CSBO SYTADEL : SYNCHROMODAL PROTOTYPE FOR DATA SHARING AND PLANNING

Task 4.4 Data space business model principles

June 14, 2025

CONTENT

Abstract

The logistics industry is undergoing significant transformations, with data sharing emerging as a critical enabler of collaboration and sustainable logistics practices. This deliverable presents the development and implementation of a taxonomy for business models of federated data spaces within the logistics sector, with a specific focus on synchromodal transport. The taxonomy serves as a structured framework to assess and design business models, and it has been applied to real-world use cases to identify concrete, stakeholder-specific business model configurations. This foundational study clarifies both the operational and economic implications of data spaces and demonstrates their practical relevance through the mapping of business models in defined logistics scenarios. Our findings highlight the potential of federated data spaces to drive collaboration, enhance value creation, and support innovation across diverse logistics stakeholders. By proposing viable business models grounded in actual implementations, this research contributes to the evolving discourse on digital logistics and underscores the role of data spaces in enabling more efficient, adaptive, and financially sustainable logistics systems.

1 Introduction

The connection between synchromodality and federated data spaces enhances dynamic and trustful data exchange mechanisms for optimal freight transport planning, the ability to anticipate and manage interruptions or delays during transport, and the efficiency of rerouting or changing transportation modes (Pulido et al., 2025). It also opens avenues for innovative business models that have implications for different actors: those who aim to establish a data space and those who want to determine whether they should enter an existing data space (D'Hauwers et al., 2022). Business models can leverage data relationships among actors in synchromodality by developing new services, optimizing resource utilization, and creating value for stakeholders.

An important building block within a data space is aligning a heterogeneous set of inter-organizational partners who interact for a focal value proposition to materialize (Adner, 2017). From a business perspective, existing knowledge about value creation for the involved actors in the data space is limited. According to the IEDS project (2023), which surveyed 219 German companies, the most significant economic barrier to data sharing was the unclear benefit of data exchange, cited by 68% of companies. Additionally, 59% acknowledged the absence of a suitable business model. Furthermore, a key challenge lies in aligning shared interests to develop business models. These models should prioritize strong governance, ensure seamless interoperability, and deliver value propositions for all participants. In this context, this deliverable seeks to address the following critical question:

- What is the business model taxonomy for a data space for synchromodality?

By addressing the abovementioned question, this deliverable explores the business model related to the synchromodal data space concept from the perspective of the different roles involved: data consumers, data providers, and data space orchestrators.

2 Business models landscape

A business model encompasses an organization's strategic framework to generate, deliver, and capture value in various social, economic, or other forms. In modern logistics, growing digitization and the significance of data sharing have influenced several business activities, resulting in new product and service offerings and creating new types of business relationships (Fan & Zhou, 2011; Rachinger et al., 2019). Data space could serve as a solution, but adoption concerns such as unclear benefits, unclear cost structure, and a lack of trust in the system have been recognized as significant obstacles (Hutterer & Krumay, 2024). These obstacles indicate that to drive the development of such innovations and digital transformation. It is necessary to investigate new business model opportunities (Prem, 2023; Strandhagen et al., 2017). A shared understanding is also required to help scale the innovation element of the sector, allowing different players to explore new business opportunities.

Extensive literature exists on business models for big data (Katrakazas et al., 2019; Kim et al., 2016), centralized platforms (Abrahamsson et al., 2003), multisided platforms (Hoch & Brad, 2021), decentralized business ecosystems (Lage et al., 2022; Radonjic-Simic & Pfisterer, 2019; Radonjic-Simic et al., 2017; Tumasjan & Beutel, 2019; Wang et al., 2019), and open data ecosystems (Immonen et al., 2014; Kitsios et al., 2017). While these studies provide valuable insights, a specific focus on business models for data spaces that facilitate freight transport—particularly in the context of synchromodal logistics—remains underexplored, presenting a clear research opportunity.

In this context, establishing a taxonomy that encompasses the various facets of business model development could be a fundamental step toward addressing this gap (Notteboom et al., 2017). Such a taxonomy would aim to identify the essential components of relevant business models and offer a structured framework for innovation (Möller et al., 2020). Although existing studies address taxonomies for big data (Hartmann et al., 2016), data-driven business models (Dehnert et al., 2021; Möller et al., 2020), and data ecosystems (Gelhaar et al., 2021), limited attention has been given to developing a taxonomy specifically tailored to data spaces supporting synchromodal transport. Advancing such a taxonomy could significantly enhance the development of business models in federated data spaces by enabling a comprehensive analysis of value creation, value delivery, value proposition, and the scope of data space (DS) revenue (Lüdeke-Freund et al., 2019). These components are crucial for aligning business models with the operational demands of synchromodal logistics and the broader goals of the logistics sector, including efficiency, sustainability, and innovation.

