European Commission

Open Science and Intellectual Property Rights

How can they better interact?
State of the art and reflections

Report of Study

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Research and Innovation

EUROPEAN COMMISSION

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Report of Study

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We are like dwarfs on the shoulders of giants, so that we can see more than they, and things at a greater distance, not by virtue of any sharpness of sight on our part, or any physical distinction, but because we are carried high and raised up by their giant size.

Bertrand de Chartres ([1])

([1]) Usually attributed to Newton. See Merton (1965).

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ABBREVIATIONS

Aginfra+	Accelerating user-driven e-infrastructure innovation in food agriculture
ALLEA	All European Academies
API	Application Programming Interface
BOAI	Budapest Open Access Initiative
CJEU	Court of Justice of the European Union
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats
CUDOS	Communism, Universalism, Disinterestedness and Organised Scepticism
DG	Directorate-General
EARTO	European Association of Research and Technology Organisations
EIF	Interoperability Framework
EOSC	European Open Science Cloud
EPC	European Patent Convention
EPO	European Patent Office
EUIPO	European Union Intellectual Property Office
ERA	European Research Area
FAIR	Findable, Accessible, Interoperable and Reusable
FOSS	Free and Open-Source Software
FSF	Free Software Foundation
GPL	General Public License
HLEG	High-Level Expert Group
ICESCR	International Covenant on Economic, Social and Cultural Rights
IETF	Internet Engineering Task Force
IP	Intellectual Property
IPR	Intellectual Property Rights
JRC	Joint Research Centre
OA	Open Access
OECD	Organisation for Economic Co-operation and Development
ORD	Open Research Data
OS	Open Science
OSPP	Open Science Policy Platform
PCR	Polymerase Chain Reaction
PID	Persistent Identifier
R&I	Research and Innovation
RFC	Request For Comments
SDG	Sustainable Development Goal
TDM	Text and Data Mining
TRIPS	Trade-Related Aspects of Intellectual Property Rights
UDHR	Universal Declaration of Human Rights
UNESCO	United Nations Educational, Scientific and Cultural Organization
WIPO	World Intellectual Property Organization
WTO	World Trade Organisation

EXECUTIVE SUMMARY

Open science (OS) is considered the new paradigm for science and knowledge dissemination. OS fosters cooperative work and new ways of distributing knowledge by promoting effective data sharing (as early and broadly as possible) and a dynamic exchange of research outcomes, not only publications. On the other hand, intellectual property (IP) legislation seeks to balance the moral and economic rights of creators and inventors with the wider interests and needs of society. Managing knowledge outcomes in a new open research and innovation ecosystem is challenging and should become part of the EU's IP strategy, underpinning EU policies with the new open science–open innovation paradigm.

The usual justification for copyright and patents is the incentive and reward for inventors, resulting in benefits for society, fostering innovation and societal impact. Various organisations recognise the need to maintain a balance between the rights of authors and the larger public interest, particularly in education, research and access to information, and to consider the scope, extent and application of intellectual property rights (IPR) in relation to the equitable production, distribution and use of knowledge. However, there are cases of tacit tension in the relationship between IPR and open knowledge distribution noticed on a global scale in different contexts, initiatives and attitudes of the scientific community. This tension has been confirmed during the COVID-19 pandemic, where there is a concern that IPR may prevent public access to medicines, particularly vaccines. Governments, scientists, media and society at large are discussing new licensing provisions to circumvent barriers to human rights such as the right to health or the right to science, without preventing innovation. There is a clear need for reflections such as the one we present here, to address the necessary compatibility of some IPR with OS and open innovation.

This report provides a critical analysis of the literature on the relation between OS and IPR protection and how they might live harmoniously, by scoping the statement 'as open as possible, as closed as necessary'. The starting point for the analysis about IPR and OS in Europe is the following hypothesis.

- There are no incompatibilities between IPR and OS. 'On the contrary the IPR framework, if correctly defined from the onset, becomes an essential tool to regulate open science' (Barbarossa et al., 2017, p. 2).

- The European Commission has a role in promoting OS and its balance with IPR. This was especially important when copyright was redefined in Europe and the European Open Science Cloud was being established.

- Existing best practices have to be a source of inspiration, for example understanding how public research-performing organisations and industrial partnerships are striking a balance between IPR and open knowledge.

In general, there are very few studies, documents, reports and specific scientific works (papers, books, etc.) that directly and comprehensively address the coexistence of OS and IPR. However, various authors, stakeholders and reports point to IPR as one of the obstacles to making OS a reality without inhibiting its valorisation and open innovation. By providing an interdisciplinary analysis of economic rights and authorship, this report

fills a gap, but it goes further into other components of OS and their relationship with IPR, notably data and software, as well as other aspects of digital science and online scientific communication. We review the main literature from the last 10 years on this topic, but also provide an in-depth reflection on the state of the art.

In the Mertonian view of sociology of science, the principle of openness has been seen as inherent in academic activity and harks back to the original precepts underpinning the conduct of researchers. However, OS has different definitions, which are not always consistent with each other. For the purpose of this report, 'OS' refers to the entire process of conducting research as well as a systemic change highlighted by the European Commission that might improve science through collaborative and open ways of producing and sharing data and knowledge as soon as possible throughout the entire research cycle. A different paradigm must be created for scientific knowledge production, communication and valorisation, coherent with current technological possibilities and societal needs. The eight components of OS (i.e. the future of scholarly communication, findable, accessible, interoperable and reusable (FAIR) data, the European Open Science Cloud, next-generation metrics, rewards and incentives, skills in open science (open education), citizen science and research integrity) which have been discussed and challenged by the European Commission, have definite implications for IPR and have to be analysed with IPR in mind to guarantee their correct implementation.

OS is supported by the fundamental right to science and, on the other hand, IPR protects the rights of the creators. The five domains where transformations should be made, to evolve from the current paradigm of research to OS, are from open access (OA) to OS; from human-readable to machine-readable content; from open data to FAIR data, data sharing and data reuse; from traditional publishing to technology-driven service; and from semantic enrichment of content to semantic publishing.

This report also analyses these aspects of IPR with regard to OS components and principles.

- **Copyright**. In general, IPR includes rights that are related to some kind of effort or achieving the creation of a work through intellectual efforts for the common good, so affecting scientific results. This study analyses in depth copyright, patents, trademarks and trade secrets. Studies of IPR and opening scientific knowledge have most frequently been devoted to copyright and OA to research publications, but this study also covers the economic impact of IP, concluding, in line with the World Bank data analysis, that IPR have geopolitical importance and the EU does not occupy a significant place. In Europe, IP is based on the concept of territoriality, which implies that national rules govern copyrighted subject matter within the territory of a given Member State.

  Several authors (Hess, Ostrom and Unger) have concluded that the concept of IP ownership is not relevant in the digital age: what are crucial are the different possibilities attached to the possession of or access to digital information. As the Budapest Declaration says, 'An old tradition and a new technology have converged to make possible an unprecedented public good' (BOAI, 2002). The old tradition is the willingness of scientists and scholars to publish the fruits of their research in scholarly journals without payment, for the sake of inquiry and knowledge. The new technology is the internet. The public good they make pos-

sible is the worldwide electronic distribution of the peer-reviewed journal literature and completely free and unrestricted access to it for all scientists, scholars, teachers, students and other curious minds.

In the normative context of copyright in Europe, set up by the Berne Convention, from the creation of the work the author is entitled to two different sets of rights: moral and economic. Remuneration rights are directly connected to economic rights, which are configured legally in Europe as a closed list with exceptions or limitations (to copy, alter, distribute or communicate to the public). It is in this normative context that science has to communicate its results to the public. One of the reasons why science needs to be public is because it must be falsifiable. To become public, at least two activities are needed: reproduction and distribution or reproduction and public communication. IPR and their default 'all rights reserved' rule affect one of the core necessities of science: public dissemination to allow public scrutiny.

- **Patents**. A patent describes an invention and creates a legal situation in which the patented invention can normally only be exploited (manufactured, used, sold, imported) with the authorisation of the owner of the patent. In Europe, a group of contracting states signed the European Patent Convention, establishing a single European procedure for the grant of patents on the basis of a single application, and created a uniform body of substantive patent law designed to provide easier, cheaper and stronger protection for inventions in the contracting states.

  The European Commission actively promotes the implementation of the European patent with unitary effect (the 'unitary patent'). Unitary Patents will make it possible to get patent protection in up to 25 EU Member States by submitting a single request to the European Patent Office (EPO). They will build on European patents granted by the EPO under the rules of the European Patent Convention, so nothing will change in the pre-grant phase and the same high standards of quality search and examination will apply. After a European patent is granted, the patent proprietor will be able to request unitary effect, thereby getting a Unitary Patent which provides uniform patent protection in up to 25 EU Member States. Note that the new system will only apply in Member States that have ratified the Unitary Patent Court Agreement. So far, 17 Member States have done so.

  However, some authors (e.g., Stiglitz, 2008) think that the patent system is not ideal for innovation, because it creates distortionary and transaction costs, and it is not the best option available for disseminating knowledge. IPR are important but they are just 'part of a portfolio of instruments'. The other elements should be strengthened, and IPR should be redesigned to 'increase its benefits and reduce its costs'. Each industrial or innovative sector has different conditions for invention, so every sector should be analysed separately, avoiding the temptation to assert general conclusions. Although different strategies are followed to gain better competitive positions, the disclosure of the invention remains central to patents. Tens of millions of patent documents can be accessed for free from various databases (e.g. the EPO's EspaceNet), as soon as 18 months after their first filing. Moreover, most of them have already expired, which means that the technologies concerned are now in the public domain.

- **Trademarks**. A trademark is an informational reference to an object. By nature it does not play any role in the transmission of information in which the object may consist. Having (or not having) a trademark that identifies goods or services provided by any natural or moral person does not alter their reproducibility or transmissibility, although it affects public perception of the objects represented. However, perception of an object is not an element that affects its replicability.

  A point of friction may appear in certain common uses of a trademark without consent of the rightholder. Nevertheless, it would not disturb the transmission of information.

- **Trade secrets**. Trade secrets, as part of IPR, consist of secrets of all kinds. They may be of a personal, commercial or industrial nature, or concern the state and its administration. Their origin may be found in the protection the guilds exercised over the practices of their members. Trade secrets are incompatible with OS.

When analysing the balance between OS and IPR, the default legal requirement for the transmission of a work is explicit consent, the use of an exception or the existence of public domain. In the event of conflict, it is the user of the work who has the burden of proof that one or more of these requirements exist. Therefore, using works for a scientific activity may produce risks that should be avoided by the correct use of the permissions designed in the IP legislation.

- Although OA to scientific publications is the cornerstone for OS regarding IPR, in the last 20 years, new strategies and approaches to OA have tried to obtain immediate OA to all scientific publications coming out of publicly funded research by having the researchers retain the necessary IPR, allowing them to license their works with open licences.

- When it comes to data and IPR, it could be summarised that data and facts do not have protection under copyright, but databases do. In the digital world and economy this is no longer acceptable. Working with FAIR data challenges IPR in the reuse of data sets, which bears an inherent risk of IPR infringement. Hence, in order to guarantee interoperable and reusable data, it is necessary to check the validity of the consent of the rightholder or whether an exception/limitation applies.

- Regarding free software, there is a general misunderstanding that it is not under copyright. Free software is another way authors have to exercise their copyright and then manage their intellectual assets. Free software advocates use copyright to force the openness of their creations, which is a legitimate way to manage IP, often based on ethical considerations. In OS, access to source code is not only a matter of IPR but also the necessary requirement to operate at all knowledge levels. Access to and operability of source code (for copying, modification, dissemination) are among the core aspects of OS that are not because of IP.

- IPR have also an impact in daily activities held by scientists when managing data (application programming interfaces, taxonomies and ontologies; hyperlinks,

and text and data mining). Awareness of these points would avoid the risk of IP infringement faced by scientists or the organisations they belong to. In this sense, current European legislation should be adapted to include exceptions for OS, including levies on remuneration rights.

One of the big issues to address for a better shared understanding of OS and IPR and for their better interaction is to scope the principle 'as open as possible, as closed as necessary'. Few studies attempt an analysis of that expression in reference to OS and, when it is tackled, they only occasionally refer to the reusability of the data and their licences. The limitations to the openness of the information based on the nature of the content could be imposed by the normal limitations that exist in a democratic regime, and the exceptions to the limitations could be decided, by local, national or regional pertinent governing instances. However, when the scope of the expression 'as open as possible, as closed as necessary' is analysed under IP norms, then the decisions to close scientific knowledge on publicly funded projects should be analysed, scrutinised, rejected by default and only accepted if a closed catalogue of reasonable conditions is met. OS categorically does not mean indiscriminate openness, but the default rule is that any reason for making it closed should be made evident and that the limits based on the nature of the information already serve as a reasonable scenario.

The main remarks and lessons to be learnt from this report are classified in three sections: general findings, recommendations for policymakers and recommendations for practitioners/users.

Findings

- Although it is acknowledged that managing IP requires particular skills and incurs costs, there is a need to achieve a balance between the need to protect and to disseminate knowledge. Therefore, based on the notion of "as open as possible as close as necessary", the protection of knowledge is an important step for the achievement of the Union's policy goals, such as strategic autonomy and green and digital transition.

- The scientific literature and main reports on OS do not systematically address IPR issues as a key element in reviewing the establishment of a new OS paradigm. It appears that the assertion that better IPR management promotes innovation is not the common understanding in the research and innovation community. Although the Commission's new EU IP policy is clarifying the crucial role of IP for the Union's growth[2], more studies on the cross-section of IP and open science are needed.

[2] https://www.epo.org/about-us/services-and-activities/chief-economist/studies.html

- The idea that a stronger IPR system produces more innovation and creativity could benefit from more data and quantitative analysis. Although the implementation of the EU IP Action Plan provides data on the use of IP, data on open innovation needs to be further collected and analysed at Union level.

- There is an epistemic blindness regarding the existence of free IP works. This leads to the absence of analysis and data about the wealth they represent and produce. The status of the internet as a free IP work composed of the set of more than 9 000 requests for comments is simply ignored by the literature.

- Government funding, prize systems and the IPR system are tools to incentivise more and better inventions that can later be transferred and become innovations to solve serious problems such as the global COVID-19 pandemic. Distortionary and transaction costs of patents should be further analysed.

- If a researcher wishes to place their research results in the public domain, no IP-related formalities are required. Therefore, there is no additional burden on the researcher. However, if the researcher wants to protect their results, current IPR regulation can impose a burden in at least two ways. Firstly administrative, when it comes to allowing access to and use of the research results with the proper IPR; and secondly, financial, as regards the payment of levies to remunerate literary or artistic authors.

- Basic science opens unforeseen pathways. It is both essential and incalculable. Its value cannot be estimated because its results are unknown.

- The term 'IP' comprises two main areas: (1) literary and artistic property, which is mainly covered by copyright, and (2) industrial property, which mainly includes patents (as well as utility models and supplementary protection certificates), trademarks, industrial designs, geographical indications and trade secrets. Each one has a different impact on OS.

- Under the current copyright regime, works are closed by default. Therefore, to foster openness in science, consent must be given by the author or an exception/limitation must apply. Consent of the author must be proactive.

- Dynamic processes (such as science production) require IP licences that do not hinder changes or burden the process with unnecessary bureaucracy. A community's ability to sustain dynamic processes depends on this.

- Under international treaties and legislation, it is not possible to create an autonomous scientific author whose works would merit different IP conditions from the 'all rights reserved' default rule. Exceptions related to scientific IPR should be legally maximised, avoiding as far as possible the risk of legal proceedings.

Recommendations for policymakers

- It is urgent to address new copyright and IPR regimes to guarantee better IP protection responsive to the needs of open, transparent and collaborative science. The international pragmatism resulting from COVID-19 and the positive reactions to OS-OA paradigms should be taken advantage of. COVID-19 suggests that the incentives generated by IPR might be improved by global solidarity or, in the EU context, by subsidiarity.

- Current IPR standards and regimes should keep up with rapid technological developments, with legal provisions that offer online protection. A new IPR framework for OS should be created at global level, adapted to the new digital technologies, the new requirements of science, and modern scientific communication needs and facilities, in order to find the right balance between OS and IPR.

- Basic science should be promoted on account of its essential importance for applied science. Evaluation of basic science through IPR (copyright or patents) indicators should be further analysed. Awareness of the value of basic science and free intellectual works needs to be raised, taking the request for comments model as an example. The more basic science and the more requests for comments, the more opportunities for small and medium-sized enterprises to build on free components and appropriate the results. Special attention must be paid to avoiding appropriation of the basic science and the IP under free licences.

- The right of an author to provide for the openness of his or her work must receive from the EU and the Member States the same support as the right of an author to keep his or her intellectual work closed. Authors of free works should be treated at least equally to authors of closed works.

- An Office for Free Intellectual Property Rights and Open Science should be created. This office can be inspired by the functioning of the Office for Harmonization in the Internal Market and the European Observatory on Infringements of Intellectual Property Rights (EU 386/2012) and should be aligned with the EU IP action plan. It could be piloted through the Horizon Europe Framework Programme.

- EU IP legislation should be reviewed and amended to define hyperlinks as a mere linguistic reference, to expand the text and data mining copyright exception to match the United Nations Educational, Scientific and Cultural Organization's diversity and inclusiveness values, to include clear and stronger exceptions for OS not affected by levies to remunerate rightholders of closed copyright works.

Specific recommendations on intellectual property for practitioners

- All organisations, when using data, should analyse the terms and conditions of each data set. If these are not clear or no consent has been given, then it should be treated as an 'all rights reserved' piece of information.

- Lessons can be learnt from the free software communities:
    - licence diversity: the possible activities that the creator may allow the users to exercise are innumerable, although a side effect of using different licences is that they may be incompatible;
    - awareness of the necessity of including a licence to avoid the 'all rights reserved' by default system;
    - inclusion of licences within the source code: the licence should be included as a text file in the source code trunk, which raises an author's awareness of the necessity for a licence;
    - awareness of the necessity for the licence to be updated because of changes in the technological or legal context;
    - building tools to standardise the references to licences and to make them readable by both humans and machines;
    - existence of communities that take care of projects' sustainability;
    - the ethos of 'release early, release often'.

We are in a new research and innovation paradigm in which digital technologies, particularly the World Wide Web, enable distributed behaviour in collaborative research and the possibility of communicating knowledge immediately, openly and at scale through the network. Opening up research processes and science leads us towards a promising transformation of the way we do science. Despite this, we continue to carry out, publish, finance, attribute and evaluate research in the same way as in the last century. In the more than 30 years of coexistence with the web, we have undergone various paradigm changes in the creation of a new digital society, challenging old regulations, including the traditional IPR.

1. INTRODUCTION AND OBJECTIVES

Research and innovation (R&I) is crucial to creating a better and healthier society that can take full advantage of the new knowledge economy. Research is becoming increasingly complex, digital, interdisciplinary, data driven and reliant on large-scale computing capabilities. This new R&I paradigm has given rise to e-science and scientific computing. Likewise, digital technologies, particularly the World Wide Web, enable distributed behaviour in collaborative research (David et al., 2006) and the possibility of communicating knowledge immediately, openly and at scale through the network. By opening up research processes, this new environment leads us towards a promising transformation of the way we do science. Despite this, we continue to carry out, publish, finance, attribute and evaluate research in the same way as in the last century. In the more than 30 years of coexistence with the web, we have undergone various paradigm changes in the creation of a new digital society, challenging old regulations, including the traditional intellectual property rights (IPR).

Open science (OS) is the new paradigm for science and knowledge dissemination (Ardil, 2007; Kunst and Degkwitz, 2019; Smart et al., 2019). OS fosters cooperative work and new ways of knowledge distribution by promoting effective data sharing (as early and broadly as possible) and a dynamic exchange of research outcomes, not only publications. On the other hand, intellectual property (IP) legislation seeks to balance the moral and economic rights of creators and inventors with the wider interests and needs of society. Managing knowledge outcomes in a new open R&I ecosystem is challenging and should become part of the EU's IP strategy, underpinning EU policies with the new open science–open innovation paradigm. One of the debates around OS is taking place in the context of discussions about 'the evolving nature of scientific knowledge production regimes with the emergence of other descriptive and prescriptive theories of how the creation of scientific knowledge is changing' (Smart et al., 2019).

A traditional justification for copyright and patents 'is that incentives and rewards to inventors result in benefits for […] society' (Chapman, 1998) and are a powerful tool to strengthen science and culture (Bammel, 2014), fostering innovation and societal impact (European Commission, 2020a). For instance, the World Intellectual Property Organization (WIPO) Copyright Treaty, enacted in 1996, recognised in its preamble the need 'to maintain a balance between the rights of authors and the larger public interest, particularly in education, research and access to information' ([3]). Likewise, in 1999, the United Nations Educational, Scientific and Cultural Organization (UNESCO) Declaration on Science and the Use of Scientific Knowledge recognised the need 'to consider the scope, extent and application of intellectual property rights in relation to the equitable production, distribution and use of knowledge' ([4]).

However, there are cases of tacit tension in the relationship between IPR and open knowledge distribution noticed on a global scale in different contexts, initiatives and attitudes of the scientific community. For example, for some researchers Sci-Hub is a public good allowing publicly funded research to be made available for free, and for others it is no more than pure piracy and infringement of copyright. Sci-Hub is an illegal repository of scientific papers, but it is 'a symptom of many people's frustration with the status quo in academic publishing', as stated by Stephen Curry (Schiermeier, 2017), a reaction to a problem that has to be solved (González-Solar and Fernández-Marcial, 2019) or a wake-up call to show that 'the current intellectual property regime can be made irrelevant' (Lawson, 2017). This tension has also appeared during the COVID-19 pandemic, when there is a concern that IPR may prevent public access to medicines, particularly vaccines. Governments such as that of the United States, scientists, media

([3]) https://wipolex.wipo.int/en/text/295157
([4]) http://www.unesco.org/science/wcs/eng/declaration_e.htm

and society at large are discussing new licensing provisions to circumvent barriers to human rights such as the right to health or the right to science, without preventing innovation (see Section 2). The recent launch (2021) of the initiative Right to Research in International Copyright Law ([5]) is also evidence of the need for reflections such as the one we present here to address the necessary compatibility of some IPR with OS and open innovation.

Understanding the relationship between the protection of intangible assets with IPR and knowledge circulation is the key to developing sound policies and practical approaches to knowledge valorisation. At European level, during the last decade, policies around OS and IPR have been developed by the European Commission in parallel but not always in conjunction with each other. The **objective** of this report is to produce a critical analysis of the literature on the relationship between OS and IPR protection and how they might live harmoniously by scoping the statement 'as open as possible, as closed as necessary'.

A literature review on the relationship between OS and IPR protection will help adjust the academic overview of the topic (major problems, challenges, possible misunderstandings, etc.), from the perspectives of both copyright law and trade-related issues of IPR, to analyse the adaptability and concessions of IP and OS, in order to suggest solutions that strike a balance between openness and reserving some rights, and to highlight shared benefits that may be useful as a reference for the development of future policies. Therefore, the two key questions that this report aims to answer are the following.

- How should the ownership of research results be approached nowadays in an OS context?
- What amount and type of IPR protection is desirable in the new scientific paradigm of OS? Has this concept evolved with the digitalisation and increased mobility of researchers?

Reviewing these questions throughout the current literature will inspire some insight into how IPR and OS can be reconciled, beyond the elementary clash of interests and traditional confrontation. The report will suggest some recommendations to strike a balance between openness and reserving some rights for the benefit of science.

1.1. Scope, methodology and structure

For the purpose of this report, we have employed a systematic literature review to analyse the state of the art in OS and IPR. The scientific literature dedicated to the relationship between IPR and OS has been surveyed and synthesised in order to reflect the state of play and the main trends in the topic. Not only scientific papers and scholarly works have been reviewed, but also the main reports, declarations and publications around OS or IPR, particularly in the way that they refer one to another. The information gathered is critically analysed by identifying gaps, inconsistencies or contradictions in the current system; it is expanded upon by showing limitations of theories and points of view; and the report concludes with a review of areas of controversy and by the formulation of areas for further research. This essay provides clues for future work in OS and IPR, and suggests a constructive analysis of the approaches of other researchers and policymakers.

The **scope and specific features** of this report are as follows**:**

([5]) https://www.wcl.american.edu/impact/initiatives-programs/pijip/impact/right-to-research-in-international-copyright/

- this report is conceived as a formal essay that gathers the authors' arguments in the light of the common current literature on the topic;
- it focuses mainly on European trends between 2010 and 2021, without ignoring science's universal characteristics, and so includes, where relevant, comparisons between European and non-European approaches towards IPR and OS, as well as those of global institutions such as the Organisation for Economic Co-operation and Development (OECD) or UNESCO (United Nations Educational, Scientific and Cultural Organization);
- the reviewed literature includes different types of information (primary and secondary resources) published in English: first, academic papers and books included in various academic databases of scholarly journals; second, EU Directives and Regulations regarding IPR, OS, open access (OA) or open data; and, third, the main policy reports addressing either OS or IPR or both simultaneously.

The **methodology** adopted includes a systematic literature review, sometimes understood as a meta-analysis on the topic, along with the continuously changing environment of OS and IPR in the light of the COVID-19 pandemic. The methodological approach also combines the complementary expertise of the co-authors in a dialectic approach to the topic.

This study undertook multiple steps to address the topic in the literature.

1) **Research and selection of information resources and literature** (January–February 2021). The initial databases selected to address the search were traditional academic databases such as Scopus, Web of Science, ABInform and JSTOR, but also openly available resources including Google Scholar, Dimensions and LENS among others, to offset the bias of the former. The query was initially 'open science' AND 'intellectual property rights' OR 'IPR', in the title, abstract or keywords field. Other combinations of keywords were also used: 'open access' OR 'open data' OR 'open source' AND 'Copyright'; 'Open Science' AND 'Trade'; 'Open Innovation' AND 'Open Science'; etc. Subsequently, a filter by language of publication (English) and publication year (the first timeframe was approximately 10 years, 2010–2021) was applied. After these iterative searches and subsequent query adjustments, a comprehensive list of references was established and managed in a Zotero collection.

2) **Evaluation and strategy for quality assessment and complementary information.** Along with the initial search in scholarly databases, the overview was complemented with other fundamental primary resources such as legislation and major EU Regulations, European Commission and other official reports, and declarations, as well as significant resources on OS and IRP available through the Web (e.g. ALLEA, 2020; Barbarossa et al., 2017; EARTO, 2020; Kalff-Lena, 2021; Zacherl and Zatloukal, 2017).

   The comprehensive bibliography in Zotero currently includes around 500 references. The aim is to continue updating it as new contributions are added to the field. However, only some of them are cited in the report. The works cited or reflected in this report were selected on the basis of:

   - having been published when OS and IPR policies were being developed in Europe, with priority given to publications published in the core period between 2015 and 2021;
   - including a fundamental contribution for the purposes of this study, even if published prior to 2015 or not focused on Europe (e.g. Hess and Ostrom, 2003; UNESCO, 2020).

3) **Synthesis review and identification of the building blocks of the report.** This step included the classification of the literature around the research questions and topics, managing different categories in the Zotero collection and afterwards highlighting the components to be discussed and extracted from the literature.
4) **Discussion of topics and consolidating the main elements of the report.** This phase included drafting the table of contents, identifying the main issues to be addressed under each section and reviewing the relevant literature.
5) **Reflecting the discussion in an essay, and providing recommendations and concluding remarks** towards the happy coexistence of IPR and OS in a new R&I landscape of the European Research Area (ERA) based on a competitive and open scientific paradigm.

The **content is structured** from the most abstract to the most specific, reflecting different approaches and discussing them. After this introductory section, in which the objectives and scope of this report are discussed as well as a general overview of the most current literature on the intersection of OS elements and IP, the essay is composed of six additional sections. It begins by analysing the fundamental right to science and characteristics of science, which is populated with ideas, informal conversations, serendipity and other actions or facts that belong to the right to research but are not regulated by IPR. This section also reflects the current boost in global support for OS resulting from the COVID-19 pandemic, which entails a waiver of IPR and a new revival of the idea of a right to science (**Section 2**). The concept and evolution of OS in Europe is then analysed, along with the main components and challenges and whether they are connected with IPR, based on the reports and literature produced by the European Commission (**Section 3**).

After analysing the right to science and the concept and fundamental elements of OS, this essay reviews specific issues related to IPR (**Section 4**), notably copyright, patents, trademarks and trade secrets, focusing on Europe but also reviewing the historical background and justification of IP in general, and concluding with a global comparison between major trends in the EU and the approaches of China, Israel and the United States to the OS–IPR interface.

Being aware of the barriers, this report describes the strategies employed to avoid them and to promote openness. As it will be argued, although data are not subject to IPR regulation, databases are, so a different approach should be taken to promoting openness depending on the underlying object. The experience of the free software movement ('free' in the sense of freedom to perform activities forbidden by default) will be used as an example in **Section 5**. This section also reviews other IP-specific issues arising from scientific communication via the web, such as application programming interfaces (APIs), hyperlinks or text and data mining (TDM), as well as the specific case of levies on remunerating IPR.

The traditional tension between openness and closedness will be also explored (**Section 6**), but with a new approach: 'as open as possible, as closed as necessary'. OS could be a completely new paradigm, or just the current expression of an old phenomenon. In order to take into account the current context, this report will delve into the EU initiatives that are being built by developing OS-specific infrastructures (such as the European Open Science Cloud (EOSC) ([6]) or Open Research Europe ([7])) in this new reconciliation of openness and closedness.

The report finishes with a review of the main conclusions, and recommendations and lessons to put into practice based on what has been analysed and reflected on

([6]) https://eosc-portal.eu
([7]) https://open-research-europe.ec.europa.eu

throughout this work (**Section 7**). Finally, a comprehensive list of references cited in the essay is collected at the end of the work. The annexes include a particularly detailed analysis of some of the important European Commission documents and publications addressing OS issues and policies, in which IPR issues are partially addressed.

1.2. General appraisal of the state of the art

There are very few studies, documents, reports and scientific literature (papers, books, etc.) that directly and comprehensively address the coexistence of OS and IPR. However, various authors, stakeholders and reports point to IPR as one of the obstacles to making OS a reality without inhibiting its valorisation and open innovation.

The first time IPR and OS were clearly addressed jointly in a way comparable to this essay was in the workshop 'IPR, Technology Transfer & Open Science: Challenges and opportunities', co-organised by the European Commission's Joint Research Centre (JRC) and the Directorate-General (DG) for Research and Innovation in 2017. In the final report, edited by Barbarossa et al. (2017), there are three main conclusions, which we adopt here as our **starting point hypothesis** for the analysis of IPR and OS in Europe.

- There are **no incompatibilities between IPR and OS**. 'On the contrary the IPR framework, if correctly defined from the onset, becomes an essential tool to regulate OS' (Barbarossa et al., 2017, p. 2).
- The **European Commission has a role in promoting OS and its balance with IPR**. This was especially important when copyright was redefined in Europe and the EOSC was being established.
- Existing **best practices have to be a source of inspiration.** For example, understanding how public research-performing organisations and industrial partnerships are striking a balance between IPR and open knowledge.

In July 2020, the European Association of Research and Technology Organisations (EARTO) published a paper stressing the need for a balanced approach between IPR and OS but focused on the policy issues (EARTO, 2020).

The OECD (2015a) has also made a detailed analysis of the implications of OS and IPR, giving a general overview of the international IP regimes that are or may be applicable to the protection of scientific output, pointing to the current European legislative framework (OECD, 2015a, pp. 381–383). These outputs include scientific and scholarly publications as well as collections of any type of data. Data and publications can be protected by a number of rights within the category of IP, chiefly copyright and database protection. 'These two rights are granted to their owners without any formality, at the moment an original work or qualifying database is created. Many other rights exist in the area of industrial property, such as trademarks, patents, topographies of integrated circuits, design rights, or protection of plant varieties' (OECD, 2015a).

More recently (23 April 2021), UNESCO organised a meeting on the topic 'Towards a Global Consensus on Open Science – Online expert meeting on open science and intellectual property rights' ([8]) in order to discuss and align OS and IPR in the light of the new global approach to OS and science commons promoted not only in Europe but also by UNESCO at international level. The UNESCO draft recommendation, approved in May 2021, recognises the importance of the existing international frameworks, in particular on IP and protecting the rights of scientists to their scientific productions (UNESCO, 2021a) ([9]).

