Rethinking Openness in Data Platforms

The Impact of Data Artifact Characteristics on Platform Openness: Consequences, Scope and Mechanisms

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RESEARCH NOTE

Rethinking Openness in Data Platforms: The Impact of Data Artifact Characteristics on Platform Openness

Consequences, Scope and Mechanisms

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Abstract Data platforms enable actors to exchange personal and business data. While data is relevant for any digital platform, data platforms exclusively revolve around data artifacts. This paper argues that the specific characteristics of data artifacts challenge the authors' understanding of platform openness. Specifically, it is argued that data artifacts are editable, interactive and distributable, which means that the consequences of opening up a data platform extend far beyond the focal platform and its context. From this, the study infers that the scope of platform openness extends beyond the data platform on which data artifacts originate. At the same time, the very nature of data artifacts afford new mechanisms to realize and reduce the risks of openness. New avenues are suggested to study platform openness in the realm of data platforms. These avenues include (1) exploring and incorporating novel consequences of platform openness in a data platform setting, (2) examining new arenas for defining openness beyond a focal platform's confines, and (3) theorizing the implications of new mechanisms for realizing openness while maintaining apparent control over data artifacts.

Keywords Data platforms · Data artifacts · Platform openness · Editability · Interactivity · Distributedness

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1 Introduction

Data platforms are a new and emerging class of digital platforms. Data platforms are multi-sided platforms that enable the exchange of personal, business, and real-time data between buyers and sellers (Fricker and Maksimov 2017). Unlike traditional digital platforms that generate data as a side product, data platforms are distinguished by the fact that their core offering is data. For instance, on the IOTA platform, businesses exchange industrial sensor data for healthcare, automotive, and financial services (van de Ven et al. 2021). Another example is Otonomo, which enables automotive companies to sell mobility data to insurance companies and third parties for value-added services (Sterk et al. 2022; Kaiser et al. 2021). The significance of data platforms is expected to grow as businesses generate massive amounts of data, while the demand for data rises due to its essential role in artificial intelligence (AI) as an input (European Commission 2020).

As for any digital platform, platform openness is critical for data platforms. Generally, platform openness is a central concept in the platform literature. It refers to "the extent that [a platform can] place restrictions on participation, commercialization, development, or use of a technology" (Eisenmann et al. 2009, p.1). For most types of digital platforms, the scope of openness typically includes platform resources (e.g., software modules) that are available to complementors (e.g., developers) or other user groups (e.g., end-users) (Eisenmann et al. 2009). For data platforms, these resources can be raw data, aggregated data, or data-driven services (Aaltonen et al. 2021). For data platforms, openness relates to the conditions under which actors can use a data platform, such as buying and selling data or offering complementary services. However, it is crucial to balance openness to facilitate data exchange

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while also mitigating the negative consequences of openness for data owners and buyers. For data buyers, greater openness brings a broader variety of data artifacts and complementary services. However, this advantage may be offset as openness allows lower-quality data providers and complementors to join. For data providers, greater openness means that they can reach a broader audience for their data artifacts. Still, it may come at the cost of relinquishing control and sovereignty over their data artifacts.

The premise of this paper is that data platforms are a novel class of platforms that require a re-evaluation of predominant conceptualizations of platform openness. From this, the paper builds a line of argument comprising two main steps. First, the multifaceted nature of data as an artifact has implications for understanding the outcomes of openness. For instance, the ability to re-combine data with other artifacts means that implications of openness reach beyond the boundaries of the focal platform. Second, these specific characteristics of data as an artifact require rethinking the scope of platform openness. For instance, editability and interactivity imply that opened-up data artifacts can be re-contextualized in settings beyond the focal platform (Aaltonen et al. 2021). Together, these implications challenge the existing focus in platform openness literature, which primarily centers on a focal platform and its complementary modules (Ondrus et al. 2015; Benlian et al. 2015). These two lines of argument open up new avenues for research on conceptual (e.g., new units of analysis) and substantial aspects (e.g., new tensions related to openness).

In this conceptual paper, we reevaluate platform openness in the context of data platforms to derive new research avenues. Our main research question is: How do the distinct characteristics of data artifacts lead to new questions of platform openness? To answer this question, we consider how the multiple facets of data affect openness for data platforms. By exploring specific attributes of data platforms, we aim to unravel new conceptual and substantial research questions. The paper thus contributes to the literature on platform openness, raising new questions relevant to the emerging phenomenon of data platforms.

This paper is structured as follows: Sect. 2 provides a background on data platforms and platform openness. Section 3 discusses how the multifaceted nature of data affects the understanding of openness implications, and Sect. 4 focuses on the scope of openness and mechanisms to realize openness. Section 5 provides research opportunities and questions to advance the understanding of platform openness for data platforms. Section 6 concludes the paper.