3 Designing the transport data spaces business taxonomy

Despite existing sector-specific initiatives like the Catena-X (2022) and the Federated Network of Information Exchange in Logistics (Fenix Network (2019)), current practices and literature lack discussion on implementing data spaces for broader business value. This gap extends to finding shared interests that would enable expansion and the creation of a unified business framework across sectors. As this field is still relatively new, there's an opportunity to bridge this gap by either expanding existing initiatives or fostering collaboration to develop shared interests. We developed a taxonomy encompassing various components and characteristics to describe business models for data spaces in the freight transport.

This analysis captures the characteristics of data spaces relevant to the logistics industry, integrating them within the broader landscape of digital business models in data ecosystems. The framework enables stakeholders to consider a wide range of components and characteristics when designing or analyzing business models derived from data spaces in freight transport. It aligns with traditional transport concepts, such as multimodality and intermodality, and newly developed concepts, such as synchromodality.

The development of the taxonomy comprises three main components, as illustrated in **Error! Reference source not found.**. The first component involves analyzing existing data spaces and the associated use cases in the logistics domain, as documented in the IDSA Radar. The second component is a literature review focused on business model taxonomies for data spaces. Given the early stage of this field, the review also incorporates relevant studies on data-driven and big data digital business models, such as those from the IEDS project (2023), Schweihoff et al. (2022), and Wiener et al. (2020), as well as digital logistics business models, including works by Mikl et al. (2021), and Möller et al. (2019; 2020). The third component is validating the taxonomy with stakeholders interested in the developments of the data space in the context of synchromodality.

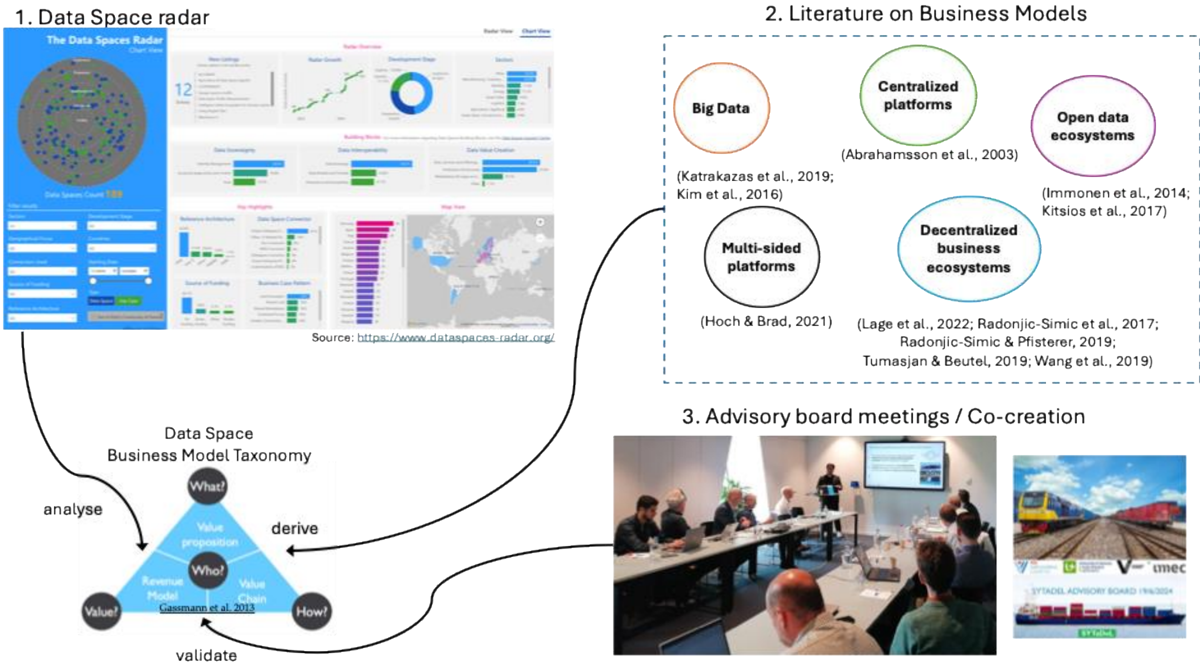

Figure 1. Taxonomy development steps

3.1 Data Space Business Model Meta-characteristics

Following the taxonomy-building process, we define the following meta-characteristics as the principal attributes from which all other relevant characteristics are derived, ensuring coherence and relevance within the taxonomy and the scope of the living labs. The aim is to distinguish potential business models for data spaces in the context of freight transport. Based on our analysis, we identify four foundational dimensions (Figure 2) that serve as base for the identification and structuring of general business models taxonomy (Figure 3).