([8]) https://events.unesco.org/event?id=1767422131&lang=1033
([9]) The version used during the writing of this report is the final draft sent to the UNESCO Member States

Studies of IPR and opening scientific knowledge have most frequently been devoted to copyright and OA to research publications (Atkinson et al., 2018; Bammel, 2014; Caso, 2020; Dawson and Yang, 2016; Joo, 2020; Koutras, 2018, 2020; Scheufen, 2015; Sondervan, 2020; Suber, 2016), currently highlighted again by the Plan S and cOAlitionS rights retention strategy (see also Section 5.1 below) ([10]). Although the topic of copyright of scientific publications has been explored, there remains a lack of in-depth interdisciplinary analysis into the relationship between authorship and economic rights (Caso, 2020). This report aims to fill that gap (see Section 4.3), and goes further into other components of OS and their relationship with IPR, notably data and software, as well as other aspects of digital science and online scientific communication.

Since approximately 2015, the study of IPR in scientific outcomes has attracted interest, owing to the open research data (ORD) initiative and research data infrastructures (mainly the launch of the EOSC, also known as the European Open Science Commons) and the reusability of publicly funded research data. Open data raises different and fragmented legal issues including copyright, ownership, data protection and privacy, and even human rights challenges (see Section 2 on COVID-19, and Section 5.1.2, on FAIR (open) data). Data ownership is an oxymoron (Penev, 2019) because copyright cannot exist over ideas or facts, therefore no data ownership rights exist; however, database rights are protected by the *sui generis* property right or *sui generis* database right (OECD, 2015a) and copyright in Europe ([11]), as we will analyse in Sections 5.1.2 and 5.2.1. The literature reflects this issue regarding databases, but there are very few authors who address the openness of the research data from an IPR perspective (Labastida and Margoni, 2020; Penev, 2019). There are also several works on the limitations on sharing research data in the light of legal issues concerning data protection (Landi et al., 2020; Phillips and Knoppers, 2019) or addressing both legal issues (privacy and IPR) together, as barriers to sharing data and making them publicly accessible (Beugelsdijk et al., 2020; Graber-Soudry et al., 2021; Landi et al., 2020; Lipton, 2020; Wessels et al., 2014).

Since law is a discipline with an extensive tradition of handbook publication, there are several books addressing the recent challenges to knowledge communication in IPR and the digital sphere, targeting the 21st century as a new landscape for urgent review of IPR and access to knowledge, but not always focusing on OS (Beldiman, 2013; Dreyfuss and Pila, 2018; Perry, 2016).

This report reviews the main literature on the topic but also provides an in-depth reflection on the state of the art.

in March 2021, and the basic document for the discussion at the Intergovernmental meeting of experts (Category II) during 6–7 and 10–12 May 2021.

([10]) https://www.coalition-s.org/rights-retention-strategy

([11]) See Chapter III of Directive 96/9/EC of the European Parliament and of the Council of 11 March 1996 on the legal protection of databases (http://data.europa.eu/eli/dir/1996/9/2019-06-06).

2. A STARTING POINT: THE FUNDAMENTAL RIGHT TO SCIENCE

Access to scientific results is a fundamental right. From a broader perspective, Erin McKiernan (2014) concluded in a post in *The Guardian* that 'Access to information is a human right, but it is often treated as a privilege. This has to change. And it will take all of us to make it happen.' OS has emerged as a way to challenge the status quo of privileged access to scientific knowledge, particularly that which results from publicly funded research.

The Universal Declaration of Human Rights (UDHR) of 1948 established the fundamental right to science and culture in Article 27: '(1) Everyone has the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and in its benefits. (2) Everyone has the right to the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author' ([12]). The UDHR acknowledges the IP paradox by contrasting a right to access to knowledge in the first paragraph with the right to the protection of the moral and material interests of the author in the second paragraph (Geiger et al., 2018).

The International Covenant on Economic, Social and Cultural Rights (ICESCR), issued in 1966, is considered the major international human rights instrument addressing science and culture as fundamental rights (Chapman, 1998). Endorsed by 130 countries, the ICESCR expanded to include the enjoyment of scientific progress, as well as the need for the conservation and diffusion of science, in its Article 15 ([13]):

> 1. The States Parties to the present Covenant recognize the right of everyone:
>
> (a) To take part in cultural life;
>
> (b) To enjoy the benefits of scientific progress and its applications;
>
> (c) To benefit from the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author.
>
> 2. The steps to be taken by the States Parties to the present Covenant to achieve the full realization of this right shall include those necessary for the conservation, the development and the diffusion of science and culture.

This principle of conservation, development and diffusion, already recognised in 1966, is, more than 50 years later, at the heart of the legitimacy of OA according to Commission Recommendation (EU) 2018/790 of 25 April 2018 on access to and preservation of scientific information ([14]). This recommendation defines the preservation of scientific research results as being in the public interest, and the Commission exhorts the Member States to put in place infrastructure and solutions for the long-term preservation of all the research outcomes in digital formats, including publications and research data.

Finally, Article 15 of the ICESCR introduced the freedom of researchers as an indispensable value, as well as cooperation in science, which is one of the main features of new OS practices:

> 3. The States Parties to the present Covenant undertake to respect the freedom indispensable for scientific research and creative activity.

([12]) Universal Declaration of Human Rights, GA Resolution 217 A (III), UN Doc. A/RES/217 A, 10 December 1948 (https://www.un.org/en/universal-declaration-human-rights).
([13]) https://www.ohchr.org/Documents/ProfessionalInterest/cescr.pdf
([14]) http://data.europa.eu/eli/reco/2018/790/oj

4. The States Parties to the present Covenant recognize the benefits to be derived from the encouragement and development of international contacts and co-operation in the scientific and cultural fields.

The UDHR and the ICESCR jointly recognise the right to science and the right of protection of the moral and material interests of the results. Both rights are to be treated equally (or together) in the scientific process. Globalisation and the increasing commercialisation of science, along with the oligopoly of the big publishers and a traditional misleading perception of how and where to publish, have made it even more difficult to achieve the balance envisaged in Article 15 of the ICESCR. These trends have affected the nature of science, one of the most international activities. Advances in science require freedom of inquiry, the full and open availability of scientific data on an international basis, and open publication of the scientific outcomes (Chapman, 1998).

Other international and regional human rights instruments recognise this right. At EU level, the Charter of Fundamental Rights of the European Union ([15]) does not expressly mention the right to science as a specific fundamental right, but underlines something very important for the purpose of this report: the freedom of the researcher. Article 13 says 'The arts and scientific research shall be free of constraint. Academic freedom shall be respected.' That aspect is also included as indispensable for scientific research in Article 15(3) of the ICESCR.

The weakness of the UDHR (1948), the ICESCR (1966) and the Charter (2012), which should be considered when reflecting on the controversial marriage of IPR and (open) science results, is that scientific and cultural works are treated together, putting science at the same level as the creative and entertainment industries. As argued further below, when it comes to IPR, the same norms regulate two domains with opposite interests: it is in the interest of the entertainment industry to control the dissemination of a work, establishing different release windows ([16]) in which to sell the same creation for different prices (Ranaivoson et al., 2014, p. 13), while, on the contrary, it is in the interest of science to share the work as early and widely as possible. The rule that everything is interdicted by default matches the interests of the entertainment industry, because it is the legal tool that allows for the windowing commercial strategy, but it works against the necessities of science, which are to remove all possible dissemination barriers with no obstructive windows at all.

The right to the benefits and results of science has been explored from different perspectives regarding the right to science and IP (Bammel, 2014; Chapman, 1998; Petitgand et al., 2019; Shaver, 2009) but, unlike other human rights, it is not legally defined or regulated (Wyndham and Vitullo, 2018). The scope, normative content and obligations of the right to science remain underdeveloped, while scientific innovations are changing human existence in ways that were inconceivable a few decades ago (Shaheed, 2012). Despite these normative foundations, the right to science has long remained a 'Cinderella right' (Petitgand et al., 2019, p. 3, citing Professor Bartha Maria Knoppers). By virtue of this right, individuals should not only benefit from the products of science but also be able to adopt scientific concepts, theories and methods in order to become more independent and capable of conducting their personal lives and participating in their community (Irwin, 2015; Wyndham and Vitullo, 2018).

In 2018 the United Nations Committee on Economic, Social and Cultural Rights organised a day of general discussion on Article 15 of the International Covenant on Economic, Social and Cultural Rights and issued discussion paper a list of questions

([15]) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012P/TXT&from=EN

([16]) A window is defined as 'that period of time when a distributor or broadcaster is given an exclusive right to exploit a film' (WIPO, 2007, p. 95).

related to the right to enjoy the benefits of scientific progress and its applications([17]). Some of the most important questions were the following: What is the ideal balance between the right to benefit from science and IPR? How should government obligations, under the right, differ based on available national resources? What is 'scientific knowledge' and how should it be differentiated, if at all, from other kinds of knowledge?

At the beginning of 2020, the committee prepared a draft general comment on science to expand the 'right to science' and sought input from stakeholders including Member States ([18]). This comment finally asserts the right to science and also underlines, again, the need to find 'measures to harmonize intellectual property with the right of all persons to access science and its benefits; and adequate protection against all forms of discrimination' (Uprimny and Mancisidor, 2020, p. 16). It particularly refers to a balance between OA and the sharing of scientific knowledge and intellectual property. However, the committee underlines that 'intellectual property is a social product and has a social function' (Uprimny and Mancisidor, 2020, p. 12), and unreasonably high costs for access to scientific knowledge should be prevented just as other essential goods enshrined in human rights (such as medicines, food, learning materials) should not be prohibitively expensive. This claim may also be tacitly reflected in Sustainable Development Goal (SDG) 10 on reducing inequalities ([19]).

In November 2019, the UN organised a roundtable discussion on a global science commons to discuss the crucial role of OS in the achievement of the UN 2030 Agenda, resulting in a document outlining a science commons as a framework organised around principles, universal values and the architecture of open research, and based on OS as a key accelerator of the SDGs ([20]).

2.1. COVID-19 pandemic: confirmation of the 'right to science'

Since early 2020, especially because of the consequences of the COVID-19 pandemic, the right to science has been highlighted along with the urgent need for science to be open and collaborative (Akligoh, 2020; Barbour and Borchert, 2020; Besançon et al., 2020; Moradian et al., 2020; Zastrow, 2020) ([21]). In this extraordinary situation, Capps (2020) defines OS as an 'open commons, in which a right to science renders all possible scientific data for everyone to access and use'. He argues that open commons generate a community of rights, made up of people and institutions, whose interests jointly support the public good.

The European Commission reacted in 2020 to the 'right to (open) science' global trend at both political and infrastructure levels. It launched the Manifesto for EU COVID-19 research 'Maximising the accessibility of research results in the fight against COVID-19' (European Commission, 2020b), which invokes three simple but clear principles: (1) to make public and accessible all COVID-19 research outcomes coming from EU-funded research; (2) to make all the papers and research data immediately openly available, particularly sharing the data related to COVID-19 research on the specific platform created for that purpose ([22]); and (3) to grant (where possible) for a limited time non-exclusive royalty free licences on IP resulting from EU-funded projects. The same spirit also inspired the Open COVID Pledge ([23]) to make IP available free of charge for use to end the COVID-19 pandemic and to minimise the impact of the disease. This pledge can

([17]) https://www.ohchr.org/EN/HRBodies/CESCR/Pages/Discussion2018.aspx
([18]) https://www.ohchr.org/EN/HRBodies/CESCR/Pages/DraftGeneralComment_Science.aspx
([19]) https://www.un.org/sustainabledevelopment/inequality
([20]) https://research.un.org/ld.php?content_id=51390330
([21]) A comprehensive list of initiatives and resources regarding open science and COVID-19 has been compiled by the OECD (https://community.oecd.org/docs/DOC-172520).
([22]) https://www.covid19dataportal.org
([23]) https://opencovidpledge.org

be fulfilled by adopting a specific open COVID licence or adopting another open licence that carries out the intent of the pledge ([24]).

The importance to call for more OS has also been underlined by different authors, international organisations, non-governmental organisations and even private institutions in the business of science. But it reached its full harmonisation with the right to science in the 'Joint appeal for open science' launched by UNESCO, the World Health Organization and the Office of the UN High Commissioner for Human Rights ([25]), which specifically reasserted Article 15(1)(b) of the ICESCR as the fundamental right to enjoy the benefits of scientific progress and its applications, and clearly advocated open, inclusive and collaborative science. This joint appeal states everything discussed in this section regarding the value of OS and the legitimacy of the right to science. OS is the new paradigm for science that will help us respond to the immediate challenges of international health emergencies like COVID-19, reduce inequities and accelerate progress towards the implementation of the 2030 Agenda for Sustainable Development.

The OECD ([26]), UNESCO ([27]), The World Academy of Sciences ([28]) and the European Commission ([29]) have underlined how critically important openness is to combating COVID-19 (Besançon et al., 2020). Specific open platforms have been created by countries ([30]), institutions and collective initiatives ([31]) and even by commercial publishers ([32]). Although it seems obvious that there is no going back (Barbour and Borchert, 2020), it is necessary to analyse under what conditions publishers provide OA. Another study (Arrizabalaga et al., 2020) analysed more than 5 600 articles about COVID-19 in PubMed, and, although 97 % are technically published open, almost 70 % of them belong to the OA bronze category, meaning that publishers 'open' COVID-19 publications but without granting a licence to reuse them, meaning they can shut off access at the push of a button.

Along with pledges, declarations, statements and particular temporary copyright waiver initiatives, concrete action has been undertaken by the US Trade Representative on the COVID-19 Trade-Related Aspects of Intellectual Property Rights (TRIPS) waiver, announcing the Biden administration's support for waiving IP protections for COVID-19 vaccines (Office of the United States Trade Representative, 2021). This idea was immediately supported by UNESCO and other countries. UNESCO's president states: 'The decision of the United States and many other countries to call for the lifting of patent protection for coronavirus vaccines could save millions of lives and serve as a blueprint for the future of scientific cooperation. COVID-19 does not respect borders. No country will be safe until the people of every country have access to the vaccine' (UNESCO, 2021b).

The pandemic has opened up a confrontation between different human rights, as well as between those who adamantly support IPR in medicines and those who demand access to cheaper drugs to save lives. IP does not exist in isolation but is a crucial

([24]) https://opencovidpledge.org/licenses
([25]) https://en.unesco.org/sites/default/files/joint_appeal_for_open_sciences_fin_en_fin_0.pdf
([26]) http://www.oecd.org/coronavirus/policy-responses/why-open-science-is-critical-to-combatting-covid-19-cd6ab2f9/
([27]) https://en.unesco.org/covid19/sciencesresponse
([28]) https://twas.org/article/statement-covid-19
([29]) https://ec.europa.eu/info/research-and-innovation/research-area/health-research-and-innovation/coronavirus-research-and-innovation/covid-research-manifesto_en
([30]) The Health Data Research Gateway (https://www.healthdatagateway.org) gathers datasets, tools, papers and related resources used in health research across the United Kingdom.
([31]) For example CORD-19: COVID-19 Open Research Dataset (https://www.semanticscholar.org/cord19).
([32]) Examples include Elsevier's Novel Coronavirus Information Center (https://www.elsevier.com/connect/coronavirus-information-center) and Springer Nature's Coronavirus (COVID-19) Research Highlights (https://www.springernature.com/gp/researchers/campaigns/coronavirus).

element in the human rights *acquis*. As Robin Ramcharan suggests, there is a direct relationship between IP and human rights (Ramcharan, 2013). IP is a key factor, as it modulates access to knowledge that is essential for human dignity. From an individual perspective, it affects human security, education, health and food; from a collective outlook, it affects the right of nations to develop and the right of corporations to innovate and engage in commerce.

3. TOWARDS A COMMON UNDERSTANDING OF OPEN SCIENCE: ELEMENTS AND CHALLENGES

OS entails a radical change in how research is done and outcomes are disseminated, combining great technological development and a cultural shift towards openness and collaboration, promoting more efficient science that is transparent and accessible. Collaboration and immediate dissemination of research results are logical aspects of the digital world. However, defining OS is no easy task, nor is the apprehension of all of its components. It is important to clarify that, when we talk about OS, we are talking about open knowledge from a global perspective; 'open science' is the brand but it is not restricted to the sciences; it includes all disciplines and the different ways to share knowledge created by both researchers and the public.

There is no agreed-upon definition of OS, and it could be asserted that, if science is not open, it is not science. In this sense, to combine the terms 'open' + 'science' would be a pleonasm, since making science in the open should be the standard way to perform research. There are differing opinions on the topic (e.g. Vicente-Sáez and Martínez-Fuentes, 2018), even suggesting schools of thought in order to classify the concept (Fecher and Friesike, 2014). Nevertheless, despite its complexity, for some authors the definition is very simple: it consists in 'showing the work one does in science' (Lafuente and Alonso, 2011, p. 40). Although a definition of OS is not the main objective of this essay, this section will focus on the concept of OS as well the components, elements and challenges therein, in order to determine which of them are affected by IP restrictions and regulations.

3.1. Concept of open science in Europe and its relationship with intellectual property rights

As with any new concept, there are multiple theories about the origins of OS (Bücheler and Sieg, 2011; David, 2008, 2014). OS emerged in the fields of economic history and sociology of science, which focus on the economic dimension of knowledge and on the intellectual capitalism of the late 17th century. There is tacit agreement that the term was coined by Paul David in his attempt to distinguish the scientific results generated by publicly funded research from the perceived extension of IPR into the area of information. Economists consider scientific knowledge generated by publicly funded research to be 'commons', which means that everyone can make use of that knowledge at no additional cost once it is made public (OECD, 2015b).

In sociology of science, the principle of openness has been seen as inherent in academic activity and hearkens back to the original precepts underpinning the conduct of researchers (Merton, 1974). The race to be the first to claim recognition in science has traditionally been a strong incentive for scientists to make their knowledge public. The way scientific knowledge supported with public money is shared becomes a societal and political issue, but is not always reflected in the current legislation.

However, in Europe the term 'open science' was chosen after a detailed consultation process carried out by the European Commission between 2014 and 2015 and endorsed by the stakeholders and the Member States (Burgelman et al., 2019). The process concluded in February 2015 with a final validation report, which legitimised the term 'open science' and gave it preference over other terms such as 'Science 2.0' or 'science in transition' (European Commission, 2015). Member States supported the report in the policy debate held by the Competitiveness Council on a data-driven economy (Council of the European Union, 2015). For some time, 'OS' and 'Science 2.0' were used synonymously (Bücheler and Sieg, 2011; Burgelman et al., 2010; Mayer, 2015; Vignoli et al., 2015). However, OS, as a concept, term and brand, is clearly enshrined in Europe in the political discourse of the former Commissioner Carlos Moedas (2014–2019), in

which OS was one of the emblems of the EU's vision of the three Os: open innovation, open science, open to the world (European Commission, 2016a).

Most of the theories and definitions of OS refer to it as a movement. This characterisation has been widely adopted, from the Wikipedia definition ([33]) to various organisations (UNESCO, French Open Science Policy ([34]), Center for Open Science ([35])), and by many authors (Crüwell et al., 2018; Leonelli et al., 2015; Nielsen, 2011a,b; Ramachandran et al., 2021; Roman et al., 2018), assimilating it to other movements that share the ideals of OS: open source, OA, open data (Willinsky, 2005), open educational resources, open pedagogy, open course development (Jhangiani and Biswas-Diener, 2017) and even open standards and open design (Pomerantz and Peek, 2016). However, 'movement' evokes a bottom-up approach to OS and embodies the concept of activism. In contrast, OS comes with a new ethos that transcends the 'open/closed' binary discussion (see Section 6.1). Some of the most cited, discussed and endorsed definitions describe OS as an effort (OECD, 2015b), a practice (the FOSTER project, see below) or a disruptive phenomenon (Vicente-Sáez and Martínez-Fuentes, 2018).

- The OECD defines OS as the effort to make the results of publicly funded research more accessible in digital form to the scientific community, business or society in general, and to promote long-term research and innovation: 'Open science is a means and not an end' (OECD, 2015b, p. 14). OS strategies and policies are a means to support better-quality science, increased collaboration, and engagement between research and society that can lead to higher social and economic impacts of public research. OS is more than OA to publications or data; it includes many aspects and stages of the research processes (OECD, 2015b).
- Project FOSTER focuses on OS as the practice of science in such a way that others can collaborate and contribute, whereby research data, laboratory notes and other research processes and outcomes are freely available, 'under terms that allow reuse, redistribution and reproduction, both of the research itself, as well as the underlying data and methods' (Bezjak et al., 2018).
- Vicente-Sáez and Martínez-Fuentes (2018) in their systematic literature review state that the term OS refers, in a general way, to the scientific creation of transparent and accessible knowledge that is shared and developed through collaborative networks. They start from the assumption that it is a disruptive phenomenon, bringing together a sociocultural and a technological change, based on openness and connectivity, in how research is designed, performed, captured and assessed.

The comprehensive handbook *Open Science by Design* focuses on motivations for OS including 'the taxpayer's right to the results of publicly funded research; the ability of any member of society to scrutinize, evaluate, challenge and reproduce scientific claims; and the opportunity for anyone, including private citizens, to build directly on the scientific investigations of others' (Committee on Toward an Open Science Enterprise et al., 2018, p. 25116).

For the purpose of this report we use 'OS' to refer to the entire process of conducting research. The definition of OS by the European Commission (2019) (further discussed in Section 5) highlights the 'system change' that might improve science through collaborative and open ways of producing and sharing data and knowledge as soon as possible throughout the entire research cycle. The Commission also states that OS 'increases the quality and impact of science by fostering reproducibility and

([33]) Note that the Wikipedia definition (https://en.wikipedia.org/wiki/Open_science) is probably the first one that a reader would find when looking for further information about OS.
([34]) https://www.ouvrirlascience.fr/category/open_science
([35]) https://www.cos.io

interdisciplinarity. It makes science more efficient through better sharing of resources, more reliable through better verification and more responsive to society's needs'.

Since 2015 the European Commission has clearly chosen the openness path, despite difficulties (Burgelman, 2021b), and 'open science' as the way to name it (European Commission, 2015). The policies suggested by the Amsterdam Call for Action (Government of the Netherlands, Ministry of Education, Culture and Science, 2016) reflect the systemic change needed for researchers to collaborate, interact, share resources and disseminate results, driven by new technologies and data. These principles, along with the increasing demand in society to address societal challenges, and the readiness of citizens to participate in research, were also supported in the Commission communication on the European cloud initiative (European Commission, 2016b). This communication also proposed the creation of a flagship research data e-infrastructure for OS: the EOSC, based on a federation of existing scientific data infrastructures scattered across disciplines and Member States, with the ambitious aim of making all scientific data produced by the Horizon 2020 programme open by default. This ambition is also included in Horizon Europe, the current (ninth) Framework Programme.

EUR-lex includes 170 documents about 'open science' but only ten dated between 2010 and 2015, which confirms it as the main period when OS was specified and developed in Europe. In the same period, IPR policies and regulations have been defined, not necessarily in line with OS. Besides the key Communications and legislation developed during this period, the European Commission has also published and promoted the main policy documents regarding OS. These reports include differing approaches and an abundance of recommendations (see Section 3.2 and Annex I).

For the Commission, OS is not only a concept, it needs to be applied. The final report of the Open Science Policy Platform (OSPP) (Méndez et al., 2020) provided an update on the last four years of its mandate (2016–2020), focusing on the practical commitments for implementation of OS at stakeholder level. While the report does not propose a definition of OS or of open innovation, it proposes five attributes to be accomplished by a 'Research System based on shared knowledge by 2030': (1) 'An academic career structure that rewards a broad range of outputs, practices and behaviours to maximise contributions to a shared research knowledge system'; (2) 'A research system that is reliable, transparent and trustworthy'; (3) 'A research system that enables innovation'; (4) 'A research culture that facilitates diversity and equity of opportunity'; and (5) 'A research system that is built on evidence-based policy and practice' (pp. 23–27). This final report of the OSPP recognises the importance of embedding IPR within an OS framework that protects the interests of different stakeholders, including private and commercial research organisations, but without limiting the scientific and societal benefits of sharing and reusing of scholarly knowledge for all humanity, or limiting innovation in a transparent competitive market. It particularly refers to the need to address the dilemma faced by business and industry in adopting OS practices while fulfilling the requirements of IPR.

In the communication about the European Research Area (European Commission, 2016c), the Commission states that:

> Open science makes the R&I systems more efficient and creative and reinforces excellence and society's trust in science. This is because opening and sharing research results and data, making them reusable and reproducible, and having access to research infrastructures provides the basis for peer scrutiny and quality, as well as efficiency in taking research reflections, analysis and innovation further.

Although it is key to prosperity, peace and a healthy planet (all priorities for the UN's 2030 Agenda and the SDGs) and despite the European Commission's leadership, OS still has no common definition or international policy framework (Azoulay, 2021). To conclude this section on the definition and scope of OS, we should cite the two most comprehensive and up-to-date definitions of OS. Ramachandran et al. (2021) underline the inherent collaborative and interdisciplinary nature of (open) science enabled by the technological developments accelerating scientific research and understanding, by empowering data- and information-sharing capabilities reaching not only the scientific community but the public at large. Their 'vision of open science converges around three overarching dimensions: (a) increasing the accessibility to the scientific process and the corresponding body of knowledge; (b) making both the research process and knowledge sharing more efficient; and (c) understanding and assessing scientific impact through innovative new metrics'. As part of its comprehensive definition, UNESCO's *First draft recommendation on open science* defines it as 'an inclusive construct' and stresses that 'Open Science critiques and transforms the boundaries of intellectual property to increase access to knowledge by everyone' (UNESCO, 2021a, p. 8). This open approach does not contradict the use of IP as a possible route to benefiting private exploitation, the use of scientific knowledge to bring about potential tangible economic benefits, or the creation of new competitive products and services. However, these definitions do not include any practical measure regarding IPR to make knowledge sharing and the research process more efficient.

Finally, the UNESCO draft recommendation crystallised 'open science' as the preferred term (instead of other possibilities: 'open knowledge', 'open scholarship' and 'open research') and it includes societal actors (citizens) as a key component. OS includes 'all scientific disciplines and aspects of scholarly practices, including basic and applied sciences, natural and social sciences and the humanities, and it builds on the following key pillars: open access to scientific knowledge, open science infrastructures, open science communication, open engagement of societal actors and open dialogue with other knowledge systems' (UNESCO, 2021a). This is also crucial to have a global understanding and implementation of OS beyond the EU.

Open science/knowledge is the new paradigm in which research will flourish, with a common brand to name it: OS. OS implies a paradigm shift in the broadest sense that Thomas Kuhn used in *The Structure of Scientific Revolution*s in 1962 when analysing the behaviour of scientific communities in charge of selecting the most suitable way to practice science. In research, when a paradigm stops answering a problem, disruptions occur at scientific level and new paradigms are created (Kuhn, 2012). The same has occurred in the way the scientific community discloses and valorises research outcomes. The present paradigm does not work. It is a paradigm created in the 17th century based exclusively on publications and the impact of the journals in which they are published. Particularly regarding scientific knowledge valorisation, another reason why the current/traditional framework for IPR might be dysfunctional is because it is unable to quickly respond to extreme situations affecting fundamental rights, such as the right to health or security. OS can speed up knowledge transfer and reduce delays in the reuse of the results of scientific research, facilitating a swifter path from research to innovation. OS could increase access to the results of publicly funded research, foster spillovers and boost innovation across the economy (OECD, 2015b). As the current pandemic has evidenced, even though patents on vaccines may be waived, supply bottlenecks and worldwide shortages of essential components, especially nucleotides, enzymes and lipids, remain. This is because relatively few companies make these products, and not in sufficient numbers for global supply. Moreover, these companies are slow to license other manufacturers to produce their products too (Irwin, 2021). The change should not be only specific to IP strategies, but must relate to the entire paradigm. As Kuhn suggests, a paradigm is changed when it is evident it does not function properly.

A different paradigm must be created for scientific knowledge production, communication and valorisation, coherent with current technological possibilities and societal needs. The very notion of a paradigm has the character of a foundation or organising model and supplies an epistemological orientation. Therefore, OS, on the one hand, adds a fourth model to the research process itself, traditionally based on three paradigms (theoretical, experimental and observational), to which is now added another model based on massive data computing. On the other hand, OS fosters a new way of communicating research: deconstructing the traditional scientific communication process, used in the current/traditional (print) paradigm, and reconstructing it in a way that makes sense on the World Wide Web.

3.2. Open science components

In a very simplistic approach, it seems that OS is just adding open data to the already well-known scenario of OA. However, the coverage of OS implies many elements yet to be put in place and harmonised at EU level and beyond. These OS elements are called either challenges or pillars in the European literature (Ayris et al., 2018; Masuzzo and Martens, 2017), but they are still the components necessary to create the whole picture. We can classify them into two groups: results-related components and actor-related components or challenges. In Appendix II, these European Commission reports and other relevant ones regarding the different challenges and components of OS are carefully analysed with regard to IPR.

3.2.1. Results-related components

The challenges that we classify here as results-related (Table 3.1, in yellow) go beyond the mere fact of opening publications (OA) and data (ORD); they should entail more concrete and complex actions, from technical, legal and political points of view.

- One of these components in relation to research results is OA in the broader context of the **future of scholarly publishing and scholarly communication**, on which subject a European Commission expert group made a report with 26 recommendations (Guédon et al., 2019). The report includes a brief but categorical mention of the IPR: 'present intellectual property laws are not well adapted to the needs of researchers and other users, and, as a result, they work less efficiently and effectively than they might otherwise do' (p. 31).
- Before that report, Plan S (September 2018) was launched at the initiative of the European Commission's then OA Envoy (and former Director-General for Research and Innovation), Robert-Jan Smits, together with various heads of European research funding organisations that pledged to put it into practice (cOAlitionS), with the support of Science Europe. Plan S is a concrete plan of action composed of 10 principles, according to which all publications resulting from projects financed with funds by the cOAlitionS organisations must be published immediately in OA journals or on OA platforms or made immediately available through OA repositories. In addition, on 26 March 2021 the Commission officially launched its own publishing platform for immediate OA, called Open Research Europe, also based on open peer review.
- More than just opening research data, OS implies sharing **findable, accessible, interoperable and reusable (FAIR) data** (Wilkinson et al., 2016). FAIR is a backronym that not only reflects an underlying principle but also envisages high technical complexity in relation to metadata, vocabularies, persistent identifiers and other standards applicable to data. FAIR extends to other research results and even to software (Lamprecht et al., 2020). To turn the FAIR data challenge into reality, the European Commission also named a specific high-level expert group (HLEG), led by Simon Hodson, that collected 27 recommendations to make data FAIR (European Commission Expert Group on FAIR Data, 2018). Its report does not address IPR

issues in a way that would have been desirable. It only refers to the open licences to be added to the data sets in order to improve their reusability, including 'a clear and accessible data usage license' (p. 19), but it does not explain what that implies.

- Opening access to data, in addition to the publications, is another step that promotes greater transparency and reproducibility of research. The revision of the European Directive on open data and the re-use of public sector information([36]), published in June 2019, includes data from research financed with public funds as part of the data that can be shared and reused, which strengthens the obligation to make the data available not only to researchers, but also to citizens. The directive expressly cites the FAIR principles and also the principle 'as open as possible, as closed as necessary' (Article 10; see Section 6 below).
- Along with FAIR data, another of the OS elements and challenges is the creation of the **EOSC** (which has recently also been called EU Open Science Commons), a federated European infrastructure for data and research services, in which all researchers can deposit, access, analyse and reuse scientific data. The EOSC was officially presented in Vienna in November 2018. It is a very complex infrastructure that is still under construction from both a technical and a governance point of view, through multiple projects that make up the EOSC ecosystem. To define this challenge, two groups of experts were appointed, which led to two reports (Mons et al., 2016; Muscella et al., 2018) and a total of 36 recommendations. The first report (Mons et al., 2016) does not mention any IPR concerns at all, but the second (Muscella et al., 2018) points out that the data distributed via the EOSC will have different levels of access control, depending on various issues including IP. Muscella et al. (2018) specifically mention the importance of research into blockchain technologies, whereby IPR can be kept with the source, creating a new concept of trust for communities.
- **Next-generation metrics** and indicators will make it possible to replace the incentive system based on the journal impact factor and the count of citations exclusively by publications. This fundamental OS component seeks responsible metrics and alternative metrics. The European Commission named two HLEGs to work on two subsequent reports, which made 12 (Wilsdon et al., 2017) and 13 recommendations and 149 potential indicators (Wouters et al., 2019). The first report does not mention IP issues, whereas the second one clearly states that OS policies need to address generic issues such as IP and infrastructures, while they also need to be sensitive to these specific contexts (Wouters et al., 2019, p. 5).

