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The Openness of Data Platforms: A Research Agenda

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ABSTRACT

Data platforms are the keystone of the data economy. When opened up, data platforms allow data owners, data consumers and third parties to interact. Yet, openness may also harm business and societal interests. Literature on platform openness does not cover data platforms, and data economy scholars rarely study platform openness. Therefore, this paper develops a research agenda on the openness of data platforms. We explore how data platforms differ from conventional digital platforms (e.g., software platforms). From those differentiating characteristics, we identify areas for future work: (1) The specific characteristics of data require re-conceptualizing the object of platform openness; (2) New ways in which data platforms can be opened should be conceptualized; (3) As data platforms are tailored to specific industries, platform-to-platform openness should be a novel unit of analysis; (4) Because opening up data platforms create novel risks, new reasons to (not) open up data platforms should be studied.

CCS CONCEPTS

• Information systems→Database management systems • Applied computing→Enterprise computing→IT governance

KEYWORDS

Data platform; Data marketplace; Platform openness; Data ecosystem

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1 Introduction

Data platforms facilitate businesses to trade data [2,36,54,78]. While any digital platform creates data as a side-product of platform usage [89], the main offerings of data platforms revolve exclusively around data. Data platforms are essential enablers of a data economy in which businesses can freely exchange and monetize data. An archetypical example is the data marketplace, where data owners can sell their data to other businesses [54]. Another example is a data space, which provides an ecosystem for parties to share data [11].

Proponents of the data economy typically argue that data platforms should be fully open to third parties [see, e.g., 62]. By opening a data platform, data consumers and owners can freely exchange data or access third-party analytics or AI modules. However, complete openness is often not desirable. Data owners typically wish to retain control and sovereignty over their data [49,55]. Similarly, data consumers will require safeguards against low-quality or malicious third-party offerings. Hence, setting the appropriate level of openness of a data platform is a significant challenge for data platform providers.

The issue of platform openness has been studied extensively in digital platform literature in the information sciences discipline [26]. Here, platform openness is defined as allowing third parties to access platform resources [12:1851], either by going open source or making specific interfaces available [40,50]. Trade-offs and tensions regarding platform openness are studied in industries such as software [9] and gaming [20].

Yet, existing understandings of platform openness cannot simply be transferred to the newly emerging data economy domain. In this paper, we argue that data platforms fundamentally differ from digital platforms that have been studied to date. One example is the object of openness: while conventional platforms typically make software modules available to third parties, the object of openness for data platforms ranges from raw or aggregated data to full-fledged analytics solutions. These differentiating characteristics (explored in Section 3) imply that new research questions await, which are unique to the domain of platforms for the data economy. The central goal of the paper is thus to develop a research agenda on the openness of data platforms.

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Our research agenda aims to inspire interdisciplinary work on the intersection of digital platforms literature and data economy studies. For digital platforms scholars, our research agenda provides novel questions relating to openness in the newly emerging area of the data economy. This new setting challenges the assumptions of the existing discourse on platform openness. Although research agendas on data platforms exist [e.g., 11], these do not delve into the specific characteristics of data as an artefact [46]. For the data economy community, our research agenda calls for studies that go beyond often-studied questions of technology and pricing issues [2]. Ultimately, our premise is that we need both a deep understanding of the data economy and a conceptual basis of digital platform studies. Only by combining these disciplines, we can start to unravel the issue of the openness of data platforms.

2 Background

Digital platforms have become a mainstream research topic in the information sciences, a sociotechnical field which partly overlaps with information systems, media studies, and telecommunications. A commonality in these streams of literature is the recognition that the digital nature of platforms matters, which sets them apart from generic literature on platforms in business and economics [30]. Within the digital platforms literature, platform openness is a mainstream issue in older [27,95] and recent work [19].

Platform openness refers to reducing `restrictions on use, development and commercialization of a technology' [12:1851]. Platform openness is a continuum rather than a black-and-white issue [96]. Generally, openness is contrasted with retaining control [94], although some studies argue that the tension between openness and control can be resolved through governance [82,92]. Two main pathways to openness dominate the platform literature: giving up control (e.g., through open-source) and selectively granting access to platform technologies (e.g. through open interfaces) [40,50]. Most recent literature focuses on the latter scenario, where so-called boundary resources (such as application programming interfaces or software development kits) are made available to third parties [40].

In discussions of platform openness, scholars relate openness to three main outcomes: (1) economic outcomes: openness makes platforms valuable by creating network effects between user groups [32,67]; (2) innovation-related outcomes: openness allows third parties to innovate and thus make a platform `generative' [14]; (3) strategic outcomes: openness affects the competitive position of a platform provider [50]. Existing work on openness focuses on platforms for software development [9,39], gaming [20], Internet-of-Things [63] and payment [29,72].

3 What makes data platforms special?

Generally, data platforms inherit the characteristics of digital platforms. For example, the economic perspective on digital platforms stresses their multi-sidedness [73], whereas data platforms are indeed used by data owners, data consumers and third parties. Innovation scholars stress that platforms facilitate transactions and allow recombinant innovation [37], and data platforms do so by facilitating transactions between data consumers and owners while enabling third-party innovation. From a technical perspective, digital platforms are extensible systems [84], and data platforms can indeed be extended with additional features such as analytics [see 64].

