오픈사이언스 정책을 통한 포스트팬더믹 경제의 선재적 대응방안 연구

2022년 11월

과학기술정보통신부

박 인 영

차 례

국외훈련 개요

1. 훈련국 : 미국 (United States of America)

2. 훈련기관명 : Mind the Bridge

3. 훈련분야 : 과학기술

4. 훈련기간 : 2021. 12. 15. ~ 2022. 12. 14.

1. 훈련기관 개요

1. 기 관 명 : Mind the Bridge

2. 주 소 : 450 Townsend St, San Francisco, United States

3. 연 락 처 : (415) 857-3517

4. 홈페이지 : www.mindthebridge.com

5. 이 메 일 : mmarinucci@mindthebridge.org (CEO)

6. 기관소개

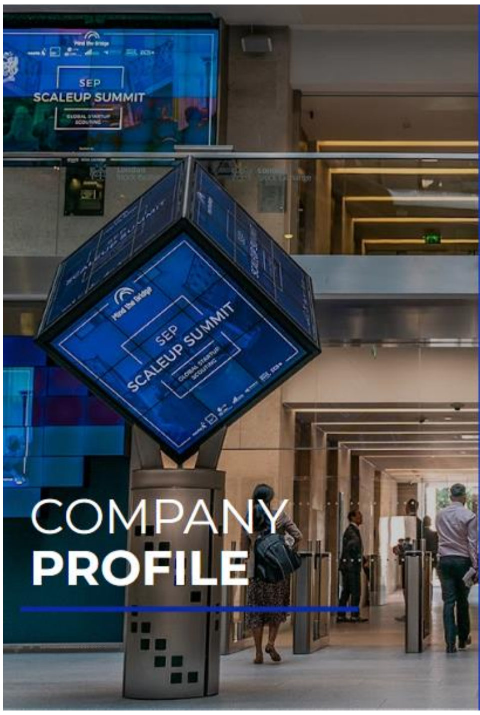
(주요기능 및 분야) 지속가능한 글로벌 기업 생태계 육성을 목표로 설립

① 기업의 개방형 혁신 프로세스를 지원하는 자문 서비스

② 기술고도화 기업을 위한 전용 기술 스카우트 서비스

③ 스타트업 서밋을 통한 기업과 스타트업 간 매칭 활동 및 스타트업 엑셀러레이팅 교육프로그램 지원

④ 스타트업 생태계에 대한 데이터 공유 목적의 정기적 보고서 발간 등 스타트업 생태계 활성화 지원을 위한 서비스 제공



MISSION

Our goal is to foster a sustainable global entrepreneurial ecosystem. Our programs and activities focus on bringing startups, corporates, and governments together to enhance the growth of all parties, and to bring new value to ecosystems through innovation.

ACTIVITIES

- Providing open innovation advisory services for **government entities** and Fortune 2000 **corporates**;
- Researching and developing **reports** focused on innovation ecosystems;
- Organizing and operating global **matching platforms**;
- Providing **startup education** and scaleup market entry programs.

OUR STORY

Mind the Bridge (MTB) was established in 2007 by then Googler Marco Marinucci together with the university professor as well as serial entrepreneur Alberto Onetti. Respectively, Marco serves as the company's CEO and Alberto as Chairman. In Mind the Bridge we believe in the societal value created by embracing the principles of entrepreneurship as a key accelerator of economies.

MIND THE BRIDGE **AT A GLANCE**

Mind the Bridge is a boutique innovation advisory firm working at the intersection of Startups and Corporates since 2007.
With HQs in San Francisco and offices and operations in Europe and Asia, **we bridge innovation ecosystems.**

SUCCESSFUL TRACK RECORDS

5000+
Startups engaged / year

100+
Corporates served / year

300+
Investor partners engaged / year

400+
Startups graduated from MTB Innovation School

INNOVATION DNA

Taylor-made **strategic observatories** and **assessments for specific verticals / industry**.

Data driven research and **reports** to intercept the relevant trends in the innovation space (cited as a source by Financial Times).

Collaborations with the main **European Stock Exchange** (London, Milan, Madrid, Stuttgart,...).

VERTICAL AGNOSTIC

We have **experience**, **experts** and **networks** within the following verticals:

Automotive & E-Mobility
Industry 4.0
Fintech & Insurtech
Healthcare
Circular Economy
Decarbonization
Energy Tech
Oil & Gas
Cyber Security
Safe Tech
Clean Tech
AI/ Machine Learning
And more...

SILICON VALLEY HQ

Long-term presence in San Francisco (12+ yrs).

Fully integrated with the **local ecosystem** with knowledge on the different actors of the innovation ecosystem.

Host of **innovation outpost** for Italian and International corporates.

The first Mind the Bridge Innovation Center opened in San Francisco in 2019.

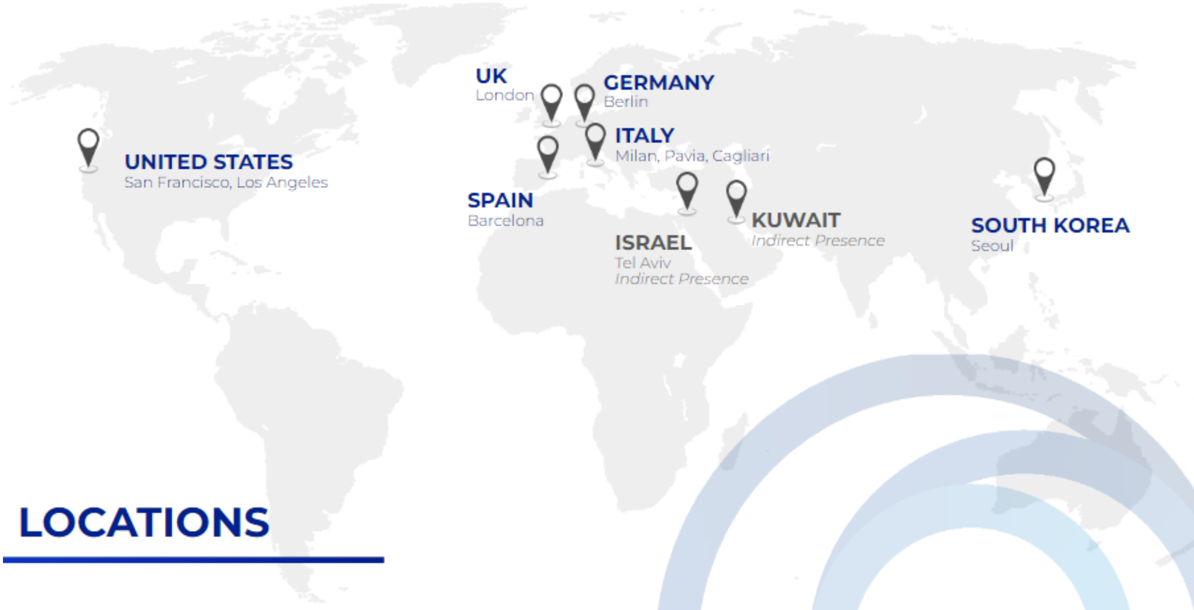
INTERNATIONAL NETWORK

Operating globally with strong relationships with local partners.

Offices and operations in the **US** (San Francisco) **Europe** (Spain, UK, Italy and Belgium), **Korea** (Seoul) and **Middle East** (Israel, Kuwait).

Chosen by the European Commission to run **Startup Europe Partnership (SEP).**

(글로벌오피스) 샌프란시스코를 본사로 하며, 스페인 바르셀로나, 이탈리아 밀라노, 독일, 영국 등에 사무소 소재



(정기보고서 생성) Mind Bridge는 매년 Tech Scaleup Silicon Valley, Tech Scaleup China, Startup M&A 등과 같은 수십 개의 대화형 보고서를 생성하여 전 세계 혁신 생태계의 상태를 정기적으로 모니터

- 보고서는 글로벌 새로운 트렌드와 새로운 기술에 대한 심층 분석 제공할 뿐만 아니라, 지역의 특성에 맞게 맞춤형 연구에 특화되어 있으며 수요와 니즈에 따라 발간되며 이노베이션 생태계 파트너 프로필에 통합되고 Scaleup Summits 동안 주로 발표

2. 훈련결과보고서

오픈사이언스 정책을 통한 포스트팬더믹 경제의 선재적 대응방안 연구

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I. Introduction

1.1 Background

Since the Covid 19 pandemic initially emerged and produced a widespread epidemic, more than two years had passed. The pandemic has helped the general public realize that infectious diseases are a worldwide problem that affects the entire world. Because of this, everyone is aware that there is a problem that requires international cooperation to solve. In addition to COVID 19, there are several concerns that need to be handled by nations, such as climate change, and it is becoming increasingly clear how important and essential the international scientific cooperation is.

The need for open research is growing, and the debate is getting livelier. Open science offers unfettered access to scientific knowledge and data, as well as open information sharing and cooperation. In particular, UNESCO created a code of practice that can be widely accepted by the international community and proposed the 'Open Science Recommendation' at the 41st General Assembly (UNESCO, 2021). Furthermore, open science is not summarized in a single philosophy or publication. Instead, a set of procedures that improve the openness and accessibility of scientific research can be referred to as "open science." (Van der Zee &Reich, 2018).

Science will become more effective, dependable, and sensitive to societal concerns as a result of open science. Since its foundation, the European Commission has worked to improve open science policy in a comprehensive and integrated manner, addressing every stage of the research cycle, from knowledge sharing and publication to scientific discovery and review. (Jean-Cluade Burgelman et al, 2019) Open science as a concept is not new, and other titles, like Science 2.0, have been used to describe the evolution of scientific methods. (Burgelman et al., 2015). Multiple approaches that exist to the transformation to open science are all rooted in the tradition of openness of science. The European Commission started using the term "open science" as a result of the public consultation on Science 2.0 Science in Transition in 2014 (European Commission, 2015). Horizon Europe, the new EU Framework Programme for Research and Innovation, will promote open science in the full meaning of open scholarship. In this vein, it is defined open scholarship as sharing knowledge and data as early as possible in the research process in open collaboration with all relevant knowledge actors. (Von Schomberg, 2019)

Science is traditionally regarded as an open endeavor. The P2P Foundation's concept of open science starts by acknowledging that science has historically been an open endeavor and that the Internet has the ability to broaden and improve the openness in novel ways:

Openness is arguably the great strength of the scientific method. At its core is the principle that claims and the data that support them are placed before the community for examination and critique. Through open examination and critical analysis models can be refined, improved, or rejected. Conflicting data can be *compared and the underlying experiments and methodology investigated to identify which, if any, is more reliable. While individuals may not always adhere to the highest standards, the community mechanisms of review, criticism, and integration have proved effective in developing coherent and useful models of the physical world around us. As Lee Smolin of the Perimeter Institute for Theoretical Physics recently put it, 'we argue in good faith from shared evidence to shared conclusions.' (p2pfoundtation)*

Another crucial component of science ethics is openness. Scientists are expected to publish their work in full and to make public their methods and procedures just as much as the data or findings because of their professional stature and involvement in scientific groups. Most importantly, scientists should be willing to accept criticism and take part in peer reviews of their work. According to David Resnik, science's peer review depends on openness, science cannot become dogmatic, unthinking, or biased if it is not open (Resnik, 1998).

The benefit of open research insofar as it relies on commons-based peer production is more and more recognized as a mode or system of production characterized by extensive collaboration and driven by goals other than financial gain. According to Benkler & Nissenbaum, it is said that:

Commons-based peer production is a socio-economic system of production that is emerging in the digitally networked environment. Facilitated by the technical infrastructure of the Internet, the hallmark of this socio-technical system is collaboration among large groups of individuals, sometimes in the order of tens or even hundreds of thousands, who cooperate effectively to provide information, *knowledge or cultural goods without relying on either market pricing or managerial hierarchies to coordinate their common enterprise. While there are many practical reasons to try to understand a novel system of production that has produce d some of the finest software, the fastest supercomputer and some of the best web-based directories and news sites, here we focus on the ethical, rather than the functional dimension. What does it mean in ethical terms that many individuals can find themselves cooperating productively with strangers and acquaintances on a scope never before seen?*

The ICT sector is heavily reliant on Open Science in particular. Jean-Claude Burgelman (2019) demonstrate that ICT is critically enabling open science, but open science is more than a technology-driven change. As Open Science consists of 3 main component - open data, open access and open source, one of the most important ones for open science to succeed is open data. Open data speed up the research process by facilitating re-use and enriching datasets (King, 2011; Piwowar et al., 2011; Whitlock, 2011) while making the most of (public) investment in the production of research data. Opening up data enables to detect false claims and inaccuracies and allows for replicability tests (Ioannidis and Khoury, 2011) In essence, it permits more utilization of the same investment, which increases the potential for discovery, especially for solving cross-cutting research concerns like the majority of the major global challenges. (UN Sustainable Development Goals 1). Finally, it acknowledges data producers who increase their rate of citation and, thus, the impact of their research. (Piwowar et al., 2007).

Ebola and Zika from the previous pandemic can serve as good examples of the benefits of open science. The numerous Ebola-related deaths that occurred in West Africa between 2014 and 2016 could have been avoided with the use of already available information (Knobloch et al., 1982). The World Health Organization (WTO) calls for a paradigm shift in the way information sharing is handled in times of public health emergencies, moving away from embargoes imposed on publication deadlines and toward free sharing using contemporary, fit-for-purpose prepublication platforms (WHO, 2015). This paradigm shift will require active participation from researchers, journals, and funders. The WHO has acknowledged that patents on natural genome sequences may impede future research and product development. As a result, the WHO urges research organizations to use caution when patenting and licensing genome-related inventions in order to avoid impeding the development of new products and to ensure fair benefit sharing. Large-scale genomic data must henceforth be made public by grantees at the time of publication, at the latest, according to the National Institutes of Health in the United States.

The usage of data across disciplines broadens the field of study and diversifies viewpoints (Fischer and Zigmond, 2010). It additionally enables the production of new knowledge (Evans and Foster, 2011). However, the sharing of data is hampered by formal recognition as data citations are not currently common practice and by reluctance from researchers who believe that open data will harm their individual publishing trajectory and effect (Costas et al., 2013).

One of the major open science challenges and a larger one, changing the reward and incentive structure for researchers, is one for which the scientific community is mostly responsible (universities and funders). This entails using particular markers for researchers' engagement with open science as well as making open scientific approaches commendable and financially feasible.

1.2 Research Structure and Methodology

This report consists of the open science policy analysis and related open data, open access and open sources concept in reflect of open science field.