3.2.2. Actor-related components

The other four elements of OS in Europe are related to the agents of the research process and involve constituent elements of OS, but also challenges (Table 3.1 in blue).

- Create a **new way of evaluating a research career that fully recognises and encourages OS**. Without a doubt, this is the fundamental challenge that increasingly affects researchers, and is intended to adopt new metrics, abovementioned. HLEG wrote another report on this topic with only four crucial recommendations aimed at both policymakers and funders, in addition to new criteria for evaluating researchers, collected in the OS Career Assessment Matrix (O'Carroll et al., 2017a), that some countries such as the Netherlands ([37]) and Norway ([38]) have begun to implement. The matrix defined in that report mentions

([36]) Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L1024&from=EN).
([37]) https://www.vsnu.nl/files/documenten/Domeinen/Onderzoek/SEP_2021-2027.pdf
([38]) The consortium Universities Norway has adapted the OS Career Assessment Matrix and implemented it for evaluating researchers in its member universities (https://sfdora.org/case-study/universities-norway/).

IP (patents and licences) as an OS practice in the realm of research impact, including being knowledgeable on the legal and ethical issues relating to IPR and transferring IP to the wider economy, as a criterion to be evaluated.

- All researchers need the knowledge and **skills necessary to apply OS to their research practices.** Training in OS has given rise to various projects and initiatives to educate researchers, librarians, research assistants, etc. The FOSTER project and FOSTER+ are key projects in this respect and the latter delivered a very interesting multilingual training manual (Bezjak et al., 2018b). There are also voluntary community efforts on providing researchers with skills in OS, such as the Open Science Massive Open Online Course ([39]). The European Commission created another HLEG on this key aspect, which drafted another report with six recommendations (O'Carroll et al., 2017b), fully in line with the incentives report. This report shows the results of a survey of EU researchers, and recognises that one quarter of researchers are aware of courses on IP and patenting (IPR), but also recognises that researchers lack legal support surrounding IPR and the technical infrastructure to facilitate OS. It also mentions that IPR should be protected as one of the OS-related elements for employers and funders, included in the European Charter for Researchers ([40]). IP, research ethics and integrity should be integrated into the curriculum.

- A new **research integrity and a collectively agreed code of ethics must recognise OS** as the standard. In this case, the European Commission did not appoint a new specific working group, but rather adopted the principles of *The European Code of Conduct for Research Integrity* by All European Academies (ALLEA) (ALLEA, 2017), which recognise the opening of publications and data, as well as incentives for and recognition of open and reproducible science practices. In terms of IP, the ALLEA *European Code of Conduct for Research Integrity* (2017) recognises that 'Researchers, research institutions and organisations should ensure that any contracts or agreements relating to research outputs include equitable and fair provision for the management of their use, ownership, and/or their protection under intellectual property rights' (p. 6). It also mentions the necessity of protecting the IP of all partners and collaborators in a research project related to research data, as well as managing procedures to handle possible conflicts. ALLEA has recently published a specific report on the IPR issues on the implementation of the EOSC, noting that the principle 'open by default' may require setting proportionate limitations in 'duly justified cases' of IPR concerns (ALLEA, 2020, p. 1).

- **Citizens' significant contribution to research** is paramount ([41]) and citizens should be recognised as producers of knowledge in European science. This component did not give rise to a specific expert group appointed by the European Commission. However, Socientize, a Commission-funded project, has provided a very successful and dynamic forum for the citizen science community of experts. Its *White Paper on Citizen Science in Europe* (Socientize, 2020) is a valuable input to policymaking on this topic. The OSPP worked directly with the European Citizen Science Association on this topic to state recommendations and settle citizen science practices. The Socientize report mentions IPR related to research data in the context of ethical guidelines for EU-wide data policy. Socientize supports a culture of openness for data and access to data, and among the implications of handling data

([39]) https://opensciencemooc.eu
([40]) European Charter for Researchers | EURAXESS (europa.eu)

([41]) This is not new. As Conner puts it, 'The "folk" wisdom and lore of early societies was not an inferior kind of knowledge about nature that later was simply canceled out and replaced by more accurate scientific knowledge. Science as it exists today was created out of folk and artisanal sources' (Conner, 2005, p. 4).

it mentions taking into account IPR, fundamental personal data protection rights, ethical standards, legal requirements and scientific data quality.

The UNESCO (2021a) draft recommendations state eight components of OS: OA, open data, open source/software and hardware, open science infrastructures, open evaluation, open educational resources, open engagement of societal actors and openness to diversity of knowledge. The 'Joint appeal for open science' ([42]), already cited in Section 2, simplifies the three core elements of OS: OA, open data and open to society. However, this categorical appeal refers to all research outputs as susceptible to being open: data and outputs to be more widely accessible (OA) and more reliably harnessed (open data) with the active engagement of all stakeholders (open to society). It has probably inspired some of the most recent definitions we have mentioned in the previous section (Ramachandran *et al*., 2021). Table 3.1 below offers a comparative analysis of the OS components referred to here.

Table 3.1. Comparison of the European Commission's OS components with some of the main definitions provided

European Commission	OECD	FOSTER	UNESCO
Future of scholarly communication	OA	OA to scholarly outputs	OA
FAIR data/ORD	Open data Data-driven and evidence-based research	Open data	Open data
	Open source	Open source	Open source software/open hardware
EOSC			OS services and research infrastructures (including storage, stewardship, data commons)
Next-generation metrics	Alternative metrics	Open evaluation	Open evaluation
Rewards and incentives		Open evaluation	Open evaluation
Skills in OS (open education)		Massive online open courses Open lessons	Open educational resources

([42]) UNESCO's members are expected to adopt the Recommendation on Open Science in their next General Conference, to be held in Paris in November 2021, and launch the recommendation at the World Science Forum in South Africa (to be confirmed). If the draft is approved, we will have a comprehensive global official text regarding OS and its constituent parts, which will serve as a guide for the immediate and not-so-near future.

European Commission	OECD	FOSTER	UNESCO
Citizen science	Citizen science and research crowdfunding		Open engagement of societal actors
Research integrity		Open science policies	
Interdisciplinarity	Interdisciplinary and international coordination		Openness to diversity of knowledge
Reproducibility		Open reproducible research	

Sources: OECD (2015b); Pontika et al. (2015); UNESCO (2021a).

The European Commission has been working since 2016 on aligning and extending these components, for example those related to interdisciplinary collaborative research and reproducibility (Baker et al., 2020). But the different documents and reports published or supported by the European Commission do not always sufficiently highlight the importance of exploring a more balanced approach between OS and IPR. Annex I presents a detailed analysis of some relevant reports on OS from 2015 to 2021 and how they approach IPR issues, when they do.

When exploring the linkages between IPR and OS, this study includes an analysis of the following: OA; FAIR (open) data; free software; APIs, taxonomies and ontologies; hyperlinks; TDM; levies on remuneration rights; and, finally, the relationship between basic science and IPR along with other issues (see Section 5). A thorough explanation of the state of the art in IP will be provided in the next section, as the issues that arise in the OS–IPR binomial cannot be understood without a depiction of how IP currently affects data, information and knowledge.

4. INTELLECTUAL PROPERTY

Current legislation considers that information with certain characteristics is subject to what has been traditionally understood as protection, which grants the owner the legal right to request others to cease any use of said information and to be compensated in case of unlawful use. IP legislation forbids the use of the asset protected unless one or more of these conditions are met: consent from the rightholder; the use of the asset in accordance with a specific legal permission (such as a limitation of copyright or the waiver of a patent), which is always interpreted restrictively; and the right of the owner expired due to the passage of time. This context of forbidden by default, as we will describe below, is a legal obstacle to the free transmission of information.

The term IP comprises four major fields: copyright, patents, trademarks and trade secrets (Anderfelt, 1971; Bainbridge, 2012; Bouchoux, 2013; Kur and Dreier, 2013; McJohn, 2021; Sinnreich, 2019; Vaidhyanathan, 2017; WIPO, 2008). Copyright applies to original works of authorship as soon as they are fixed in any tangible medium of expression. Patents relate to the invention of a process or a product. Trademarks refer to a symbol used in commerce to identify the original producer of goods or services so as to distinguish them from other products in the market. Trade secrets consist of information that is valuable because it is not generally known.

Although most literature mentions only these four categories as the components of IP, other rights have been included under this term, such as designs, plant varieties, domain names, geographic marks (Blakeney, 2014), personality rights, industrial designs and integrated circuits, fashion and traditional knowledge (Vaidhyanathan, 2017; Dreyfuss and Pila, 2018), confidentiality and computer technology (Torremans, 2013). According to some authors, this concept should only include 'rights that are related to some kind of effort or achievement and not to a person's personality or personal characteristics' (Rognstad, 2018, p. 8). Thus, the characteristic common to all categories would be the creation of a work through intellectual efforts using common goods.

4.1. Historical background and justification

Traditionally, IPR have been divided into two types: artistic and industrial IP. Artistic IP would refer to copyright, and industrial IP would comprise patents and trademarks. In order to understand the current IPR legislation, it is important to realise the different paths through which the two types came to be protected under it.

Several authors have justified IP on works produced with an intellectual effort. The groundings of their justification use theories from John Locke, Hegel, the utilitarians Bentham and Mill (Spinello and Bottis, 2009, pp. 149–172) and Kant (Merges, 2011). Using John Locke's theories, the justification for property is built on the legitimacy that a person obtains when appropriating to oneself the fruits of work performed using common goods. A person who fishes or harvests is allowed to appropriate the result, thus beginning a cycle whereby the original owner may pass his or her rights over this object to another person. The Lockean expression of the 'sweat of the brow' exercised over a good accessible to all would legitimise the original author's appropriation of the result of his or her effort (Spinello and Bottis, 2009). The legitimacy of the second owner is built on the legality of that person's agreement with the first and so on. 'Hegel espouses the principle that property is a natural right with intrinsic value because it provides freedom for the self, which, through the exercise of that freedom, objectifies itself in the external world, that is, gives its personality a reality outside itself' (Spinello and Bottis, 2009, p. 166). A utilitarian foundation would be based on the presumption that 'the development of scientific, literary and artistic works will promote general utility or social welfare' (Spinello and Bottis, 2009, p. 168).Finally, regarding the justification based on Kant, his theories about property do not have empirical or factual groundings

but rather are based on abstract concepts such as the need for humans to control objects in order to act and obtain the results they intend. In order to achieve this, humans need the possibility to enforce their rights over the things they use, which necessitates a strong legal system. This, as Merges puts it, is only possible with a government and a civil society. Therefore, 'it could be said that for Kant property … lies at the heart nothing less than civilization' (Merges, 2011, p. 73).

A similar approach is taken by Ole-Andreas Rognstad (2018, pp. 13–41), who distinguishes four categories of justification: utilitarianism, the labour idea, personality ideas and other ideas. The utilitarian approach is rooted in Jeremy Bentham's utilitarian moral philosophy and it would justify property using Bentham's 'principle of utility'. The labour idea follows Locke's theories. The personality justification is based in Kant and Hegel's thoughts, due to the capacity of persons to be autonomous entities, from which it derives the possibility (or necessity) of holding rights. Rognstad's fourth category of IP justification is based on various authors such as Aristotle and his view of *eudaimonia* as the ultimate end of human life, and the continuation of this approach under moral principles.

4.2. Stages of intellectual property rights legislation

Since their inception, IPR have been the object of a globalisation effort to harmonise their content and enforceability. We could summarise the different phases in three stages. The first began with the legal recognition of IPR and lasted until 1886, the year of the signing of the Berne Convention. The second stage would be from the Berne Convention to the TRIPS Agreement and the third would cover the period from the TRIPS Agreement until today (Olwan, 2013, p. 36).

In their initial conceptualisation, IPR were legally recognised and enforceable in the national state of the author or, in the case of copyright, in the country where the book was first published. The doctrines of IPR justification were, during this stage, based more on utilitarian than on natural theories, which implied a local and not universal vision. This initial system was criticised by some authors, the best known complaints being those made by Mark Twain against Canadian and English publishers who used his works without permission (Courtney, 2017; Vaidhyanathan, 2001). As Carla Hesse observes, owing to this local regulation 'the first great publishing houses in New York, Philadelphia, and Boston built fantastic fortunes on unauthorized, and unremunerated, publication of British writers' (Hesse, 2002, p. 40). She goes on to say (p. 40):

> *Positions on copyright were clearly not the product of disinterested jurisprudential reflection. By the nineteenth century it became clear that nations that were net exporters of intellectual property, such as France, England, and Germany, increasingly favored the natural rights doctrine as a universal moral and economic right enabling authors to exercise control over their creations and inventions and to receive remuneration. Conversely, developing nations that were net importers of literary and scientific creations, such as the United States and Russia, refused to sign on to international agreements and insisted on the utilitarian view of copyright claims as the statutory creations of particular national legal regimes. By refusing to sign international copyright treaties, the developing nations of the nineteenth century were able to simply appropriate the ideas, literary creations, and scientific inventions of the major economic powers freely.*

But since the United States 'evolved from being a net importer of intellectual property to a net exporter, its legal doctrines for regulating intellectual property have tended to shift from the objectivist-utilitarian side of the legal balance toward the universalist-natural-rights side' (p. 40). Therefore, instead of protecting IPR from a local

perspective, international protection became necessary for the economic interests of the net exporters.

The second stage began on 3 December 1887, with the entry into force of the Berne Convention for the Protection of Literary and Artistic Works. It was signed on 9 September 1886 initially by 20 countries, although through the 'colonial clause' in its Article 19 it was applicable to the European colonies (Olwan, 2013, p. 44).

The Berne Convention was based on three basic principles, which totally altered the regulation applicable before the Convention ([43]):

- **Reciprocity between contracting parties.** According to the WIPO website: '(a) Works originating in one of the Contracting States (that is, works the author of which is a national of such a State or works first published in such a State) must be given the same protection in each of the other Contracting States as the latter grants to the works of its own nationals (principle of "national treatment")'.
- **No requirement of previous registration.** '(b) Protection must not be conditional upon compliance with any formality (principle of "automatic" protection)'.
- **Best protection status.** '(c) Protection is independent of the existence of protection in the country of origin of the work (principle of "independence" of protection). If, however, a Contracting State provides for a longer term of protection than the minimum prescribed by the Convention and the work ceases to be protected in the country of origin, protection may be denied once protection in the country of origin ceases'.

From the initial ten countries, the number of signatories has grown to the current number of 179 contracting parties ([44]). It underwent several amendments until its final version, dated 1971.

In 1967 a Convention established the WIPO, which in December 1974 became a UN specialised agency responsible 'for promoting creative intellectual activity and for facilitating the transfer of technology related to industrial property to the developing countries in order to accelerate economic, social and cultural development' ([45]). Under this new umbrella, the Berne Convention was adapted to the new context of digital technologies through the adoption of the WIPO Copyright Treaty ([46]) and the WIPO Performances and Phonograms Treaty ([47]) in Geneva on 20 December 1996.

Although it might seem like a good instrument for protecting authors, scholars such as Drahos and Braithwaite (2002), Sell (2003), Smiers (2006), Smiers and van Schijndel (2008), and Patry (2009), among others, have studied the disadvantages that the Berne Convention meant for the political and economic interests of big corporations and states.

The limitations of the Berne Convention, primarily the impossibility of obliging a third country to uphold certain conduct, led to the third stage of regulation, represented by the TRIPS Agreement. In the Uruguay Round of GATT negotiations (1986–1994) two broad groups were formed, one that discussed goods and another that discussed services. Within these two broad groups, 14 further subgroups were formed. One of those was the Trade-Related Aspects of Intellectual Property Rights including Trade in Counterfeit Goods. The work of all groups ended with the signing in Marrakesh, on 15 April 1994, of the Constitutive Agreement of the World Trade Organisation (WTO).

([43]) https://www.wipo.int/treaties/en/ip/berne/summary_berne.html
([44]) https://wipolex.wipo.int/en/treaties/ShowResults?search_what=C&treaty_id=15
([45]) https://wipolex.wipo.int/en/text/305623
([46]) https://wipolex.wipo.int/en/text/295166
([47]) https://wipolex.wipo.int/en/text/295578

Beside this Agreement, the signatories adopted the TRIPS Agreement, which included a settlement resolution system under the WTO rules.

Through the TRIPS Agreement, IPR entered the domain of trade, and a country that would not abide by the rules of the dominant states would be subject to trade sanctions. IPR were no longer a matter that concerned authors, but an asset that concerned owners. As Sell stated, 'TRIPS incorporates a notion of intellectual property rights as a system of exclusion and protection rather than one of diffusion and competition. It extends rights holders' privileges and reduces their obligations' (Sell, 2004, p. 314). According to Andres B. Schwarzenberg, 'The United States retains the flexibility to determine whether to seek recourse to challenge unfair foreign trade practices through the WTO or to act unilaterally' (Schwarzenberg, 2020, p. 2), which allows the United States to identify, investigate and impose sanctions on foreign countries for four types of practices (pp. 5–6):

- a denial of US rights under any US trade agreement by a foreign country,
- an 'unjustifiable' action that 'burdens or restricts' US commerce,
- an 'unreasonable' action that 'burdens or restricts' US commerce,
- a 'discriminatory' action that 'burdens or restricts' US commerce.

A side effect of this regulation was the imposition of a system that, only focusing on the commercial characteristics of IP works, rendered invisible the huge IP production made by collectivities under free licences, whose intention is not to trade with their works (Benkler, 2006; de la Cueva, 2012; Kelty, 2008; Lessig, 2004; Olwan, 2013; Smart et al., 2019). The global regulation only foresaw a commercial and trade context, and ignored the fact that one of the most important intellectual work of humankind, the Internet, was created outside that paradigm. This legislation now regulates two opposed models (de la Cueva, 2014, pp. 86–87, emphasis original)**:**

> *The first model, the only one the media cares to take into account, is to protect work in the way property rights have always been protected: by developing mechanisms (that take the form of alarms, offendicula, fences, walls, boundaries, and other restrictions) to exclude outside use. Preventing the unauthorized use of work means markets can be created and fares can be charged for the work's use. This is the model of entertainment, of the circus, and the main model for the merchants of culture, whose icons are the blockbuster movie, the summer hit and the best-selling novel, all of which are shamelessly pedalled as culture.*
>
> *The second model considers that the best way to protect an intellectual work is to develop ecosystems that will allow it to reproduce. Examples include the Instituto Cervantes, Alliance Française, the British Council, or the Goethe Institute, where the idea is not to exclude outsiders from a work or language but to disseminate it as widely as possible. This is the model of free software, of Internet protocols, of Wikipedia, or of protecting the DNA of the Iberian Lynx. This kind of system is nothing new: it has been in existence for as long as academia. But such universal collective authorship is a serious challenge to the individualistic basis of copyright, … In this case, wealth is not given to a minority by commercializing different, fragmented uses of a work; instead, wealth is generated for all via secondary means, in a general context of increased wealth: a country with a literate population has a higher chance of generating income than one where illiteracy prevails.*

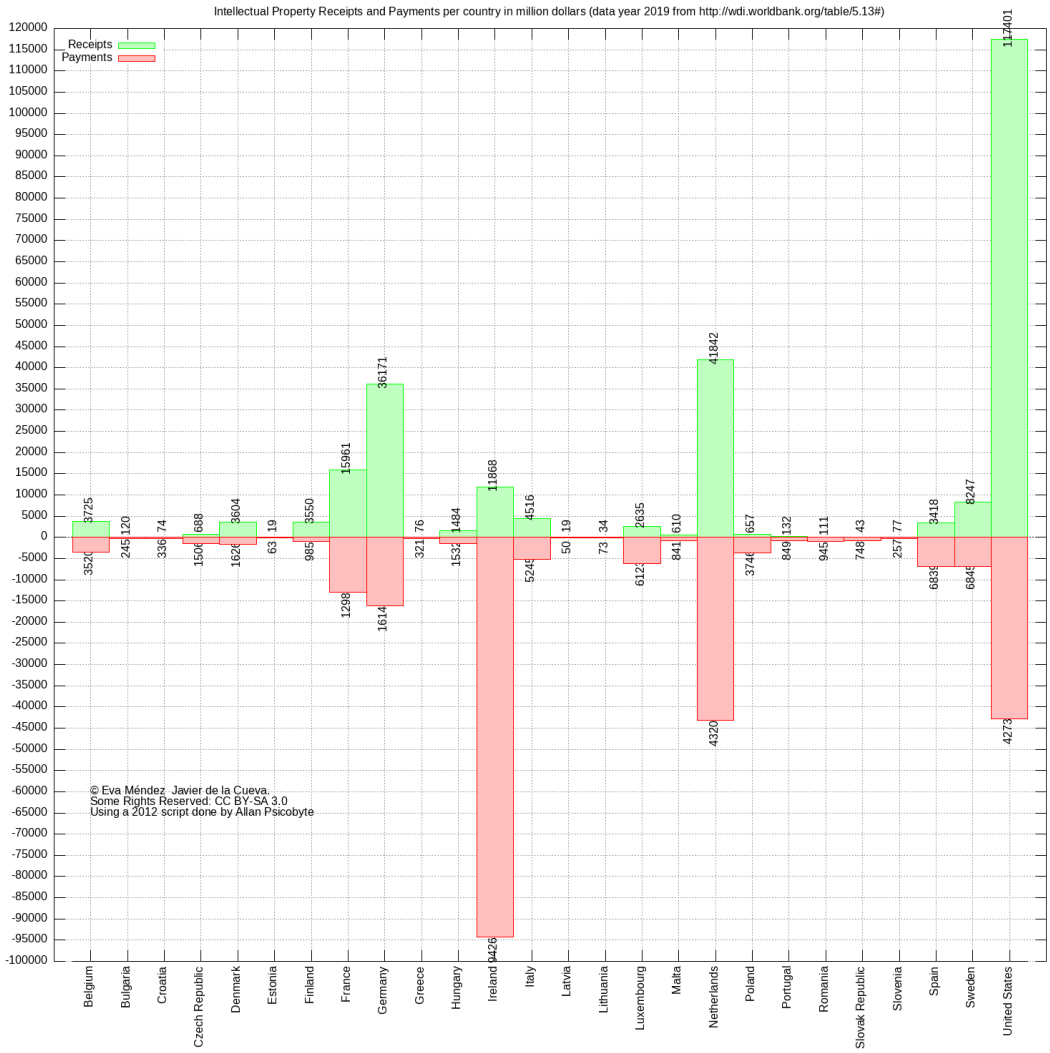
As detailed in Section 5.1.3, IP is witnessing two different types of works: one that protects static works or results, and a second that protects processes. In the first type,

the protection is guaranteed through the 'all rights reserved' system, which denies the usage of a work to all except the rightholder. In the second type, the community involved in the creation uses IP to protect the process and its dynamic result. The outcome of these dynamic processes (the request for comments (RFC), Wikipedia, OpenStreetMap, Linux, Apache server, etc.) would be impossible to obtain through the bureaucratic burdens posed by the 'all rights reserved' system ([48]).

4.3. The economic balance of intellectual property rights

To analyse the economic impact of IPR, open data from the World Bank ([49]) have been downloaded, plotted and represented in the following graph (Figure 4.1), which presents the balance of IPR between EU Members and the United States in millions of dollars.

Figure 4.1. IP receipts and payments per country



The results of the receipts and payments per country are detailed in Table 4.1, ordered by net profit. In addition, Annex III includes a graph for all the countries of the world

([48]) The existence of a Wikipedia in which for each edit (the creation of a derivative work) consent must be given previously through a written agreement with the prior authors of the edited page is unimaginable.

([49]) http://wdi.worldbank.org/table/5.13#

and a table with the data, ordered by net profit. Table 4.1. IPR receipts and payments of US and EU Member States, 2019 (million USD)

Country	Receipts	Payments	Net
United States	117 401	42 732	74 669
Germany	36 171	16 149	20 022
France	15 961	12 982	2 979
Finland	3 550	985	2 565
Denmark	3 604	1626	1 978
Sweden	8 247	6 845	1 402
Belgium	3 725	3 520	205
Latvia	19	50	– 31
Lithuania	34	73	– 39
Estonia	19	63	– 44
Hungary	1 484	1 532	– 48
Bulgaria	120	245	– 125
Slovenia	77	257	– 180
Malta	610	841	– 231
Greece	76	321	– 245
Croatia	74	336	– 262
Austria	1 421	2 091	– 670
Slovakia	43	748	– 705

Country	Receipts	Payments	Net
Portugal	132	849	– 717
Italy	4 516	5 245	– 729
Czechia	688	1 506	– 818
Romania	111	945	– 834
Netherlands	41 842	43 203	– 1 361
Poland	657	3 746	– 3 089
Spain	3 418	6 839	– 3 421
Luxembourg	2635	6 123	– 3 488
Ireland	11 868	94 262	– 82 394

The World Bank data shows that the net profit of the United States is USD 74 669 million, more than three times the net profit of Germany, the second country on the list. Ireland's negative balance of –USD 82 394 million is not a result of extreme IP consumption, but rather a consequence of the specificities of the country's tax system.

The aggregate figure for EU Member States in comparison with the United States is in Table 4.2 below.

Table 4.2. Aggregate IPR receipts and payments in the United States and the EU, 2019 (aggregated figures (million USD))

Country/ies	Receipts	Payments	Net
United States	117 401	42 732	74 669
EU	141 102	211 382	– 70 280

What we find relevant from the above table is that IPR have a geopolitical importance and that the EU does not occupy an important position, notwithstanding the self-interests of Germany, France, Finland, Denmark, Sweden and Belgium, the only six Member States that have positive balances.

4.4. Innovation with and without intellectual property rights

Innovation and intellectual works predate IPR, as it is evident that humankind has been creative and innovative since its appearance as a species. For thousands of years, there has been creativity and innovation without legislation. IPR are a more recent social construction, created to regulate a domain that existed without formal rules. The assumption that creativity and innovation only exist if IP legislation exists is therefore false. It is challenged by ethnographic, anthropological, cultural and art studies (Groĭs, 2008, pp. 93–100; Groĭs, 2016; Sontag, 1994, pp. 263–274; Steyerl and Berardi, 2012, pp. 31–45; Williams, 2011, pp. 48–71; Williams, 2017, pp. 19–60).

Rather than treating it as a chicken and egg problem, a more pertinent question to consider is whether IPR fosters or hampers innovation and its effect on economic welfare. Yet it seems that on this point the existing data and analysis is not definitive. The gross figures about the importance of IPR for the gross domestic product of countries lack qualitative analysis and are built on assumptions that are not sufficiently demonstrated. As Mark A. Lemley puts it in his article 'Faith-based intellectual property' (Lemley, 2015, p. 1334):

> *The problem isn't that we don't have enough evidence, or the right kind of evidence. The problem is that the picture painted by the evidence is a complicated one. The relationship between patents and innovation seems to depend greatly on industry; some evidence suggests that the patent system is worth the cost in biomedical industries but not elsewhere. Copyright industries seem to vary widely in how well they are responding to the challenge of the Internet, and their profitability doesn't seem obviously related to the ease or frequency of piracy. The studies of the behavior of artists and inventors are similarly complicated. Money doesn't seem to be the prime motivator for most creators, and sometimes it can even suppress creativity. […] The decidedly ambiguous nature of this evidence should trouble us as IP lawyers, scholars, and policymakers.*

Lemley's article provides an extensive list of references to empirical work on 'virtually every aspect of IP law and innovative and creative markets' over the previous 30 years: who obtains IP rights, who enforces them, who wins, how IP rights affect stock performance, what drives creativity in virtually every field, including those protected by patents, by copyright and by no IP right at all, how innovation has succeeded under IP changes, the growth of the internet, how subjects envisage the sale of things they have created, games that model economies with different IP regimes, surveys of creators and inventors about their motivations, and psychological studies that study why and how people create and the relevance of money in their creative impulse (Lemley, 2015, p. 1333).

Similarly, authors such as William M. Landes and Richard A. Posner have stated that 'Economic analysis has come up short of providing either theoretical or empirical grounds for assessing the overall effect of intellectual property law on economic welfare' (Landes and Posner, 2003, p. 422). The US Government Accountability Office stated that 'Most experts we spoke with and the literature we reviewed observed that despite significant efforts, it is difficult, if not impossible, to quantify the net effect of counterfeiting and piracy on the economy as a whole' (United States Government Accountability Office, 2010, pp. 15–16). For Albert G. Z. Hu and Adam B. Jaffe, 'Even within the technologically advanced world, there is surprisingly little empirical evidence for the proposition that stronger IPR regimes produce faster innovation' (Hu and Jaffe, 2014, p. 106). Brian T. Yeh, in a report for the US Congress, enumerates the difficulties in calculating trade secret infringements due to the variables that operate, one of which is that it is impossible 'to measure the monetary value of some forms of sensitive information' (Yeh, 2016, pp. 13–14). Xabier Seuba asserts that 'estimates concerning

the scale of infringement, the value of intellectual property or the impact of intellectual property infringement have been elaborated by private stakeholders who often have a direct interest in the object of analysis' (Seuba, 2017, p. 67). Finally, Robert P. Merges, in an opinion which may be reasonable in certain domains but should not be acceptable for OS policymakers, has made it clear in his book *Justifying Intellectual Property* that what drives him is 'faith' (Merges, 2011, p. 3, emphasis added):

> This is a truth I avoided over the years, sometimes more subtly (for example, heavily weighing the inconclusive positive data, showing IP law is necessary and efficient, discounting inconclusive data on the other side), and sometimes less so (ignoring the data altogether, or pretending that more solid data were just around the corner). But try as I might, there was a truth I could never quite get around: the data are maddeningly inconclusive. In my opinion, they support a fairly solid case in favor of IP protection – but not a lock-solid, airtight case, a case we can confidently take to an unbiased jury of hardheaded social scientists. And yet, through all the doubts over empirical proof, *my faith* in the necessity and importance of IP law has only grown.

Studies that focus more prominently on the European context, tend to be more favourable about the relationship between IPR and economic welfare and performance. A joint study from EPO and EUIPO on *IPR-intensive industries and economic performance in the European Union* finds that the combined contribution to the economies of the EU from industries that heavily utilise IPR is substantive. 38.9% of all employment in the EU (83.3 million) can be attributed, directly or indirectly, to IPR-intensive industries; 45% of the total economic activity (GDP) in the EU is attributable to IPR-intensive industries, worth EUR 6.6 trillion; and IPR-intensive industries pay significantly higher wages than other industries, with a wage premium of 47% (EPO & EUIPO, 2019, p. 7). When comparing the economic performance of companies that own IPR to those that do not, clear advantages emerge. Companies that own IPR have 20% higher revenue per employee than companies that do not and firms that own IPR pay on average 19% higher wages than firms that do not (EPO & EUIPO, 2021, p. 12). The positive association between IPR ownership and economic performance is particularly strong for SMEs (EPO & EUIPO, 2021, p. 14,).

Considering all of the above, the idea that a stronger IPR system produces more innovation and creativity could benefit from more quantitative data and analysis. Although the implementation of the EU IP Action Plan provides data on the use of IP, data on open innovation needs to be further collected and analysed at Union level.

Despite that, it is important to note that the purpose of IPR is not solely to promote innovation. Rather, IPR are necessary for the valorisation of knowledge and to ensure that this knowledge reaches the European market and benefits society. The EPO's study on the *Valorisation of scientific results – Patent commercialisation scoreboard* finds that European universities and public research organisations use the European patent system in order to commercially exploit their inventions on a national and international scale (EPO, 2020b). Additionally to using patents to protect and market inventions, inventors also leverage IPR to secure higher margins, license technology, establish collaboration agreements with partners and attract investors, as concluded in two further studies from EPO (EPO, 2019; EPO, 2019b). Finally, better use of IPR is also essential for the achievement of the Union's policy goals, such as its strategic autonomy and the green and digital transitions.

4.5. Intellectual property rights in the European Union

The EU approach to IPR legislation is based on the principle of territoriality. IPR legislation is mainly based on Directives, which design general frameworks later incorporated into national law by the Member States.

4.5.1. Copyright

As described above, copyright is regulated by a hierarchical system composed of the WIPO treaties and the TRIPS Agreement. The Berne Convention for the Protection of Literary and Artistic Works (as amended on 28 September 1979) ([50]), Articles 2–20, regulates, among other aspects, the protected works, the possible limitations, the criteria of eligibility for protection, the rights guaranteed, the possible restriction of protection, the moral rights, the term of protection, the right of translation, the right of reproduction, certain free uses of works, rights in dramatic and musical works, broadcasting, rights in literary works, right of adaptation, arrangement or other alteration, cinematographic and related rights, *droit de suite*, right to enforce the protected rights, seizure of infringing copies, control of circulation of works and expiry of protection. The Berne Convention has been updated and complemented by the WIPO Copyright Treaty ([51]) and the WIPO Performances and Phonograms Treaty ([52]), to adapt WIPO treaties to the internet.