2 Background

2.1 Data Platforms

This section provides a background on data platforms, including an overview of related work. Data platforms are multi-sided platforms that enable multiple user groups to interact (Eisenmann et al. 2006). These user groups are data providers, data buyers and complementors. Data providers hold property rights to data artifacts made available on the platform, data buyers access or purchase these data artifacts, and complementors offer value-adding services such as machine learning modules. From a technical perspective, digital platforms are also extensible systems (Tiwana et al. 2010). Data platforms can indeed be enhanced with additional features such as analytics (see, e.g., Ofe et al. 2023). The platform provider or complementors could offer these additional features.

Yet, data platforms are different in meaningful ways. On any digital platform, users create traces of data that a platform provider can monetize (van der Vlist and Helmond 2021) or use to improve the platform (Gregory et al. 2022). However, data is not a by-product of platform usage for data platforms. Instead, data is the core value element being exchanged and built upon. Rather than passively leaving a data trail, data platforms empower owners to offer their data proactively (Van Alstyne et al. 2021).

Data platform literature can be grouped into three overarching types of studies. The first group of papers focuses on providing taxonomies of data platforms (Spiekermann 2019; Stahl et al. 2016) and their business models (van de Ven et al. 2021; Fruhwirth et al. 2020). Data platforms vary in whether they facilitate the exchange of personal, business data, or both (Fruhwirth et al. 2020). Data platforms also vary in whether they focus on specific industries, e.g., health care, automotive, and financial services. Data platforms vary in orientation, i.e., market or hierarchical-oriented (Koutroumpis et al. 2017). Market-oriented data platforms are sometimes called data marketplaces: multi-sided platforms in which unrelated buyers and sellers can trade data (Koutroumpis et al. 2017). Data platforms could be operated by commercial providers or by a consortium of collaborating public and private actors. The latter form is increasingly called a data space (Beverungen et al. 2022). Data platforms are hierarchical if a platform provider determines pricing and interaction rules (Koutroumpis et al. 2017). In contrast, in market-oriented data platforms, prices are determined based on the market interactions of buyers and sellers (Stahl et al. 2016; Koutroumpis et al. 2017).

Data platforms can be classified based on whether they operate centralized or decentralized business models (van de Ven et al. 2021). Distributed ledgers with smart

contracts enable trading in the decentralized data platform (Fruhwirth et al. 2020).

A second group of papers focuses on exploring barriers hindering the creation of platforms for data exchange (Van Panhuis et al. 2014; Koutroumpis et al. 2017). Common barriers identified on the business side include pricing data (Fricker and Maksimov 2017; Spiekermann 2019) and establishing trustworthy relationships among platform users (Spiekermann 2019). On the technical side, challenges include maintaining quality, security, and data privacy (Koutroumpis et al. 2017; Parra-Arnau 2018; Zöll et al. 2021).

A third group of papers focuses on architectural and technical solutions for data platforms (Ramachandran et al. 2018; Roman and Stefano 2016). These papers seek solutions to ensure the security and integrity of data trading (Biennier and Favrel 2005; Park et al. 2018; Nasonov et al. 2018; Hynes et al. 2018; Banerjee and Ruj 2018) and the privacy of personal data (Parra-Arnau 2018). The key outcomes of these papers are solutions that revolve around using smart contracts with privacy-preserving techniques for security and privacy.

While the existing literature provides a general description of data platforms, it pays minimal attention to the issue of openness. Openness is subsumed within privacy and security discussions in the literature. As a result, we lack insights into platform openness from a sociotechnical perspective.

2.2 Platform Openness

Platform openness is defined as reducing restrictions to access a platform (Eisenmann et al. 2009). In this way, platform openness is a key aspect of platform governance, although governance includes other aspects, such as allocating decision rights. Openness is realized through two mechanisms: giving up control (e.g., open source) or granting access to platform resources (e.g., open interfaces) (Ghazawneh and Henfridsson 2013; Karhu et al. 2018). Platform openness is relevant at three levels: platforms, users and complementors (Ondrus et al. 2015). First, *platform-level openness* concerns interoperability with other platforms (Ondrus et al. 2015). Interoperability allows user groups to switch at relatively low costs, increasing platform competition (Setzke et al. 2019). For instance, a digital platform could be designed to be compatible with various operating systems and software frameworks, thereby enhancing its accessibility for diverse users. Second, *user-level openness* pertains to the level of discrimination between user groups of the platform (Ondrus et al. 2015). Third, *complementor-level openness* refers to restrictions or controls that platform providers devolve to complementors in extending platform modules (Ondrus et al. 2015).

