Policy Recommendations

Cost-Benefit analysis for FAIR research data

Written by PwC EU Services
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Cost-Benefit analysis for FAIR research data - Policy recommendations

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EUROPEAN COMMISSION

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Directorate-General for Research and Innovation
Open Science

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EXECUTIVE SUMMARY

To drive the implementation of the FAIR principles in Europe, the European Commission together with a number of pioneering European research stakeholders is taking measures to raise the awareness about costs and benefits of FAIR data, and is encouraging funding bodies to set guidelines or support the development of an infrastructure for publishing FAIR data. In a study which preceded this report, the cost of not having FAIR data for the EU-28 has been estimated at EUR 10,2 bn per year, and this is bound to grow unless action is taken.

Despite this, many research performing organisations and infrastructures are still reluctant to apply the FAIR principles and share their datasets due to real or perceived costs, including time investment and money. To answer such concerns, this report formulates 36 policy recommendations on cost-effective funding and business models to make the model of FAIR data sustainable. It provides evidence to decision makers on setting up short and long-term actions pertinent to the practical implementation of FAIR principles.

The recommendations presented in this report are organised in two groups:

- The first covers recommendations for covering the initial costs for FAIR research data implementations in Europe, while
- The second covers recommendations for covering the sustainability of FAIR research data implementations in Europe.

Recommendations for covering the initial costs for FAIR research data implementations in Europe:

(a) Work out the business case for FAIR at the national level

Rec. 1. Apply the cost-of-not-having FAIR methodology in every EU member state

Rec. 2. Apply the cost benefit mechanism for the strategic research centres in EU member states, such as data-intensive research labs (e.g. genomics), and data infrastructures (e.g. ELIXIR, CLARIN)

Rec. 3. Think beyond of organisations and disciplines. Cross-disciplinary FAIR data use cases have the potential to create positive externalities, spill-over effects and innovation

Rec. 4. Integrate the outcomes of the national FAIR cost benefit assessments at the European level to identify and quantify positive spillovers and externalities

(b) Prioritise investments in the national FAIR implementation roadmap

Rec. 5. Build a solid FAIR baseline across Europe by prioritising high-impact and high-feasibility activities to maximise ROI. Start with activities related to Findability and Accessibility, such as common data management policies and practices, metadata standards, persistent identifiers and common research data infrastructures

Rec. 6. ROI will come only if the current working behaviours around data management and sharing change. Invest early enough in culture change and skills development

Rec. 7. Establish a working group under EOSC which will be mandated to decide on FAIR investment priorities, evaluate current progress and prepare future development roadmaps

Rec. 8. Move towards shared national and European cross-discipline Cloud-based data infrastructures which can significantly reduce the data storage and compute costs, and can drive time and cost efficiencies in data access, sharing and collaboration

Rec. 9. Use emerging technology, such as artificial intelligence and robotic process automation for automating and industrialising repetitive, standardised and time-consuming activities, such as data transformation, data classification or assignment of identifiers, to reduce operational costs linked to FAIR implementation

Rec. 10. Working in iterations and increasing the maturity of FAIR research data implementations in well-defind cycles helps to align investments with progress towards achieving the policy objectives

Rec. 11. Engage in the iterations at least one discipline or country which has not yet started their FAIR implementation or is lagging significantly behind to achieve buy-in, encourage them and share with them lessons learnt, actionable advice and reusable outcomes of others

Rec. 12. Opt for demand-driven provisioning of FAIR data, within and across research disciplines, to optimise investment expenditure and maximise ROI. Sustainable growth in the maturity of the FAIR implementations as well as in the number of FAIR data available will lead to network effects

Rec. 13. Provide financial incentives, such as grants and funding, for making legacy data FAIR on a demand-driven basis

(c) Measure progress and impact of FAIR implementation

Rec. 14. Endorse and provide financial support to a working group under EOSC which coordinates and monitors FAIR implementation at the European level to ensure the alignment between investments and spending compared to the level of achievement of the FAIR policy objectives

Rec. 15. Create a European mechanism for measuring progress, for example based on earned value management

Rec. 16. Create a European FAIR implementation maturity model which will define the activities required to achieve a specific level, the associated costs and the expected benefits.

Rec. 17. Provide the expertise and financial assistance for helping countries apply the maturity level and making the transition from one level to the next one.

Rec. 18. Define templates for service-level agreements with which trusted FAIR research data infrastructures will need to comply, for establishing a European baseline for service quality

(d) Share and reuse knowledge and solutions within and across countries and disciplines

Rec. 19. Benefit from significant efficiency savings in the total cost of ownership of FAIR data implementation by reusing solutions, technical assets, practices and experiences between FAIR and other data-related policy implementation initiatives, such as those of the revised PSI directive, GDPR, INSPIRE and CEF Telecom

Rec. 20. Mutualise FAIR implementation resources and investments across countries and disciplines by co-investing in common frameworks, solutions, technical assets and shared services

Rec. 21. Explore business models for FAIR research data infrastructures and services based on shared service provision, e.g. following the example of the CEF building blocks

Rec. 22. Provide financial support for developing and customising FAIR-compliant open source software in collaboration with the European open source

community, and multiplicate savings by sharing across the EU research community

Recommendations for the sustainability of FAIR research data implementations in Europe

(e) Explore mixed business models for FAIR research data infrastructures

Rec. 23. For the sustainability of FAIR research data implementation, research data infrastructures and research performing organisations must shift the focus towards data monetisation and value-added data services.

Rec. 24. Several alternatives exist for FAIR data and data services pricing models, from profit maximisation and cost recovery through to charging only for marginal costs (hence coming closer to the open data paradigm). Several parameters have to be considered for the selection of the right one, including the way data creation was funded, applicable IP or patents, data management costs, and value added.

Rec. 25. FAIR research data infrastructures must be encouraged and supported via fiscal incentives, such as seed funding, tax breaks or deductions, and policy interventions, including legislation, to explore mixed business models, which combine a healthy balance between public funding and other revenue streams.

Rec. 26. Fiscal incentives, e.g. tax breaks or deductions, will encourage industry to form partnerships, collaborate, sponsor, fund or buy data/services from FAIR research data infrastructures, to broaden the market for FAIR data.

(f) Secure public funding for implementing and sustaining FAIR research data implementation

Rec. 27. Funding FAIR data implementation has to remain available not only at the European level, e.g. as part of Horizon 2020 and Horizon Europe, but also as part of the national research and innovation programmes. FAIR applies to all publicly funded research in Europe

Rec. 28. FAIR-related costs, e.g. for data stewardship and management, or data infrastructure operational costs must be made eligible for specific cases and only if repored at a granular level respecting transparent cost accounting practices

Rec. 29. Culture change related costs, including training and awareness raising activities, must be made eligible based on transparent cost accounting practices

Rec. 30. FAIR-by-default policies and mandatory FAIR compliance must be included in the award criteria of research grants.