The TRIPS Agreement refers in Articles 9–15 to Articles 1–21 of the Berne Convention in its 1971 version. In this way, the TRIPS Agreement extends the Berne Convention and includes new provisions regarding computer programs and compilations of data (Article 10), rental rights of 'at least computer programs and cinematographic works' (Article 11), term of protection no less than 50 years for all works except photographic works (Article 12), limitations and exceptions to exclusive rights 'which do not conflict with a normal exploitation of the work and do not unreasonably prejudice the legitimate interests of the right holder' (Article 13) and protection of performers, producers of phonograms and broadcasting organisations (Article 14).

Regarding the EU ([53]), the regulation of copyright is contained in different Directives and Regulations that follow the WIPO treaties and the TRIPS Agreement. EU provisions encompass diverse thematic areas, as shown in Table 4.3 below.

Table 4.3. Summary of EU legislation regarding IPR issues

Directive/Regulation	Regulated content
Directive 93/83/EEC (http://data.europa.eu/eli/dir/1993/83/oj) Amended by Directive (EU) 2019/789 (http://data.europa.eu/eli/reg/2019/789/oj)	Satellite broadcasting and cable retransmission
Directive 96/9/EC (http://data.europa.eu/eli/dir/1996/9/oj) Amended by Directive (EU) 2019/790 (http://data.europa.eu/eli/dir/2019/790/oj)	Databases

([50]) https://wipolex.wipo.int/en/text/283698
([51]) https://wipolex.wipo.int/en/text/295166
([52]) https://wipolex.wipo.int/en/text/295578
([53]) See https://digital-strategy.ec.europa.eu/en/policies/copyright

Directive/Regulation	Regulated content
Directive 2001/29/EC (http://data.europa.eu/eli/dir/2001/29/oj) Amended by Directive (EU) 2017/1564 (http://data.europa.eu/eli/dir/2017/1564/oj) and by Directive (EU) 2019/790 (http://data.europa.eu/eli/dir/2019/790/oj)	Harmonisation of certain aspects of copyright and related rights in the information society
Directive 2001/84/EC (http://data.europa.eu/eli/dir/2001/84/oj)	Resale right of an original work of art
Directive 2004/48/EC (http://data.europa.eu/eli/dir/2004/48/oj) (Corrigendum (http://data.europa.eu/eli/dir/2004/48/corrigendum/2004-06-02/oj))	Enforcement of IP rights
Directive 2006/115/EC (http://data.europa.eu/eli/dir/2006/115/oj)	Rental right, lending right and certain rights related to copyright
Directive 2006/116/EC (http://data.europa.eu/eli/dir/2006/116/oj) Amended by Directive 2011/77/EU (http://data.europa.eu/eli/dir/2011/77/oj)	Term of protection
Directive 2009/24/EC (http://data.europa.eu/eli/dir/2009/24/oj)	Computer programs
Directive 2011/77/EU (http://data.europa.eu/eli/dir/2011/77/oj)	Term of protection
Directive 2012/28/EU (http://data.europa.eu/eli/dir/2012/28/oj)	Orphan works
Directive 2014/26/EU (http://data.europa.eu/eli/dir/2014/26/oj)	Collective management of copyright and related rights and multiterritorial licensing of rights in musical works for online use in the internal market
Regulation (EU) 2017/1128 (https://eur-lex.europa.eu/eli/reg/2017/1128/oj)	Cross-border portability of online content services in the internal market

Directive/Regulation	Regulated content
Directive (EU) 2017/1564 (https://eur-lex.europa.eu/eli/dir/2017/1564/oj)	Certain permitted uses of certain works and other subject matter protected by copyright and related rights for the benefit of persons who are blind, visually impaired or otherwise print-disabled
Regulation (EU) 2017/1563 (http://data.europa.eu/eli/reg/2017/1563/oj)	Cross-border exchange between the Union and third countries of accessible format copies of certain works and other subject matter for the benefit of persons who are blind, visually impaired or otherwise print-disabled.
Directive (EU) 2019/789 (http://data.europa.eu/eli/reg/2019/789/oj)	Satellite broadcasting and cable retransmission
Directive (EU) 2019/790 (http://data.europa.eu/eli/dir/2019/790/oj)	Copyright and related rights in the digital single market

Authors and works

Copyright covers intellectual works that are created from the fixation of the work in some material form (Berne Convention, Article 2.2). No further formal requirement is needed.

An author of an intellectual work must be a natural person, although in certain cases a legal person can be considered. There are discussions about who is to be considered an author when it relates to the participation of natural persons in collective filmography works (Bowrey and Handler, 2014) due to the dual participation of director and producer, or when a work is the result of the use of technology (Eno, 1979). Regarding authorship, one of the novelties that ICT has allowed is collective creation (Benkler, 2006). Websites such as Wikipedia, GitHub or OpenStreetMap are designed for this purpose and facilitate joint usage by contributors and the public, allowing a transparent review of the different contributions by the authors. This peculiarity facilitates a double role as a user and author of an IP work simultaneously. Using the Wikipedia example, when a person connects to the website and reads a page, his or her role is as a user. But suddenly this person decides that there is some information he or she wants to include, clicks on the edit form, alters the previous work and submits the form. This possibility of transforming oneself nearly instantly from user to co-author, with no further planning, is only possible when the technology has developed platforms that allow it. As we explain below, this way of working is only possible through a permissive IPR licensing model.

It should not be necessary to mention that the author has to be a person, but there are discussions in two areas. First, the famous case of Naruto, a monkey that took several photographs of himself with a journalist's camera (the monkey selfie case), was subject to controversy in the United States. The first instance ruling stated that there is no mention of animals anywhere in the Copyright Act, which was confirmed by the Court

of Appeal ([54]). The concept of authorship is therefore not extended to animals. The same conclusion can be made in the EU regarding Directive 2006/116/EC.

Second, there is no clear answer as yet to the question of the authorship of computer-generated works. Perry and Margoni (2010) propose four possible answers: the author of the program; the user of the program; the program; and none (public domain). On the contrary, Grimmelmann argues that computer-authored works do not exist (Grimmelmann, 2016, p. 403) and therefore it is a question that needs no answer. According to him, nearly all works created nowadays are made using computers, and where algorithms are used there is no reason why these creations should have a different status, as 'all creativity is also algorithmic in the sense that we could encode the work as a program making completely explicit what the creator did to produce it' (p. 409). Other ways to create works, such as sequential or non-deterministic uses of computer programs, should not be considered to create copyright. Grimmelmann uses the Spirograph as an example of sequential work to assert that the result is the same no matter who the user is. With respect to non-deterministic creations, in which the author uses some variable elements to produce a work, copyright cannot be generated simply because 'dice are not authors, and neither are computer programs' (p. 414). Andrés Guadamuz (2017, p. 17) recalls that 'most jurisdictions, including Spain and Germany, state that only works created by a human can be protected'. As Guadamuz points out, EU ([55]), US ([56]) and Australian ([57]) courts have denied the possibility of a computer being an author, but there are jurisdictions (Hong Kong, India, Ireland, New Zealand and the United Kingdom) where there is a specific provision that considers the author the person 'by whom the arrangements necessary for the creation of the work are undertaken' ([58]). The relation between artificial intelligence innovation and creation and authorship is also at the centre of recent discussions and deserves to be further investigated.

Regarding the subject matter of protection, the Berne Convention defines what should be considered as a work subject to copyright legislation. This field of IPR regulates productions in the literary, scientific and artistic domain, independently from their form of expression. The only requirement is that the work must be original. This condition is only applicable to the work, not to the ideas that underpin it, as is clearly stipulated in Article 9(2) of the TRIPS Agreement: 'Copyright protection shall extend to expressions and not to ideas, procedures, methods of operation or mathematical concepts as such.' The variety of works that are eligible to copyright protection shows the various forms creativity can take. Some compelling examples are John Cage's musical piece entitled '4'33"', which refers to 4 minutes and 33 seconds during which the performer is in complete silence; Dieter Roth's organic decomposition sculptures; and the works of Alexander Orion, who uses the technique known as reverse graffiti, whereby instead of painting a public space he cleans a dirty surface. Art has few limits when challenging itself with traditional concepts of IP, and all of the results fall under copyright legislation.

([54]) http://cdn.ca9.uscourts.gov/datastore/opinions/2018/04/23/16-15469.pdf
([55]) Judgment of the European Court of Justice of 16 July 2009, *Infopaq International A/S* v *Danske Dagbaldes Forening*, C-5/08, ECLI:EU:C:2009:465 (https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:62008CJ0005).
([56]) Opinion of the US Supreme Court of 27 March 1991, *Feist Publications* v *Rural Telephone Service Company, Inc.*, 499 U.S. 340 (https://supreme.justia.com/cases/federal/us/499/340/).
([57]) Judgment of the Federal Court of Australia of 2 March 2012, *Acohs Pty Ltd* v *Ucorp Pty Ltd*, FCAFC 16 (http://www6.austlii.edu.au/cgi-bin/viewdoc/au/cases/cth/FCAFC/2012/16.html).
([58]) United Kingdom, Copyright, Designs and Patents Act 1988, Section 9(3).

Rights and their limitations

As stated before, from the creation of the work, with no other formality, the author is entitled to two different sets of rights: moral and economic.

The moral rights hold a direct connection with the personality of the author. They are regulated in Article 6*bis* of the Berne Convention as follows:

> (1) Independently of the author's economic rights, and even after the transfer of the said rights, the author shall have the right to claim authorship of the work and to object to any distortion, mutilation or other modification of, or other derogatory action in relation to, the said work, which would be prejudicial to his honor or reputation.
>
> (2) The rights granted to the author in accordance with the preceding paragraph shall, after his death, be maintained, at least until the expiry of the economic rights, and shall be exercisable by the persons or institutions authorized by the legislation of the country where protection is claimed. However, those countries whose legislation, at the moment of their ratification of or accession to this Act, does not provide for the protection after the death of the author of all the rights set out in the preceding paragraph may provide that some of these rights may, after his death, cease to be maintained.
>
> (3) The means of redress for safeguarding the rights granted by this Article shall be governed by the legislation of the country where protection is claimed.

Economic rights are related to the use of the work. It is the author's exclusive decision to allow activities involving what the author created. These activities depend on the jurisdiction but are generally limited to four: reproducing (or copying) the work, altering it (or making derivative copies), distributing it and publicly communicating it. The author may trade in these activities, conferring the right to exercise one or more activities to a third party. This assignment may be done by written agreement, by clicking on a web page, by a public licence or by any other legal instrument. The rights over these activities are known as the 'exclusive rights', but they are not the only economic rights. In addition to the exclusive rights, the rightholder of the work may receive remuneration rights. The reason to be entitled to this second category of economic rights originates in the existence of certain activities performed on intellectual works that are impossible to control (for example scanning a book at home or recording a film from TV) or that seem reasonable, as they could be considered a *ius usus inocui* over the work, even if they consist in one of the four exclusive activities (copying, altering, distributing or communicating to the public). These activities are known as the exceptions or limitations of copyright and may be configured legally either as a closed list, which is the EU system (Article 5 of Directive 2001/29/EC) or as requirements open to judicial interpretation, which is the 'doctrine of fair use' ([59]) system used in the United States. The remuneration rights are directly connected to these exceptions or limitations. As stated in the law, some of them are free of charge but others imply a payment (i.e. the remuneration).

Termination of copyright

The termination of copyright is no less than 50 years after the death of the author, according to Article 7 of the Berne Convention, which allows its signatories to extend it. The same term is included in Article 12 of the TRIPS Agreement. The EU regulates termination in its Directive 2006/116/EC ([60]), amended by Directive 2011/77/EU ([61]),

([59]) https://www.copyright.gov/title17/92chap1.html#107
([60]) http://data.europa.eu/eli/dir/2006/116/oj
([61]) http://data.europa.eu/eli/dir/2011/77/oj

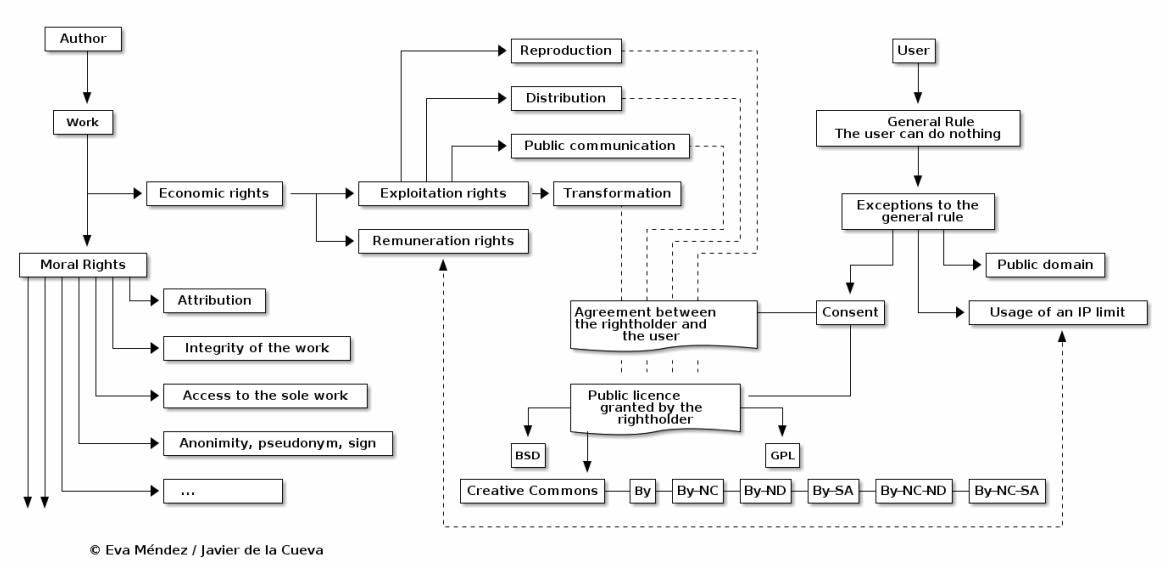
according to which the term of protection for literary, artistic and scientific works is 70 years, 'calculated from the first day of January of the year following the event which gives rise to them' (Directive 2006/116/EC, Article 8). To summarise what has been explained before, two perspectives may be useful, as shown in Table 4.4.

Table 4.4. Author and user perspectives of rights and activities over a work

Author's perspective	**User's perspective**
The creation produces instantly two sets of rights: 1. Moral rights. They refer to the personality of the author. 2. Economic rights. They refer to economic transactions. There are two types of economic rights: - exclusive rights, involving trading in activities done using the work by consent, - remuneration rights, involving payment to compensate for the use of a limitation.	The rule by default is that the user may not perform any activity on the work, unless one of the following applies. 1. The owner accepts for a price or for free that the user performs on the work one or more activities that are included in the exclusive rights. 2. The user exercises a limitation. The exercise of a limitation may trigger a remuneration in favour of the rightholder. 3. The work is in the public domain. In this case, no consent is necessary.

It is in this normative context that science has to communicate its results to the public. One of the reasons why science needs to be public is because it must be falsifiable, and to become public at least two activities (reproduction and distribution, or reproduction and public communication) are needed. IPR and its default 'all rights reserved' rule operate against one of the core necessities of science: public dissemination to allow public scrutiny.

Figure 4.2. Copyright author, work, rights, activities, limits and consent scheme



How have open knowledge activists dealt with openness?

As previously stated, there are only two possible legal ways to reproduce, alter, communicate to the public or distribute a work subject to current copyright: either obtain the consent of the rightholder or exercise a limitation. 'Scientific communities are communication systems' (Stichweh, 2001, p. 288). Therefore, open knowledge activists have worked to enhance both possibilities: on one hand, making authors declare that certain uses of the works are permissible, which has been done by disaggregating the copyright in a work and announcing publicly the activities allowed by attaching a free licence; on the other, trying with little success to expand the copyright exceptions based on research or on scientific uses ([62]).

One of the main contributions to this field was made by the Nobel laureate Elinor Ostrom and her colleague Charlotte Hess. During her career, Ostrom studied common goods, understood as shared natural resources, which led to finding an analogous nature between the traditional commons and 'academic research, open science, traditional knowledge, and the intellectual public domain' (Hess and Ostrom, 2003). Hess and Ostrom produced their seminal article 'Artifacts, facilities, and content: Information as a common-pool resource' (Hess and Ostrom, 2003) with the goal of summarising 'the lessons learned from a large body of international, interdisciplinary research on common-pool resources in the past twenty-five years and consider[ing] its usefulness in the analysis of scholarly information as a resource'.

One of the key points of their article was to assess which of the aspects related to IPR were relevant for researchers (Hess and Ostrom, 2003):

> *Property rights define actions that individuals can take in relation to other individuals regarding some-'thing.' If one individual has a right, someone else has a commensurate duty to observe that right. Schlager and Ostrom identify five major types of property rights that are most relevant for the use of common-pool resources, including access, extraction, management, exclusion, and alienation. These are defined as:*

- *Access: The right to enter a defined physical area and enjoy non subtractive benefits (e.g., hike, canoe, sit in the sun).*
- *Extraction: The right to obtain resource units or products of a resource system (e.g., catch fish, divert water).*
- *Management: The right to regulate internal use patterns and transform the resource by making improvements.*
- *Exclusion: The right to determine who will have access rights and withdrawal rights, and how those rights may be transferred.*
- *Alienation: The right to sell or lease management and exclusion rights.*

Therefore, the relevant aspects of property in the digital domain were, according to these authors, different from the traditional ones. As Marcelo Corrales Compagnucci puts it, 'Insofar as it refers to data, the concept of "ownership" is not a legal construct. This notion has been borrowed from tangible properties and is used as an analogy, which is extended to intangible rights such as data or information' (Corrales Compagnucci, 2020, p. 7). Based on these findings, in the spring of 2004 Hess and Ostrom conducted a workshop on scholarly communication as a commons, which bore fruit in a book edited by both scholars, *Understanding Knowledge as a Commons* (Hess and Ostrom, 2007). The workshop participants sought to (p. xi):

> *integrate perspectives that are frequently segregated within the scholarly-communication arena, such as intellectual property rights; information technology (including hardware, software, code and open source, and infrastructure); traditional libraries; digital libraries; invention and creativity; collaborative science; citizenship and democratic processes; collective action; information economics; and the management, dissemination, and preservation of the scholarly record.*

The contributors to Hess and Ostrom's edited book were David Bolier, Nancy Kanich, James Boyle, Donald J. Waters, Peter Suber, Shubha Ghosh, Peter Levine, Charles M. Schweik, Wendy Pradt Lougee, James C. Cox and J. Todd Swarthout: important and distinguished scholars in the field of knowledge studies. Based on the theories that Robert K. Merton published in his essay, *The Normative Structure of Science*, James Boyle asserted in the chapter he wrote for the Hess and Ostrom book that 'Access to and citation of the peer-reviewed literature is crucial to the scientific project as Merton describes it, indeed it is one of its principal methods of error correction' (Boyle, 2007, p. 123). However, instead of favouring this necessary activity for science, copyright now is acting as a fence, preventing access to works, he claims. Boyle distinguishes between two types of information on the internet: data, which are not subject to copyright, and works under copyright legislation. Comparing them, he finds that data are creating knowledge but works under copyright are not, as they are unusable because of IP legislation, which makes him pose the following question (Boyle, 2007, p. 139):

> *Working in an arena where facts are largely free from intellectual property rights, the Net has assembled a wonderful cybernetically organized reference work. What might it do to the 97 % of the culture of the twentieth century that is not being commercially exploited if that culture was available for everyone to annotate, remix, compare, compile, revise, create new editions, link together in archives, or make multimedia reference works?*

As Boyle concludes:

> Successful commons are frequently characterized by a variety of restraints – even if these are informal or collective, rather than coming from the regime of

> private ownership. It even gives us generalizable tools that can help us to match types of resources with types of commons regimes. The web confirms those lessons. As I pointed out earlier, standard intellectual property theory would posit that to get high-quality factual reference works, we need strong property rights and single-entity control for at least three independent reasons related to the tragedy of the commons: the need for exclusive control over reproduction in order to produce the incentives necessary for large-scale investment in writers and fact-checkers, the need for control over content and editing in order to ensure quality, and the need for control over the name or symbol of the resource itself as a signal to readers and an inducement to invest in quality in the first place.

Therefore, the Mertonian CUDOS, the four sets of institutional imperatives, cannot be achieved with digital technologies if IP, instead of being a system of rewards, consists in a system of payments not to the contributors to science but to intermediaries only interested in monetary income.

The possibility of disaggregating IP from its traditional understanding into different components is also referred to by the Brazilian philosopher Roberto Mangabeira Unger. In his book *The Knowledge Economy* (Unger, 2019), he dissects the different rights that can be included in digital IPR. The conclusion that may arise from the Hess, Ostrom and Unger thesis is that the concept of IP ownership is not relevant in the digital age: what is crucial is the different possibilities attached to the possession of or access to digital information (Unger, 2019, pp. 125–126):

> An advantage of the unified property right is that it allows a risk-taking entrepreneur to do something in which no one else believes without having to avoid potential vetoes by multiple stakeholders. Its disadvantage is the reverse side of this benefit. It fails to provide a legal setting for the superimposition of stakes of different kinds, held by multiple stakeholders, in the same productive resources. For that use, we need fragmentary, conditional, or temporary property rights, resulting from the disaggregation of unified property.

According to Unger, IPR are a matter of not only sharing knowledge but exercising power. As is well known, the companies that own scientific publications exercise control contrary to the interests of universities and other research centres (Larivière et al., 2015; see for example Kell, 2019; Elsevier, 2020). Therefore, in order for the knowledge economy to flourish, this control must stop (Unger, 2019, pp. 127–128):

> An area of reform in the property regime that is vital to the future of the knowledge economy is intellectual property. The established law of patent and copyright, largely a creation of the nineteenth century, inhibits the development of an inclusive vanguardism. It does so chiefly by imposing a highly restrictive grid on the ways in which economic agents can participate in the development of the knowledge economy and share in its rewards. Its practical effect is to help a small number of mega-enterprises dominate the vanguards of production by holding exclusive rights to key technologies that they have either developed themselves or bought from the original inventors. The excuse for concentrating such rents in a small set of capital-rich economic agents is the need to provide incentives to innovation, compensating those who have made long bets on an improbable future. The consequence, however, is to benefit a few only by discouraging and excluding many. It also further enhances the already overwhelming advantages of large scale in the control of the knowledge economy.

Nevertheless, as it is evident, although we are focusing on possession of the information and not on its ownership, under the current legislation consent is still needed in order to exercise rights over the content, and the problem is that the authors are no longer

the rightholders. Trying to resolve this issue, the OA movement crystallised its first declaration in Budapest (BOAI, 2002), on 14 February 2002. Its first paragraph is notable:

> An old tradition and a new technology have converged to make possible an unprecedented public good. The old tradition is the willingness of scientists and scholars to publish the fruits of their research in scholarly journals without payment, for the sake of inquiry and knowledge. The new technology is the internet. The public good they make possible is the worldwide electronic distribution of the peer-reviewed journal literature and completely free and unrestricted access to it by all scientists, scholars, teachers, students, and other curious minds. Removing access barriers to this literature will accelerate research, enrich education, share the learning of the rich with the poor and the poor with the rich, make this literature as useful as it can be, and lay the foundation for uniting humanity in a common intellectual conversation and quest for knowledge.'

The call made by the signatories of the BOAI was to remove the financial, legal or technical barriers that stood in the way of gaining access to content. The two solutions proposed by the OA movement were self-archiving and OA journals.

One of the signatories of the Budapest Open Access Initiative (BOAI) was Peter Suber. His work as director of the Harvard University Office for Scholarly Communication makes him a leading voice in access to free knowledge, and his book *Open Access* (Suber, 2012) has been an important step in explaining the different affordances of scholarly literature, demonstrating how the granularity of IPR must be taken into consideration. As Suber puts it (2012, p. 128):

> Authors who retain rights don't violate rights belonging to publishers; they merely prevent publishers from acquiring those rights in the first place. When rights-retaining authors make their work OA, publishers can't complain that OA infringes a right they possess, only that it would infringe a right they wished they possessed.

Using a centralised organisation as intellectual property rights trustee

In the search of shared knowledge, disaggregating rights has not been the only strategy. A very successful approach has consisted in asking all the contributors of a collective work for the non-exclusive assignment of the right to publish, distribute, make derivative works, translate and display their contributions to the work and the right to sublicense these rights in favour of all other contributors of such work. A central organisation operates as a trustee, holding the rights conferred by the collaborators, who, as said, do not grant the trustee exclusivity for their contributions, and grants sublicences to all other participants in the process of constructing the common work. The trustee's name is the Internet Engineering Task Force (IETF) Trust, the intellectual property work consists, at the time of this writing, of 9 035 documents entitled RFCs ([63]) and the IP-protected result is known as the internet.

An emphasis must be added on the IP nature of the internet. Every document in the set of the 9 035 RFCs is itself a text protected by IP. The totality of them has the same legal status as any encyclopaedia and is protected under the same laws.

([63]) See the complete list of RFCs in reverse order of publication (https://www.rfc-editor.org/rfc-index2.html).

The title 'RFC' connects this recent technology with the traditional values of science: requesting comments in public follows the same principle that guided Oldenburg in 1665 to shift from a secret log book to an open *Philosophical Transactions* journal (Johns, 2009, p. 61). To ask for contributions is a way to exercise the enlightened tradition of obtaining value through the interchange of ideas, reflected in the Mertonian communism in the sense that 'The substantive findings of science are a product of social collaboration and are assigned to the community' (Merton, 1974, p. 273). However, instead of grounding the Mertonian communism in social norms, the IETF Trust uses the law, IP law, establishing compulsory rules for all participants, who are to assign their IPR to the IETF Trust, while at the same time they receive a licence from this organisation to use all the material already written by prior contributors. These legal conditions are the subject matter of RFC No 5 378 ([64]), entitled 'Rights contributors provide to the IETF Trust', in which the applicable IP conditions, especially copyright and patents, can be consulted.

It is also worth quoting the IETF summary of how the most relevant IP work of all times has been built:

> Defining characteristics of IETF standards include that they are freely available to view and read, and generally free to implement by anyone without permission or payment.
>
> Developed through open processes ([65]), once a standard is published as an RFC ([66]), anyone can download and read it from the RFC Editor ([67]) or IETF Datatracker ([68]) websites. Further reproduction of whole RFCs (including translation into a language other than English) has been allowed and is encouraged. To indicate this, most RFCs include the standard phrase, 'Distribution of this memo is unlimited'. The IETF's rules on copyright issues, including use of extracts, are described in more detail in BCP 78 ([69]).
>
> During the standards process any IETF contribution covered by patents or patent applications owned by a participant or their sponsor must be disclosed, or they must refrain from participating. A contribution is any submission to the IETF that is intended for publication as all or part of an Internet-Draft ([70]) or an RFC, or any statement made within the context of an IETF activity such as a working group discussion on a mailing list or during a meeting. BCP 79 ([71]) provides a more complete description of how Intellectual Property Rights (IPR) are handled in IETF standards processes. The IETF Datatracker maintains a list of IPR disclosures made to the IETF ([72]).
>
> Beyond IETF RFCs, the IETF operates in an open and transparent fashion, publishing records ([73]) of most of the contributions, submissions, statements and communications freely available. This includes mailing list archives ([74]), working group activity ([75]), and meeting proceedings ([76]).

([64]) https://datatracker.ietf.org/doc/rfc5378/
([65]) https://www.ietf.org/standards/process/
([66]) https://www.ietf.org/standards/rfcs/
([67]) https://www.rfc-editor.org/
([68]) https://datatracker.ietf.org/
([69]) https://datatracker.ietf.org/doc/bcp78
([70]) https://www.ietf.org/standards/ids/
([71]) https://www.rfc-editor.org/info/bcp79
([72]) https://datatracker.ietf.org/ipr/
([73]) https://www.ietf.org/how/open-records/
([74]) https://www.ietf.org/how/lists/
([75]) https://datatracker.ietf.org/wg/
([76]) https://www.ietf.org/how/meetings/proceedings/

The IETF's information about its IPR conditions makes it evident that its inspiration comes from the scientific domain. Science is not only made through formal contributions, but also through conversations held on mailing lists, and activities in working groups and in meetings (Bradner, 1999, pp. 51–52). In addition, the internet has a characteristic in common with basic science: they both serve for innovation, but it is impossible to foresee when or how the innovative results will appear, or what wealth they will produce. For example, Google, the wealthiest company in the world, is based on two free mechanisms: the first is the traditional bibliographic reference system that Google uses to calculate a web page rank; the second is the RFC protocols. The success of this company is an interesting demonstration of the emergent possibilities of free knowledge. Furthermore, RFC technologies are omnipresent, are free for use by everybody and serve as the common base where the 'sweat of the brow' allows appropriation of the results. RFCs have created a new digital scenario, that is added to the traditional ones and allows for constant wealth production and its appropriation by the individuals, companies or organisations who create it.

It is also worth mentioning that the literature does not always sufficiently mention wealth produced by RFCs. For example, there is no mention of these protocols or their contributions in the report *Enquiries Into Intellectual Property's Economic Impact* (OECD, 2015a), the recent *A roadmap toward a common framework for measuring the digital economy* (OECD, 2020) or the *WIPO Intellectual Property Handbook* (WIPO, 2008). This last publication has two sections, one related to 'The promotion of innovation' (pp. 168–171) and the other referring to 'The teaching of intellectual property law' (pp. 421–432), in which the only IPR are the restrictive ones whereby all uses are forbidden except if they are commercialised. In the literature that is the subject matter of this review, there are very few exceptions, and the ones that exist are very illustrative (Benkler, 2006; Helfrich and Heinrich-Böll-Stiftung, 2012; Kelty, 2008; Lessig, 2004; Olwan, 2013). The internet is considered by mainstream IP specialists and doctrine to be a new technology that challenged the old IPR status quo and fostered piracy, but it has not been even considered as an IP work per se. A new technical encyclopaedia, the RFCs, has revolutionised the world and yet is taken for granted and rendered invisible, even though it is the knowledge without which the infrastructure of our present world would not function.

Recommendation for policymakers

An Office for Free Intellectual Property Rights and Open Science should be created. This office can be inspired by the functioning of the Office for Harmonization in the Internal Market and the European Observatory on Infringements of Intellectual Property Rights (EU 386/2012) and should be aligned with the EU IP action plan. It could be piloted through the Horizon Europe Framework Programme.

4.5.2. Patents

Brief historical introduction

The history of patents runs separately from that of copyright because of taxonomic distinctions made from the 18th century onwards, although both concepts have a common origin: privileges that took various forms, from exclusive monopolies for inventors to exploit their work, to printing privileges for publishers or authors (Kostylo, 2010, pp. 21–22). According to Joanna Kostylo, in these initial times the focus was more

on the printing press than the immaterial *corpus mysticum* of an intellectual work. 'Ever since the thirteenth century, the Venetians led Europe in their efforts to attract foreign expertise by granting monopoly rights to immigrants who brought with them new skills and techniques to the city'; the 'most famous patent was a five-year monopoly granted on 18 September 1469 to a German print master Johannes of Speyer to establish a press and foster printing within the Venetian Republic' (Kostylo, 2010, p. 23). In 1474 the Venetian Republic passed a decree that protected for 10 years 'any new and ingenious device in this City', and in 1624 the English Statute of Monopolies ([77]) 'crystallized the pronouncements of the common law courts concerning the use by the English Crown of its prerogative power to grant monopolies in business … for "any manner of new manufactures within this realm"' (Drahos, 2010, p. 91). These initiatives were followed by diverse patent statutes in Europe: France 1791, Austria 1810, Russia 1812, Prussia 1815, Belgium and the Netherlands 1817, Spain 1820, Bavaria 1825, Sweden 1834, Wurtemburg 1836, Portugal 1837 and Saxony 1843 (Drahos, 2010, pp. 91–92), although statutes had been anticipated by customary law (Pohlmnan, 1961, cited by Anderfelt, 1971, p. 14). Finally, in order to avoid the territorial application of the patents and to obtain international recognition, in 1883 the Paris Convention for the Protection of Industrial Property was signed.

Despite the expansion of patent statutes, Sam Ricketson narrates how the patents 'could be seen as restraints on the development of a free market economy, particularly in those European countries that were commencing to industrialize'. This understanding of patents produced their abolition in the Netherlands, which repealed its patent law in 1869, and a strong contestation in Germany and Switzerland (Ricketson, 2015, Sections 1.07–1.08), beginning discussions that still continue today related to the foundations of patents (Anderfelt, 1971, pp. 50–58), the malfunctioning of the procedure to obtain one ([78]), the endangering of innovation or their inefficiency (Jaffe and Lerner, 2004), notwithstanding the danger to innovation caused by the existence of a myriad of patent assertion entities, also called 'patent monetization entities' or better known by their colloquial name, 'patent trolls' (Lallement, 2017, p. 101; Tucker, 2011).

