An Organizational Maturity Model for Data Spaces: A Data Sharing Wheel Approach

Edward Curry and Tuomo Tuikka

Abstract This chapter presents a maturity model for Data Spaces, which provides a management system with associated improvement roadmaps that guide strategies to continuously improve, develop, and manage the data space capability within their organization. It highlights the challenges with data sharing and motivates the benefit of maturity models. This chapter describes the Maturity Model for Data Spaces (MM4DS) and its use to determine an organization's data space capability maturity. The MM4DS takes an organization's user-centric/demand-side perspective utilizing a data space. The development process for the MM4DS is discussed, along with the role of design science in the model development process. Finally, the chapter details an illustrative case using the model to benchmark data space capabilities in five fictitious organizations. The MM4DS can be applied within organizations to better manage their data space capabilities, with assessment, providing insights into what they are doing well and where they need to improve.

Keywords Data space · Maturity model · Data ecosystem · Big Data value · Data innovation

1 Introduction

To leverage the benefits of data sharing, many organizations are now looking at developing data space capabilities to create new value and business opportunities. A data space capability goes beyond technology to encompass other factors such as alignment with organization strategy, project planning, developing expertise,

E. Curry (✉)
Insight SFI Research Centre for Data Analytics, University of Galway, Galway, Ireland
e-mail: edward.curry@insight-centre.org

T. Tuikka
VTT Technical Research Centre of Finland, Oulu, Finland
e-mail: tuomo.tuikka@vtt.fi

E. Curry et al. (eds.), *Data Spaces*, https://doi.org/10.1007/978-3-030-98636-0_2

culture, and governance. Unfortunately, because the field is new and evolving, few guidelines and best practices are available, resulting in many organizations not fully exploiting data sharing potential. As a result, organizations face many challenges in developing and driving their overall data strategies and programs. The point of departure for this work is the call for the community to engage substantively with the topic of Data Spaces [1]. The chapter contributes to theory by discussing organizational capabilities for Data Spaces. We have developed a model for systematically assessing and improving data space capabilities. We have used an open-innovation collaboration model, engaging academia and industry in creating the Maturity Model for Data Spaces (MM4DS), and especially when developing BDVA Data Sharing Value Wheel which is used as a conceptual basis for MM4DS. The core of this maturity model for Data Spaces provides a management system with associated improvement roadmaps that guide strategies to continuously improve, develop, and manage the data space capability. The maturity model can be applied within an organization to better manage its data space capabilities. The assessment provides insights into what they are doing well and where they need to improve.

The chapter highlights the opportunities of data ecosystems and Data Spaces and motivates the need for maturity models to develop and manage organizational capabilities. First, the chapter describes the MM4DS and its use to determine the maturity of data space capability. Next, the development process for the MM4DS is discussed, detailing the role of design science and the model development process. Finally, the chapter details an illustrative use of the model to benchmark organizations.

2 Background and Context

The European data strategy identifies data as an essential resource for economic growth, competitiveness, innovation, job creation, and societal progress. IDC forecasts worldwide investments in Big Data and analytics to reach 294 B€ by 2025, of which 16%, corresponding to 47 B€, was generated in the EU27. A key enabler for AI and data-driven business opportunities is the growth in data, with more than 175 zettabytes of data available by 2025. In parallel, we are witnessing a shift of data to the edge and cloud environments. While, in 2020, 80% of processing and analysis takes place within data centers, the transition is onto more data being processed at the edge of the network in smart connected devices and machines. IDC predicts that 46% of the world's stored data in 2025 will be in the public cloud. This creates new opportunities for Europe to lead edge data processing and maintain control of their data [2]. As EU Commissioner Thierry Breton stated, "the goal is to prepare ourselves so the data produced by Europeans will be used for Europeans, and with our European values."

2.1 Data Ecosystems

A data ecosystem is a socio-technical system that enables value to be extracted from data value chains that interact with organizations and individuals. Data value chains can be oriented to business and societal purposes within an ecosystem. The ecosystem can create a marketplace competition between participants or enable collaboration among diverse, interconnected participants who depend on each other for mutual benefit. Data ecosystems can be formed in different ways around an organization, community technology platforms, or within or across sectors [3]. A well-functioning working data ecosystem must bring together the key stakeholders with a clear benefit for all. The key actors in a data ecosystem include data suppliers and consumers, technology and infrastructure providers, data end-users, marketplaces, regulators, and standardization bodies.

There is a need to bring together data from multiple participants within a data ecosystem [4]. For example, smart cities show how different systems within the city (e.g., energy and transport) can collaborate to maximize the potential to optimize overall city operations. At the level of an individual, digital services can deliver a personalized and seamless user experience by bringing together relevant user data from multiple systems [5] that cross organizational boundaries, come from various domains (e.g., finance, manufacturing, facilities, IT, water, traffic, and waste), and operate at different levels (e.g., region, district, neighborhood, building, business function, individual).

Data ecosystems present new challenges to data sharing. How can we support data sharing within a data ecosystem? What are the technical and nontechnical barriers to data sharing within the ecosystem [4]?

2.2 Data Value Chains and Data-Driven AI

Data enables AI innovation, and AI makes data actionable. Data flows link the emerging value chains improved or disrupted by new AI services and tools, where new skills, business models, and infrastructures are needed [3]. The Data Governance models and issues such as data access, data sovereignty, and data protection are essential factors in developing sustainable AI- and data-driven value chains respecting all stakeholder interests, particularly SMEs. The latter is currently lagging in AI adoption. AI and data innovation can generate value not only for business but also for society and individuals. There is increasing potential to use AI and data for social good by contributing solutions to the UN Social Development Goals (SDGs) and the goals of the EU New Green Deal. Enterprises are developing sustainability programs in the context of their corporate social responsibility strategies, leveraging data and AI to reduce their ecological footprint, cutting costs, and contributing to social welfare at the same time. Public authorities are also looking into unlocking private data for general purposes. Business and social value can be pursued simultaneously, encouraging the reuse and sharing of

data collected and processed for AI and data innovation (sharing private data for the public good, B2G, and not only B2B). Expertise is needed to increase awareness about the potential value for society and people and the business of data-driven innovation combined with AI [6].

