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Adoption of Data Spaces as Multi-Sided Platforms: Towards A Preliminary Adoption Framework

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ABSTRACT

Organizations recognize the strategic value of data and explore diverse means of harnessing its potential. Opportunities for data sharing and collaboration via platforms have been discussed. Among these platforms, data spaces, as multi-sided platforms, have gained prominence. Yet, the motivations behind their adoption by organizations remain unclear. Existing literature primarily delves into technical aspects, neglecting socio-organizational considerations. Recognizing the influence of socio-organizational factors in information system adoption, our study addresses this gap. Through a structured literature review, we identify 15 adoption approaches and corresponding factors, spanning individual and organizational levels. Thus, allowing us to derive a preliminary data space adoption framework.

Keywords: Data spaces, Multi-sided platform, Platform adoption, Adoption factors.

INTRODUCTION

The so-called digital economy depends to a great extent on data as a strategic resource for enabling the value generation of organizations. One particular concept that has been considered a "game changer" is the use of platforms (Dmitrieva, 2020; Otto et al., 2015), particularly digital platforms. Their main functions are to act as intermediaries and to bring together supply and demand (Bartelheimer et al., 2022; Kenney & Zysman, 2016). Due to these functions and their importance for the digital economy, the number of digital platforms has increased tremendously, leading to the establishment of the term 'platform economy' (Bartelheimer et al., 2022; Kenney & Zysman, 2016). In particular, their intermediary function, i.e., connecting participants sharing economic objectives (e.g., buyers and sellers), has led to the term 'multi-sided platforms' (MSPs) to describe this phenomenon (Abdelkafi et al., 2019; Hagiu, 2007). Due to the characteristics of digital platforms (e.g., scalability, marginal transaction costs, exploitation of network effects) platformization has become a trend, mainly in business-to-consumer (B2C) markets, over the past decade (Akberdina & Barybina, 2021). There is some evidence that the adoption of MSPs depends on the type of ownership, e.g., single organization vs. alliance-driven (De Reuver et al., 2018). However, many platforms have failed in recent years, due in part to non-adoption (Özcan et al., 2022; Spiekermann, 2019; Yoffie et al., 2019). The idea of MSPs nonetheless remains valid, including concepts beyond the exchange of goods; MSPs facilitate data sharing, as is reflected by the concept of data spaces (Otto & Jarke, 2019a). In this regard, data spaces are typically seen as multi-sided platforms driven by alliances, enabling federated data sharing among multiple organizations (Otto & Jarke, 2019a).

Aside from the enormous potential of digital platforms in terms of doing business (e.g., for transactions of goods and services), it has been argued that the data linked to such platforms comprises an extensive "treasure trove" for participants (Otto & Jarke, 2019b). While data platforms aim at managing the collection of data, they can also be understood in terms of technical infrastructure (Strnadl & Schöning, 2023). Data spaces enable a different means of data sharing amongst participants, as well as the integration of both data and data intelligence (Curry, 2020). As an institutionalization of distributed data integration, a federator in data spaces provides intermediary services (Otto, 2022). Despite their potential, data spaces are a novel type of digital platform and have not yet garnered substantial attention (Beverungen et al., 2022a). Data spaces can be implemented in data environments to ensure data sovereignty (Hutterer & Krumay, 2022; Otto et al., 2016). Interestingly, data spaces and their associated platforms are designed to create data ecosystems that streamline data sharing both within and between organizations (Schleimer et al., 2023). Even though the data space concept is promising (Franklin et al., 2005), the knowledge base about data space adoption remains low (Otto, 2022). Consequently, a "conditional relationship exists between the product platform that underlies the data space and the industry platform that is multi-sided towards its participants" (Strnadl & Schöning, 2023, p. 24). Initially, data spaces were proposed in the industrial sector, in 2010 (J. Guo et al., 2021). More recent initiatives focus on a broader establishment and use of data spaces (European Commission, 2018; IDSA, 2019; Minghini et al., 2022).

As the current literature on data spaces mainly adopts a technical perspective and describes functionalities (Hutterer & Krumay, 2022), it lacks an independent theoretical foundation (Hirsch-Kreinsen et al., 2022). The current body of literature has analyzed the requirements of data spaces and data-driven organizations (DDOs) with a primary focus on delineating capabilities (Hupperz & Gieß, 2024). However, what remains absent is a theoretical framework that can comprehensively describe the adoption of data spaces. Additionally, the socio-organizational aspects of adopting and implementing data spaces have rarely been researched. Therefore, the present study's focus is on exploring reasons for implementing or adopting data spaces, from a management

perspective. Specifically, we seek to identify the driving factors that motivate organizations to participate in data spaces in a globalized data economy.

Interestingly it has been stated that the body of knowledge regarding B2C platform adoption can hardly be applied to B2B platforms, due to the distinctive conditions under which they operate (Pauli et al., 2021a). In contrast to B2C platforms, B2B platforms have a higher level of technical and commercial complexity, with organizations rather than individual users taking on the role of participants (Hein et al., 2019; Pauli et al., 2021b). Notable, there are several platform concepts in the IS literature (Bartelheimer et al., 2022). Due to definitional inconsistencies of platform subtypes, e.g., MSP (Hagiu & Wright, 2015), we assume that platform adoption research in general may inform data space research. There is research on the adoption of platforms in general, as well as digital platforms in particular (Akberdina & Barybina, 2021; Dmitrieva, 2020). As for data spaces as MSPs, however, research remains—to the best of our knowledge—rather scarce (Beverungen et al., 2022b; Otto & Jarke, 2019b), as "especially the (very) early stages of the MSP emerging – are still relatively unexplored" (Otto & Jarke, 2019b). The goal of this study is therefore to identify factors influencing data space adoption. Given that only a few data spaces have presently been implemented, obtaining the requisite empirical data is challenging. We therefore address the following research question: Which factors influencing platform adoption in general can be identified as also affecting the adoption of data spaces as MSPs? However, as previously noted, data spaces are MSPs and thus share characteristics with digital platforms. Therefore, we present a structured literature review to identify approaches (models, theories, frameworks, etc.) for platform adoption and use the results as a basis for drawing conclusions via analogy. Based on those conclusions and the results from the literature review, we offer a preliminary data space adoption framework for the scientific community.

