Balance is Key—Insights on the Governance Design of Data Space-Based Ecosystems

Pauline Liebert
LMU Munich School of Management
pauline.liebert@lmu.de

Robin Oswald
LMU Munich School of Management
robin.oswald@campus.lmu.de

Thomas Hess
LMU Munich School of Management
thess@lmu.de

Abstract

Data space-based ecosystems (DSEs) rely on decentralized infrastructures and promote broad member participation to counteract the monopolistic tendencies of platform-based data ecosystems. While this approach enhances fairness for DSE members, it also creates complexity that poses a challenge for effective governance. In this study, we investigate how DSEs can design their governance to integrate these dual goals of fairness and effectiveness. Drawing on a case study of Catena-X, a DSE in the automotive sector, we adopt an exploratory qualitative approach to analyze DSE governance in depth. Our findings reveal four governance dimensions: structures, decisions, relations, and behavior. Across these dimensions, the two goals manifest in different design choices that need to be balanced with each other. This study contributes to the nascent literature on DSEs by providing a nuanced understanding of how they can incorporate both normative principles of fairness and operational aspects fostering effectiveness into their governance.

Keywords: Data space-based ecosystems, Governance, Fairness, Design choices, Catena-X.

1. Introduction

As data space-based ecosystems (DSEs) proliferate across domains and challenge the prevalent design of platform-based data ecosystems (Gawer, 2022), their goal to enable fair data sharing among members (Otto, 2022) introduces new complexities for their governance (Kari et al., 2025; Schurig et al., 2024). Currently, the most prominent example is Catena-X, a DSE that enables organizations to collaboratively share data along the entire automotive supply chain. Data spaces, as an alternative to centrally controlled platforms, provide a new foundation for trusted and secure data sharing among organizations (Beverungen et al., 2022; Möller et al., 2024). As decentralized data infrastructures, data spaces promise their members sovereignty by ensuring that data is only shared bi- or multilaterally via standardized connectors, and with the data provider retaining complete control (Möller et al., 2024; von Scherenberg et al., 2023). The ecosystems of organizational actors emerging around data spaces are characterized by openness and participation (Beverungen et al., 2022; Schurig et al., 2024).

Due to the difficulty of aligning the independent members, DSEs rely on a well-functioning governance design to enable collaborative value creation (Adner, 2017; Jacobides et al., 2018) and data sharing (Oliveira et al., 2019). Governance describes the central building blocks of an ecosystem and how they relate to each other (Tiwana et al., 2010). A variety of design choices thereby allows for tailoring the governance to specific requirements. If purposefully designed, governance can serve as a key lever for growing an ecosystem and achieving intended goals (Wareham et al., 2014).

Most literature on (data)ecosystems assumes that one focal actor, typically the platform owner, determines the governance (e.g., Iansiti & Levien, 2004; Lv & Schotter, 2024). While this has proven effective in ensuring strategic coherence and scalability (Adner, 2017; Foss et al., 2023), it has also led to the emergence of powerful platform owners exploiting their focal position to profit from strategic dependencies and (data) network effects (Gawer, 2022; Lv & Schotter, 2024). To counter these monopolistic tendencies, DSEs explicitly promote decentralization and member participation (Möller et al., 2024; Schurig et al., 2024).

However, this deviation from centralized control challenges established governance approaches: Values such as (data) sovereignty, openness, equitable interest representation, and trust enhance fairness (Beverungen et al., 2022; Otto, 2022). At the same time, their implementation via decentralization and participation can increase coordination costs and slow down developments (Chen et al., 2021). Consequently, governance in DSEs needs to consider two goals: On the one hand, DSE governance needs to fulfill fundamental principles of ***fairness*** (Otto, 2022; Schurig et al., 2024). On the other hand, governance requires a focus on ***effectiveness*** to ensure that coordination remains

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efficient, processes are reliable, and collective outcomes can be realized (Iansiti & Levien, 2004; Provan & Kenis, 2008). Moreover, because platform-based data ecosystems already dominate most industries, DSEs must be governed effectively to attract a critical mass of members to establish themselves as a viable alternative (Cennamo & Santaló, 2019; Gregory et al., 2021). Yet, despite the growing number of DSE initiatives, few operational examples exist to date (IDSA, 2024). We, thus, currently lack an understanding of how these two goals can be translated into well-functioning governance designs, leading us to ask: *How can data space-based ecosystems integrate the goals of fairness and effectiveness in their governance design?*

We follow a qualitative research approach with a single case study in Catena-X, one of the few operational DSEs in practice, to analyze its governance design in depth. Our findings indicate that DSE governance comprises four dimensions (*structure*, *decisions*, *relations*, *behavior*), each exhibiting different design choices associated with fairness or effectiveness. In our discussion, we connect the identified design choices to the goals of fairness and effectiveness and explain how the governance design of an operational DSE integrates both. We then assess how Catena-X balances fairness- and effectiveness-oriented design choices within each governance dimension. With that, we contribute a nuanced understanding of the specific characteristics of DSE governance and explain how they can integrate the goals of fairness and effectiveness by implementing different design options simultaneously.