2.3 High-Level Europe Opportunity and Challenges

For the European data economy to develop further and meet expectations, large volumes of cross-sectoral, unbiased, high-quality, and trustworthy data must be made available [7]. There are, however, significant business, organizational, and legal constraints that can block this scenario, such as the lack of motivation to share data due to ownership concerns, loss of control, lack of trust, the lack of foresight in not understanding the value of data or its sharing potential, the lack of data valuation standards in marketplaces, the legal blocks to the free flow of data, and the uncertainty around data policies [8]. Therefore, the exploration of ethical, secure, and trustworthy legal, regulatory, and governance frameworks is needed. European values, e.g., democracy, privacy safeguards, and equal opportunities, can become the trademark of European data economy technologies, products, and practices. Rather than be seen as restrictive, legislation enforcing these values should be considered a unique competitive advantage in the global data marketplace.

3 Data Spaces and Organizational Capabilities

Data Spaces, platforms, and marketplaces are enablers, the key to unleashing the potential of data. Significant technical challenges such as interoperability, data verification and provenance support, quality and accuracy, decentralized data sharing and processing architectures, maturity, and uptake of privacy-preserving technologies for Big Data directly impact the data available for sharing [1]. Aligning and integrating established data sharing technologies and solutions and further developments in architectures and governance models to unlock data silos would enable data analytics across a European data sharing ecosystem. This will allow AI-enhanced digital services to make analyses and predictions on European-wide data, thereby combining data and service economies. New business models will help exploit the value of those data assets by implementing AI among participating stakeholders, including industry, local, national, and European authorities and institutions, research entities, and even private individuals. The European data strategy sets out a vision for the EU to become a role model for a data-driven society and create a single data market to ensure Europe's global competitiveness and data sovereignty. As highlighted by Breton, "to be ahead of the curve, we need to develop suitable European infrastructures allowing the storage, the use, and the creation of data-based applications or Artificial Intelligence services. I consider this as a major issue of Europe's digital sovereignty."

3.1 BDVA Data Sharing Value Wheel

The Big Data Value Association has used an open-innovation model of collaboration, engaging academia and industry in creating the Data Sharing Value Wheel. In the Wheel, as depicted in Fig. 1 and introduced in Scerri et al. [1], the success of widespread data sharing activities revolves around the central key concept of trust: in the validity of the data itself and the algorithms operating on it, in the entities governing the data space; in its enabling technologies, as well as in and among its wide variety of users (organizations and private individuals as data producers, consumers, or intermediaries). To achieve the required levels of trust, each of the following five pillars must meet some of the necessary conditions:

- Organizations—More organizations (including business, research, and governmental) need to rethink their strategy to fully embrace a data culture that places

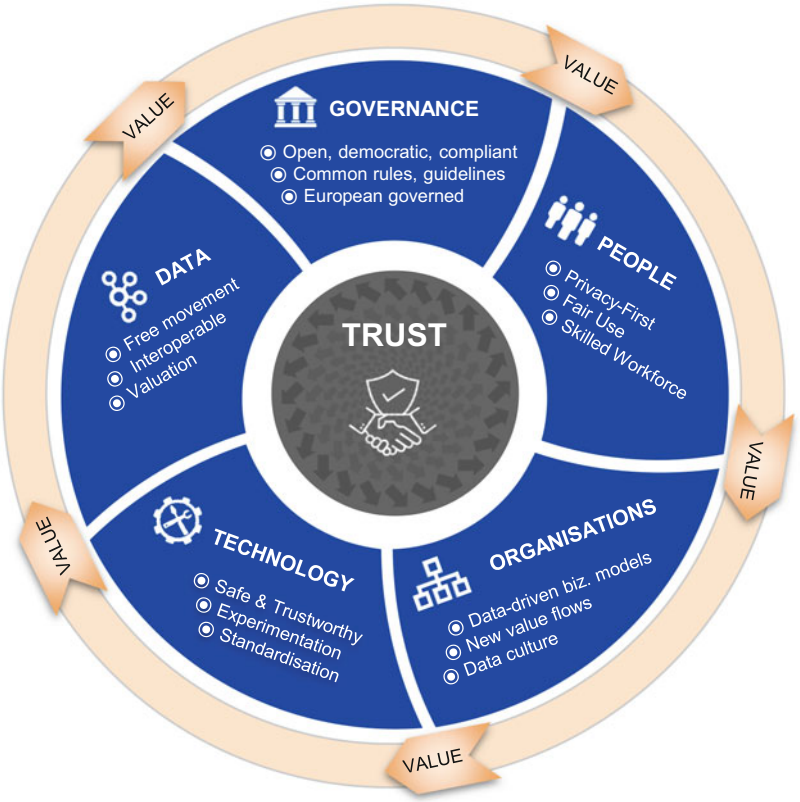

Fig. 1 The Data Sharing Value "Wheel"—core pillars and principles of the envisioned European-governed data sharing space that generate value for all sectors of society [1]

data at the center of their value proposition, exploring new data-driven business models and exploiting new data value flows.
- Data—As a touted 5th European fundamental freedom, free movement of data relies on organizational data strategies that embed methodologies for data sharing by-design (e.g., interoperability) and clear standard guidelines that help determine the market value of data assets.
- Technology—Safer experimentation environments are needed to catalyze the maturation of relevant technology behind trustworthy data, data access, and algorithms (privacy, interoperability, security, and quality). In addition, standardization activities need to adjust for faster reaction times to emerging standards and the identification of new ones.
- People—Data sharing needs to guarantee individual privacy and offer fair value or compensation of shared personal data. For Europe to drive data sharing activities, the European workforce needs appropriate reskilling and upskilling to meet the evolving needs of the labor market.
- Governance—A European-governed data sharing space can inspire trust by adhering to the more advanced European rules, guidelines, and regulations and promoting European values. Participation should be equally open to all and subject to transparent and fair rules of conduct.