The remainder of this paper is structured as follows. Section two provides background information on platforms, data spaces, and adoption approaches. In section three, we present the structured literature review. Our results, particularly focused on outcomes from the literature review, are presented in section four. Section five discusses these results, focusing mainly on the applicability of the approaches for the adoption of data spaces, including the emergent preliminary data space adoption framework. Finally, we present the study's conclusions, discuss its limitations, and propose future research priorities.

BACKGROUND INFORMATION

Platforms, which have become a central component of digital business models in the past ten years, provide an infrastructure for commodity exchange (De Reuver et al., 2018; Dmitrieva, 2020). Electronic marketplaces, for example, are platforms characterized by both buying and selling features (Schmid & Lindemann, 1998), making them an integral part of the entire transaction of goods and services (Yanagisawa & Guellec, 2009). Marketplaces in general (electronic or otherwise) serve three main functions: (1) matching buyers and sellers, (2) facilitating transactions, and (3) providing the institutional infrastructure for business markets (Bakos, 1998). Although transaction platforms represent marketplaces, not all platforms connecting buyers and sellers manage whole transactions (Koutroumpis et al., 2017). Platforms also allow technological and engineering perspectives, qualifying platforms as a type of technological architecture classified by their participants, e.g., internal platforms, supply-chain platforms, or industry platforms (Gawer, 2014). Digital platforms, naturally generate data as a byproduct of their operations, primarily provide a diverse range of services that extend beyond data-related functions (De Reuver et al., 2022). In contrast, data platforms specialize in facilitating data exchange and monetization, playing a crucial role in driving the emerging data economy and manifesting in diverse forms, i.e., data marketplaces (Abbas et al., 2021), data collaboratives (Susha et al., 2017) and data spaces (Beverungen et al., 2022b). Further, the literature does not offer a comprehensive exposition elucidating the motivations and incentives underpinning data sharing (Gelhaar et al., 2023). In the realm of academic discourse, there remains an ongoing lack of precise definition regarding the concept of data sharing, particularly in the context of its interchangeable usage within the literature, e.g., data exchange (Jussen et al., 2023). In addition, there is a notable lack of research that addresses the barriers organizations face in the practice of data sharing (Fassnacht et al., 2023).

The digital economy has yielded not only digital marketplaces but also platforms to enable extensive data exchange (De Reuver et al., 2022; Stahl et al., 2014). Although data can also be made available free of charge, as in the case of open data (Zuiderwijk et al., 2014), data marketplaces, also referred to as data platforms, have been specifically designed to facilitate data exchange (Abbas et al., 2021, 2023; Fruhwirth et al., 2020). In their digital form, their potential is fully exploited, allowing fast and easy exchange of data and thus contributing to the value generation of organizations (Abbas et al., 2022; Spiekermann, 2019). The architecture of such marketplaces may be either centralized or decentralized (Koutroumpis et al., 2017). While centralized architectures are mainly driven by a cloud service or data storage provider, decentralized architectures allow the preservation of data sovereignty, as the data remains with the organization providing the data (Spiekermann, 2019). However, this makes "the exercise of data processing and data storage more difficult for the actors" (Spiekermann, 2019). In this regard, the data space concept exhibits the same characteristics: It is defined as an MSP for sharing data, allowing data management via a Data Space Support Platform (DSSP), while following a decentralized approach (Franklin et al., 2005; Otto & Jarke, 2019b). Data Spaces allows data sharing amongst participants while also preserving data access at the same time (Franklin et al., 2005). When data sharing between different organizations in data spaces is established, data ecosystems evolve (Gelhaar & Otto, 2020). Beyond the technical perspective, a data space also represents a sociotechnical system (M. Singh & Jain, 2011), with specific requirements related to the socio-organizational perspective, such as security (Brost et al., 2018).

The data space concept (Franklin et al., 2005) and in particular DSSPs serve as the basis for data spaces designed as a multi-sided data platform (Otto & Jarke, 2019b). While the term 'data space' appears to have broad usage in both academic and

business contexts, there is significant variation in the understanding of its defining characteristics (Hutterer et al., 2023). Its design aims to establish a platform ecosystem while ensuring data sovereignty by developing an architecture (Otto & Jarke, 2019b), as proposed by the IDS initiative (IDSA, 2022c). The DSSPs, i.e. federators, as conceptions of a data intermediary, provide data intermediation services between participants (Schweihoff et al., 2023), enabling direct exchange between participants (Otto, 2022). Moreover, data spaces consist of six elements: (1) a connector (ensures that participants maintain sovereignty over the data); (2) a metadata broker (i.e., a data source registry); (3) a vocabulary provider (service to create, maintain, manage, monitor, and validate identity information of and for participants); (4) an identity provider (a one-stop-shop to safeguard and secure data exchange); (5) a app store (for provision of apps); (6) a clearing house (provides clearing and settlement services for all financial and data exchange transactions) (Drees et al., 2021; Pettenpohl et al., 2022). Interestingly, a data space can have different architectures (Schleimer et al., 2023) or designs (Gieß et al., 2023). Specifically, there are several design options for data space connectors (Gieß et al., 2024). Varying centralized approaches with operating companies as federators (Catena-X, 2023; Mobility Data Space, 2023), or more decentralized approaches like Pontus-X (Pontus-X, 2023). For example, the Pontus-X network (GEN-X) blockchain-network (Pontus-X, 2023) is a distributed ledger technology based on Ocean Protocol (Ocean Protocol Foundation, 2022). Various data space projects have been initiated (Steinbuss et al., 2023), unfortunately mostly focus on Europa at the beginning. Due to global value chains, such as Catena-X in the automotive sector (Catena-X, 2022), there is a pursuit of internalization (Catena-X, 2023; IDSA, 2022b). Thus, the IDSA becomes a global initiative (Bub, 2023; Jürjens et al., 2022), which additionally certifies components (Pettenpohl et al., 2022), i.e., connectors (Giussani & Steinbuss, 2023).