Rec. 31. Incentivise research data infrastructures and research performing organisations to reinvest savings made as a result of FAIR in the sustainability of FAIR implementations

(g) Develop a community and an ecosystem around FAIR data

Rec. 32. Provide financial support for communication, knowledge sharing, community building and marketing projects and activities for example via continuing with coordination and support actions through European and national research programmes. Full costs to be made eligible for all types of participants

Rec. 33. Provide financial support for organising mutual learning exercises, in the context of which member states, third countries, FAIR data practitioners and experts work together on a topic of common interest, such as FAIR data management on the open science cloud, FAIR data management in AI applications, or the costs and revenues for preparing a data

infrastructure for joining the open science cloud using the cost benefit mechanism developed by the current study

Rec. 34. Take measures and make the means available for encouraging innovation through cross-disciplinary projects and applications. Such means may include promoting the use of FAIR research data in projects funded under the current focus areas of existing European and national research programmes, or defining new innovation stream with a focus on research, life sciences and/or SMEs under future European and national research programmes, such as Horizon Europe

Rec. 35. Consider the establishment of a public-private partnership focusing on creating societal and economic value from FAIR data

Rec. 36. Place universities at the heart of the European FAIR data community of practice. They are the most important type of research performing organisations and are also the ones preparing the workforce of tomorrow who will be able to support the implementation of FAIR principles in Europe. To this end, support and incentives should be provided to them for reviewing their curricula and current data management practices in the light of FAIR.

INTRODUCTION

Policy context

To drive the implementation of the FAIR principles in Europe and realise the European Open Science Cloud (EOSC) following a federated model[1], the European Commission together with a number of pioneering European research stakeholders is taking measures to raise the awareness about costs and benefits of FAIR data, and is encouraging funding bodies to set guidelines or support the development of an infrastructure for publishing FAIR data. To this end, the EOSC declaration[2] at the end of 2017 acknowledged the importance of the FAIR principles and how it should be incorporated in building the EOSC data infrastructure.

The fact that the FAIR principles[3] are not common practice yet is due to numerous reasons. Some are concerned about the lack of awareness in the research community[4], about how to share data, in which format, what information or metadata should be provided etc. Others touch upon existing cultures and behaviours in conducting research, from research funders forbidding researchers to share their data to researchers not even considering that the data they produce can be valuable for others, the lack of attention given to the preparation of a data management plan, missing metadata[5], various competing standards for research data and metadata, and the lack of persistent identifiers for data, datasets and metadata[6].

Moreover, many research performing organisations and infrastructures are still reluctant to apply the FAIR principles and share their datasets because of **real or perceived costs**, including time investment and money.

Figure 1 - The four foundational characteristics of FAIR

As the costs and benefits of FAIR research data and infrastructures are being heavily debated among the stakeholders, the European Commission, under this specific contract, has commissioned two studies; one on the cost of not having FAIR research data, and a Cost-Benefit Analysis of FAIR research data. Both studies have

1 https://ec.europa.eu/research/openscience/pdf/eosc_strategic_implementation_roadmap_short.pdf#view=fit&pagemode=none

2 https://ec.europa.eu/research/openscience/pdf/eosc_declaration.pdf

3 FAIR Principles described by GO-FAIR, https://www.go-fair.org/fair-principles/; FAIR Principles described by Force 11, https://www.force11.org/group/fairgroup/fairprinciples; and (Wilkison, Dumontier, & Mons, 2016).

4 Interview with Barend Mons, 2018-01-17

5 (Zahedi, Haustein, & Bowman, 2014), and (Parsons, Grimshaw, & Williamson, 2013)

6 (Johnson, Parsons, Chiarelli, & Kaye, JISC Research Data Assessment Support - Findings of the 2016 data assessment framework (DAF) surveys, 2016), Stehouwer & Wittenburg, 2014 and Tenopir C. , et al., 2011

revealed a number of areas of investment to be made in order to move towards sustainable provision of FAIR data.

The implementation of the FAIR principles can bring direct and indirect benefits to research stakeholders, from research funders and infrastructures to research perfoming organisations and researchers, and can have a positive impact on the quality and the return on investment (ROI) of research itself. Studies investigating the impact of the implementation of the FAIR principles converge on the following positive impacts and externalities:

- Reducing duplication in research, in terms of time, effort and funding. A study[7] by Garner, H., McIver L., and Waitzkin, M. (2013) proposed a factual approach to measure the amount of funds allocated to duplicate grants. When applying this methodology to the EU economy, we estimated the approximate cost of research duplication to 60 million euro per year;

- Better management and stewardship of digital resource helps researchers adhere to the expectations and requirements of their funding agencies[8]. Through our study, we saw that costs related to the current way of conducting research are not sustainable, and justify the investments required, for example in data stewardship skills development and in day-to-day data management activities. The most important measurable benefit concerns the time efficiency gains for each person dealing with existing research data. This benefit is directly correlated to the number of people reusing data. In the case of data infrastructures, this benefit will be considered as a **spillover effect**, not directly perceived by them but significant for all organisations reusing their datasets;

- Scaling up research findings based on integrated and analysed existing data from multiple disciplines and regions[9]. As more and more data will become machine-readable in standardised formats, not only the time required to integrate different datasets will decrease significantly but new studies at a larger scale will be possible, clearly realising positive network effects;

- Enabling research to focus more on adding value activities such as interpreting the data rather than on searching, collecting or re-creating existing data[10]; and

- Enhancing the science infrastructure to support knowledge discovery and innovation. While the impact of the findability, accessibility, interoperability and reusability of data on innovation has been acknowledged by several studies from a macroeconomic perspective[11], it has so far only been measured based on case studies[12][13][14][15].

[7] https://www.healthra.org/download-resource/?resource-url=/wp-content/uploads/2013/11/Garner_Nature_1_2013.pdf

8 (Wilkison, Dumontier, & Mons, 2016)

[9] (Bonino da Silva Santos, et al., 2016)

[10] http://visit.crowdflower.com/rs/416-ZBE-142/images/CrowdFlower_DataScienceReport_2016.pdf

[11] https://ufm.dk/en/publications/2018/filer/preliminary-analysis-introduction-of-fair-data-in-denmark_oxford-research-og-hbs.pdf

[12] https://beagrie.com/static/resource/EBI-impact-report.pdf

[13] http://www.vises.org.au/documents/2013_Beagrie&Houghton_Value&Impact_Brit_Atmospheric_Data_Centre.pdf

[14] https://beagrie.com/krds.php

Scope and objective of this report

As discussed, two key outcomes have preceeded this report:

- A study on the cost of not having FAIR research data for the EU science and innovation system and as a result to the EU data economy; and
- A mechanism to estimate the costs and benefits of becoming compliant with the FAIR principles, for research performing organisations and data infrastructures, which has been applied in a number of real-life cases[16][17].

The objective of this report, which builds further on the findings of the two aforementioned ones, is to provide policy recommendations on the next steps concerning making research data FAIR, to propose cost-effective funding and business models to make the model of FAIR data sustainable and provide evidence to decision makers on setting up short and long-term actions pertinent to the practical implementation of FAIR principles.

This report is intended primarily for research funders, addressing policy makers both at the European and the national levels.

To this end, this set of policy recommendations, focusing on costs and financial aspects of the implementation of the FAIR principles provides answers to the following questions:

- What are the main areas where financial interventions are required for implementing the FAIR principles within an EU member state?
- What are the type of investments needed for the FAIR principles to be implemented by research data infrastructures and research performing organisations?
- How can FAIR implementation activities be prioritised to maximise ROI and establish quickly a FAIR baseline on which one can build further?
- How to avoid one-off investments which focus on single disciplines or projects and excessive upfront investment in the hope of broad-based adoption?
- What are possible business and revenue models for sustaining FAIR research data and infrastructures?