2. Conceptual background

This section introduces data spaces as decentralized data infrastructures for sovereign data sharing. After conceptualizing DSEs as socio-technical systems, we outline their organizational structures. Lastly, we explain DSEs' governance and associated challenges.

2.1. Data space-based ecosystems

In an increasingly data-driven economy, companies must share data across organizational boundaries to unlock its full potential (Möller et al., 2024). However, barriers such as fear about losing competitive advantages hinder interorganizational data sharing (Jussen et al., 2024)—especially via proprietary platforms offered by major tech companies, since these systematically build up strategic dependencies and curtail autonomy (Gawer, 2022; Lv & Schotter, 2024). In contrast, data spaces are currently emerging as an alternative that allows sovereign, secure, and trusted data sharing (Otto, 2022). Data spaces are "*decentralized data infrastructures designed to enable data-sharing scenarios across organizational boundaries by implementing mechanisms for secure and trustworthy data sharing* […]" (Möller et al., 2024, p. 41). Unlike in centralized data-sharing platforms, data remains at its source, and providers only present metadata in the data space. Prior to each transaction, the involved partners agree on the terms of using the data and conclude a contract to secure the exchange (von Scherenberg et al., 2023). The actual data exchange occurs bi- (or multi-)laterally through standardized connectors (Möller et al., 2024). Establishing standards across DSEs enables interoperability between domains, contributing to a sovereign data economy (Otto, 2022).

The outlined technical foundations above are embedded in organizational ecosystems, defined as the systemic alignment structure of multiple interdependent actors' cooperation toward a common value proposition (Adner, 2017; Hein et al., 2020). Focusing on collaborative data sharing, DSEs represent a specific type of data ecosystem (Oliveira et al., 2019). In line with current literature, we thus conceptualize DSEs as socio-technical systems in which multiple organizational partners use one or more data spaces as a technical foundation to achieve collaborative goals through trusted data sharing (Möller et al., 2024; Oliveira et al., 2019).

Besides decentralizing technical infrastructures, DSEs break with the centralized authority of platform-based data ecosystems by emphasizing participation and openness in their organizational structures (Beverungen et al., 2022; Schurig et al., 2024). This implies that, in general, every organization can participate in DSEs if a certification organization has identified them upfront to ensure trusted relationships (Guggenberger et al., 2025). Besides, various data intermediaries can offer services facilitating data exchanges, such as maintaining data space connectors or providing metadata catalogs (Möller et al., 2024; Schweihoff et al., 2024). Finally, to represent different interests, multiple actors can form a governing body (Beverungen et al., 2022).

2.2. Governing data space-based ecosystems

Governance describes the central building blocks of an ecosystem and how they relate to each other (Tiwana et al., 2010). As such, governance presents the framework that aligns the independent members and their contributions for collective outcomes that exceed the capacity of a single organization (Adner, 2017). An ecosystem's success depends on realizing such outcomes, which is captured by the notion of effectiveness (Provan & Kenis, 2008). In this context, effectiveness concerns operational aspects such as efficient coordination and reliable processes, ultimately

enabling ecosystem-level performance (Foss et al., 2023; Kernstock et al., 2025).

However, striving for fairness-oriented principles such as (data) sovereignty, openness, equitable interest representation, and trust increases complexity in DSE governance and leads to several challenges. This includes defining how value flows (i.e., data or services) are organized between different data intermediaries and other members (Chen et al., 2021; Jacobides et al., 2018)—without centralized control contradicting the principle of sovereignty (Otto, 2022). Similarly, while a focal authority provides a coherent strategic path, such as in platform-based data ecosystems (Foss et al., 2023), DSEs emphasize openness and participation (Beverungen et al., 2022). The distributed nature of DSEs, therefore, calls for mechanisms that facilitate collective action and value-creating interactions among members (Ellinger et al., 2024). Further, to ensure security and encourage interorganizational data sharing, DSEs rely on contractual agreements and trust (Jussen et al., 2024; von Scherenberg et al., 2023). This raises questions about ensuring trusted relationships without focusing too much on compliance-related issues. Finally, DSEs require incentives for (potential) members to get involved (Hannah & Eisenhardt, 2018).

