DATA SPACES SUPPORT CENTRE

Participant Adoption and Sustainability in Data Spaces

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- Le voice lab.

The paper has been peer-reviewed by Christoph Mertens (IDSA).

Content

Executive Summary

This paper is the result of collaborative efforts, discussions and input collection activities which have been driven by the Data Spaces Support Centre (DSSC)[1] and its Strategic Stakeholder forum (SSF)[2]. The SSF is a multi-stakeholder platform composed of key organisations in the data space ecosystem that supports the DSSC in delivering its policy objectives. The SSF produces collaborative papers, such as this one, to articulate discussions taking place within the community and report on their outcomes with the aim to support data spaces overall positioning, influence actions and offer guidance.

The present paper dives into two important themes for the data space community and namely sustainability in data spaces and participant adoption. This focus was deliberate and based on community priorities. The SSF has prioritised those topics, due to pressing challenges in data spaces but also emerging insights that would be beneficial to be documented to support the collective growth of the ecosystem.

The paper explores available knowledge from existing literature - some recent and very relevant publications - and couples it with community experiences which were captured through various means (discussions, questionnaires and interviews, etc.). Two important value-adding elements to this paper need to be highlighted: a) this paper builds upon viewpoints from data spaces and sharing initiatives, including common EU data spaces[3] and b) it also includes viewpoints from potential data space participants in order to build a better holistic view over current realities, barriers and potential solutions. As this document reflects community opinions, some of the statements might not entirely reflect the actual state of play of developments. The presented insights are still of very high value for DSSC and the community to learn where communication and education are needed to support the learning process and thus help the adoption of fundamental data space concepts and standards.

The paper is organised into 8 chapters, following a narrative arc that moves from the theme of data space sustainability, to participant adoption (as a sustainability enabler), to practical realities and case studies from data sharing initiatives and finally recommendations for the target audiences.

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[1] https://dssc.eu/

[2] https://dssc.eu/space/DC/28049509/

[3] https://digital-strategy.ec.europa.eu/en/policies/data-spaces

Data space sustainability is examined from the lens of ecosystem (who is involved and plays a relevant role in sustaining the data space), infrastructure (how the data space operates in a sustainable way) and value dimensions (what value all stakeholders get individually and collectively). This approach was chosen as it better aligns with the ecosystem way of thinking, keeping the data spaces blueprint structure as its core. The integration of data spaces into a wider European AI and cloud ecosystem (and keeping pace with it) is also considered as a sustainability element that is worth noting.

However, sustainability means very little without concrete real-life adoption and market validation. Data spaces, just as any other socio-technical system or venture, need to be justified under clear uptake and adoption indicators (volume of participants, transactions, etc.) to prove that they serve their purpose. In this context, challenges that are hindering participant adoption are becoming noticeable as data spaces are becoming fully operational and seek for participant uptake. Some of the challenges that have been identified are: unclear value propositions and incentives (and very connected to this: the lack of awareness), fragmented and inaccessible onboarding pathways, legal and regulatory uncertainty, technical and infrastructural incompatibilities (and very connected to this: the required investments for data preparation). The use of emerging solutions (like Generative AI and Large Language Models for data spaces) could lower barriers and facilitate adoption in data space uptake.

The paper proceeds with case studies from data sharing initiatives (common EU data spaces and beyond) that outline **current realities for sustainability and adoption**. These case studies reveal initiatives that are:

- relying on or exploring public or government-led institutional arrangements to survive the "valley of death" period,
- already considering participation and revenue strategies for reaching financial sustainability,
- experiencing challenges in scaling, adapting and proving value over time,
- investing in compelling use cases in order to generate immediate value in the ecosystem and attract participants,
- encountering foundational challenges threatening uptake: data quality, availability and usefulness of the data offerings in operating scenarios and
- operating in direct competition with other data sharing paradigms.

Case studies also highlight different adoption characteristics and patterns in various data spaces with some examples being offered in the sectors of mobility, agriculture, language and media.

The paper concludes with a set of 9 recommendations. These recommendations are relevant for different target audiences (data spaces, the DSSC or policy makers) and are described below:

Recommendations mainly for data spaces:

1. **Enable "test-before-invest" participation**

Data spaces can accelerate adoption by offering demonstration, experimentation and technical and business facilitation capabilities (e.g. testbeds, sandboxes). These environments will help potential participants to identify the benefits of participating in data spaces and build confidence before fully onboarding and proceeding to relevant investments.

2. **Offer tailored onboarding support**

During participant onboarding, data spaces can further lower barriers of participation by offering customised (business) onboarding packages. These packages should accommodate diverse participant needs - especially those of SMEs - by guiding them through business, technical, and legal onboarding steps in a clear and user-friendly way.

3. **Continuously enhance data space value proposition**

Expand offerings with compelling use cases (e.g. for regulatory reporting scenarios) and added-value services (e.g. AI-powered) that generate clear benefits for participants and their businesses. This will lower participation reluctance and help the data space in scaling.

4. **Form partnerships with legacy systems**

Collaborate strategically with legacy platforms and systems that support daily operations of multiple users. Leveraging existing user bases would allow data spaces to reach greater participation in a batch-way.

5. **Integrate with the broader European innovation ecosystem**

Build strong connections with AI, cloud, HPC and IoT ecosystems to ensure interoperability and scalability potential at Pan-European level. Keep pace with the rapid evolution of these existing (but also emerging) ecosystems.

6. **Explore diversified and novel funding models**

Decrease reliance on public funding - although crucial in the early stages of a data space - by exploring a more balanced investment mix. In this context, encouraging entrepreneurial involvement, attracting private capital and piloting novel outcome-based revenue-sharing models could enhance financial sustainability.

7. Incorporate the foundations for building sustainable revenues early in data space design

Prioritise use case scenarios that are grounded on concrete, real-world business needs rather than novel or untested cases. Identify ongoing operational costs and revenue triggers on data transactions to select the most appropriate revenue model for the data space and its participants.

Recommendations mainly for policy makers and the DSSC:

8. Drive actions for raising awareness & incentivising participation in data spaces

Coordinate EU-wide awareness raising and incentivising campaigns (especially for SMEs / startups) to communicate the benefits of data space participation. This will reduce the burden of basic community outreach that is often conducted by sectoral data spaces.

9. Continue fostering a rich ecosystem of dynamic, interoperable & interconnected data space solutions

Foster an ecosystem of mature, easy to use, interoperable solutions. Support standardisation activities related to data space and the links with open-source solutions and Simpl[4]. Acting on this recommendation will enable the creation of a cohesive landscape, allowing for broader and seamless participation in data spaces.

It is important to note that this paper is considered as a discussion paper that captures emerging viewpoints and experiences from the community in a non-exhaustive manner. It can be viewed as a very practical, experience-driven paper that is not intended to act as a position paper for the DSSC. Additionally, it doesn't aim to introduce new theories or pursue a structured academic or theoretical orientation.

The paper was built with the Data Spaces Blueprint v2.0[5] being the main reference point, and its content reflects this context.

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[4] https://simpl-programme.ec.europa.eu/

[5] https://dssc.eu/space/BVE2/1071251457/Data+Spaces+Blueprint+v2.0+-+Home

1   Introduction

1.1   Motivation & Objective

This paper explores two important challenges for the data space community: the sustainability of data spaces and the participant adoption. These themes, and the dynamic interplay between them, as they are closely connected, have been increasingly attracting the interest of the community over the last period - an anticipated development considering the current momentum within the common EU data spaces and the overall ecosystem. In greater detail, the motivation for driving the production of this paper stems from the following statements:

- The common EU data spaces - essentially EU-funded initiatives - are in their majority in a transitioning stage facing the challenge of becoming sustainable beyond the initial public funding from the Digital Europe Programme (DEP) or Horizon Europe (HE) that was crucial as an emergence catalyst. In order to avoid discontinuation, each initiative should explore options and make strategic decisions that will give them continuity and allow them to sustain their developments and operations.
- In maturity terms, data spaces are no longer considered just a concept. They are gradually becoming fully operational and as such it is only natural that the focus shifts from technical proof of concepts or governance definitions to the practical realities of delivering real value through use cases, attracting, onboarding and retaining participants and reaching a working business model with long-term viability.

Recent community discussions have highlighted the need to address and further explore these key themes. While the discussions have approached these issues in alternative angles and using various terms for expressing similar concerns - ranging from how to incentivise participation in data spaces, identify scalable business strategies for data spaces, demonstrate the Return on Investment (ROI) for participating organisations, how to shift the focus from supply to demand side, etc. - a shared reality became evident: sustainability in data spaces and participant adoption are very prominent topics for the community and it would be beneficial if tackled together in order to ensure long-term success for the data spaces program as a whole.

As such, a key objective of this paper is to address the aforementioned community needs and provide very practical perspectives: including challenges, realities and recommended solutions on

both topics of sustainability and participant adoption, by treating them not in isolation but rather as interconnected themes.

This paper builds upon findings that are documented in previous studies and further **enriches the body of knowledge with a - first of its kind - synthesis of reflections and realities drawn from the DSSC community, including several common EU data spaces**. While previous studies have rather focused on data sharing/space initiatives - either national or market-driven - that were in a position to share their experiences on these themes, the common EU data spaces have only recently reached a comparable maturity. As such, it becomes highly relevant to **capture their emerging experiences aiming to identify common patterns or differentiating factors**. Additionally, this paper complements the view of data space initiatives with those from participants, allowing for a more **holistic understanding**. It was an important aim of this paper to present prominently **the participant viewpoint** and draw upon experiences from those organisations that have expressed interest or are getting onboarded into the ecosystem. As this document reflects community opinions, some of the statements might not entirely reflect the actual state of play of developments. The presented insights are still of very high value for DSSC and the community to learn where communication and education are needed to support the learning process and thus help the adoption of fundamental data space concepts and standards.

Finally, it should be noted that it was not an ambition of this paper to conduct a highly structured theoretical exercise. This paper was built by blending literature reviews with a collection of insights from open discussions and practitioner inputs that aim - as already mentioned - to bring into the surface **timely and tactically important practical perspectives** of sustainability and adoption in data spaces. These **cross-sectorial, cross-organisational, EU-wide perspectives** will support guidance towards evolving data space initiatives, in a way that adds **legitimacy** and aligns well with core **EU values**.

Insights from the community have been captured by working closely with a large team that contributed to the production of the paper. The contributing team includes members of the DSSC community and namely representatives from its consortium (both full consortium members and associated partners), its Community of Practice (CoP)[6] and its Strategic Stakeholder Forum (SSF) that are interested and well positioned to share experiences and lessons learnt for the key themes of the paper.

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[6] https://dssc.eu/space/DC/27983886/

Additionally to this, all SSF members had the opportunity to scope, shape and offer feedback during several of the regular meetings organised by the SSF during the paper's production period (from February to September 2025)[7].

1.2 Role of the DSSC and the Strategic Stakeholder Forum

The DSSC supports the deployment of the common European data spaces, that collectively create a data sovereign, interoperable and trustworthy data sharing environment, to enable data reuse within and across sectors, fully respecting EU values and supporting the European economy and society. The DSSC is co-creating, together with a large Network of Stakeholders (NoS) important assets for the data space community to support its vision and ultimately the realisation of the European single market for data.

Part of this NoS is the Strategic Stakeholder Forum (SSF). The SSF is a think-and-do tank that supports the DSSC in delivering its objectives. It is a multi-stakeholder group that has an active advisory and strategic role for the DSSC. The organisations that form part of the SSF share expertise on data spaces and could be considered key enablers, promoters, or users of data spaces. Some organisations in the SSF are also leading or contributing to setting up and deploying data spaces.