Structure of the report

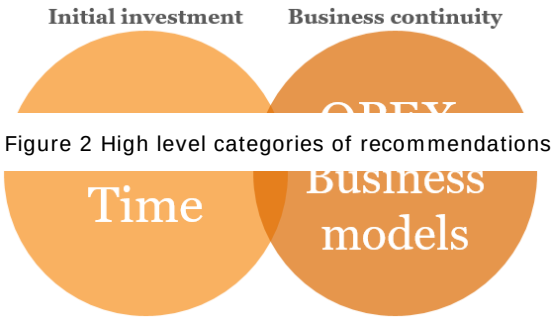

Figure 2 High level categories of recommendations

The policy recommendations introduced in this report are organised in two main categories:

1. Recommendations for covering the initial costs for FAIR research data implementations in Europe, presented in Chapter 2, and;
2. Recommendations for covering the sustainability of FAIR research data implementations in Europe, presented in Chapter 3.

Chapter 4 concludes the report.

15 http://repository.jisc.ac.uk/5509/1/ADSReport_final.pdf

16 Cost-Benefit analysis mechanism

17 Cost-Benefit analysis guidebook

RECOMMENDATIONS FOR COVERING THE INITIAL COSTS FOR FAIR RESEARCH DATA IMPLEMENTATIONS IN EUROPE

Work out the business case for FAIR at the national level

While the current study took a macroscopic view based on existing data for estimating the costs and benefits of becoming FAIR-compliant, the costs and benefits should be assessed as part of each national, specific context in Europe. Few member states have already started with FAIR implementation, whereas others are still exploring 'what's in it for them'. The answer to this question is neither easy nor straightforward. FAIR implementation requires a number of initial investments as well as associated recurring costs. At the same time, benefits and efficiencies identified in one country cannot be directly projected or replicated in another, because of cultural differences, non-harmonised policies and technological choices. As for every EU policy, the implementation of the FAIR principles will not be achievable without the commitment and the active involvement of the member states. Therefore, each member state has to be invited to perform detailed analysis to estimate on the one hand the investments for implementing the FAIR principles in each country, and on the other hand to identify and quantify the benefits. The outcomes of this study can be used as a basis for this.

Combining the data collected at the national level, an aggregated European view will be built. While the national perspectives will provide estimates to the specific context of the countries, the European assessment will cover the spillover effects and externalities of the FAIR principles. This is important since the FAIR principles are supposed to bring substantial spillover benefits such as on the time gained by external researchers for manipulating data, on the quality of the researches or on the new, innovative, researches undertaken.

During the preparation of national FAIR implementation business cases, or organisation-specific ones, emphasis should be placed on cross-disciplinary use cases. Sharing FAIR data across disciplines is expected to create positive externalities, spill-over effects and ultimately to drive innovation at the touching points between disciplines.

Our recommendations

Rec. 1	Apply the cost-of-not-having FAIR methodology in every EU member state.
Rec. 2	Apply the cost benefit mechanism for the strategic research centres in EU member states, such as data-intensive research labs (e.g. genomics), and data infrastructures (e.g. ELIXIR, CLARIN).
Rec. 3	Think beyond of organisations and disciplines. Cross-disciplinary FAIR data use cases have the potential to create positive externalities, spill-over effects and innovation.
Rec. 4	Integrate the outcomes of the national FAIR cost benefit assessments at the European level to identify and quantify positive spillovers and externalities.

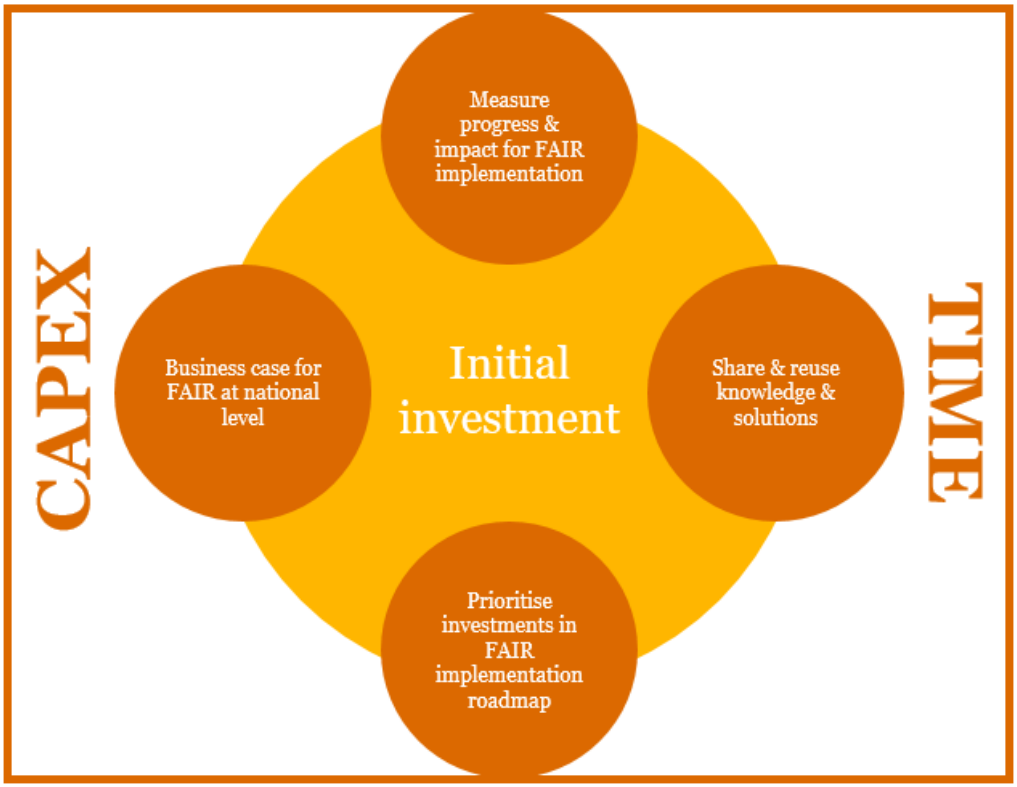

Figure 3 Overview recommendations on initial investment

Prioritise investments in the national FAIR implementation roadmapResources available for implementing FAIR are limited. On the one hand, organisations and countries cannot afford one-off investments which focus on single disciplines or projects and excessive upfront investment in the hope of broad-based adoption. On the other hand, our study has shown that the cost of not having FAIR will only increase if no action is taken. As such, prioritisation of activities and investments across different dimensions is imperative.

Major investments have already been made in FAIR data infrastructures both with national scope in individual member states and at the EU level. The investments already made and those still to be made for implementing the FAIR principles concern activities and developments in different areas:

- developing and agreeing on *data and metadata standards*,
- developing solutions for *data management*,
- persistent *identifiers and storage*,
- raising *awareness*, changing *culture* and increasing *skills*.

Some activities, such as describing datasets with quality standardised metadata and assigning persistent identifiers may yield a seemingly high initial costs because they require an understanding of new metadata models, creating mappings and transformations. However, these initial costs are in the medium term evened out and paid back by savings and positive externalities due to more easily findable and accessible data *(priority to F and A, I to follow)* and consequently more reusable data *(R)*. Hence, these activities form an integral part of what we call **the FAIR baseline**. The FAIR baseline underpins the right to have access to FAIR data.