Thus, the goal for fairness, manifesting in DSEs' decentralized structures and participatory approaches, renders effective governance difficult. As research on blockchain-based ecosystems illustrates, decentralization and participation undermine effectiveness through coordination challenges and slower decision-making (Chen et al., 2021; Li & Chen, 2024). These implications affect an ecosystem's attractiveness, as its members are less likely to engage with or remain part of an arrangement that struggles to deliver results (Ellinger et al., 2024; Gulati et al., 2012). This is particularly severe, given that platform-based data ecosystems already dominate most industries (Gawer, 2022), necessitating DSEs to compete with them to acquire and retain a critical mass of members for long-term sustainability (Cennamo & Santaló, 2019; Gregory et al., 2021). Consequently, ineffective governance not only hampers internal alignment but also makes it harder for DSEs to establish themselves as a viable alternative for interorganizational data sharing.

The resulting dual goals of fairness and effectiveness necessitate DSEs to develop a governance design that integrates both normative principles and operational requirements. Achieving this requires deliberate design choices, such as distributing decision rights or selecting mechanisms to facilitate trusted relationships. Yet, how governance in DSEs can be designed to integrate the two goals remains, thus far, underexplored and calls for deeper investigation.

3. Methodology

We pursued a qualitative research approach to explore and understand the governance design of DSEs as an emerging phenomenon. To gain an in-depth understanding, we conducted a single case study with a (currently) unique case (Yin, 2018). This approach allowed us to generate rich insights and account for the specific contextual factors in DSEs. Within this case setting, we could thoroughly investigate the intricacies of DSE governance, favoring depth over width (Dubois & Gadde, 2002).

3.1. Data collection

We selected Catena-X as our research context because it is one of the few operational DSEs. In addition, Catena-X offers a comprehensive and well-documented governance framework involving a wide range of stakeholders. By institutionalizing participatory governance through its legal form as an association, Catena-X stands out as a unique case in realizing the core idea of DSEs.

Between January and September 2024, we conducted 18 semi-structured interviews with representatives from the Catena-X ecosystem (see Table 1 for an overview). We focused on organizational actors that actively contribute to the governance of Catena-X. We aimed to select a diverse sample of interview partners to assess various perspectives. Interviewees labelled *management team* are either part of the association's executive board or operational office. *Data intermediaries* include representatives from different companies providing supporting services in Catena-X. Due to its prominence, we had to disclose the name Catena-X. Thus, to ensure anonymity, we only indicate the interviewees' roles and general functions in Catena-X's governance.

The interviewees were acquired via LinkedIn and the authors' network. Our interview guideline evolved around (1) governance structures, (2) the distributed responsibilities, (3) relations between involved actors, (4) their goals, and (5) challenges. We continuously adapted the guideline during the data collection to incorporate emerging topics. This approach allowed us to structure the interviews consistently, while remaining flexible enough to adapt to novel insights. The interviews were conducted in German and English, mostly via online meeting applications, and one in person. On average, the interviews lasted 35 minutes and were recorded and transcribed afterward.

Additionally, publicly available information was used to triangulate the interview data and deepen our understanding. This includes the Catena-X website and the association's articles. Further, we analyzed two

whitepapers published by the Catena-X association (about its operating model and an onboarding guide) and two from companies offering advisory services (general overviews). We enriched our case database with notes from twelve informal exchanges with ecosystem members and external advisors, such as the International Data Space Association (IDSA) and Gaia-X.

ID	Role	Function in Catena-X
#1	General Manager	Management team
#2	General Manager	Management team
#3	General Manager	Management team
#4	IT-Project Manager	Management team
#5	IT-Project Manager	Management team
#6	IT-Project Manager	Management team
#7	Solutions Manager	Management team
#8	Community Manager	Management team
#9	CEO	Data intermediary
#10	CEO	Data intermediary
#11	IT-Project Manager	Data intermediary
#12	IT-Project Manager	Data intermediary
#13	R&D Manager	Data intermediary
#14	Business Development Manager	Data intermediary
#15	Research Associate	Software architecture
#16	Research Associate	Open-source project
#17	Research Associate	Expert committee
#18	Attorney	Legal consultancy