3.2 Organizational Capabilities

The resource-based view (RBV) is one of the significant firm-theoretical perspectives with solid tradition within the business research community [9]. Within the RBV, an organization is conceptualized as a collection of resources, where a resource is "anything which could be thought of as a strength or weakness of a given firm" [10]. According to Wade and Hulland [9], resources comprise (a) capabilities and (b) assets. The term capability refers to the ability of an organization to perform a coordinated set of tasks to achieve a particular result [11]. Assets are defined as anything tangible or intangible that can be used in the firm's processes [9]. Capabilities can be viewed as repeatable patterns of actions [9] or coordinated set of tasks [11] that utilize the firm's assets as input [11]. IT capabilities enable the firm to acquire, deploy, combine, and reconfigure IT resources to support and enhance business strategies and processes [12]. Bharadwaj [13] describes IT capabilities as the "firm's ability to mobilise and deploy IT-based resources in combination or copresent with other resources and capabilities."

Teece et al. [14] differentiate between different types of capabilities which exist in the firm. Operational capabilities are the firm's ability "to perform the basic functional activities of the firm, such as plant layout, distribution logistics, and marketing campaigns, more efficiently than competitors" [15]. These capabilities are targeted toward the operational functioning of the firm [16]. On the other hand, dynamic capabilities are "the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments" [14].

Dynamic capabilities do not directly affect the firm's output but indirectly contribute to the firm's output through an impact on operational capabilities [11]. In turbulent settings, IT dynamic capabilities become even more critical. These processes and routines facilitate learning and transform firm asset/resource positions [17].

The research reported here aims to explore the capabilities needed for Data Spaces within organizations. The study aims to identify the critical foundations needed within the organization that permit firms to build the capabilities that can deliver value from Data Spaces. Focusing on foundations enables researchers to build a detailed conceptual foundation for data space capability and devise strategies for implementation by a firm's management.

3.3 Maturity Models

Maturity models are conceptual models that outline anticipated, typical, logical, and desired evolution paths toward maturity [18], where maturity is a measure to evaluate the capabilities of an organization concerning a particular discipline [18]. Maturity models are tools that have been used to improve many capabilities within organizations, from business process management (BPM) [18] and project management [19] to software engineering [20]. In addition, several maturity frameworks have recently been developed related to information technology (IT) management and IT/business alignment [21].

Maturity models contain two aspects, one capturing the assessment of the current status and another one guiding organizations toward higher maturity levels. They can have multiple uses within an organization, from helping them find a place to start, providing a foundation to build a common language and shared vision, to helping organizations prioritize actions and define roadmaps [22]. If a community of organizations defines the model, it can capture the collective knowledge of the community's prior experiences. A maturity model could also be used as an assessment tool and benchmark for comparative assessments of the capabilities of different organizations. Furthermore, the model can help transform organizations toward higher maturity levels by suggesting how these capabilities are developed.

4 A Maturity Model for Data Spaces

This chapter presents the Maturity Model for Data Spaces (MM4DS), which provides a management system with associated improvement roadmaps and strategies to continuously improve, develop, and manage the data space capability within an organization. The MM4DS takes an organization's user-centric/demand-side perspective utilizing a data space to gain business value. The MM4DS has been designed following the high-level dimensions of the BDVA Data Sharing Wheel and is used to determine an organization's data space capability maturity. The MM4DS

offers a comprehensive value-based model for organizing, evaluating, planning, and managing data space capabilities.

The initial model was developed by a subgroup of Data Space Task Force of the Big Data Value Association (BDVA), which is comprised of university-based academic researchers and industry-based practitioner-researchers drawn from over 200 organizations across Europe using "engaged scholarship" [23] and "open-innovation" principles [24]. The initial version of the model presented in this chapter will be developed further by the task force to refine it and validate it within real-world Data Spaces.

The section details the design methodology, describes its capabilities, associated maturity curves, and outlines the assessment approach for the MM4DS.

4.1 Model Design Methodology

The design science paradigm seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts, including constructs, models, methods, and instantiations [25]. Maturity models in design-oriented research are located between models and methods in the form of state descriptions (e.g., the maturity levels) and guidelines [26]. In order to transform organizations from one maturity level to another, the method component is usually described by "maturity curves" or "maturity profiles." Thus, a maturity model represents both model elements in the form of assessments and method components in the form of improvement guidelines. In this regard, "method engineering" is central to our approach and can be seen as elements of design science-oriented information systems research [25, 27].

The MM4DS follows design science principles within a rigorous design process that facilitates scholars' engagement and ensures consistency by providing a meta-model for structuring the maturity model. The design science approach used in the MM4DS is closely aligned with the three design science research cycles (relevance cycle, rigor cycle, and design cycle) proposed by Hevner [28]. A group was established to develop the model, including a mix of subject matter experts (SMEs) and key opinion leaders (KOLs), including academic researchers and industry-based practitioners. The objective was to capture the collective learnings and experiences of the group within a maturity model for data.

4.2 Capabilities

The MM4DS model consists of 15 capabilities (see Table 1) across the following 7 pillars of the data sharing wheel.