It is clear that research infrastructures and technology or FAIR data availabity

alone will not deliver the expected value and benefits without strong culture and capability development. Current research data management and sharing behaviours and practices need to change. Hence, emphasis must be put there.

Once findability and access are put in place, implementing data interoperability is the next step. Data interoperability is a very broad area. For some research disciplines, data interoperability standards and services have already been developed such as in the cases of health and geospatial information. In those cases, interoperability-related FAIR implementation costs will be lower because of efficiencies achieved via reuse and prior work. In other cases, however, common interoperability agreements need to be defined. In those cases, interoperability costs will be significantly higher.

In practice, the investment priorities will have to be decided after consultation with the main stakeholders of the FAIR ecosystem. Their needs with regards to FAIR implementation must be collected and assessed based on feasibility and return on investment. The national or organisation-specific FAIR business cases, discussed previously, can also provide input to the prioritisation exercise. It is, in our view one of the EOSC governance responsibilities to monitor prioritisation exercises nationally, and coordinate those within and across disciplines and at the European level. For this, we recommend the establishment of a working group under EOSC mandated to to decide on FAIR investement priorities, evaluate current progress and prepare future development roadmaps.

Cloud-based models should also be explored for implementing national and European cross-discipline data infrastructures for sharing and federating services. Private, public or hybrid cloud models are all possible and can significantly reduce the high data storage and computing costs, and the total cost of ownership. The cost of cloud computing has been steadily decreasing the last years. At the same time they can drive time and cost efficiencies in data access, sharing and collaboration. Data preservation costs and costs due to (partial) data loss are also expected to be driven down as result of shared cross-discipline cloud-based research data infrastructures.

Figure 4 Cost reduction via Emerging Technologies

We also advise the use of emerging technologies, such as artificial intelligence and robotic process automation, for automating and industrialising repetitive, standardised and time-consuming activities, such as data transformation, data classification or assignment of identifiers. This will lead to significant operational cost savings for research organisations.

The need for prioritisation applies also to the selection of datasets to be published as FAIR. Research performing organisations own hundreds of datasets which could fit the selection criteria for being published as FAIR. Some of this data dates years ago, and is stored in legacy formats and proprietary systems. Is it worth going for a big bang or a one-size-fits all approach that opts for publishing *all* (legacy) data simultaneously? And even more, do all datasets have the same reuse and value potential?

Experience from implementation of other data-related policies, such as the Revised PSI directive, say that even in open data by default scenarios, data supply should be supply-driven and

targeted. A market segmentation study and a market analysis can help identify high-value datasets and prioritise their provisioning as FAIR data. A line should be drawn between data published as of today, where FAIR by default must be the guiding principles, and legacy data which must be published as FAIR on a demand-driven basis. We believe that the sooner in the research lifecycle data is made FAIR compliant, the more cost-efficient it is.

A possible way of prioritising FAIR publication of legacy data is to start with data underlying open access publications. Such a market study will also help identify and select machine-readable formats and data provision paradigms, e.g. data as a service, to be implemented first.

Following such a "think big, start smart" approach means that FAIR implementation activities have to be organised in iterations. To be representative, each iteration can engage at least two disciplines or research organisations and should cover a minimum set of characteristics from each of the FAIR principles to gradually start developing the FAIR baseline.

Iterative development is also an opportunity to move disciplines or countries from the long-tail of silence to the adopters space. Hence, we propose to engage in the iterations at least one discipline or country which has not yet started their FAIR implementation or is significantly lagging behind. Working with countries or disciplines that are more advanced in their FAIR implementation trajectory will help achieve buy-in of the late comers, encourage them and benefit from lessons learnt, actionable advice and reusable outcomes of others. This is expected to reduce the initial implementation costs for late comers.

Our recommendations

Rec. 5	Build a solid FAIR baseline across Europe by prioritising high-impact and high-feasibility activities to maximise ROI. Start with activities related to Findability and Accessibility, such as common data management policies and practices, metadata standards, persistent identifiers and common research data infrastructures.
Rec. 6	ROI will come only if the current working behaviours around data management and sharing change. Invest early enough in culture change and skills development.
Rec. 7	Establish a working group under EOSC which will be mandated to decide on FAIR investement priorities, evaluate current progress and prepare future development roadmaps.
Rec. 8	Move towards shared national and European cross-discipline cloud-based data infrastructures which can significantly reduce the data storage and compute costs, and can drive time and cost efficiencies in data access, sharing and collaboration.
Rec. 9	Use emerging technology, such as artificial intelligence and robotic process automation for automating and industrialising repetitive, standardised and time-consuming activities, such as data transformation, data classification

or assignment of identifiers, to reduce operational costs linked to FAIR implementation

Rec. 10 Working in iterations and increasing the maturity of FAIR research data implementations in well-defind cycles helps align investments with progress towards achieving the policy objectives.

Rec. 11 Engage in the iterations at least one discipline or country which has not yet started their FAIR implementation or is lagging significantly behind to achieve buy, encourage them and share with them lessons learnt, actionable advice and reusable outcomes of others

Rec. 12 Opt for demand-driven provisioning of FAIR data, within and across research disciplines, to optimise investment expenditure and maximise ROI. Sustainable growth in the maturity of the FAIR implementations as well as in the number of FAIR data available will lead to network effects.

Rec. 13 Provide financial incentives, such as grants and funding, for making legacy data FAIR on a demand-driven basis.

Measure progress and impact of FAIR implementation

The execution of national and European FAIR implementation roadmaps should be managed as programmes. This calls for the establishment of programme management office capabilities and the development of monitoring and progress evaluation mechanisms to assess investments and spending compared to the level of achievement of the FAIR policy objectives. In the previous group of recommendations, we have already referred to the need for a working group, part of EOSC, which has to be established and mandated to prioritise investement, coordinate activities, monitor progress, bring together the stakeholders in a vibrant community and assess the provision of trusted and quality services by FAIR research data infrastructures.

To ensure comparability, a single monitoring and progress evaluation mechanism is required. Such a mechanism should be complemented by a maturity model to illustrate the implementation progress. The maturity model will define the activities required to achieve a specific level, the associated costs and the expected benefits. Member states as well as research data infrastructures and research performing organisation will need to be assisted through expertise and financial means, such as grants, with progressing from one maturity level to next.

At the same time, to have a European standard service-level baseline for FAIR data implementations, the working group should create templates for service-level agreements by which trusted FAIR research data infrastructures should abide.

Our recommendations

Rec. 14	Endorse and provide financial support to a working group under EOSC which coordinates and monitors FAIR implementation at the European level to ensure the alignment between investments and spending compared to the level of achievement of the FAIR policy objectives.
Rec. 15	Create a European mechanism for measuring progress, for example based on earned value management.
Rec. 16	Create a European FAIR implementation maturity model which will define the activities required to achieve a specific level, the associated costs and the expected benefits.
Rec. 17	Provide the expertise and financial assistance for helping countries apply the maturity level and making the transition from one level to the next one.
Rec. 18	Define templates for service-level agreements with which trusted FAIR research data infrastructures will need to comply, for establishing a European baseline for service quality.

Share and reuse knowledge and solutions within and across countries and disciplines, and mutualise resources

Several countries have already made significant investements in FAIR data implementations. In parallel, the revised PSI directive, GDPR, INSPIRE, CEF Telecom and other data-related policies have all required organisations to make investments related to data management and data infrastructures, e.g. open data catalogues, (secure) data exchange infrastructures, persistent identifier services and semantic standards. Active communities have also been established, which are creating knowledge, lessons learnt and good practices based on their implementation challenges and experiences.