In this paper, first of all, I will overview the current open science policy in each region – EU, US, China and Korea to understand the open science ecosystem. Second part covers the main three component of open science – open data, open access and open source. The third part suggests some possible ways of improving open science policies in Korea.

First, the current section was organized to understand the meaning of the open science and why it is so important after pandemic phenomenon, including the introduction. It also summarizes the importance of open science as a new tool to cooperate between countries to develop research depth and openness

In the Section 2, it explores the different open science policy between counties and also analyzes Science 2.0 based on the Web 2.0. It is already a era to enter into Web 3.0, but would like to explore the correlation between Science 2.0 and Web 2.0 and how they interact each other. Finally in the last, it explores the open innovation living lab. I mainly focus on the three component of open science – open data, open access and open source.

In Section 3, it focuses on the open data aspect and emphasize why it’s important to focus on open data in terms of open science.

Section 4 aims to derive implications for open access aspect and how it can improve its related policy.

Section 5, it analyzes the open source as an open science to develop its policy and researcher/developer-friendly ecosystem.

Finally in Section 6, I draw some implication to develop open science policy in Korea.

II. Open Science

1. EU's Open Science Policy

Europe is advanced in terms of open science policy. Europe is the one of the leading countries to launch projects about research data sharing which is one of the core subjects of open science. For the innovation of science and technology, it is necessary for data sharing and building framework for process. For example, in Europe, European Open Science Cloud (EOSC) is one of the representative tools for open science. EOSC is to provide European researchers, innovators, companies and citizens with a federated and open multi-disciplinary environment where they can publish, find and reuse data, tools and services for research, innovation and educational purposes. (European Commission, 2021)

Given that it enhances the quality, effectiveness, and responsiveness of research, open science is a strategic objective for the European Commission and the usual manner of operation under its research and innovation funding programs. Researchers can better disseminate the most recent findings by sharing knowledge and data with all pertinent actors as early as possible in the research process. The Commission mandates that recipients of funds for research and innovation make their publications open access and their data as accessible and closed as possible. It honors and rewards citizens and end-users' participation.

It is explained by the 'taxpayer argument' to enforce government accountability to citizens who pay for research via taxes, and by the expectation to increase the value of public funds invested in research by reducing duplicate, low-quality or difficult-to-find research work.

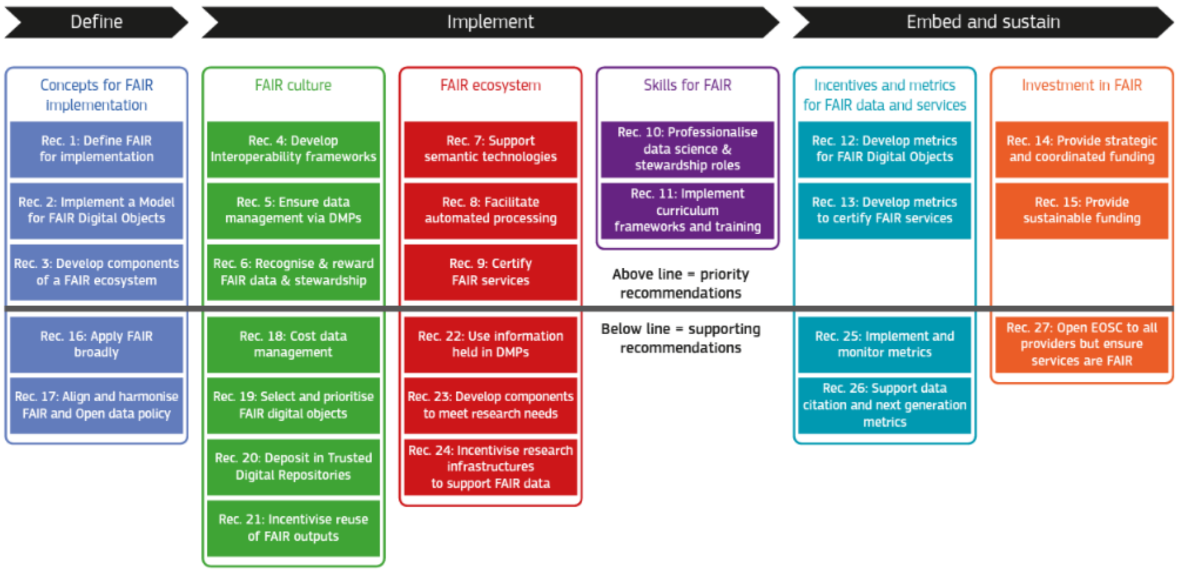
For example, a 2019 study commissioned by the European Commission (EC) estimated the annual cost of not having Findable, Accessible, Interoperable and Reusable (FAIR) research data at the level of EUR 10 billion within the European Union (EU) economy, which amounted to 78% of the Horizon 2020 budget per year; one of the indicators to measure that cost involved in duplication of funding in the EU public research. (Shmagun, Shim, Choi, Shin, Kim, Oppenheim, 2022)

As mentioned above, the EOSC will make it possible for researchers from different fields and nations to store, organize, and share data. Specifically, open research approaches must be effectively linked to innovation and business models, which calls for careful examination of concerns like Intellectual Property Rights (IPR), license contracts, interoperability, and data reuse.

There are eight main factors of EU's open science policy.

1. Open Data

EU put heavily importance on the open data research stands for FAIR. FAIR represents Findable, Accessible, Interoperable and Reusable data. This became the default for the results of EU-funded scientific research. The implementation of FAIR is supported through the EOSC. Each of the member states should support this movement by aligning their policies and investments in relation to FAIR data.



< Figure 1 : Index to FAIR Action Plan recommendations >

- Application and implementation of FAIR

The term "FAIR" or "FAIR data" is used in the research community to refer to a notion that incorporates a variety of academic resources that are related to research data, such as methods, workflows, and pipelines. The FAIR principles are effective in serving their purpose of being a simple set of fundamental qualities. Some ide as require extension and unpacking in order to be put into practice and to make FAIR data a reality.

The Royal Society report states that data should be evaluable so that conclusions about their dependability and the skill of people who created them can be drawn. Details that show assessability should be included in the information needed to accomplish reusability. It is essential that prospective consumers have access to the data so they may evaluate the truthfulness, dependability, and caliber of the information to decide whether it satisfies their demands.

“FAIR” also contains the meaning that research data should be available whenever possible. In public health emergencies, it is crucial to guarantee that research networks and health authorities can work together efficiently to increase the speed of reaction and future research, much as it is in pandemic situations around the world. Keeping data and information under embargo is debatable, but the benefits that researchers have seen through quick data sharing agreements and the growing acceptance of data sharing suggest that there is little justification for embargos.

- A FAIR ecosystem to support FAIR

It requires major shifts in terms of research culture and practice. The implementation is essential for a number of data services and components to be in place in the broader ecosystem that enables FAIR. It is recommended in European Union to support research communities to adopt and coordinate data standards and mechanisms for Fair sharing, making strategic investments in technology, services and tools to support FAIR data in coordinated, interoperable and cross-disciplinary way.

2. European Open Science Cloud (EOSC)

The EOSC is a tool to provide European researchers, innovators, companies and citizens with a federated and open multi-disciplinary environment where they can publish, find and reuse data, and services for research and educational purposes. It's ultimate goal is to develop a 'Web of FAIR Data and services' for science in Europe where a wide range of value-added services can be built.

EOSC brings together institutional, national and European stakeholders, initiatives and infrastructures. This FAIR concept came from the G8 Science Minister's

Statement drew together properties mentioned in 2013. These criteria were adopted in the European Commission's first set of data guidelines for the Horizon 2020 framework programme later. The FAIR principles were received at the Lorentz conference in 2014 and published following consultation via FORCE11.

3. New generation metrics

New indicators must be developed to complement the conventional indicators for research quality and impact, so as to do justice to open science practices.

4. Mutual learning exercise on open science - altimetrics and rewards

Mutual learning activities concentrate on a practical project-based exchange of best practices and center on specific research and innovation concerns that concern a number of EU member states and affiliated nations. This activity has a definitional focus.

- alternative metrics to measure the qualities and impact of research outcomes
- rewards for researchers to engage in open science activities

5. Future of scholarly communication

All peer-reviewed scientific publications should be freely accessible, and the early sharing of different kinds of research outputs should be encouraged.

6. Rewards

Research career evaluation systems should fully acknowledge open science activities. A working group in this area produced a report in 2017 on rewards, incentives and recognition for researchers practicing open science, which is mainly about that strategy must be acknowledged and rewarded by both employers (when hiring and promoting academics) and research funders for it to be supported and incentivized (when performing peer review of researchers in grant applications). It also emphasized that senior researchers must also play a significant part in this change because they have a significant impact on peer review and researcher recruitment/promotion for funding organizations and publishers.

7. Research integrity & reproducibility of scientific results

In the EU, all publicly sponsored research must abide by established guidelines for scientific integrity. Research and innovation activities should produce repeatable results. In December 2020, a scoping report on the reproducibility of scientific findings in the EU was released. According to this paper, it promotes European Commission's understanding of the lack of reproducibility in Europe by exploring the main traits and underlying causes of the lack of reproducibility, including bias, poor experimental design and statistics, issues with scientific reporting, research culture, career-related factors and economics. (EU, 2020)

8. Education and skills

In order to implement open scientific research routines and practices, all scientists in Europe should have the necessary training and assistance. Providing researchers with the abilities and competencies they need to undertake open science was the title of a paper issued by a working group in this field in 2017, which provides the results of a survey amongst researchers in Europe on their perceptions on Open Science policies and practices and then focuses on the specific skills researchers need for Open Science.

9. Citizen science

The general public should be able to contribute significantly and be acknowledged as legitimate producers of European scientific knowledge. It is also well-illustrated in Citizen Science published by EU in 2020, highlighting that citizen science can be described as the voluntary participation of non-professional scientists in research and innovation at different stages of the process and at different levels of engagement, from shaping research agendas and policies, to gathering, processing and analyzing data, and assessing the outcomes of research. Research and its results could be improved through active involvement with individuals and society, which would also increase public confidence in science. By ensuring that R&I is in line with societal requirements, expectations, and values, it can enhance relevance and effectiveness, originality and quality, transparency, science literacy, and public trust in research. It can also broaden the scope of research and improve the quantity and quality of data.

1.1. International policy and Horizon Europe

The EU's Open Data Directive, also known as the PSI Directive or Open Data Directive, was adopted on June 20, 2019, and its implementation by Member States and is expected to be complete by July 16, 2021. The Directive emphasizes the importance of improving the accessibility, use, and sharing of publicly financed research data. This directive was changed with the intention of improving digital public services by, among other things, a stronger emphasis on data transparency, more use of AI, and financial support for tech start-ups. The directive applies to data that are created through publicly funded research as well as those that are generated in co-funded public and private sector projects. The directive follows the European Commission maxim of 'as open as possible, as closed as necessary' and accordingly allows for legitimate data sharing exceptions. (SPARC Europe and DCC, 2021)

According to The European Commission, it has collected and shared information on how different Member States and European Economic Area (EEA) countries have implemented the directive. As made clear by this excellent resource, there are several ways to put the directive into practice, including the adoption of specific PSI re-use measures, through a combination of new measures specifically addressing re-use and legislation anted the Directive, and by modifying legal frameworks for document access to include re-use of public sector information. The European Commission has reaffirmed its commitment to facilitating open science in the requirements for participation in the upcoming R&I Framework Programme Horizon Europe, which runs from 2021 to 2027, in addition to the Directive on

Open Data and the Re-use of Public Sector Information (PSI Directive). The programme aims to mainstream 'open science practices for improved quality and efficiency of R&I, and active engagement of society'.

Under Horizon Europe there is a shift from open research data to research data management which reflects the fact that not all data can be shared openly and reinforces the maxim 'as open as possible, as closed as necessary'. As with Horizon 2020, costs associated with RDM (for example data storage, processing and preservation) remain eligible. To support this, the European Commission is going to provide dedicated support to open science policy actions, including its new Open Research Europe publishing platform to allow for the sharing of outputs (Open Research Europe, 2021). This platform requires open access to research data supporting articles under the principle 'as open as possible, as closed as necessary'. The European Commission also encourages modernising recognition and reward systems on national levels which are crucial to the success of OA and OS.

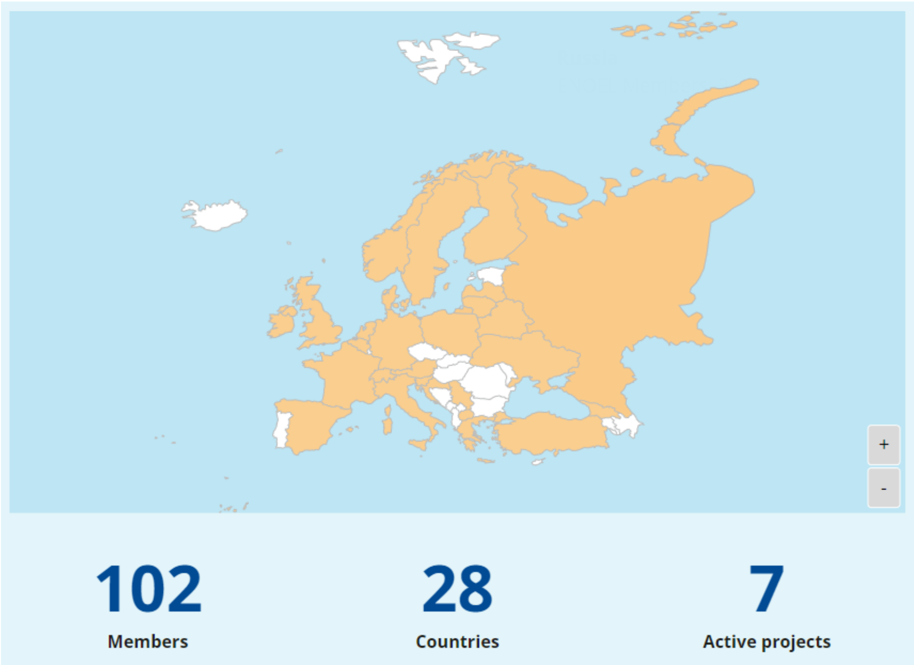
The recent EC communication on the ERA (European Research Area) makes explicit the European Commission's commitment to open science. The idea for creating a single scientific and technological region is outlined in the ERA for Research and Innovation. It asserts that conventional "single market" components of the ERA, such as the adoption of open science, need to move more quickly if they are to boost the excellence and efficiency of the European R&I system. It highlights how making research more reusable and reproducible promotes excellence and trust in science, enhancing research quality, efficiency, and creativity.