Although the concept of platforms is generally promising, some platforms have failed (Özcan et al., 2022). Such failures can be due to a lack of adoption or falling short of the critical mass of participants needed to benefit from network effects (Spiekermann, 2019; Yoffie et al., 2019). Information systems research has explored the adoption of technologies broadly, as is reflected by the various concepts, theories, and frameworks that have been proposed to address the issue of factors influencing technology adoption (Alhammadi et al., 2015; Al-Suqri & Al-Aufi, 2015). Technology adoption in general has been defined as "the first use or acceptance of a new technology or new product" (Khasawneh, 2008). Technology adoption can be analyzed at an individual or organizational level or both (Jeyaraj et al., 2006; Stieglitz et al., 2018), both of which have been addressed by the Innovation Diffusion Theory (IDT), also referred to as diffusion of innovation (DOI) (Al-Suqri & Al-Aufi, 2015; Rogers, 1995). However, many other approaches focus on the individual level, i.e., determining the factors that influence an individual's decision to adopt or not adopt certain technologies (Deng et al., 2019). Within the information systems literature, the Technology Acceptance Model (TAM) (Davis et al., 1989; Venkatesh & Davis, 2000) seems to be the most widely used (S. Hong et al., 2006; Rahimi et al., 2018; Scholten, 2017). TAM has progressed through different iterations and has been applied to a range of topics, including online investments (Konana & Balasubramanian, 2005), telemedicine services (Kamal et al., 2020), and autonomous driving (Koul & Eydgahi, 2018). Other approaches to explaining adoption include the Perceived Characteristics of Innovations (Moore & Benbasat, 1991), Social Cognitive Theory (Bandura, 1986), the Theory of Planned Behavior (TPB) (Ajzen, 1991), and the Theory of Reasoned Action (Fishbein & Ajzen, 1975). The Unified Theory of Acceptance and Use of Technology (UTAUT) is another example that combines eight different approaches in a condensed model (Venkatesh et al., 2003). In contrast, at an organizational level, the technology–organization–environment (TOE) framework is widely applied, mainly regarding technology adoption decisions (Tornatzky et al., 1990). The framework is a versatile approach for evaluating technology adoption and can be extended to include other approaches (Oliveira & Martins, 2011). It has been applied to topics including cloud computing (Low et al., 2011; Oliveira et al., 2014), the Internet of Things (IoT) (Lin et al., 2016; Sivathanu, 2019), or Enterprise Systems (Boumediene & Kawalek, 2008). Other models of organizational-level technology adoption include the diffusion/implementation model (Kwon & Zmud, 1987) and the Tri-Core Model (Swanson, 1994). Some research to date has compared different approaches on different levels. For example, comparing adoption on the individual level based on TAM versus adoption on the organizational level based on the TOE framework showed that both frameworks are valid but can be integrated based on specific variables (Gangwar et al., 2015).

METHODOLOGY

This study aims to identify factors influencing data space adoption. Our research uses existing approaches (models, theories, frameworks, etc.) for platform adoption in general to draw analogy conclusions for data space adoption. We apply a three-stage process approach for the structured literature review (SLR), as developed by Tranfield et al. (2003), to create a reliable knowledge stock. The approach has been applied in various IS research studies, e.g., in the context of digital twin (Jones et al., 2020), industry 4.0 (Ghobakhloo, 2020) or digital transformation (Hanelt et al., 2021). In the first stage, the procedure is planned based on the research question. In the second stage, the literature is selected and analyzed. In the final stage, the results are presented.

We drew inspiration for the screening from the process proposed by Dybå and Dingsøyr (2008). For a high-quality selection of scientific literature, the following databases were consulted: ACM Digital Library, IEEE Explore, ScienceDirect, and Scopus. Based on our study's research question, keywords were identified (i.e., 'platform', 'adoption'). Given that data platforms and data spaces exhibit distinctions from digital platforms, and their characteristics are not readily transferable (De Reuver et al., 2022), we have opted to employ the broad term "platform" as a keyword. As the combination of these keywords ('platform' AND 'adoption') yielded more than 15,000 results, the search criteria were further refined. First, only articles published in English from 2010 to 2021 were considered, in order to prioritize more recent results. The timeframe was set this way because data spaces first appeared in the industrial domain in 2010 (J. Guo et al., 2021). Literature was excluded due to a lack of content fit (e.g., title not focusing on platforms); we also excluded technical articles, newsletters, and gray literature. Because there has

already been an exploration of the technical problem-solving aspects of data spaces (Hutterer & Krumay, 2022), we have conducted a focused search for non-technical dimensions. After the additional exclusion of unavailable papers, 107 remained. Next, redundant and inaccessible studies were excluded, leaving a total of 83 publications. By reading their abstracts, further studies were excluded due to not fitting the research aim (n=27). Following the final quality assessment, a total of 21 papers were used for the analysis. Because our research question centers on identifying factors related to the adoption of data spaces, this step involved excluding articles that do not address technology adoption approaches, as they do not align with the scope of this study, i.e., Hallikainen & Aunimo (2020).

RESULTS

The studies selected for further analysis showed that there is growing interest in the adoption of digital platforms. In our sample of papers published between 2010 and 2021, only one paper (X. Guo et al., 2010) was published 2010, with a growing number of studies published over time, including five publications in 2020 (De Prieelle et al., 2020; Delgosha & Hajiheydari, 2020; Tamilmani et al., 2020; Tomičić-Pupek et al., 2020; Zeng et al., 2020). Eight papers in the sample were published in conference proceedings, whereas 13 are journal papers, some of which were in highly ranked journals.