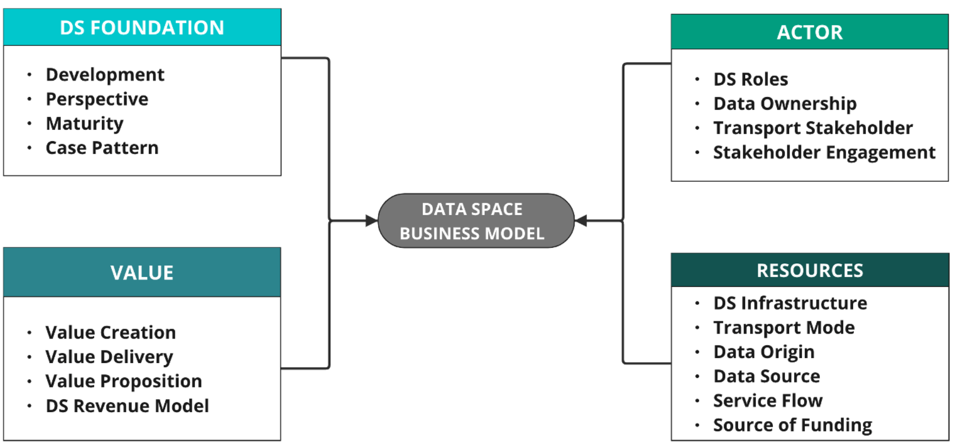

Figure 2. Data space business model dimensions

3.1.1 Data Space Foundation

The *DS Foundation* block is based on the underlying pillars described by the IDSA (2024) and outlines the structural and strategic context in which the data space operates. The **Development** dimension distinguishes between a full *Data Space*, which is a federated infrastructure for trusted data exchange, and a *Use Case*, which applies data-sharing principles to solve specific operational problems. The **Perspective** can be either *private*, *public*, or *mixed*, depending on the strategic goals and ownership of the data initiative. **Maturity** describes the stage of development, ranging from *Exploratory* to *Scaling*, reflecting how advanced the data space or use case is. The **Case Pattern** dimension classifies the purpose and participation model of the data space, from *Shared Cost* and *Joint Innovation* to more market-driven approaches like *Shared Marketplace* or Greater Community Good. These dimensions collectively help establish the foundational intent, maturity, and trajectory of the business model.

3.1.2 Actor

The *Actor* block focuses on the key participants and their roles in the data space, particularly within the freight transport domain. Business models for data ecosystems have implications for two types of actors: those aiming to establish a data space and those assessing whether to join an existing one. Depending on their role, these actors may provide or receive data or perform additional supporting functions (D'Hauwers et al., 2022).

The **DS Roles** dimension outlines various responsibilities such as *Service Provider*, *Data Trustee*, *App Store Provider*, *Ecosystem Orchestrator*, and *Marketplace Operator*, based on an analysis of 64 use cases from the IEDS project (2023). This classification offers deep insights into emerging data-driven business models and ecosystems. These roles are tightly interlinked with the **Data Ownership** dimension, which includes categories such as *Own Data*, *Derived Data with Uncertain Ownership*, and *Data Owned by Another Entity* (Schweihoff et al., 2022). The **Transport Stakeholder** dimension encompasses actors from traditional hinterland transport settings (e.g., *Shippers*, *Carriers*, *Infrastructure Managers*, *Logistics Service Providers*, *Authorities*), while also reflecting the complexity of synchromodal networks. In synchromodality, additional roles emerge, most notably the *Orchestrator* (Ceulemans et al., 2024) and entities involved in *software and technology provision* (Pulido et al., 2024). Lastly, **Stakeholder Engagement** captures the collaboration models used, such as *Data Sharing Agreements*, *Partnership Models*, and *Consortiums*, emphasizing the cooperative mechanisms needed to sustain value exchange across diverse actors.

3.1.3 Value

The *Value* block captures the essence of business models by representing the benefits and utility generated by data space applications. It reflects how value is created, delivered, and monetized across logistics stakeholders. **Value Creation** refers to the key processes and resources the data space enables (Mikl et al., 2021). In the logistics context, these include *secure and smooth data sharing*, *provider-consumer matching*, *process optimization and simulations*, and *(big) data analytics*. These characteristics were derived from the IDSA (2024) logistics data space database and are rooted in the core purpose of data spaces: to "enable the sovereign and self-determined exchange of data via a standardized connection across company boundaries" (Pettenpohl et al., 2022, p. 29).