The activities of the SSF involve discussions on key topics of interest for the data space community. Collaborative papers, such as this one, are offering the means to articulate these discussions and report on their outcomes, thus helping to continuously position data spaces in the European and worldwide landscape and ultimately to influence external actions and offer strategic guidance to the support centre.

1.3 Target Audience

This paper is mainly intended for data space initiatives and practitioners that wish to capitalise on learnings from the community on these prominent themes and additionally the DSSC, since outcomes and recommendations could influence next asset iterations.

At the same time, it is anticipated that this paper would be insightful for policy makers as well. Over the past years, Europe has made significant investments and has to highlight concrete

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[7] SSF meetings of February and March 2025 supported scoping discussions, while the ones of April and May 2025 were used for the provision of more targeted feedback to the main themes of the paper. An SSF meeting organized in September was used for validating the paper recommendations and outcomes.

achievements connected to the deployment of data spaces and the overall European data strategy, including: EU investments in data spaces (e.g. funding the deployment of the common European data spaces, Simpl, the DSSC, HE research and innovation projects contributing to data spaces) and relevant legislative instruments (Data Governance Act - DGA, Data Act - DA, Implementing Act - IA on High Value Datasets)[8]. Outlining and attempting to resolve barriers hindering the success of these investments would be of paramount importance for policy makers.

Finally, this paper might be also interesting material for potential data space participants, who wish to learn from experiences from peers to evaluate the potential of becoming part of the ecosystem.

1.4 Structure of the paper

The paper is structured in 8 chapters:

- Executive summary is offering a summary of the paper's key findings,
- Chapter 1 introduces the reader to the scope of the paper, motives, objectives and the target audience,
- Chapter 2 provides a brief exploration of existing literature that serves as a baseline for the production of the paper,
- Chapter 3 brings up the foundation of data space sustainability from the lens of the ecosystem, the infrastructure and the value. It also frames data spaces as one part of the wider European AI and Cloud ecosystem,
- Chapter 4 follows and introduces participant adoption as a pillar of data space sustainability. It offers practical evidence and the unfiltered participant viewpoint from a set of already participating (or soon to be onboarded) organisations in data spaces,
- Chapter 5 presents case studies from data sharing initiatives. It unfolds current data space realities in sustainability and adoption and offers an overview of adoption patterns in various data spaces, together with concrete sectorial examples,
- Chapter 6 offers recommendations that are elicited during the production of the paper,
- Finally, chapter 7 concludes the paper.

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[8]

https://dssc.eu/space/DC/28049509/Strategic+Stakeholder+Forum?attachment=%2Fdownload%2Fattachments%2F28049509%2FDSSC%2520White%2520paper_Generative%2520AI%2520and%2520Data%2520Spaces_V4.pdf&type=application%2Fpdf&filename=DSSC%20White%20paper_Generative%20AI%20and%20Data%20Spaces_V4.pdf

2   Brief exploration of existing literature

Previous studies have supported the discussion on sustainability and participant adoption in data spaces. This section offers a brief exploration of existing literature which serves as a body of knowledge for the production of the paper. It summarizes key outcomes and recommendations from a set of papers, offering to the reader an understanding of opportunities and challenges ahead and a solid baseline for this paper to unfold upon. It is important to note that what follows is not intended as an exhaustive literature review, but offers a brief overview of selected publications that have been considered particularly relevant during discussions of the contributing team. The papers that have been identified and explored are:

- "Why Data Spaces? A business and users' perspective"[9] 1st collaborative paper of the DSSC's SSF,
- "Economics of Data Sharing"[10] Position paper from Gaia-X Institute,
- "Data Space Business Models"[11] a recent publication from IDSA,
- "Sustainable Revenue Models for Data Sharing Initiatives"[12] publication from Tilburg University,
- "Business perspective of inspiring data space examples"[13] an upcoming publication from the DSSC.

The DSSC even from its first year of operations has been considering the participant viewpoint with the 1st collaborative paper of the SSF under the title "Why Data Spaces? A business and users' perspective". This early publication from the DSSC community provides an overview of the user typology in the ecosystem and the added value from the participation in data spaces. The perceived value of data spaces is presented under the lens of: a) pain relievers to distinct challenges and pains faced by users of data spaces, b) expected gains, c) business potential and d) EU values and

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https://dssc.eu/space/DC/28049509/Strategic+Stakeholder+Forum?attachment=/download/attachments/28049509/1st%20collaborative%20discussion%20paper%20Why%20data%20spaces%20A%20business%20and%20user%27s%20perspective.pdf&type=application/pdf&filename=1st%20collaborative%20discussion%20paper%20Why%20data%20spaces%20A%20business%20and%20user%27s%20perspective.pdf

10 https://gaia-x.eu/wp-content/uploads/2024/03/Study-on-the-emergence-and-creation-of-value-within-data.pdf

11 https://internationaldataspaces.org/wp-content/uploads/dlm_uploads/IDSA-Position-Paper-Data-Spaces-Business-Models.pdf

12 https://www.rijksoverheid.nl/onderwerpen/zakendoen-met-het-rijk/documenten/rapporten/2025/04/22/sustainable-revenue-models-for-data-sharing-initiatives

13 Upon its publication, this paper will be available here: https://dssc.eu/space/PE/881393668/Publications

value for individuals and the society. This paper is supported with real user and business stories from the community and ends up with a set of concrete recommendations that foster data spaces uptake: from the need to reflect on the value propositions, to better considering needs, challenges, roles, digital readiness, etc. of participants and further developing user-centric narratives as a means to incentivise participation. Particular emphasis should be made on recommendations that refer to the incorporation of testbeds or sandboxing facilities into data spaces to facilitate innovation and experimentation and enhancing gain creation in data spaces. These recommendations are particularly relevant to recommendations that are also elicited in the present paper and amplify their message.

This user-centric view of data spaces is featured and also broadened in the "Position Paper: Economics of Data Sharing" from Gaia-X Institute. This publication offers an analogy of data spaces with "clubs" and frames them as providers of "club goods" - a specific type of economic asset extensively studied in the economic literature that is aiming to address the so-called "free-rider" problem. Within this analogy, the value that participants extract from the data space ecosystem is calculated by comparing the expected benefits (e.g. gains from cost savings or increased innovation capacity at a higher maturity level) vs costs (in production processes, organisation, R&D, marketing) for contributing to the club good. The report is also presenting the role of the ecosystem orchestrator - a role that is not defined in the DSSC Glossary. This role refers to the entity that is supporting organising the data sharing ecosystem and could be either a key player in the value chain or an intermediary. The orchestrator could act as a driver of emergence of the data sharing ecosystem and as a service provider once the ecosystem is operating, offering services of strategic/business or technical nature that the ecosystem deems necessary or relevant. The role of the ecosystem orchestrator introduces another aspect connected to the capacity of the ecosystem to emerge and remain sustainable in the long-run. Orchestrators can be represented in two dimensions that reflect the characteristics of the value chain. These dimensions refer to one sided vs multi-sided needs and the atomicity of the ecosystem.

Moving from the conceptual framings to practical examples, a recent publication of IDSA on "Data Space Business Models" analyses real-world business models of market data space initiatives (Catena-X[14], SCSN[15], Mobility data space[16]). The publication sketches the context and provides common terminology and key understandings that enable stakeholders to speak the same language

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[14] https://catena-x.net/
[15] https://smart-connected.nl/en
[16] https://mobility-dataspace.eu/

when discussing the business models of data spaces. It highlights differences between the business model of data space participants and the business model of the data space itself (that needs to stimulate adoption). Next to this, it offers practical examples of data space business models: from exploiting public funding schemes during the initial development stages (Catena-X) to "bootstrap-like" approaches (SCSN) and from multi-sided models of adoption - matching data & service providers to data consumers (Mobility Data Space) - to marketplace approaches (Catena-X) and intermediaries that enable adoption and scaling (SCSN).

Another publication that draws upon practical realities in the data space ecosystem is the publication of Tilburg University that focuses on "Sustainable Revenue Models for Data Sharing Initiatives". The paper is analysing data of 155 data sharing initiatives and insights from 17 interviews and 2 roundtable discussions with various Dutch and European data spaces, besides literature review findings. It supports the hypothesis of other publications that data spaces are enablers of societal and economic value, however, it echoes that most of current data space initiatives are in early development stages and haven't defined concrete plans for financial sustainability. The report from Tilburg University identifies 4 key barriers preventing data spaces from reaching sustainable scales:

- The missing "killer app": Data spaces, unlike data platforms, are struggling to find "a killer app": a breakthrough use case that will help solve real-world problems, build network effects, attract participants and ultimately to ensure sustainability.
- Limited entrepreneurial engagement: Most data space initiatives are led by researchers, technologists or public agencies. There is little private investor involvement and entrepreneurial models are missing, to bring fresh ideas, business discipline and the ability to scale solutions.
- Government-led governance models: Many data sharing initiatives are using governance models which are dominated by public or semi-public institutions. While these approaches promote trust and compliance, they can be the reason behind bureaucratic delays, strategic drift and limited responsiveness to market signals.
- Lack of sustainable revenue models: The report reveals that only 15% of the analysed data space initiatives have defined clear revenue models, with the majority still relying on public funding (80% of Dutch data sharing initiatives rely on government funding) with limited movement toward long-term economic viability.

Next to the above points, the report also identifies additional challenges that hinder the development of sustainable revenue models for data spaces:

- Governance and Trust: many organisations are hesitant to join data spaces when data ownership and privacy responsibilities are unclear.
- Economic Value proposition: candidate data space participants often fail to see the immediate benefits of sharing their data. The value is frequently indirect, delayed, or diffused, making it hard for organisations to justify investment.
- Technology and usability: lack of intuitive and user-friendly interfaces, particularly for SMEs or non-technical users.
- Structural and regulatory barriers: Although EU regulatory frameworks: DA, DGA, Digital Services Act (DSA), the Interoperable Europe Act, offer important safeguards but they also create challenges for initiatives attempting to determine which rules apply to whom under what conditions.

The Tilburg university paper offers recommendations to address those challenges, including: raising awareness and usage, encouraging entrepreneurial involvement, transitioning to co-investment models (attracting private capital from venture funds, corporate investment arms or mission-driven investors alongside public funding), supporting Pan-European scaling (beyond national borders), bringing standardization and regulatory clarity and above all following a user-centric design and logic.

Further, the DSSC has been recently working on an additional publication connected to the business challenge of data spaces with the title **"Business perspective of inspiring data space examples"**. The business challenge concerns the balance between revenues and costs. This paper (soon to be published) delves into the development pathways of data spaces and other data space related initiatives (DjustConnect[17], SCSN, JoinData[18], FEDeRATED[19], Europeana[20]) along five dimensions of the business challenge. These dimensions are: 1. data and Infrastructure, 2. users and authorisation, 3. use cases and their applications, 4. vision and governance, 5. business and viability.

The paper concludes amongst others that data spaces:

[17] https://djustconnect.be/en
[18] https://join-data.nl/en/homepage/
[19] https://www.federatedplatforms.eu/
[20] https://www.europeana.eu/en

- Can start from different dimensions and perspectives on the business challenge- public or private — that both require a different approach.
- Require value propositions for different user types.
- Multi-sided business models for data spaces are difficult to establish and require network effects to become sustainable.

Finally, it should be noted that several DSSC assets have been referenced as the paper unfolds and the reader might benefit from acknowledging their content. Among the assets referenced you may find the following:

- The glossary[21],
- The co-creation method[22],
- The Data Spaces Blueprint and specific building blocks connected to the discussions and how (not an exhaustive list):
  - Business Model: Through network effects, revenue & pricing, cost model, stakeholders (ecosystem integration),
  - Use Case Development: and all the central elements of it (e.g. identifying and monitoring use case scenarios, improvement processes),
  - Data space offering: Relevant aspects for the development, maintenance and enforcement of the governance rules of the data space offering, Services that lower barriers to participant/enter,
  - Participation Management Building Block: participants (profile), onboarding process of participants,
  - Organisational Form and Governance Authority Building Block: Legal entity connected to sustainability.