Significant savings and efficiencies can be achieved in the total cost of ownership of FAIR data impementation if assets, solutions, services and knowledge are shared and reused between the FAIR data community and data-intensive policy areas, for example between PSI, INSPIRE or CEF Telecom and FAIR.

Likewise, cost savings and efficiencies in time and effort can be achieved by sharing and reusing solutions, services, technical assets, practices and experiences between FAIR implementation communities active in different countries and/or disciplines, especially between the pioneers and the long tail of research. For example, federating services and sharing commodity services such as storage and compute can lead to economies of scale.

This requires investments and financial support, in the form of grants or funding, for:

- Defining a common interoperable reference architecture and reference components for FAIR research data infrastructures, based on the principles of the European Interoperability Framework[18];
- Developing reusable open source software following the CEF building blocks paradigm and business model. It should not be forgotten that the FAIR implementation is by default required to reuse – wherever possible – open source software[19]. Creating synergies between the FAIR national implementation roadmaps and the agenda and priorities of the European open source community can lead in the long term to signficant savings through reuse. Hence, policy makers need to foresee financial support, for example via the provision of grants for implementing or customising FAIR-compliant open source software solutions in the different countries or disciplines.
- Implementing cloud-based platforms and solutions which can be used across countries and disciplines for example in the form of shared services. Such services can also be a source of income for FAIR research data infrastructures;
- Facilitating cross-country and cross-discipline knowledge sharing and collaboration by making use of digital platforms and community building events

[18] https://ec.europa.eu/isa2/eif

[19] https://www.crcpress.com/Data-Stewardship-for-Open-Science-Implementing-FAIR-Principles/Mons/p/book/9780815348184

We recommend referring to the Sharing and Reuse Framework for further guidelines in this area[21].

Our recommendations

Rec. 19	Benefit from signficant savings in effiencies in the total cost of ownership of FAIR data implementation by reusing solutions, technical assets, practices and experiences between FAIR and other data-related policy implementation initiatives, such as those of the revised PSI directive, GDPR, INSPIRE and CEF Telecom.
Rec. 20	Mutualise FAIR implementation resources and investments across countries and disciplines by co-investing in common frameworks, solutions, technical assets and shared services.
Rec. 21	Explore business models for FAIR research data infrastructures and services based on shared service provision, e.g. following the example of the CEF building blocks .
Rec. 22	Provide financial support for developing and customising FAIR-compliant open source software in collaboration with the European open source community, and multiplicate savings by sharing across the EU research community

[20] https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/CEF+Digital+Home

[21] https://joinup.ec.europa.eu/collection/sharing-and-reuse-it-solutions/sharing-and-reuse-framework-it-solutions-pdf

RECOMMENDATIONS FOR THE SUSTAINABILITY OF FAIR RESEARCH DATA IMPLEMENTATIONS IN EUROPE

Explore mixed business models for FAIR research data infrastructures

Successful FAIR research data implementation relies heavily on reliable research data infrastructures. Their role is instrumental in the long-term stewardship and preservation of FAIR research data. We know however that good data stewardship, data provision and preservation is costly and requires serious investments in infrastructure and operations. At the same time, these critical pillars of the FAIR ecosystem are operating in an environment where research budget is limited and other sources of income/revenue are hard to find. To this end, the development of sustainable business models for FAIR research data infrastructures should be a top priority for all countries.

Different business models for FAIR research data infrastructures can be imagined depending on the type of the infrastructure. Looking at the future FAIR landscape, we see, new data infrastructures, open for new business models, which are in turn federating existing infrastructures and scientific clouds. The latter ones have been operating since their foundation already following some business model, but may be open to reinventing themselves and reviewing their business model.

The ultimate objective of a business model is to ensure the sustainability of a FAIR data infrastructure. Hence, business models need to explore existing as well as new revenue sources. We believe that, in the long-term, the objective must be to diversify away from public funding as the sole source of income. We understand that for an existing data infrastructure, even for those committed to review their business model, change is gradual. We are not talking about a one-shot transformation from a public funding business model to one based primarily on private initiative and revenues from selling data or services. In this process, a research data infrastructure can start with business models that allow to recover opportunity costs and cover operational costs, and with the current financial, commercial and legal assistance move towards profit-making business models.

This gradual business model transformation path for FAIR data is summarised in Figure 5. We are plotting the business models in a two-dimensional space, looking on the one hand, at the volume of FAIR data available, and on the other hand at the increase in innovation potential.

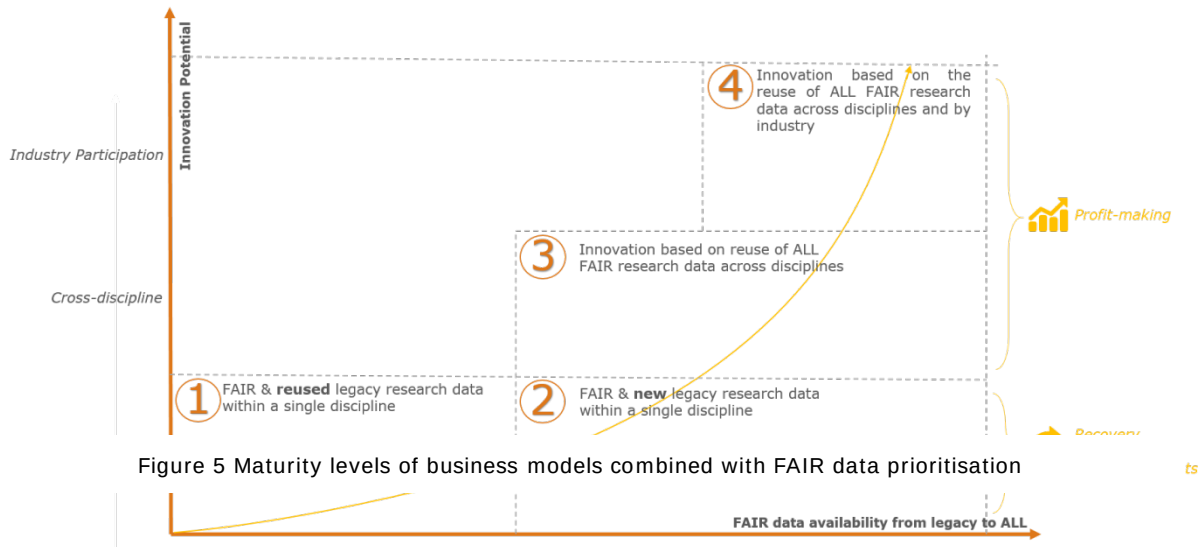

Figure 5 Maturity levels of business models combined with FAIR data prioritisation

1. FAIR legacy research data: We are expecting that existing or new players initially will prioritise recovery of opportunity and operational costs focusing at the same time on making (on-demand) legacy science data FAIR. Specific funding and intervention at the European level will be required for this, especially in case of large-scale applications, for example the scenario of making all legacy Copernicus data FAIR. The aim of this first step is to create the FAIR baseline and a critical mass of FAIR data available. Data reuse will most likely still be limited within the scope a particular discipline.
2. The second level is adding the publication of new research data as FAIR, even by default (unless specific privacy, safety, security, legal or competition barriers exist). All other parameters remain the same.
3. At this point, well-established research organisations and infrastructures are looking at new cross-discipline business models, with high innovation potential, which can generate revenues and profit (see later in this section). We are still however at a level where all players are science and research organisations.
4. Industry players are now also entering the market and collaborating with research organisations common projects or develop their own value-added services and applications reusing FAIR research data. Profit-making opportunities arise in this scenario not only for industry but also for research data infrastructures and research performing organisations

Inspired from a 2017 OECD report on business models for sustainable research data repositories[22] and a previous study of PwC for the European Commission on business models for linked open government data[23], we are citing below possible business model archetypes, which are in our view the most feasible. The proposed business model can also be implemented in combination with each other.