Value Delivery addresses the mechanisms through which these propositions reach the participants. This includes *API and platform integration*, *shared digital twins*, *automation/event triggering*, *stakeholder training*, and *real-time visibility*. These delivery methods are essential to realizing the benefits of data sharing, especially in transport ecosystems driven by intermodal and synchromodal coordination.

Value Proposition defines what the data space offers its participants. These include services and outcomes such as *improved planning*, *risk mitigation*, *operational efficiency*, *collaboration*, and *transparency*. Such offerings often extend beyond service to include enriched *data assets* and decision-support capabilities, making them a core aspect of stakeholder engagement and adoption (Möller et al., 2019).

Finally, the **DS Revenue Model** outlines how digital infrastructure participation is monetized. Models include *subscription plans*, *pay-per-use*, *licensing*, and *customized pricing* structures. These approaches are grounded in business model literature (e.g., Möller et al., 2019) and align with emerging data space implementations (IDSA, 2024), ensuring financial sustainability and incentivizing long-term ecosystem participation.

3.1.4 Resources

The *Resources* block encompasses the tangible and intangible assets necessary to support the operation of a data space, offering the foundational elements that enable value creation and delivery for participants. A key component is the **DS Infrastructure**, which may take the form of a *Data Ecosystem*, a *Marketplace*, or a *hybrid* model. This infrastructure is not just technical but also conceptual, serving as the environment in which actors exchange data and derive value. At its core, data is the primary resource, and its relevance is strongly influenced by the actor's role. For example, the DS role of a *Transport Stakeholder* such as a *shipper* will vary significantly depending on whether they act as a *Data User*, *Data Provider*, or *Ecosystem Orchestrator* within the data space.

Data Origin, as proposed by Dehnert et al. (2021), classifies the source of data input as either *Internal*, originating from within the data space (or *External)* supplied by external Data Providers, irrespective of ownership. Complementing this, **Data Source** refers to whether data is *self-generated*, *existing*, *freely available*, *acquired*, or provided by a *customer or third party*. These distinctions are essential for designing appropriate access, sharing rights, and monetization models within the data space.

The **Service Flow** defines how services or data outputs are delivered. This can be *manually driven*, where users explicitly request services; based on *predefined time steps* for scheduled delivery; *event-driven*, where triggers activate specific services; or as a *data stream*, offering continuous, real-time availability of data or services. These modes determine both the technical setup and user experience, and they must align with the operational requirements of transport scenarios such as intermodal or synchromodal logistics.

Finally, the **Source of Funding** addresses how the data space initiative is financed—through *EU support*, *government funding*, *private investment*, or *other* means. This dimension not only supports the sustainability of the data space but also reflects the broader institutional and strategic alignment behind its development.

	Dimension	Characteristics								E/N	Approach
DS Foundation	*Development*	Data space	Use Case							E	IDSA (2024)
DS Foundation	*Perspective*	Private	Public	Mixed						N	European Commission (2020)
DS Foundation	*Maturity*	Exploratory	Preparatory	Implementation	Operational	Scaling				E	IDSA (2024)
DS Foundation	*Case Pattern*	Shared Cost	Joint Innovation	Shared Marketplace	Grater Community Good					N	IDSA (2024)
Actor	*DS Roles*	Service Provider	Data Trustee	Data-infrastructure provider	App-Store Provider	Data Provider	Data Consumer	Ecosystem Orchestrator	Marketplace Operator	N	IEDS project (2023)
Actor	*Data Ownership*	Own Data	Derived data, ownership uncertain	Data owned by another entity						E	Schweihoff et al. (2022)
Actor	*Transport Stakeholder*	Shipper	Carrier	Infrastructure Management	LSP	Authority	Terminal Operator	Orchestrator	Software and Technology	N	Ceulemans et al. (2024) Pulido et al. (2024)
Actor	*Stakeholder engagement*	Data Sharing Agreements	Partnership Models	Consortiums	Independent Operations					N	Allen et al. (2014) OECD (2017)
Value	*Value Creation*	Secure and smooth Data Sharing	SC. Real Time Visibility	Provider & Consumer Match/ Collaboration	Process Optimization/ Simulations	SC. Efficiency	SC. Responsiveness	(Big) Data Analytics/Enrichment		N	IDSA (2024) Logistics data spaces
Value	*Value Delivery*	API and platform integration	Shared Digital Twins	Automation/ Event Triggering	Stakeholders engagement / Training	Real-time visibility	Match / Collaboration hub	DS Service level agreements		N	Bastiaansen et al. (2020) Pulido et al. (2024) Möller et al. (2020)
Value	*Value Proposition*	Improved planning	Environmental & Cost benefits	Operational Efficiency	Risk & Disruption mitigation	Improved decision making	Collaboration & Transparency	Customer satisfaction	Regulatory Compliance	N	Schweihoff et al. (2022) Möller et al. (2020)
Value	*DS Revenue Model*	Fees	Pay-per-Use	Licensing	Commission	Subscription plan	Customized			N	Möller et al. (2019) IDSA (2024)
Resources	*DS Infrastructure*	Data Ecosystem	Marketplace	Hybrid						E	Schweihoff et al. (2022) IEDS project (2023)
Resources	*Transport Mode*	Truck	Rail	IWT	Deep Sea	Air				N	Möller et al. (2020)
Resources	*Data Origin*	Internal	External							N	Dehnert et al. (2021)
Resources	*Data Source*	Self-generated data	Existing data	Restricted data	Freely available	Customer or 3rd party data	Acquired data			N	Schweihoff et al. (2022)
Resources	*Service Flow*	Manually driven	Predefined time steps	Event/Auto driven	Data stream					N	Dehnert et al. (2021)
Resources	*Source of Funding*	EU	Government	Private	Other					N	IDSA (2024)