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[21] https://dssc.eu/space/BVE2/1071251749/Glossary

[22] https://dssc.eu/space/BVE2/1071257869/Co-Creation+Method

3   Sustainability in Data Spaces

This chapter frames the sustainability concept in the context of data spaces. It does not attempt to introduce new theories, and it is not intended to provide an official position of the community. Instead, it reflects the outcome of ongoing practitioner discussions that articulate different but complementary viewpoints. The aim is to highlight the diversity of perspectives, and to enrich the knowledge of participants during the exchange rather than resolve them into a single narrative.

When discussing the topic of **sustainability in data spaces** within the community, it quickly became clear that the word itself can mean very different things to different people. For some, the word *sustainability* is considered too broad and often associated primarily with environmental impact, which could risk diverting attention away from financial and operational challenges. Others suggested that the term *viability* would be more accurate, as it captures the ability of a data space to function in practice without the broader connotations of sustainability. What became clear through those exchanges is that sustainability is a multidimensional and complex concept that can be approached by different perspectives, and no single agreed framework exists yet. The existing literature on this topic presented in chapter 2 was used in the discussions with the community; the exercise was useful not only to make the community aware and reflect on the existing content (which many considered of high interest) but also to acknowledge the existence of those different perspectives. We have explored sustainability in data spaces through complementary lenses that practitioners have found meaningful:

- Technical, governance, and business dimensions, in full alignment with the DSSC blueprint structure (and this was the guiding structure followed during the first stages of creation of this paper).
- Infrastructure, ecosystem, and value creation dimensions, classification finally chosen by the editors in the paper as better aligns with the ecosystem way of thinking, keeping the blueprint structure as its core.
- Supply and demand dynamics, between participants and the data space itself (as the governance authority can offer specific services to the participants), or between participants that exchange data and services.
- A temporal perspective, considering that sustainability in our current state of play also refers to the transition from deployment (often through publicly funded projects or public-private partnerships) to operational phases of running, growing, and evolving.

Beyond the mentioned elements, sustainability could include more dimensions like environmental and societal sustainability, e.g. ensuring that data spaces contribute to a wider societal goal. Although environmental and societal sustainability is increasingly relevant in the EU discourse in some sectors (e.g. public health and green transition) and Horizon Europe Programme has been stimulating the development of projects for energy-efficient infrastructure and responsible data practices, this paper does not focus much on this particular aspect of sustainability. This, however, does not diminish their importance and might be gradually integrated into the sustainability of data spaces.

Next subsections dig into the different elements of sustainability chosen: the **ecosystem** (*who* is involved and plays a relevant role in sustaining the data space), the supporting **infrastructure** (*how* the data space operates in a sustainable way) and the **value generation** (*what* value all stakeholders get individually and collectively, including not only primary stakeholders such as participants and governance authority, but also policy makers, investors, technology and services providers of any nature and society at large). An additional subsection is added to reflect on the importance of looking at data spaces as part of larger digital ecosystems, notably cloud and AI, as a key element of sustainability affecting ecosystem, infrastructure and value.

3.1 Ecosystem sustainability

Ecosystem sustainability refers to the various stakeholders and actors, the roles and organisational forms that ensure a data space can be sustained in time and evolve.

The roles within a data space can be analysed through three interconnected dimensions: business, governance and technology. Each dimension contributes to the overall functioning, sustainability, and trustworthiness of the data space ecosystem.

Rather than introducing a new layered model or substituting existing perspectives in which roles in data spaces are offered, this approach should be considered as a repackaging (synthesis) that helps analyze and offer clarity in how existing roles and functions contribute to the long-term sustainability of data spaces.

In the **business layer**, data space facilitates the creation and operation of data-driven use cases that involve various economic and societal actors. Roles in this dimension reflect different business functions such as data offering providers and consumers, service providers, data intermediaries and rights holders. The governance authority also plays a fundamental role in the business layer, as it establishes the business model of the data space and a data space offering (from the data

space authority to the rest of the participants). Other stakeholders such as public and private investors and policy makers (providing incentives and regulating the market) are of relevance as well.

In the **technical layer**, the data space provides a shared infrastructure that supports secure, standardised, and interoperable data exchange. Core roles to the data space include data providers and consumers, IAM/trust service provider and data space operator. At this level we should also include all technology and software providers of the data space components and infrastructure. They play a notable role in data space sustainability, and their business (or specific business unit) also depends on the growth and sustainability of data spaces. Besides providing business-grade and cross-vendor interoperable technology, they should provide sensible deployment and upgrade pathways, with corresponding financial models to the technology adopters.

The **governance layer** of sustainability relates to the organisational form and governance authority of the data space, as well as to its legal components, for the definition of activities, processes, and roles. Sustainability is reflected in all phases of the governance lifecycle[23]: from the formation of the governance authority, its operations and functions, to the monitoring, enforcement, and continuous improvement of processes, portfolios and resources. Ultimately, sustainability is achieved by attracting new (or the key participants) and generating value for them, with all (technical, financial, and ethical-social) dimensions incorporated, and the data space existence and persistence insured.

From a governance standpoint, a data space requires a clearly defined governance framework that ensures transparency, fairness, and accountability among participants. A dedicated governance authority is the body that should oversee the operation of the data space, comprising representatives from all participant groups. This body may also engage external stakeholders, such as regulators, standard-setting organisations, and civil society actors, to ensure broader legitimacy and alignment with societal values. The **institutional design of the data space governance authority** involves either the foundation of a legal entity[24] or the contractual arrangement among participants[25]. This choice influences other factors, such as the definition of applicable national law, the establishment of capacity of contracting and employing staff, and the regime of taxes and

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[23] https://www.greatproject.eu/wp-content/uploads/2023/10/D4.1-v1.0-Phase-1-Governance-Requirements-and-Endorsed-Governance-Scheme_web.pdf

[24] https://dssc.eu/space/BVE2/1071253671/Organisational+Form+and+Governance+Authority#3.1.2-Data-space-with-legal-personality-(incorporated-data-space)

[25] https://www.sitra.fi/en/publications/rulebook-for-a-fair-data-economy/#2-3-introduction-to-rulebook-contractual-framework

fees. They have different impacts on data space sustainability, corresponding to different costs, obligations, and risks. At the same time, they provide trust and institutional stability that allows economic activities, apply for and receive public funding, and establish cooperation with other data spaces.

3.2 Infrastructure sustainability

To support business and governance sustainability, the data space must offer and maintain a technical structure that enables its adoption by a growing number of participants, and the development of new use cases. Technical sustainability goes hand-in-hand with the operational dimension of the data space, which allows the effective use of the shared infrastructure, the connection of participants, and the interoperability with other data spaces.

The technical infrastructure offered by the data space is important to lower the entry barriers, by providing easier installation of the data space connector or any other onboarding mechanism, and to enable the operations in the data space, through interfaces for contracting and negotiation, interoperability, protocols maintenance and support to participants and potential participants. Equally important is the continuous development of technology, with adoption of the newest standards and provision of technical solutions that are updated and relevant to the participants[26], in line with their needs and market advances, as pointed out in the section above. The technical level under the data space's responsibility refers to the *control plane*[27], making it viable for participants to join and use the data spaces' offers. On the *data plane*, the technical structure must be operated by the participants from their own side, in terms of maintenance and development of the necessary protocols, tools and standards to connect to and use the data space.

By offering technical services, the data space can create revenue, via subscription, or membership fees. By other turn, the technical development and maintenance of the technical layer also generate costs. They can be optimised using interoperable standards and open-source resources, as well as publicly available solutions, and protocols. The data space can create an environment for the cooperative development of technical operations and standards, fostering solutions developed and applied by its own participants, through community building.

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[26] Idem

[27] https://dssc.eu/space/BBE/178422298/Control+plane+vs.+Data+plane

3.3 Value sustainability

The first collaborative paper released by the DSSC in collaboration with the Strategic Stakeholder Forum *"Why data spaces: A business and user's perspective"* (also briefly outlined in section 2) introduced the link of data spaces and value creation. That paper explained the link of data space value with the value of data, the value of data and the data-value chain, foundations of the purpose of data spaces, and the value creation sustainability. That paper also reflected on all the users involved (as described in the ecosystem sustainability section) and the value for them of data spaces, either as primary or secondary users (as described in the paper). Finally, the paper touched on the different dimensions of value, and the different perception of value by different users, emphasizing business value as the most critical, but also considering customer value, employee value, stakeholder value, Innovation value, reputation, social and environmental value, strategic or operational value, cultural and ethical value which would eventually revert on business value for the organisation. One important reflection of that paper is that the **sustainability of data spaces has a strong dependency on the balanced distribution of value among all different participants and stakeholders, individually and collectively**.

In this paper, focused on sustainability, that value perspective is complemented with a perspective on the financial sustainability of a data space, and in particular the governance authority.

At the business layer, the data space's financial sustainability will derive from a viable business model that ensures the data space can operate, expand, and remain competitive without relying solely on a single source of external financing, such as public funding, to cover its costs and invest in the necessary infrastructure. Moreover, the data space must not only create value, bringing participants into the ecosystem, but also capture value, through balancing revenue streams and cost structures, to achieve financial sustainability.

Financial sustainability requires understanding the cost structures through concrete measures, such as the cost of data space operation or orchestration, and how the participants' investment can lead to benefits. The investment approaches must be aligned with technological trends, to secure interoperability within other data initiatives, and correspond to organisations' budgets regarding innovation. An example is the offers regarding the current increase of generative AI by data spaces[28]. Furthermore, the data spaces require an umbrella structure for funding that is also long-

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[28] https://dssc.eu/space/News/blog/380600324/The+new+%E2%80%9CGenerative+AI+and+Data+Spaces%22+white+paper+of+the+Strategic+Stakeholder+Forum+is+now+available

term and hybrid, considering both the revenue generated by its participants, the attraction of private investments, scaling initiatives, and public funding. Public investment is essential for achieving a data ecosystem based on citizen-centric values, as outlined in the European digital strategy, especially in early stages of data space development.

Generating financial returns is crucial for the long-term sustainability of the data space. It varies within the sector, the organisational and technological structure available in the data space. From the data economy, various models, such as subscription, usage fees, or licensing, might be considered, depending on the offers available at the data spaces. The tools, services, and applications in the data space enhance the value creation and increase participation. In turn, the broad adoption of the data space (either in terms of volume of participants or volume of transactions) is a key factor in its sustainability, as the next chapter of this paper points out.

3.4 Data spaces as one part of the wider European AI and Cloud ecosystem

The first collaborative paper of the SSF "*Why data spaces: A business and user's perspective*" also established an important link between the data spaces and digital ecosystems. In this third paper we argue that this link is a very important element in the sustainability of data spaces. This integrated approach as part of larger digital interoperable ecosystems seems to be crucial for the long-term sustainability of data spaces.

Data spaces do not operate in isolation with respect to other technologies and ecosystems (e.g. cloud/data and computing infrastructure and AI ecosystems). First, they must be connected to data providers (including IoT devices), which supply the datasets required for their functioning. Next, they need to be integrated with the necessary infrastructures to realize their capabilities (e.g., cloud, High Performance Computing - HPC). Finally, they should interface with the applications, to deliver use cases they are meant to support and to integrate with AI infrastructures and platforms (e.g AI Factories[29]). Without being properly embedded within the broader European innovation ecosystem (including IoT, edge, cloud, HPC and the overall computing continuum and AI, along with data providers, infrastructure providers, service providers, end users, and AI practitioners) data spaces are unlikely to function effectively or scale successfully. This interplay also introduces

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[29] https://digital-strategy.ec.europa.eu/en/policies/ai-factories

an additional challenge: keeping pace with the rapid evolution of these existing (and emerging) ecosystems.