We decided not to refer to business models which are predominantly focused on funding via public research grants, even if those may be longer-term and multi-year in nature. We believe in the importance of continuing public funding (see next section), as FAIR data is by default a common good. We are though convinced that FAIR research data infrastructures should be encouraged and supported via fiscal incentives, such as seed funding, tax breaks or deductions, and policy interventions, including legislation, to explore *mixed business models*, which combine a healthy balance between public funding and other revenue streams.

Figure 6 Mixed business models for FAIR research data

Mixed business models will also contribute to the distribution of the FAIR benefits more evenly between research performing organisations and data infrastructures. Taking the extreme scenario, research performing organisations enjoy all the benefits because of more efficient data management, wider reaching

[22] https://www.oecd-ilibrary.org/docserver/302b12bb-en.pdf?expires=1527066558&id=id&accname=guest&checksum=727DFBA8383566F0EE7E4F26DF6B1C7C

[23] https://joinup.ec.europa.eu/document/study-business-models-linked-open-government-data-bm4logd

dissemination and outreach, new research and innovation, whereas data infrastructures have to carry the vast majority of the costs. This can discourage data infrastructures from taking up their instrumental role in the FAIR ecosystem.

We are looking primarily at cross-institutional, cross-industry and/or cross-country FAIR data research infrastructures and federations, in order to avoid fragmentation, the development of institutional silos, and the duplication of initial investments and operational costs.

We believe in business models for FAIR data infrastructures that move from charging for data to charging for data services. Such a data-driven transformation normally entails monetising data assets, integrating data from different sources, and developing analytics to gain powerful insights, which will underpin the development of new products and services. In this spirit, some examples of business model archetypes follow:

1. **Provide paid FAIR data services such as data wrangling, data transformation based on FAIR data standards, provision of persistent identifiers, data documentation or data export in specific FAIR data formats and at (near) real-time.** Such services can be provided on top of the traditional data storage services. While more and more research performing organisations will include data stewardship activities in their budgets, there will always be organisations who prefer to pay for creating FAIR data.

   As a consequence, FAIR data infrastructures will be in a position to provide additional cleansing and wrangling services on top of their traditional services. The research performing organisations would pay for the services used in a flexible manner such as when preparing a dataset for publication as FAIR. At the same time, research performing organisations who prefer to manage their data themselves could still be rewarded, for example if they contribute quality data by being able to publish their data with no charge.

2. **Provide paid data analytics services targeting different customer segments.** With the right capabilities, FAIR research data infrastructures might propose analytical services on the FAIR data they are hosting. A FAIR research data infrastructure can be seen as a cloud-based data lake which allows data to easily be accessed, integrated and analysed. Depending on the demand, services throughout the analytics continuum may be considered, from descriptive analytics and data reporting to advanced prescriptive analytics and Artificial Intelligence. Such services could help research performing organisations and industry to identify new areas of research, especially cross-discipline, discover new links between data and reveal hidden or unknown patterns.

3. **Charge big industry players for access to data or obtain private investments.** We know from experience that knowledge-intensive industries with high R&D budgets, such as pharma, chemicals, oil and gas and professional services are willing to pay for services that provide quality reusable data. Companies such as Thomson Reuters and Wolters Kluwer are implementing in fact this business model for other types of data, which in raw formats is even available as open

data. Private companies could receive fiscal incentives for reusing FAIR data and creating additional value from it. One example could be to be partially or completely exempt from the tax on the revenue created as an outcome of the reuse of FAIR data. On a different thread, sponshorships and investment from industry may also be subject to tax breaks or deductions. Revenue and profit-making opportunities exist here for both research data infrastructures and research organisations.

However, we would not advice to charge data access fees to research performing organisations, spin-offs, start-ups, scale-us or SMEs as this can be disincentive and may negatively impact data reuse.

4. **Provide a FAIR data certification.** FAIR research data infrastrastructures have the know-how and the means to provide validation services which can check FAIR conformance, and can consequently "certify" the FAIRness of datasets or research performing organisations/projects. The cost charged would have to be marginal, otherwise the intention to pay among the research performing organisations will be very low. FAIR certification costs can be made eligible in research grants.

5. **Act as a training provider.** FAIR research data infrastrastructures have the know-how and the means to provide training services on FAIR data stewardship and management to other stakeholders, including other research data infrasturctures and research performing organisations, in order to help them with capability buidling and upskilling of research staff. This is partly the business model of GoFAIR.

6. **Provide legal assistance.** FAIR research data infrastrastructures have the know-how and the means to provide legal assistance to research projects on the best licensing model to be selected for publishing the data produced in a specific project as FAIR data. Very often project outcomes are locked in non-concluding conversations between legal departments and technology transfer offices of research performing organisations and companies collaborating in research projects. In this context, paid legal assistance provided by a FAIR research data infrastructure, can be there to serve and safeguard the interest and the priorities of FAIR implementation.

For facilitating the implementation of any of the cited business models archetypes, we are putting forward a framework which is based on the Business Model Canvas™[24], a de-facto industry standard technique for developing business models. Hence, a FAIR research data infrastructure would have to respond to the following questions:

1. **What is the value proposition**, namely the collection of value-added services which a FAIR research data infrastructures services can provide to its customers, and in fact what is the value proposition for each customer segment.
2. **What are the key resources** that are necessary to create value for the customer. Such resources may include FAIR datasets available via the infrastructure, data management policies,

[24] https://strategyzer.com/canvas/business-model-canvas

persistent identifier management policies, the underlying data storage and provision infrastructure, a persistent identifier services, and last but not least the human resources with the required skills and competences for performing the activities *(non-exhaustive list)*.

3. **Who are the key partners**, namely those organisations who either on voluntarily basis or under some formal cooperative agreement will collaborate in order to create value for the customer. This can include other FAIR research data infrastructures (e.g. in other countries), sofware or platform providers, research funders, standards organisations, learning organisations and research community associations.
4. **Which are the key activities** that are necessary to create value for the customer. Such activities may include data stewardship and management, service management, communication and promotion, knowledge sharing, training and customer support *(non-exhaustive list)*.
5. **What is the cost structure**, namely the representation in money of all the means employed in the business model. The cost-benefit mechanism for FAIR data developed in this study can be used as a basis for quantifying and calculating such costs.
6. **Which are the target customer segments**. Data infrastructures will need to identify market segments and assess their value potential (who is willing/going to pay for what). This will enable them to identify the main revenue streams. We encourage FAIR research data infrastructures to look beyond research performing organisations and connect with industry as potential buyer of FAIR data and/or services. We know from experience that knowledge-intensive industries, such as pharma, chemicals, oil and gas and professional services are willing to pay for services providing quality reusable data.
7. **Which are revenue streams** through which the FAIR research data infrastructure will make its income. FAIR data has to be provided for free by default, therefore, we can see different pricing policies, which can be applied either across all datasets available via a FAIR research data infrastructure or even at the granularity of an individual dataset. The selection of the right pricing policy depends on different aspects, including the way data creation was funded, e.g. through public and/or private funds, existing use terms and conditions, IP or pattents, data management costs, services available which provide extra value on top of the data etc. These pricing policies, which may apply to data and/or to services provided by the FAIR research data infrastructure, include:
    - *Profit maximisation*, i.e. setting a price to maximise the profit either in the short run or in the long run and creating revenue via data/or service usage fees. On-platfom advertising may provide additional revenues. FAIR research data infrastructures that want to decrease their dependency on public funding are likely to explore such policies.
    - *Cost recovery,* i.e. setting a price equal to average long run operational costs (see examples earlier under *activities*) and

creating revenue via data or service usage fees. FAIR research data infrastructures that rely on public funding are likely to explore such models. On-platform advertising may also be explored for covering operational costs.