Figure 3. Morphological box of data spaces business model taxonomy.

4 Taxonomy application

4.1 Scope identification:

According to the description of the data space living labs, the objective of the developed data space is to implement core data space principles within the freight transport domain (e.g., Figure 4). As a critical first step, scope identification needs to be conducted to clearly define the application domain, the relevant stakeholders, and the types of data flows involved. This process establishes the functional and technical boundaries of the data space by identifying key logistics actors, such as shippers, barge operators, terminal operators, and infrastructure managers, and understanding their roles, interests, and interdependencies in the synchromodal transport chain. It also involves selecting the primary data types to be exchanged, such as real-time voyage data from inland barges, deep-sea shipping legs, cargo-specific attributes, the status of transit routes, and updates from terminals.

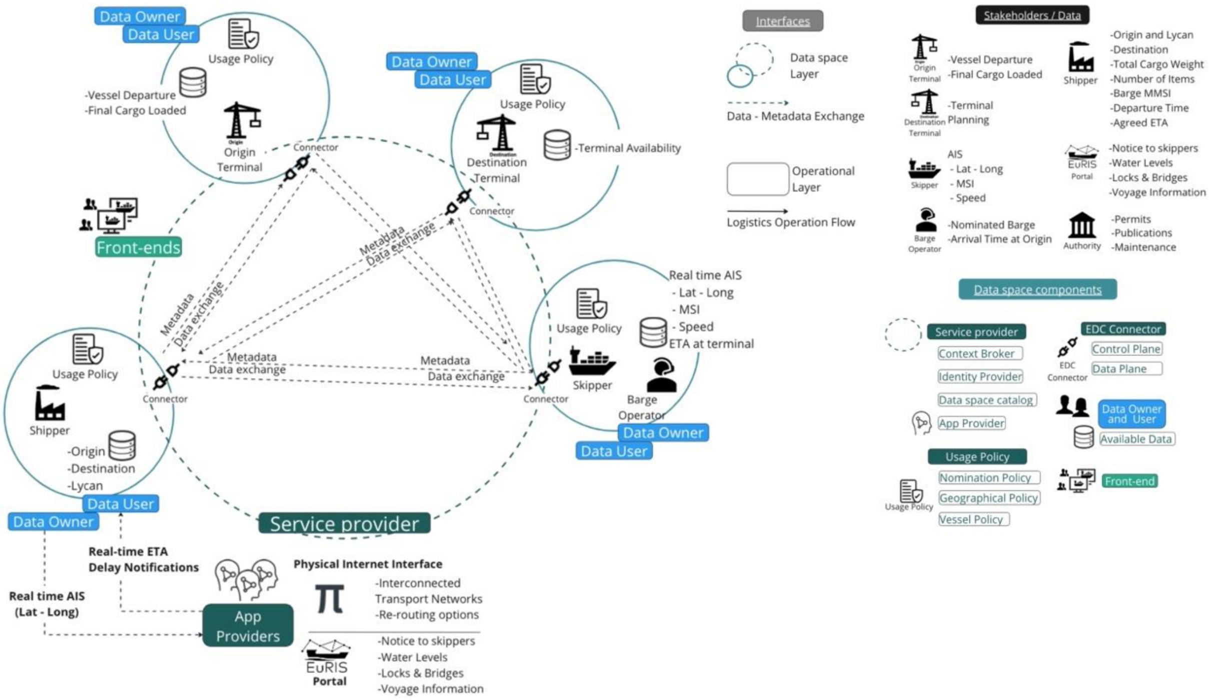

Figure 4. Synchromodal data space overview. Extracted from Pulido et al. (2025)