Table 1 Organizational capabilities for Data Spaces

Pillars	Capability	Description
(O) Organization *Definition and execution of data space strategy to influence and align with the organization's business goals*	(O1) Strategy and planning	*Definition and agreement of the strategy and scope of objectives for the data space initiative*
	(O2) Business alignment	*Influencing and aligning with the organization's business goals*
	(O3) Performance monitoring	*Monitoring progress against specific data space objectives within the organization and the ecosystem*
(V) Value *Sensing and capture of business value opportunities*	(V1) Sensing	*Value sensing for the business strategy via constant monitoring of data space business opportunities*
	(V2) Capture	*Value capture via constant improvement of core business activities and new business opportunities*
(D) Data *Facilitating data sharing, management, and stewardship in the organization*	(D1) Life cycle	*Provision of data sharing in the data product and services' data management life cycle*
	(D2) Management and stewardship	*Processes for the management and stewardship of data assets for the data space*
(T) Technology *Sourcing and operation of technical infrastructure and support services for Data Spaces*	(T1) Infrastructure	*Sourcing and operation of technical infrastructure to deliver data space objectives*
	(T2) Support services	*Provision of support services that facilitate data space usage and application development*
(P) People *Develop data space skills and culture. Drive adoption of Data Spaces*	(P1) Skills and culture	*Establish a structured approach to data space skills and development and promote a data space culture*
	(P2) Adoption and communication	*Embed data space principles and communicate a common understanding across the organization*
(G) Governance *Establish clear policies, compliance, and accountability for Data Spaces*	(G1) Policies	*Establish common and consistent policies to support data space strategy to meet current and future objectives*
	(G2) Compliance	*Enablement and demonstration of compliance with data legislation, regulation, and directives*
	(G3) Accountability	*Clear accountability for data space roles and decision making within the organization and the ecosystem*
(T) Trust *Level of trust for data owners*	(T1) Assurance	*Level of assurance provided to data owners (organizations and individuals) on their data*

- Organization (O) includes data space strategy and planning and its alignment and reporting with the organization's overall business strategy, objectives, and goals.
- Value (V) develops the sensing of data space business opportunities and value capture.
- Data (D) includes the provision of data sharing within the life cycle and the management and stewardship of data in the data space.
- Technology (T) includes the operation of infrastructure and support services that facilitate data space usage.
- People (P), which develops skills and the organization culture together with communication and adoption activities to help embed data space principles across the organization and the broader ecosystem.
- Governance develops common and consistent policies and requires accountability and compliance with relevant regulations and legislation.
- Trust, which needs to provide assurances to data owners and users.

4.3 Maturity Curve

A maturity curve serves two important purposes. First, it is the basis of an assessment process that helps determine the current maturity level. Second, it provides a view of the growth path by identifying the next set of capabilities an organization should develop to drive business value from Data Spaces. A contrast of low- and high-level capability maturity for Data Spaces is offered in Fig. 2 to illustrate the comprehensiveness and range of data space maturity; such comparisons can facilitate understanding the concept of process maturity [20]. Humphrey [29] emphasizes that there is no ultimate state of process maturity, but that maturity implies a firm foundation established from where continuous improvement initiatives can be

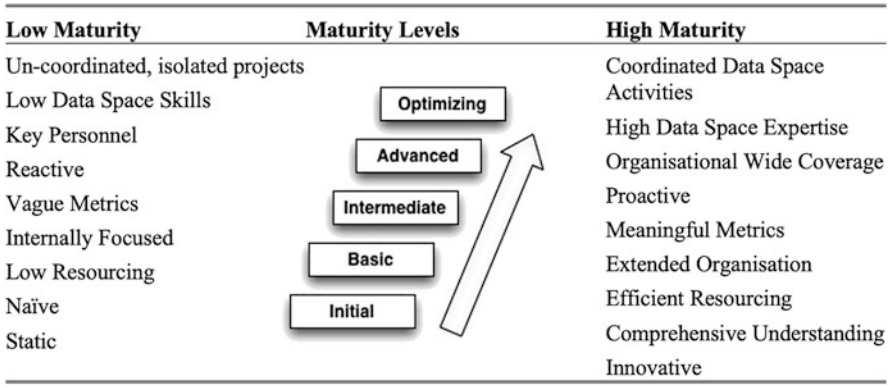

Fig. 2 Comparison of low and high maturity of Data Spaces (adapted from Rosemann and de Bruin [18])

launched. The model defines a five-level maturity curve, as detailed in Table 2, for identifying and developing data space capabilities:

- **Initial:** Data space capabilities are ad hoc; there is little understanding of the subject and few or no related policies. Data space activities are not defined and are not considered in the organizational processes.
- **Basic:** There is a limited data space strategy with associated execution plans. It is mainly reactive and lacks consistency. There is an increasing awareness of the subject, but accountability is not clearly established. Some policies may exist but with inconsistent adoption.
- **Intermediate:** A data space strategy exists with associated plans and priorities. The organization has developed capabilities and skills and encourages individuals to contribute to data space programs. The organization includes Data Spaces across its processes and tracks targets and metrics.
- **Advanced:** Data Spaces are a core component of the data and business planning life cycles. Cross-functional teams jointly drive programs and progress. The organization recognizes Data Spaces as a significant contributor to its business strategy. It aligns business and data space metrics to achieve success across the organization. It also designs policies to enable the achievement of best practices.
- **Optimizing:** The industry recognizes the organization as a Data Space leader and uses its data space practices as an example to set industry standards and best practices. In addition, the organization recognizes Data Spaces as a key factor in driving data-driven innovation as a competitive advantage.