Definition and regulation

According to the WIPO definition (WIPO, 2008, p. 17):

> A patent is a document issued upon application by a government office (or a regional office acting for several countries), which describes an invention and creates a legal situation in which the patented invention can normally only be exploited (manufactured, used, sold, imported) with the authorization of the owner of the patent. 'Invention' means a solution to a specific problem in the field of technology. An invention may relate to a product or a process. The protection conferred by the patent is limited in time (generally 20 years).

Although patents are referred to as 'monopolies', this term is not exact because they do not confer the inventor the right 'to make, use or sell anything'. A patent gives the owner of the patented invention the right to 'exclude others from commercially exploiting his invention' (WIPO, 2008, p. 17). Similarly, the European Patent Office (EPO) asserts that 'Patents confer the right to prevent third parties from exploiting an invention for commercial purposes without authorisation' (European Patent Office,

([77]) https://www.legislation.gov.uk/aep/Ja1/21/3/contents
([78]) One notorious examples of malfunction can be mentioned: the wheel was patented in 2001 in Australia as a 'circular transportation facilitation device' (https://www.newscientist.com/article/dn965-wheel-patented-in-australia/)

2016, p. 6). It is the patentee who will have to take action upon the infringement of his or her rights so as to exclude others.

Patents are regulated in Articles 27–34 of the TRIPS Agreement, which establish an applicable default rule, that 'patents shall be available for any inventions, whether products or processes, in all fields of technology, provided that they are new, involve an inventive step and are capable of industrial application' (Article 27(1)), and provides the possibility for the signatories to exclude the following from patentability:

- inventions whose commercial exploitation could contravene public order or morality;
- diagnostic, therapeutic and surgical methods for the treatment of humans or animals;
- plants and animals other than microorganisms, and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes.

In Europe, a group of contracting states ([79]) signed the European Patent Convention (EPC), which entered into force in 1978. The EPC has been revised twice: in 1991 and more extensively in 2000. This last revision took effect in 2007. According to Article 52 of the EPC:

> (1) European patents shall be granted for any inventions, in all fields of technology, provided that they are new, involve an inventive step and are susceptible of industrial application.
> (2) The following in particular shall not be regarded as inventions within the meaning of paragraph 1:
> (a) discoveries, scientific theories and mathematical methods;
> (b) aesthetic creations;
> (c) schemes, rules and methods for performing mental acts, playing games or doing business, and programs for computers;
> (d) presentations of information.

'The EPC has established a single European procedure for the grant of patents on the basis of a single application and created a uniform body of substantive patent law designed to provide easier, cheaper and stronger protection for inventions in the contracting states' (European Patent Office, 2020a, p. 10). Thanks to this convention, a patentee may file a single application and obtain the registration of an invention in the countries designated by the patent candidate (pp. 12–14). It is not a single patent, but a bundle of them, which, although it has advantages, 'has the disadvantage that infringement and/or invalidation procedures must be conducted separately in the individual Member States' (Kur and Dreier, 2013, p. 88). However, continue these authors, 'obtaining patent protection for the major EU countries such as the UK, France, Germany and perhaps Italy or Spain, may be sufficient to secure *de facto* EU-wide protection'.

A final possibility for filing a patent is provided by the Patent Cooperation Treaty, which was signed in Washington in June 1970, and today has 153 contracting states. According to Article 2, item (ix), 'references to a "patent" shall be construed as references to national patents and regional patents'. Inventors who wish to file their application in several countries may use the proceedings of this treaty and issue their petition via WIPO's International Bureau or through a national patent office. This does

([79]) This group initially included 16 states. Currently, EPC contracting states are: Albania, Austria, Belgium, Bulgaria, Cyprus, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, the Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

not mean the applicant will obtain a single patent for all the countries; patents will be issued only in the ones where it is asked for.

In addition to the above, a unitary patent for protection in all the EU territory is currently under development. The legal norms that regulate it are the following:

- Regulation (EU) No 1257/2012 of the European Parliament and of the Council of 17 December 2012 implementing enhanced cooperation in the area of the creation of unitary patent protection ([80]);
- Council Regulation (EU) No 1260/2012 of 17 December 2012 implementing enhanced cooperation in the area of the creation of unitary patent protection with regard to the applicable translation arrangements ([81]);
- Agreement on a Unified Patent Court ([82]), not yet enforceable, as ratification by signatories is pending. The two Regulations abovementioned will be applicable only once the Agreement enters into force.

Note that the new system will only apply in those Member States that have ratified the Unitary Patent Court Agreement. So far, 17 Member States have done so.

Requirements for patentability and disclosure of the invention

For an invention to be eligible for patent protection it must follow certain requirements: it must be industrially applicable (useful) and new (novel), it must exhibit a sufficient 'inventive step' (be non-obvious) and the disclosure of the invention in the patent application must meet certain standards (WIPO, 2008, p. 17). According to Article 52(1) of the EPC, 'European patents shall be granted for any inventions, in all fields of technology, provided that they are new, involve an inventive step and are susceptible of industrial application'.

The challenges that are faced by the patent offices in order to review the applications are increasingly complex. According to EPO, 'Prior art is the starting point for searching any patent application. EPO examiners have access to the world's most extensive prior art collection, which includes 1.5 billion technical records in 182 databases' (European Patent Office, 2020c, p. 14), not counting the 120 million patent documents, 4.1 million standards documents and non-patent literature (pp. 15–16). The existence of prior art will be an issue for granting the patent. Therefore, patents and publications about the patents may coexist, but the patent application must be earlier than the publication, so as to accomplish the requirement of novelty.

The application of the patent must disclose the invention in a clear manner so it could be reproduced by a third person. Therefore, a patent in principle does not avoid public disclosure of the invention, however, to preserve the novelty requirement before the patent is obtained, a common practice is to temporarily keep the invention secret (Alonso Puelles and Echeverría Ezponda, 2014, p. 16). According to Bainbridge, 'Disclosure is a central prerequisite for the grant of a patent and it must be total, with nothing of substance withheld, otherwise it might be difficult for others to make use of the invention once the patent has expired' (Bainbridge, 2012, p. 389). Tens of millions of patent documents can be accessed for free from various databases (e.g. the EPO's EspaceNet), as soon as 18 months after their first filing. Moreover, most of them have already expired, which means that the technologies concerned are now in the public domain. The disclosure requirement is key for the relationship between OS and this field of IP because in theory a patent should not hide knowledge or hinder access to it.

([80]) http://data.europa.eu/eli/reg/2012/1257/oj
([81]) http://data.europa.eu/eli/reg/2012/1260/oj
([82]) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:42013A0620(01)

Other authors such as Boldrin and Levine consider that, although patents were meant to reduce secrecy, this is not always the case. An innovator may prefer not to disclose the creation 'to make sure that imitation cannot take place until it is profitable for him to make use of the patent' (Boldrin and Levine, 2008, p. 167). Imitation costs may nevertheless vary significantly by industry, which means that, when analysing the relationship between the patent system and OS, there is no single answer because 'the contribution of patenting to inventing activity varies by sector' (Bottomley, 2014, pp. 10–11). It could be thought that a sector is quite innovative, when the only reason for a patent boost would be 'ring-fencing' an invention to avoid competition: patents may be used defensively, networking an invention with other patents 'trying to predict future applications and improvements on the basic invention for the purpose of preempting competitors and covering any possible future applications. If successful, this ties a competitor's hands together and deprives him of technical mobility and flexibility' (Bainbridge, 2012, p. 399).

Patents, markets and innovation

A different aspect to take into account is how patents influence markets (Godoy, 2013) or whether patents foster or hinder innovation (Boldrin and Levine, 2008; Stiglitz, 2008, pp. 1710–1712). This aspect is, at the time of this writing, being studied by the United States Patent and Trademark Office ([83]):

> At the request of Senators Tillis, Hirono, Cotton, and Coons, the United States Patent and Trademark Office (USPTO) is undertaking a study on the current state of patent eligibility jurisprudence in the United States, and how the current jurisprudence has impacted investment and innovation, particularly in critical technologies like quantum computing, artificial intelligence, precision medicine, diagnostic methods, and pharmaceutical treatments. The USPTO seeks public input on these matters to assist in preparing the study.

Stiglitz asserts that the patent system is not ideal for innovation, because it creates distortionary and transaction costs, and for the dissemination of knowledge it is not the best possibility available. He proposes a mixed system (Stiglitz, 2008, p. 1713):

> government-funded research is best (because knowledge is generally made freely available); the prize system is second (though there may be little difference with government-funded research if, after the prize is awarded, knowledge is made freely available, or, if, with government-funded research, the government charges a licensing fee); and the patent system is the worst, given that it relies on monopolization, which entails high prices and restricted usage. In short, under the prize and the government-funded research systems, knowledge, once acquired, is more efficiently used.

His conclusion is that IPR are important but they are just 'part of a portfolio of instruments'. The other elements should be strengthened, and IPR should be redesigned to 'increase its benefits and reduce its costs' (p. 1724).

Therefore, it is necessary to analyse in a more granular way the relationship between OS and patents, owing to the differences between sectors, where strategies for not disclosing information or for ring-fencing may apply. Further studies of each industrial sector should be developed.

([83]) https://www.federalregister.gov/documents/2021/07/09/2021-14628/patent-eligibility-jurisprudence-study

4.5.3. Trademarks

Trademarks are regulated in Articles 15–20 of the TRIPS Agreement, and in Directive (EU) 2015/2436 of the European Parliament and of the Council of 16 December 2015 to approximate the laws of the Member States relating to trade marks (recast) ([84]). According to the TRIPS definition, 'Any sign, or any combination of signs, capable of distinguishing the goods or services of one undertaking from those of other undertakings, shall be capable of constituting a trademark.' Article 3 of Directive (EU) 2015/2436 specifies the signs a trademark may consist of:

> any signs, in particular words, including personal names, or designs, letters, numerals, colours, the shape of goods or of the packaging of goods, or sounds, provided that such signs are capable of:
>
> (a) distinguishing the goods or services of one undertaking from those of other undertakings; and
>
> (b) being represented on the register in a manner which enables the competent authorities and the public to determine the clear and precise subject matter of the protection afforded to its proprietor.

As a trademark is an informational reference to an object, by its nature it does not play any role in the transmission of information in which the object may consist. Having (or not having) a trademark that identifies goods or services provided by any natural or moral person does not alter their reproducibility or transmissibility, although it affects public perception of the objects represented. However, perception of an object is not an element that affects its replicability.

A point of friction may appear in certain common uses of a trademark without consent of the rightholder. Nevertheless, it would not disturb the transmission of information.

4.5.4. Trade secrets

Trade secrets, as part of IPR, consist of secrets of all kinds. They may be of a personal, commercial or industrial nature, or concern the state and its administration' (Bainbridge, 2012, p. 345). Their origin may be found in the protection the guilds exercised over the practices of their members (Kostylo, 2010, pp. 32–33):

> The institutions devoted to guarding trade secrets were the guilds (*arti*). The guilds developed and used various mechanisms in order to protect these trade secrets and traditional techniques inherited from the past: most technical and craft knowledge was transmitted orally through apprenticeship and under secrecy oaths; the guilds restricted the movement of workers to prevent them from disseminating this 'tacit' knowledge of their trades abroad; and, the guilds also sought to place limits upon the initiative of individual entrepreneurs by keeping workshops small, forcing artisans to work on only a single project at a time, and by taxing individual masters for hiring additional assistants. Such mechanisms were intended to keep any single interest from breaking out of the guild system.

The TRIPS Agreement regulates what it calls 'Protection of undisclosed information' in its Article 39. Item 2 of this article allows that 'Natural and legal persons shall have the possibility of preventing information lawfully within their control from being disclosed to, acquired by, or used by others without their consent in a manner contrary to honest commercial practices'; by a dishonest practice it means 'breach of contract, breach of confidence and inducement to breach, and includes the acquisition of undisclosed

([84]) http://data.europa.eu/eli/dir/2015/2436/2015-12-23

information by third parties who knew, or were grossly negligent in failing to know, that such practices were involved in the acquisition'. The protected information must comply with three requirements set forth in Article 39(2), which states that it:

> (a) is secret in the sense that it is not, as a body or in the precise configuration and assembly of its components, generally known among or readily accessible to persons within the circles that normally deal with the kind of information in question;
>
> (b) has commercial value because it is secret; and
>
> (c) has been subject to reasonable steps under the circumstances, by the person lawfully in control of the information, to keep it secret.

EU regulation of trade secrets is included in Directive (EU) 2016/943 of the European Parliament and of the Council of 8 June 2016 on the protection of undisclosed know-how and business information (trade secrets) against their unlawful acquisition, use and disclosure ([85]). Article 2(1) of the directive directly copies the definition of 'trade secret' included in the TRIPS agreement.

Trade secrets are incompatible with OS.

4.6. Comparison between the major European trends and the Chinese, Israeli and US approaches

As explained above, IP regulation is hierarchically designed using a global approach. The WIPO treaties and the TRIPS Agreement occupy the peak of the pyramid; hence the EU, China, Israel and the United States, which are signatories of the WIPO and the TRIPS Agreement, participate in a common ground regulation. Nevertheless, there are differences between their *acquis* and while the international instruments only provide for a minimum regulation, EU and national instruments offer a more complete regulation.

The literature review reveals the existence of a myriad of works that explore the US IPR system, but very few works published in English cover China's IPR regulation (Conde, 2019; Devonshire-Ellis, 2011; Guan, 2014; Hilty and Nérisson, 2012; Pang, 2012; Perry, 2016; Pisacane and Zibetti, 2020; Prud'homme and Zhang, 2019; Taplin, 2014; Thomas, 2017) or that of Israel, for which only two works have been found (Melchior, 2019; Pesach, 2012). None of the publications in English reviewed related to China or Israel refer to any OS aspect.

Comparing the European situation with other countries, already in 2016 the Directorate-General for Research and Innovation of the European Commission concluded that 'the EU is lagging behind the US and South Korea in important framework conditions such as product market regulation, barriers to entrepreneurship, ease of doing business or intellectual property right protection' (European Commission, Directorate-General for Research and Innovation, 2016, p. 9) and that 'Intellectual property protection (IPP) in the EU is lower than in Japan and the United States' (p. 94). This report was updated in 2020 by the publication *Science, Research and Innovation Performance of the EU, 2020* (European Commission, Directorate-General for Research and Innovation, 2020a), which said that this situation had not changed: 'the EU lags behind Japan and the United States in terms of innovation output, mainly due to its poor performance in PCT [Patent Cooperation Treaty] patent applications, with very slow progress in recent years' (p. 417). Nevertheless, the methodology used in the reports to compare the EU with

([85]) http://data.europa.eu/eli/dir/2016/943/oj

other countries should be considered carefully. Vertésy and Damioli, authors quoted in the 2020 update report, assert that 'Patent indicators are known to have drawbacks when it comes to measuring technological innovation' (Vertésy and Damioli, 2020, p. 6) due to the existence of strategic patenting, which serves not for innovation but to avoid competition, and because patents are sector specific, which could lead to a distorted or erroneous economic analysis of other sectors that do not rely on patents for their growth, innovation or importance. Similarly, Jürgen Janger et al. have stated that 'The EU2020 Innovation Indicator mainly focuses on innovation outcomes and includes little information on the quantity or quality of innovation output. It only uses patents, which we have argued are difficult to use as an innovation output indicator because they conceptually do not need to imply actual innovations' (Janger et al., 2017, p. 38).

In terms of receipts and payments, the importance of the United States in IPR trade in comparison with the rest of the world is remarkable. Figure 4.3 below shows the figures regarding IPR receipts and payments between the United States, the EU, China and Israel using the same World Bank data.

Figure 4.3. IPR receipts and payments by the United States, EU, China and Israel, 2019 (million USD)

Country/ies	Receipts	Payments	Net
United States	117 401	42 732	74 669
EU	141 102	211 382	–70 280
China	6 605	34 370	–27 765
Israel	1 579	1 520	59

Concerning US IP trends or peculiarities in comparison with the EU, it is worth mentioning two aspects. The first one is in regard to hyperlinks, which in the United States do not imply communicating a work to the public, as will be detailed in the next section. This is relevant to OS because the links between works are not exposed to an IPR infringement risk. The second aspect, again important for OS, is the difference between the US and EU systems in relation to limitations of copyright. As stated earlier, the EU system is based on a *numerus clausus* of limitation and exceptions spread over different directives (Directive 2001/29/EC and Directive (EU) 2019/790). In contrast, Section 107 of the US Copyright Act ([86]) includes a framework for determining whether a certain use of an intellectual work is allowed in the absence of the rightholder's consent. The four factors that Section 107 establishes are:

> (1) the purpose and character of the use, including whether such use is of a commercial nature or is for nonprofit educational purposes;
>
> (2) the nature of the copyrighted work;
>
> (3) the amount and substantiality of the portion used in relation to the copyrighted work as a whole; and
>
> (4) the effect of the use upon the potential market for or value of the copyrighted work.

([86]) https://www.copyright.gov/title17/92chap1.html#107

In principle, it seems that OS could profit from this system of exceptions because of its open nature. As demonstrated, the EU system is quite rigid about allowing activities not included in the law, which could operate as a burden for OS.

In relation to China, the literature reviewed refers to the difficulties that the cultural particularity of *shanzhai* (Pang, 2012, pp. 222–223; Pisacane and Zibetti, 2020, pp. 8–9) imposed when adopting the TRIPS regulation. This term 'has both negative and positive connotations: negative because of its illegal and low-quality status, but also positive precisely because of its implication of IPR offenses, as it implies a culture of rebellion, irony, and self-marginalization' (Pang, 2012, p. 222). Further to this defiance and according to the works consulted, the challenge that now faces China is to enforce the TRIPS Agreement in its territory, given the necessity to pass amendments to major laws and regulations (OECD, 2015a, pp. 332–333; Thomas, 2017, pp. 85–103). A summary made by Kristie Thomas analysing the data she collected from the phases between 2005 and 2015 concludes that in 2005 there was an enforcement gap, and in the decade from roughly 2005 to 2015 there were new laws, changes in the enforcement framework and the introduction in 2014 of specialist IP courts. 'Nevertheless, concerns about inadequate damages still persisted from a decade earlier' (Thomas, 2017, p. 169). The Chinese system adopts a closed list of exceptions under Article 22 of China's Copyright Act, the ones relevant to OS being 'Translation, or reproduction in a small quantity of copies, of a published work, for use in classroom teaching or scientific research by teachers or scientific researchers, but such translation or reproduction shall not be published or distributed' and 'Reproduction of a work in its collections by a library, archive, memorial hall, museum, art gallery, etc. for the purposes of display, or preservation of a copy, of the work'. Article 6 of the Internet Regulation contains the exception 'For the purpose of a school's classroom education or scientific research, to make available a published work to a small number of teachers and researchers' (Lin and Liu, 2012, p. 270).

Finally, apropos Israel, Guy Pesach reports that the Israeli Copyright Act from 2007 includes provisions related to the ownership of publications 'made by or commissioned for, the State or by an employee of the State in consequence of his service and during the period of his service. In this regard "State employees" includes soldiers, policemen and any other person who holds a position according to a statute in a State entity or institution' (Pesach, 2012, p. 523). Regarding exceptions and limitations, 'Section 19 of the Israeli Copyright Act, 2007, includes a quasi-open, standard-based fair-use defense … Section 19 is phrased in the following terms "Fair use of a work is permitted for purposes such as: private study, research, criticism, review, journalistic reporting, quotation, or instruction and examination by an educational institution"' (p. 527).

5. How can open science and intellectual property better interact?

The two subsections below correspond to different typologies of findings from the literature review. Subsection 5.1 will analyse the interaction between IP and three components of OS, namely OA to publications, data management and free software. Subsection 5.2 will cover four specific IP issues that scientists may face when performing data science in the ICT context that unbalance the relation between OS and IP, unwittingly producing IP infringement risks.

5.1. Open science components and intellectual property rights

In the previous sections, the components of OS and IP meant to interact with each other have been identified. On one side, OS is supported by the fundamental right to science, and, on the other side, IPR protect the rights of the creators. Nevertheless, when analysing the balance between OS and IPR, the default legal requirement for the transmission of a work is explicit consent, or the use of an exception, or the existence of public domain. In cases of conflict, it is the user of the work who has the burden of proof that one or more of these requirements exist. Therefore, using works for a scientific activity may produce risks that should be avoided by correct use of the permissions designed in IP regulations.

As mentioned in Section 1.2, the literature review found very few analyses focused on how OS and IPR can coexist. EARTO has produced some abstract and general recommendations towards a balanced approach between IPR and OS, encouraging 'RD&I organisations and their researchers to efficiently disseminate and exploit their research results and encourage their translation 'into the commercial world, especially through patent filing' (EARTO, 2020).

The European project Accelerating user-driven e-infrastructure innovation in food agriculture (Aginfra+) proposed five domains where transformations should be made in order to evolve from the current paradigm of research to OS. These were:

- from OA to open science;
- from human-readable to machine-readable content;
- from open data to FAIR data, data sharing and data reuse;
- from traditional publishing to technology-driven service;
- from semantic enrichment of content to semantic publishing.

Decomposing the analysis of Aginfra+ into scientists' practices, we find that all the activities mentioned in the transformations are subject to IP regulations. As Aginfra+ states, these activities, which are necessary to shift into OS, affect the whole ecosystem of producing, communicating, linking, semantic tagging and reusing research results, at the levels of data, information and knowledge, by using machine readability techniques, automated harvesting and text mining. A comparison between scientific and intellectual property activities can be found in Table 5.1.

Table 5.1. Comparison between scientific activities and corresponding IP activities

Scientific activity	Intellectual property activity
Collecting data	Creating a database/work
Communicating	Public communication
Linking	Public communication

Scientific activity	Intellectual property activity
Semantic tagging	Public communication (a tag may include a hyperlink to the tagged object, thus linking)
Reusing research results	Reproduction
Use of machine readability	Reproduction
Use of automated harvesting	Reproduction
Text mining	Reproduction (*)

(*) Although Articles 3 and 4 of Directive (EU) 2019/790 of the European Parliament and of the Council of 17 April 2019 on copyright and related rights in the Digital Single Market mention 'extraction', extraction is only relevant under IPR if it constitutes reproduction (Geiger et al., 2018, p. 6; Triaille et al., 2014, p. 31).

In addition to challenges that Aginfra+ identified, UNESCO's comprehensive enumeration of OS components should be considered. They include the following items: OA, open data, open source software / open hardware, open evaluation, open educational resources, open engagement of societal actions and openness to diversity of knowledge (see Table 2.1). From this aggregated base we may begin to analyse the challenges OS and IPR have to face.

5.1.1. Open access to scientific publications

OA is one of the best-studied and most necessary transformations for OS. In the past 20 years, since the Budapest Declaration, an overwhelming amount of publications, specific and thorough literature reviews, etc. has been published, describing and categorising OA from different perspectives, frequently challenging IP. Some of the most cited and generic approaches to OA are Peter Suber's contributions (Suber, 2012), but there are also important literature reviews from the CREATe project (Frosio, 2014) and the systemic and comprehensive analysis of legal action in the light of international IP that Scheufen (2015) summarises in his book, covering the debate over copyright law and its impact on the distribution of scientific knowledge from an economic perspective. The European Commission's Recommendation (EU) 2019/790 on open access and preservation of scientific information was first published in 2012 and updated in 2018 ([87]), and since then it has been clear that all Member States 'should ensure, in compliance with the EU *acquis* on copyright and related rights, that as a result of these policies or action plans: all scientific publications resulting from publicly-funded research are made available in open access as from 2020 at the latest' (paragraph 1). While 2020 is over, the objective remains applicable for immediate OA to research publication. Plan S, and other newer strategies and approaches to OA, try to obtain that objective by having the researchers retain the necessary IPR, allowing the possibility of licensing their works with open licences.

The activities regulated by copyright (copying, distribution, communication to the public and the creation of derivative works) are forbidden by default. The impact of these activities on knowledge transmission is crucial, so their interdiction by default creates a

([87]) Commission Recommendation (EU) 2018/790 of 25 April 2018 on access to and preservation of scientific information (C/2018/2375) (http://data.europa.eu/eli/reco/2018/790/oj), which replaces Recommendation 2012/417/EU.

hostile environment for science as it imposes access barriers, as was underlined in the Budapest Declaration in 2002.

It is instead a question about copyright that places OA to publications at the heart of the revolution, since publications are still at the heart of research evaluation. OA questions the appropriateness of, the need for and ultimately the success of copyright itself, in the future of scholarly publishing (Harper, 2009). Nevertheless, several political, rather than technical, decisions are pending, mainly on how to avoid the current oligopoly of journal publishers. The regulatory approach should take into account jurisdiction and the necessity of the EU's digital sovereignty (Burgelman, 2021a). This regulatory approach, which seems to be followed by the proposals for the Digital Single Markets Act ([88]) and the Digital Services Act ([89]) and Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe ([90]), should be the way to dismantle the business model over science developed by big publishers, as Buranyi details in his article published in *The Guardian*, 'Is the staggeringly profitable business of scientific publishing bad for science?' (2017).

5.1.2. Data, the data cycle, and findable, accessible, interoperable and reusable (open) data

When it comes to data and IPR, it could be summarised that data and facts do not have protection under copyright but, as will be described below, databases do. Directive 96/9/EC of the European Parliament and of the Council of 11 March 1996 on the legal protection of databases ([91]) defines 'database' in its Article 1(2) as 'a collection of independent works, data or other materials arranged in a systematic or methodical way and individually accessible by electronic or other means' and determines that 'databases which, by reason of the selection or arrangement of their contents, constitute the author's own intellectual creation shall be protected as such by copyright. No other criteria shall be applied to determine their eligibility for that protection' (Article 3(1). This definition may have been reasonable in a world where the digital was not ubiquitous, the use of laptops was not universal and fax machines were the most advanced method of transmitting documents, but nowadays it seems outdated. Under the directive, the legal concept of a database falls under the directory and file structure of a computer. The result of any classification in a computer is therefore copyright. As will be described in subsection 5.2.1 'Application programming interfaces, taxonomies and ontologies', ICT-driven basic OS activity is to create taxonomies and ontologies through the harmonisation of different concepts used in science, defining a common realm. If Linnaeus had created his taxonomy of living animals today, it would have been subject to these regulations and by default his classification would have been unable to be used.

In addition, the Directive establishes for databases an extra layer of rights, known as *sui generis* rights, in its Article 7(1), 'a right for the maker of a database which shows that there has been qualitatively and/or quantitatively a substantial investment in either the obtaining, verification or presentation of the contents to prevent extraction and/or re-utilization of the whole or of a substantial part, evaluated qualitatively and/or quantitatively, of the contents of that database.'

Ohad Graber-Soudry et al. (2021) have insightfully studied this regulation at both theoretical and practical levels. 'From an EOSC perspective, the protectionist approach

([88]) https://eur-lex.europa.eu/legal-content/en/TXT/?qid=1608116887159&uri=COM%3A2020%3A842%3AFIN
([89]) https://ec.europa.eu/digital-single-market/en/digital-services-act-package
([90]) http://data.europa.eu/eli/reg/2021/695/oj
([91]) http://data.europa.eu/eli/dir/1996/9/oj

of the Database Directive is problematic because it automatically frames access to data as a threat. This is counter to legal interoperability and in general to the Open Science idea. There should be more balance between the protection of databases on the one hand and access and re-use of data on the other' (p. 29). The authors make a complete analysis of the relations between the two domains, identify properly permissive IPR and conclude with 31 very specific recommendations. Having the same opinion of the relation between databases and OS, Vera Lipton (2020, pp. 28–29) states that:

> The examination found that copyright law poses serious challenges to data release and reuse in all three jurisdictions under examination – the United States, Australia and the European Union. The problems arise due to uncertainty surrounding the scope of copyright protection as it applies to the various forms of data, especially databases. The situation is even more complicated in the European Union which provides a double layer of sui generis and copyright protection. Therefore, using the data created by European research organisations carries an inherent risk of IP infringement. Another source of legal uncertainty is the ownership of data and the inability of users to identify data owners, which poses challenges to data licencing and subsequent reuse due to lack of clarity around the conditions governing data reuse.

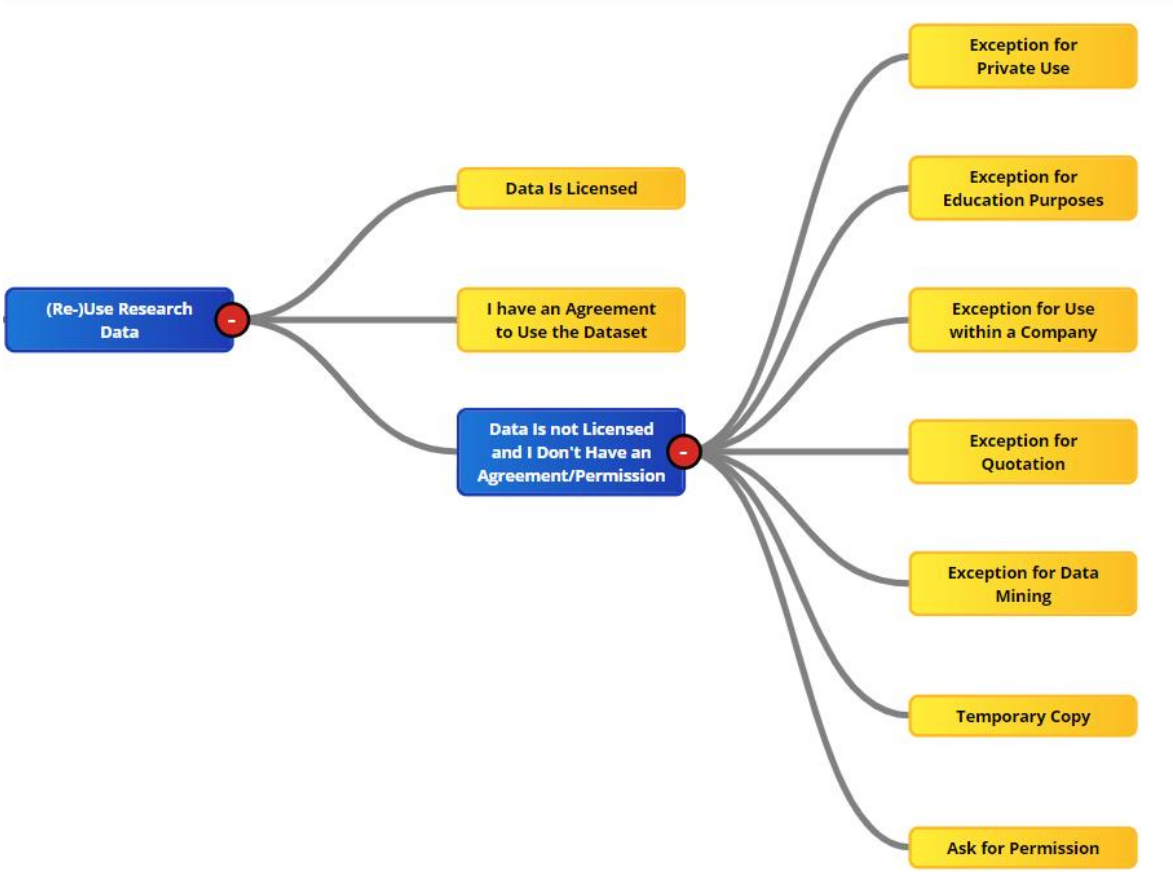
FAIR data exist under this legislation. As asserted by the EOSC Executive Board (2021, p. 70): 'The FAIR principles were born with research data. Today, applying FAIR principles has to be extended to the whole research lifecycle, to ensure transparency, assessment, attribution and reproducibility. For this to happen, all outcomes of science, such as data, software, other products and services, have to be FAIR.' Hence, FAIR guiding principles are not a theoretical static photograph that can be taken of a project at a certain moment of its life, but rather they constitute a lighthouse that guides permanently the activities that compose the whole research life cycle. When studying the data cycle of research projects, the following phases are applicable (Floridi, 2010, p. 8):

> occurrence (discovering, designing, authoring, etc.), transmission (networking, distributing, accessing, retrieving, transmitting, etc.), processing and management (collecting, validating, modifying, organizing, indexing, classifying, filtering, updating, sorting, storing, [normalizing] etc.), and usage (monitoring, modelling, analysing, explaining, planning, forecasting, decision-making, instructing, educating, learning, etc.).