4.2 Taxonomy usage: Mapping a living lab on the business model taxonomy framework

The morphological box presented in Figure 5 captures the multidimensional aspects of the data space supporting the synchromodal transport system. Each subcategory within a given dimension is selected based on the stakeholder's role in the data space and the specific characteristics of the use case. The perspectives of primary stakeholders in this example are represented: the data space developer (indicated by a green dot labeled "1"), who represents the overarching interests of the data space; the shipper (orange dot labeled "2"), who faces logistics challenges due to limited visibility into transport execution; and the barge operator (blue dot labeled "3"), a company managing a significant fleet of barges across Europe.

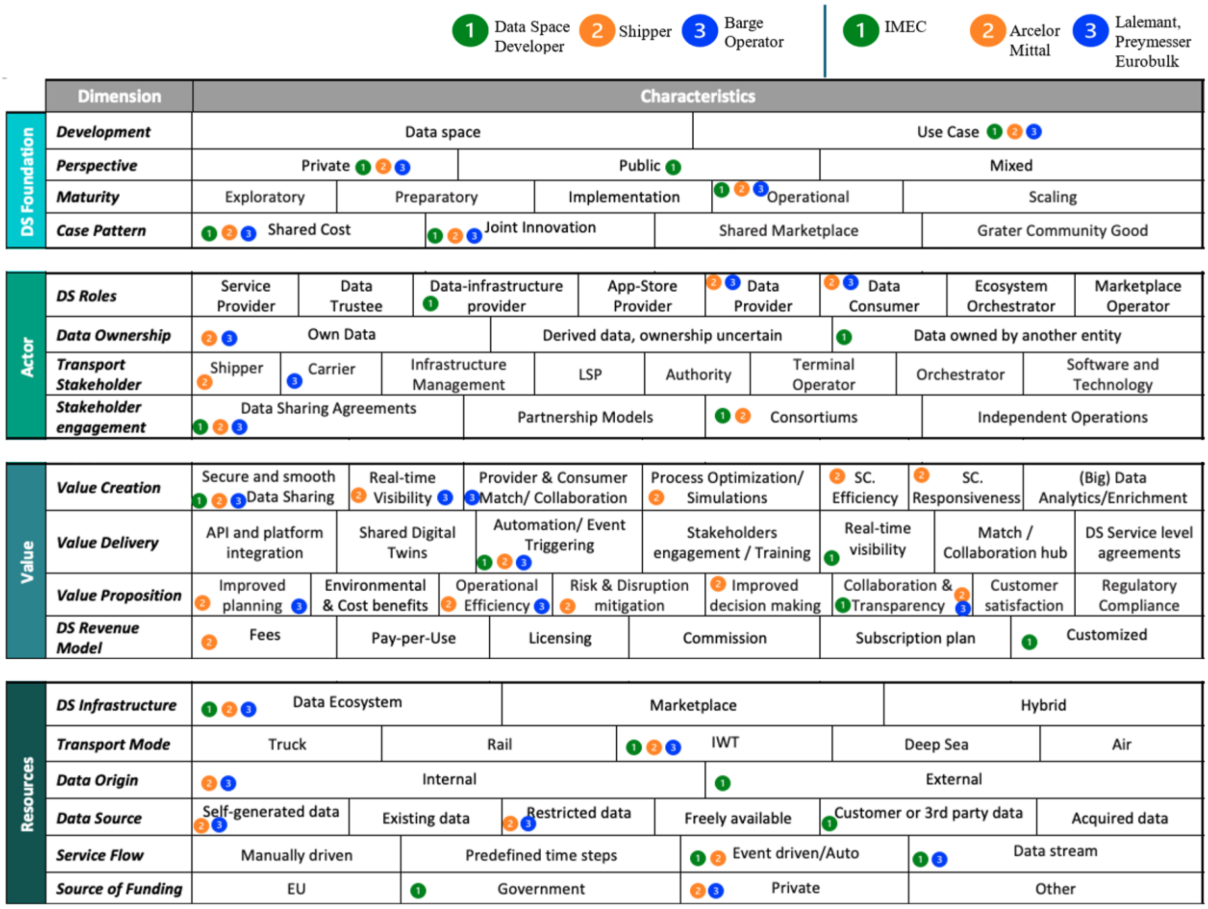

Figure 5. Case Study Mapping on Taxonomy Framework.