Another important element is the Integration and evolution of legacy systems into data spaces: In some scenarios (e.g smart cities), data spaces evolve from legacy systems at organisations that support the daily operations for their customers and users (i.e. smart city platforms where cities are aggregating data from their providers, sensors, and citizens and sharing it with other providers to provision a city service). Thus, the adoption of the data spaces approach by these organisations implies **facilitating the evolution and integration of these legacy systems into the new paradigm to ensure the continuity of their business** and at the same time providing an additional profit to their usual business model.

The aspects outlined above have been influential for shaping relevant recommendations that are found in section 6 of the paper.

4 Participant Adoption in Data Spaces

The previous section explores sustainability in data spaces in its multi-faceted perspective that could be seen through the lens of ecosystem, value and infrastructures. However, sustainability means very little without concrete real-life adoption and market validation. Without active participants, even very robust governance and sustainable infrastructure will not succeed. Participant adoption has been already recognised as an important enabler of (financial) sustainability. Data spaces just as any other socio-technical system or venture, need to be justified under clear uptake and adoption indicators (volume of participants, volume of transactions, etc.) to prove that they serve their purpose, demonstrate traction and generate revenues. Data spaces cannot succeed without the active participation of organisations that are motivated to share or consume data under the data space paradigm.

In the brief exploration of literature in section 2, adoption of data spaces has been correlated - among others - with how compelling the revenue/pricing models are, the existence of clear governance structures and of high-value use cases. This section zooms into the key challenges which prevent a wider adoption of data spaces in real life and businesses; analyses the practical insights offered by real data space participants - which has been an important objective of this paper - and provides some emerging solutions to facilitate overcoming some of the identified challenges and barriers.

4.1 Key challenges for adoption

At the heart of every data space lies its community of participants - data providers, consumers, and intermediaries - whose engagement is essential for both short-term functionality and long-term sustainability. The complexity typology highlights how adoption challenges are closely tied to participants' characteristics, expectations, and capacities. As participant diversity increases across language, geography, sector, and size so does the difficulty of ensuring effective and equitable participation. Community discussions have highlighted five major challenges for participant adoption that data spaces could target to address:

1. **Unclear value propositions and incentives.** For many potential participants - particularly small and medium-sized enterprises (SMEs), local authorities, and non-profit entities - the motivation & benefits of joining a data space are not immediately apparent. These groups may lack familiarity with data-driven business models or may not perceive a direct ROI.

Without clear, accessible explanations of the advantages of participation - whether in terms of monetization, service improvement, innovation, or compliance - engagement remains limited. In other cases, these groups are indeed familiar and convinced about sharing data but not through data spaces. Then, the challenge is for data spaces to find a way to attract them with a better value proposition than their current way of sharing (data platform, marketplace, data lake, etc.).

2. **Fragmented and inaccessible onboarding pathways.** Many data spaces struggle to provide participants with intuitive, low-friction onboarding. This issue is compounded in multilingual and non-technical environments where users may be unfamiliar with complex data architectures or interfaces. Participants who encounter barriers early in their journey - whether linguistic, technical, or procedural - are more likely to disengage. Tailored support and inclusive onboarding materials are critical, especially for first-time data contributors.

3. **Deficits in trust and transparency.** Trust is a foundational concern for participants considering whether to share sensitive or commercially valuable data. In cross-sector or transnational data spaces, concerns over competitive misuse, unclear governance, or uneven benefits can deter engagement. Without strong, transparent governance mechanisms and enforceable safeguards, participants may perceive the risks of participation to outweigh the benefits.

4. **Legal and regulatory uncertainty.** Participants frequently face uncertainty regarding legal responsibilities and rights within the data space. Questions about intellectual property, data licensing, personal data protection, and liability in cases of misuse often remain unresolved. Especially for smaller participants lacking legal departments or technical guidance, this uncertainty becomes a practical deterrent to joining or contributing to the ecosystem.

5. **Technical and infrastructural incompatibilities.** Stakeholders operate with varied levels of digital maturity and infrastructure readiness. While some large organisations have well-established data pipelines, others - particularly in agriculture, public administration, or the cultural sector - may lack even basic interoperability tools. Without standardised technical protocols and plug-and-play solutions, smaller participants struggle to align with the expectations of the data space.

4.2 The participant viewpoint: from current practices, to barriers and incentives for participation

Considering the above included information in this document, this section will compile in a synthetic and practical manner the barriers, incentives and suggestions for adoption collected through various workshops organized by DSSC (targeted for innovation hubs, CoP and SSF members) and conducted interviews/questionnaires to organisations, either already members of data spaces or potential participants in future to them. The interviews/questionnaires involved 10 organisations of different types (startup, SME, large), countries (Estonia, Spain, France, Poland, Belgium), sectoral focus (energy, media, culture, logistics, automotive) and involvement level / maturity (already active in data spaces, just started, not involved yet) in relation to data spaces. It should be noted that 60% of those interviewed are already participating in a data space (Catena-X, regional data spaces, Energy and Language Data Space) while the remaining 40% forecast their participation in the medium term (6 to 12 months). The next figure offers a panoramic view over the profile of the 10 organisations involved in these interviews/questionnaires.

Figure 1: Overview of the profile of the organisations that contributed to the

The overall ambition of this section was to bring prominently the unfiltered voice of the participant, in order to complement the existing body of knowledge with further bottom-up experiences. It wasn't intended to include a DSSC interpretation and position over those voices, considering the

discussion nature of this paper. It is evident that the collected insights are not offering an exhaustive participant viewpoint. Instead, the aim is to present the perceived realities of some early adopters of the ecosystem.

Initially, through the interviews and questionnaires, it was made possible to shed light on the **current data sharing approach**, that is, how data is shared today and under which conditions. What has been expressed is that in some cases organisations currently share data through bilateral agreements between two peers, typically with no central platform in between. In other cases, it could be that a data lake or data platform already exists, enabling central storage and controlled access via user accounts. Direct data monetization might not always be possible. Instead, data exchanges occur in return for service provision rather than for direct financial compensation. Decision-making on data sharing varies across organisations: sometimes it is handled by C-level executives, overseen by the legal departments or in other cases, a director (supervising digital activities) takes the lead. Main investments focus on training employees and preparing data for sharing, ensuring both technical readiness and internal capacity building.

Regarding the participation in data spaces (as a way forward from current data sharing practices, or as a totally new paradigm), the following **barriers** were identified by the respondents. This bottom-up information complements nicely the set of challenges already offered in section 4.1 and offers the opportunity to identify patterns among the top-down community reflections and the unfiltered participant viewpoints listed below:

- **Level of awareness/knowledge** of the participant about what is a data space and the benefits it may have for them. The lower the knowledge is, the harder the participation is. Reluctance to change is connected to this. Still some companies are reluctant to join data spaces, even though they perceive the need for sharing data. There is still a lack of knowledge and guidance to do it properly, at limited cost and easily, that is compatible with their business-as-usual way of doing.

  This viewpoint could be seen as related to the 1st challenge for adoption of section 4.1.

- **Difficulties in identifying and involving the right people (decision makers)** in bigger companies. There might be multiple people (from different departments and levels) that need to be internally aligned and involved in a decision to enter a data space. Since they might not be aware of data spaces or they might not understand the value proposition overall, they may be reluctant to change and to dedicate resources. They could also be

afraid of giving away important intellectual property rights or their data. They claim practical and real examples to demonstrate that data spaces do work and do not create additional problems.

- **Limited availability of technical data space solutions** which facilitates the onboarding in a data space. The existing technology seems to lack usability and is difficult to deploy. Also, the completeness of functionality seems to be below the expected level.

This viewpoint could be seen as related to the 5th challenge for adoption of section 4.1.

- **Significant investments in data preparation are often required before sharing**, to ensure compliance with quality standards and regulatory requirements in each data space. Organisations with strong data governance are better positioned to meet these demands. Participants also need assurance that these investments will deliver reliable returns within the data space.

This viewpoint could be seen as related to the 5th challenge for adoption of section 4.1.

- **Lack of alignment in initiatives and standards** to favor the availability and **interoperability** of data. The multiplicity of approaches, technologies and standards does not help in making the data spaces interoperable, either between participants or across data spaces from various domains.
- **Cost of participation** since most of the data spaces require a participation fee to support the provisioning and maintenance of the data space. This relates to perceived difficulties in finding the right business case, value proposition and ultimately to calculate the RoI that will justify the investment and onboarding in a data space.
- **The digital maturity and organisational capacity** of the organisations willing to participate. Not all the organisations are ready to join a data space, so they need help to understand where they are and get support to be ready.

This viewpoint could be seen as related to the 5th challenge for adoption of section 4.1.

- **Unclear impact of legal framework.** The regulatory burden reduction might not be so clear to all.

This viewpoint could be seen as related to the 4th challenge for adoption of section 4.1.

Additionally, the interviewed and consulted organisations have expressed which elements would act as concrete **incentives** and would lower participation hesitation. More specifically:

- Trusted, qualified and secured access to data sources required for their business as usual. In some cases, the value is getting richer datasets than they used to have.
- Ensure compliance with existing regulations.
- Collaboration with other participants, sometimes customers of their business, in a better position.
- Cost efficiency.
- Gaining competitive advantage by providing better services with higher quality data.
- Join forces in a sector to address sectoral challenges.
- Acceleration of use cases, which in isolation with no data sharing would take longer and more difficult resolution.
- Find alternative ways of remuneration (tokens, data shared for other data, access to outcomes of data usage,…).
- Avoid vendor lock-ins than in platform economy.
- Adhere to European values, especially on trusted data transactions and data sovereignty.

The interviewed stakeholders were also requested to provide their recommendations to increase the adoption of data spaces. The collected recommendations are integrated in the recommendations of section 6.

4.3 Emerging solutions to facilitate adoption

Despite growing interest and investment in data ecosystems, the adoption of data spaces continues to face substantial hurdles. As outlined in Section 4.1 and 4.2, these challenges include among others: lack of awareness and the steep learning curve for new participants, investments in data preparation, alignment and interoperability gaps, etc. Emerging capabilities and solutions offer transformative potential to address these barriers at scale. The latest advancements in Generative AI - particularly Large Language Models (LLMs) - are offering a potential to facilitate adoption in data spaces.

Interoperability (in its many dimensions) remains one of the most persistent and technically demanding issues to be addressed in data space implementation. From a technical perspective, even when participants conform to common standards, they often rely on divergent data schemas, terminologies and conceptual models that reflect their unique sectoral or organisational contexts.

Traditional solutions - such as semantic standards, ontologies, and manual mappings - have proven valuable but are limited in terms of scalability and agility. These methods:

- Require extensive manual alignment efforts,
- Are brittle in the face of evolving semantics, and
- Often fail to resolve heterogeneity across large-scale or cross-sectoral data spaces.

An **LLM-based Semantic Mediation Engine** can dramatically improve this situation. Fine-tuned on sector-specific vocabularies, ontologies, and usage patterns, such an engine can act as an adaptive translation layer. It dynamically maps terms, resolves semantic conflicts, and generates harmonised views across disparate datasets, without requiring hard-coded rules or one-off mappings. This approach allows:

- Real-time schema and terminology reconciliation,
- Context-aware data integration,
- Multilingual and multi-standard translation across data silos.

In effect, LLMs offer the potential to "learn" the semantics of the ecosystem and act as an autonomous semantic broker, enabling plug-and-play interoperability in a domain where plug-and-play has historically been a myth (see reality 5 of section 5.1).