It highlights the development of the European Open Science Cloud (EOSC) as a common, federated, European framework for openly sharing research data and services and sees it grow into a trusted European research and innovation space and platform for various sectors. Additionally, it announces the opening of its publication platform for Open Research Europe, which seamlessly combines publicly funded research into a unified European data environment. The new ERA emphasizes the value of providing incentives for collaboration and disseminating findings to encourage multidisciplinary research.

It makes the point that in order to coordinate and synchronize transformation in the research assessment system at institutional, regional, national, and international levels, a multi-stakeholder strategy will be required. According to a press release from the Commission, it will "launch, via the Horizon Europe Programme, a platform of peer-reviewed open access publishing; analyze authors' rights to enable sharing of publicly funded peer-reviewed articles without restriction; ensure a European Open Science Cloud that is offering findable, accessible, interoperable, and reusable research data and services (Web of FAIR); and incentivize open science practices by improving the research assessment system."

1.2 The European Network of Open Education Librarians (ENOEL)

ENOEL is a community of academics from across Europe who share educational values and advocate for Open Education (OE). Established in 2018, the network encourages and facilitates the exchange of ideas with peers, and values learning from one another to drive Open Education possibilities forward.



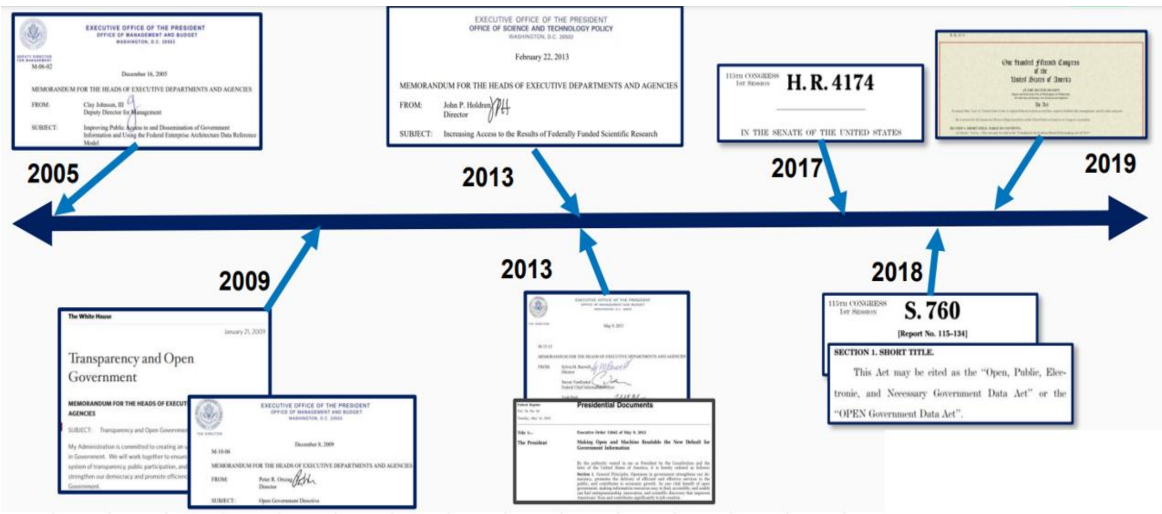
< Figure 2 : ENOEL members per country >

Source : https://sparceurope.org/what-we-do/open-education/enoel/

2. US' Open Science Policy

In the United States, the federal public access policy has been guided by the *Memorandum on Increasing Access to the Results of Federally Funded Research*. Issued by the White House Office of science and Technology Policy (OSTP), the 2013 Memorandum directed all federal departments and agencies with more than $100 million in annual research and development expenditures to develop a plan to support increased public access to the results of federally funded research, with specific focus on access to scholarly publications and digital data resulting from such research. Every federal agency covered by the 2013 Memorandum has created and put into effect a public access policy in accordance with its recommendations almost ten years later. The American public has benefited greatly as a result, with more than 8 million scholarly articles being available to them so that 3 million people read these stories for free every day. A paradigm changes away from research silos and toward a scientific culture that encourages collaboration and data sharing was made possible by the 2013 federal public access legislation. By sharing findings with the general public and the scientific community in an unrestricted and transparent manner, the 2013 Memorandum contributed to reshaping the data and research landscape.

The 2013 Memorandum's policy recommendations might be strengthened in light of these significant developments in order to ensure that all Americans have access to the data and outcomes of government supported research. Years of public comment have shown that the 2013 Memorandum's main restriction is the choice to place a 12-month embargo on any publications originating from publicly supported research. Those who can afford it or have special access through libraries or other organizations can now only view the results of federally supported research. The American public should never be opted out of the benefits of government supported research because they lack the financial resources or access to those benefits. A federal public access policy that upholds our ideals of equality of opportunity must permit rapid and extensive dissemination of research that has received federal funding, enabling all Americans to immediately reap the rewards of investments in R&D. Maintaining these fundamental American values in public access policy also improves the capacity to lead and collaborate on open science challenges globally. The United States is committed to the notions that freedom and integrity are critical, security is necessary, and openness in science is fundamental.



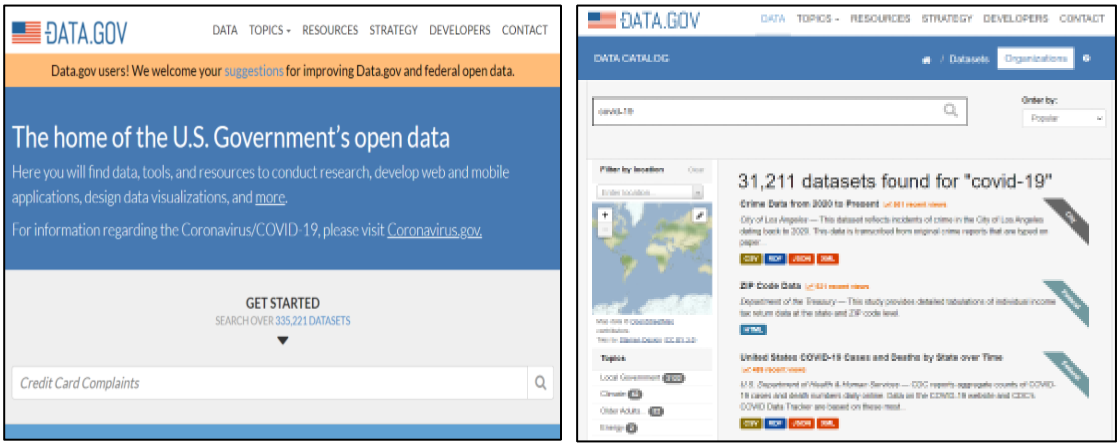
< Figure 3 : U.S. Government-Funded Science: Policies 2005 to 2019 >

Source : https://beopen-project.eu/

2.1 Learning from the Lessons of COVID

Access by the general public to federally funded research has the ability to save lives, speed up scientific discovery and application, encourage more equitable outcomes across all facets of society, and provide decision-makers with critical data on which to base important decisions. Americans first saw a peek of the immense benefits of direct public access to publicly funded research during the start of the COVID-19 epidemic. Government, industry, and the scientific community joined together voluntarily to develop an instant public access policy in the wake of the public health emergency. The results of this collaboration were significant: research and data flowed effectively, the rate of discovery was boosted by new, easily accessible insights, and science translation rose significantly.

The policy shift during COVID-19 demonstrated how allowing prompt access to data and publications from federally funded research can have an almost immediate positive impact on the investments made in science and technology by American taxpayers. One compelling illustration of the benefits of making research findings and data readily available to the general public is the immediate public access to COVID-19 study. The outcomes of recent, state-of-the-art research enabled by support from federal organizations should be accessible always, not just in times of need. To better understand important subjects like cancer, clean energy, income inequality, and climate change as well as to fight a pandemic. The United States' general happiness, economic prosperity, and health are dependent on American investment in this kind of research.



< Figure 4 : U.S. Government Funded Science Technology: Data.gov >

Source : https://data.gov/

For example, in the Data.gov which is the U.S. Government's open data to find data, tools and resources to conduct research, develop web and mobile application or design data visualizations, more than 30,000 Covid-19 relate data sets are found. Along with those data, some other resources are also available

- DCAT-US Schema v1.1 (Project Open Data Metadata Schema)
- Principles of Open Government Data
- Data Ethics Framework
- Geoportal Server
- JSON Validator
- Digital Analytics Program (DAP)
- Improving Agency Data Skills Playbook
- Case studies & examples

2.2 Ensuring Scientific and Research Integrity in Agency Public Access Policies

A crucial instrument for maintaining the integrity of scientific and research endeavors is public access policies that provide transparent, accessible, secure, and free transmission of federally supported research and activities in a timely manner. Federal agencies should take action to ensure that public access policies support the integrity of science and research by transparently disseminating important information to the public, such as that pertaining to the authors, funding, affiliations, and stage of development of federally funded research. The federal agencies that support certain investments in science, the researchers who work on those projects, and the level of peer review should all be transparent to the public. These activities uphold the principle that openness, security, freedom, and honesty are necessary for preserving and reestablishing the public's trust in science.

2.3. Public Access Plan Coordination Among Federal Agencies

Successful delivering American research to the public depends on cooperation between government science agencies. In collaboration with OSTP, the National Science and Technology Council Subcommittee on Open Science was established to promote such coordination between federal science agencies. The Subcommittee on Open Science will:

a) coordinate between federal science agencies to enhance efficiency and reduce redundancy in public access plans and policies, including as it relates to digital repository access;

b) improve awareness of federally funded research results by all potential users and communities;

c) consider measures to reduce inequities in publishing of, and access to, federally funded research and data, especially among individuals from underserved backgrounds and those who are early in their careers;

d) develop procedures and practices to reduce the burden on federally funded researchers in complying with public access requirements;

e) recommend standard consistent benchmarks and metrics to monitor and assess implementation and iterative improvement of public access policies over time;

f) improve monitoring and encourage compliance with public access policies and plans;

g) coordinate engagement with stakeholders, including but not limited to publishers, libraries, museums, professional societies, researchers, and other interested non-governmental parties on federal agency public access efforts;

h) develop guidance on desirable characteristics of, and best practices for sharing in, online digital publication repositories;

i) identify the key parameters that must be considered in planning how to maximize appropriate sharing of federally funded scientific data that have not been used to support scholarly publications; and,

j) develop strategies to make federally funded publications, data, and other such research outputs and their metadata are findable, accessible, interoperable, and re-useable, to the American public and the scientific community in an equitable and secure manner.

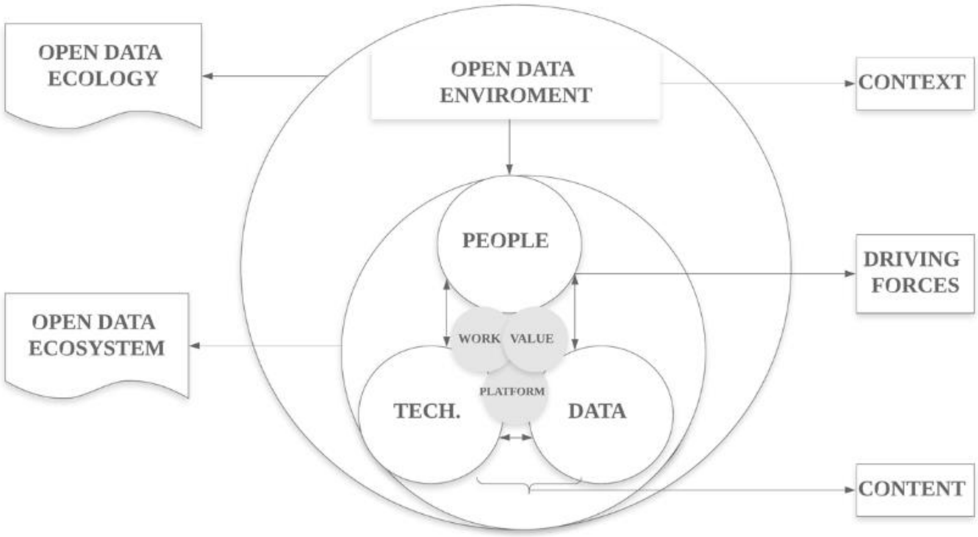
2.4 Following steps for federal agencies

These essential following steps have been made possible by the remarkable advancements in open science and public access spearheaded by federal agencies. The OSTP works on with a shared vision for an ever-stronger and more equitable federal scientific ecosystem as go forward in putting these important steps into practice. The objectives of accelerating scientific discovery, enhancing translation and policymaking, and lowering the obstacles to accessing science for all Americans will be served by immediate public access to America's research papers and data. OSTP would set up a procedure for aiding in the application of these upgrades.

3. China's Open Science Policy

Like many of the countries involved in the international efforts to improve capabilities for open research data sharing and stewardship, China plays a significant role in enhancing data policies and practices (UNESCO, 2015; Shen, et al, 2015; Tollefson, 2018). Original research data generation in China reached 83.72PB by the end of 2017, according to the National Science and Technology Infrastructure Center (NSTI) of the China Ministry of Science and Technology (MOST) (2019). Understanding current developments and new prospects for international research data management and sharing can be improved by knowing how data policies and related practices have changed in China.

The ecology viewpoint is used to provide a thorough analysis of the development of open research data in China. Data ecology uses the idea from biological science and studies the environment, the relationships among organisms within and across ecosystems made up of data, people, and technologies, and their interactions, as well as other intersectional aspects, like platforms, work, and value (Nardi and O'Day, 2000; Parsons, et al., 2011; Pritchard and Martel, 2019). This idea is frequently used in information ecology (Nardi and O'Day, 2000; Wang et al., 2015). These possible components could be categorized into three main categories: context, content, and driving factors. Together, they make up the complexity of dynamic equilibrium (see Figure 5). This open data ecology also highlights open service trends across many ecosystems.



< Figure 5 : Potential components within an open data ecology and its ecosystem>

Source : https://datascience.codata.org/articles/10.5334/dsj-2021-003/

3.1 National level legislations

As shown in Table below, the fundamental guidelines for research data stewardship were established by the "Law of the People's Republic of China on Science and Technology Progress" (2008), which stated that "The Science and Technology Administrative Department of the State Council shall, in coordination with the relevant competent departments of the State Council, establish information systems for scientific and technological resources, such as S&T research bases, scientific institutes, and research data repositories."