4.4 Assessment Approach

The MM4DS assessment determines how data space capabilities contribute to the organization's overall data innovation goals and objectives. This gap analysis between what the business wants and their current capabilities is delivering positions the MM4DS as a management tool for aligning and developing data space capabilities to meet business objectives. The model focuses on the execution of four key actions for increasing data space value:

- Define the scope and goal of data space.
- Understand the current data space capability maturity level.
- Systematically develop and manage the data space capability.
- Assess and manage data space capability progress over time.

Here we outline these actions in more detail and discuss their implementation.

Table 2 Maturity curve for each data space capability

Pillars	Capability	Initial	Basic	Intermediate	Advanced	Optimizing
(O) Organization	(O1) Strategy and planning	Any data space objectives that have been defined are limited and inconsistent	A minimum set of data space objectives are available and benchmarked	Data space objectives are part of an improvement roadmap for the medium term covering all aspects of the data space	The data space strategy is managed at the senior executive level and is executed as an integrated part of the organization's overall business strategy	Strategic planning for the data space extends outside the organization to include stakeholders from the broader ecosystem
	(O2) Business alignment	Any data space alignment that takes place is informal and inconsistent	The data space group reviews objectives that can be aligned to business goals	A complete set of short- and medium-term objectives for Data Spaces are agreed with the business	Longer-term data space objectives are agreed upon and integrated into business goals	Data space objectives are reviewed and set as part of board-level reviews of the organizational goals and aligned with the broader ecosystem value chain
	(O3) Performance monitoring	Performance measurement or reporting is ad hoc	Some data space performance metrics may exist, but reporting occurs at the project level	Data space performance is aggregated across all Data Spaces. Thus, there is the beginning of an alignment with corporate objectives	Data space performance is aggregated and reported across Data Spaces and aligned with business metrics	Data space performance is aggregated and reported across the organization and aligned with business metrics for the broader ecosystem
(V) Value	(V1) Sensing	Limited value opportunity sensing	Occasional business improvements are identified	A dedicated data space team identifies value opportunities for the organization	Cross-functional capabilities to identify new data space business opportunities	Data space value opportunities drive business strategy and collaborations with ecosystem partners
	(V2) Capture	Value undefined and not managed	Value capture is driven by individual efforts with limited recognition of value	A dedicated data space team advises on value capture to the business groups	Cross-functional capabilities to capture repeatable impact to the business	Data space value capture drives business revenue in cooperation with the ecosystem value network

(D) Data	(D1) Life cycle	Data sharing criteria included in data life cycles are inconsistent and ad hoc	Basic data sharing criteria are implemented for the data life cycle of a limited number of data products and services	Data sharing criteria and policies are regularly implemented within the life cycle of data products and services. Data sharing follows open standards	Data sharing criteria and policies are consistently implemented within the life cycle of data products and services	Industry-leading implementation of data sharing life cycle for Data Spaces. The organization influences and leads industrial best practices and standardization for data sharing
	(D2) Management and stewardship	Ad hoc management and stewardship processes	Processes are basic and project-based	Limited dedicated resources are dedicated to management and stewardship	Cross-functional capabilities for data management and stewardship. Processes are integrated into the workflow of business groups and are aligned with the data sharing life cycle	Industry-leading implementation of processes for data management and stewardship for Data Spaces. Influences and leads industrial best practices and standardization activities
(T) Technology	(T1) Infrastructure	Infrastructure is implemented using ad hoc technology choices	Basic infrastructure architecture guidelines and reference models are in place. Infrastructure interoperability complies with open standards	New data/IT systems deployed with defined data space interfaces	Roadmaps guide infrastructure technology choices and interoperability	The organization leads data space infrastructure research and driving industry best practices and standardization
	(T2) Support services	Limited or no data space support services	Services provide a minimal level of support with basic functionality over data assets (e.g., browsing)	Services are available to provide essential functionality at the data-item/entity level within data assets (e.g., search) and basic identification/naming of items	Data sources are integrated with most support service features (e.g., queries) with support for federation. Application development is supported with a toolbox to simplify development	Full semantic integration of data assets into the support services with a consistent global view of the data space. The organization leads industry best practices in data space support services

(continued)

Table 2 (continued)

Pillars	Capability	Initial	Basic	Intermediate	Advanced	Optimizing
(P) People	(P1) Skills and culture	Ad hoc informal training and culture at the project level	An informal mentoring network exists for Data Spaces. Dissemination of Data Spaces best practices	Data space competencies are integrated into HR strategies for managing technical and business personnel, including recruitment, training, and career development	Data space goals are an integral part of the company's core values and mission statement. There is a common culture focused on Data Spaces across the organization	Data space culture is engrained across the enterprise such that everyone feels empowered to develop innovative data-driven solutions using Data Spaces. Staff create best practices and drive industry thought leadership
	(P2) Adoption and communication	The adoption, language, and communication of Data Spaces are at best ad hoc and at the project level	Communication of basic data space principles, including basic terminology, to technical and business groups. Team events, informal training, and other communication channels encourage informal knowledge sharing and adoption	Data space adoption targets are defined for business groups, and regular reviews are undertaken to assess progress. Regular communication initiatives occur across the organization to improve awareness of key data space concepts and practices	Embedding of data space principles across the organization. Incentivization of data space membership and active participation. Establishment of ecosystem stakeholder engagement process. Dissemination of data space success stories	The organization is recognized internationally as a thought leader in Data Spaces and evangelizes best practices. Data Spaces are a key part of board level thinking and are included in internal and external communications
(G) Governance	(G1) Policies	No individual or team has overall responsibility for data space policies	A person or team is responsible for data space policies	A joint cross-functional team has responsibility for compliance with relevant regulations and standards applicable to Data Spaces	Performance is regularly reviewed against data space standards and policies. Changes are made in line with internal organization targets and external regulatory requirements	The organization is part of international bodies which define best practices and relevant regulations and standards applicable to Data Spaces