Most platform studies focus on complementor-level openness because complementors are crucial in a digital platform context. Complementors are actors that extend the core functionality of digital platforms by developing and integrating complementary modules (Tiwana et al. 2010). The extensible nature of digital platforms drives the variety of products and services by structurally separating the platform core and its complementary modules (Tiwana et al. 2010; Baldwin and Woodard 2009). To facilitate the integration of complementary modules, platform providers offer boundary resources, such as application programming interfaces (APIs) or software development kits (SDKs) (Ghazawneh and Henfridsson 2013; Eaton et al. 2015). Boundary resources can be made accessible to any third party or created explicitly for a specific third party (Engert et al. 2022). The assumption is that tension exists between openness and control: by making boundary resources available, platform providers intend to restrict third parties and safeguard their core technologies (Ghazawneh and Henfridsson 2013). By tuning the level of accessibility and transparency of these boundary resources (Benlian et al. 2015), platform providers can govern the level of openness to complementors.

Openness to complementors directly benefits platform providers in various ways, including increased flexibility (de Reuver et al. 2011), attractiveness for adopters (Gebregiorgis and Altmann 2015), end-user adoption (West 2003), efficiency (Lee et al. 2015), ability to learn (Weiss et al. 2020), long-term 'evolvability' (Tiwana 2013), legitimacy of market entry (Khanagha et al. 2022), and likelihood to reach critical mass (Ondrus et al. 2015). Additionally, open platforms offer indirect benefits through potential network effects (Parker et al. 2017) and cross-side network effects (Saadatmand et al. 2019). By promoting openness, third parties are motivated to join the platform (Choi et al. 2019) and share their knowledge (Choi et al. 2020), leading to higher external innovation (Boudreau 2010; Gawer 2014; Schreieck et al. 2021), more complementors (van Angeren et al. 2016), diversity of complementors (Tiwana et al. 2010), and cocreation by third parties (Ceccagnoli et al. 2012). Finally, openness creates strategic advantages, such as aligning platform features with the platform provider's strategy (Henfridsson et al. 2018) or quickly conquering the market (Ondrus et al. 2015).

However, high degrees of openness between platforms can also create challenges for platform providers in value appropriation (Oh et al. 2015). Platform providers risk their platform being embedded in a higher-order platform by competing actors (Karhu et al. 2018) or their identity being challenged as the platform and associated ecosystem

evolve (Lindgren et al. 2015). Additionally, allowing more third parties to join the platform may result in lower-quality offerings (Wareham et al. 2014) as some third parties may free-ride on the collective reputation of the platform and provide low-quality complements, reducing user satisfaction (Cennamo and Santalo 2019). Unrestricted openness can also result in chaos due to unprompted change from different user groups (Tilson et al. 2012). Ultimately, reduced user satisfaction may trigger instability and collapse of the platform ecosystem (Wessel et al. 2017).

Studies on platform openness have traditionally centered on a focal platform and its complementors, where the locus of openness largely depends on the platform providers' control over the interface between the platform core and peripheral elements (Baldwin and Woodard 2009). Focusing on a focal platform allows researchers to evaluate openness effects on platform-level outcomes such as platform revenue (Wessel et al. 2017), complementary contributions (Ghazawneh and Henfridsson 2013), rate of new product development (Boudreau 2010), market potential (Ondrus et al. 2015) or quality of complements (Wareham et al. 2014). While this focus on the locus of the platform provides valuable insights, it limits the understandability of the implications of openness in the context of data platforms. In the next section, our attention shifts to data platforms and the unique characteristics of their core offerings, which revolve around data artifacts. We will demonstrate how these unique characteristics call for examining the consequences of platform openness beyond the locus of the focal platform.

3 Data as an Artifact: Implications for the Consequences of Platform Openness

The essence of data platforms lies in their pivotal connection with data. As they are digital, data artifacts inherit characteristics of digital artifacts: editability, interactivity and distributedness (Kallinikos et al. 2013; Kallinikos and Mariátegui 2011). Within the realm of data, these attributes assume distinctive significance, casting a new light on the traditional notion of platform openness. These distinctions and their implications for understanding platform openness are explored in this section.

3.1 Editability

Digital artifacts possess editability, allowing them to undergo modifications, updates, deletions, and rearrangements (Kallinikos et al. 2013). The concept of editability also applies to data, involving processes such as data cleaning (removing bugs and incomplete data) and processing the data to derive meaningful insights. Editing of data also occurs when data is repurposed for new contexts. An illustrative instance is transforming audience data, like likes or views, into advertising data through algorithms and machine learning techniques (Aaltonen et al. 2021).

The trait of editability empowers different stakeholders to make alterations to data artifacts within and beyond the confines of data platforms. Various stakeholders can perform these alterations, including data buyers, complementors, platform providers, and data owners. These alterations may take place within or beyond the platform's boundaries. Several examples can be considered. Data buyers may subject acquired data to cleaning and processing to appropriate value. Third-party complementors may offer services on a data platform for debiasing data sets before subjecting them to machine learning modules. Platform providers may collect raw data from data owners and aggregate these into high-level metrics ready for use. Data owners may anonymize their data, which implies that identifiers are detached from the data.