Given that the government is one of the major donors to open research data in China, this law also addresses the disclosure of official information.

According to Zhang, other rules also affect research data stewardship by providing provisions on cybersecurity and intellectual property, as well as those governing particular elements, such as research outcomes. The "Data Security Law of the People's Republic of China (Draft Version)" was specifically released for public comment in June 2020. This law seeks to ensure the countrywide flow of data for the protection of data rights in a secure environment, much as the General Data Protection Regulation (GDPR) in Europe. The promotion of various data flows in sound ways, the clarification of and implementation of data security protection requirements for various stakeholders, and guidance for institutional steps to maintain the security of governmental data sharing are key measures.

LEGISLATIONS	ISSUED BY
Law of the People's Republic of China on Science and Technology Progress (2008 amended)	Standing Committee of the National People's Congress (SCNPC, P.R.C.)
Copyright Law of the People's Republic of China (2010 amended)	
Law of the People's Republic of China on Promoting the Transformation of Scientific and Technological Achievements (2015 amended)	
Cybersecurity Law of the People's Republic of China (2017)	
Measures for Managing Scientific Data (2018)	General Office of the State Council, P.R.C.

< Figure 6 : Key legislations guiding open research data in China >

Source : https://datascience.codata.org/articles/10.5334/dsj-2021-003/

3.2 Responsible Driving Forces

- MINISTRY OF SCIENCE AND TECHNOLOGY (MOST)

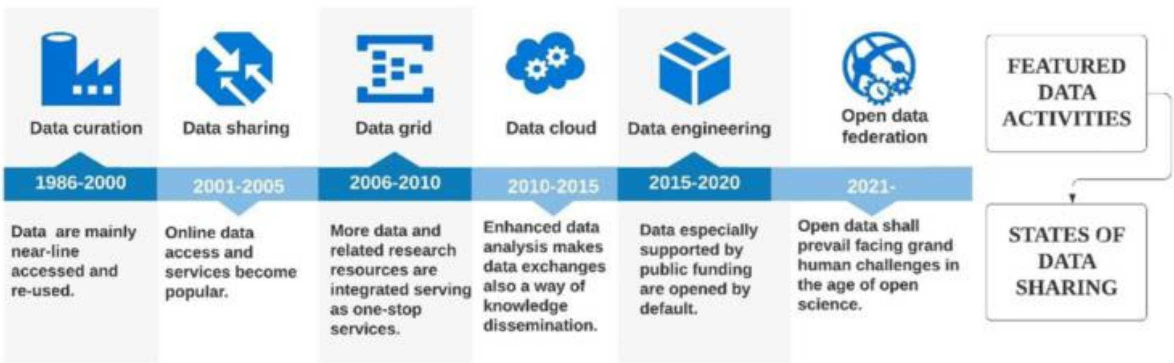
In terms of promoting open data across domains, the MOST takes the lead. Since its first efforts in 2001, the MOST has been assisting the NSTI program with the initial establishment of 13 scientific data centers covering a variety of fields, including population and health, agriculture, forestry, seismicity, meteorology, marine science, Earth systems, and biology, chemistry, materials, and energy. 21 Pre-funding awards have given way to subsidies for the continued growth of several data portals in recent years, encouraging the sustainability of data (MOF, 2013). Another significant contribution to increasing the general service capabilities of national data infrastructures currently facing open data and open research is the design, implementation, and evaluation of national scientific data centers (MOST and MOF, 2019).

- CHINESE ACADEMY OF SCIENCES (CAS)

As one of China's most significant and significant research institutes, CAS takes the initiative to encourage the generation of research data and significantly supports the work of the scientific community across a range of fields (i.e. Chen, 2018; Zhang, 2018). Since 2006, the Scientific Database Program (SDP), one of the CAS projects, has made the generation, curation, and sharing of research data its top priorities (CESDCAS, 2009).

Data was distributed offline, near-line, and to some extent online before the year 2000. The main goals of the SDP program were to increase the volume of research data and curation in order to enhance data management and sharing capabilities (Zhang and Li, 1997). Data sharing possibilities were then

From 2011 to 2015, the adoption of the data cloud has provided an opportunity for attaining flexible, but more robust data infrastructures, and also for supporting value-added data analysis (Liu, et al, 2016 By the end of 2015, the volume of transdisciplinary scientific data had grown to 655 TB, with more than 96,290,000 unique visitors and 456 TB of downloads overall (Li, et al, 2016). The next "Big Data Engineering" program carries on the open data trend based on combining engineering building (CAS, 2017). The basic need to give open, publicly funded data is further clarified in the "Measures of Managing Scientific Data." These efforts prove beyond a shadow of a doubt that the open scientific paradigm, which favors open data, will be adopted globally. The evolving history of SDP is depicted in Figure 7.



< Figure 7 : Data management and sharing in CAS Scientific Database Program. >

Source : https://datascience.codata.org/articles/10.5334/dsj-2021-003/

- CHINA ASSOCIATION FOR SCIENCE AND TECHNOLOGY (CAST)

The largest non-governmental organization in China dedicated to science and technology (S&T) professionals is called CAST23. The issues covered by CAST include data sharing and database sharing. Data have been acknowledged as the primary source of research outputs in the typical project, titled "Discipline development in CAST member societies," and sharing of datasets for scientific research, offered by over 200 national-level academic organizations, has been highlighted in particular (CAST, n.d.).

Additionally, there are other motivating factors, such as global organizations operating in China as CODATA China and the World Data System (WDS). These international organizations and their members support regional data exchanges through detailed regulations, exhibits, trainings, and workshops, as well as through other cutting-edge strategies that make it easier to share and communicate about lifecycle data. Additionally, neighborhood administrative offices, research associations, and their affiliated branches act as stakeholders and contribute to the dynamics that are driving the data ecosystem. It is crucial to emphasize that data producers, data stewards, and data users are the stakeholders whose efforts and needs are of paramount importance and necessary for the development and evolution of an ecosystem for curating and sharing open data, even though the significance of people and the research community is implied in the discussion of such organizational stakeholders.

4. Korea's Open Science Policy

In Korea, Open Science Policy is strongly led by government and government-funded research institute. Since the end of the 1990s, and particularly with the adoption of the E-Government Act, the Korean government has made aggressive investments in e-Government infrastructure and services as part of its national information policy (Turner, Kim, Kwon, 2022). The latter was passed in 2001 and was the first law of its kind anywhere in the world (originally titled "Act on Promotion of Digitalization of Administrative Work for E-Government Realization"). Improving access to and use of government data was on the agenda.

As a result, Korea has been known among OECD members as a pioneer in projects involving open government data (OECD, 2017). The nation has consistently placed first in the OECD Open, Useful, Reusable data (OURdata) Index on open government data since 2014, in particular.

Information created with public funding should, in theory, be given to a wide audience according to policies on open government data and access to public sector information. The Open Science policy domain in Korea, however, is substantially less developed in other ways, though. There aren't any laws that specifically mention open science, and there aren't many additional legal instruments that deal with open science. However, there is mounting political pressure to advance open science principles and procedures.

For instance, the "Joint Declaration," which was signed in 2021 by six of Korea's key open science supporting organizations, calls for collaboration in OA national promotion.

Summary of Open Science –related legal and quasi-legal instruments in Korea

No.	Title	Type	OS practices or their elements	Mandatory or encouraging/ supporting for OS
1	Framework Act on Science and Technology [29] + related presidential enforcement decree [53]	Legislation	It provides a basis for policies and services of OS supporting institutions, such as Korea Institute of Science and Technology Information/ KISTI (Art. 26 of the Act; Art. 40 of the Decree)	Encouraging/supporting (NOT explicitly)
2	National R&D Innovation Act [21] + related presidential enforcement decree [54]	Legislation	In principle, it is related to Green OA in a broad sense (Art. 17 of the Act; Art. 35 and 43 of the Decree)	Encouraging/supporting (NOT explicitly)
3	Act on the Performance Evaluation and Management of National Research and Development Projects [55] + related presidential enforcement decree [56]	Legislation	In principle, it is related to Green OA in a broad sense (Art. 14 and 16 of the Act; Art. 13 of the Decree)	Encouraging/supporting (NOT explicitly)
4	Academic Promotion Act [30] + related presidential enforcement decree [57]	Legislation	In principle, it is related to Green OA in a broad sense (Art. 6(3), 14 and 16 of the Act; Art. 9 of the Decree)	Encouraging/supporting (NOT explicitly)
5	Regulation on ICT and Broadcasting Research Management (enforced by an ordinance of the Ministry of Science and ICT) [58]	Legislation	Opening up software source code produced by researchers (Art. 27, 40(5), 49)	Encouraging/supporting
6	National R&D Information Processing Standard (enforced by an ordinance of the Ministry of Science and ICT) [59][6]	Legislation	RDM (Art. 23)	Encouraging/supporting
7	The National Research Foundation of Korea's (NRF) DMP Guideline [60] + data sharing and RDM provisions in RFPs *(applied only to certain R&D projects for which a DMP is deemed necessary)*	Research funder policy and call documents	Open research data sharing and RDM (software source code is considered as a type of research data and can be covered by this policy)	Mandatory (with permitted restrictions for sharing of actual data)
8	The Korea Institute of Science and Technology Information (KISTI) OA Policy [61]	Research institute policy	OA to scientific publications (journal articles)	Mandatory (with permitted embargo and exceptions)

< Figure 8 : Adapted from Korea's national approach to Open Science >

Source: https://journals.sagepub.com/doi/full/10.1177/01655515221107336

4.1 Explicit institutional policy on Open Science

The only policy in Korea which explicitly requires OA (Green route) to scientific publications and is registered in the international Registry of OA Repository Mandates and Policies (ROARMAP) is an institutional OA policy adopted by KISTI. In accordance with this policy, KISTI researchers are required to deposit an electronic copy of the published version or the final author's version of journal articles in the KISTI OA repository with a Creative Commons Attribution-Noncommercial (CC-BY-NC) license. The institute offers a variety of support mechanisms to cover costs associated with OA publishing in journals, including support for individual APC costs of OA publications, including in hybrid journals, produced as a result of projects in the institute's core R&D area (as part of a project's direct cost); or OA publishing through transformative agreements. Regarding the latter, transformative agreements were reached with Elsevier (2021-2023) and Wiley by the National Research Council of Science and Technology (NST), a consortium of 25 government-funded research institutions, including KISTI (2022-2024). Finally, it is worth noting that the KISTI OA policy permits an embargo period and exceptions for article deposition in the repository and the fact that it does not penalize non-compliance.

4.2. National digital infrastructure supporting Open Science

Korea is among the top nations in the world for having a widespread Internet connectivity infrastructure, excelling particularly in the speed of Internet connections, according to numerous international comparative studies, particularly those by the EC and OECD to measure countries' performance related to the digital economy and digital transformation. Additionally, Korea has gained recognition for its extensive ICT R&D efforts and investments in its dispersion throughout all economic sectors. In particular, the country gives priority to Fourth Industrial Revolution technologies, driven by big data. For example, in 2017, the Presidential Committee on the Fourth Industrial Revolution was established to promote data-driven innovation. The promotion of data infrastructures and services for R&D system innovation, including research data sharing and reuse in data-intensive fields, are part of the Committee's plan. Thus, a mature ICT infrastructure and a commitment to promote technologies for data-driven innovation have shaped the context for OS development in Korea.

The government assigned KISTI to support a number of duties involving the management and distribution of knowledge resources relevant to the S&T sector and national R&D programs. KISTI runs high performance computing and data analysis resources, including Nurion, a fifth-generation national supercomputer that ranks 38th in the world in terms of speed, to support domestic researchers. In addition, it provides multiple knowledge platforms and Artificial Intelligence-powered information services, such as the NTIS - integrated service for national R&D projects. As part of these infrastructures and services, Open Science is being promoted, which highlights an overarching knowledge infrastructure called 'ScienceON'. One of the oldest services within this infrastructure is NTIS, which has been provided since 2006 mainly by KISTI in cooperation with the Korean

Institute of Science and Technology Evaluation and Planning (KISTEP) and the STEPI.

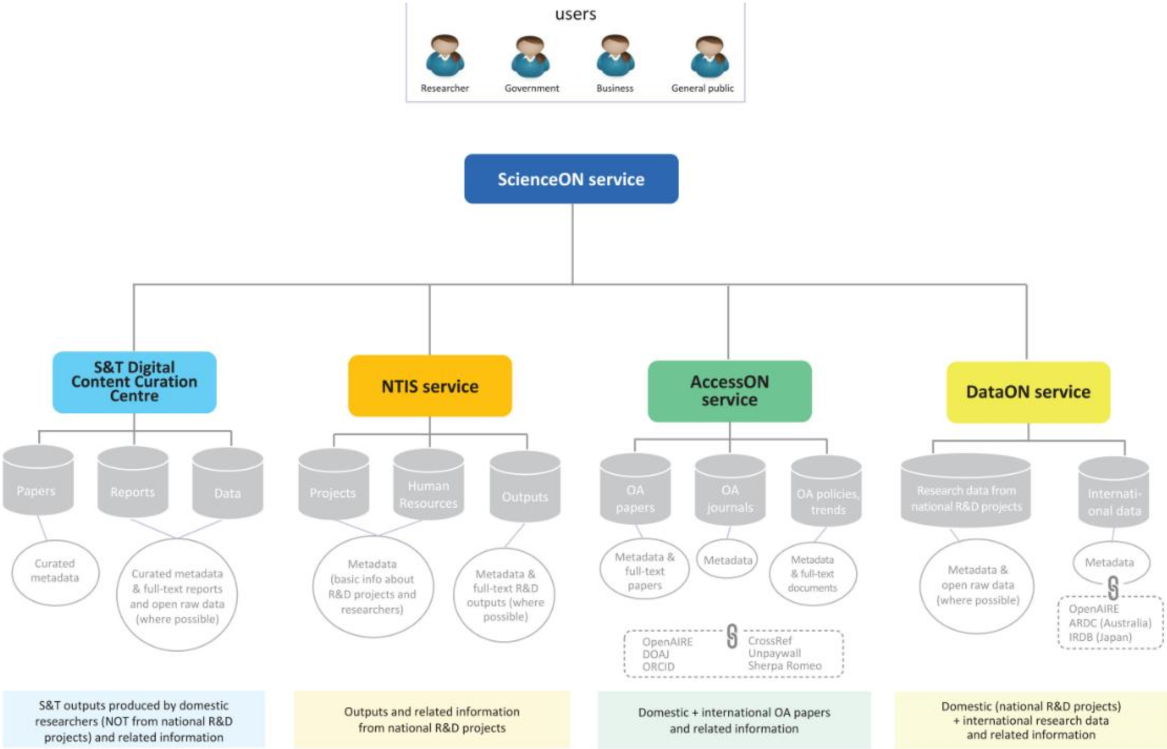
The main objectives of the NTIS service are to improve R&D productivity by maximizing the reuse of available R&D information and to increase the efficiency of national R&D investment by preventing duplicate investments, which can occur when information from national R&D projects is managed by different government organizations and institutions. The National Technology Information System (NTIS) is an integrated information system that functions as a portal to link information on national R&D projects that is dispersed across several databases and deliver it in one location. The information includes standardized management information/meta data (e.g. project name and number, budget, names of R&D performing and funding organizations, names of participating researchers and their ID numbers, basic information about the produced R&D outputs, such as Digital Object Identifiers/DOIs), and links to open R&D outputs, in case the latter are made publicly accessible in the databases of R&D output management institutions. Nevertheless, the deposition of actual R&D outputs, except a full-text R&D report, is not mandatory.