Classification Results

To identify approaches related to platform adoption, we performed an analysis of the papers in our sample. Based on this analysis, we identified 15 different approaches, of which only five focused on the organizational level (see Table 1). Only one study (X. Guo et al., 2010) investigated adoption on both levels, six studies focused exclusively on the organizational level, and the rest (14) were at the individual level. Interestingly, some studies based their investigation on more than one approach or even combined approaches (Arif & Suzianti, 2019; Blesik & Bick, 2016; Freire et al., 2014; X. Guo et al., 2010; Hasyati & Suzianti, 2018; S. Hong et al., 2006; Song et al., 2018). At the individual level, we found UTAUT to be the most widely used approach (seven times), followed by TAM (five times), and IDT/DOI (three times). All other individual-level approaches were each used in only one study. At the organizational level, most studies applied the TOE framework (five studies), followed by the IDT/DOI approach (two studies). In addition, two studies provided comprehensive overviews of adoption factors (De Prieelle et al., 2020; J. Hong et al., 2021). Table 1 shows a detailed analysis of the 21 selected articles, identifying a total of 154 adoption factors.

Table 1: Adoption approaches for platforms on individual and organizational levels

Adoption Level	Study	Factors from approaches	Research framework	Platform
Individual & Organizational	(X. Guo et al., 2010)	Consumer: Intention, Attitude, Subjective Norm, Controllability, Self-Efficacy, Merchant Abundance, Product Abundance, Usefulness, Ease of use, Facilitating Conditions, External Influence, Information Protection Merchant: Usage Decision, Relative Advantage, Compatibility, Costs, Security Concern, Organization Size, Competitive	Consumer: TPB Merchant: TOE framework and IDT	Mobile Marketing Platform
Individual	(Xie et al., 2021)	Social Influence, Facilitating Conditions, Performance Expectancy, Effort Expectancy, Perceived Risk	UTAUT	FinTech Platform
	(A. Singh et al., 2021)	Perceived Usefulness, Perceived Ease of Use, Cost Effectiveness, Interactivity	TAM	Digital Collaboration Platform
	(Tamilmani et al., 2020)	Social Influence, Performance Expectancy, Effort, Expectancy, Hedonic Motivation, Facilitating Conditions, Self-Efficacy, Trust	Revised UTAUT	Airbnb Platform
	(Delgosha & Hajiheydari, 2020)	Perceived complexity, Platform application security concerns, Service provider performance ambiguity, Service provider trust worthiness issues, Financial concerns, Financial benefits, Flexibility, ODSP application superior functionality, ODSP special services	Behavioral Reasoning Theory (BRT)	On-demand Service Platform

	(Tomičić-Pupek et al., 2020)	Relationship history, Payment options, Comfort & convenience, Customer recommendations (C2C2C), Community support, Producer's reliability, Trust & traceability, Regulatory compliance, Incentives and sustainability, Outbound logistics, Innovations, Inbound logistics, Resources, Product Quality, Producing technologies, Health & food safety, Sales channels, Eco-friendliness, Location & time (from farm to fork)	Value Adoption Model (VAM)	Digital Platform in Agriculture
	(Arif & Suzianti, 2019)	Cognitive Need, Affective Need, Social Need, Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions	Uses and Gratification Theory (UGT)	Mobil learning platform
	(Syafinal & Suzianti, 2019)	Confirmation, Perceived Usefulness, Perceived Ease of Use, Perceived Risk, Satisfaction, Attitude, Subjective Norms, Continuance Intention	Technology Continuance Theory (TCT)	Booking service platform
	(Kurniawan, 2019)	Ease of use, Usefulness, Perceived Benefit, Perceived Risk, Credibility, Trust, Attitude, Behavior Intention to Use, Actual Use	TAM	Lending service platform
	(Hasyati & Suzianti, 2018)	Performance Expectancy, Effort Expectancy, Facilitating Conditions, Social Influence, Information Quality, System Quality, Trust, Compatibility	Information Systems Success Model (ISSM)	Online Platform for Development Planning Discussion
	(Song et al., 2018)	Relative advantage, Platform innovativeness, Technical compatibility, Platform openness, Market potential, Marketability, Developer tools, Personal benefit, Enjoyment, Related knowledge, Personal innovativeness, Social influence	SCT = Social Cognitive Theory	IT-Platform for mobile application developers
	(Blesik & Bick, 2016)	Internal Motivation, External Motivation, Internal Self Concept, External Self Concept, Importance of Crowdsourcing Features, Importance of Restrictive Features, Perceived Ease of Use, Perceived Unintentional Risk	TAM and UTAUT	Medical Information Platforms
	(Steiner et al., 2016)	Perceived Hardware Price, Perceived Software Price, Perceived Monetary Sacrifice, Perceived Software Quality, Perceived System Value, Perceived Software Variety, Expected Installed Base, Expected Direct Network Effect, Expected Indirect Network Effect	Perceived Value Model (PVM)	Platform-based systems for entertainment products
	(Freire et al., 2014)	Social influence, trust, perceived privacy, perceived security, age, gender, internet experience, perceived web design, perceived ease of use, relative advantage	TAM, DOI, and UTAUT	E-government platforms
	(Miranda et al., 2014)	Testability, Observability, Compatibility, Complexity, Relative Advantage	Diffusion of innovations	Mobile development platforms
Organizational	(Chaudhary & Suri, 2021)	Price, Transaction Cycle, Easy to User, Infrastructure, Customer Career, Social Influence, Trust, Cost	Multilayer Perceptron (MLP)	Agricultural e-trading platform
	(J. Hong et al., 2021)	Organizational resources, External pressures, Ease of use, Relative advantage, SCSP adoption, Quality performance, Economic performance, Platform governance	Inter-organizational Relationship Theory (IOR)	Supply chain service platforms
	(Zeng et al., 2020)	Ease of use, Usefulness, Relative advantage, Cost, Information confidentiality, Service quality, Top management support, Firm size, Ownership structure, Industrial characteristics Power: authority, supply chain partners, Institutional environment	TOE Framework	Inter-organizational information systems (IST)