Data editing can take place once or continuously. However, editing often lacks comprehensive documentation, leaving changes ambiguously recorded. Unfortunately, many editing actions strip contextual information from data, disconnecting details such as the time, location, and data generation method. Conversely, data editing may introduce fresh contextual attributes, resulting in data re-contextualization, which allows insights that differ from the original use intention of data artifacts (Aaltonen et al. 2021).

With higher levels of platform openness, data platforms reduce restrictions on data editing, allowing a wider range of actors to make more far-reaching changes. Thus, the likelihood increases that data artifacts become detached from their original contexts while acquiring new contextual information. Consequently, data artifacts hosted on open platforms might possess fluid and inscrutable qualities, potentially compromising data quality for users. Moreover, the re-contextualization of data bears the risk of misrepresentation as data is repurposed or interpreted beyond its intended scope, raising concerns about privacy breaches and misuse by malicious entities.

3.2 Interactivity

Interactivity is a defining characteristic of digital artifacts, enabling users to trigger functions and rearrange information items (Kallinikos et al. 2013). In contrast to editability, interactivity does not entail altering an object's underlying structure or information. Interactivity may, however, reveal the loose couplings of the underlying structure of digital artifacts (Kallinikos et al. 2013).

Within the context of data, interactivity implies that data can be engaged with to infer outcomes and rearrange

information. For example, applying analytics or machine learning techniques to the data can reveal underlying patterns, thereby altering the representation or meaning of the data.

Data users or complementors may interact with data in undesirable ways for data providers. A notable instance is the potential for de-anonymization through information rearrangement, exposing personal data that was initially concealed. Moreover, interactivity can lead to reverse engineering (de Prieëlle et al. 2020), unveiling a digital artifact's embedded properties or functions. This comprehension of underlying data structures allows insights into possible (re)combinations with other interoperable digital artifacts, which malicious actors can exploit. By rearranging data and understanding its interrelations, malicious actors might exploit vulnerabilities, edit, rearrange, or combine it with other digital artifacts.

As platform openness increases, constraints on interacting with data artifacts diminish. Consequently, the potential expands for undesirable operations, such as de-anonymization and reverse engineering. Particularly in scenarios where users can interactively interconnect data artifacts from diverse sources, interactivity may yield unforeseen side effects.

3.3 Distributedness

Distributedness is another intrinsic characteristic of digital artifacts, allowing for their movement or replication across various contexts with minimal or no cost implications (Kallinikos et al. 2013). Within the realm of data, the non-material nature of data artifacts magnifies their non-rivalrous essence, permitting widespread spatial dissemination without limitations on duplication (Faulkner and Runde 2019). Because data artifacts are non-material, they can be embedded in, written onto, or transported by other objects, offering boundless opportunities for diverse locations and bearers (Faulkner and Runde 2019).

Within the context of data, distributedness implies that exchanged data can be (re)shared or re-sold to different parties. Therefore, data buyers and complementors can utilize data beyond the confines of the data platform on which it was purchased. In addition, data artifacts can be re-combined with other data artifacts in settings other than the focal data platform. For example, a data buyer may source a data artifact from a data platform for use on its premises or even other platforms. Hence, data artifacts are employed in contexts that extend beyond the confines of the original data platform of purchase.

As platform openness increases, data platforms also relax their control over the distribution of data artifacts. Hence, increasing openness allows for a wider spectrum of potential usage contexts for data artifacts. This increases the potential for data artifacts to be edited or interacted with outside the control of data platform providers and data owners.

3.4 Summary

In this section's exploration of data as a multifaceted artifact, the concepts of editability, interactivity, and distributedness have been discussed. Digital data artifacts can be edited, modified, and repurposed, unlocking potential value through diverse transformations. Interactivity empowers users to engage with data, uncovering hidden meanings and exposing underlying structures. Distributedness, a hallmark of digital artifacts, liberates data products from the confines of their origins, enabling them to traverse contexts seamlessly.

As platform openness increases, so does the canvas for editability, interactivity, and distributedness. Although these qualities enhance the potential for value creation within data platforms, an excessive degree of openness introduces potential pitfalls.

Increased editability allows data artifacts to extend beyond their initial context, often enriching them with new contextual facets. Such re-contextualization poses risks of misrepresentation and privacy concerns as data undergoes re-contextualization beyond its intended scope. Higher interactivity can invite undesirable actions like de-anonymization and reverse engineering, unveiling sensitive information and underlying structures. As distributedness increases, so does the potential for data products to be edited or interacted with outside the control of platform providers and data owners.

Table 1 summarizes our argumentation. Each characteristic of data creates specific risks that materialize when data platforms are opened.

These three characteristics are interwoven, their effects often reinforcing each other. For instance, distributedness and interactivity may empower data buyers to re-combine artifacts from varied sources, a potential that, while fostering innovation, could also amplify the risk of undesirable actions such as de-anonymization and reverse engineering.