Other NTIS services include, for instance, AI-powered personalized recommendation services based on user search history information analysis, R&D information on social issues delivered as a package, requests for downloading Excel data related to national R&D projects, visualization of research collaboration networks of researchers and research institutes on a specific R&D topic, S&T

statistics and trends dashboards, etc. The Korea Open Access Platform (AccessON), which was introduced in 2020, is another crucial KISTI service and a component of the national OS digital infrastructure.

AccessON is a single-point-of-access platform that offers a comprehensive search for and access to open-access papers from domestic and foreign journals and archives. To achieve this, AccessON gathers metadata for open access articles from a variety of sources, such as OpenAIRE, the Directory of Open Access Journals (DOAJ), Unpaywall aggregators, and the CrossRef and ORCID registries, using the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) interface.

The site also gives users access to other information sources, like OA policies and global trends, in addition to OA papers (original text and metadata). A robust academic activity support system, including the provision of information on predatory conferences and predatory OA journals, is one of AccessON's additional services. It also offers a self-archiving (national repository) service for domestic OA journals and researchers, including preprint archiving for researchers, an online co-authoring collaboration tool, which includes management of references, files, and article versions, and a tool for online co-authoring collaboration. Another element of KISTI's OS digital infrastructure is the Korea Research Data Platform Service (DataON), which has been fully operational since 2020.



< Figure 9 : The system of management and distribution of outputs from national R&D projects >

Source: Korea's national approach to Open Science: Present and possible future

Domestic researchers can register, store, and share their research data from national R&D programs in DataON, which also functions as a national data repository for them (raw data can be saved in DataON or in institutional repositories/data centers). Additionally, the DataON platform offers an online tool for DMP construction as well as a cloud-based environment for research data analysis like JupyterLab. In order to promote the visibility and reuse of the outputs (research articles, reports, and data) from domestic S&T research (other than national R&D initiatives), KISTI's Digital Content Curation Centre offers curation services. It should be highlighted that the aforementioned KISTI platforms, like AccessON, merely collect the content curation services from external databases and repositories for the research output metadata. The KISTI's Curation Center model is centered on a standardized semantic description of curated research outputs (an extended Digital Curation Lifecycle Model based on the one developed by the UK Digital Curation Center) (Shmagun, 2022)

5. Open Science 2.0 based on Web 2.0 and Open Innovation

Both Web 2.0 and Open Innovation are concepts that are applied in business to encourage inter-personal interaction and the development of innovation environment. The methods are adaptable to science, opening up a new direction for study and instruction. If the relevant conditions are met, Open Science 2.0 makes it possible for the public to write scientific publications and hold public seminars, both of which utilize collective intelligence. By doing so, it is possible to foster the exchange of theory and practice while also enhancing individual outcomes.

A closer examination of science finds a similar situation: issues have grown more complicated and frequently need for collaborative efforts to discover solutions. According to Bozeman and Corley, access to expertise or inaccessible equipment, the accumulation of knowledge and productivity, or just the enjoyment of working with others, are some of the most prominent justifications for collaborative research. In reality, during the past few decades, empirical research on scientific collaboration has increased in popularity across a wide range of disciplines.

5.1 Open Innovation

In recent years, the concept of Open Innovation has become known to companies as a new paradigm for developing products and services more efficiently. Instead of relying solely on their own internal research, some firms foster intensive exchange with external sources. The integration of customers or users into the entire development process, in particular, can be significant for the creation of value. According to Tacke, there are three possible core processes:

1. Outside-In Process

Not just from within the organization, but also from outside, can come worthwhile ideas. Therefore, it is meant to incorporate distributed knowledge from clients, vendors, other businesses, or research institutions across the entire innovation process. In 2007, Cisco Systems sought for a new company through an outside innovation competition. The idea for a sensor-enabled smart electrical grid originated from over 1,200 different suggestions that were ultimately submitted by over 2,500 people from 104 different nations.

2. Inside-Out Process

By launching spin-offs or start-ups in industries that do not yet fall under corporate strategy, companies take external routes to market. They also have the option of actively licensing some of their technologies to third parties. Finally, businesses can benefit by allowing spillovers to occur on purpose 4 Open Science 2.0 (so-called free revealing), forgoing the opportunity to appropriate future rents from this information through patents or secrecy, which may bring a corporation multiple benefit.

3. Coupled Process

The Coupled-Process is created when the Outside-In and Inside-Out perspectives are combined. It includes everything from coming up with ideas together to commercializing new items and is defined by give and take. For their Eclipse programming environment, IBM, for instance, adopted the Open Source methodology. On the complicated basic platform, a number of businesses and individuals worked together to speed up time to market and increase the adoption of standards. They still engaged in competition over certain goods and services that may be added.

Making the barriers between you and your environment more porous can result in a better conclusion, since solutions that no one could ever expect might emerge, according to a comparison of open innovation and open science. Despite the fact that these terms are used in distinct fields, they exhibit a number of similarities (such as the ability to solve complex issues, a strong need for creativity, etc.) and are consequently thought to adhere to very similar tenets. As a result, Open Science will carefully adopt results concerning Open Innovation while still taking into account any potential disparities.

5.2. Web 2.0

Although the phrase Web 2.0 is not clearly defined, it is frequently linked to web-based tools that allow for the socialization of material. These tools promote openness and collective intelligence by facilitating communication as well as the cooperative generation and use of information disseminated online. Because they are simple to use, they blur the lines between producer and consumer. With Web 2.0, anybody may contribute to the creation of knowledge by using a common web browser. Blogs, wikis, online community websites, and media-sharing platforms are examples of typical generic classes of applications; nevertheless, their roles and characteristics are frequently merged, making it challenging to identify between them. Given that both Open Science and Open Innovation share characteristics like openness and widespread participation, using Web 2.0 to accomplish both seems like a logical strategy. In conclusion, Open Science 2.0 refers to the application of Web 2.0 tools and Open Innovation tenets to the fields of research and education, not a new iteration of Open Science.

Being Open Openness is the basic prerequisite for employing Web 2.0 apps in research and reaping its benefits. The phrase "publish or perish" has created a self-serving system in science, where people are afraid to disclose their ideas before they have been published because they worry that someone else would steal their "intellectual property," publish a paper first, and take all the credit. On the one hand, this point of view ignores the fact that very little of what can be found in scientific literature comes directly from the author; rather, it is the result of the author building on the work of others. Some people could also be reluctant to publicly acknowledge their errors for fear of losing their social standing. This apprehension might be traced to the notion that making errors is always detrimental, even if they can also be viewed as opportunities to grow. In order to practice open science generally, one must accept the possibility that one may be mistaken while believing that others are correct and that it may be possible to jointly approximate the truth. The characteristics of a community built on mutuality provide another another justification for why openness is essential.

It is crucial to keep a sizable network and activate it when necessary because the more supporters there are, the better the outcome may turn out to be. Web 2.0 tools appear to be especially well suited for this purpose because they even let non-technical users contribute their thoughts. Otherwise, those might be missing. People must also specialize and use local knowledge in order to ensure diversity. To avoid the growth of groupthink, they must therefore take a decentralized approach to their actions.

Open Science 2.0 promotes collaborative knowledge generation, which may increase participant engagement and produce a more diverse pool of problem-solving ideas. However, in order to get the best outcomes, a number of requirements must be satisfied. The participants must be willing to communicate their ideas freely and without fear of mockery or "intellectual theft." Additionally, diversity must be promoted, which calls for respecting all points of view regardless of the contributors' hierarchical positions.

The right mechanisms must also be in place for fusing the various ideas into an unified answer. Information generation and utilization can be more easily collaborated on thanks to Web 2.0 capabilities. The Web 2.0 community, which is equally based on openness and reciprocity, can make a good setting for the Open Science technique if the participants can develop a sensitivity for networks.

6. Open Innovation 2.0 for Living Lab

6.1 Definition of Living Lab

Living Lab is an open innovation ecosystem where cutting-edge methods and research are used in the real world. Users can actively contribute, and the development takes into account what they think. The development of technological innovation involves citizen participation and is at the heart of society. ENoLL is one of several international organizations that represents the ICT Living Lab sector and is the largest organization overall. Living Lab, according to ENoLL, is a combined effort between users and producers that advances technological innovation. It includes a variety of participants in order to create user-oriented open innovation, also known as PPPP: Public-Private-People-Partnership. In this user-centered open innovation method, all interested stakeholders work together to innovate new ideas. Furthermore, the function of an innovation agent is provided to the end users. Users actively contribute ideas for new goods, services, and systems, and the environment in which they live in society serves as a laboratory in which users engage in innovative activities.

The idea for Living Lab came from Professor W. Mitchell of MIT, and it was first intended to study and record domestic life. In its Big Data-based Living Lab research, MIT gathered all of the individual's IoT tiny data in order to do research on the big data. The experiment's findings were used to inform the users' feedback. Then, its feasibility and applicability to IoT services in the home environment were researched. Additionally, MIT assigned roughly 300 square meters of MIT

PlaceLab, gave it the name An Alive Laboratory, and began conducting observations. A service that locates people using IT tools, sensors, and other methods was the initial model. Users were production- or producer-oriented, and they knew the replies and areas where the service's specifications may help to improve. Under the backing of the European President of Finland, ENoLL was founded in November 2006 and eventually developed into a worldwide league. The European Union government has roughly 390 separate living laboratories, and research is conducted across a wide range of sectors, including energy, media, mobility, medicine, and agriculture. About 390 of the Living Lab research projects are registered on ENoLL and are supported systematically by organizations like the EU and states.

With the involvement and co-creation of users, partners, and other parties, living labs move experimentation from firms' R&D departments to actual surroundings. Using the terms utilizer-driven, enabler-driven, provider-driven, and user-driven, this study describes living labs as four distinct types of networks that are defined by open innovation. Interviews with participants in 26 living labs conducted in Finland, Sweden, Spain, and South Africa served as the basis for the typology. Knowing the features of each sort of living lab is advantageous for businesses because it enables them to determine who is driving innovation, predict expected outcomes, and choose what kind of role to play when "living labbing." Living labs are networks that can aid in the development of technologies that are more suited to user demands and can be quickly scaled up to the international market.

Living labs are networks that can help them create innovations that have a superior match with user needs and can be upscaled promptly to the global market. Living lab can be any space, anywhere, suitable for collaborative design, the application of knowledge for empowerment, uplift, and development of people and communities for the use of innovation.

Successful innovation development is nowadays dependent on understanding both existing and emerging user needs, through which business opportunities are developed. An increasing number of managers are interested in living labs as a way to transform their conventional R&D organizations to follow an open-innovation model (Westerlund and Leminen, 2011). Open innovation is based on rigorous user co-development, and the finished product is anticipated to better address customer demands and desires. As a result, consumers play an entrepreneurial role in the development of new goods and services (Pascu and van Lieshout, 2009). A living lab is a network that combines open innovation and user-centered research. Open innovation's emergence has sparked the creation of complex networks where businesses collaborate with a variety of partners and customers to produce new goods, services, and technologies (Chesbrough and Appleyard, 2007).

Open-innovation networks now refer to these cooperative players, innovation approaches, and processes. However, little is known about the many different forms that these networks can take or the distinctions among the many forms; these classifications would aid researchers and practitioners in understanding how living labs operate. In this article, we concentrate on living labs as a type of open innovation network. Depending on the kind of central party whose interests drive the operation of the network, we categorize living labs into four main categories. The rest of this article is divided into the following sections. Following this quick introduction, we go over the history of living labs from the standpoint of a network. We then offer our data as well as the findings of an empirical investigation on the four main categories of living labs.

Characteristic	Type of Living Labs			
	Utilizer-driven	***Enabler-driven***	***Provider-driven***	***User-driven***
Purpose	Strategic R&D activity with preset objectives	Strategy development through action	Operations development through increased knowledge	Problem solving by collaborative accomplishments
Organization	Network forms around an utilizer, who organizes action for rapid knowledge results	Network forms around a region (regional development) or a funded project (e.g., public funding)	Network forms around a provider organization(s)	Network initiated by users lacks formal coordination mechanisms
Action	Utilizer guides information collection from the users and promotes knowledge creation that supports the achievement of preset goals	Information is collected and used together and knowledge is co-created in the network	Information is collected for immediate or postponed use; new knowledge is based on the information that provider gets from the others	Information is not collected formally and builds upon users' interests; knowledge is utilized in the network to help the user community
Outcomes	New knowledge for product and business development	Guided strategy change into a preferred direction	New knowledge supporting operations development	Solutions to users' everyday-life problems
Lifespan	Short	Short/medium/long	Short/medium/long	Long

< Figure 10 : Different types of living labs >

Source : https://timreview.ca/

Leminen highlights that there are three types of living labs.

Type 1: Utilizer-driven living labs

Companies that use living labs to grow their operations are called utilizers. Utilizer-driven living labs put an emphasis on creating and evaluating business products and services. Because the entire network's functioning is built on achieving objectives and producing specific outcomes that would facilitate the utilizers' activities, "live labbing" hence primarily produces value for utilizers. Utilizers utilize living labs as a strategic tool to gather information on the consumers of their goods or user communities. To help the companies' long-term and short-term commercial development, user data on usage patterns, trends, and even rivals is gathered.