The four phases of occurrence, transmission, processing and management, and usage exist in all the activities of which data, information or knowledge constitute the building blocks. Therefore, they are applicable to the daily work of all researchers 'whose activities are symbolic–based [and] are continuously creating, transmitting, managing and using data in a net woven and twisted with other participants' (de la Cueva, 2018, p. 10). This scheme of information management is valid for an analytical approach to the study of the data activities exercised by any type of organisation with multiple relationship between agents and where it is useful to understand the data cycle as a threefold entity composed of three scenarios for data-related activities: the first scenario is data-in, the second data-inside and the third data-out. The data-in scenario is when an organisation collects data. These data may either come from a third party or be constructed by activities carried out by the organisation through surveys, sensors, personal interviews, observations, etc. The second scenario, data-inside, is when an organisation transforms, orders, catalogues, analyses and deletes the data. The third scenario, data-out, corresponds to private delivery or public dissemination of the data.

The three-scenario approach may help to understand where the different activities regulated by IPR ([92]) are being carried out and thus where to deal with possible conflicts.

Figure 5.1. Reuse of research data

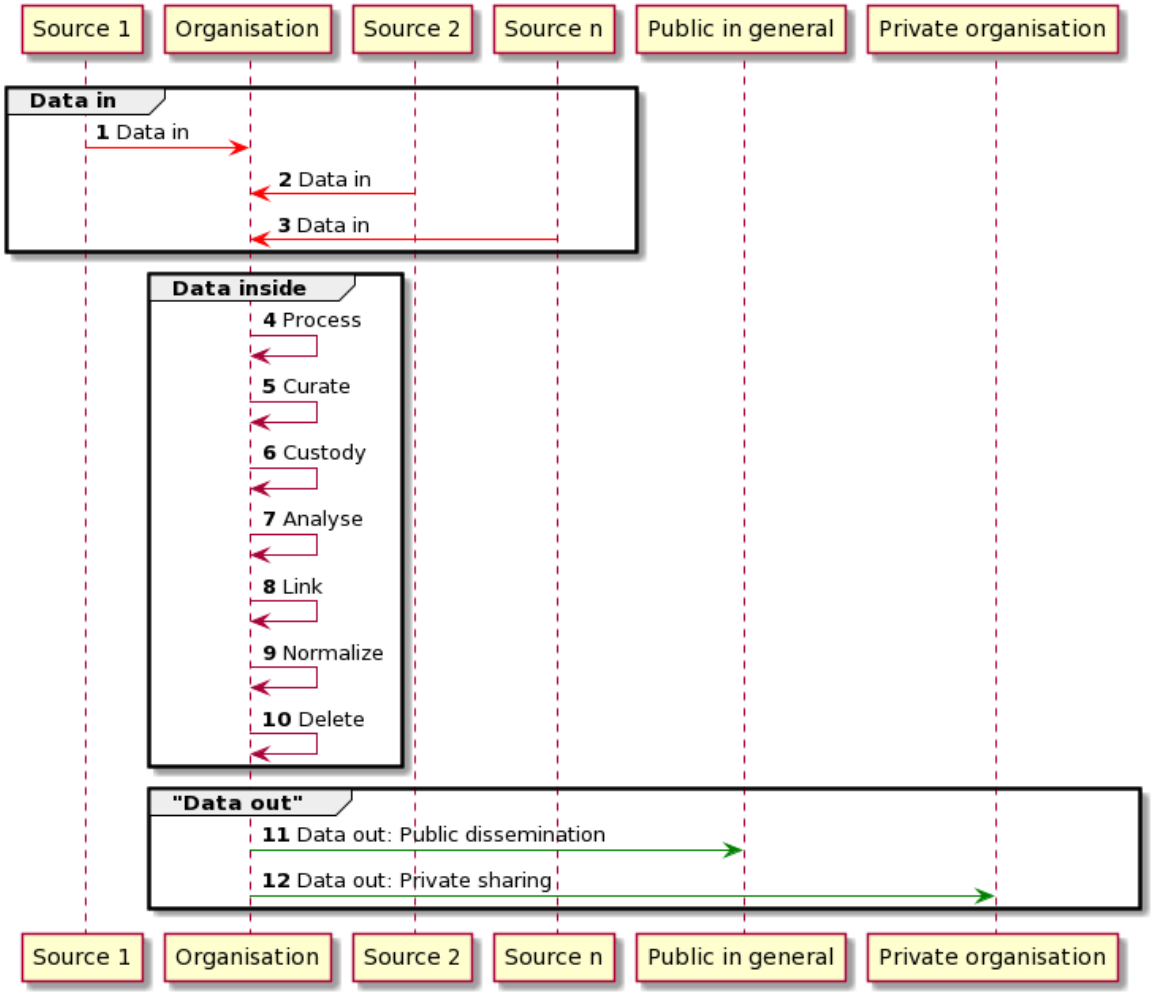


Source: DMlLawTool (https://dmlawtool.ccdigitallaw.ch).

The flow of information in the three scenarios has limits that depend on factors external to the agents involved: limits that enable, impede and/or hamper the information cycle. These limits are legal, economic and technical. In Table 5.2 we propose a data management scenario applicable to all organisations that manage digital data in their activities. The table uses the three-scenario approach and includes the activities normally exercised in every scenario and the legal, economic and technical aspects that may appear in each of the different activities.

([92]) This analytical approach was first proposed by and is being used in Food Nutrition Security Cloud (2021). The author of the deliverable is a co-author of this report. Parts of the deliverable are used in this subsection.

Figure 5.2. Activity diagram of data-in, data-inside and data-out



- In a data-in scenario, the only activity is collecting data, which may be newly created (survey, direct observation, sensors) or come from third-party materials (data either structured or unstructured, personal interviews, analysis of images, texts, audio, code).
- In a data-inside scenario, all the activities are inside an organisation. The typical activities consist in transformation of the data, such as processing, curating, keeping, analysing, normalising, deleting and linking it. Special care must be made to document the provenance of the data.
- In a data-out scenario, the main activity is the dissemination of the data, which may be done either privately to a known number of persons or to the public.

Table 5.1. Data activities and their barriers for interoperability

Scenario	Activities	**Legal issues**	**Legal checks**	**Economic barriers**	**Technical barriers**
Data-in	Collect	Privacy (GDPR) IPR Patents Company secrets Trademarks Personal image Respect for religion M&M clauses ([93]) National security Unknown origin (orphan works)	Apart from the ownership of the data, list the different rights and obligations that receiving the data may have. These limitations may come not only from IPR but also from a varied set of parameters (patents, religion, national security limits, hate speech, privacy, commercial secrets, etc.)	Financial burdens in favour of a third party: price, levies, fees, etc.	Hardware and software barriers Sensors Proprietary formats Superseded formats

([93]) M&M clauses take their name after a clause required in the agreements to be signed with the music group Van Halen. The agreements set forth the conditions of what was to be provided in the backstage area of the concerts and one term was that there should be M&M sweet but 'WARNING: NO BROWN ONES'. Although this seemed to be an irrational pop star condition, it was not: it was a way to check the care taken by the other contractual party in carrying out the agreement's conditions. Since then, it has been a tactic used by some lawyers to verify the attention paid to an agreement. See a copy of the Van Halen clause (http://www.thesmokinggun.com/file/van-halens-legendary-mms-rider?page=8).

Scenario	Activities	**Legal issues**	**Legal checks**	**Economic barriers**	**Technical barriers**
Data-inside	Process, curate, keep, analyse, link, normalise, delete	International transfers between bodies of the same organisation Consent extra limitations Anonymisation Pseudo-anonymisation	Analyse if the activities done inside the organisation are allowed by the legal conditions imposed by the data licence or transfer agreement	Payments between parent organisations and subsidiaries Costs in person-hours to clean, massage, order, structure and organise the data for internal use or external dissemination Hardware and equipment costs necessary to handle the data	Non-existent protocols Frankenstein architectures No standardisation inside the organisation or between parent bodies and subsidiaries
Data-out	Dissemination, distribution	Privacy (GDPR)[94] Licence Terms and conditions	Analyse if the dissemination is allowed by the legal conditions applicable to the data	Financial conditions in favour of the organisation not acceptable/ affordable for third parties	API documentation Obsolete/rotten websites Technologies soon to be superseded or changed (e.g. Apple USB stick)

Source: Food Nutrition Security Cloud project.

([94]) GDPR, general data protection regulation (Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC).

In order to be able to produce a more granular study of the IPR conditions of a project, the data cycle may be analysed taking into account the FAIR principles detailed below in Table 5.3 and their application in the three scenarios.

- Data-in: analyse the data to be used under the recommendations set forth by the EOSC FAIR Working Group. Grade the FAIRness of the data.
- Data-inside: analyse if the activities done by the organisation will affect the FAIRness of the data.
- Data-out: analyse if the organisation has contributed to making the data comply with more FAIR principles than when data came in. Grade the FAIRness of the data to build an indicator of the contribution of the organisation.

FAIR guiding principles impose certain conditions that could oblige certain activities to be carried out by the data manager, as envisaged specifically for reusability by Ignasi Labastida and Thomas Margoni (Labastida and Margoni, 2020), in the general and deep analysis of all FAIR data principles provided by Ohad Graber-Soudrey, Timo Minssen, Daniel Nilsoon, Marcelo Corrales, Jakob Wested and Bénédict Illien (Graber-Soudry et al., 2021), in *Legal Interoperability of Research Data: Principles and implementation guidelines* by the RDA-CODATA Legal Interoperability Interest Group (2016) and in Section 2.4. of the *EOSC Interoperability Framework* (Corcho et al., 2021).

Table 5.3. FAIR data principles underlying the role of licensing in reusability

Findable *The data and metadata can be found by the community after their publication, using search tools*	**Accessible** *(Meta)data are accessible and can therefore be downloaded by other researchers using their identifiers*
F1. Assign the (meta)data a globally unique and persistent identifier F2. Describe the data with rich metadata F3. Register/index the (meta)data in a searchable resource F4. The metadata should clearly and explicitly include the identifier of the data described	A1. (Meta)data are retrievable by their identifiers using a standardised communications protocol **A1.1. The protocols have to be open, free and universally implementable** A1.2. The protocol must allow for an authentication and authorisation procedure (where necessary) A2. The metadata must be accessible, even when the data are no longer available
Interoperable *Both the data and the metadata should be described following the rules of the community, using open standards, in order to allow for their exchange and reuse*	**Reusable** *(Meta)data can be reused by other researchers, since their origin and conditions of reuse are clear*

I1. (Meta)data must use a formal, accessible, shared and broadly applicable language for knowledge representation I2. (Meta)data use vocabularies that follow FAIR principles I3. (Meta)data include qualified references to other (meta)data	R1. (Meta)data have a plurality of accurate and relevant attributes **R1.1. (Meta)data are released with a clear and accessible data usage license** **R1.2. (Meta)data are associated with information on their provenance** **R1.3. (Meta)data meet domain-relevant community standards**

To conclude this section, it is clear that, when operating with data, there is an inherent risk of IPR infringement. Hence, in order to guarantee interoperability, it is necessary to check the validity of the consent of the rightholder or whether an exception/limitation applies.

Recommendation for practitioners

All organisations, when using data, should analyse the terms and conditions of each data set. If these are not clear or no consent has been given, then it should be treated as an 'all rights reserved' piece of information.

5.1.3. Free software

Apart from the studies abovementioned from Professor Yochai Benkler in *The Wealth of Networks* (Benkler, 2006), Professor Christopher M. Kelty has also made an important contribution to the study of free software in his work *Two Bits: The cultural significance of free software* (Kelty, 2008) on the massive production of software under free licences. He has also studied the scientific newsletters and their importance for OS (Kelty, 2012). The relevance of Kelty's book is explained in below (Kelty, 2008):

> Two Bits explains how Free Software works and how it emerged in tandem with the Internet as both a technical and a social form. Understanding Free Software in detail is the best way to understand many contentious and confusing changes related to the Internet, to 'commons,' to software, and to networks. Whether you think first of e-mail, Napster, Wikipedia, MySpace, or Flickr; whether you think of the proliferation of databases, identity thieves, and privacy concerns; whether you think of traditional knowledge, patents on genes, the death of scholarly publishing, or compulsory licensing of AIDS medicine; whether you think of MoveOn.org or net neutrality or YouTube – the issues raised by these phenomena can be better understood by looking carefully at the emergence of Free Software.

It is important to deny some extended theories that assert that free software creates 'largely outside IP', as some authors maintain (Jones, 2014, pp. 28–29). According to Jones, 'The fundamental principle of the open source approach is that either no one owns the IP, or that if they do, they grant everyone else royalty free licences for its use, development and wider application'. This is a common error because every free work is really owned by its author, in a conscious way. Authors exercise their rights in a gradient of possibilities that escape the traditional 'all rights reserved'. The question here is not if there is no IP, because it is evident that it exists and the authors are aware of their rights (why else would they license their works?) but how the rights are exercised. Jones continues: 'As Wikipedia itself puts it: "open source refers to a program in which the source code is available to the general public for use and/or modification from its original

design free of charge"'. But this really does not mean very much. A book has its source code available (letters, words, paragraphs, etc.) – it is the paradigmatic case of a work where the user can access what the author desires to transmit – but its 'openness' to be accessed does not imply the possibilities of exercising the legally interdicted activities of copying, altering, public communication or distribution. Even though the source code may be available, if it does not have a licence then it will be 'all rights reserved'. For this reason, for many years there has been a rich flourishing of different open source licences ([95]), which have adapted dynamically to new technological situations, as for example the General Public License (GPL) did when it upgraded from version 2 to version 3 on account of the appearance of digital rights management and patent deals (Stallman, 2014).

This generalisation, that free software is against copyright, is a common misunderstanding. Free software is another way authors have to exercise their copyright and then manage their intellectual assets. It does not mean that a work is free of copyright; it means that those rights are exercised in a different way from the traditional 'all rights reserved' paradigm. What these theories miss is that free software advocates the use of copyright to force the openness of their creations, which is a legitimate way to manage IP, often based on ethical considerations (Carver, 2005, p. 445; de la Cueva, 2013). The most important point that should be raised here is that the traditional IP concept of a 'work' was a fixed creation; that is to say, after 'the sweat of the brow' a static final result was obtained (a book, a film, a song, a photograph, an invention, a logo, etc.). This final result was a static product in which all the creative actions were solidified. But the free software IP concept protects not a work per se, but a process, guaranteeing that this process could not be stopped. Therefore, the traditional copyright is underpinned by a view of protecting static products, whereas free software creation is based on protecting the dynamic process.

That free software creates largely inside IP is also evidenced by the vigorous discussions held inside developers' communities, from which two opposite poles emerged. On one hand, some use the GPL, drafted in 1989 by Richard Stallman, which includes what has been called a 'copyleft' clause ([96]), a provision that permits reproduction and distribution of the source code of a programme, 'but does not allow anyone to place further restrictions on them' (Heffan, 1997, p. 1491), requiring at the same time that works deriving from the work under the GPL must be licensed under the GPL as well. For Stallman, who channelled his efforts through the Free Software Foundation (FSF), the main focus of importance was the developer's freedom. On the other hand, a group concerned about Stallman's anti-business message decided in early 1997 to use the term 'open source' instead of 'free software'. The licences adopted by this group allowed 'the use and redistribution of open-source software without compensation or even credit' (DiBona et al., 1999, p. 3), which included the possibility of appropriating prior code inside a derivative work, and therefore the possibility of closing the initial work. Their focus was the expansion of open-source works. Works made by both groups are now known jointly under the term 'free and open-source software' (FOSS), whose principles have been widely studied by many scholars (Benkler, 2006; Carver, 2005; DiBona et al., 1999; Heffan, 1997; Kelty, 2008; Lessig, 1999; Olwan, 2013; Raymond, 1999; Stallman, 2002; Torvalds and Diamond, 2002). Olwan analyses this new paradigm using the following approach (Olwan, 2013, pp. 266–268):

> The Free and Open Source Software (FOSS) methodology has challenged traditional approaches to copyright management by using copyright to build 'openness' and reuse. In doing so, it not only has shown new ways for managing

([95]) https://opensource.org/licenses/category

([96]) 'Copyleft is a general method for making a program (or other work) free (in the sense of freedom, not "zero price"), and requiring all modified and extended versions of the program to be free as well' (https://www.gnu.org/licenses/copyleft.en.html).

> copyright but also has underpinned new methods for constructing and disseminating knowledge. To some extent, it has been seen to put the power to develop and share knowledge and technology in the hands of users rather than of an elite or cloistered group of experts. To this end, it has great significance for developing countries.
>
> […]
>
> Many copyright systems, particularly those in common law jurisdictions, are based on the 'stimulus' or 'reward' or 'utilitarian' theories. These legal systems justify giving limited property rights (copyright) to the author for the creative work that has been presented to the public. Without adequate compensation and protection of the work, the author would not invest time and effort in producing creative work and society would suffer as a result. FOSS challenges this long-established justification theory of copyright by proving that this is certainly not true for certain collaboration projects where the author produces software without being stimulated by the 'reward theory', as known in copyright. Furthermore, FOSS challenges the 'personal theory', which justifies giving protection to authors in continental European civil law system jurisdictions by not considering their work to be a stamp of their singular personality but accepting that it might be altered by others for the purpose of contributing to a larger discourse and common goal. The FOSS movement challenges the traditional notions of copyright by describing alternative approaches to software copyright protection and licensing as 'copyleft'. This logic, which challenges the 'reward' and 'personal' theories of copyright, and the philosophy of encouraging authors to be more tolerant toward others in terms of sharing and building on their work, is an interesting subject of research in FOSS and IT.

The reference made by Olwan to 'certain collaboration projects' in which the author produces software without being stimulated by the 'reward theory' is not only applicable to software. As Peter Suber states, 'scholarly journals generally don't pay authors for their research articles, which frees this special tribe of authors to consent to OA without losing revenue. This fact distinguishes scholars decisively from musicians and moviemakers, and even from most other kinds of authors' (Suber, 2012, p. 9). What is relevant is that IP is a tool that may serve either to protect the fixation of a work using the 'all rights reserved' system or, as the case may be, to protect the openness of a stream where the work is inserted as one of its constitutive elements.

There is an additional approach that is not found in the literature reviewed but provides elements for ICT analysis. As stated before, data and information in the digital world are just a list of ones and zeros. Some lists are executable; they are called software. Some lists do not have that function; they are just information, which is then managed by software, although Grimmelmann's opinion is that 'a Word document is also a program, one that tells Word itself what characters to display and how to format them' (Grimmelmann, 2016, p. 409). In any case, software is written in formal languages and, according to Charles W. Morris (1971, p. 25):

> A language, then, as a system of interconnected signs, has a syntactical structure of such a sort that among its permissible sign combinations some can function as statements, and sign vehicles of such a sort that they can be common to a number of Interpreters. … so a language is completely characterized by giving what will later be called the syntactical, semantical, and pragmatical rules governing the sign vehicles.

Morris considers that a language has three layers: the signs (or the syntactic), the semantics, which 'deals with the relation of signs to their designata and so to the objects which they may or do denote' (p. 35) and the pragmatics, which refers to the usage of

a linguistic sign in combination with other signs by the members of a community. 'In short, to understand a language or to use it correctly is to follow the rules of usage (syntactical, semantical, and pragmatical) current in the given social Community' (p. 48). When dealing with knowledge, it can be said that the scientific work may be done in any of the three layers: operating in the syntactics (or the source code of software), in the meanings of the information or in the social relationships that are, as John Searle puts it, building the institutions (Searle, 2010, pp. 90–122).

An example for jurists could be as follows. The source code of law is the word. Law is built with words that make sentences (syntactics), and a long tradition gives these words the meanings (semantics). Through these laws, institutions are built. Fortunately for jurists, they may use the words and sentences they consider appropriate when regulating a domain. They do not have to include in the legislative proposal whole immutable blocks of text that come from a company in Silicon Valley and contain content they will never be able to know. The more granularly the jurists may operate, the better they can tailor a norm to the policy needed. This immutable block system, which seems irrational when creating laws, is simply what is happening within the digital environment.

When it comes to science, access to source code is not only a matter of IPR but also the necessary requirement to operate at all knowledge levels: syntactic, semantic and pragmatic. Therefore, access to and operability of source code (copying, modification, dissemination) form one of the core aspects of OS not because of IP, but rather because of epistemology and technological sovereignty (Lafuente et al., 2009). The effects do not stop here: access to source code is necessary for cybersecurity (see Scarfone et al., 2008), to create societal, economic and political advancement and for respect of privacy. Carissa Véliz asserts that 'Privacy and ethics have to be requirements from the very start of any tech project' (Véliz, 2020, p. 199), which is in accordance with the need for access to the algorithm source (source code), for which activists in Europe concerned with privacy are fighting ([97]).

Hence, recommendations that assert that 'Supporting Open Source licences as the preferred licensing model for software involved in digital standards could hamper the development of the Digital Single Market. It would prevent the creation of technology-based start-ups in the digital field' (EARTO, 2020, p. 9) should be read with caution, as standards, by their own nature, must always be open. Note also that the recommendation is speculative, as there is no evidence of what affirms, and that transparency is needed when the source code is used by a public organisation and it is managing private data.

This possibility for the scientist to tinker with the code must be guaranteed at any stage of the process. Given the movable nature of the subject matter of any scientific discipline, the most appropriate IP licences are the ones that promote openness, because they give permission to develop the scientific research while simultaneously allowing the project to be sustained by all stakeholders, and not only by a subgroup of agents authorised by the rightholders, using an IP limitation or operating in a scientific field where the works are in public domain. This last possibility is the opposite to the current state of affairs.

Finally, the report on *The impact of open source software and hardware on technological independence, competitiveness and innovation in the EU economy* (Blind et al., 2021)

([97]) The resolution of the Dutch Rechtbank Den Haag dated 5 February 2020 (https://uitspraken.rechtspraak.nl/inziendocument?id=ECLI:NL:RBDHA:2020:865, in Dutch) is a landmark in algorithm transparency. It obliges the Dutch government to allow access to the source code of software used by the public administration. The court bases its decision on Article 8 of the Charter of Fundamental Rights of the European Union (privacy).

includes an extensive analysis of 'the economic impact of Open Source Software (OSS) and Hardware (OSH) on the European economy. It was commissioned by the European Commission's DG CONNECT'. According to its abstract (p. 14):

> It is estimated that companies located in the EU invested around € 1 billion in OSS in 2018, which resulted in an impact on the European economy of between € 65 and € 95 billion. The analysis estimates a cost–benefit ratio of above 1:4 and predicts that an increase of 10 % of OSS contributions would annually generate an additional 0.4 % to 0.6 % GDP [gross domestic product] as well as more than 600 additional ICT start-ups in the EU. Case studies reveal that by procuring OSS instead of proprietary software, the public sector could reduce the total cost of ownership, avoid vendor lock-in and thus increase its digital autonomy.

The recommendations of this last document are structured along three dimensions: a digitally autonomous public sector; open research and development enabling European growth; and a digitised and internationally competitive industry (pp. 314–343). There is no doubt that a better balance between the IPR of free software authors and OS may be reached through the development of public policies.

Recommendations for practitioners

Lessons can be learnt from the free software communities:

- licence diversity: the possible activities that the creator may allow the users to exercise are innumerable, although a side effect of using different licences is that they may be incompatible;
- awareness of the necessity of including a licence to avoid the 'all rights reserved' by default system;
- inclusion of licences within the source code: the licence should be included as a text file in the source code trunk, which raises an author's awareness of the necessity for a licence;
- awareness of the necessity for the licence to be updated because of changes in the technological or legal context;
- building tools to standardise the references to licences and to make them readable by both humans and machines;
- existence of communities that take care of projects' sustainability;
- the ethos of 'release early, release often'.

Recommendations for policymakers

Institutionalise FOSS through the design of European organisations to increase European open-source institutional capacity.

- An Office for Free Intellectual Property Rights and Open Science should be created. This office can be inspired by the functioning of the Office for Harmonization in the Internal Market and the European Observatory on Infringements of Intellectual Property Rights (EU 386/2012) and should be

aligned with the EU IP action plan. It could be piloted through the Horizon Europe Framework Programme.

5.2. Specific intellectual issues

In this subsection, four specific IP-related issues are analysed. They represent four items in which IPR have an impact in daily activities carried out by scientists when managing data. Awareness of these points would avoid the risk of IP infringement faced by scientists or the organisations they belong to.

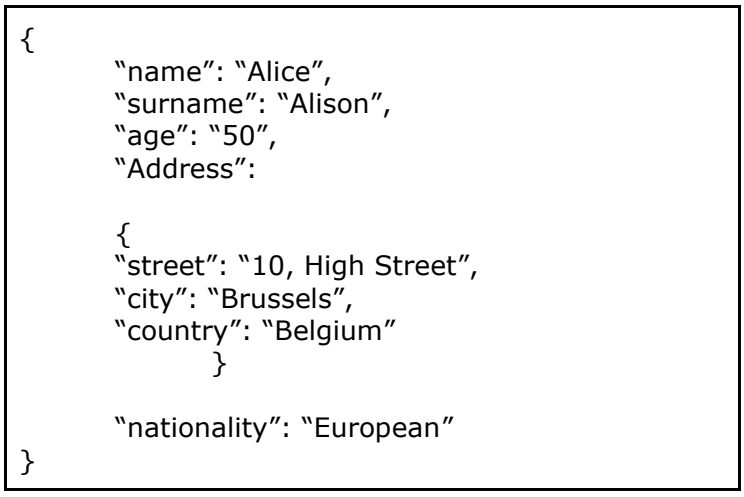
5.2.1. Application programming interfaces, taxonomies and ontologies

One of the most common ways to interchange data in ICT is through APIs. An API is an endpoint in a server where a computer client connects and, after it makes a request, the server allows the client to copy data. This connection may be with or without authentication. The copied data are usually structured.

When an API is designed, several intellectual activities must be performed. A necessary condition for an API is that the information to be shared must be structured into its relevant entities, that is to say, the developer creates a taxonomy and decides how its integrants relate to each other, which in this case is called ontology. Once a decision is made on the structure and the components of the information, it is necessary to determine which parts of the structure will be exposed, so they can be shared. Therefore, there are decisions on what categories are relevant to the specific knowledge domain the API is designed for and which ones are chosen for sharing, building a pattern of information. When a client machine contacts the server at the API and makes a request, the server responds by passing the categories with an attached set of attributes that correspond to the defined categories.

The data referring to a person can be self-explanatory. For example, the relevant entity is a person, and the categories would be the name, the surname, the age, the address and the nationality. When the API is called, the structure of the data is passed from the server to the client with the attributes that correspond to a specific person.

Figure 5.2. Example of information collected from an API and its structure



Therefore, in the functioning of the APIs, it is not only data that are passed to a third party, but also a way to represent (or structure) some information ([98]). As is known, one of the challenges ICT-driven science is facing is how to build taxonomies and ontologies that represent the scientific domain. This materialised representation of scientific domains represented as taxonomies and ontologies and disseminated through APIs is an intellectual work regulated by IPR.

Recommendation for practitioners

In order to avoid friction points, it is recommendable to expressly mention the legal conditions to access an APIs, waiving the IPR through free licences to make it free (de la Cueva, 2008).

5.2.2. Hyperlinks and persistent identifiers

Hyperlinks need special attention. When enriching data with metadata to apply the FAIR principles, the data scientist adds some meaningful information to a data set. The information is added, in a very significant number of cases (data provenance, persistent identifiers (PIDs), digital object identifiers, international standard book numbers, etc.), as a hyperlink in the form 'http://…'.

Unlike in the United States, hyperlinking has been considered in the EU an activity that implies public communication of the linked object. Therefore, a PDF version of this report read in the EU communicates to the public all the works that are referred to herein with a hyperlink, that is to say, the bibliographic items in the References section that include 'http//…' and the hyperlinks in the footnotes.

In order to understand the issue, a series of antecedents must be explained. One of the IPR battles that were finally resolved by the Court of Justice of the European Union (CJEU) was whether a hyperlink was an activity that served to communicate a work to the public. The problem arose from the existence of websites ([99]) whose only content were hyperlinks to files hosted in user networks connected through peer-to-peer software. The nature of a hyperlink is of metadata: it is data that represent other data, but it is not an intellectual work per se because its nature is a pure reference, such as an international standard book number, a DOI, the serial number of a computer or a car registration plate. Thus, a hyperlink is a linguistic element, a reference, that represents an object different from the hyperlink. US courts have understood this nature and have not included hyperlinking as an activity that results in public communication of a work, although it may contribute to infringement, which is a different category. In the United States, linking is an activity that does not constitute a copyright infringement.

In the EU, the Decision of the European Court of Justice ([100]) dated 13 February 2014 gave a different response in the case *Nils Svensson and Others* v *Retriever Sverige AB*. Even though a group of highly regarded scholars of the European Copyright Society (Bently et al., 2013) recalled the words of Tim Berners-Lee, inventor of the web, 'a standard hyperlink is nothing more than a reference or footnote, and that the ability to

([98]) A more complex definition of an API can be found in the US Supreme Court judgment of 5 April 2021 in the case *Google LLC* v *Oracle America, Inc.* (https://www.supremecourt.gov/opinions/20pdf/18-956_d18f.pdf). This ruling does not enter into the 'transmission' of information through copying, but deals with the legal nature of the act of Google in copying approximately 11 500 lines of code. The court finally declared that the act was covered under the doctrine of fair use, resolving thus that it did not constitute IPR infringement.

([99]) Pirate Bay is the most notorious. It is still online.

([100]) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:62012CJ0466

refer to a document is a fundamental right of free speech' ([101]), the CJEU declared that 'the provision of clickable links to protected works must be considered to be "making available" and, therefore, an "act of communication"' but, the ruling continued:

> None the less, according to settled case-law, in order to be covered by the concept of 'communication to the public', within the meaning of Article 3(1) of Directive 2001/29, a communication, such as that at issue in the main proceedings, concerning the same works as those covered by the initial communication and made, as in the case of the initial communication, on the Internet, and therefore by the same technical means, must also be directed at a new public, that is to say, at a public that was not taken into account by the copyright holders when they authorised the initial communication to the public.

A decision of the CJEU dated 9 March 2021 ([102]), in a case that involved the German cultural heritage foundation Stiftung Preußischer Kulturbesitz and a German collectors' society, concluded that the activity of framing (including displaying in one's website parts of another) is also an activity that requires consent from the copyright holder. The activity analysed in the conflict was described as follows:

> (10) The DDB [Deutsche Digitale Bibliothek] website contains links to digitised content stored on the internet portals of participating institutions. However, as a 'digital showcase', the DDB itself stores only thumbnails, that is to say smaller versions of the original images of the subject matter. When the user clicks on one of those thumbnails, he or she is redirected to the page concerning the particular subject matter on the DDB website, which contains an enlarged version of the thumbnail concerned, with a resolution of 440 by 330 pixels. When that enlarged thumbnail is clicked on, or the 'magnifying glass' function is used, a further enlarged version of the thumbnail, with a maximum resolution of 800 by 600 pixels, is overlaid by means of a 'lightbox'. Further, the 'Display object on original site' button contains a direct link to the website of the institution providing the subject matter, either to its home page or to the page relating to that subject matter.

The importance of this ruling is that it summarises the case-law of the CJEU related to hyperlinking. For the CJEU, hyperlinking is a communication to the public activity, but it understands that on the internet:

> (38) … in a situation in which an author gives prior, explicit and unqualified authorisation to the publication of his or her articles on the website of a newspaper publisher, without making use of technological measures restricting access to that work from other websites, that author may be regarded, in essence, as having authorised the communication of that work to all internet users.