4 Reimagining Platform Openness for the Context of Data Platforms

Like most digital platforms, data platforms cater to multiple user groups (e.g., data buyers and owners), which can be extended by complementary offerings (e.g., machine learning modules). However, data platforms revolve around data artifacts, and the specific characteristics of these artifacts have important consequences for

Table 1 Data artifact characteristics and specific risks

	Interactivity	Editability	Distributedness
Risks of openness in a data platform context	Losing control over how data is used as underlying properties of data can be activated to reveal identifiers or compromise privacy	Misrepresentation as edited data is (re)interpreted or reused with new meaning detached from its original context	Losing control over the data and harm to business interest as data is (re)distributed or accessible to malicious data buyers or competitors
Examples	Reverse engineering and de-anonymizing data can reveal identifiers of personal or business data	Data is re-combined beyond its original purpose with a potential risk of misrepresentation	Losing control over potential outcomes as data allows interoperability with other artifacts, resulting in new meanings

understanding platform openness. In this section, we explore how the characteristics of data artifacts (i.e., editability, interactivity and distributedness, as discussed in Sect. 3) extend the scope of platform openness beyond the focal platform (Sect. 4.1). Additionally, we explore how the same characteristics enable new mechanisms to realize platform openness (Sect. 4.2).

4.1 Scope of Platform Openness

In existing conceptualizations of platform openness, the scope of openness typically entails platform modules (e.g., software modules) to be used by complementors (e.g., developers) or other user groups (e.g., end-users) (Eisenmann et al. 2009) (see Sect. 2.2). For data platforms, the scope of openness could similarly relate to generic modules that enable complementary providers to create value-adding offerings, e.g., analytics modules (Mucha and Seppala 2020). However, the openness of data platforms also entails the extent to which user groups can use or provide data artifacts.

Data artifacts manifest in diverse formats within data platforms: data tokens, objects, and commodities (Aaltonen et al. 2021). Data tokens are raw data that represent the properties of objects and events (Ackoff 1989). For example, raw data could be sales data from various data owners. By conducting operations, raw data are transformed into objects with higher representational value. In the same example, data objects could be aggregated sales data that depict generic trends. Data commodities are offerings that emerge from relating data (Aaltonen et al. 2021). In our example, these would be readily usable tools for benchmarking sales performance. These diverse data artifacts can be provided and utilized by data owners, data users and complementors.

In non-data-centric digital platforms, openness typically implies that resources are available on the focal platform. For instance, a software platform makes generic modules available so developers can create applications that are consumed on the platform. In the case of data platforms, data artifacts could similarly be used on the platform from which they originate. However, data artifacts can also be used in other contexts, thanks to data being editable, interactive and distributable. This variability underscores how the scope of openness is contingent on the specific usage context and user objectives. To derive value, user groups typically engage in amalgamation (i.e., editability) and alignment of data artifacts (i.e., interactivity) sourced from diverse origins (i.e., distributedness). These activities can be done by various actors (e.g., consultants, solution providers, and data analysts) that are not necessarily tied to the data platform from which the artifacts originate. For instance, a consultancy firm could leverage data artifacts accessed from a data platform open to create complementary services (e.g., a sales benchmarking tool) offered through a different channel (e.g., consultancy services). Thus, the openness of data platforms allows for usage scenarios that are not exclusively tied to the focal platform. In this way, the scope of openness transcends beyond the confines of the data platform.

As data artifacts can be re-contextualized outside the scope of the data platform from which they originate, openness allows for widely diverging outcomes. Beyond their initial form, raw data or data products, once acquired, can undergo a transformational journey as they are edited and interacted with by secondary parties, who augment them with novel contextual insights. For example, consider the scenario where a third party procures sales data and then enhances it with supplementary contextual information, such as weather patterns or seasonal trends, repurposing it into a predictive forecasting tool. Thus, the scope of openness is not solely delimited by enumerating accessible data artifacts. On top of that, the usage contexts in which the data artifacts may be utilized need to be specified (Bergman et al. 2022).

The fragmented nature of the data platform landscape heightens the possibility of unanticipated re-contextualization beyond the focal platform's scope. Many data platforms cater to specific sectors (e.g., Otonomo for the mobility industry) (Sterk et al. 2022; Kaiser et al. 2021). The survival of data platforms has hinged on this tailored approach, as witnessed by the struggles of non-specialized

platforms like Microsoft's discontinued data-sharing platform. Such fragmentation is not per se problematic, as interoperability between data platforms is increasing, for instance, through industry standards like Gaia-X. Gaia-X is a European initiative to achieve interoperability between cloud systems. As data artifacts are valuable in a specific context, specialized data platforms will likely sustain in the future (Mosterd et al. 2021). Yet, by being distributable and editable, data artifacts originating in one industry-specific platform can traverse vastly different sectors, undergoing substantial re-contextualization. For instance, data artifacts from an automotive data-sharing platform may be fed into a data platform for healthcare to calculate lifestyle-related health hazards. This implies that platform openness extends beyond the industry in which the focal data platform operators operate.

