Both the European and the French cases are confirming this tendency, even if it appears that they come from different origins. However, both cases also confirmed that Open Science policies are still fragmented and that a comprehensive policy in charge of fostering the development of an Open Science is still in the making. The adoption of the “Open Science” concept is thus playing a key role that should allow the elaboration of a more comprehensive policy. The creation of governing bodies is also a key element in this process. Those new structures, specifically dedicated to Open Science, have

the ability to deal with all the aspects created by the digitalization in science. The transition toward an Open Science has such a great impact that it is difficult for a traditional administration to deal with all those elements and to develop a comprehensive policy on this subject. At the EU level, those new structures ease the cooperation between European institutions and Members States with the emergence of a single administration.

The study of both cases, however, confirms the difficulties of going toward a real digitalization in scientific activities and not only toward a simple digitization, that is to say a digitization of a paper-based system. This evolution is complex because, to be fully achieved, it needs to come not only from the top-down but to adopt a bottom-up approach. A more comprehensive approach would be necessary to better understand the challenges and difficulties that such a bottom-up approach must face.

The analysis of the elaboration of the public policies to favor the digitalization of scientific activities also shows that it paradoxically comes across two movements. Frontrunners have already created and implemented a lot of local initiatives that directly improve their daily scientific activities and enable them to develop innovative research approaches. The case of the elaboration of HAL, the French scientific archive platform, is an example of a local initiative, later taken over by the government to develop a more global policy. The elaboration of public policies toward those initiatives comes late and tries to encompass them in a more general and coherent framework. This step, a governmental intervention in this transitory period, appears to be a necessity in the development of a coherent scientific community organized around the Open Science concept.

At the same time, it also appears that in the broader scientific community, digital technologies lead to digitization rather than to digitalization. Due to that public intervention regarding the digitalization of science is facing a strong inertia within the scientific communities. The most important challenge regarding a true evolution toward the digitalization of scientific activities is related to the lack of knowledge of scientists about the movement itself, its implication and to the lack of incentives for a change in habits that could be seen positively in a career perspective. Studies about the subject are currently underway and should later play a key role in the revision of the career logic of scientists to foster the development of Open Science habits. The role of government in this movement will also be fundamental.

The assessment that digitalization is just emerging, through a transition from innovative practices implemented by frontrunners toward a much more general diffusion, means that the role of government is still central in its evolution. The digitalization of science cannot come only from a bottom-up approach, i.e., from an inherent and progressive change of researcher behaviors. The transition process is just beginning, but it is characterized by a tendency of governments to transform local initiatives in general behaviors. The Open Science and the Open Data movements are examples of such ambitions. Going further is also requesting a strong implication of governments to ease and soften the conditions of the transition. This accompanying role comes out with the creation of the needed

infrastructure (archive, data center, innovative tool) but also from the progressive creation of the conditions needed for the emergence of new research practices. The movement is here just in the making. It will go through an evolution in the career system of researchers, in the evaluation of their works, of the methods used to analyze the impact of their work and through a lot of pedagogy toward this movement. The role of government is central because it has created the legal conditions to foster such evolution. It is also because it can use funding requirements to promote certain habits and behavior, as it was done by the EU regarding Open Data and Open Access for example. It is, however, too early to really identify the consequences of this evolution on the relation between governments and science when this transition process is over. Even though some tendencies can be mentioned such as the horizontalization of the research process, the diversification of research funding possibilities or the increasing importance of multidisciplinary and multi-stakeholder's research, they remain tendencies that will need to be confirmed in the long term.

This study of the elaboration of public policies toward Open Science is also opening new research perspectives. Among them, several could be mentioned:

- Research about the structures of local initiatives implemented by so-called frontrunners to favor the full digitalization of science. Such an approach could start with the cartography of these initiatives. It should also lead to a better understanding of how these initiatives are later taken over by governments;
- The other research perspective that could be pursued should be related to the implementation of the policies previously described: the creation of innovative governing structures, the way they are working and interacting with the research community but also with the policy-making process is a theme of research per se;
- The other aspect that deserves more attention is the connection between the so-called Open Science and Open Innovation. Open Science is seen as a major tool to close the gap between academics, businesses and government spheres. This connection clearly appears within the administrative structure of the European Commission because Directorate B is in charge both of Open Innovation and Open Science;
- More broadly, digitalization of science questions how knowledge is produced and used in a given society, finally asking the question of collective intelligence.

5. Conclusion

The study of the European and French policy toward Open Science has demonstrated that the way Open Science has been put on the agenda was the result of a progressive evolution that encompassed the debate around Open Access, then about Open Data and later the question of the infrastructure. Open Science later appeared as a convenient concept to encompass all the dynamics, changes and opportunities generated by the digitalization of science, thus all the policies implemented regarding this change.

Nonetheless, much remains to be done regarding the emergence of this potential new scientific revolution. The movement toward Open Science comes mainly from local and individual initiatives that have pushed in favor of Open Access, Open Data but also for the development of innovative research habits. The proliferation of such initiatives in the French context is the best example of the vitality and the expectation that this digitalization movement is creating. However, the spread of this bottom-up evolution is also facing barriers. Because of them and because of the importance of the stakes involved, governments have started to implement top-down approaches. Their objective is to encompass existing initiatives and to encourage a broader implication of the whole scientific community.

Regarding the evolution of the relation of government toward science, the transition toward the digitalization of research activities is ongoing. Thus, the role of governments is still central, as they must accompany this transition and create the progressive conditions needed for a generalization of innovative practices so far implemented by frontrunners.

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Note

- 1 This evolution can be traced back to some various symbolic decisions. Two of which are the following: (1) the 2018 amendment of the title of the annual conference organized by COUPERIN from the “Open Access Days” to the “Open Science Days”. (2) The transformation of the Digital Scientific Library into a new Committee for Open Science. This evolving transformation reflects the broader French interest in regards to the issue of Open Science.

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