	(De Prieelle et al., 2020)	Benefits, Costs, Ease-of-use, Compatibility, Reliability, Scalability, Security, Technological readiness, Financial readiness, Human readiness, Application user readiness, Enabling party readiness, Trust in application user, Trust in enabling party, Relative power application user, Relative power enabling party, External pressure, Regulation, Governance mode, Governance of data ownership, access, Governance of data usage	TOE Framework	Data platform
	(Shim et al., 2018)	Network Effect Benefits, New Platform Benefits, New Platform Risk, Organizational Learning, Mimetic Pressure, Competitive Pressure, Firm Size, Firm Year, Profit	TOE Framework	Open platform
	(Gebregiorgis & Altmann, 2015)	Attractiveness of IT Platform, Number of Actual Customers, Revenue, Allocated Budget for Improving QoS, Usability, Portability & Interoperability, Standards, Market Power, Platform Maturity, Trust, Switching & Integration Cost, Training Cost, Charge per Customer, Quality of Service, Total Cost, Customer Satisfaction, Attractiveness of IT Platform.	Value Creation Model (VCM) and System Dynamics Methodology	IT-Service platforms

Individual and organizational level

As already mentioned, only one paper in the sample investigated adoption at both the individual and the organizational level (X. Guo et al., 2010). For that study, an integrated two-sided framework was developed to analyze platform adoption by consumers and merchants. The consumer side was based on TPB, whereas the merchant side combined IDT and TOE approaches, which were extended to include factors that incorporate cross-network effects. Based on a quantitative approach, Guo et al. (2010) concluded that a platform's cross-network effects do not directly affect user attitudes toward the platform. In addition, the effect of information protection was also found to be insignificant. However, network effects were found to be of particular importance. On the merchant side, competitive pressures harm adoption decisions; thus, network effect factors have significant effects. The size and value of the consumer group were found to have significant impacts on relative advantage. Overall, the two-sided cross-effects were found to promote the adoption of platforms by smaller firms.

Individual level

Our sample included 14 studies that focused on the individual level. These papers investigated a range of different platforms, including FinTech platforms (Xie et al., 2021), digital collaboration platforms (A. Singh et al., 2021), and Airbnb (Tamilmani et al., 2020). The majority of the papers used UTAUT; however, this was mostly in combination with other approaches and applied quantitative analysis. Xie et al. (2021) even extended UTAUT in the context of FinTech platforms, by using financial consumption attributes to complement UTAUT. They concluded that adoption intention in this context is strongly influenced by perceived value, perceived risk, and social influence. Furthermore, perceived value is influenced by the effects of performance expectancy, effort expectancy, and perceived risk. As an example, Freire et al. (2014) investigated the adoption of e-government platforms by Portuguese citizens. To develop a conceptual model, they used TAM, DOI, and UTAUT as a basis. To measure usage intentions, they employed a combination of factors, including trust, privacy, social influence, security, relative advantage, web design, and perceived ease of use. Similarly, Arif and Suzianti (2019) investigated the adoption of mobile devices for a learning platform, by combining UTAUT and UGT approaches. Their quantitative analysis showed that four factors significantly influence mobile application usage: (1) cognitive need, (2) effort expectancy, (3) intention to use, and (4) facilitating conditions. Furthermore, Blesik and Brick (2016) studied crowdsourcing platforms for medical diagnostics, by combining TAM and UTAUT approaches. Integrating user acceptance, risk avoidance, and motivational influencing factors revealed a correlation between risks and functions; in addition, these factors also influenced perceived usefulness (PU), i.e., PU is decreased by perceived risks and increased by crowdsourcing functions. Furthermore, external motivation was identified as an influencing factor.

In contrast, Hasyati and Suzianti (2018) aimed to develop an adoption strategy based on UTAUT and ISSM. They investigated the Online Platform for Development Planning Discussion and identified six acceptance factors, of which social influence, facilitating conditions, and performance expectancy were found to significantly influence adoption intentions. Song et al. (2018) based their research on TAM, UTAUT, DOI, and social cognitive theory; they used these approaches to analyze platform adoption of developers, consumers, and manufacturers. In the first step of their study, factors from perceived platform characteristics, perceived network externalities, individual characteristics, and social interaction were identified. Unlike previous adoption studies, this study also incorporated technology characteristics and network externalities. The analysis determined that IT platform adoption is influenced by developers' perceived platform characteristics, individual characteristics, network externalities, and social influence. Furthermore, Tamilmani et al. (2020) investigated individuals' usage intentions of Airbnb based on a revised UTAUT model, which included hedonic motivation, trust, and self-efficacy factors. They found that effort

expectancy, social influence, and facilitating conditions have a major influence on technology usage intentions; performance expectancy, attitude, trust, and self-efficacy also exert a direct influence.

In addition to UTAUT, TAM was identified as an investigation basis five times in our study's sample, with TAM and UTAUT combined in three of these studies (Blesik & Bick, 2016; Freire et al., 2014; Song et al., 2018). The two remaining studies using TAM to investigate digital collaboration platforms (A. Singh et al., 2021) and a peer-to-peer lending platform (Kurniawan, 2019). Kurniawan (2019) based their research on TAM, showing that perceived benefit, trust, usefulness, and ease of use all represent significant influencing factors. In contrast, A. Singh et al. (2021) examined adoption intentions on digital collaboration platforms based on TAM, finding that interactivity, cost-effectiveness, perceived usefulness, and perceived ease of use all positively influence adoption. DOI was found to be the underlying theory used in three studies, while two other studies (Freire et al., 2014; Song et al., 2018) combined it with UTAUT and TAM. Only Miranda et al. (2014) relied solely on DOI, to investigate software developers' mobile platform choices. Interestingly, this study applied a qualitative method (i.e., semi-structured interviews) and grounded theory techniques (Charmaz & Belgrave, 2012). The results showed that developers value different characteristics of mobile platforms, with the Android platform being valued for accessibility and compatibility and iOS being valued for the seemingly more lucrative platforming.