Table 1. Overview of interview partners

3.2. Data analysis

We pursued an inductive coding process following the principles of grounded theory (Strauss & Corbin, 1990) and informed by the recursive structure proposed by Gioia et al. (2013) to develop novel theoretical insights from the complex phenomenon. Refraining from imposing predefined theoretical categories, this allowed us to remain open and ensure an unbiased exploration of the data. The coding was conducted in three rounds and involved two researchers working independently before consolidating and visualizing the results in a shared data structure. First, we used open coding to detect salient features and recurring themes across the interview transcripts. In this phase, we identified meaningful segments in the data and assigned them labels close to the participants' language. As patterns and connections between the open codes emerged, we moved to axial coding, where we grouped related codes into categories. This helped us to understand underlying patterns and relationships based on conceptual similarities, such as modes of coordination or decision-making. Finally, in an iterative process, we integrated these categories through selective coding into four central governance dimensions in Catena-X: *structures*, *decisions*, *relations*, and *behavior*, each comprising of different design choices.

3.3. Case description

Originating from the *Automotive Alliance*, the Catena-X ecosystem was founded by a consortium of actors from the industry to tackle emerging (regulatory) challenges in the automotive supply chain. Funded by the German Federal Ministry for Economic Affairs and Climate Action, the consortium developed the initial technical framework in accordance with the principles of the IDSA and Gaia-X. In 2021, the consortium founded the Catena-X e.V. (non-profit association) as a governing body that steers the ecosystem. All participating organizations can join the association by paying a membership fee. These fees finance the association's management team, which fulfills key administrative tasks. Promoting inclusivity, an open-source community and multiple expert committees support the continuous development of the data space. Various data intermediaries facilitate data exchanges by supporting technical services or advisory offerings. Generally, each member may take on multiple roles, provided they comply with the current legal framework.

The emerging ecosystem evolves around use cases in which organizational actors share data and work collaboratively on common problems. For instance, a use case related to digital product passports works on fulfilling the prerequisites for a circular economy. As Catena-X is still in an early phase, its initially designed governance will likely change and develop over time.

4. Findings

Our findings indicate that Catena-X's governance balances a range of design choices across the four identified dimensions: *structures* exhibit distributed and consolidated forms; *decisions* may be made participatory but are implemented in a directive manner; informal and formal *relations* are used complementary; and both cooperative and competitive *behavior* is fostered among ecosystem members. In the following, we explain each governance dimension and describe how different design choices manifest in Catena-X to support either fairness- or effectiveness-oriented goals.

4.1. Structure

The case analysis reveals that Catena-X relies on dedicated structures to coordinate how data and services flow between DSE members. For that, Catena-X establishes two different design options: While distributed structures emphasize fairness by enabling

sovereign data sharing between members, consolidated structures in a management team aim to align the different involved actors and activities effectively.

Distributed. All data exchanges in Catena-X rely on a peer-to-peer logic to ensure sovereignty. This implies that intermediaries are not directly involved in this process: "*When you exchange data, there is no intermediary like in a cloud or something like this. The exchange is made directly between two, three or more partners*" (#8). Instead, the intermediary functions are distributed across different roles. This prevents the emergence of too-powerful actors: "*If you think about previous supply networks, one large player usually gathers the supply chain around itself, mandates that they provide their respective data, and determines the conditions for doing so. This is different in Catena-X*" (#13). Therefore, there are distinct roles that can (mostly) be filled by multiple companies in Catena-X. The main role is the Core Service Provider, who delivers essential infrastructures and business functionalities, ranging from the management of semantic models and marketplace offerings to secure identity handling and the discoverability of partners and services. Currently, this service is only provided by one company. Still, over time, the functionalities are planned to be dispersed among multiple companies: "*In the beginning, this needed to be in the hands of just one actor. But now […] the clear goal is to scale Catena-X. And that also means there will be more Core Service Providers*" (#13). A second core role are the neutral Conformity Assessment Bodies, which certify services and solutions in Catena-X to ensure they adhere to the required standards. Additionally, multiple roles support members in the DSE, including Onboarding Service Providers, Enablement Service Providers, Business Application Providers, and Advisory Service Providers. Taken together, this distributed structure provides a checks-and-balances system for all data intermediaries: "*You need these many roles to balance the power. It is not one company where everything is concentrated. […] the different roles check each other*" (#2).