A utilizer's initialization of a living lab is connected to tactical decisions made by the company's product-development department. The objective is to use assistance from people in the living lab's network to develop new goods and services. The utilizer directs knowledge creation in the network to guarantee that it produces knowledge that will be beneficial to it, such as information on potential user environments. Thus, to stress its important role in the network, the utilizer centers living lab activity around itself. Utilizers want quick outcomes that are simple to incorporate into their business strategy, hence utilizer-driven living labs are usually short-lived. With regard to the jointly generated innovation, they employ the ephemeral "take it and utilize it" technique.

Type 2: Enabler-driven living labs

The public sector, non-governmental organizations, and financiers like towns, municipalities, or area development groups are examples of enablers. Enabler-initiated living labs are frequently public-sector initiatives that aim to better society. Work on development builds on societal or geographical needs. For instance, enabler-driven living labs seek to improve a particular city or region by lowering local unemployment or by addressing a variety of social and structural issues. In these types of living labs, the enabler is the party with the most stake in the outcomes, which include the development of rural communities. Considering that regional development requires multi-party cooperation over an extended period of time, fostering collaboration among the major actors may be a crucial consequence in and of itself.

Enabler-driven living labs are frequently created around a particular regional development organization or initiative. Universities and other educational institutions frequently encourage developers to work close to users and their daily lives. Company involvement in enabler-driven living labs, however, has typically been negligible. This low level of involvement shows that utilizer firms are unclear about the possible business benefits. Companies do not perceive the benefit of taking part in living labs that primarily address enabler objectives and concentrate on generating value for the enabler. However, "living labbing" lasts a lot longer than utilizer-driven living laboratories since information is created and disseminated across the network by the living lab's actors.

Type 3: Provider-driven living labs

Living labs are often either utilizer-driven or provider-driven, with an emphasis on business investments and efficiency in both cases. As a result of the actions of various developer organizations, such as educational institutions, universities, or consultants, provider-driven living labs are established. In provider-driven living labs, the open-innovation network is structured around these providers. They seek to advance theory and research, increase knowledge production, and identify answers to particular issues. For instance, several colleges explore the development of innovative research and teaching methodologies while using live laboratories for instructional objectives. A large portion of innovation is on producing knowledge and information that is helpful to everyone in the network.

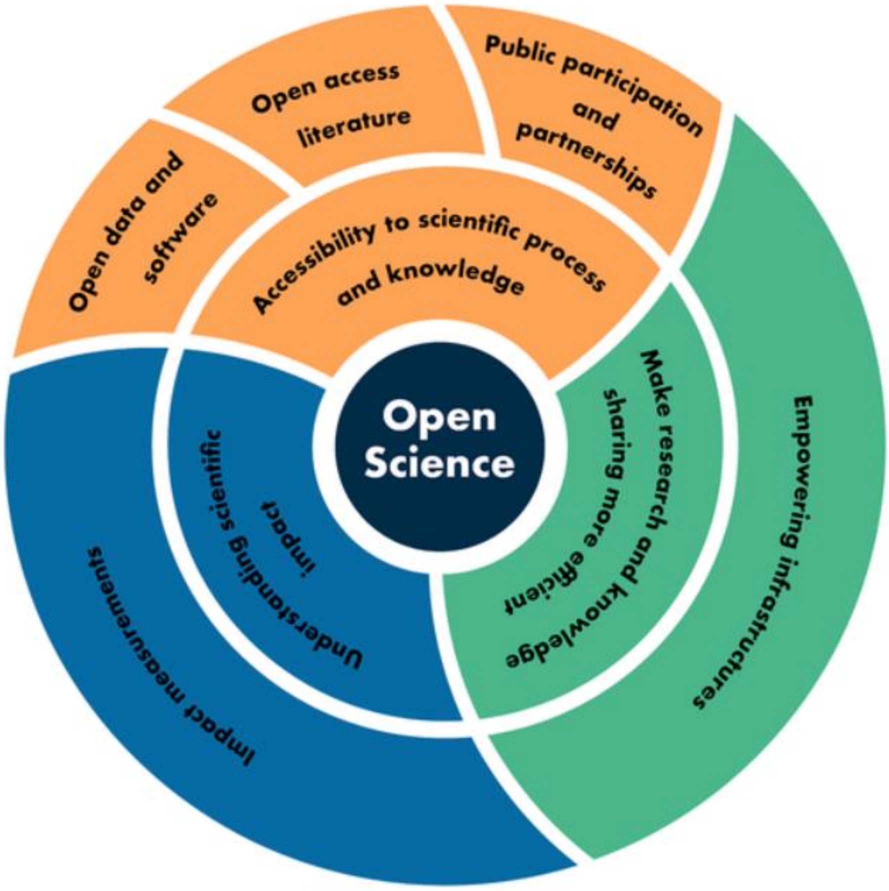
Living labs that are driven by providers put an emphasis on enhancing users' daily lives so that everyone in the network can profit from the innovation that results. These advantages can take several forms depending on the participant and can include things like fresh research findings, workable business solutions that can be sold, or enhanced fixes for issues that arise frequently. Even then, it might be difficult for providers to entice enablers and users to join the network. Others have been successful in establishing themselves as more durable innovation platforms. Some provider-driven living labs are constructed around a particular project. Provider-driven living labs provide a problem in terms of duration because businesses seek quicker development cycles and quick returns. In spite of this, the network's information is accumulated and employed in subsequent "live labbing" instances.

Type 4: User-driven living labs

User communities create user-driven living laboratories, which are geared toward addressing users' day-to-day issues. The goal is to address particular issues in a manner that complies with the expectations and values of users and user communities. User-driven living labs emphasize the development demands of a particular community of interest or important concern, such as a local housing community or a hobby group. The user community is the primary beneficiary of the value that is (co-)created, but businesses and society at large are also indirectly benefited. User-driven living labs have a lengthy lifespan since the user community is at the center of their design. These kinds of living labs are, however, relatively unusual at this time.

User-driven living labs' activities are loosely structured. Users or the user community do not oversee the network or its operations, despite the fact that these living labs are driven by users. Instead, a supplier who affects consumers' behavior facilitates the operation. User-driven living labs are characterized by the bottom-up philosophy, hence they cannot be administered as such. As a result, the other players in the network take part by helping the users by giving them access to tools, information, equipment, mentorship, or direction. While the network gathers and uses user and usage data, the resulting innovation may later be put to use and marketed by the participating businesses in a different application or consumer context.

III. Open Data as an open science



< Figure 11 : Open Science Concept as layers >

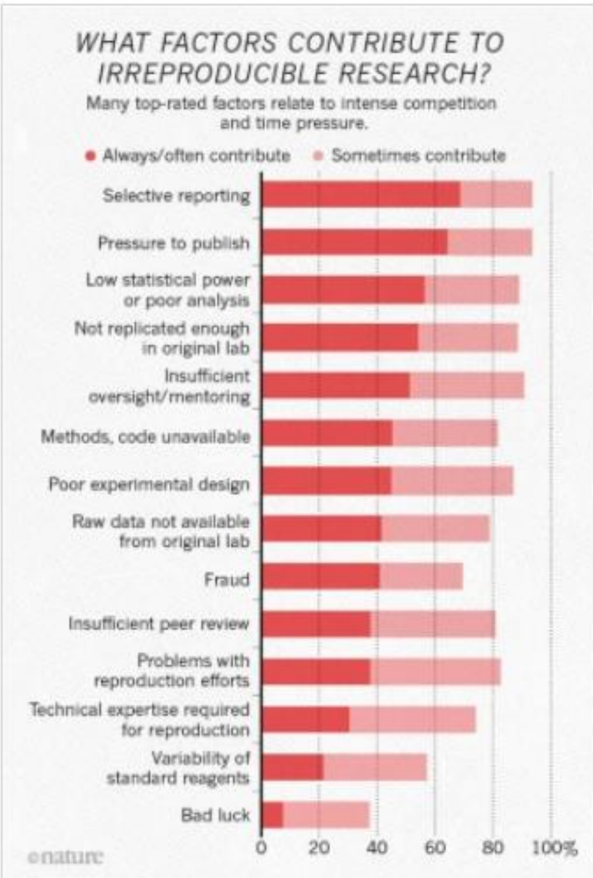
Source : Open Data to Open Science

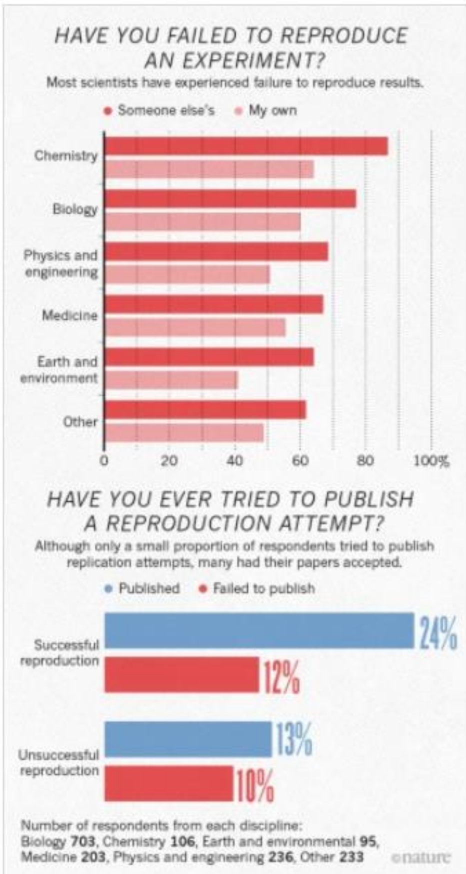
I would like to explore the broad concept of open science which includes Open Data and Open Access. The table above illustrates the three broad focus areas of open science which is 1) increasing the accessibility to the scientific process and the corresponding body of knowledge; 2) making both the research process and knowledge sharing more efficient; and 3) understanding and assessing scientific impact through innovative new metrics. (Rahul Ramachandran & Kaylin Bugbee &

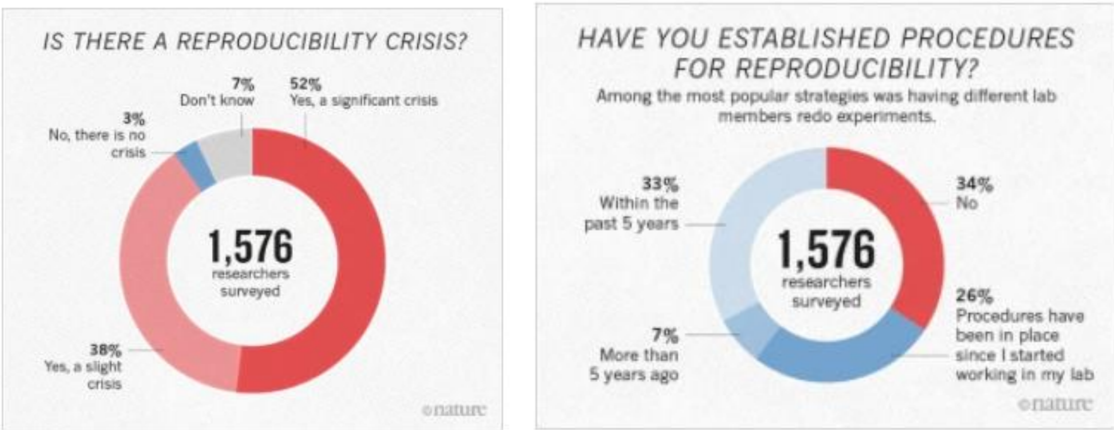
Kevin Murphy, 2021)

The scientific method is driven by data in two ways. First, data are the end result of research efforts and are essential parts of the corpus of knowledge in science. Second, data are examined for conclusions and scientific insights. Since data are crucial to the scientific method, open research initiatives have concentrated on increasing the accessibility of data. Open data can be used, shared, and accessed for any purpose without any limitations. Government and commercial entities generally adopt open data policies that specify what data will be shared, with whom, at what cost, and under what circumstances the data can be reused or redistributed (Borowitz, 2017). The degree of openness of data sharing rules ranges, with the most open data being fully accessible only for free or at the cost of replication (Group on Earth Observations, 2020; Open Knowledge Foundation, 2020). On the other hand, access to data may be limited or restricted because of security issues, the presence of personally identifiable information (PII), or licensing agreements that are frequently connected to commercial data purchases.

The open scientific movement gains from open data in a variety of ways. First, open data policies stop businesses from collecting data twice, freeing up resources to collect a wider variety of data and enabling the keeping of a more thorough record of observations. An almost complete constellation of observations from the Landsat series and Sentinel-2 has been made feasible, for instance, thanks to data exchange agreements between NASA and the European Space Agency (ESA). Data from these two platforms can be combined to enhance the frequency of observations over land, which is crucial for research on land monitoring applications. Second, when data are made publicly available, open data rules dramatically improve data use and reuse. A successful open data policy is best exemplified by the Landsat free and open data policy. the USGS witnessed a 20-fold increase in data downloads from 2009 to 2017 and a 4-fold rise in the use of the data in the annual number of publications after making Landsat data freely and openly available in 2008. (Zhu et al., 2019).