DS Foundation:

The maturity level of the initiative is at the **operational** stage, indicating that both the infrastructure and governance framework are actively in use, with data being exchanged and the use case delivering its intended benefits (IDSA, 2024). The **case pattern** is best described as a combination of **Joint Innovation** and **Shared Cost**. Joint Innovation reflects the collaborative nature of the initiative, where value can only be created through the collective effort of ecosystem participants—no single actor holds all the necessary data to innovate independently. Simultaneously, the Shared Cost model highlights the mutual benefits for stakeholders such as the data space developer and the shipper, who are motivated to exchange data to address common goals like improving process efficiency and enhancing transparency. This shared responsibility allows participants to reduce individual investment and operational burdens while maximizing collective gains (IDSA, 2024).

Actor:

The initiative focuses on the deployment of digital infrastructure, with the **data infrastructure provider** playing a central role in enabling data access and exchange. Applications, typically offered through an **App Store provider**, are crucial for accessing, processing, and visualizing data. In the context of a synchromodal data space, these applications facilitate incident monitoring within the inland navigation ecosystem and trigger event-based alerts when deviations from planned **ETAs** occur, thus enhancing cargo tracking and transport transparency.

Under the **Data Ownership** dimension, much of the data is categorized as *owned by another entity*, indicating a decentralized model where control and rights are assigned across stakeholders rather than held centrally by the developer. This structure reflects the role of the **Ecosystem Orchestrator**, who is responsible for enabling participation, aligning interests, and facilitating value co-creation among all actors involved (IEDS project, 2023).

Transport Stakeholders—such as *shippers* and *carriers*—often operate as both **Data Providers** and **Data Consumers**, contributing operational data while benefiting from enriched insights or services generated by the data space. This dual role underscores their active involvement in optimizing logistics performance and ensuring a responsive, data-driven transport system.

Value:

This dimension encompasses **value creation**, **value delivery**, and **value proposition** within the data space. The **data space developer** facilitates value creation by providing a secure environment for collaboration and networking, enabling data-driven services that form the core of its value proposition. This reflects a service model built on data analysis and actionable insights. For the **shipper**, the primary benefit is *real-time visibility*, which is essential for effectively tracking and managing shipments. The **barge operator**, on the other hand, benefits from *data-enriched services*, using shared data—such as integrating their operational data with the shipper's—to enhance the efficiency and reliability of their transport offerings.

The **DS Revenue Model** implemented by the data space developer is *customized*, allowing services and solutions to be tailored to the needs and data interests of individual participants. This personalized approach supports pricing based on delivered value, offering opportunities for premium revenue through differentiated services. In terms of **fees**, the shipper pays an *annual participation fee* that reflects their dual role as both a data provider and consumer, aligning financial contributions with the value they derive from the data space ecosystem.

Resources:

This section outlines how the **data space developer**, **shipper**, and **barge operator** utilize and contribute resources within a synchromodal transportation data space. All three stakeholders operate within a *Data Ecosystem*, supported by shared **DS Infrastructure** that enables secure and efficient data exchange. The **data space developer** primarily integrates *external data* to build the baseline services and functionality of the data space. In contrast, both the **shipper** and **barge operator** rely on *internal data* sourced from their logistics operations to contribute value to the ecosystem.

The **Service Flow** varies by stakeholder role. For the **data space developer** and **shipper**, it is *event-driven*, reflecting the need for timely responsiveness to situational changes inherent in synchromodal logistics. In contrast, the **barge operator** functions on a *data stream* model, continuously sharing real-time voyage and vessel status data. This ensures immediate updates and supports dynamic transport optimization based on live operational conditions.

Regarding the **Source of Funding**, the **data space developer** is publicly funded, with the initiative supported by government contributions. In contrast, both the **shipper** and **barge operator** are privately funded entities. The shipper, in particular, contributes financially through *annual participation fees*, reflecting its role as both a data provider and consumer within the data space.

5 Business model definition

Model 1 focuses on real-time matching of barge capacity with cargo demand, emphasizing secure data sharing and real-time barge visibility as core value creation mechanisms. Its value delivery lies in real-time notifications and rerouting, with a strong value proposition centered on operational efficiency, risk mitigation, and transparency. The revenue model is subscription-based, particularly targeting shippers, while offering low-cost access to barge operators to encourage adoption. This model benefits from simplicity and smooth data exchange but may face scalability and data quality consistency challenges.