Consolidated. Nevertheless, to coordinate the many intermediary roles efficiently, Catena-X is administered by the association's management team, which bundles key organizational and operational tasks in one place: "*We tried to describe the role in a way that it preserves the essence, and sets some steering signals, but the others eventually implement it*" (#18). The management team sets the strategic direction for the association and comprises two parts: an executive board consisting of representatives from companies in the association, and an operational office that supports administrative activities. Their responsibilities include organizing tenders for and nominating key intermediary roles and orchestrating the various functions: "*We have this operating model. Which roles and responsibilities are there in the data space? Everyone who wants to join needs to accept this*" (#1). With that, they provide the framework conditions and act as a neutral referee to ensure compliance: "*Even small companies should have a chance in this new data economy. This is also the task of our association to ensure that it is possible"* (#2). To consolidate the distributed efforts, the management team acts as a focal communication hub and administers the associated open-source project as an ideation space for development. So-called 'Keep it Together' (KITs) are used to share information in the open-source environment: "*KITs are the documentation, or an explanation of how the different aspects work together […] they are a summary of the operational part, from development to adoption*" (#6). Lastly, the management team provides a contact point to coordinate, acquire, and communicate with external partners.

4.2. Decisions

This dimension outlines how Catena-X distributes decision rights among its members. On the one hand, participatory decision-making ensures fairness through openness and equitable interest representation. On the other hand, directive decision-making is used to effectively implement standards to ensure adherence with the overall strategy.

Participatory. Catena-X emphasizes participatory decision-making and encourages the representation of diverse interests: "*In the Catena association, this industry representation or negotiation of interests is the main way to ensure that this ecosystem is supported by the entire automotive industry and not primarily by the main beneficiaries*" (#1). This mandates openness, meaning that (after being identified) any company can join the Catena-X association and take part in decisions: "*An open data ecosystem needs to comply with these ideas […] meaning that if I want to join—provided that I have a valid means of identification, I should be able to join*." (#12). To further anchor diversity in the strategic functions, the management team comprises representatives from different companies to ensure heterogeneous points of view in the discourse. The chosen legal form as an association implies that members oversee the management team (i.e., the executive board) through general assemblies, necessitating transparent processes: "*This is a huge difference from being a limited company […] you get insights, and it is very transparent how we make decisions*" (#2). Besides this, all members can participate in developing rules and norms for the Catena-X ecosystem: "*The association, with 180 members today, defines the rules […] we have defined a rulebook for this and agreed it within the association*"

(#3). Participation in committees, expert councils, or working groups can accelerate and leverage influence on the (strategic) developments of Catena-X.

Directive. While most decision-making processes promote openness and encourage diverse influences, as described above, the agreed requirements for exchanges in the data space are then implemented in a directive mode to ensure the core values of security, sovereignty, and interoperability. As the executing body of the association, the management team establishes the collective decisions. In terms of security, the identity and access management of (potential) members is a crucial factor: "*I need a pass. This pass is an identity and that needs to be completely unambiguous […] this is the first rule: if you want to join the data space, you need an identity*" (#3). To receive the identity, the Core Service Provider checks the self-description of a company and then issues a business partner number as proof to join Catena-X. Although the principle of sovereignty is embedded in the technical architecture, this is also prescribed in binding statutes: "*This principle of contractual freedom has been codified*" (#18). Besides security and sovereignty requirements, interoperability is a key feature for Catena-X: "*Interoperability is the foundation that a data [space-based] ecosystem can work […] but this requires a lot of effort that everyone speaks about the same things, that the technical requirements are present along the entire supply chain.*" (#2). This mandates standard formats, semantics, and data models, which also depend on the use cases. Specifying the Eclipse Dataspace Connector (EDC) as the standardized interface in Catena-X then supports efficient yet sovereign data exchanges as a central communication component: "*Data provider and consumer agree on the exchange. This communication takes place via the EDCs, through which they exchange information*" (#11).

4.3. Relations

This dimension focuses on facilitating trusted relations between Catena-X's members. Our analysis shows two complementary types of mechanisms designed to increase trust and security. Informal mechanisms emphasize the normative framework, strengthening Catena-X's fairness orientation, whereas formal mechanisms aim for reliability and compliance to facilitate the overall effectiveness of interactions.

Informal. From the early stages of the consortium, it was clear that a shared culture is the foundation for trusted relationships among members: "*We talk a lot about technologies, but the core element was that we brought together 20 leaders that reached an agreement to enable data sharing*" (#8). This is reflected in Catena-X's values, emphasizing sovereignty and trust to build long-term oriented relations and a thriving community. Since this might not be enough to alleviate members' concerns about data sharing, Catena-X needs to educate about these principles and their implications: "*The first barrier would be not knowing fully about data spaces. Because, if I were a data provider and did not know what data spaces are about, I would be reluctant to share my data, because it might be business critical or contain some sensitive information*" (#12). This is done, for example, through providing KITs or publishing whitepapers. Besides, crucial functions are assigned to neutral organizations (e.g., the association) in Catena-X to strengthen trust in its governance: "*We as humans, we want to see somebody is accountable for what we are doing. Somebody is trying to ensure that everything is transparent and fair*" (#12). Currently, these trust measures are crucial to overcome (initial) barriers in collaborative data sharing.