	(G2) Compliance	Compliance with external requirements or standards is at best ad hoc	Common access point for assessing relevant data space standards and regulations. Inconsistent application across the data space	A dedicated individual or team advises on incorporating data space standards and regulations into relevant business activities with a focus on minimum regulatory compliance	Regular audits and compliance reviews with internal targets and external data space standards and regulations	The organization participates in industry-wide peer reviews of compliance with data space standards/regulatory requirements. New developments in standards and regulations are implemented at an early stage
	(G3) Accountability	No formal accountability roles and processes are in place	A person/team is responsible for data space standards and regulations. The relevance of regulation to the organization is understood	A dedicated team is given responsibility for compliance with standards and regulations for the data space. The organization can demonstrate regulatory compliance	Regular audits and compliance reviews with internal targets and external data space standards and regulations. The structure and roles in the team changes in line with changes to regulatory requirements	The team head reports to the Chief Information Officer (CDO), Chief Data Officer (CDO), or directly to the Board
(T) Trust	(T1) Assurance	Limited or ad hoc control on a project basis	Coarse-grained (data asset level) access control	Fine-grained (entity-level/record-level) access control and data provenance	On-demand data anonymization and basic usage control	Full usage control across internal and external Data Spaces

4.4.1 Defining the Scope and Goal

First, the organization must define the scope of its data space effort. As a prerequisite, the organization should identify how it views data sharing and its aspirations. Typically, organizational goals involve one or more of the following:

- Develop significant capabilities and a reputation for leadership in Data Spaces.
- Keep pace with competitors or stakeholder expectations.
- Meet minimum compliance requirements and reap readily available benefits.

Second, the organization must define the goals of its data space effort. It is essential to be clear on the organization's business objectives and the role of the data space in enabling those objectives. A transparent agreement between business and technical stakeholders can tangibly help achieve those objectives. Significant benefits can be gained by simply understanding the relationship between business and data strategy goals.

Over time the goals and scope of a data space can evolve and change. As a data space grows, it may develop many subgoals or shared goals with other Data Spaces. The design and development of goals is a continuous interactive process to manage this systematically. Agreeing on the desired business goals for data innovation will significantly impact business and thus data strategy goals and priorities. After deciding to improve data space, organizations are often keen to aim for a consistent and widespread approach across the organization. Developing appropriate and effective capabilities is an iterative process and requires investment from both business and technical groups to learn from experience and deliver the desired benefits. This is because data innovation goes beyond technology. It is also about helping the whole business leverage data-driven innovation to meet its targets.

Once the scope and goals of data space capability are clear, the organization must identify its current capability maturity level by examining its data space capabilities.

4.4.2 Assessment Data Collection and Analysis

The first step is to assess the organization's status for the 15 capabilities within the MM4DS model. The assessment begins with the survey to understand their assessments of the maturity and importance of their data space capabilities. The survey consisted of 45 questions. The survey structure is aligned with the assessment approached and divided into three sections:

- **Current maturity (15 questions):** Participants are invited to score the organization's current maturity for data space capabilities. Each question describes the characteristics of a maturity level that follow maturity level logic across five stages: initial, basic, intermediate, advanced, and optimized.
- **Desired maturity (15 questions):** Participants are invited to score the organization's future desired maturity for data space capabilities. Each question describes

the characteristics of a maturity level that follow maturity level logic across five stages: initial, basic, intermediate, advanced, and optimized.
- **Importance of capability (15 questions):** Participants are asked to value each data space capability by grading them on a 1 to 5 scale, with 1 being not important and 5 being very important.

4.4.3 Using the Assessment Results to Develop and Manage Capabilities

With the assessment complete, organizations will have a clear view of current capability and key areas for action and improvement. However, to further develop data space capabilities, the organization should assess and manage progress over time by using the assessment results to:

- Develop a roadmap and action plan
- Add a yearly follow-up assessment to measure progress and the value of data space adoption over time

Agreeing on stakeholder ownership for each priority area is critical to developing short-term and long-term action plans for improvement. The assessment results can be used to prioritize the opportunities for quick wins. Those capabilities have smaller gaps between current and desired maturity and those recognized as more important but might have a more significant gap to bridge.

5 Illustrative Benchmarking Example

In this section, we use five fictitious organizations to illustrate the usage of the MM4DS. In addition, this section details the assessment process and the analysis which can be performed to benchmark capabilities across the organization.

5.1 Benchmark Results

The survey should be taken by a range of stakeholders from different parts of the organization to get a holistic view. The results of the surveys are then averaged to determine the overall level of maturity for the organization. The results for the MM4DS of the example organizations are presented in Table 3. From the benchmark, we can understand the state of maturity of data space capabilities within each of the benchmarked organizations.

Table 3 MM4DS assessment results for data space capability maturity of five organizations (average from survey responses)

Pillars	Capability	Org1	Org2	Org3	Org4	Org5
(O) Organization	(O1) Strategy and planning	2.7	2.5	2.4	3.2	2.3
	(O2) Business alignment	2.8	2.3	2.1	2.8	2.1
	(O3) Performance monitoring	2.4	2.3	2.4	2.8	2.4
(V) Value	(V1) Sensing	3	2.5	2.9	2.6	2.5
	(V2) Capture	3	2.5	2.5	2.8	1.2
(D) Data	(D1) Life cycle	2.1	1.9	1.9	2.3	2.0
	(D2) Management and stewardship	2.4	2.0	2.1	2.9	2.2
(T) Technology	(T1) Infrastructure	2.9	2.4	2.1	1.8	1.8
	(T2) Support services	2.9	2.5	2.1	2.5	1.4
(P) People	(P1) Skills and culture	2.7	2.5	2.4	3.2	2.3
	(P2) Adoption and communication	2.8	2.3	2.1	2.8	2.1
(G) Governance	(G1) Policies	2.4	2.3	2.4	2.8	2.4
	(G2) Compliance	3	2.5	2.9	2.6	2.5
	(G3) Accountability	3	2.5	2.5	2.8	1.2
(T) Trust	(T1) Assurance	2.1	1.9	1.9	2.3	2.0