Another major adoption barrier is the steep learning curve faced by new and even existing data space participants. Understanding the principles, governance models, architectural building blocks, legal frameworks, and technical interoperability requirements demands significant time and cognitive investment. Here, GenAI can serve as a scalable educator offering means for training and onboarding. A **data space Training Bot**, powered by an open-source LLM and fine-tuned on high-quality corpus material—such as documents from the Data Spaces Support Centre (DSSC), sector-specific data space initiatives, and related regulatory frameworks—can deliver:

- Interactive, personalised training for participants,
- On-demand explanations of complex topics (e.g., data sovereignty, trust frameworks, IDSA compliance),
- Conversational simulations to walk users through data space onboarding scenarios, governance setup, and semantic integration.

This capability turns training from a static, top-down process into a dynamic and user-centric experience. Faster comprehension accelerates participant readiness, lowers onboarding friction, and significantly improves adoption velocity—a critical factor in data space sustainability.

5   Case Studies from data sharing initiatives

Having outlined sustainability in data spaces in its multifaceted perspective and participant adoption as a key enabler of it (bringing prominently the participant perspective), it's now time to bring up concrete case studies from data sharing initiatives (including some of the common EU data spaces and beyond), illustrating how sustainability and adoption play out in practice. Section 5.1 presents a set of current realities in the ecosystem, that are embedding inline actual cases from data sharing initiatives, relevant for each specific reality. Section 5.2 zooms a little deeper into the participant adoption theme and offers a typology of data space adoption based on adoption characteristics with 4 examples from sectoral initiatives.

5.1   Current realities for sustainability and adoption

1st Reality: Public or government-led institutional arrangements and funding supporting data spaces to survive the "valley of death" period.

Several common European data spaces are already relying or considering their continuation connected to further public funding (e.g. in the form of a new EU-funded project/grant) or other public or government-led institutional instruments that will support the data space from both governance and financial perspectives. This is due to still little or no venture capital and private investor interest, a reality that is complicating the funding landscape for data spaces and highlights the importance of public support in sustaining data spaces during their initial years and in overcoming the "valley of death" period. The "valley of death" is a well-known economic metaphor - also explained in the examined "Business perspective of inspiring data space examples" DSSC paper, summarised under section 2 - that describes the critical period that a new venture exhausts its initial funding but revenues from network effects still haven't kicked in to allow it to be self-sustained.

The European Digital Infrastructure Consortia (EDIC)[30] is considered an instrument that could ensure sustainability for a set of the common European data spaces. The EDICs are a new implementation mechanism for multi-country projects that have been inspired by the provisions on European Research Infrastructure Consortia (ERICs)[31], but differ from them in terms of focus: in fact, their principal realms of action are deployment and industry, not research as was the case for

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[30] https://ec.europa.eu/newsroom/lds/items/797960/en

[31] https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/our-digital-future/european-research-infrastructures/eric_en

ERICs. The main objective of EDICs is to provide a legal framework to invest in multi-country projects which, given their scale, cannot be set up effectively by single Member States. Therefore, EDICs will facilitate coordination of funding, and enable speedy establishment and flexible implementation of multi-country projects to create incentives for Member States, while ensuring common standards and interoperability.

What is worth noting is that a one-fits-all solution might not be applicable: While some of the common European data spaces are working on their sustainability plans and are considering specific supporting instruments, such as the EDICs, it might be that for multiple reasons (sector-specific characteristics, different stages of development) a uniform model might not work across all sectoral data spaces to support their sustainability.

The Common European Language Data Space (LDS)[32]

The European Language Data Space is one of the most mature and technically advanced data spaces. Active efforts are underway to ensure its long-term sustainability, with various options being explored to better integrate the LDS into the European ecosystem for language technologies. The socio-economic aspect of languages, both from cultural and technological angles need to be adequately addressed. Since the LDS is funded and operated under a European Commission (EC) procurement contract, the Commission currently oversees its governance. One of the scenarios for the future is to integrate LDS governance with ALT-EDIC (Alliance for Language Technologies-EDIC), which could take over its maintenance and operation. In this scenario, sustainability responsibility would move to the Assembly of Members.

Right now, the LDS focuses on a specific use case: allowing owners of large language data collections, such as media companies, public archives, and libraries, to offer datasets for sale or for free to organisations that need them, particularly AI companies developing large language models. The LDS functions as a digital marketplace, managing the entire transaction process, from preparing offers to data transfer, including licensing, policies, and contracts. Since LDS is designed to be managed and governed by a public entity, rather than a private, profit-driven company, developing a business model is not the current focus. It will be considered alongside future decisions about long-term governance.

European Genomic Data Infrastructure (GDI)[33]

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[32] https://language-data-space.ec.europa.eu/index_en

[33] https://gdi.onemilliongenomes.eu/

GDI - and subsequently The Genome-EDIC's unique position is that it is an infrastructure that bridges stakeholders across health care, life science research and innovation and due to the generic nature and scalability of the technical platform it has an enormous potential to be applied to many different needs. The key driver of the Genome-EDIC is to harvest the potential of genomic data, and build an infrastructure that can deliver on this goal specifically.

The main sustainability problem is scaling the infrastructure to match the needs of the users, considering also the width of the potential use cases. This is because: data management for genomic data & compute capacity for advanced genomic analysis is a huge cost driver; there is a dependency on national funding for hardware acquisition; operating on extremely sensitive data is a massive task at federated and national level; recruitment and retention of skilled people is extremely difficult and the user base is extremely broad. On a generic level the main risk is ending up in the "monolithic application syndrome". Not designing for interoperability - technically, organisationally and politically - is the single biggest threat to the long term sustainability of the Genome-EDIC. The Genome-EDIC has massive scaling challenges - but it also has massive application opportunities. It aims to accommodate several user communities across the ecosystem that could foster a continuous accumulation of support and thus funding for its long term sustainability. One key challenge is that the Genome-EDIC bridges health care and research, and while the improvement of human health is the overarching goal - it is approached very differently (under different priorities, approaches to the TRL, etc..). Good governance is also required for the Genome-EDIC to fulfil its mission. Some dependencies require a constructive relationship to be built: between health care and research stakeholders and between member countries and the EC. In terms of business model, the infrastructure as a service model is considered. This would require that it can scale with differing needs in mind, with differing funding regimes and timelines. Some indicative applications that the infrastructure could accommodate are: a) national EHDS integration, b) clinical analytical platform for diagnostics and quality management, c) data analytics platform for public health and disease control, d) scalable, secure and flexible European level federated processing platform for clinical research.

2nd Reality: Exploring participation and revenue strategies for reaching financial sustainability

Several common European data spaces are already considering revenue & pricing strategies (freemium models, based on organisation size, etc.) and approaches to foster participant adoption,

considering sector-specific challenges and practicalities. The aim is to attract an increased volume of adopters - key sectorial stakeholders that could act as front-runners of adoption and explore the benefits of joining data spaces.

Common European Agricultural Data Space (CEADS)[34]

CEADS is a major initiative funded under the EU's DEP, aiming to operationalize a secure and trusted data-sharing infrastructure for the agri-food sector. Digital readiness of target stakeholders of CEADS varies tremendously, but is typically low to medium. Adoption of the data space is of high complexity due to sector fragmentation, low digital maturity in some user groups, competitive concerns, and lack of harmonized standards.

Building on the foundations laid by the AgriDataSpace project[35], CEADS brings together a diverse set of actors—farmers, SMEs, tech firms, cooperatives, public bodies—to co-develop the data space through a lean, multi-actor approach based on three Minimum Viable Product (MVP) cycles. These cycles guide the progressive integration, testing, and refinement of CEADS, ultimately concluding with a roadmap and sustainability plan.

From a financial sustainability perspective, CEADS proposes a freemium approach — offering basic services for free while monetizing advanced tools. CEADS also plans to create a business playbook to guide Data Intermediation Service Providers (DISPs) in adopting sustainable practices aligned with the broader CEADS framework. Importantly, the project draws lessons from successful regional initiatives like DjustConnect and Agronod, while exploring long-term governance through a Network Administrative Organisation and taking into account the creation of a European Digital Infrastructure Consortium (EDIC AGRI-FOOD).

On the adoption front, CEADS is taking deliberate steps to foster wide and inclusive participation, with over 350 data initiatives identified and mapped. By engaging actors across all levels the project aims to build trust, demonstrate value, and bridge the digital divide in agriculture. Special attention is being paid to involving stakeholders previously left out and aligning CEADS with national digital strategies. The ultimate goal is to establish a resilient, innovation-driven ecosystem that supports equitable growth, enhances competitiveness, and ensures long-term viability for the European agri-food sector.

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[34] https://ceads.eu/

[35] https://agridataspace-csa.eu/

Trusted European Media Data Space (TEMS)[36]

TEMS aims to secure its sustainability by favouring adoption, covering its operational costs and being able to invest in technology to be relevant for the media sector, with services and use cases that keep up with innovation. For that, any costs for participating in the data space must be lower than the benefits, and consider the diversity of the sector: organisation's size (SMEs must be less charged than big, already established companies), nature of the organisation (special regimes for non-profit organisations, civil society media, etc.) and nature of the participation. Another main challenge to secure sustainability is to create incentives for early adopters, and a fair mechanism for them not to be penalized by higher investments.

TEMS will be operated by an independent governance authority, which is planned to be created in 2026. It is important to secure TEMS institutional stability in the long-term, attract members by allowing their representative and balance within the media sector, operate the data space, and establish collaboration with other data spaces. The sustainability of TEMS entity is currently being built and counts with the development of a diverse portfolio of revenue generation. The financial plan to be created in the following phases of the project includes a value proposition that creates new or added value for the various media sub-sectors.

3rd Reality: Challenges in scaling, adapting and proving value over time

Community discussions have highlighted that attracting and onboarding participants is as of today one of the most pressing challenges for most data spaces. The challenge is very connected to the ability of a data space to prove its value with compelling use cases that could justify investments for participants not only with short-term measurable benefits but also in the long run. This path is not quick nor easy: data spaces are long-term endeavours, typically requiring years for them to evolve and mature through iterative adaptations.

Iterative adaptations might be required in (not intended as an exhaustive list):

- use case developments (refinements of existing ones, publication of new ones),
- efficient approaches to build network effects and scale participation,
- revenue and pricing strategies that move from theory to practice. Data spaces are in a better position to evaluate the effectiveness of pricing models and start introducing fees to

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[36] https://tems-dataspace.eu/

data transactions only when they secure a critical mass of participants (or similarly a critical mass of data transactions).

This reality is fully aligned with the Co-Creation method, built by the DSSC, a method that provides a structured, step-by-step approach to help data space participants navigate these challenges, ensuring informed decision-making and efficient collaboration. The co-creation method already explains that data spaces should embrace change and adaptability in the long run. By fostering a culture of adaptability and responsiveness, change management ensures that data spaces can proactively address challenges, capitalise on emerging opportunities and optimise their processes to stay in sync with overarching development objectives.

A data space initiative that is not in the position to offer proof of value over time, is at risk that candidate participants could be hesitant to enter while the ones that are already onboarded could find it difficult to stay engaged and active. This is a major sustainability risk for any data space.

Learnings from Agdatahub[37]

Agdatahub is a French data sharing initiative that was launched in 2017. It aimed to build a sovereign agrifood data space in France, providing infrastructure for trusted data exchange between farmers, agritech companies, and public bodies. During its initial phase, it successfully set up the technical foundation and explored various business models. Despite strong public support initial investment over seven years, Agdatahub struggled to become financially self-sustaining without continued public funding. While it made technological progress, slow adoption and challenges in demonstrating early economic value limited its ability to scale profitably.