In conclusion, in the context of data platforms, the scope of platform openness is significantly wider than for other digital platforms. The scope of openness in data platforms is centered around data artifacts, encompassing raw data, data objects, and data commodities. The characteristics of editability, interactivity and distributedness empower the re-contextualization of data artifacts. Consequently, when opened, the scope for utilizing data artifacts transcends the boundaries of their originating data platform while being detached from their original context.

4.2 Mechanisms to Realize Platform Openness

Most digital platforms are opened through boundary resources, such as APIs (see Sect. 2.2). Boundary resources may similarly apply to data platforms, for instance, making analytics modules available through APIs. However, as outlined in Sect. 4.1, when data artifacts are made available, they can be reused in a massively diverse contextual scope. The same characteristics of editability, interactivity, and distributedness of data artifacts allow for novel mechanisms to realize openness while reducing the risk and scope of openness. In this section, we examine how these new paradigms allow for new ways of realizing openness.

An example paradigm is collaborative computing, which allows making computations on distributed datasets without having to disclose or upload the actual data (Antunes et al. 2022). For instance, a data platform could offer a multi-party computation (MPC) facility, which allows a data buyer to generate insights (e.g., average sales data). In contrast, data owners do not have to share their data (e.g., individual sales data) with the platform provider. Instead, the data owners execute the MPC algorithm, and only the outcome is shared. Similar technologies to MPC exist, for instance, where algorithms move to data rather than vice versa (Van Alstyne et al. 2021). Another example paradigm is federated learning, which allows training machine learning models based on distributed sets of input data (Verbraeken et al. 2020).

These paradigms, to make data artifacts accessible without disclosing it, work because data artifacts are interactive (i.e., can be subjected to algorithms) and distributable (i.e., encrypted data and insights can move from data owner to data user). At the same time, the mechanisms to realize openness constrain the data artifact's editability (as the algorithm does not alter the data artifacts), interactivity (as only a specific answer can be inferred from the data artifacts) and distributedness (as the data artifacts do not leave the premises). Consequently, these mechanisms help to reduce the scope of openness by platform providers and data owners.

While these discussed mechanisms may resemble a novel variant of boundary resources that facilitate interaction between the platform and its user groups, they exhibit significant differences. Whereas boundary resources are sociotechnical, the discussed mechanisms are largely technological. Therefore, complementary social mechanisms will likely be needed, for instance, to trust the computed insights while not being able to verify the computations (Bruun et al. 2020).

In conclusion, new mechanisms are emerging to realize openness in the context of data platforms, such as collaborative computing, multi-party computation, and federated learning. These mechanisms are afforded by data artifact interactivity and distributedness. At the same time, the mechanisms allow for making data artifacts available to third parties while reducing the degrees of freedom for editability, interactivity, and distributedness.

4.3 Summary

Figure 1 summarizes our conceptualization. The characteristics of editability, interactivity and distributedness influence the implications of openness: they create specific risks, both directly (arrow a, e.g. interactivity allows for de-anonymization) and indirectly through re-contextualization and re-combination (arrow b, e.g. editability allows for modifications, which can lead to data being repurposed or interpreted beyond its original context, posing risks of misrepresentation). Re-contextualization and re-combination also increase the scope of openness (arrow c, e.g. data can be re-combined with data from other platforms), which expands the scale on which the risks can materialize (arrow d). The same characteristics enable mechanisms to realize openness (arrow e, e.g. distributedness allows for federated learning) that can be applied to reduce risks (arrow f, e.g. federated learning reduces de-anonymization risk).

The figure illustrates the contradictory effects of data characteristics. The same data characteristics both promote

and reduce the risks of opening up platforms. The relationship between data characteristics and openness is intricate and multifaceted, with opposing forces.

5 Discussion: Potential Avenues for Research

In this section, we derive implications for research on openness within the area of data platforms. Section 5.1 suggests new research directions on the potential negative consequences of platform openness, building upon the analysis of data artifact implications outlined in Sect. 3. Similarly, Sect. 5.2 capitalizes on the wider scope of platform openness, as discussed in Sect. 4.1, to suggest new arenas for platform openness studies. Finally, Sect. 5.3 extends to the new mechanisms for implementing platform openness as outlined in Sect. 4.2, identifying opportunities to examine both the influence on well-known openness-related tensions and newly emerging ones.

5.1 Consequences of Opening up Data Platforms

As we explored in Sect. 3, the inherent characteristics of data artifacts–editability, interactivity, and distributedness–create opportunities for innovative usage while simultaneously introducing potential unintended consequences for both data owners and platform providers. The re-contextualization of data creates consequences that are difficult to predict, let alone influence proactively. While the consequences of generativity are a mainstream topic for digital platform researchers (e.g., Ghazawneh and Henfridsson 2013; Boudreau 2010; Cennamo and Santaló 2019; Pauli 2020; Sun et al. 2021), the inherent characteristics of data artifacts both amplify and amend these consequences.