5.1.1 Capability Gap Analysis

Using the benchmark results, we can determine a capability gap analysis by contrasting the current and desired maturity of the organization's data space capabilities. The results of this capability gap analysis are presented in Table 4. Looking at the organizations' current average maturity of capabilities versus the desired capability maturity, we can see a clear gap across all capabilities, as detailed in Table 4.

5.1.2 Capability Importance

As detailed in Table 5 the assessment provides valuable insight into the importance of individual capabilities. Understanding the current maturity levels and importance of a capability enables an organization to identify an action plan for improvement. Analyzing the maturity gaps between the current and desired state can identify where the organizations prioritize their actions. Where the importance of a capability is correlated with its current maturity, we can derive a prioritized ranking of capability improvements.

Table 4 Capability gap analysis

Pillars	Capability	Current			Desired			Gap
		Avg.	Low	High	Avg.	Low	High	Avg.
(O) Organization	(O1) Strategy and planning	2.6	2.4	3.2	4.0	3.8	4.5	1.4
	(O2) Business alignment	2.4	2.1	2.8	3.8	3.4	4.1	1.4
	(O3) Performance monitoring	2.5	2.3	2.8	3.7	3.5	3.9	1.2
(V) Value	(V1) Sensing	2.7	2.5	3.0	3.9	3.7	4.3	1.3
	(V2) Capture	2.4	1.2	3.0	3.9	3.7	4.2	1.5
(D) Data	(D1) Life cycle	2.0	1.9	2.3	3.6	3.3	4.0	1.6
	(D2) Management and stewardship	2.3	2.0	2.9	3.7	3.2	4.3	1.4
(T) Technology	(T1) Infrastructure	2.2	1.8	2.9	3.5	3.1	4.1	1.3
	(T2) Support services	2.3	1.4	2.9	3.7	2.9	4.0	1.4
(P) People	(P1) Skills and culture	2.6	2.4	3.2	4.0	3.8	4.5	1.4
	(P2) Adoption and communication	2.4	2.1	2.8	3.8	3.4	4.1	1.4
(G) Governance	(G1) Policies	2.5	2.3	2.8	3.7	3.5	3.9	1.2
	(G2) Compliance	2.7	2.5	3.0	3.9	3.7	4.3	1.3
	(G3) Accountability	2.4	1.2	3.0	3.9	3.7	4.2	1.5
(T) Trust	(T1) Assurance	2.0	1.9	2.3	3.6	3.3	4.0	1.6

Table 5 Capability importance analysis

Pillars	Capability	Importance		
		Avg.	Low	High
(O) Organization	(O1) Strategy and planning	4.2	4.0	4.6
	(O2) Business alignment	4.4	4.2	4.8
	(O3) Performance monitoring	4.0	3.7	4.3
(V) Value	(V1) Sensing	3.8	3.6	4.3
	(V2) Capture	4.3	4.1	4.7
(D) Data	(D1) Life cycle	4.0	3.5	4.5
	(D2) Management and stewardship	3.4	3.2	4.0
(T) Technology	(T1) Infrastructure	3.7	3.3	4.2
	(T2) Support services	4.3	4.0	4.6
(P) People	(P1) Skills and culture	4.2	4.0	4.6
	(P2) Adoption and communication	4.4	4.2	4.8
(G) Governance	(G1) Policies	4.0	3.7	4.3
	(G2) Compliance	3.8	3.6	4.3
	(G3) Accountability	4.3	4.1	4.7
(T) Trust	(T1) Assurance	4.0	3.5	4.5

6 Conclusion

The MM4DS gives user-centric/demand-side organizations a vital tool to manage their data space capability to gain business value. The model provides a comprehensive value-based model for organizing, evaluating, planning, and managing data

space capabilities. Using the model, organizations can assess the maturity of their data space capability and systematically improve capabilities to meet the business objectives. The model was developed using an open-innovation collaboration model, engaging academia and industry in scholarly work following a design science research approach. In addition, an illustrative benchmark of the data space capabilities of five organizations using the model was undertaken. The initial version of the model presented in this chapter will be developed further by the task force to refine it and validate it within real-world Data Spaces.

Acknowledgments We would like to thank the contributors from the BDVA Task Force on Data Sharing Spaces. We would also like to acknowledge the comments received from BDVA members and external communities.