Other approaches in explaining adoption were each found in only one paper and often in combination with other approaches. In particular, these include ISSM in combination with UTAUT (Hasyati & Suzianti, 2018), SCT in combination with TAM, UTAUT and DOI (Song et al., 2018), TPB in combination with TOE (X. Guo et al., 2010), and UGT in combination with UTAUT (Arif & Suzianti, 2019). Hence, four remaining approaches have not been discussed. Delgosha and Hajiheydari (2020) applied BRT to investigate the acceptance of and resistance toward on-demand service platforms to assess digital platforms as new sociotechnical systems. Their study revealed that the negative effects of reasons against can lead to bias in terms of reasons for, which could influence consumers' attitudes and adoption intentions. Consequently, their study provides insights into the logical processes for and against the use of digital platforms. In contrast, Syafinal and Suzianti (2019) investigated the factors influencing the use of platform X, a health application used to manage sports activities. Their analysis employed TCT to investigate the influence of confirmation, perceived usefulness, perceived ease of use, perceived risk, satisfaction, attitude, and subjective norms on usage continuance intentions. Tomičić-Pupek et al. (2020) examined adoption factors in the agricultural industry based on the VAM, including perceptual factors, which were used to investigate individuals' intentions to join. Overall, their study provides an improved understanding of matching between consumers and producers. Finally, Steiner et al. (2016) investigated the expectation of direct and indirect network effects on the game console market based on the PVM. The "give" components (i.e., software variety and quality) and "get" components (i.e., hardware prices, software prices, and monetary sacrifice) define the value of the system. Their study showed that new platforms can benefit from improved targeting, especially, at the beginning of the customer lifecycle; as the platform progresses, the offering can be expanded. Furthermore, the authors highlighted the need to integrate behavioral insights into go-to-market strategies.

Organizational level

At the organizational level, the platforms investigated by previous studies range from the agricultural (Chaudhary & Suri, 2021) to the maritime sector (Zeng et al., 2020). The most widely used framework is TOE (five studies); however, the TOE-based study combining organizational and individual levels (X. Guo et al., 2010) has been discussed above. Hong et al. (2021) examined the academic literature for theories applicable to supply chain service platforms that coordinate the flows of goods. The authors used TOE, IDT, and IOR as the theoretical underpinnings for their research. Their analysis revealed that organizational resources and external pressures have significant and direct influences on platform adoption. Furthermore, both factors impact the perceived value of the platform, thus illustrating that platform adoption and company performance are positively correlated. The study by De Prieelle et al. (2020) describes the facilitated exchange of IoT data via platforms. The authors identified adoption factors for inter-organizational systems in the existing literature, to supplement the TOE framework. The study's data, collected from the vegetable growing industry, were analyzed using multi-criteria decision analysis, based on the best–worst method. Interestingly, they found that benefits and readiness were considered the most important aspects, while ecosystem data governance was ranked as the most significant factor for platform providers. Using an adapted TOE framework, Zeng et al. (2020) examined the adoption of a platform for cross-organizational information sharing in the maritime sector. The authors identified factors in their model, such as industry characteristics, the confidentiality of the system's information, the power of trading partners in the supply chain, governmental power, and the ownership structure of the company. Based on their analysis, system confidentiality, service quality improvement, ownership structures, and government legislation were found to be of significant influence. Furthermore, their work identified that initiatives by market-constraining actors can drive adoption readiness. The final study applying TOE investigated the adoption of open platforms in organizations (Shim et al., 2018). For this purpose, the authors designed a TOE framework that drives herding. This model includes network effect benefits, new platform benefits, new platform risks, organizational learning, mimetic pressures, and competitive pressures. Their study reveals two distinct phases. In the first phase, new platform risk and organizational learning influence herd behavior; in the second phase, the benefits of new platforms and competitive pressures determine herd behavior. These phases can be explained by the fact that when platforms are successfully adopted, competitors then imitate the early adopters.

The studies using IDT (X. Guo et al., 2010; J. Hong et al., 2021) and IOR (J. Hong et al., 2021) have already been presented; thus, MLP (Chaudhary & Suri, 2021) and VCM approaches remain (Gebregiorgis & Altmann, 2015). Chaudhary and Suri (2021) explored the adoption factors of wholesale e-trading platforms, based on MLP. Due to the lack of literature in this area, the

authors identified adoption factors in the first phase of their study and subsequently established a research framework. Predictions regarding the adoption of the agricultural trading platform were generated using a neural network-based classification tool, which incorporated the MLP procedure. On this basis, it was found that the two most crucial factors influencing the adoption of an agricultural trading platform are fast transaction cycles and higher prices. Gebregiorgis and Altmann (2015) investigated the influence of openness on cloud computing platform adoption. In contrast to closed platforms, open IT service platform systems are defined by their portability, interoperability, and usability. Accordingly, the authors designed a value creation model for IT service platforms. The simulation results reveal only an understanding of trends in the market.

DISCUSSION

Due to the expectations expressed towards data spaces in research, business, and policy making, their adoption is an important topic for the near future. Because the extant research literature lacks an approach to describe or explain data space adoption, this study aimed at identifying factors influencing data space adoption. As literature on actual data space adoption is scarce (Hutterer & Krumay, 2022), we investigated literature on platform adoption in general. We identified 15 approaches (models, theories, frameworks, etc.) as the basis for deriving a preliminary framework for data space adoption, mainly to lay the foundations for further academic discussion. Accordingly, our study contributes to the academic knowledge on this topic area, and also provides insights for prospective data space participants. Although the 21 papers examined in our study mainly focused on platform adoption, they nonetheless yield important insights for data space adoption.

The papers identified in the SLR addressing data platforms (De Prieelle et al., 2020), open platforms (Shim et al., 2018), and supply chain service platforms (J. Hong et al., 2021) even discussed challenges to data sharing via a platform. In this regard, data governance (in particular, ecosystem data governance) emerged as a relevant influencing factor for adoption (De Prieelle et al., 2020). Data governance involves governance modes, ownership and access, and data usage, all of which influence platform adoption (De Prieelle et al., 2020). Governance of data ownership and control is particularly essential for organizations that participate in platforms, and the mode of governance is a critical success factor for platforms (Provan & Kenis, 2007; Van Den Broek & Van Veenstra, 2015). In addition, the mimetic pressure in the terms of perceived rate of competitors' adoption seems essential to platform adoption (Shim et al., 2018), as does the perceived value of the platform for its participants (J. Hong et al., 2021). The results of the literature review reveal that external pressure is an environmental factor that has the potential to impact the decision-making processes regarding use of a data space (De Prieelle et al., 2020; J. Hong et al., 2021; Iacovou et al., 1995; Lippert & Govindarajulu, 2006; Rui, 2007; Shim et al., 2018; Sun et al., 2018). Furthermore, trust (Gelhaar & Otto, 2020), particularly regarding the reliability of a platform, positively affects user appeal in platforms (Chaudhary & Suri, 2021; De Prieelle et al., 2020; Gebregiorgis & Altmann, 2015). Within the literature, regulation has been recognized as an environmental factor that pertains to the guidelines and legal provisions governing the sharing of data (De Prieelle et al., 2020; Lippert & Govindarajulu, 2006).