Formal. Since "*trust* and *control mechanisms facilitate the joint use of data and the growth of the ecosystem"* (#8), formal mechanisms back the informal mechanisms in Catena-X. At the highest level, all interactions must comply with the current regulatory framework, such as data protection or competition laws. Within the ecosystem, binding rules for all members formalize the normative framework: "*We issue overarching, normative documents*" (#1). Part of this are the 'Ten Golden Rules', which describe the fundamental principles of Catena-X and must be accepted by every member. The most important principle is the requirement for data sovereignty to ensure each company retains control over its data: "*I have the control at all times over what I share. […] and I can set the authorization accordingly, via the connectors*" (#1). On the level of individual data transactions, each use case has defined framework agreements and policies that regulate the usage conditions of the specific case of data sharing. Adding to these regulatory and contractual frames, Catena-X implements formal security measures to support trust-building mechanisms. This includes, for example, certifications to signal authenticity and ensure quality standards of applications offered: "*It is like with a car. You need the stamp from the technical inspection association to ensure the car fulfills all requirements for being allowed to drive on the road. So, our business applications need official approval to comply with all the standards in the Catena-X environment*" (#7).

4.4. Behavior

Behavior refers to aligning individual members' strategies with collective objectives. Generally, Catena-X promotes cooperative behavior to foster fairer data sharing throughout the entire automotive supply chain. However, allowing members to capture individual value

through competitive strategies strengthens the ecosystem's ability to reach its goals (effectiveness), since it allows incentives to contribute to collective activities.

Cooperative. Collaboration in the Catena-X ecosystem can be a powerful vehicle to tackle problems that exceed the capacities of individual companies: "*Whether it is sustainability or end-tier supply chains […] we need digital cooperation across the supply chain and that simply does not work alone" (#1).* Thus, Catena-X offers various options to cooperate on common use cases and expert groups: "*If you are on a committee or an expert group, then you are part of this structure, that is how the organization works […]. For us, it is all about getting this ecosystem up and running and developing it further*" (#1). The open-source environment is also used to leverage the aggregated community efforts, for example, by improving standards or sharing investments for new solutions. Notably, the data intermediaries work closely together as well to provide improved solutions for ecosystem members. Multiple interview partners stated they want to co-develop and contribute to Catena-X, which is also noticeable in the overall atmosphere: "*Catena-X is a very collaborative project*" (#11). In turn, the resulting value from the joint efforts pays off for members: Data providers and consumers now have new options to generate business value through data sharing. Data intermediaries can provide services based on the shared infrastructures, such as offering business applications for use cases, thereby enabling novel revenue streams. These offerings foster the matching between data (and service) providers and consumers: "*If you want to exchange data with 100,000 parties, then you have much less operational work due to this one connection*" (#14). Through the resulting dynamics, each additional member adds more value to Catena-X: "*The more actors participate in the data ecosystem, the greater the potential for value creation for each member*" (#8).

Competitive. Besides emphasizing cooperative behavior, each organization relies on an individual competitive advantage to profit from the overall value created. As shown above, data providers and consumers can benefit directly from the business value generated through increased data-sharing activities. However, due to the possibility of filling data intermediary positions by multiple actors, members in these roles must find additional strategic levers to establish a sustainable position against competitors within Catena-X. Currently, there are many opportunities for intermediaries to differentiate their solutions: "*We have designed this relatively modular in Catena-X. […] every company can decide which offerings they want to provide. And we [as a member] use different offerings, depending on the use case"* (#4). Some companies offer specialized applications, whereas others bundle multiple functionalities in holistic solutions (e.g., as-a-service). Alternatively, members can develop their own solutions based on the open-source foundation and/or openly accessible descriptions. Despite the collaborative efforts in the ecosystem, some companies are using their positions to build up strategic dependencies: "*This is a technical dependency that we have and that we cannot resolve […] and an economic dependency, which means a strengthened negotiation position for [the company]*" (#6). To prevent the emergence of too-powerful actors, most intermediary roles are fulfilled by multiple companies. Thus, each member can freely choose between the offered services, introducing competitive pressures between the intermediaries: "*In the end the customer decides where he puts his money and to which provider he goes […]*" (#3). Only the role of the Core Service Provider is currently occupied by one individual company, but this is supposed to change over time by including more companies in this role and creating competition among them.