Agdatahub's experience highlights that building a sustainable and widely adopted data space is a long-term effort that can take a decade to mature. The process unfolds in three phases: an emergence phase to establish infrastructure and governance (first four years), a scale-up phase (years 4-8) to increase transactions and participation, and a full operational "run" phase after year eight. Contrary to common expectations, profitability cannot realistically be achieved within the initial years. While public funding in France is typically limited to the emergence phase, Agdatahub's experience demonstrates that public financial support is essential well into the scale-up period.

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[37] https://agdatahub.eu/en/

From a business model perspective, Agdatahub experimented with freemium models, transaction fees, and subscriptions, but these proved ineffective at the early stage when data flows are minimal. A telecom-style model, offering tiered access from basic (free) to premium services, has proven more flexible and scalable, accommodating both newcomers and heavy users. However, the most crucial factor for participation is early and tangible proof of value. Data providers and users need to see how their margins will improve - either through cost savings, increased revenue, or shared investments. Without this, uptake remains slow.

Adoption is further challenged in fragmented sectors, such as agriculture, where no single actor can enforce participation. Unlike centralized industries like automotive, which can rely on top-down mandates, fragmented sectors require a federated, bottom-up approach and strong public coordination. Agdatahub's advice is to frame data spaces as an alternative to dependence on primarily American platforms. Convincing stakeholders requires demonstrating both strategic importance and practical benefits, supported by continued public investment, interoperable technology, and a realistic roadmap that prioritizes usability over perfection.

4th Reality: Investing in compelling use cases in order to generate immediate value in the ecosystem and attract participants

Building upon insights gathered from past endeavors - including the AgDataHub case - and recommendations from publications of section 2, suggesting that data spaces should focus on finding their "killer app", some data spaces are concentrating efforts on use case development and data space offerings. The aim is to develop use cases that solve concrete business challenges (regulatory reporting, etc.), offering participants immediate value from participation and resolving any participation hesitancy from the beginning. In certain cases, the complexity at use case level is lifted by looking for simple scenarios that are operating on one-to-one and one-to-few basis.

The Data Space for a Sustainable Green Europe (SAGE)[38]
SAGE project will develop a federated, secure, and interoperable data space to support the European Green Deal, building directly upon the GDDS GREAT project[39] community and results. It integrates high-value datasets, establishes governance and trust frameworks, and demonstrates

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[38] https://www.greendealdata.eu/

[39] https://www.greatproject.eu/

10 pilot use cases to foster data-driven sustainability solutions across biodiversity, climate, circular economy, and pollution monitoring.

The GDDS must deal with a broad mix of open public data, research data, as well as restricted public data, private company data as well as personal data. Access needs vary from citizen access, public body access, company access and academic access which requires a mix of authentication and credentialing systems. Some of these systems have not reached an adequate level of maturity (e.g. eIDAS 2.0 is not yet available).

The pillars of SAGE' sustainability strategy are:

1. Encourage data provider participation by enabling "regulatory reporting" as a basic data exchange transaction. The participation of regulators (government agencies) establishes confidence and trust in the platform. This might be considered the "killer app" for SAGE, as well as sister DS where reporting requirements exist.

2. Formalize use cases with Data Sharing Groups (DSG), DSG governance structures, digital credentials for DSG participation. DSG credentials might be "minted" as a paid service, or with paid subscriptions. Eventually, when the technology supports more flexible credential systems (e.g. the EU's BusinessWallet), these SAGE-specific credentials can be replaced (when participants are ready for this) with more specific attributes that would help democratize sovereign data sharing.

3. SAGE will link DSG credentials to data products exposed to, or created within, the DSG. This creates club goods, and provides a mechanism for both free access to club goods to club members, and paid access for non-club members. SAGE will implement the systems to manage this - different access mechanisms will be expressed in ODRL, using standard vocabularies that SAGE hopes to compile, and accounting/payment systems will be integrated. This is more complex than simple data monetization - it is linked tightly to the form of access and use, as well as the credentials of the consumer (including DSG participation). While not an "app", this represents a key technical capability required to enable generation of value from data, value that can be shared in a controlled way with the right people.

4. In general, SAGE will make it easy and attractive for data provided at a basic level (e.g. regulatory reporting) to be shared more widely, from 1:1, to 1:few, to 1:many. For example service providers can offer data providers an aggregation service: "allow us to aggregate your data with similar data, and we will provide you with value added data products, such as benchmarking or recommendations". Offering value-added data products back to the data providers can be seen as a receipt of value.

5. Track and monitor DSGs/DSG participation, data sharing, value-added services offered and consumed, etc.

The governing body is to be determined. It is subject to revisions in DGA about data intermediation. There will also be non-legal governance bodies for each DSG. The business/financial model will split SAGE data space business model from that of each Data Sharing Group (each of which may have a different approach). Both layers are being developed as part of SAGE project.

Common European Data Space for Mobility - DeployEMDS[40]: A Deep-dive into Sofia's use case

The primary objective of Sofia's use case within the Common European Data Space for Mobility (deployEMDS) project is to alleviate congestion and traffic jams in Sofia by facilitating mobility data sharing and implementing journey planners that integrate public transport and green shared mobility options. This initiative aims to reduce traffic, thereby contributing to a better living environment for residents. Currently, the mobility data is fragmented across different departments and agencies. While a variety of shared mobility providers operate in the city, there is currently no infrastructure in place to report data on their usage to public authorities or to integrate shared mobility information. In addition, the lack of trust between the potential data space participant and data privacy and legacy concerns puts up barriers to data sharing. GATE acts as the implementation lead and data provider and may serve as the data intermediary, offering an aggregation service for shared mobility providers where direct onboarding onto the data space is not (yet) feasible. GATE is the sole data consumer, responsible for developing the journey planner app with Sofia Urban Mobility Centre (SUMC) and integrating the data. While there is interest from start-up companies in further data consumption, their potential roles or plans are not further specified. From a technical perspective, the lack of standardized data-sharing protocols and mature data space components and architectures hinders the local implementation of the use case, leading to inefficiencies and delays. Moreover, these limitations also impede seamless integration with other use cases within the common data space.

Strategic sustainability pillars	Details
Data Governance & Trust Building: Establish a reliable, privacy-respecting, and interoperable data sharing environment.	● Address fragmentation of mobility data by enabling secure, standardised sharing protocols. ● Promote trust through transparent data privacy policies, consent mechanisms, and clear roles for data providers and intermediaries (e.g. GATE).

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40 https://deployemds.eu/

	● Develop onboarding frameworks and aggregation models for shared mobility providers unable to directly integrate into the data space.
Green & Seamless Multimodal Mobility: Encourage sustainable travel by integrating green mobility options into a unified journey planner.	● Enable easy switching between public transport and low-emission shared mobility (e.g., bikes, e-scooters, EVs). ● Prioritise carbon-efficient routes and promote trip optimisation based on sustainability metrics. ● Support one-stop journey planning, booking, and (in future iterations) payment.
Innovation-Driven Ecosystem Development: Foster innovation and new business models through shared data and collaboration.	● Leverage the mobility data space to stimulate start-ups and SMEs in building new services. ● Create APIs, SDKs, and sandboxes to support experimentation and co-creation. ● Establish mechanisms for iterative feedback between developers, GATE, SUMC, and end-users.
Citizen-Centric Experience & Digital Inclusion: Ensure accessibility, usability, and benefit for all residents.	● Design the journey planner with an intuitive user interface that supports different user profiles and travel needs. ● Incorporate digital equity principles to ensure that underserved communities benefit equally from new mobility services. ● Continuously engage citizens and stakeholders in co-design and usability testing.

Business Model: The use case aims to develop a multimodal journey planner employing the vision and value proposition of a data space approach and involving all main mobility players of the city of Sofia to offer a seamless experience to users. The application will allow easy planning by combining multiple travel modes in the same trip based on real-time data shared through the common EMDS by all mobility providers, while optimising the carbon footprint of each trip. Booking all trip segments with different providers will require a user profile for an effortless user experience and enable a single payment method as a future direction for improving the journey planner. The availability of high-quality mobility data through the data space will facilitate the development of additional mobility services and business models beyond the multimodal journey planner. A financial plan is not in place.

5h Reality: Encountering foundational challenges threatening uptake: data quality, availability and usefulness of the data offerings in operating scenarios

Following the previous reality that delves into the "killer-app" paradigm, practical lesson-learnt from data exchange initiatives emphasize the need to focus on the data product and apply strong governance rules on data providers and services that are consumed at operational level. This need is already described in the DSSC Blueprint and its Data Space Offering building block in the form of a key element of the building block strategy: the development, maintenance and enforcement of the governance rules of the data space offering which will ultimately lead to increasing the data space participants' trust. This reality - trust issues in availability and quality of data - complements other trust-related governance and legal aspects (e.g. fear of misuse) elaborated in previous sections of the paper.

>20 years of experiences from Estonia's X-Road: Challenges in scaling data exchange

Estonia has been a global leader in digital government and business for more than two decades. One of the key pillars supporting the Estonian interconnected and distributed digital ecosystem is X-Road. X-road is an open-source software that provides unified and secure data exchange between organisations in a collaborative ecosystem. It streamlines data exchange processes, enhances security, and facilitates interoperability, enabling organisations to derive greater value from their data assets. X-Road is a centrally managed distributed data exchange layer between information systems that provides a standardized and secure way to produce and consume services. In Estonia, a secure data exchange platform that has been operational since 2001 and is by now delivering more than 270 million monthly requests in order to connect the data of more than 52000 organisations[41] from both the public and private sector. In total, the data exchange on X-Road is annually saving more than 2500 years of working time across its users.

While X-Road is not a data space (it is rather a technological component facilitating data exchange inside and between a number of data collaborations), there are a number of practical challenges and lessons-learnt of relevance for the wider data spaces community that Estonia has been tackling.

The main reasons why (sometimes) data sharing scenarios are not being implemented, even though the central technical platform is available and easy to use are:

1) **Data and metadata quality:** the most important reason for failing data sharing is data quality at large. While a data product might be initially interesting for reuse, a first look at the actual data might reveal that it is either incomplete or out of date, that the structure used is not compatible with the needs, or that the metadata (that is used to find the dataset

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[41] https://e-estonia.com/solutions/interoperability-services/x-road/#:~:text=52%20000,e%2Dservices%20available

of interest) is incomplete and doesn't provide an accurate view of the data itself. All of these issues can also negatively affect the attractiveness of a data space.

2) **Trust in (technical) availability of data and related services:** while trust as such is a very wide concept, the more specific consideration in the Estonian context is the trusted (technical) availability of data and related services. If a data provider is not willing or not capable of ensuring the continuous availability of their data, it is difficult for data users to make the decision of using the data, especially if the data is intended for the delivery of time- and business-critical services. A statement of "oops, our system crashed" is of little use if the result for the data user is the loss of client trust.

3) **Availability of support services and readiness to change:** the issues highlighted above are often made worse by the lack of support from the data provider. Simply put - if requests for clarification (for example on the content or structure of data) or change requests for data services are not met in a timely manner, there are less incentives for data users to engage in data exchange.

In addition to the aforementioned issues, the X-Road has been mapping additional "blockers" for data exchange which are connected to legislation and contractual aspects. These haven't been further elaborated as are often too specific to the Estonian legal landscape; are not occurring/cited as much as the issues above.

To summarise, on one hand the Estonian experience demonstrates that the key to successful long-term sustainable data collaborations is a good level of data management across its data providers. Further, we see that the focus of a data collaboration ecosystem, after its initial procedural and technical setup, shifts very quickly to the actual value and usefulness of the data provided.