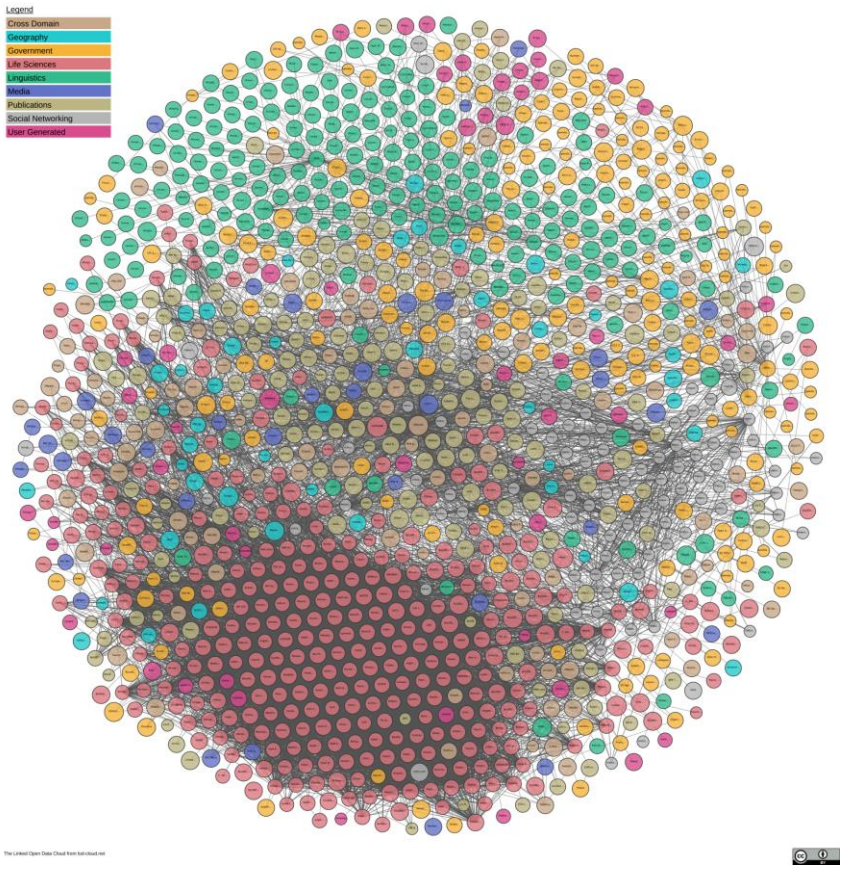
Therefore, the key element to understanding that there is no infringement is that the work is publicly available on the internet, and the access to it does not contravene any technological measures.

The CJEU understanding of hyperlinking as an act of communication to the public is bad news for ICT data-driven science ([103]), because it produces, again, a hostile environment for OS. As stated under one of UNESCO's core OS principles, quality and integrity: 'Open

([101]) https://www.w3.org/DesignIssues/LinkMyths.html
([102]) https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:62019CJ0392
([103]) And good news for the entertainment industry. Although all rulings from CJEU insist on the rights of the 'authors', it would be very interesting to know how many of the exclusive rights remain in the authors' domain and have not been waived to the organisations or companies they work for. No data analysing this fact have been found.

Science should support high quality research by bringing together multiple sources of knowledge and making research methods and outputs widely available for rigorous review and scrutiny'. There are two sources of IPR risk: first, OS projects are built to bring together multiple sources either by hosting or by linking to them; second, the purpose of data-driven science is to establish connections between disciplines, and this is done by linking ontologies to build what are known as linked open data (Figure 5.4). In line with the CJEU's view, when an ontology links to another, then an activity of communicating it to the public is exercised. The main intention of this report is not to criticise how legal operators understand technology but to identify the friction points, and this is one. Therefore, special care is required when 'bringing together multiple sources of knowledge' using hyperlinking technology to ensure the source is not protected by technological measures. Nevertheless, as Canada's Supreme Court stated that 'inserting a hyperlink into a text gives the author no control over the content in the secondary article to which he or she has linked', then a hyperlink that is legal today can become illegal tomorrow because of a change in the linked object. This risk does not exist if the hyperlinking is made in Canada or in the United States to content hosted in either of those countries.

Figure 5.3. The linked open data cloud



Source: https://lod-cloud.net, 05-May-2021, CC-BY.

This IP risk is embedded at the core of the development of the EOSC. The report *A persistent identifier (PID) policy for the European Open Science Cloud (EOSC)* (European Commission, Directorate-General for Research and Innovation and EOSC Executive Board, 2020) asserts that a PID is resolvable when it allows both human and machine users 'to access … a digital object, a digital representation, or information on how the object can be accessed'. PIDs are used 'to support a functioning environment

of FAIR research' and they are a type of hyperlink with a defined scheme that 'can identify many different entities. These can be born digital (e.g. documents, data, software, services – otherwise known as digital objects – and collections made of them), physical (e.g. people, instruments, artefacts, samples), or conceptual (e.g. organisations, projects, vocabularies)'. Under the CJEU doctrine, a PID that identifies a digital object performs an activity of communicating the object to the public.

In conclusion, when hyperlinking to third-party content, it is not necessary to obtain consent except in those cases where the link circumvents technological measures. Of course, this rule does not apply to content whose licence allows its public communication. Nevertheless, special attention must be taken when hyperlinking, because, as the CJEU case-law demonstrates, it implies an inherent risk of IP infringement.

Recommendation to policymakers

This report recommends an EU legislative amendment to define hyperlinks as a mere linguistic reference.

5.2.3. Text and data mining

Before the copyright reform included in the 2019 directive, TDM was discussed and studied extensively in the European Commission context in various reports from expert groups (Geiger et al., 2018; Hargreaves et al., 2014; Triaille et al., 2014). In 2015, led by the European Association of Academic Libraries, a group of experts also made The Hague Declaration on Knowledge Discovery in the Digital Age ([104]). This declaration underlined the benefits of content mining for current research and claimed an exception from IPR for TDM, on the basis that IP was not designed to regulate the free flow of data, ideas and facts, but has the key objective of promoting research activity. In 2018, the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the request of the Committee on Legal Affairs undertook an in-depth analysis of the proposed exception for TDM in the then-proposed directive on copyright in the digital single market, which introduced a mandatory exception to allow the carrying out of TDM of protected works, assessing its positive and negative impacts (Geiger et al., 2018).

According to Jean-Paul Trialle et al. (2014), mining of text is just one subset of mining of data. To keep it simple, data mining has been defined as the extraction of knowledge from data according to data science principles (Provost and Fawcett, 2013, p. 2). This technique may involve the activities of reproduction of text and data, and 'reproduction, translation, adaptation, arrangement, and any other alteration of a database protected by copyright'. Thus, it 'might infringe *sui generis* database rights, in particular the extraction – and to a minor extent the re-utilization – of substantial parts of a database' (Geiger et al., 2018, pp. 6–7). It is a technique widely used and necessary in data-driven science.

The copyright reform introduced by Directive (EU) 2019/790 ([105]) included an exception in Article 3(1) 'for reproductions and extractions made by research organisations and cultural heritage institutions in order to carry out, for the purposes of scientific research, text and data mining of works or other subject matter to which they have lawful access' and another exception in Article 4 'for reproductions and extractions of lawfully accessible works and other subject matter for the purposes of text and data mining'. This proposal was criticised by the European Copyright Society ([106]) and the Max Planck

([104]) https://libereurope.eu/the-hague-declaration
([105]) https://eur-lex.europa.eu/eli/dir/2019/790/oj
([106]) https://europeancopyrightsocietydotorg.files.wordpress.com/2015/12/ecs-opinion-on-eu-copyright-

Institute for Innovation and Competition ([107]) for, among other reasons, the limited number of organisations that could exercise the activity, being only research organisations and cultural heritage institutions (but not data-driven journalists), and the obligation of these organisations to store the databases in such a way as to prevent unauthorised uses by third parties. The final wording of Article 3(3) reads as follows: 'Rightholders shall be allowed to apply measures to ensure the security and integrity of the networks and databases where the works or other subject matter are hosted. Such measures shall not go beyond what is necessary to achieve that objective.'

On the other hand, the UNESCO OS core values of inclusiveness and diversity have the following meanings according to the previously mentioned draft recommendation (UNESCO, 2021a):

> (iv) Diversity: Open Science should embrace a diversity of practices, workflows, languages, research outputs and research topics that support the needs and epistemic pluralism of diverse research communities, scholars, knowledge holders and social actors from different countries and regions;
>
> (v) Inclusiveness: In the common pursuit of new knowledge, Open Science should meaningfully engage the whole scientific community, as well as the wider public and knowledge holders beyond the institutionalized scientific community, including indigenous peoples and other traditional communities, engages the scientific community as a whole, as well as the wider public and knowledge holders.

As remarked above, the exception for TDM regulated in Directive (EU) 2019/790 ([108]) requires that the activity be conducted by research organisations and cultural heritage institutions. According to the directive's wording, these organisations are the only ones allowed to legally conduct TDM activities, as the norm only includes these two types. However, as is widely known and encouraged by EU policies, science is made not only by professionals who carry out activities in a formal organisation but also by a myriad of other agents who produce knowledge, including citizen scientists. This is evident in many European Commission-funded projects, such as Plastic pirates ([109]), and it is defended by associations such as the European Citizen Science Association, and also in other countries such as Australia (Australian Citizen Science Association) and the United States (Citizen Science Association). Science must be open to be produced by everybody, without exception, and the current directive excludes participants in citizen science from performing TDM activity. Therefore, its current wording is contrary to UNESCO's core values.

Recommendation to policymakers

This report recommends an EU legislative amendment to expand the TDM copyright exception to match UNESCO's diversity and inclusiveness values.

5.2.4. Levies on remuneration rights

As evidenced throughout this report, IP norms, organisations, institutions and scholars mainly think of commercial IP, forgetting about internet protocols which can be used for free (in both senses of without charge and with no IP restrictions). The *Padawan* case ([110]), resolved by the CJEU in its ruling dated 21 October 2010, demonstrated that

reform-def.pdf

([107]) https://www.ip.mpg.de/fileadmin/ipmpg/content/stellungnahmen/MPI-Position-Paper_TDM_2017-01-14-corr_def.pdf

([108]) https://eur-lex.europa.eu/eli/dir/2019/790/oj

([109]) https://www.plastic-pirates.eu

([110]) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:62008CJ0467

all the digital reproduction equipment, devices and media of a Member State were subject to the levy on private copying ([111]). As the ruling states, 'the indiscriminate application of the private copying levy to all types of digital reproduction equipment, devices and media, including in the case expressly mentioned by the national court in which they are acquired by persons other than natural persons for purposes clearly unrelated to private copying, does not comply with Article 5(2) of Directive 2001/29'.

Another example may be found in Directive 2006/115/EC of 12 December 2006 on rental right and lending right and on certain rights related to copyright in the IP field. Article 5(2) says that 'The right to obtain an equitable remuneration for rental cannot be waived by authors or performers', and Article 6(1) that 'Member States may derogate from the exclusive right provided for in Article 1 in respect of public lending, provided that at least authors obtain a remuneration for such lending. Member States shall be free to determine this remuneration taking account of their cultural promotion objectives.' As is evident, OS dissemination is subject to this remuneration, which is collected through private agencies. The limitation to the exception included in Article 10(1)(d), related to the sole use 'for the purposes of teaching or scientific research', forgets the necessary scientific public dissemination. Therefore, a sole commercial understanding of IP produces a burden on OS, with no compensation paid back from the collecting agencies to science. It is paradoxical that Wikipedia, an IP work to which thousands of authors contribute, is ignored by the collecting agencies promoting culture.

As a final analysis related to this topic, Directive 2001/29/EC includes in Article 5 the exceptions and limitations listed in Table 5.4.

Table 5.2. Exceptions included in Article 5 of Directive 2001/29/EC

Limitation	Right/activity	Levy
Temporary acts	Reproduction	No
Reproductions on paper (photographic technique)	Reproduction	Yes
Reproductions on any medium – private copy	Reproduction	Yes
Reproductions by libraries, education, museums	Reproduction	No
Ephemeral recordings of works made by broadcasting organisations	Reproduction	No
Reproductions of broadcasts made by social institutions	Reproduction	Yes
Illustration for teaching or scientific research	Reproduction	No

([111]) The levy was even paid on the CDs for the recordings of courts' public hearings.

Limitation	Right/activity	Levy
Uses for the benefit of people with a disability	Reproduction and communication to the public ([112])	No
Reproductions by the press of notable works (under conditions)	Reproduction and communication to the public	No
Quotations for purposes such as criticism or review	Reproduction and communication to the public	No
Public security, administrative, parliamentary or judicial proceedings	Reproduction and communication to the public	No
Use of political speeches and extracts from public lectures	Reproduction and communication to the public	No
Use in religious celebrations or official celebrations	Reproduction and communication to the public	No
Works of architecture or sculpture located permanently in public places	Reproduction and communication to the public	No
Incidental inclusion of a work in other material	Reproduction and communication to the public	No
Advertising a public exhibition or sale of artistic works	Reproduction and communication to the public	No
Caricature, parody or pastiche	Reproduction and communication to the public	No
Demonstration or repair of equipment	Reproduction and communication to the public	No
Use of a work for the purposes of reconstructing a building	Reproduction and communication to the public	No
Dedicated terminals on premises of libraries, educational establishments or museums	Reproduction and communication to the public	No
Analogue uses of minor importance	Reproduction and communication to the public	No

([112]) Rights of reproduction and communication to the public under these exceptions can include the right to distribute the work.

Recommendation to policymakers

Adapt the current legislation to include clear and stronger exceptions for OS.

5.3. Basic science and intellectual property rights

Understanding IPR in only the commercial sense will miss an essential point for OS: the importance of basic science. The literature is full of examples of the importance of basic science, but two will serve for the purpose of this report. The first one refers to clustered regularly interspaced short palindromic repeats (CRISPR), the second to polymerase chain reaction (PCR).

Around the early 1990s, Francisco Mojica, a researcher at the University of Alicante, Spain, was trying to understand how an archaeal organism, *Haloferax mediterranei*, could survive in the coastal salt marshes of Santa Pola. When sequencing its DNA, he discovered repetitions that he first thought were errors that arose from the methodology they used. On 21 August 1992, he was writing down the letters dictated by his assistant Francisco Soler, so he asked him to be careful, as he had repeated some sequences. Mojica checked the results and discovered 14 repetitions in the *Haloferax mediterranei*. Years before, in 1987, Japanese researchers under the direction of Atsuo Nakata had also discovered repetitions in the DNA of the bacterium *Escherichia coli*, and in 1991 Dutch researchers under the supervision of Jan van Embden, discovered repetitions in *Mycobacterium tuberculosis*. The three organisms were so different that an interchange of DNA between them was out of the question, so Mojica devoted his time to finding a plausible reason. He found it in 2003, when he discovered that the spaces between repetitions were part of the immune system of the organism. He coined the term CRISPR in an email interchange with the Dutch researcher Ruud Jansen. Years later, these repetition patterns were used by Jennifer Doudna and Emmanuelle Charpentier to create a tool to edit genes. Thanks to their tool, they received the Nobel Prize in Chemistry in 2020 (Montoliu and Martínez Mojica, 2020, pp. 40–59).

The second example begins with Thomas D. Brock who discovered a high-temperature bacterium in Yellowstone National Park, which he named *Thermus aquaticus.* This organism lived at between 50 ° and 80 °C, and his discovery was published in 1967 in the journal *Science*, which spurred on research on thermophiles. This research led to the understanding of how the enzyme Taq DNA polymerase works and its use in the technique known as PCR. In 1993, Kary Mullis was awarded the Nobel Prize in Chemistry for his invention of PCR (Briones Llorente, 2020, pp. 82–83), which has proven to be instrumental in the diagnostic of the COVID-19 disease.

The two above examples lead to the same conclusion: the importance of basic science as a driver of future IPR (patents in the above cases). A good practical example of the importance of open science–open innovation in the context of new knowledge valorisation is the EU project Spoman ([113]), in which researchers from different disciplines work together with large companies and small and medium-sized enterprises to translate industrial challenges into basic research. Promotion of basic science is key, owing to its essential importance for applied science. Nevertheless, the evaluation of basic science through IPR (copyright or patent) indicators should be further analysed because basic science belongs to a stage where the results are not obvious.

([113]) https://spoman-os.org

6. SCOPE OF 'AS OPEN AS POSSIBLE, AS CLOSED AS NECESSARY'

6.1. Generic considerations

In the literature review, few studies have been found that address the expression 'as open as possible, as closed as necessary' with reference to OS. When it is tackled, they only occasionally refer to the reusability of the data and their licences (Labastida and Margoni, 2020). It is much more common that this expression relates to the accessibility of the data due to another legal issue, privacy, instead of copyright (Landi et al., 2020). The statement 'as open as possible, as closed as necessary', overcited and beautifully phrased, is very difficult to pin down in practice. It has become the principle to define the balance needed between openness and protection of scientific information, particularly in the context of research data. This principle became popular in the recommendations for research data management in Horizon 2020. It was first established as part of the specifications of the ORD pilot in the rules for 2016 ([114]) and then extended to all Horizon 2020 projects ([115]). The ORD pilot aimed to improve and maximise access to and reuse of research data generated in European Commission-funded projects, and explicitly took 'into account the need to balance openness and protection of scientific information, commercialisation and Intellectual Property Rights, privacy concerns, and security, following the principle "as open as possible, as closed as necessary"' (Burgelman et al., 2019, p. 3).

The expression is mentioned in paragraph 10 of UNESCO's (2021a) draft recommendations, and includes two types of limitations, the first referring to the nature of the information and the second regarding its ownership. This paragraph draws the boundaries between 'open' and 'closed', taking sides in favour of openness but allowing exceptions:

> Scientific outputs should be as open as possible, and only as closed as necessary. Open Science affords necessary protection for sensitive data, information, sources, and subjects of study. Proportionate access restrictions are justifiable on the basis of national security, confidentiality, privacy and respect for subjects of study. This includes legal process and public order, trade secrets, intellectual property rights, personal information and the protection of human subjects, of sacred indigenous knowledge, and of rare, threatened or endangered species. Some research results, data or code that is not opened may nonetheless be made accessible to specific users according to defined access criteria made by local, national or regional pertinent governing instances. The need for restrictions may also change over time, allowing the data to be made accessible at a later point.

This expression has become commonplace and it would be useful to analyse it through the interpretation of the four ambiguous terms 'open', 'close', 'possibility' and 'necessity' that it contains. A spectrum exists from closed to open, which depends on various parameters (see Table 6.1) such as knowing that the information exists, physical access to the container where the information (e.g. the document) is stored and to its content, being able to understand the code in which the content is written and, finally, its usage

([114]) https://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-data-mgt_en.pdf

([115]) The ORD pilot was extended from 2017 to all Horizon 2020 projects, as can be seen in the annotated model grant agreement (2019) (https://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/amga/h2020-amga_en.pdf#page=243).

conditions. 'Closed' and 'open' are not two opposed states of the same binary reality, but opposite ends of a continuum that accepts different grades of openness.

Table 6.1. Parameters of access to and usage of information

Parameter	Type of parameter
Knowing the information exists	Epistemological
Access to the container of the information	Physical
Access to the content	Physical
Understanding the content	Epistemological/legal ([116])
Content limited by the nature of the information	Legal
Content limited by ownership	Legal

Given the focus of this report, neither the epistemological nor the physical parameters will be studied. Regarding the epistemological issues, cognitive success as a precondition for OS is the subject matter of philosophical studies, while the physical hindrances are studied under the topic of interoperability, and both hardware and software will be the keys that make possible access to and use and reuse of the information. This literature review is oriented to the analysis of the legal conditions, in which two types of limitations of 'openness' can be found: the first one is related to the nature of the information, and the second to the ownership of such information. While the first limitation refers to the content of the message, the second refers to its owner.

6.2. As open as possible based on the nature of the information

The nature of the information as a legitimate reason to limit its public availability is a reason that already exists and is accepted in democratic regimes. When it comes to information circulation, modern democracies are based on the existence of default rules, which are freedom of thought, freedom of press, freedom of information and freedom of expression. All information is allowed by default to become public, except when certain limits apply that are rooted in the tension with other rights that deserve equal or similar protection. UNESCO's draft recommendation takes into account this regulation and mentions the exceptions of 'legal process and public order, … personal information and the protection of human subjects, of sacred indigenous knowledge, and of rare, threatened or endangered species'. International courts justify these limits based on the nature of the information and have granted protection to restrictions on access to

([116]) The epistemological impossibility may be caused by the use of digital rights management that enciphers the content.

and reuse of information due to national security ([117]), privacy ([118]), blasphemy ([119]), reputation ([120]), hate speech ([121]), the right to be forgotten ([122]) and access to the documents of the institutions based on privacy ([123]), among other rights. Some of these limitations are based on legal concepts with clear boundaries – for example, there is a strict personal data regulation – but other terms such as 'national security' are subject to interpretation. Moreover, criminal codes have strict regulations that include conduct whereby disclosure or dissemination of information constitutes a crime. All these cases may constitute legitimate reasons that limit the possibility of access to and use and reuse of scientific information and therefore allow us to draw the boundaries of the expression 'as open as possible, as closed as necessary'. These limits can be imposed by a state in the exercise of its sovereignty, and the discussion about their existence and enforceability should be aligned with which ones are acceptable in a democratic society where, as we have seen, freedom of information is the default rule.

Furthermore, as UNESCO explicitly establishes, these generic limits based on the nature of the information may be raised in specific cases: 'Some research results, data or code that is not opened may nonetheless be made accessible to specific users according to defined access criteria made by local, national or regional pertinent governing instances' (UNESCO, 2021a, paragraph 10).

The summary of this subsection is that the expression 'as open as possible, as closed as necessary' can therefore be interpreted in the sense that a governing instance may impose conditions on the openness based on reasons acceptable in a democratic society and, simultaneously, regulate exceptions to the limiting conditions. The necessity to close the information will be based on laws that forbid access to and use and reuse of the information solely on account of the nature of its content.

6.3. As open as possible based on the ownership of the information

Regarding limitations based on the ownership of the information, UNESCO's text includes 'trade secrets' and 'intellectual property rights' (UNESCO, 2021a, paragraph 10) – even though trade secrets are one of the fields of IP. In this context, notwithstanding the scarcity of the analysis of the expression 'as open as possible, as closed as necessary' in scholarly publications, a vigorous discussion of what is to be considered 'open' in regard to IP has been held in the FOSS communities and can help to delimit the scope. The most recent outcome of this debate was the 'Open Definition' obtained thanks to the efforts of the Open Knowledge Foundation ([124]):

([117]) See Commission Decision (EU, Euratom) 2015/444 of 13 March 2015 on the security rules for protecting EU classified information (http://data.europa.eu/eli/dec/2015/444/oj).
([118]) Judgment of the Court (Grand Chamber), 8 April 2014, *Digital Rights Ireland Ltd* (C-293/12) v *Minister for Communications, Marine and Natural Resources, Minister for Justice, Equality and Law Reform, Commissioner of the Garda Síochána, Ireland, The Attorney General, intervener: Irish Human Rights Commission*, and *Kärntner Landesregierung* (C-594/12), *Michael Seitlinger, Christof Tschohl and others*, Joined cases C-293/12 and C-594/12, ECLI:EU:C:2014:238; judgment of the Court (Grand Chamber) 6 October 2015, *Maximillian Schrems* v *Data Protection Commissioner, joined party: Digital Rights Ireland Ltd*, C-362/14, ECLI:EU:C:2015:650.
([119]) Judgment of the European Court of Human Rights, 20 September 1994, *Otto-Preminger-Institut* v *Austria*.
([120]) Judgment of the European Court of Human Rights, 30 March 2010, *Petrenco* v *Republic of Moldova*.
([121]) Judgment of the European Court of Human Rights, 23 September 1994, *Jersild* v *Denmark*.
([122]) Judgment of the Court (Grand Chamber), 13 May 2014, *Google Spain SL, Google Inc.* v *Agencia Española de Protección de Datos (AEPD), Mario Costeja González*, C-131/12, ECLI:EU:C:2014:317.
([123]) Judgment of the Court (Grand Chamber), 29 June 2010, *European Commission, United Kingdom of Great Britain and Northern Ireland, Council of the European Union* v *The Bavarian Lager Co. Ltd, Kingdom of Denmark, Republic of Finland, Kingdom of Sweden*, C-28/08, ECLI:EU:C:2010:378.
([124]) https://opendefinition.org/

> The Open Definition sets out principles that define 'openness' in relation to data and content.
>
> It specifies the meaning of 'open' in the terms 'open data' and 'open content' and thereby ensures quality and encourages compatibility between different pools of open material.
>
> It can be stated that:
>
> > 'Open means anyone can freely access, use, modify, and share for any purpose (subject, at most, to requirements that preserve provenance and openness).'
>
> Put most succinctly:
>
> > 'Open data and content can be freely used, modified, and shared by anyone for any purpose'.

The discussion held under the aegis of the Open Knowledge Foundation was the heir of the debates that confronted the FSF and the OS movement during the 1980s. The 'Open Definition 2.1' web page narrates its historical background in the following words ([125]):

> The Open Definition was initially derived from the Open Source Definition, which in turn was derived from the original Debian Free Software Guidelines, and the Debian Social Contract of which they are a part, which were created by Bruce Perens and the Debian Developers. Bruce later used the same text in creating the Open Source Definition. This definition is substantially derivative of those documents and retains their essential principles. Richard Stallman was the first to push the ideals of software freedom which we continue.

As explained in Subsection 5.1.3 'Free software', even though the FSF and OS movements had different positions regarding whether or not the author of a derivative work could close it (the GPL obliged the derivative code, if distributed, to remain accessible, contrary to the Open Source group's position), both groups agreed on the importance of the legal permission to read and to modify the source code of a primary work, and to distribute it jointly with the derivative work. The definition supported by the Open Knowledge Foundation follows the thesis of the necessity for the derivative work to remain open. Therefore, the obligation follows that the openness must be virally transmitted between the original and its subsequent derivative works. To be 'open' means that the primary work is licensed in such a way that it allows the creation of derivative works using it, that consequently these derivative works are licensed in such a way that they allow further derivative works and so on.

But the history of the term 'open' cannot be understood without reference to the term 'free'. The reference made in the Open Definition to 'free' ('Open data and content can be **freely** used, modified, and shared by anyone for any purpose') continues the FSF tradition regarding the concept of 'freedom' in its application to source code works. The latter explains that free 'is a matter of liberty, not price. To understand the concept, you should think of "free" as in "free speech," not as in "free beer"' ([126]). This liberty is given by the author of the original work not only to future creators of derivative works but also to the users in general, so they may control the software instead of the software controlling them. It is composed of four elements ([127]).

- The freedom to run the program as you wish, for any purpose (freedom 0).

([125]) See https://opendefinition.org/od/2.1/en/
([126]) https://www.gnu.org/philosophy/free-sw.en.html
([127]) https://www.gnu.org/philosophy/free-sw.html.en

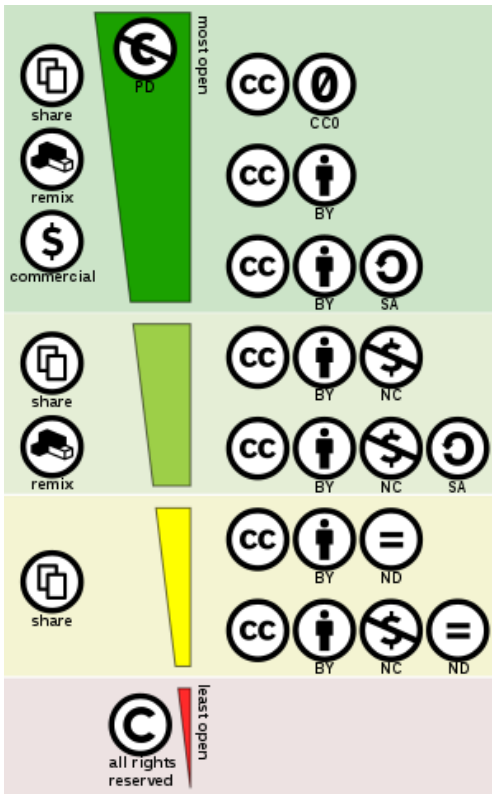
- The freedom to study how the program works, and change it so it does your computing as you wish (freedom 1). Access to the source code is a precondition for this.
- The freedom to redistribute copies so you can help others (freedom 2).
- The freedom to distribute copies of your modified versions to others (freedom 3). By doing this you can give the whole community a chance to benefit from your changes. Access to the source code is a precondition for this.

Thus, both terms 'open' and 'free' can be interpreted as synonyms, their antonym being the term 'closed'. This interpretation is found on the Creative Commons website licences page. When one chooses a licence for a work ([128]), the web page displays the message 'This is a Free Culture License' for the licences 'CC By' and 'CC By ShareAlike' and the message 'This is not a Free Culture License' for the licences 'CC By Attribution No Derivatives', 'CC By Attribution NonCommercial NoDerivatives' and 'CC By Attribution NonCommercial ShareAlike'.

Both messages link to an explanation by the organisation Creative Commons of what are considered 'free cultural works' ([129]). Creative Commons understands that a 'cultural work' is considered 'free' if it allows four possibilities: (1) to use the work itself for any kind of use (the reason why non-commercial licences are not considered 'free'); (2) 'Freedom to use the information in the work for any purpose'; (3) 'Freedom to share copies of the work for any purpose' and (4) 'Freedom to make and share remixes and other derivatives for any purpose' (the reason why 'no derivative' licensed works are not considered 'free'). The image 'Creative Commons License Spectrum' (Figure 6.1) draws a gradient between 'most open' and 'least open'. It uses the term 'open', not the term 'free'.

([128]) The form is available at https://creativecommons.org/share-your-work/
([129]) https://creativecommons.org/share-your-work/public-domain/freeworks

Table 6.2. Creative Commons Licence Spectrum



Source: Shaddim (CC BY).

However, although the discussion about 'free' and 'open' has been rich in the FOSS and Creative Commons communities, its context remained in the field of copyright, not within the other main fields of IPR (patents, trademarks and trade secrets), for which the literature review shows no results. Patents must publicly disclose the information of the invention, so ultimately they should not hinder the transmission of knowledge, despite the possibility of keeping the patent application secret temporarily; trademarks do not close off any information; and, from a logical point of view, trade secrets are the paradigm of closed information.

In the previous subsection it was stated that the limitations to the openness of the information based on the nature of the content could be imposed by the normal limitations that exist in a democratic regime, and the exceptions to the limitations could be decided, using UNESCO's words, 'by local, national or regional pertinent governing instances'. But when the scope of the expression 'as open as possible, as closed as necessary' is analysed under IP norms, then the decisions to close off scientific knowledge on publicly funded projects should be analysed, scrutinised, rejected by default and only accepted if a closed catalogue of reasonable conditions is met. It is true, as the International Science Council's Committee on Data submitted to the UNESCO Open Science Consultation (CODATA Coordinated Expert Group, 2020) that Open Science 'categorically does not mean indiscriminate openness', but the default rule is that any reason for information's being closed should be made evident and that the limits based on the nature of the information already serve as a reasonable scenario. Going beyond these limits should need a good reason, as it is legitimate that projects funded by taxpayers should return the results to society in general.

In privately funded projects, the freedom of establishment must be held. Therefore, it would be the funding body that should decide on the openness of the outcomes of the research activity. Nevertheless, a lesson learnt from Rachel Carson's *Silent Spring*

(1994) is that what private companies may do with private money can affect our environment and our health. It must be clear that risks to humans must be communicated to the public 'or to those whose job it [is] to implement and enforce the precautionary measures'. Simultaneously, the public must have the right to inquire into and receive information on these activities ([130]).

([130]) In its judgment of 19 February of 1998, in the case of *Guerra and others* v *Italy*, the European Court of Human Rights declared that Italy had violated Article 8 of the European Convention on Human Rights: 'The Court reiterates that severe environmental pollution may affect individuals' well-being and prevent them from enjoying their homes in such a way as to affect their private and family life adversely' (paragraph 60).

7. CONCLUDING REMARKS AND LESSONS TO LEARN

The main remarks and lessons to be learnt from this report are classified in three sections: general findings, recommendations for policymakers and recommendations for practitioners/users.

Findings

- Although it is acknowledged that managing IP requires particular skills and incurs costs, there is a need to achieve a balance between the need to protect and to disseminate knowledge. Therefore, based on the notion of "as open as possible as close as necessary", the protection of knowledge is an important step for the achievement of the Union's policy goals, such as strategic autonomy and green and digital transition.

- The scientific literature and main reports on OS do not systematically address IPR issues as a key element in reviewing the establishment of a new OS paradigm. It appears that the assertion that better IPR management promotes innovation is not the common understanding in the research and innovation community. Although Commission's new EU IP policy is clarifying the crucial role of IP for the Union's growth[131], more studies on the cross-section of IP and open science are needed.

- The idea that a stronger IPR system produces more innovation and creativity could benefit from more data and quantitative analysis. Although the implementation of the EU IP Action Plan provides data on the use of IP, data on open innovation needs to be further collected and analysed at Union level.

- There is an epistemic blindness regarding the existence of free IP works. This leads to the absence of analysis and data about the wealth they represent and produce. The status of the internet as a free IP work composed of the set of more than 9 000 requests for comments is simply ignored by the literature.

- Government funding, prize systems and the IPR system are tools to incentivise more and better inventions that can later be transferred and become innovations to solve serious problems such as the global COVID-19 pandemic. Distortionary and transaction costs of patents should be further analysed.