5. Discussion

The case of Catena-X illustrates how governance is designed in an operating DSE aiming to balance effectiveness and fairness in their design choices across four governance dimensions. In this section, we first show how the two goals shape DSEs' governance designs (see Figure 1) and then discuss how they can be balanced with each other.

		DSE Goals	
		Fairness	**Effectiveness**
Governance Dimensions	**Structure**	Distributed	Consolidated
	Decisions	Participatory	Directive
	Relations	Informal	Formal
	Behavior	Cooperative	Competitive

Figure 1. DSE goals reflected in Catena-X's design choices

5.1. Fairness and effectiveness shaping governance designs

Catena-X embeds ***fairness*** directly into its governance design by emphasizing the principles of (data) sovereignty, openness, trust, and equitable participation (Otto, 2022). This is reflected in the *distributed structures*, granting members control over their data and preventing dominance by a single actor (Möller et al., 2024). *Participatory decisions* further promote openness and inclusion by enabling even smaller actors to voice their interests in collective decisions (Schurig et al., 2024). Catena-X represents this through measures such as committees and expert

councils. Fostering shared cultural norms, long-term connections, and trust, *informal relations* contribute to fairness by creating conditions for respectful and reciprocal interactions. Lastly, emphasizing *cooperative behavior* among Catena-X's members (e.g., in the open source environment) aligns individual contributions with collective benefits, reinforcing a more equitable value distribution (Ammann & Hess, 2025).

Simultaneously, Catena-X integrates design choices aimed at efficient coordination, reliable processes, and ecosystem-level performance to increase the overall ***effectiveness*** (Foss et al., 2023; Iansiti & Levien, 2004). We found *consolidated structures* in Catena-X that bundle core functionalities, enabling knowledge sharing and coordinating complex value flows. Similarly, the case demonstrates that *directive decisions* are needed to support value-creating interactions by enforcing standards and strengthening collective norms. *Formal relations,* such as contracts and binding agreements, contribute to reliable governance by ensuring clarity and accountability (Cao & Lumineau, 2015). Fostering *competitive behavior* among data intermediaries in Catena-X lowers costs for DSE members and incentivizes performance (Vickers, 1995), thereby increasing competitiveness.

5.2. Balancing fairness and effectiveness

Our analysis reveals that each governance dimension reflects a delicate balance between design choices promoting fairness and those aiming to retain effectiveness. This contrasts governance in platform-based data ecosystems, within which often only one design choice dominates: they typically build on consolidated structures and directive decisions while emphasizing the type of relations and behavior best suited to maximize the platform owner's goals (Lv & Schotter, 2024). DSEs, however, seem to opt for design choices that integrate fairness in their governance. While this approach may reduce overall effectiveness compared to platform-based data ecosystems, Catena-X uses contrary design choices to mitigate these losses. The different design choices within each dimension, hence, do not replace each other but coexist. However, this dual approach remains challenging to implement, as evidenced by the limited number of operational DSEs (IDSA, 2024). Therefore, we discuss how DSEs can address this balance between fairness- and effectiveness-oriented design choices below.

Typically, governance ***structures*** within a digital ecosystem mirror their technical architecture. For example, in platform-based data ecosystems, all value flows go through the central platform, controlled by one focal actor (Lv & Schotter, 2024; Tiwana et al., 2010). Conversely, other decentralized alternatives, such as blockchain-based organizations, rely on decentralized infrastructures and shared ownership (Ellinger et al., 2024). Catena-X deviates from this coupling by building upon *distributed* technical infrastructures, maintained by different data intermediaries, but organizing the ecosystem *consolidated* through the association's management team. This combines the effectiveness of a focal coordination hub (Foss et al., 2023) with the prevention of too powerful actors. While the viability of this approach has to be proven in the long term, it might provide a suitable solution for other ecosystem types to consider deviating their organizational structures from their underlying technical infrastructures.