6ᵗʰ Reality: Data spaces in direct competition with other data sharing paradigms

Data spaces have been an evolving paradigm that is fostering trustworthy and sovereign data sharing in important sectors of the economy. It naturally operates in direct competition with alternative existing data sharing practices, including commercial marketplaces, data sharing platforms or traditional 1-to-1 data sharing agreements (e.g. one-off licensing deals that have been reported between LLM-developing companies and large publishers or media companies). These approaches often offer quick, direct, and predictable revenue, with zero or very little onboarding costs. In some cases they also benefit from their long-established market position and by having advanced their operational capacity and procedures, thus lowering entry barriers for interested organisations in data sharing. As such, data spaces are often in front of overcoming well-established market/sector dynamics and become convincing in demonstrating their unique value proposition

and differentiator factors compared to other paradigms in order to attract participants - especially to those that are currently using other mechanisms for data sharing.

| 1st Reality |
| Public or government-led institutional arrangements and funding supporting data spaces to survive the "valley of death" period |

| 2nd Reality |
| Exploring participation and revenue strategies for reaching financial sustainability |

| 3rd Reality |
| Challenges in scaling, adapting and proving value over time |

| 4th Reality |
| Investing in compelling use cases in order to generate immediate value in the ecosystem and attract participants |

| 5th Reality |
| Encountering foundational challenges threatening uptake: data quality, availability and usefulness of the data offerings in operating scenarios |

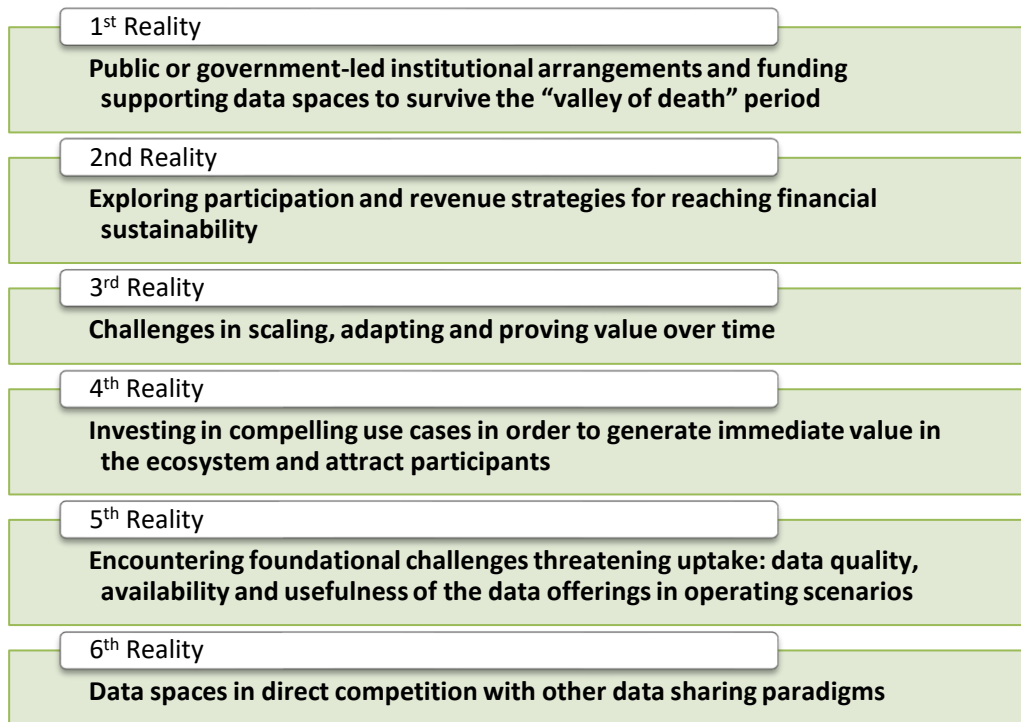| 6th Reality |
| Data spaces in direct competition with other data sharing paradigms |

Figure 2: Overview of the current realities in the ecosystem (some could be more inwards facing, some connected to the broader environment, while reality 3 brings up the time dimension).

5.2 Overview of adoption characteristics in various data spaces

The adoption of data spaces by relevant participants, data providers, consumers, and intermediaries, is both a prerequisite for and an indicator of long-term sustainability. However, motivating organisations to buy, share or sell data varies in complexity depending on several structural and contextual factors. Leveraging on practical knowledge and insights, this section develops a typology of data space adoption based on their adoption dynamics characteristics, illustrated through four officially mandated examples from data space initiatives. The simplicity or difficulty with which a data space attracts and retains participants depends highly on several interrelated criteria:

- Homogeneity vs. heterogeneity of the participant group

- Scope: regional vs. pan-European or global

- Sector focus: single-industry vs. cross-sector

- User base size: some dozens vs. unlimited

- User base characteristics: fixed/known vs. open/scalable

- Language needs: monolingual vs. multilingual

- Technical maturity and onboarding usability: mature vs. immature infrastructure of data space

- Digital readiness of target stakeholders: tech-savvy users vs. technically inexperienced user base

- Specified legal, governance, and trust frameworks vs. unclear governance model

The adoption dynamics of European data spaces are significantly influenced by their scope, sectoral alignment, governance maturity, and diversity of participants. This section compares four data spaces, each exemplifying different adoption patterns:

Mobility Data Space (Mobility DS)

- **Mandate:** Formerly financed by German Federal Ministry for Digital and Transport (BMDV) and still receiving partial federal funding, established a GmbH (not gGMBH - though non-profit is included in its 'Article of incorporation')
- **Scope:** National as well as EU (Germany and cross-border)
- **Sector:** Mobility but also cross-sectoral (e.g. weather/Geodata etc.)
- **Participants:** Primarily large industry players, infrastructure operators, and public organisations and institutions
- **Language:** Both German and English
- **Governance:** Managed by DRM Datenraum Mobilität GmbH, with non-profit in its 'Article of Incorporation' and 'acatech' as a majority shareholder working as a neutral intermediary
- **Technical Maturity:** High (operational infrastructure in place), with coordinated onboarding
- **Digital readiness of target stakeholders:** High

Adoption Moderate adoption complexity although not homogeneous participant group (from insurance companies to OEMs to Federal states among others- a lot of multistakeholder management is required). Its user base is not necessarily fixed and the ecosystem is open to all

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(all can join but need to sign membership contracts to ensure good governance). In terms of data harmonisation the Mobility Data Space follows the aim of interoperability and all widely adopted standard to ensure this.

European Language Data Space (LDS)

- **Mandate:** Procurement activity, funded by the European Commission under the Digital Europe Programme
- **Scope:** Pan-European
- **Sector:** Cross-sectoral (language data from various sectors like media, publishing, culture, public administration, can be any sector using or generating language data)
- **Participants:** Highly diverse; language data holders (media companies, public archives, public authorities, broadcasters, universities, industry), data consumers (NLP companies, AI developers); large companies, SMEs, public administration
- **Language:** Fully multilingual by default; goal is to collect data, covering all EU languages and minority languages
- **Governance:** During runtime the EC, coordinated by a European consortium, after project period, ALT-EDIC or other body mandated by the EC to act as Governance body
- **Technical maturity:** High (operational infrastructure in place based on prior infrastructures) with coordinated onboarding
- **Digital readiness of target stakeholders:** High

Adoption High complexity due to the diversity of stakeholders, multilingual challenges, and the need to convince many smaller organisations to contribute valuable speech and language data.

The European Language Data Space (LDS) is inherently multilingual and pan-European, targeting diverse stakeholders across sectors—from media archives to AI developers. While technical maturity and digital readiness are high, adoption remains complex due to stakeholder heterogeneity, linguistic diversity, and the need to convince smaller organisations to share valuable data.

Common European Agricultural Data Space (CEADS)

- **Mandate:** Grant, funded by the European Commission under the Digital Europe Programme
- **Scope:** European, with global connections (e.g., food traceability)
- **Sector:** Cross-sectoral (agriculture, agri-tech, logistics, retail)
- **Participants:** Highly diverse, including farmers, SMEs, cooperatives, processors, tech companies
- **Language:** Multilingual
- **Governance:** Federated governance structure across a broad set of data sharing initiatives is planned.
- **Technical maturity:** Relatively good technical foundations.
- **Digital readiness of target stakeholders:** Varies a lot between types of participants and other stakeholders..

Adoption High complexity due to sector fragmentation, low digital maturity in some user groups, competitive concerns, and lack of harmonized standards.

CEADS spans multiple sectors but faces additional adoption challenges. Although it builds on existing infrastructures, many potential participants, especially small farmers and cooperatives, show low digital readiness. Fragmentation and a lack of common standards further increase adoption complexity.

Trusted European Media Data Space (TEMS)

- **Mandate:** EU-funded Grant under the Digital Europe Programme
- **Scope:** Pan-European (with national-level implementation nodes planned)
- **Sector:** Media, journalism, audiovisual (several, related verticals)
- **Participants:** Broad but defined range — media companies, content creating entities, tech platforms, regulatory bodies (B2B only)
- **Language:** Multilingual
- **Governance:** Independent legal entity planned for next year. Rules for participation, templates to facilitate the negotiation for data offers, policy library and editor, enforcement mechanisms will be provided. Details are currently under discussion.
- **Technical maturity:** Medium; Early implementation phase with minimum viable data spaces in place and trials that have been adopting some of the technologies; focus on

building trust and ethical data sharing; Several links to important tech themes, such as data spaces and AI and provenance of data/content.

- **Digital readiness of target stakeholders:** Medium, highly mixed; low technical readiness in parts of the sector, as opposed to highly tech-savvy and parties who are very invested in tooling and data sharing.

Adoption: Medium to high, main challenges being: Legal sensitivities (e.g., copyright, editorial data), resistance to data sharing in competitive environments.

The Trusted European Media Data Space (TEMS) targets the media sector at a pan-European level. Despite some technical progress and defined use cases, adoption complexity is medium to high due to legal sensitivities, competitive reluctance to share data, and uneven technical maturity across participants.

The following matrix is summarizing the findings of this assessment.

Table 1: Summary table of adoption characteristics in various data spaces

Data Space	Scope	Sector	Participant Diversity	Language Complexity	Governance Maturity	Technical Maturity	Digital Readiness	Adoption Complexity
Mobility DS	National - European	Single vertical but also cross-sectoral	Low	Low	Established	High	High	Medium
LDS	Pan-European	Cross-sectoral	High	High	Defined options; Transition to be expected	High	High	High
CEADS	European-global	Cross-sectoral	High	Medium	Developing	Medium	Low to Medium	High
TEMS	Pan-European	Diverse but sector-specific	Medium	High	Emerging	Medium	Medium	Medium to High

Across all cases, participant diversity and digital readiness emerge as key determinants of adoption challenges. The more fragmented and heterogeneous the ecosystem, the higher the complexity in achieving sustainable participation.

6 Recommendations

Following the activities that led to the production of this paper, a set of recommendations has been elicited. The recommendations target different target audiences, while referring to both the key themes of the paper: sustainability and participant adoption in data spaces.