The decision to adopt data spaces may also be affected by a range of organizational factors that can either support or hinder the process. One particularly critical factor is the support of top management, which has been shown to be important for technology adoption in general and may also apply to data spaces (Ilin et al., 2017; Kurnia et al., 2015; Oliveira et al., 2014; Reyes et al., 2016; Zeng et al., 2020). Another set of key factors relates to the readiness of an organization, which consists in having the appropriate technological resources (De Prieelle et al., 2020; Grover, 1993; Iacovou et al., 1995; Kuan & Chau, 2001; Premkumar & Ramamurthy, 1995; Rui, 2007; Zhu, Xu, et al., 2003) as well as sufficient financial resources to cover the costs of implementation (Bouchbout & Alimazighi, 2008; De Prieelle et al., 2020; Grover, 1993; Iacovou et al., 1995; Kuan & Chau, 2001; Premkumar & Ramamurthy, 1995; Zhu, Xu, et al., 2003). In addition, human resources—more specifically, employees with the necessary knowledge and skills—are also important (Chau & Tam, 1997; De Prieelle et al., 2020; Grover, 1993; Iacovou et al., 1995; Rui, 2007; Zhu, Xu, et al., 2003). Finally, the size of an organization may also be a significant factor in technology adoption, including the adoption of data spaces (Harris et al., 2015; Kurnia et al., 2015; Lai et al., 2006; Oliveira et al., 2014; Shim et al., 2018; Wang et al., 2010; Zeng et al., 2020).

Interestingly, several factors were identified that may influence the technological implementation of data spaces. Relative advantage is the perceived improvement of the technology over existing alternatives (De Prieelle et al., 2020; J. Hong et al., 2021; Shim et al., 2018; Zeng et al., 2020). Furthermore, compatibility concerns how well a technology aligns with an organization's existing values, experiences, and needs (Bouchbout & Alimazighi, 2008; De Prieelle et al., 2020; Rogers, 1995; Rui, 2007). Costs are the expenses incurred by an organization when adopting the platform (Chaudhary & Suri, 2021; De Prieelle et al., 2020; Gebregiorgis & Altmann, 2015; Zeng et al., 2020; Zhu, Kraemer, et al., 2003). Scalability consists in the ease with which the platform can be adjusted, in terms of size, scope, and function (Bouchbout & Alimazighi, 2008; De Prieelle et al., 2020; Lippert & Govindarajulu, 2006). Security is a major concern in organizations when activities are performed over the internet; this relates to security attributes of the platform (Bouchbout & Alimazighi, 2008; De Prieelle et al., 2020; Fu et al., 2014; Lippert & Govindarajulu, 2006; Yang & Maxwell, 2011).

Further aspects that may play a role can be derived from the existing literature. Other influencing aspects relate to the ecosystem typology (Guggenberger et al., 2020), such as openness, centralization vs. decentralization, and data sovereignty; these are all influencing factors for platform adoption (Spiekermann, 2019; Zuiderwijk et al., 2014). However, beyond the architecture design options of the data space (Schleimer et al., 2023), there also seems to be a need for an architecture description (Bianco et al., 2014). While data spaces serve as technical platforms, they also represent sociotechnical artifacts and market intermediaries

(Otto & Jarke, 2019b). As data spaces extend from internal platforms to industry platforms, they may contribute to the development of a data ecosystem (Gelhaar & Otto, 2020). Accordingly, data ecosystems with neutral intermediary aspects should promote cross-organizational data exchange (Gelhaar & Otto, 2020). We therefore conclude that the key component for data space adoption is a data space platform that both fulfills organizations' needs and fits their interests (e.g., perceived benefits). Furthermore, a platform might also encompass the external task environment (Scholten, 2017; Tornatzky et al., 1990). Although some digital platforms have failed (Özcan et al., 2022; Yoffie et al., 2019); there are nonetheless many trends for overcoming such hurdles (Spiekermann, 2019).

Additionally, it is important to relate these factors to a theoretical underpinning. From the sample papers, we surmised that studies focusing on the individual level of platform adoption mainly used UTAUT and TAM as underlying theoretical models. By contrast, the TOE framework was dominant in the studies focusing on the organizational level. Although the platforms' contexts differed greatly, including FinTech (Xie et al., 2021), Airbnb (Tamilmani et al., 2020), or mobile learning platforms (Arif & Suzianti, 2019), especially on an organizational level, the results of the study were promising. Clearly, it is possible for an individual user to participate in a data space. However, we assume that data space adoption will generally be undertaken at an organizational level. As our study focuses on enterprises, i.e., industrial data spaces (Otto et al., 2016), the results allowed us to offer insights regarding data space adoption. Thus, we adhere to the definition of data spaces as multi-sided data platforms (Otto & Jarke, 2019b), mainly involving organizations as participants. Following the results from our sample, we used the TOE framework (Tornatzky et al., 1990) as a basis for the preliminary data space adoption model. The TOE framework depicts the technology, organization, and external task environment related to technological innovation decision-making (Tornatzky et al., 1990). Based on the insights gained from our SLR, we conclude that the TOE framework approach constitutes an opportunity to describe the adoption of data spaces. Notably, the factors of the framework are dependent on the technology it focuses on. Thus, while the TOE is generally a good solution, this framework can be extended with other approaches or individual factors specific to data spaces. In our example, the TOE framework is extended with an factor from the Interorganisational Relationship Theory (IRT) (J. Hong et al., 2021).