Model 2, on the other hand, adopts a broader scope by connecting ocean and inland legs, enabling seamless end-to-end visibility. It creates value through a unified ETA platform integrating inputs from ocean carriers, terminals, and barge operators. Delivery is automated and predictive, supporting proactive terminal resource planning. Its value proposition lies in reducing delays and improving decision-making. This model uses a hybrid revenue approach combining subscriptions with commission-based analytics. Although it offers holistic visibility and reduced disruptions, the challenge lies in integrating diverse data sources and aligning standards across stakeholders.

Overall, both models demonstrate how the taxonomy supports structured analysis by revealing unique stakeholder needs, system capabilities, and revenue potential, while also highlighting key implementation challenges. The following table outlines potential business models derived from the mapping exercise based on the developed taxonomy:

Table 1. Business models baseline proposal for Living Lab 1 and 2.

	Model 1 Synchromodal Data Space	Model 2 Dual-Leg Visibility Connect
Primary Focus	- Real-time matching of barge capacity & cargo demand	- Seamless visibility across ocean and inland legs for inbound shipments
Value Creation	- Secure data sharing - Real-time barge visibility - Process optimization & simulations	- Single platform for ocean & inland barge ETA data - Collaboration between ocean carrier, barge operator, and terminal
Value Delivery	- Real-time voyage delay notification - Real-time rerouting options - Notifications of transshipments availability	- Automated updates if ocean vessel ETA changes - bridging to barge schedules - Triggers for terminal resource allocation
Value Proposition	- Improved planning & operational efficiency - Risk & disruption mitigation - Transparency & collaboration	- More accurate, end-to-end inbound visibility - Reduced layover & handling times - Better decision-making & lower risk
Revenue Mechanism	- Shipper subscriptions (plus premium analytics) - Barge operators free or low-cost subscription to encourage adoption	- Hybrid: Subscription for real-time multi-leg visibility - Commission fees for advanced scheduling or data-driven analytics
Key Advantages	- Straightforward revenue model (predictable subscriptions) - Smooth data exchange	- Holistic door-to-door approach bridging ocean and inland - Reduces overall lead times & disruptions - Encourages synergy among all participants
Potential Challenges	- Ensuring consistent data quality from all barge operators - Scaling to multiple shippers	- Integrating multiple data sources (ocean tracking, port data, barge ETA) - Aligning different carriers' schedules and data stan

6 Concluding discussion

The logistics sector requires a wide array of data-sharing collaborations, leading to diverse expectations for enabling infrastructures such as data spaces. While it is difficult to anticipate every possible use, service, or application of these infrastructures, well-designed data-sharing ecosystems have the potential to give rise to novel applications, products, and business models that are yet to be imagined (Bastiaansen et al., 2020).

Our research began by identifying the fundamental business model building blocks for a freight transport-focused data space, particularly in contexts like synchromodality, where data exchange is critical. This was followed by the development of a baseline taxonomy that highlights both the operational value of data spaces from the perspective of transport stakeholders and the potential sources of economic return to support the data space's sustainability.

Our contribution lies in synthesizing a data space business model taxonomy that, through the integration of its components, can support the development of innovative transport services not yet realized, despite the availability of key elements. The dimensions and characteristics identified within the taxonomy provide a practical starting point for the further advancement of digitally enabled transport solutions for synchromodal transport. These include functions such as provider-consumer matching, shared digital twins, process optimization, big data analytics and enrichment, real-time visibility, and smart contract management.

In conclusion, the business model analysis presented offers a structured and comprehensive framework for evaluating and refining data space initiatives, particularly within synchromodal logistics. By emphasizing value alignment, the framework ensures clarity around value creation, delivery, and proposition. The inclusion of an actionable checklist supports model validation and highlights gaps or improvement areas. Finally, the step-by-step evaluation approach enables a thorough analysis of revenue models, cost structures, and scalability, supporting strategic decision-making and the development of effective, sustainable business models for data spaces.

For practitioners and stakeholders in freight transport, our research offers a valuable framework for guiding the development of sustainable and financially viable data spaces. Organizations can benchmark their digitalization efforts, internal and external data-sharing practices, and data-driven initiatives against the defined building blocks, with particular emphasis on intermodal and synchromodal transport strategies. Crucially, developing revenue-generating mechanisms is essential, as long-term sustainability depends on the data space's ability to cover its operational costs. Future research should focus on the cost structures underlying these business models and analyze the financial dynamics across different transport stakeholders. Additionally, identifying current and emerging services enabled by data spaces, such as predictive analytics or dynamic routing and pricing, will help uncover new revenue opportunities.

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