< Figure 12 : Sharing data to improve reproducibility and transparency >

Source: 1,500 scientists lift the lid on reproducibility (Nature, 2016)
https://www.nature.com/articles/533452a

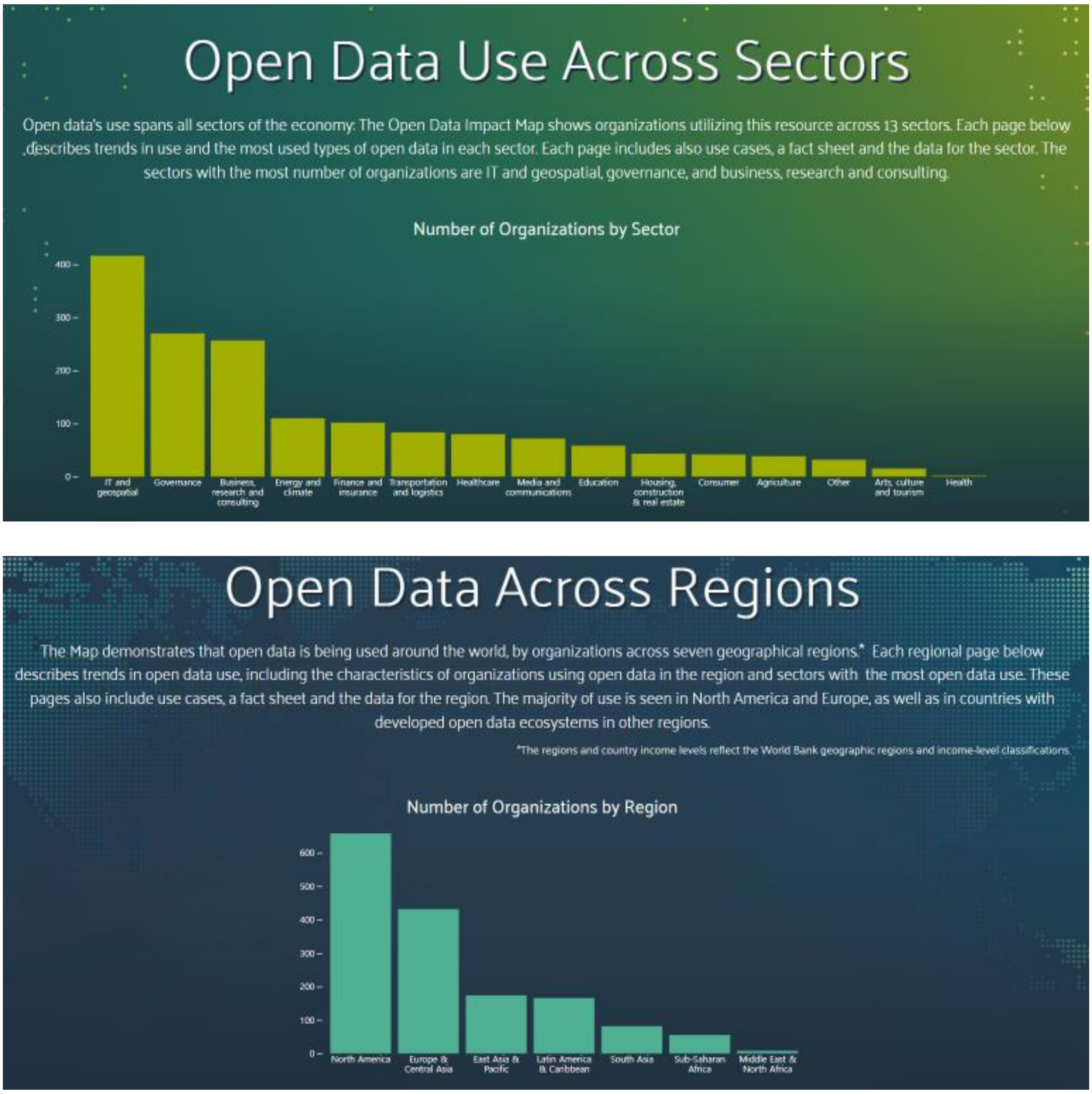
Open data has a variety of societal and economic advantages in general. Economic researchers have found remote sensing data to be especially useful due to its high spatial resolution, extensive geographic coverage, and capacity to provide access to data not otherwise available (Donaldson & Storeygard, 2016). A range of economic applications, such as agriculture, infrastructure investments, tourism, resource availability, and insurance, have made use of remote sensing. Providing open data also has a variety of positive social effects. Remote sensing data are useful for monitoring disputes, unlawful activity, pollution events, and the effects of land use policies. They also assist in disaster mitigation, response, and recovery (Donaldson & Storeygard, 2016; Zhu et al., 2019).

Open data is divided into public data for the general public and data with a research focus. The government of the United States, for instance, offers a platform for open data called Data.gov. It is the open data portal for the federal government and strives to increase transparency and accountability in government. It is said that having public data available encourages citizen involvement in politics, opens doors for economic growth, and helps both the public and commercial sectors make better decisions.

Data.gov implements Title II of the Foundations for Evidence-Based Policymaking Act of 2018. The OPEN Government Data Act makes Data.gov a requirement in statute, rather than a policy. It requires federal agencies to publish their information online as open data, using standardized, machine-readable data formats, with their metadata included in the Data.gov catalog.

Data.gov is working with an expanded group of federal agencies to include their datasets in Data.gov as they implement the new law. In addition, the law requires that GSA work with the Office of Management and Budget and the Office of Government Information Services to establish an "online repository of tools, best practices, and schema standards to facilitate the adoption of open data practices across the Federal Government."

That's how Data.gov was built with open-source software. Anyone, especially local, state, and foreign governments are welcome to borrow the code behind Data.gov.



< Figure 13 : Open Data Impact Map >

Source: https://www.opendataimpactmap.org/index

IV Open Access as an Open Science

A publication and distribution approach known as "open access" enables scientific research literature—much of which is supported by tax payers around the world—freely and unrestrictedly accessible to the general public online. The results of academic research are made available to an unprecedented number of scientists, academics, doctors, patients, inventors, students, and members of the general public through open access, which democratizes information access while promoting innovation and discovery.

The Directory of Open Access Journals currently lists more than 12,000 academic journals, and the Directory of Open Access Repositories lists more than 3,500 archives. Currently, open access is used in about 28% of peer-reviewed articles, and this percentage is rising.

The importance of research funders is growing as the acceptance of Open Access is hastening. As the first funder to require open access for the publication of the research it finances, the Wellcome Trust in the United Kingdom has taken the lead. Numerous other research funders, including the United States National Institutes of Health, the largest research funder in the world, have since adopted comparable regulations. In the meanwhile, in 2013, the Obama Administration issued an executive order directing all U.S. science funding organizations to make the results of research funded by the federal government accessible to the general public.

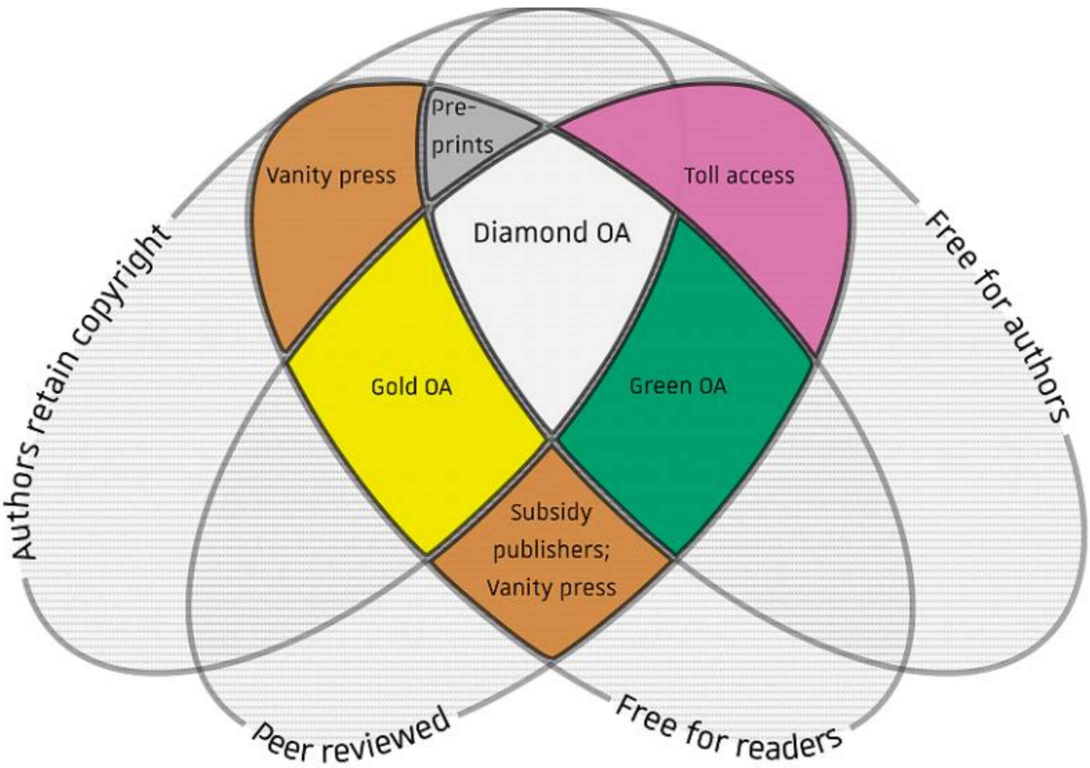
The faculty at more than 850 colleges and universities voted to approve campuswide open access policies, demonstrating the academic and research community's support for open access. Universities with open access requirements now include Harvard, MIT, the University of Nairobi, and the entire University of California System.

< Figure 14 : Benefits of open access diagram >

Source : https://www.jisc.ac.uk/guides/an-introduction-to-open-access

1. Open Access Colors

Publishers may employ one or more of the various open access publishing models that exist. A color-coded scheme is often used to categorize various open access categories. The phrases "green," "gold," and "hybrid" open access are the most well-known; however, a variety of different models and alternative terminology are also used.



< Figure 15 : Key features of different types of open access in scholarly publishing >

Source : https://figshare.com/articles/dataset/Diamond_open_access_venn/6900566/1

< Gold OA>

In the "gold OA" model, the publisher instantly makes all articles and related materials freely accessible on the journal's website. Articles in these periodicals have sharing and reuse rights through Creative Commons or other similar licenses.

APCs, which are frequently covered by institutional or grant support, are levied by almost all gold open access publishers. Although this is not a fundamental characteristic of gold OA, the majority of gold open access journals that charge APCs adhere to the "author-pays" paradigm.

< Green OA >

Authors are allowed to self-archive under green OA. The author also posts the work to a website that is under their control, the website of the research institution that provided funding for or hosted the work, or to a central open repos itory that is unaffiliated with them. These places allow readers to download the work for free.

The author receives Green OA at no cost. A free license on the publisher-authored copyrightable elements of the printed edition of an article is one of the extr a services that some publishers (less than 5% and declining as of 2014) may charge a fee for.

A "postprint" is the name of the archived version of an author's work that has been posted following peer review by a journal. This can be the accepted manuscript as returned by the journal to the author after successful peer review.

< Hybrid OA >

Open access and restricted access publications can both be found in hybrid open-access journals. This type of publisher receives some of its funding from subscriptions and only offers open access to the specific publications for which the authors (or research sponsor) have paid a publication fee. In general, hybrid OA is more expensive than gold OA and may provide lower-quality service. In hybrid open access journals, "double dipping," or charging both authors and subscribers, is a particularly contentious practice.

< Bronze OA >

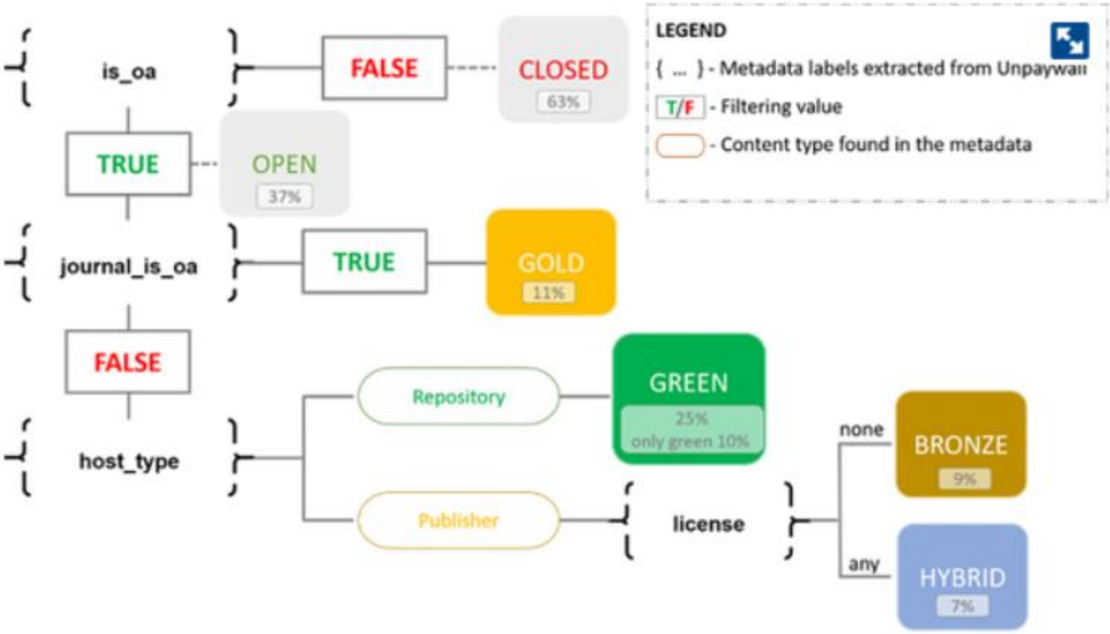
Bronze open access articles are free to read only on the publisher page, but lack a clearly identifiable license. Such articles are typically not available for reuse.

< Diamond/platinum OA >

Journals which publish open access without charging authors article processing charges are sometimes referred to as diamond or platinum OA. Since they do not charge either readers or authors directly, such publishers often require funding from external sources such as the sale of advertisements, academic institutions, learned societies, philanthropists or government grants. Platinum Open Access is a model of scholarly publishing that does not charge author fees. The costs associated with scholarly publication are covered through other means, such as volunteer work, donations, subsidies, grants, etc.

< Black OA >

Paywall literature can now be accessed for free thanks to the development of illicit digital copying caused by widespread copyright infringement. This was accomplished using both established social media platforms and specific websites (e.g. Sci-Hub). This is, in some ways, a technical expansion of an established practice in which persons with access to pay-walled books would distribute copies to their contacts. However, since 2010, the convenience and scale have increased, which has altered how many individuals view subscription magazines.



< Figure 16 : Open Data Impact Map >

Source: https://onderzoektips.ugent.be/en/tips/00000461/

Ⅴ. Open Source as an Open Science

These days, software programs and web-based applications are widely applied open-source software today. The term open source refers to something people can modify and share because its design is publicly accessible. The term originated in the context of software development to designate a specific approach to creating computer programs. But now, the term "open source" refers to a broader set of principles, which we refer to as "the open-source approach." Open- source efforts, projects, and products embrace and celebrate the values of meritocracy, quick prototyping, open communication, and community-centered development (opensource, n.d.). Among programmers, it is getting critical source to develop coding for the next step. It is getting very common to expand from the basis which other developers already built.

Open source reduces tremendous time to develop software algorithm, eliminates redundant obstacles from negotiating intellectual property, and minimize conflicts related with raising capital for software development (Nagle, 2019b; Wen, Ceccagnoli, and Forman, 2016). Two decades of experience have routinized resource sharing (Lakhani and Wolf, 2003, Lakhani and von Hippel, 2003) and communications between programmers with different backgrounds (Aksulu and Wade, 2010, Krogh et. al., 2012).