The nature of the negative implications varies based on the data type being considered. For example, within the context of business data, platform openness creates potential issues related to competitiveness. Data users might reverse engineer critical processes by interacting with data artifacts, potentially compromising a competitive advantage (de Prieëlle et al. 2020). Such issues are especially relevant when dealing with real-time data, for instance, from connected or Internet-of-Things devices. Within the context of personal data, platform openness creates concerns for privacy and regulatory compliance. As we saw in Sect. 3, even if anonymization is applied, editability and distributedness allow combining data artifacts, which in turn may allow the de-anonymization of shared data.

The consequences of platform openness are difficult to foresee for any type of platform due to generativity: how third parties use them is difficult to predict (Bygstad 2017). However, the characteristics of data artifacts increase this unpredictability. The ability to re-contextualize and re-combine data in novel ways adds a layer of uncertainty to the qualitative consequences that may surface, only becoming evident as they materialize.

The unpredictable consequences of opening up data platforms give rise to various avenues of research. Exploratory studies may identify the relevant (adverse) outcomes of opening up data platforms, which are valid for specific data types. Besides understanding the implications

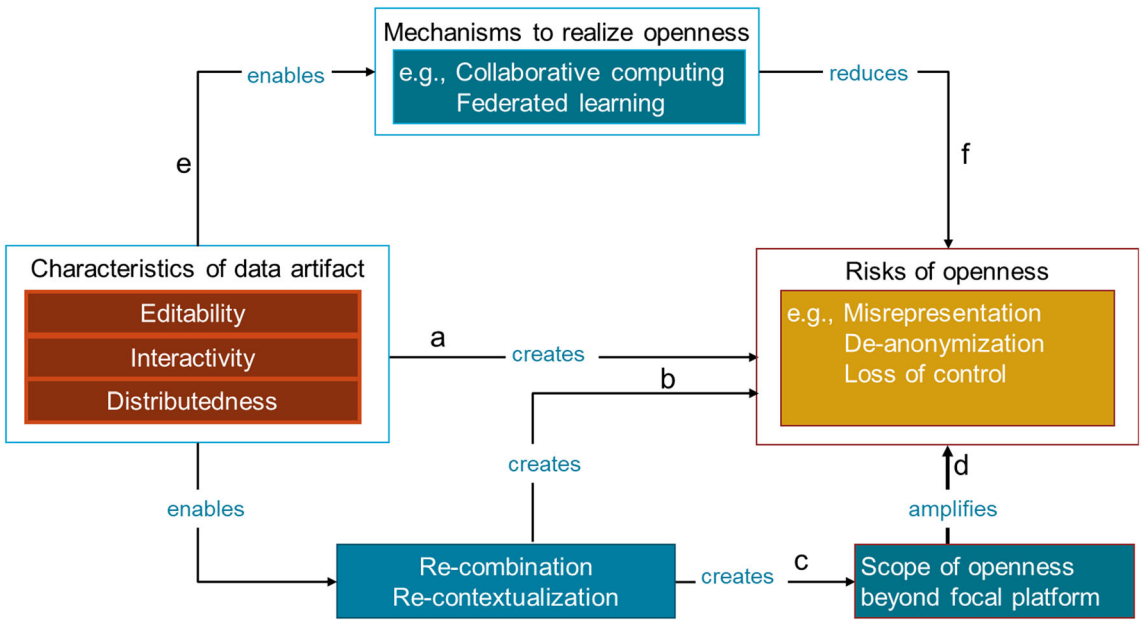

Fig. 1 Consequences of data artifact characteristics for platform openness

of data platform openness, theorization is required on whether and how this feeds back into the decisions of platform providers to (not) open up their data platforms. Quantitative studies on platform openness should capitalize on these insights to define outcome variables beyond generativity, profitability and attractiveness.

5.2 Widening the Scope of Platform Openness

As examined in Sect. 4.1, the context of data platforms implies that platform openness has a broad scope. By being editable, interactive and distributable, opened-up data artifacts may be utilized beyond the data platform from which they originate. Thus, the scope of platform openness needs to be reconsidered beyond the focal platform.

The possibility to re-combine and mix-match data across diverse data platforms raises questions about the boundaries that researchers should draw in delineating their phenomenon of study (De Reuver et al. 2018). For example, the ability to edit and distribute data through different use contexts and industries challenges the idea of studying one focal platform to understand openness and its implications (e.g. Eisenmann et al. 2006). This is important in understanding the interaction between openness and generativity (Zittrain 2006). Not constraining generativity is thought to lead to adverse outcomes, such as affecting the quality of platform complements (Ghazawneh and Henfridsson 2013; Boudreau 2010). However, due to the distinct nature of data artifacts, attempts to control generativity or its effects are challenging. Data artifacts' inherent tendency for new changes, interpretations, meanings, and contextual cues makes them highly unpredictable. Consequently, efforts to limit generativity at the platform level are likely to be of limited effectiveness.