References

1. Scerri, S., Tuikka, T., & Lopez de Vallejo, I. (Eds.). (2020). *Towards a European data sharing space*.
2. Curry, E., Metzger, A., Zillner, S., Pazzaglia, J.-C., & García Robles, A. (2021). *The elements of big data value*. Springer International Publishing. https://doi.org/10.1007/978-3-030-68176-0
3. Curry, E. (2016). The big data value chain: Definitions, concepts, and theoretical approaches. In J. M. Cavanillas, E. Curry, & W. Wahlster (Eds.), *New horizons for a data-driven economy* (pp. 29–37). Springer International Publishing. https://doi.org/10.1007/978-3-319-21569-3_3
4. Curry, E. (2020). *Real-time linked dataspaces. Springer International Publishing.*https://doi.org/10.1007/978-3-030-29665-0
5. Curry, E., & Sheth, A. (2018). Next-generation smart environments: From system of systems to data ecosystems. *IEEE Intelligent Systems, 33*(3), 69–76. https://doi.org/10.1109/MIS.2018.033001418
6. Zillner, S., Bisset, D., Milano, M., Curry, E., Hahn, T., Lafrenz, R., Liepert, B., Robles, A. G., Smeulders, A., & O'Sullivan, B. (2020). *Strategic research, innovation and deployment agenda - AI, data and robotics partnership. Third Release* (Third). BDVA, euRobotics, ELLIS, EurAI and CLAIRE.
7. Zillner, S., Gomez, J. A., García Robles, A., Hahn, T., Le Bars, L., Petkovic, M., & Curry, E. (2021). Data economy 2.0: From big data value to AI value and a European data space. In E. Curry, A. Metzger, S. Zillner, J.-C. Pazzaglia, & A. García Robles (Eds.), *The elements of big data value* (pp. 379–399). Springer International Publishing. https://doi.org/10.1007/978-3-030-68176-0_16
8. Zillner, S., Curry, E., Metzger, A., Auer, S., & Seidl, R. (Eds.). (2017). *European big data value strategic research & innovation agenda*. Big Data Value Association. http://www.edwardcurry.org/publications/BDVA_SRIA_v4_Ed1.1.pdf
9. Wade, M., & Hulland, J. (2004). Review: The resource-based view and information systems research: Review, extension, and suggestions for future research. *MIS Quarterly, 28*(1), 107–142. https://doi.org/10.2307/25148626
10. Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal, 5*, 171–180. https://doi.org/10.1002/smj.4250050207
11. Helfat, C. E., & Peteraf, M. A. (2003). The dynamic resource-based view: Capability lifecycles. *Strategic Management Journal, 24*(10), 997–1010. https://doi.org/10.1002/smj.332

12. Sambamurthy, V., & Zmud, R. W. (1997). At the heart of success: organisationwide management competencies. In C. Sauer & P. Yetton (Eds.), *Steps to the future: Fresh thinking on the management of IT-based organisational transformation* (pp. 143–163). Jossey-Bass.
13. Bharadwaj, A. S. (2000). A resource-based perspective on information technology capability and firm performance: An Empirical investigation. *MIS Quarterly, 24*(1), 169. https://doi.org/10.2307/3250983
14. Teece, D. J., Pisano, G., & Shuen, A. M. Y. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(March), 509–533. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7%3C509::AID-SMJ882%3E3.0.CO;2-Z
15. Collis, D. J. (1994). How valuable are organisational capabilities. *Strategic Management Journal, 15*, 143–152. https://doi.org/10.2307/2486815
16. Zollo, M., & Winter, S. G. (2002). Deliberate learning and the evolution of dynamic capabilities. *Organization Science, 13*(3), 339–351. https://doi.org/10.1287/orsc.13.3.339.2780
17. Butler, T., & Murphy, C. (2008). An exploratory study on IS capabilities and assets in a small-to-medium software enterprise. *Journal of Information Technology, 23*(4), 330–344. https://doi.org/10.1057/jit.2008.19
18. Rosemann, M., & de Bruin, T. (2005). Application of a holistic model for determining BPM maturity. *BPTrends, February*, 1–21. http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Application+of+a+Holistic+Model+for+Determining+BPM+Maturity#0
19. Crawford, J. K. (2006). The project management maturity model. *Information Systems Management, 23*(4), 50–58. https://doi.org/10.1201/1078.10580530/46352.23.4.20060901/95113.7
20. Paulk, M. C., Curtis, B., Chrissis, M. B., Weber, C., & v. (1993). The capability maturity model for software. *Software Engineering Project Management, 10*(CMU/SEI-93-TR-24 ESC-TR-93-177), 1–26.
21. Luftman, J. (2003). Assessing it/business alignment. *Information Systems Management, 20*(4), 9–15. https://doi.org/10.1201/1078/43647.20.4.20030901/77287.2
22. Curry, E., & Donnellan, B. (2012). Understanding the maturity of sustainable ICT. In J. vom Brocke, S. Seidel, & J. Recker (Eds.), *Green business process management - Towards the sustainable enterprise* (pp. 203–216). Springer. Retrieved from http://www.edwardcurry.org/publications/Curry_SICTMaturity_PrePrint.pdf
23. van de Ven, A. H. (2007). Engaged scholarship: A guide for organizational and social research. In A. H. van de Ven (Ed.), *Process studies* (Vol. 33, 4). Oxford University Press. https://doi.org/10.2307/20159463
24. Chesbrough, H. W. (2003). Open innovation: The new imperative for creating and profiting from technology. In H. W. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *Perspectives academy of management* (Vol. 20(2). Harvard Business School Press. https://doi.org/10.1016/j.jengtecman.2004.05.003
25. Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly, 28*(1), 75–105. https://doi.org/10.2307/249422
26. Mettler, T., & Rohner, P. (2009). Situational maturity models as instrumental artifacts for organisational design. In V. Vaishanvi & S. Purao (Eds.), *Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology* (pp. 1–9). ACM Press. https://doi.org/10.1145/1555619.1555649
27. Braun, C., Wortmann, F., Hafner, M., & Winter, R. (2005). Method construction - A core approach to organisational engineering. *Proceedings of the 2005 ACM Symposium on Applied Computing SAC 05, 2*(c), 1295–1299. https://doi.org/10.1145/1066677.1066971
28. Hevner, A. R. (2007). A three cycle view of design science research. *Scandinavian Journal of Information Systems, 19*(2), 87–92. http://aisel.aisnet.org/sjis/vol19/iss2/4
29. Humphrey, W. S. (1989). *Managing the software process*. Addison-Wesley Longman Publishing Co., Inc.