- Marginal (or zero) costs, i.e. setting a price equal to the short run marginal cost of providing FAIR research data. In this case, we are talking about FAIR *and* open research data and we are refering to FAIR research data infrastructures which resemble (or may be) open data catalogues. Such FAIR research data infrastructures will most likely rely solely on public funding, donations or advertising. Here, the regulator will need to find the right balance between regulations and incentives: the regulation will help to reach a critical mass of FAIR data available while the incentives will support value creation.

As indicated already, these pricing policies, in particular profit maximisation and cost recovery, may still combine different pricing models, from free of charge for bulk data to premium for quality data available at real-time. The pricing options may also be different from on-demand fees to monthtly or annual subscription fees.

8. **Which are channels** that the FAIR research data infrastructure will use for servicing its customers. In this case, the primary channel would be via Web API which allows for data discovery, access and retrieval. However, depending on the selected business model, one could also imagine that a customer portal could be provided, allowing customers to manage services, subscriptions, relationships with each other (networking and community building) or published datasets (for FAIR data providers).
9. **What type of customer relationships** a FAIR research data infrastructure establishes with its customers, spanning from self-service and automated services to personalised assistance for premium customers through to the animation of user communities that collaborate, exchange knowledge and promote innovations through co-creation of services on the platform.

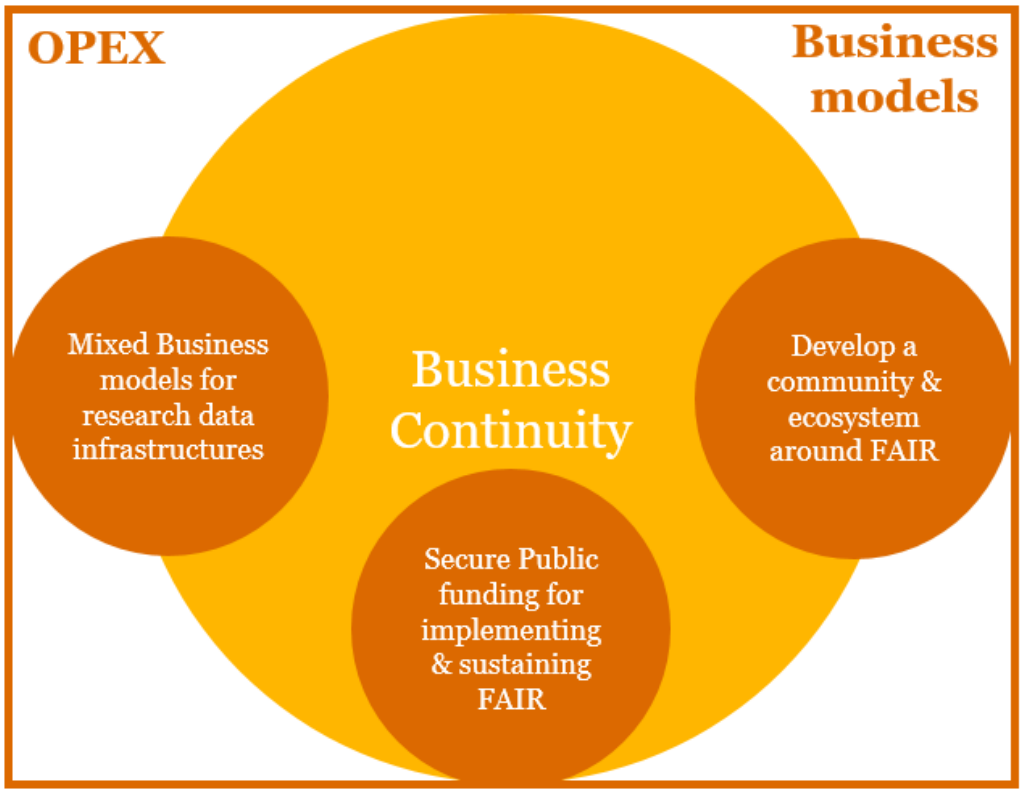

Figure 7 Overview recommendations on Business continuity

Our recommendations

Rec. 23	For the sustainability of FAIR research data implementation, research data infrastructures and research performing organisations must shift the focus towards data monetisation and value-added data services.
Rec. 24	Several alternatives exist for FAIR data and data services pricing models, from profit maximisation and cost recovery through to charging only for marginal costs (hence coming closer to the open data paradigm). Several parameters have to be considered for the selection of the right one, including the way data creation was funded, applicable IP or pattents, data management costs, and value added.
Rec. 25	FAIR research data infrastructures must be encouraged and supported via fiscal incentives and policy interventions to explore mixed business models, which combine a healthy balance between public funding and other revenue streams.Mixed business models will also contribute to the distribution of the FAIR benefits more evenly between research performing organisations and data infrastructures.
Rec. 26	Fiscal incentives, e.g. tax breaks or deductions, will encourage industry to form partnerships, collaborate, sponsor, fund or buy data/services from FAIR research data infrastructures, to broaden the market for FAIR data.

Figure 8: Business Canvas Model™ FAIR research data infrastructure

Secure public funding for implementing and sustaining FAIR research data implementation

As discussed earlier, in our view, the sustainability of FAIR research data implementations should in the future move towards mixed business models, combining public funding with other revenue streams. That said, we do not anticipate in the short or medium term cases where FAIR research data implementations will not be funded, even as a small fraction of their total budget, via public funding.

This means, on the one hand, that research funding for FAIR data should continue being available not only at the European level, for example as part of Horizon 2020 and Horizon Europe, but also as part of national publically funded research and innovation programmes. On the other hand, it implies that FAIR-related costs, such as data stewardship and management, or data infrastructure operational costs need to be made eligible for public funding. Costs must be reported unbundled and clearly indicate the cost category, e.g. data management, storage or training, to allow for transparent cost accounting and avoid misuse of public money. For example, market-dominant internet players, who could also act as privately-funded research data infrastructures, could claim back storage costs, thus indirectly subsidising competitive services. Such phenomena must not be allowed, and hence storage costs must be non-eligible for this type of organisations.

FAIR-by-default policies may be explored, and FAIR compliance can be included in the award criteria of research grants, building further on the requirement for having a data management plan. As a by-product, research funders will also have the opportunity to monitor more easily duplicate grants.