Here, we suggest three arenas where platform openness can be studied to acknowledge the wide scope of openness in a data platform context. First, openness could be defined as being between data owners and complementors. Openness then relates to the conditions that data owners put over how complementors can access and use their data artifacts. A high-level condition could be that a complementor can only access data artifacts in ways that benefit the data owner. A more operationalized condition would be that a complementor can clean input data, combine these with other data artifacts and create insights relevant to a predefined context. For example, a data owner might share sales data that are then cleaned and combined with other data artifacts, such as weather data, to create context-specific predictions of sales figures. The resulting sales figures are then fed back to the data owner. In this way, platform openness concerns the conditions data owners put on complementors receiving data through the data platform.

Second, openness can be defined between data owners to define conditions under which they permit the distribution of their data to other data owners. Here, openness includes data owners' restrictions on distributing their data beyond the data platform on which they share data. For instance, transport operators may make data available via distinct platforms but still intend to enhance their joint service delivery. Because the exchanged data is confined within organizations and intended for a specific use, openness at the level of data providers could be governed bilaterally (Koutroumpis et al. 2017). Yet, such agreements are complicated as data may be used in a novel context that does not follow design rules stipulated by the platform where the data was accessed. As such, openness has to be defined between data owners outside the view of the focal platforms on which they share or access data.

Third, openness can be construed between data users as they interact, re-combine, or edit data outside the view of the focal platform. For example, acquired raw data can be aggregated and analyzed on other systems or platforms. Data users from the same or different platforms can make arrangements on the conditions under which they share data artifacts. Hence, openness is relevant for practices in which independent users seek to co-create value from data artifacts.

For all three arenas, platform openness is defined between user groups (e.g., data users, data providers and complementors). However, platform providers may intermediate in defining conditions that define openness and enforce and monitor adherence to the conditions. For future research, this implies that the unit of analysis should shift from the focal platform and its conditions towards these new arenas in which openness is defined. For instance, case study research should consider not only a focal data platform and its conditions but also how user groups make arrangements outside the view of the focal platform.

5.3 Mechanisms to Realize Openness: Resolving and Re-creating Tensions of Control

The editability, interactivity and distributedness of data artifacts give rise to new mechanisms to realize openness, as discussed in Sect. 4.2. These mechanisms, such as collaborative computing or federated learning, allow data artifacts to be made available without disclosing or uploading the actual data. These new mechanisms to realize openness are essential as they may redefine well-known tensions in platform openness.

A central tension in platform-related literature is openness and control (Ghazawneh and Henfridsson 2013; Boudreau 2010; Eaton et al. 2011; Wareham et al. 2014). With collaborative computing or federated learning paradigms, data platforms can make data artifacts available

without disclosing them. For instance, an algorithm may travel to the data and only disclose the answer to a meaningful question without altering or re-distributing the data artifact (Van Alstyne et al. 2021). As such, the tension between openness and control may be resolved. At the same time, the novelty of these mechanisms may have implications that are not accounted for by existing understandings. For instance, the risk of undesirable disclosure may shift to data users, who reveal their interests in how they look to utilize data through their queries (Agahari et al. 2022).

Important questions emerge as to whether traditional tensions resolve tensions between openness and control and whether they can be resolved with new mechanisms. Those questions include whether technological mechanisms are sufficient to realize and steer openness. Future research may consider the impact of our identified mechanisms on achieving openness to tensions traditionally related to a lack of control.

6 Conclusion

In this paper, we show that the newly emerging phenomenon of data platforms creates new questions to understand the openness of platforms. We have demonstrated that data artifacts have specific forms of editability, interactivity, and distributedness, and the implications of opening up data platforms differ substantially from those of non-data-centered platforms. Consequently, the openness of data platforms has (negative) consequences that are even more difficult to foresee. Furthermore, the scope of platform openness widens as data artifacts can be edited, interacted with and distributed in a wide variety of contexts, including beyond the data platform from which data artifacts originate. At the same time, these characteristics of editability, interactivity and distributedness enable new mechanisms to realize openness while retaining control over data artifacts.

Our paper suggests various avenues for further research, which substantially differs from the existing discourse in platform openness literature. The potentially negative consequences of opening up data platforms warrant attention. Moreover, we advocate a shift in focus to study platform openness in broader contexts, extending beyond the traditional focal platform, such as between data owners or between a data owner and a complementor. Lastly, the impact of data-specific mechanisms on achieving openness should be examined in terms of addressing well-known tensions regarding openness and control and identifying new tensions that may arise.

With the proliferation of the data economy and policymakers' determination to make data platforms a reality, it is timely to examine how data platforms challenge existing understandings in the digital platform literature. By illuminating the multifaceted nature of data artifacts and their implications for platform openness, this paper lays the foundations to do so. We anticipate that future research will go deeper into platform openness within a data platform's context, uncovering new insights and solutions.

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