The factors identified may also serve as bases for decisions made by organizations aiming to participate in a data space, as well as decisions made by data space providers. The main goals of a data space seem to be to generate value and increase organizations' competitiveness (Beverungen et al., 2022b). Hence, data platform providers should aim to realize added value and innovations for organizations (Bartelheimer et al., 2022). Because applications of data spaces are scarce (Czvetkó & Abonyi, 2023; Steinbuss et al., 2023), prospective participants are forced to rely on the few existing implementations. For example on supranational level, the EU Data Strategy (European Commission, 2023; Minghini et al., 2022) aims to create nine interoperable domain-specific data spaces that should ensure data sovereignty, realizing data availability within a single market, i.e., European Health Data Space (European Commission, 2022). At the national level, the National Initiative for AI-driven Advancements (NITD) operationalizes the progress of data spaces (acatech – National Academy of Science and Engineering, 2023a) as an outcome of the German Digital Strategy (Cabinet of Germany, 2022), i.e., Culture Data Space (acatech – National Academy of Science and Engineering, 2021, 2023b). Additionally, there is ongoing global cooperation in the field of the data economy interconnection of data infrastructures and data ecosystems (Braud et al., 2021; Tardieu, 2022). Collaborative initiatives expand beyond Europe and advancing notably in Asia, connecting European and Japanese data spaces (DATA-EX, 2023; IDSA, 2022b; NTT Corporation, 2022), establishment of Gaia-X Hubs in Korea and Japan (Bonfiglio, 2023; Tardieu, 2022), as well as the creation of IDSA Competence Centers in China (IDSA, 2022a). Current practical examples for data spaces are "EuProGigant" in the industrial domain (Dumss et al., 2021; EuProGigant, 2023), "Mobility Data Space" for mobility data (Drees et al., 2021; Mobility Data Space, 2023), and the "Catena-X" in the automotive sector (Catena-X, 2022, 2023). The overarching goal is to establish a federation among and within data spaces, with interoperability being a critical factor (Pettenpohl et al., 2022). Interestingly, the Mobility Data Space links existing data platforms to each other on national level (Pretzsch et al., 2022), effectively functioning as data space mesh (Drees et al., 2022; MaaS Alliance, 2022). Furthermore, PrepDSpace4Mobility lay the foundation for sharing securely mobility data across Europe (PrepDSpace4Mobility, 2023). However, our study can help to inform both providers and participants about how adoption can be achieved.

To summarize, the factors identified above need to be considered when developing a data space adoption framework. The framework aims to help organizations better evaluate the implementation of data spaces in their operations and ensure successful adoption. Overall, it is important to consider these various factors when assessing the potential for data space adoption. Based on our results, we offer a preliminary framework for exploring the adoption of data spaces. We suggest using the TOE-framework, which has been used in the literature on data platform adoption (De Prieelle et al., 2020). We assume that the proposed framework focuses on achieving the successful adoption of data spaces, with a focus on data sovereignty, when implementing data governance in the data ecosystem. We aim to provide a preliminary framework, by combining the innovation characteristics of data spaces with the results. The framework is based on the three dimensions suggested in the TOE framework: technological, organizational, and environmental (see Table 2). Due to the focus of this study, the identified factors cover all dimensions and may provide a holistic perspective. There appear to be certain factors that are associated with multiple aspects and cannot be clearly attributed to any one of them. Interestingly, the technological dimension only shows up in five of the factors we have considered. Although the literature has addressed many organizational factors, our SLR revealed only six. As this is a preliminary model, and mainly a collection of factors in relation to the TOE framework, interdependencies and possible inconsistencies have not been assessed.

Table 2: Preliminary data space adoption model related to dimensions of TOE (Tornatzky et al., 1990)

Preliminary data space adoption model and related factors		
Technological Factors	Organizational Factors	Environmental Factors
Relative advantage	Top management support	Data Governance
Compatibility	Technological resources	Mimetic pressure
Cost	Financial resources	Perceived platform value
Scalability	Humane resources	External Pressure
Security	Organization size	Trust
		Regulation

CONCLUSION, LIMITATIONS & FUTURE RESEARCH

Due to the increasing importance of data spaces and the interest shown in this area by policymakers and global players, research on data spaces needs to increase. In this study, we presented approaches used to describe or explain platform adoption, so as to draw analogous conclusions for data space adoption. Based on our results, we offer a preliminary data space adoption model. The data space is an emerging research topic, so the results should not be considered definitive. Further research is necessary to gain more knowledge about the adoption of data spaces. In particular, there is no adoption model for data spaces in the existing literature. Overall, this work constitutes a starting point for further research on data space adoption. Based on our SLR, a model for explaining data space adoption can be developed. The preliminary framework we propose may also serve as a starting point of sorts as a starting point. However, this study admits of some limitations. First, the sample used for the analysis was rather small. The use of literature on platform adoption for theories in field of data spaces is also subject to some well-known limitations (Touboulic & Walker, 2015). Importing existing theories to understand the adoption of data space is appropriate, but must be done judiciously and with consideration (Amundson, 1998). Not all platform principles of B2C platforms can be easily transferred to the B2B context (Culotta & Duparc, 2022). With regard to the literature, to characterize specific domains and their platform use in more detail (De Reuver et al., 2018), i.e., specifically for data spaces. Second, the approaches identified represent only a fraction of the existing technology adoption models. Thus, studying other research areas, for example, might provide further insights. In order to assess the validity of the presented preliminary data space adoption model, we invite researchers to extend our investigation to obtain a more comprehensive understanding. However, the fact that our study focused on various platforms limits the generalizability of our results to data spaces. While this study reviews the literature from a perspective that a federated data space refers to a decentralized infrastructure for trustworthy data sharing, future research should examine similarities and differences of the identified factors. Further studies will aim to confirm the framework and identify other factors not mentioned in this preliminary framework. Finally, although we have laid the foundations for developing a framework for data space adoption, we have not yet commenced this process. This is in part because so few data spaces have been implemented, making it hard to evaluate such a model. Thus, as a next step, we hope to develop an initial conceptual framework, based on this study's findings.

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