Finally, research data infrastructures and research performing organisations could be encouraged or incentivised to reinvest savings made due to FAIR, e.g. from reducing data management, storage or research duplication costs, in the sustainability of FAIR implementations. For example, a formula can be devised where the government is matching twice every euro reinvested, i.e. if a university reivests 1000 euro it will receive an additional 2000 euro from the research funder.

Our recommendations

Rec. 27 Funding FAIR data implemenation has to continue being available not only at the European level, e.g. as part of Horizon 2020 and Horizon Europe, but also as part of the national research and innovation programmes. FAIR applies to all publicly funded research in Europe.

Rec. 28 FAIR-related costs, e.g. for data stewardship and management, or data infrastructure operational costs must be made eligible for specific cases and only if repored at a granular level respecting transparent cost accounting practices.

Rec. 29 Culture change related costs, including training and awareness raising activities, must be made eligible in research grants based on transparent

cost accounting practices.

Rec. 30 FAIR-by-default policies and mandatory FAIR compliance must be included in the award criteria of research grants.

Develop a community and an ecosystem around FAIR data

At various points throughout this document, we have emphasised the importance of building a community and ecosystem around FAIR data. Such a community should be broad and open enough to engage and involve all relevant stakeholders, including technology providers, research-intensive industries, research performing organisations, data infrastructures, research funders, standardisation bodies and public institutions.

Figure 9 The FAIR research data ecosystem

The support of an FAIR data community of practice in Europe will greatly help the implementation of the FAIR principles and its sustainability. Such a community plays an orchestrating role in:

- strengthening the link between all the stakeholders;
- organising mutual learning exercises, in the context of which member states, third countries, FAIR data practitioners and experts work together on a topic of common interest, such as FAIR data management on the open science cloud, FAIR data management in AI applications, or the costs and revenues for preparing a data infrastructure for joining the open science cloud using the cost benefit mechanism developed by the current study;
- raising awareness for the FAIR principles, implementations and progress;
- exchanging knowledge and sharing solutions and assets;
- developing skills and capabilities related to FAIR data stewardship management;
- managing the supply-demand equilibrium for FAIR research data.

At the same time, we believe that the links between FAIR research data and open or legacy data from other domains, such as geo-spatial data, public data, within the European data economy have to be strengthened as well. The value potential from cross-disciplinary applications and the network effects can be massive. We therefore believe that policy interventions, measures and means should be put in place in order to encourage such cross-disciplinary data innovation projects and applications. Such means may include promoting the use of FAIR research data in projects funded under the current focus areas of European and national research programmes, such as Horizon 2020, or think of a new innovation stream with a focus on research, life sciences and/or SMEs to be included under under future European and national research programmes, such as Horizon Europe.

Animating an active community of practice is neither trivial nor cheap. It is

however of fundamental importance. Therefore, the financial means should be made available for the governance of the community, the community building activities and the community platforms both digital and physical.

Our recommendations

Rec. 32	Provide financial support for communication, knowledge sharing, community building and marketing projects and activities for example via continuing with coordination and support actions through European and national research programmes. Full costs to be made eligible for all types of participants.
Rec. 33	Provide financial support for organising mutual learning exercises, in the context of which member states, third countries, FAIR data practitioners and experts work together on a topic of common interest, such as FAIR data management on the open science cloud, FAIR data management in AI applications, or the costs and revenues for preparing a data infrastructure for joining the open science cloud using the cost benefit mechanism developed by the current study.
Rec. 34	Take measures and make the means available for encouraging innovation through cross-disciplinary projects and applications. Such means may include promoting the use of FAIR research data in projects funded under the current focus areas of existing European and national research programmes, or defining new innovation stream with a focus on research, life sciences and/or SMEs under future European and national research programmes, such as Horizon Europe.
Rec. 35	Consider the establishment of a public-private partnership focusing on creating societal and economic value from FAIR data.
Rec. 36	Place universities at the heart of the European FAIR data community of practice. They are the most important type of research performing organisations and are the ones also preparing the workforce of tomorrow who will be able to support the implementation of FAIR principles in Europe. To this end, support and incentives should be provided to them for reviewing their curricula and current data management practices in the light of FAIR.

CONCLUSION

Despite the significant annual cost of not having FAIR research data, which has been estimated by our previous study at EUR 10,2 bn, many research performing organisations and infrastructures are still reluctant to apply the FAIR principles and share their datasets because of *real or perceived costs*, mostly related to time investment and money. At the same time, countries and organisations who have already invested in the implementation of the FAIR principles are now raising questions regarding the sustainability of those investments.

This report formulated 36 policy recommendations on cost-effective funding and business models to make FAIR data sustainable. The recommendations will help the Commission and funders in the Member States and in third countries provide pragmatic solutions for the optimising the costs and the ensuring the sustainable financing of the EOSC.

These recommendations put forward a step-wise approach towards sustainable FAIR research data implementations in Europe, which allows policy makers and research funders to set up short and long-term actions. The first key milestone in this approach is the establishment of a FAIR baseline in Europe. The FAIR baseline gives priority to data findability and accessibility, and recognises interoperability as the catalyst for improving those, and for increasing further FAIR research data use and reuse.

The development of the FAIR baseline requires in our view to answer first the “what’s in it for me question” posed by research funders, research data infrastructures and research performing organisations. Identifying and quantifying the costs and the benefits, and finding ways of funding the initial costs for achieving the FAIR baseline is key for unlocking investments. Hence, we proposed ways for working out the business cases for FAIR data at the national level, and use this as the basis for prioritising investments following a “think big, start smart” approach. In this process, cross-disciplinary use cases have to be given priority, as this is where most of the benefits will be realised and where innovation will be driven.

We also identified a strong need for governace and monitoring of progress, looking at benefits vis-à-vis investments, which should be established as part of EOSC. The role of this governance structure would also expand to community building and the nurturing of an ecosystem around FAIR data. This ecosystem will facilitate sharing of solutions, software, services, knowlewde and good practices and would bring the different stakeholders closer, hence creating network effects, positive externalities and fueling innovation. The importance of this governance structure emphasises the need to secure the necessary funding and support.

Once the FAIR baseline has been achieved, the sustainability of FAIR research data investments and implementations becomes a key priority for funders and policy makers. Public funding will remain one of the sources of income, as FAIR data is a public good. However, FAIR data in combination with advances in big data analytics, AI and Cloud computing open new horizons to research data infrastructures, who can now start thinking about data monetisation and value-added data services. This way mixed business models like the ones discussed earlier will start emerging, and alternative pricing models pricing models, from profit maximisation and cost recovery through to charging only for marginal costs (hence coming closer to the open data paradigm), will have to be explored and evaluated. Intervention from the Commission and national funders, in the form of fiscal incentives, such as seed funding, tax deductions, and policy interventions, including legislation, can encourage and accelerate the shift towards mixed business models.

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FAIR research data encompasses the way to create, store and publish research data in a way that they are findable, accessible, interoperable and reusable. In order to be FAIR, research data published should meet certain criteria described by the FAIR principles. Despite this, many research performing organisations and infrastructures are still reluctant to apply the FAIR principles and share their datasets due to real or perceived costs, including time investment and money. To answer such concerns, this report formulates 36 policy recommendations on cost-effective funding and business models to make the model of FAIR data sustainable. It provides evidence to decision makers on setting up short and long-term actions pertinent to the practical implementation of FAIR principles.

Studies and reports