The ongoing debate about the power of platform owners (Gawer, 2022; Hunt et al., 2024) has led some to grant ecosystem members a greater voice in governance ***decisions*** (Engert et al., 2025). Nevertheless, the extent of this inclusion ultimately remains at the platform owner's discretion. DSEs, thus, anchor *participation* in their organizational structures (e.g., general assemblies in the Catena-X association). As previous literature on DSE governance has shown, this facilitates the goals of inclusion and fairness (Beverungen et al., 2022; Schurig et al., 2024). However, as illustrated in Catena-X, the *directive* implementation of decisions, such as mandatory security requirements enabling sovereign data exchange or using common standards that foster scalability across domains, has been overlooked so far. While this top-down implementation of decisions needs to be carefully handled to prevent the overrepresentation of individual interests (Wareham et al., 2014), it safeguards the values embedded in the (collectively) defined rules and ultimately helps to pursue a unified strategic direction more easily than in purely participatory approaches.

To our knowledge, literature on platform-based ecosystems has paid little attention to the nature of ***relational*** ties between members. DSEs, however, require more emphasis on such ties to address common issues in interorganizational data sharing (Jussen et al., 2024) and represent a viable alternative to platform-based data ecosystems through increased trust. As Catena-X exemplifies, *formal* and *informal* mechanisms work together to ensure security and trust (von Scherenberg et al., 2023). Connecting to the literature on interorganizational governance, we argue that in DSEs, both mechanisms act as complements and enhance the overall performance of the collaboration (Cao & Lumineau, 2015). Normative pillars (Lusch & Nambisan, 2015), like the shared culture in Catena-X, support the implementation of contractual frameworks coordinate interactions among members effectively (Cao & Lumineau, 2015). In turn, formalizing these rationales, like in the 'Ten Golden Rules', protects data exchanges between members and ensures sovereignty.

While previous research has focused on managing the co-opetitive ***behavior*** between ecosystem members (Hannah & Eisenhardt, 2018), Catena-X leverages this tension actively for two main reasons: First, by highlighting the overall value resulting from *cooperation* (e.g., solutions to common problems and use cases), Catena-X attracts members to join the ecosystem and thereby aims to generate crucial network effects. Second, by allowing *competitive* strategies between service providers, DSEs introduce a new level for competition. The idea of inducing competition between different providers of core services, presents a novelty in ecosystem research, since only competition between ecosystem members (Hannah & Eisenhardt, 2018), members and the platform owner (Foerderer et al., 2018), and between ecosystems (Cennamo & Santaló, 2019) have been observable so far. This pressures providers to continuously improve their offerings and lower costs for DSE members (Vickers, 1995). Further, the competitive pressures between data intermediaries counter the emergence of monopolistic structures and lead to efficient operations.

6. Conclusion

In this paper, we set out to understand how DSEs' governance can be designed to integrate their goals of fairness and effectiveness. Based on an in-depth single case study with Catena-X, we found that DSEs comprise four distinct, yet interrelated governance dimensions, each exhibiting certain design choices. These findings reveal that each goal manifests in different design choices that must be balanced across dimensions.

Our study adds to the nascent literature on DSEs and their governance by examining the intricate relationship between their normative goals and operational effectiveness. The resulting ***theoretical contributions*** are threefold. First, based on our inductive analysis, we advance current knowledge on DSEs by identifying four distinct governance dimensions (*structure*, *decisions*, *relations*, and *behavior),* and describing specific design choices within each. Second, we link the identified design choices to the goals of fairness and effectiveness, thereby showing how they can be integrated into DSE governance. Third, by discussing how Catena-X balances different choices within each governance dimension, we explain how DSEs can balance their dual goals and contrast this novel approach to established concepts from the broader literature on ecosystem governance.

Since many DSE initiatives are currently emerging, but only a limited number of fully operational DSEs exist to date, the case of Catena-X offers unique ***practical insights*** into DSE governance. The four governance dimensions identified in our study provide a structured overview to guide the design of DSE governance by highlighting their specific requirements—from fostering trusted relationships to inducing competition among data intermediaries. Rather than solely relying on unilateral governance approaches, managers in DSEs should consider the full range of design choices within each dimension. Our findings further show that balancing fairness and effectiveness requires design choices to ensure that the need for operational efficiency and reliability does not undermine core principles of DSEs such as (data) sovereignty, interest representation, openness, and trust.

It is important to recognize that the governance design described does not automatically eliminate pre-existing tensions. As some interview partners noted, strategic dependencies are already beginning to emerge despite anchoring fairness in Catena-X's design. This raises the question of whether existing power asymmetries from industrial contexts may persist. ***Future research*** could therefore examine how specific actors' goals, interests, and strategic positions shape the initial governance and its development over time. Moreover, while the case of Catena-X provides rich insights, governance choices are likely influenced by contextual conditions such as prevailing industry structures or regulatory environments. Accordingly, further studies could help identify which contextual factors matter (most) and how they shape governance in different DSEs—now and over time.

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