Recommendations mainly for data spaces:

Recommendation 1	
Title	**Enable "test-before-invest" participation**
Description	Data spaces can accelerate adoption by offering demonstration, experimentation, technical and business facilitation capabilities. Acting on this recommendation is critical for potential participants to "test before invest", reach an adequate level of data and digital maturity (technical, legal, business) and build confidence in the benefits that are offered by the data space paradigm. It will ultimately allow candidate data space participants to evaluate the ROI for joining a data space in a risk-free way. To realise this recommendation, data spaces could offer these technical and business facilitation capabilities (testbed, sandbox, etc.) and additionally involve free trial periods allowing for testing & experimentation in data sharing scenarios, training packages (ranging from beginners training to more advanced hands-on technical training) and well-documented real-life examples and success stories that could play a powerful role in demonstrating impact. By showcasing how data sharing leads to innovation, efficiency, or societal value, data spaces could attract new participants and reinforce commitment/retention among existing participants.
Target audience	Mainly data spaces, but also relevant for policy makers (indirectly)
Target theme	Participant adoption

Recommendation 2	
Title	**Offer tailored onboarding support**
Description	Data spaces must acknowledge that stakeholder groups vary widely in their

	needs and capacities. Data spaces can benefit from offering customised (business) onboarding packages to support participants during their initial days in the data space. Early-stage onboarding support can lower barriers to enter and accelerate the time needed for participants to begin deriving value from the data space. Participants could benefit from tailored onboarding - according to their distinct needs and capacities - and structured guidance in getting further acquainted with business or administrative elements (e.g. value propositions, data space offerings and use cases, pricing, terms and conditions). By acting on this recommendation, data spaces would increase their user-centric logic and ultimately participation accessibility by being able to support organisations with limited capacity. Additionally, it would create favourable conditions for participants to be well-engaged and to commit further resources to the data space (as benefits could be quickly visible) in order to get the most out of their involvement.
Target audience	Data spaces
Target theme	Participant adoption

Recommendation 3	
Title	**Continuously enhance data space value proposition** in order to motivate participants and scale
Description	Participation reluctance could be decreased if data spaces could provide additional gains and value propositions to their participants through services or compelling use cases. As such, some participants could see their participation in a data space under a more favourable lens if the data space operator (or an intermediary) provides additional services or features which create value to their business (e.g. AI models as a service for simulation and predictions from shared data, more user-friendly and less time-consuming interfaces, tools that help data providers verify the quality of their data, create and publish detailed metadata descriptions or tools that help evaluate a dataset format/structure against set standards). The provision and expansion with a "killer-app" use case could be also considered under this recommendation (e.g. compliance/regulatory reporting - as a response to the legal/regulatory uncertainty challenge - to government agencies, or a use case scenario that works well and exhibits transactions within a data sharing platform model and replicating it in data spaces).

Target audience	Data spaces
Target theme	Participant adoption and sustainability (indirectly as a participation drives revenues)

Recommendation 4	
Title	**Form partnerships with legacy systems**
Description	Many data spaces emerge from existing infrastructures or from legacy systems at organisations which support the daily operations for their customers and users (i.e. smart city platforms where cities are aggregating data from their providers, sensors, citizens and sharing it with other providers to provision a city service). Whether or not this is always the case, data spaces could seek for support from legacy systems, be synergetic with existing platforms or integrate as a plugin to specific existing customer bases of widely used ERP providers. Such strategic collaborations will allow for data spaces to reach greater participant numbers in a batch-way, thus, accelerating adoption in an efficient manner.
Target audience	Data spaces
Target theme	Participant adoption and sustainability

Recommendation 5	
Title	**Integrate with the broader European innovation ecosystem**
Description	Very connected to the previous recommendation, Data spaces should be properly embedded within the broader European innovation ecosystem (including IoT, edge, cloud, HPC, and AI, along with data providers, infrastructure providers, service providers, end users, and AI practitioners). Without such integrations at Pan-European scale, data spaces are unlikely to function effectively or scale successfully. This interplay also introduces an additional challenge and consequently a very relevant recommendation: data spaces should keep pace with the rapid evolution of these existing (and emerging) ecosystems.
Target audience	Mainly data Spaces but also relevant for the DSSC and policy makers

Target theme	Sustainability

Recommendation 6	
Title	**Explore diversified and novel funding models** for ensuring long-term financial sustainability
Description	Data spaces can benefit from exploring co-investment and other (innovative) funding models to decrease their reliance on public funding, even if this has been proven crucial in their early stages. In this context, private capital and further entrepreneurial involvement could be encouraged for a more balanced investment mix. Novel funding models could be also explored and piloted by data spaces. For example, an outcome-based funding model, could offer the means to resolve the investment risk taken by those organisations involved in the development stages of a data space (where no revenues are generated) and tie this with revenue sharing mechanisms which are applied during the scaling and operational stages of a data space.
Target audience	Mainly data spaces but also relevant for policy makers
Target theme	Sustainability

Recommendation 7	
Title	**Incorporate the foundations for building sustainable revenues early in data space design**
Description	This recommendation is well aligned with guidelines that are already in the Data Space Blueprint (Business model and use case development building blocks) and involves identifying and calculating aspects like the participant perceived value, cost of operations for the data space and revenue triggers and models. As a starting point, data spaces could benefit from identifying and refining use case scenarios that are grounded on concrete, real-world, value-adding business scenarios. Prioritising the implementation of these (especially in the beginning) over more novel - or untested in terms of real value for the ecosystem - use cases, can reduce the level of uncertainty and hesitation among participants - which in any case might already exist due to data/digital maturity and other tech requirements (this part of the

	recommendation is very connected to the 3rd recommendation of this paper). Next to this, cost calculation at data space level is another important element that needs to be well reflected - and also added in the data space business model. Data spaces should carefully calculate ongoing costs of the data space and the costs of the ecosystem itself as any other operating business. Finally, data spaces are advised to calculate transactions that could potentially trigger revenues. With a clear view on the above points: generated value, the costs and the data transactions that could trigger revenues, the data space could be in a better position to identify the most appropriate revenue models for ensuring better viability.
Target audience	Mainly data spaces but also relevant for the DSSC
Target theme	Sustainability

Recommendations mainly for policy makers and the DSSC:

Recommendation 8	
Title	**Drive actions for raising awareness & incentivising participation in data spaces**
Description	Top-down interventions are needed for raising awareness & for supporting adoption in the data spaces program at large. Acting on this recommendation would be very important for data spaces that are committing a lot of resources on the first steps of the so-called lead generation funnel. Efforts related to raising awareness on data spaces (as a concept) and the benefits for participating are often handled individually by sectoral data spaces. Considering that these initiatives might be ending soon and their sustainability might be uncertain, it would be beneficial if there were top-down interventions (from policy makers at EU but also member state level) that could demonstrate effectively the benefits of participation to the broader community - moving beyond the organisations that are in the close proximity of EU initiatives. These interventions could be accompanied by concrete incentives for participation for SMEs and startups which would accelerate adoption and enable sectoral data spaces to focus more on value creation tasks and activities rather than basic community outreach.
Target audience	EC and policy makers (at EU and member state level)

Target theme	Participant adoption & sustainability

Recommendation 9	
Title	**Continue fostering a rich ecosystem of dynamic, interoperable & interconnected data space solutions**
Description	This recommendation links the notions of scalability and sustainability in data spaces with the ecosystem of solutions that is supporting them. Data space solutions should bring up elements that are fostering interoperability across different data spaces, ease of use (also considering any legal or organisational barriers, accessing data from different data spaces), openness and are operationally and technically mature, etc. This would allow broader participation in data spaces, even of smaller or digitally immature participants and improve trust and the overall user experience. Exhibiting continuous progress on standardisation activities and connection with open-source solutions connected to data spaces and Simpl[42] is also very relevant to this recommendation. Getting inspiration from how - global soft infrastructures have evolved and financed over time - like the internet or GSM - might be beneficial.
Target audience	Mainly the DSSC, policy makers, but relevant also for data spaces.
Target theme	Participant adoption and sustainability

Building upon and **synthesizing on the previous recommendations that are connected to the theme of participant adoption only**, it becomes evident that to ensure long-term adoption and retention of users in data spaces a multi-dimensional approach must be applied. Essential components of a sustainable adoption strategy are building trustworthiness, reduced complexity and a clear added value for users. This would include the following:

- To be successful, **data spaces must acknowledge that stakeholder groups vary widely in their needs and capacities**. Onboarding processes, tools, and communication strategies should be segmented to address the specific contexts of different user groups,

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[42] https://simpl-programme.ec.europa.eu/

like SMEs, large enterprises, public sector bodies, or research institutions. Customised onboarding increases accessibility and reduces barriers to entry.

- Clear and transparent governance frameworks are fundamental to building participant confidence. Clearly defined roles, responsibilities, rights, and decision-making procedures foster trust and reduce perceptions of risk. It also facilitates conflict resolution and long-term accountability within the ecosystem.

- Support for potential target groups on legal regulations like GDPR, the EU Data Act but also sector-specific legislation lowers the barriers to engage with data spaces a lot. Discussions with stakeholders have shown that levels of insecurity are very high, even for larger companies. Legal templates and guidance help reduce uncertainty and smoother onboarding, particularly for participants lacking in-house legal expertise. Many stakeholders, especially smaller organisations, require support to engage meaningfully in data spaces. Training, outreach campaigns or support hubs can help improve digital readiness and technical integration. Especially in sectors where technological savviness is low, this will raise adoption significantly.

- Participant motivation increases when the benefits of engagement are clear and immediate (financial benefits, speed, new information, etc.). This also includes easy to grasp pricing models. Pilot projects, well-documented use cases, and publicly shared success stories can play a powerful role in demonstrating impact. By showcasing how data sharing leads to innovation, efficiency, or societal value, data spaces motivate new users and reinforce commitment among existing participants.

7   Conclusions

This discussion paper examines the topics of sustainability and participant adoption in data spaces. It is the outcome of a collaborative effort conducted under the DSSC and its SSF with the support of a large contributing team. The paper has been built by leveraging on bottom-up, practical, community experiences (including several common European data spaces, other initiatives and potential data space participants) and on existing relevant publications with the ultimate ambition to highlight the current realities, pressing challenges, concerns and recommendations over the paper's main themes. As this document reflects community opinions, some of the statements might not entirely reflect the actual state of play of developments. The presented insights are still of very high value for DSSC and the community to learn where communication and education are needed to support the learning process and thus help the adoption of fundamental data space concepts and standards.

During the production of the paper, it became evident that creating a paper on the interplay between sustainability and participant adoption in data spaces could be quite challenging. This was due to two main reasons:

- The key themes of the paper are by nature multifaceted and the community uses various terms for expressing these. Sustainability in data spaces could be approached from multiple perspectives: technical, organisational, financial, environmental, infrastructure, ecosystem, etc. while the "adoption" term is often used for expressing participant attraction, onboarding, retention, engagement or scaling.
- The paper needed to cater for and build a compelling narrative arc around elements that are generic (sustainability) vs more specific (participant adoption), theoretical vs practical or top-down (and reflect the data space viewpoint) vs bottom-up (and reflect the participant viewpoint).

The paper is structured in 8 sections. Following the executive summary, the reader is introduced to the motives, objectives, target audience and main sections of the paper. The paper then presents an overview of the brief exploration that was conducted on existing relevant literature. This offers a nice foundation upon which the rest of the paper unfolds. Sustainability in data spaces is presented under the lens of ecosystem, infrastructure and value. Participant adoption is linked as an important enabler for reaching (financial) sustainability and the unfiltered viewpoint of participants is prominently outlined, together with current practices, challenges/barriers and

incentives for participation. Case studies from the DSSC community on both sustainability and adoption are following and demonstrate the current realities in the ecosystem. The paper concludes with the following key recommendations:

Recommendations mainly for data spaces:

1. Enable "test-before-invest" participation
2. Offer tailored onboarding support
3. Continuously enhance data space value proposition
4. Form partnerships with legacy systems
5. Integrate with the broader European innovation ecosystem
6. Explore diversified and novel funding models
7. Incorporate the foundations for building sustainable revenues early in data space design

Recommendations mainly for policy makers and the DSSC:

8. Drive actions for raising awareness & incentivising participation in data spaces
9. Continue fostering a rich ecosystem of dynamic, interoperable & interconnected data space solutions

By implementing these recommendations, data space initiatives and their stakeholders, with support from the DSSC and policy makers, can foster participant adoption and build sustainable ecosystems that drive Europe's data economy forward. The DSSC and its community will continue to facilitate this journey, capturing lessons and encouraging synergies and knowledge sharing to ensure the long-term success of the European data spaces ecosystem.