Today open source is an essential component of artificial intelligence, of web-enabled commerce, and of most software for big data. While the benefits to participating in open-source communities have been documented within high-income countries (Lerner and Schankerman, 2010), the focus on developed economies limits the observation and ignores the state of global labor markets. Programmer workforces have grown in the middle-income countries of Central Europe and Asia, and account for tens of billions of dollars of services a year (Agrawal, Lacetera, and Lyons, 2016; Stanton and Thomas, 2015; Barach, Golden and Horton, 2020). Just like their counterparts in developed economies, programmers around the globe employ open-source tools, speak the vocabulary of open source, and interact with open-source libraries (Nagle et. al, 2020).

Additionally, the adaptability and affordability of open source could present a chance for low- and middle-income countries to advance technologically more quickly than if they had to create such software from scratch or buy it from expensive sources, easing the difficulties of "catching up" in areas where knowledge of software and associated business processes fosters capabilities in new geographies (Lee and Lim, 2001). The conventional wisdom holds that open source stimulates creative business endeavors, facilitates duties inside existing work, and improves employment chances for participants.

According to Nataliya Langburd Wright, for a wide set of specifications, participation in OSS predicts entrepreneurship, and the evidence suggests participation is not coincident with other factors that affect entrepreneurship. It is consistent with policies that treat open-source participation as an independent factor shaping the prevalence of innovative entrepreneurship in a country. It also indicates the impact of increasing OSS contributions will have a differing impact across countries. Thus, the ability of OSS to help countries catch-up (Lee and Lim, 2001) and create technological leaders will also vary across countries. Investors seeking to invest in emerging entrepreneurial ecosystems may look to open source as an important factor. Policymakers seeking to build innovative entrepreneurial ecosystems may use open source as a channel of development. Policies that reduce barriers to and/or incentivize participation in OSS may be important stimulants to realize the benefits of OSS for entrepreneurship. Globally- and mission-oriented, as well as high-quality ventures, play a self-reinforcing role. Many countries, such as India, China, Russia, Korea, and the Ukraine, contain large open-source communities.

1. Open-Source Software

Among software developers, the open source is especially important to share the ideas. With this necessity, the idea of making source code freely available originated in 1983 from an ideological movement informally founded by Richard Stallman, a programmer at MIT. Stallman believed that software should be accessible to programmers so they could modify it as they wished, with the goal of understanding it, learning about it, and improving it. According to Stallman, he began releasing free code under his own license, called the GNU Public License (Synopsys, n.d.). This new approach and ideology surrounding software creation took hold and eventually led to the formation of the Open-Source Initiative in 1998.

Factors	Open Source	Closed Source
Price	Available for nominal or zero licensing and usage charges.	Cost varies based upon the scale of the software.
Freedom to customize	Completely customizable but it depends on the open-source license. Requires in-house expertise.	Change requests must be made to the company selling the software. This includes bug fixes, features, and enhancements.
User-friendliness	Typically, less user-friendly, but it can depend on the goals of the project and those maintaining it.	Typically, more user-friendly. As a for-profit product, adoptability and user experience are often key considerations.
After-sales support	Some very popular pieces of open-source software (e.g., OSS distributed by Red Hat or SUSE) have plenty of support. Otherwise, users can find help through user forums and mailing lists.	Dedicated support teams are in place. The level of service available depends on the service-level agreement (SLA).
Security	Source code is open for review by anyone and everyone. There is a widespread theory that more eyes on the code makes it harder for bugs to survive. However, security bugs and flaws may still exist and pose significant risk.	The company distributing the software (i.e., software owner) guarantees a certain level of support, depending on the terms of the SLA. Because the source code is closed for review, there can be security issues. If issues are found, the software distributor is responsible for fixing them.
Vendor lock-in	No vendor lock-in due to the associated cost. Integration into systems may create technical dependency.	In most cases, large investments are made in proprietary software. Switching to a different vendor or to an open-source

		solution can be costly.
Stability	This will depend on the current user base, the parties maintaining the software, and the number of years in the market.	Older, market-based solutions are more stable. New products have similar challenges as open-source products. If a distributor discontinues an application, the customer may be out of luck.
Popularity	Some open-source solutions are very popular and are even market leaders (e.g., Linux, Apache).	In some industries, proprietary software is more popular, especially if it has been in the market for many years.
Total cost of ownership (TCO)	TCO is lower and upfront due to minimal or no usage cost, and depends on the level of maintenance required.	TCO is much higher and depends on the size of the user base.
Community participation	The community participating in development, review, critique, and enhancement of the software is the essence of open source.	Closed community.
Interoperability with other open-source software	This will depend on the level of maintenance and goals of the group, but it is typically better than closed source software.	This will depend on the development standards.
Tax calculation	Difficult due to undefined monetary value.	Definite.
Enhancements	Can be developed by the user	Request must be made to the

or new features	if needed.	software owner.
Suitability for production environment	OSS might not be technically well-designed or tested in a large-scale production environment.	Most proprietary software goes through multiple rounds of testing. However, things can still go wrong when deployed in a production environment.
Financial institution considerations	The financial industry tends to avoid open-source solutions. If used, a vetting process must take place.	Financial institutions prefer proprietary software.
Warranty	No warranty available.	Best for companies with security policies requiring a warranty and liability indemnity.

< Figure 17 : Difference between open source and closed source >

Source: https://www.synopsys.com/glossary/what-is-open-source-software.html#B

2. Use cases of Open-Source Software

Some software has source code that only the person, team, or organization who created it can modify and maintain and exclusively control over it. People call this kind of software "proprietary" or "closed source" software.

Proprietary software may only be copied, inspected, and modified by the original authors. Additionally, in order to utilize proprietary software, users must affirm that they will not use it for any purpose that the product's creators have not specifically authorized (often by signing a license displayed the first time they run the software). Examples of proprietary software are Adobe Photoshop and Microsoft Office.

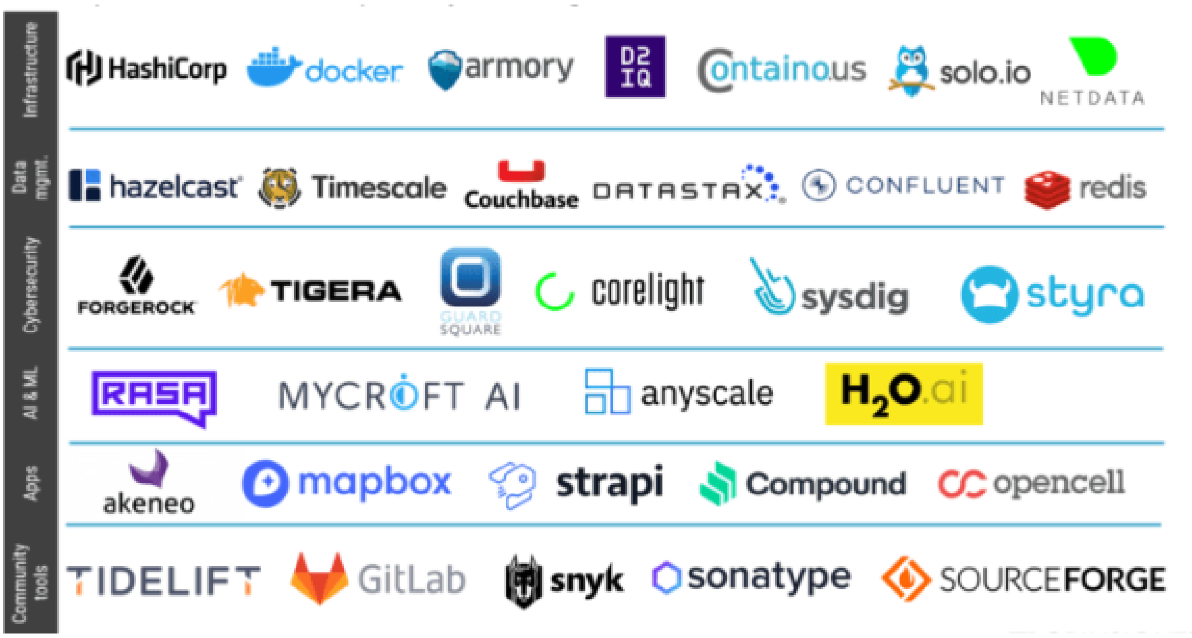
Open-source software is different. Its creators make the source code accessible to anyone who wants to look at, copy, modify, or share the code. Users of open-source software must agree to a license's terms just like those of proprietary software, but the legal requirements for open-source licenses are very different from those for proprietary licenses.

Open-source licenses affect the way people can use, study, modify, and distribute software. In general, open-source licenses grant computer users permission to use open-source software for any purpose they wish. Some open-source licenses stipulate that anyone who releases a modified open-source program must also release the source code for that program alongside it.

Moreover, some open-source licenses stipulate that anyone who alters and shares a program with others must also share that program's source code without charging a licensing fee for it.

By allowing others to modify the source code and incorporate those changes into their own projects, open-source software licenses encourage collaboration and sharing by nature. They promote access to, viewing of, and modification of open-source software by computer programmers whenever they please, provided they permit others to do the same when they share their work.

3. Examples of Open Source



< Figure 18 : The open-source software ecosystem >

source: cbinsights.com

There are several open-source software examples that may be found online, and many well-known programs allow for user-submitted changes. Working with these source codes can be informative and entertaining for some people, even though not all of the modifications and enhancements made by programmers will be made available to the general public.

1. LibreOffice

2. GNU/Linux

3. VLC Media Player

4. Mozilla Firefox

5. GIMP

6. VNC

7. Apache web server

8. jQuery

While open-source software allows pretty much all programmers to use and modify it, it does come with a distribution license. Some may require anyone who modifies a program to release the new code without compensation.

The most popular licenses include:

1. MIT License

2. GNU General Public License (GPL) 2.0

3. GNU General Public License (GPL) 3.0

4. Apache License 2.0

5. BSD License 2.0 (3-clause, new or revised)

(source: businessinsider.com)

4. Advantages and disadvantages of Open-Source software

There are advantages and disadvantages of open-source software. First of all, using open-source software provides several benefits over its proprietary counterparts, particularly for companies and organizations that are just entering the mark et. Also Open-source software tends to be more flexible as it offers programmers multiple ways of solving problems and encouraging creative solutions. In addition, On OSS, updates and bug fixes occur considerably faster. Collaboration is possible with open-source software, which speeds up the implementation of fixes and advancements. It's cost-effective. Generally speaking, proprietary software requires internal employees to work on its source code to keep the information private. Open-source software allows those unaffiliated with the project access without its authors having to pay out for further development.

On the other hands, open-source software can be more difficult to use since they may have less user-friendly interfaces or features that aren't familiar to all programmers. Compatibility issues may arise if the hardware used to create a piece of open-source software isn't available to all programmers working on it. This could also drive-up costs of the project.

Lastly, open-source apps do not include the same warranties and indemnity as proprietary ones. Given that open-source software might not actually offer any protection against infringement, this could become a concern.

Ⅵ. Conclusion and policy recommendation

1. Set appropriate national policies

In nations where the research culture is still forming, financial and career incentives to publish (or consequences for not publishing) are typical government programs. In an effort to keep up with other nations, they want to publish more, yet unintentionally promote subpar research methods. Unsuitable publishing incentives in some nations with underdeveloped research methodologies are thought to degrade overall quality in those nations. Consequently, some people don't believe the studies coming out of these areas.

Lower-income nations cannot squander funds on financing dubious research. Therefore, rather than just increasing output, policies should be created to boost transparency, relevance, and scientific rigor, especially if governments intend to use research to guide decision-making. Governments must also offer the instruction, materials, and inspiration required for citizens to adopt these reforms. The policies must take into account the unique requirements of each nation, as must their implementation. For instance, requesting that researchers upload their raw data to open-access databases will increase transparency by enabling others to duplicate and confirm their results. Another advantage is that by using the same data, additional discoveries can be made by other researchers. For instance, some nations, like Indonesia, built a secure national data repository known as the National Scientific Repository to resolve disputes involving the use of raw data without the consent of the original data holders (RIN). For ownership, each submission has a metadata tag.

Different problems will be faced by other nations. However, all stakeholders, not just the wealthy or prominent ones, should be involved in coming up with a solution.

2. Train for open science

Universities should teach researchers how to enhance scientific practice as well as field-specific theories. The traps of contemporary academia should be covered, such as how publication bias has been influenced by prestige and academic metrics. It must discuss the effects of giving in to these influences on the caliber, reproducibility, and credibility of research. And it should openly draw attention to disputes over whether and when these procedures are effective, such as arguments over when pre-registration of research is and is not beneficial. And rather than having to change current procedures afterwards, researchers must learn about these problems as they start their research careers, even as undergraduates.

Training in ethical scientific conduct will position scientists to embrace techniques that strengthen the veracity of their work and to think more critically. Additionally, training will give researchers the tools they need to participate in ongoing discussions on open science and to actively examine how science may advance both local and global societal goals.

To avoid an onerous workload, this trend toward open research may necessitate revising the overall training program by lowering the number of field-specific courses. It should also advance scientists' careers because respected universities are more frequently looking for proof of open-science practices when hiring new faculty members.

3. Retool universities for research

Most universities in Latin America, Asia, and Africa were built with an emphasis on education. Many lack the necessary infrastructure and inadequate research equipment. For university research to be supported, dedicated, trustworthy funding is crucial. The funds might be used to hire support personnel, fund researcher travel, and set up protocols for data collecting, ethics, and grant management. Academics could conduct research and impart knowledge more effectively. In general, investments should result in a positive feedback loop where long-term adjustments in research output lead to increased government and foreign financing.

5. Reflect and adapt

Metrics and regulations can only be put into place if they serve science's goal of accumulating information for the benefit of society. As a result, persistent observation and introspection are necessary. The future may render some of the most successful science improvement initiatives outdated.

Emerging research cultures will be able to create a new type of open research approach if they can stop harmful habits from taking root. By doing this, researchers may be able to avoid the demands that Western cultures sometimes put on research, producing work that is both acceptable and beneficial to society. The objective is to enhance what is currently being done in Australia, Europe, and North America.

Both Web 2.0 and Open Innovation are concepts that are applied in business to encourage inter-personal interaction and the development of fresh innovations. The methods are adaptable to science, opening up new avenues for study and instruction. If the relevant conditions are met, Open Science 2.0 makes it possible for the public to write scientific publications and hold public seminars, both of which utilize collective intelligence. By doing so, it is possible to foster the exchange of theory and practice while also enhancing individual outcomes.

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