- If a researcher wishes to place their research results in the public domain, no IP-related formalities are required. Therefore, there is no additional burden on the researcher. However, if the researcher wants to protect their results, current IPR regulation can impose a burden in at least two ways. Firstly administrative, when it comes to allowing access to and use of the research results with the

[131] https://www.epo.org/about-us/services-and-activities/chief-economist/studies.html

proper IPR; and secondly, financial, as regards the payment of levies to remunerate literary or artistic authors.

- Basic science opens unforeseen pathways. It is both essential and incalculable. Its value cannot be estimated because its results are unknown.

- The term 'IP' comprises two main areas: (1) literary and artistic property, which is mainly covered by copyright, and (2) industrial property, which mainly includes patents (as well as utility models and supplementary protection certificates), trademarks, industrial designs, geographical indications and trade secrets. Each one has a different impact on OS.

- Under the current copyright regime, works are closed by default. Therefore, to foster openness in science, consent must be given by the author or an exception/limitation must apply. Consent of the author must be proactive.

- Dynamic processes (such as science production) require IP licences that do not hinder changes or burden the process with unnecessary bureaucracy. A community's ability to sustain dynamic processes depends on this.

- Under international treaties and legislation, it is not possible to create an autonomous scientific author whose works would merit different IP conditions from the 'all rights reserved' default rule. Exceptions related to scientific IPR should be legally maximised, avoiding as far as possible the risk of legal proceedings.

Recommendations for policymakers

- It is urgent to address new copyright and IPR regimes to guarantee better IP protection responsive to the needs of open, transparent and collaborative science. The international pragmatism resulting from COVID-19 and the positive reactions to OS-OA paradigms should be taken advantage of. COVID-19 suggests that the incentives generated by IPR might be improved by global solidarity or, in the EU context, by subsidiarity.

- Current IPR standards and regimes should keep up with rapid technological developments, with legal provisions that offer online protection. A new IPR framework for OS should be created at global level, adapted to the new digital technologies, the new requirements of science, and modern scientific communication needs and facilities, in order to find the right balance between OS and IPR.

- Basic science should be promoted on account of its essential importance for applied science. Evaluation of basic science through IPR (copyright or patents) indicators should be further analysed. Awareness of the value of basic science and free intellectual works needs to be raised, taking the request for comments model as an example. The more basic science and the more requests for comments, the more opportunities for small and medium-sized enterprises to build

on free components and appropriate the results. Special attention must be paid to avoiding appropriation of the basic science and the IP under free licences.

- The right of an author to provide for the openness of his or her work must receive from the EU and the Member States the same support as the right of an author to keep his or her intellectual work closed. Authors of free works should be treated at least equally to authors of closed works.

- An Office for Free Intellectual Property Rights and Open Science should be created. This office can be inspired by the functioning of the Office for Harmonization in the Internal Market and the European Observatory on Infringements of Intellectual Property Rights (EU 386/2012) and should be aligned with the EU IP action plan. It could be piloted through the Horizon Europe Framework Programme.

- EU IP legislation should be reviewed and amended to define hyperlinks as a mere linguistic reference, to expand the text and data mining copyright exception to match the United Nations Educational, Scientific and Cultural Organization's diversity and inclusiveness values, to include clear and stronger exceptions for OS not affected by levies to remunerate rightholders of closed copyright works.

Specific recommendations on intellectual property for practitioners

- All organisations, when using data, should analyse the terms and conditions of each data set. If these are not clear or no consent has been given, then it should be treated as an 'all rights reserved' piece of information.
- Lessons can be learnt from the free software communities:
    - licence diversity: the possible activities that the creator may allow the users to exercise are innumerable, although a side effect of using different licences is that they may be incompatible;
    - awareness of the necessity of including a licence to avoid the 'all rights reserved' by default system;
    - inclusion of licences within the source code: the licence should be included as a text file in the source code trunk, which raises an author's awareness of the necessity for a licence;
    - awareness of the necessity for the licence to be updated because of changes in the technological or legal context;
    - building tools to standardise the references to licences and to make them readable by both humans and machines;
    - existence of communities that take care of projects' sustainability;
    - the ethos of 'release early, release often'.

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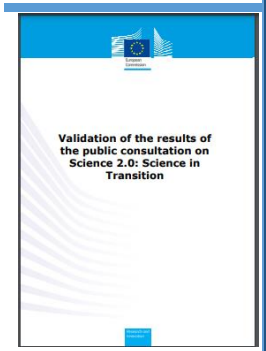
ANNEXES

Annex I: Analysis of selected European Commission reports/publications regarding OS components or challenges and how they reflect IPR issues (2015–2021)

This table shows the key reports, policy recommendations, etc. chosen, to understand the coverage of OS in relation to IPR in the realm of publications from the European Commission. All these reports were released between 2015 and 2021 to analyse the evolution of particular challenges to OS in Europe. The most significant reports published by the Commission were selected, but the European Code of Conduct for research integrity from ALLEA and the White paper on Citizen Science in Europe from Socientize were added as both are considered important policy documents. The Amsterdam Call for Action on Open Science released under the Dutch Presidency of the European Council was also added, since it is particularly relevant at Member State level to the transition towards an OS system.

	Citation	Compo-nent stud-ied	Number of recom-menda-tions	IPR	Scope of the IPR issues/comments
	Schomberg (2015)	OS	26	Yes	This document gathers the results of the European Commission's public consultation in 2015 about Science 2.0/science in transition, which ended up calling it 'open science'. It considers that developing EU guidelines for addressing IPR issues and the funding of data management is a key action at EU level to mainstream OA to publications and data.

	Citation	Compo-nent stud-ied	Number of recom-menda-tions	IPR	Scope of the IPR issues/comments
	European Commission, Directorate General for Research and Innovation (2016a)	OS	0	Yes	This publication summarises the R&I priorities of Commissioner Moedas's policies. It clearly defines that OS does not mean 'free science'. It mentions IP specifically since the publication aligns OS with open innovation in global research (open to the world). It highlights the fair and equitable treatment of IP, as a means to boost cooperation on innovation. However, IPR issues are not treated in particular detail.
	European Commission. Directorate General for Research and Innovation (2016)	OS R&I	0	Yes	This comprehensive document aims to review the 'three O' agenda of Commissioner Moedas (open innovation, open science, open to the world). It addresses IPR issues and OS but it does not relate them to each other. It shows, for example, that the EU is lagging behind the US and South Korea in important framework conditions such as IPR protection. Europe needs to do more to create a regulatory environment for innovation to flourish, and to tune the legislative processes to the increasingly shorter cycles of technologies.

	Citation	Component studied	Number of recommendations	IPR	Scope of the IPR issues/comments
	Government of the Netherlands (2016)	OS	0	Yes	This document was drawn up under the Dutch Presidency of the European Council in April 2016. It is the first real call for the implementation of Open Science in Europe. The Amsterdam Call for Action is one of the few documents in the EU context that clearly recognise the need to 'improve insight into IPR' as one of the barriers to OS, particularly in the reuse of research data in public–private partnership projects. The proposed solution is to clarify IPR regimes to all parties involved in the projects and set rules and conditions for public funding of research in which open (data) is the default standard.
	Mons et al. (2016)	EOSC	15	No	This report gathers the guiding principles to realise EOSC at policy, governance and implementation (technical) levels in its first phase of implementation but it does not address any IPR issue.

	Citation	Component studied	Number of recommendations	IPR	Scope of the IPR issues/comments
	ALLEA (2017)	Research integrity	0	No	This document is considered the key code of conduct for research integrity. Researchers, research institutions and organisations ensure that any contracts or agreements relating to research outputs include equitable and fair provision for the management of their use, ownership and/or their protection under IPR. All partners formally agree at the start of their collaboration on expectations and standards concerning research integrity, on the laws and regulations that will apply, on protection of the IP of collaborators, and on procedures for handling conflicts and possible cases of misconduct.
	Wilsdon et al. (2017)	Next-generation metrics	12	No	Although this report focuses on one of the crucial aspects of OS, and defines responsible metrics and many other issues related to the meta-research needed for OS, it does not mention IP or IPR at all.

	Citation	Component studied	Number of recommendations	IPR	Scope of the IPR issues/comments
	O'Carroll et al. (2017a)	Rewards and incentives	4	Yes	The career assessment matrix defined in this report mentions IP (patents and licences) as an OS practice in the realm of research impact, including being knowledgeable on the legal and ethical issues relating to IPR and transferring IP to the wider economy, as a criterion to be evaluated.
	O'Carroll et al. (2017b)	Skills in OS	6	Yes	This report explores the opportunities for learning by doing for involving the general public in research, fundraising and investment pitching, and IP and patenting. One quarter of researchers are aware of courses on research and data management, teaching and supervising, IP and patenting (IPR), research publishing and dissemination, and research integrity. To a lesser extent, they also lack legal support, such as for IPR and the technical infrastructure to facilitate OS. Information on research information skills, IP and research ethics and integrity can be integrated into the curriculum. It also mentions that IPR should be protected as one of the OS-

	Citation	Component studied	Number of recommendations	IPR	Scope of the IPR issues/comments
					related elements for employers and funders, included in the European Charter for Researchers.
	Lamy et al. (2017)	R&I/open innovation–OS	11	Yes	*LAB – FAB – APP* is a much-cited report by the independent HLEG and focuses on how to maximise the impact of the EU R&I programmes before the definition of the seventh Framework Programme (Horizon Europe). However, its mention of IPR is limited to the importance of IP protection in the partners' legitimate interest on accessing and reusing data.
	European Commission Expert Group on FAIR Data (2018)	FAIR data	27	No	This report is one of the most cited reports about FAIR data. Unfortunately, it does not address IPR issues comprehensively. It only refers to the open licences to be added to the data sets in order to improve their reusability, including a 'clear and accessible data usage license'.

	Citation	Component studied	Number of recommendations	IPR	Scope of the IPR issues/comments
	Muscella et al. (2018)	EOSC	21	Yes	This report proposes implementation recommendations for EOSC and mentions IP, first in the context of security of data and then as a problem to be solved through blockchain technologies Data that will be distributed via the EOSC will have different levels of access control depending on various issues, including IP. Blockchain research is important for the EOSC because it allows scientists to share digital information, but not to copy it. With blockchain, IPR can be kept with the original source, creating a new concept of trust for the communities.
	OSPP-REC (2018)	OS	5 (includes meta-recommendations by stakeholders and 5 general recommendations)	No	This report is also known as 'integrated advice' or 'prioritised recommendations' because it gives recommendations by stakeholders on the eight components or challenges of OS (see Section 3.2) taking into account the reports and recommendations of other HLEGs. The prioritised recommendations do not include any reflections on IPR; however, it highlights the IP issues in the final report (Méndez et al., 2020).

	Citation	Component studied	Number of recommendations	IPR	Scope of the IPR issues/comments
	Guédon et al. (2019)	Future of scholarly communication	26	Yes	This report states briefly but clearly that the present IP laws are not well adapted to the needs of researchers and other users, and, as a result, they work less efficiently and effectively than they might otherwise do. This has a cost for the whole of society.
	Wouters et al. (2019)	Indicators, next-generation metrics	13	Yes	This report clearly calls on OS policies to address generic issues such as IP, while they also need to be sensitive to these specific contexts. Specifically, it reflects on the indicator frameworks that should be governed by appropriate IP regimes and licensing to prevent data monopolies or oligopolies. It is the first time that we have seen mentioned the IP of the indicators, which should also be based on FAIR data, and the algorithms should be open source.

	Citation	Component studied	Number of recommendations	IPR	Scope of the IPR issues/comments
	Warin and Delaney (2020)	Citizen science	10	Yes	The topic of this report, citizen science and citizen engagement, is central for OS, particularly at the beginning of Horizon Europe and the redefinition of the ERA. However, the report does not mention any aspect related to IPR.
	Socientize (2020)	Citizen science	20 (15 supported measures and 5 proposed actions)	Yes	This report mentions IPR related to research data in the context of ethical guidelines for EU-wide data policy. It supports a culture of openness for data and access to data. This implies handling data in a very careful way, taking into account IPR, fundamental personal data protection rights, ethical standards, legal requirements and scientific data quality. Exchange of experiences and data is vital and needs to be reinforced. Deploying centralised repositories for data storage that integrate and link the existing data sets could be useful. It also proposes a specific citizen science data plan along with quality guidelines that address the handling of sensitive personal information, policy restrictions, ethical aspects and IPR in Europe. It is important to facilitate the exchange and interoperability of different citizen science data archives and public data sets following

	Citation	Component studied	Number of recommendations	IPR	Scope of the IPR issues/comments
					the standard formats (e.g. Linked Open Data standards).
	Méndez et al. (2020)	OS	5	Yes	This report is the final outcome of the OSPP. It summarises the practical commitments for implementation of OS by stakeholders represented on the platform, and it define five attributes of a framework for a new shared research knowledge system in 2030. It particularly refers to the need to address the dilemma faced by business and industry in adopting OS practices while fulfilling requirements for IPR. The OSPP recognises the importance of embedding IPR within an OS framework that protects the interests of different stakeholders, including private and commercial research organisations, but without limiting the scientific and societal benefits of sharing and reuse of scholarly knowledge for all humanity. This also includes enabling researchers from different jurisdictions and organisations to contribute to, as well as access, research knowledge, tools and practices. To enable innovation, the new envisaged 'shared research knowledge system' needs a clear regulatory framework to manage each stakeholder's interests for the collective good. In a transparent competitive market, private companies, publicly funded organisations and other research organisations have to be able to contribute and benefit of the new research system. This is not fully exploited yet, due to a wrongly perceived incompatibility with IPR and competitiveness policies or conflicting internal financial and legal rules. Regarding data, the balance between openness and protection of

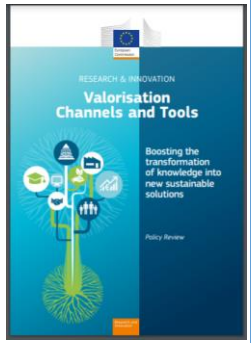
	Citation	Component studied	Number of recommendations	IPR	Scope of the IPR issues/comments
					IPR should be aligned with the principle 'as open as possible, as closed as necessary'. Regulatory frameworks must favour a community-driven and accepted approach to data and metadata standards. In particular, there needs to be more focused and active support of licensing models and other IP tools to boost the awareness of the value of IP in the research system, and the individual contribution of research actors in providing solutions to societal challenges.
	Baker et al. (2020)	Reproducibility	33 (including 'possible actions')	Yes	This report focuses on the importance of training in different topics including statistics, data management and IPR.

	Citation	Component studied	Number of recommendations	IPR	Scope of the IPR issues/comments
	European Commission (2016c)	OS (In general, ERA)	0 (but 14 key actions)	Yes	This communication about the new ERA for R&I is a crucial document that provides a roadmap for the next steps in R&I in the new OS paradigm that we have discussed in our report. The document made reference to another communication, on the industrial strategy for Europe (COM(2020) 102 final), which announced further actions to improve the management of IP by the research community, to be provided in the upcoming IP action plan. The communication also includes a concrete action for the Commission to implement by the end of 2022: update and develop guiding principles for knowledge valorisation and a code of practice for the smart use of IP.
	Corcho et al. (2021)	EOSC	27	Yes	The EOSC Interoperability Framework (EIF) is a comprehensive and solid technical document in the realm of the EOSC. The EIF defines different recommendations at different practical levels to improve data interoperability, including four layers of recommendations: technical, semantic, organisational and legal. Particularly related to IPR, this document calls for an interoperable metadata framework, to ensure openness and interoperability across disciplines while respecting privacy and security (copyright status, disclosure limitations, patents pending, other IPR on the data sets), whereby metadata should be available without restrictions. The EIF also highlights the lack of expertise in IPR in the research (open/FAIR) data environment.

	Citation	Component studied	Number of recommendations	IPR	Scope of the IPR issues/comments
	EOSC Executive Board (2021)	EOSC	7	Yes	The *Strategic Research and Innovation Agenda of the EOSC* is a key document in the development of the EOSC and all the developments in Europe towards a common federated infrastructure of FAIR research data. The agenda quotes Merton's CUDOS norms (see Section 3.1) and also reflects the statements of the EIF, relevant to creating an interoperable metadata framework, for ensuring openness and interoperability across disciplines while respecting privacy and security (copyright status, disclosure limitations, patents pending, other IPR on the data sets or workflows, the existence of personal data, designation of data as public sector information). It also underlines the integration of IP tracking as a prototype service needed to be tested under the project EOSC-Future. It also describes 'openness' as one of the guiding principles of EOSC, whereby OS requires commitments to openness from all stakeholders, although there are limits to openness with respect to privacy, security and IP.

Annex II: Analysis of selected European Commission reports/publications regarding IPR and knowledge valorisation and how they reflect OS issues (2015–2021)

This annex shows the two main reports regarding knowledge valorisation and IPR and how they cover OS.

	Citation	Compo-nent stud-ied	Number of recommen-dations	OS	Scope of the OS/comments
	European Commis-sion, Di-rectorate-General for Re-search and Inno-vation (2020b)	Knowledge valorisation	0	Ye s	This document is a policy review aiming to provide a toolbox for an R&I valorisation strategy. 'Legislation fit for innovation' and 'Open science and digital platforms' are highlighted as specific tools for knowledge dissemination and policy uptake. This report also reflects that better OS practices, such as open access to research outputs, can be instrumental in making science practice more efficient and collaborative in Europe. The European Commission has actively supported creating the right conditions for open access in Europe – for example, through the creation of the EOSC or the recommendation on access to and preservation of scientific information. Monitoring the requirements to publish the results of publicly funded research in open access and to make the data freely available is crucial for the valorisation of R&I invest-ments. The report also showcases the reward and incentive system for researchers as a key component to ensure greater take-up, and demands the involvement of major stakeholders. Finally it cites as a good example of knowledge valorisation and OS the SPOMAN platform (https://spoman-os.org), where researchers from many disciplines and companies join forces and translate industrial chal-lenges into basic research projects.

	Citation	Component studied	Number of recommendations	OS	Scope of the OS/comments
	European Commission, Directorate-General for Research and Innovation (2021)	Knowledge valorisation	0	Yes	This is a key report that states the issues that we studied in ours by surveying Member States to identify best practices on knowledge. The document recognises that reconciling open science–open innovation with IP exploitation strategies underpinning EU policy objectives and strengthening modern IP management in public research organisations is one of the key challenges for the new R&I system. Several countries pointed out that more attention should be paid at organisational level to the possibilities of IP management in research and knowledge transfer and how they relate to requirements for openness such as open access to research data and publications.

Annex III. Tables and graphics

Source: World Bank (http://wdi.worldbank.org/table/5.13#).

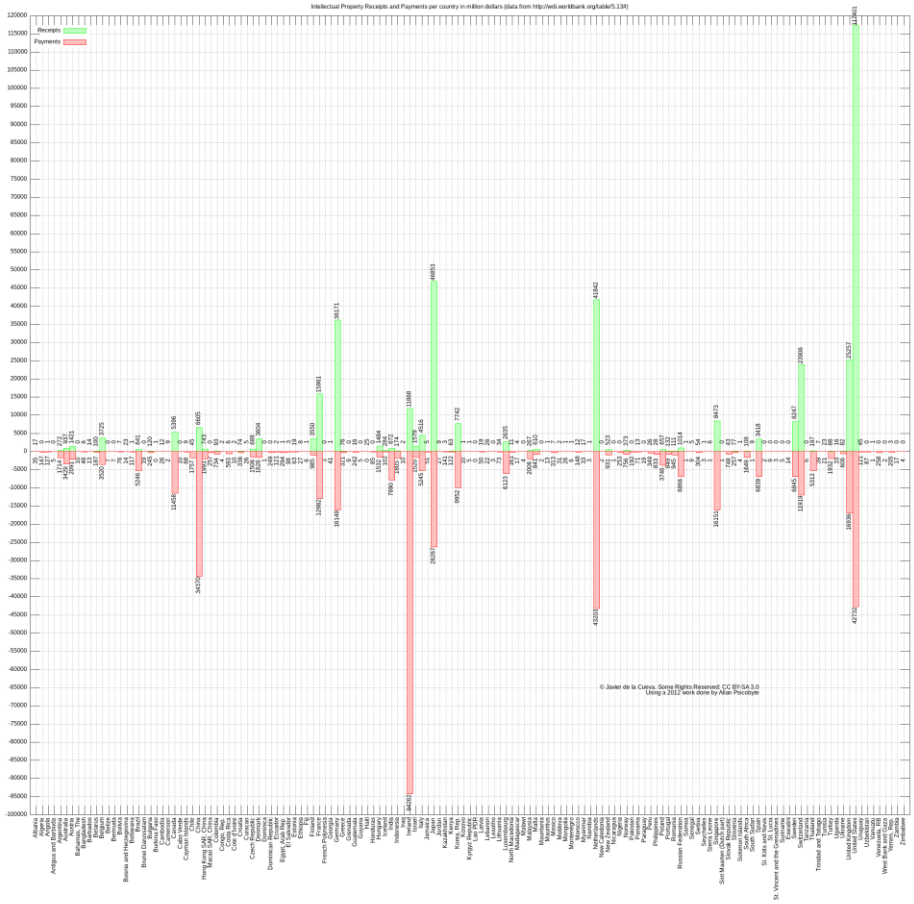


Figure A.1. IPR receipts and payments of all countries (million USD)

Table A.1. IPR receipts and payments of all countries with data, 2019, ordered by net profit (million USD)

Country	Receipts	Payments	Net
United States	117 401	42 732	74 669
Japan	46 853	26 267	20 586
Germany	36 171	16 149	20 022
Switzerland	23 906	11 919	11 987
United Kingdom	25 257	16 936	8 321
France	15 961	12 982	2 979
Finland	3 550	985	2 565
Denmark	3 604	1 626	1 978
Sweden	8 247	6 845	1 402
Belgium	3 725	3 520	205
Iceland	284	102	182
Israel	1 579	1 520	59
Haiti	25	0	25
Bosnia and Herzegovina	23	14	9
South Sudan	9	1	8
Cameroon	9	2	7
Sierra Leone	6	1	5
Lebanon	26	22	4
Tunisia	23	21	2
Barbados	14	13	1
Burkina Faso	1	0	1
Tajikistan	0	0	0
Timor-Leste	0	0	0
Togo	0	0	0
Tonga	0	0	0
Dominica	0	1	– 1

Country	Receipts	Payments	Net
Sint Maarten (Dutch part)	0	1	– 1
Congo, Rep.	2	4	– 2
Mauritania	0	2	– 2
Namibia	1	3	– 2
New Caledonia	0	2	– 2
Seychelles	1	3	– 2
St Kitts and Nevis	0	2	– 2
West Bank and Gaza	0	2	– 2
French Polynesia	0	3	– 3
Lesotho	0	3	– 3
Solomon Islands	1	4	– 3
St Vincent and the Grenadines	0	3	– 3
Kyrgyzstan	1	5	– 4
Senegal	5	9	– 4
Zimbabwe	0	4	– 4
Afghanistan	0	5	– 5
Antigua and Barbuda	0	5	– 5
Fiji	1	6	– 5
Guyana	0	5	– 5
Montenegro	1	6	– 5
Suriname	0	5	– 5
Tanzania	0	6	– 6
Belize	0	7	– 7
Bermuda	0	7	– 7
Côte d’Ivoire	2	10	– 8
Iraq	2	10	– 8

Country	Receipts	Payments	Net
Grenada	0	9	– 9
Kosovo	1	10	– 9
St Lucia	0	9	– 9
Bahamas, The	0	10	– 10
Cabo Verde	0	10	– 10
Mauritius	1	13	– 12
Madagascar	4	17	– 13
Cambodia	12	26	– 14
Eswatini	0	14	– 14
Myanmar	17	33	– 16
Uganda	16	33	– 17
Zambia	0	17	– 17
Albania	17	35	– 18
Jordan	9	27	– 18
Brunei Darussalam	0	19	– 19
Ethiopia	8	27	– 19
Curacao	5	26	– 21
Mongolia	1	26	– 25
Moldova	2	31	– 29
Latvia	19	50	– 31
Trinidad and Tobago	7	39	– 32
Lithuania	34	73	– 39
Georgia	1	41	– 40
Bangladesh	6	48	– 42
Estonia	19	63	– 44
Jamaica	5	51	– 46

Country	Receipts	Payments	Net
Hungary	1 484	1 532	– 48
Panama	13	71	– 58
Cayman Islands	9	68	– 59
Kenya	63	122	– 59
Bolivia	7	76	– 69
Uruguay	45	121	– 76
Honduras	0	85	– 85
Belarus	100	187	– 87
Uzbekistan	0	87	– 87
El Salvador	3	98	– 95
Botswana	1	117	– 116
Ecuador	2	121	– 119
Bulgaria	120	245	– 125
Angola	1	127	– 126
Morocco	12	148	– 136
Kazakhstan	3	141	– 138
Algeria	0	147	– 147
North Macedonia	11	161	– 150
Slovenia	77	257	– 180
Pakistan	0	192	– 192
Yemen, Rep.	3	205	– 202
Guatemala	16	242	– 226
Malta	610	841	– 231
Greece	76	321	– 245
Dominican Republic	0	249	– 249
Serbia	54	304	– 250

Country	Receipts	Payments	Net
Nigeria	0	253	– 253
Croatia	74	336	– 262
Egypt, Arab Rep.	1	294	– 293
Mexico	7	313	– 306
Peru	26	349	– 323
Norway	373	756	– 383
New Zealand	523	931	– 408
Ukraine	82	606	– 524
Costa Rica	6	593	– 587
Colombia	93	734	– 641
Austria	1 421	2 091	– 670
Slovakia	43	748	– 705
Portugal	132	849	– 717
Italy	4 516	5 245	– 729
Philippines	28	833	– 805
Czechia	688	1 506	– 818
Romania	111	945	– 834
Hong Kong SAR, China	743	1 993	– 1 250
Netherlands	41 842	43 203	– 1 361
Argentina	272	1 714	– 1 442
South Africa	108	1 649	– 1 541
Indonesia	174	1 805	– 1 631
Chile	45	1 757	– 1 712
Malaysia	267	2 006	– 1 739
Turkey	88	1 932	– 1 844
Korea, Rep.	7 742	9 952	– 2 210

Country	Receipts	Payments	Net
Australia	937	3 429	– 2 492
Poland	657	3 746	– 3 089
Spain	3 418	6 839	– 3 421
Luxembourg	2 635	6 123	– 3 488
Brazil	641	5 246	– 4 605
Thailand	197	5 312	– 5 115
Russian Federation	1 014	6 866	– 5 852
Canada	5 396	11 458	– 6 062
India	872	7 890	– 7 018
Singapore	8 473	16 151	– 7 678
China	6 605	34 370	– 27 765
Ireland	11 868	94 262	– 82 394

Table A.2. IPR receipts and payments of all countries with data, alphabetical by country, 2019 (million USD)

Country	Receipts	Payments	Net
Afghanistan	0	5	– 5
Albania	17	35	– 18
Algeria	0	147	– 147
Angola	1	127	– 126
Antigua and Barbuda	0	5	– 5
Argentina	272	1 714	– 1 442
Australia	937	3 429	– 2 492
Austria	1 421	2 091	– 670
Bahamas, The	0	10	– 10
Bangladesh	6	48	– 42
Barbados	14	13	1
Belarus	100	187	– 87
Belgium	3725	3520	205
Belize	0	7	– 7
Bermuda	0	7	– 7
Bolivia	7	76	– 69
Bosnia and Herzegovina	23	14	9
Botswana	1	117	– 116
Brazil	641	5 246	– 4 605
Brunei Darussalam	0	19	– 19
Bulgaria	120	245	– 125
Burkina Faso	1	0	1
Cabo Verde	0	10	– 10
Cambodia	12	26	– 14

Country	Receipts	Payments	Net
Cameroon	9	2	7
Canada	5 396	11 458	– 6 062
Cayman Islands	9	68	– 59
Chile	45	1 757	– 1 712
China	6 605	34 370	– 27 765
Colombia	93	734	– 641
Congo, Rep.	2	4	– 2
Costa Rica	6	593	– 587
Côte d'Ivoire	2	10	– 8
Croatia	74	336	– 262
Curacao	5	26	– 21
Czechia	688	1 506	– 818
Denmark	3 604	1 626	1 978
Dominica	0	1	– 1
Dominican Republic	0	249	– 249
Ecuador	2	121	– 119
Egypt, Arab Rep.	1	294	– 293
El Salvador	3	98	– 95
Estonia	19	63	– 44
Eswatini	0	14	– 14
Ethiopia	8	27	– 19
Fiji	1	6	– 5
Finland	3 550	985	2 565
France	15 961	12 982	2 979
French Polynesia	0	3	– 3
Georgia	1	41	– 40

Country	Receipts	Payments	Net
Germany	36 171	16 149	20 022
Greece	76	321	– 245
Grenada	0	9	– 9
Guatemala	16	242	– 226
Guyana	0	5	– 5
Haiti	25	0	25
Honduras	0	85	– 85
Hong Kong SAR, China	743	1 993	– 1 250
Hungary	1 484	1 532	– 48
Iceland	284	102	182
India	872	7 890	– 7 018
Indonesia	174	1 805	– 1 631
Iraq	2	10	– 8
Ireland	11 868	94 262	– 82 394
Israel	1 579	1 520	59
Italy	4 516	5 245	– 729
Jamaica	5	51	– 46
Japan	46 853	26 267	20 586
Jordan	9	27	– 18
Kazakhstan	3	141	– 138
Kenya	63	122	– 59
Korea, Rep.	7 742	9 952	– 2 210
Kosovo	1	10	– 9
Kyrgyzstan	1	5	– 4
Latvia	19	50	– 31
Lebanon	26	22	4

Country	Receipts	Payments	Net
Lesotho	0	3	– 3
Lithuania	34	73	– 39
Luxembourg	2 635	6 123	– 3 488
Madagascar	4	17	– 13
Malaysia	267	2 006	– 1 739
Malta	610	841	– 231
Mauritania	0	2	– 2
Mauritius	1	13	– 12
Mexico	7	313	– 306
Moldova	2	31	– 29
Mongolia	1	26	– 25
Montenegro	1	6	– 5
Morocco	12	148	– 136
Myanmar	17	33	– 16
Namibia	1	3	– 2
Netherlands	41 842	43 203	– 1 361
New Caledonia	0	2	– 2
New Zealand	523	931	– 408
Nigeria	0	253	– 253
North Macedonia	11	161	– 150
Norway	373	756	– 383
Pakistan	0	192	– 192
Panama	13	71	– 58
Peru	26	349	– 323
Philippines	28	833	– 805
Poland	657	3 746	– 3 089

Country	Receipts	Payments	Net
Portugal	132	849	– 717
Romania	111	945	– 834
Russian Federation	1 014	6 866	– 5 852
Senegal	5	9	– 4
Serbia	54	304	– 250
Seychelles	1	3	– 2
Sierra Leone	6	1	5
Singapore	8 473	16 151	– 7 678
Sint Maarten (Dutch part)	0	1	– 1
Slovakia	43	748	– 705
Slovenia	77	257	– 180
Solomon Islands	1	4	– 3
South Africa	108	1 649	– 1 541
South Sudan	9	1	8
Spain	3 418	6 839	– 3 421
St Kitts and Nevis	0	2	– 2
St Lucia	0	9	– 9
St Vincent and the Grenadines	0	3	– 3
Suriname	0	5	– 5
Sweden	8 247	6845	1 402
Switzerland	23 906	11919	11 987
Tajikistan	0	0	0
Tanzania	0	6	– 6
Thailand	197	5 312	– 5 115
Timor-Leste	0	0	0
Togo	0	0	0

Country	Receipts	Payments	Net
Tonga	0	0	0
Trinidad and Tobago	7	39	– 32
Tunisia	23	21	2
Turkey	88	1 932	– 1 844
Uganda	16	33	– 17
Ukraine	82	606	– 524
United Kingdom	25 257	16 936	8 321
United States	117 401	42 732	74 669
Uruguay	45	121	– 76
Uzbekistan	0	87	– 87
West Bank and Gaza	0	2	– 2
Yemen, Rep.	3	205	– 202
Zambia	0	17	– 17
Zimbabwe	0	4	– 4

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This report presents the result of a study that explores the interactions and the balance between Open Science and Intellectual Property Rights. The report presents the state of the art and reflections to scope the statement 'as open as possible, as closed as necessary' in the context of an evolving and open Research and Innovation ecosystem. Furthermore, the report identifies concrete recommendations for policy makers and for IPR practitioners on the promotion of Open Science and its balance with IPR for better knowledge dissemination to the benefit of all.

Studies and reports