However, data platforms differ from other digital platforms as their main offerings revolve around data. On any digital platform, users create traces of data that a platform owner can monetize [89] or use to improve the platform [43]. For data platforms, however, data is not a by-product of platform usage. 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 [cf., 88].

Data as an artefact has specific characteristics. First, data can be de-contextualized, re-combined and re-contextualized [1]. Therefore, the openness of data platforms can be realized in new ways: the object of openness could range from raw datasets to readily usable data analytics modules. Second, thanks to new data-driven approaches such as privacy-preserving technologies, new mechanisms are emerging to realize the openness of platforms. Third, data requires context to be valuable to users. Therefore, data platforms will likely be tailored to specific industries. The resultant need for specialization reduces the strength of network effects and related winner-takes-all dynamics, implying that data platform fragmentation will likely continue in the future [60]. Fourth, making data-related resources accessible creates specific risks. These risks involve privacy (in the case of personal data) or confidentiality and sovereignty (in the case of business data). Table 1 summarizes the key differences between digital platforms and data platforms.

Table 1. Comparing digital and data platforms

	Digital platforms (e.g. software, gaming)	**Data platforms (e.g. data marketplaces)**
User groups	Developers Consumers	Data consumers Data owners Solution providers
Object of openness	Software/hardware modules	Data, aggregated data, trained models Data analytics modules
Ways to realize openness	Open source Open boundary resources	Data-driven mechanisms
Market consolidation	Strong network effects Dominant, cross-industry platforms	Moderate network effects Fragmentation and heterogeneity

Risks of opening up	Loss of control, revenues, reputation, integrity	Loss of data sovereignty, privacy violation, confidentiality

In the following sections, we develop a research agenda for each of the differentiating characteristics in Table 1: the object of openness (Section 4), mechanisms to realize openness (Section 5), market consolidation (Section 6) and risks of opening up (Section 6).

4 New objects of platform openness

In existing conceptualizations of platform openness, the object of openness typically entails platform modules (e.g. software and hardware modules that developers can build upon) [33]. For instance, platforms make available modules for authenticating users or conducting transactions. For data platforms, the object of openness could be similar [e.g. analytics modules, see 61]. However, the object of openness could also be specific to the data context, such as datasets (e.g. sales data of companies), data products (e.g. aggregated sales data) or data-driven insights (e.g. benchmarks against competitor sales data) [10]. These objects could be opened up to developers, as in conventional digital platforms, but also to intermediaries, data users and data providers. These data-specific objects of openness lead to new research questions:

- What data-related resources should data platforms make available when opening up (e.g. data, data products, data-driven insights, analytics modules)?
- Which user groups derive value from accessing data-related resources from data platforms (e.g. data providers, data users, intermediaries, developers)?

The open data literature mainly focuses on governments as data providers and businesses as data users [90], neglecting scenarios where businesses provide data. At the same time, in practice, some businesses already openly share some of their data with an open license and in a reusable format. To enhance the value of open business data, we propose the following question:

- (How) can businesses be incentivized to openly share their data for free under an open license and in an open format?

Here we argue that studying different levels of openness rather than studying openness as a 'black-or-white' concept of either being closed or open would be critical.

5 New mechanisms to realize platform openness

According to digital platform literature, openness is realized through two mechanisms: giving up control (e.g. open-source) or granting access to `boundary resources' (e.g. open interfaces) [40,50]. Boundary resources include application programming interfaces, software development kits and platform usage policies [28,39]. Boundary resources can be made accessible to any third party or created explicitly for a specific third party [34]. The assumption is that tension exists between openness and control: by making boundary resources available, platform owners intend to resource third parties and secure their core technologies [40].

Similar boundary resources may apply to data platforms, especially if analytics modules are the object of openness. However, for data-driven insights, new mechanisms are emerging. An example is collaborative computing, which enables multiple parties to compute insights without disclosing the underlying data. By leveraging privacy-enhancing technologies such as Multi-Party Computation (MPC), collaborative computing allows openness while safeguarding societal values of privacy, security, and sovereignty [4]. Similar mechanisms exist, for instance, where algorithms move to data rather than the other way around [87].

Interestingly, these new mechanisms to realize openness may break the traditional tension between openness and control: data can be made accessible without losing control over what data consumers do with the data. At the same time, the novelty of these mechanisms may have implications not accounted for by existing understandings, such as the inability to verify the computed insights that require an additional layer of trust [16]. These new mechanisms lead to new research questions:

- How can new mechanisms for realizing openness (e.g. privacy-enhancing technologies) break the tension between openness and control?
- What new tensions arise when applying data-specific mechanisms to realize platform openness?

6 New units of analysis

Existing literature on digital platforms and openness typically focuses on the openness towards complementary providers. Examples include the openness of a software platform to app developers [9] or the openness of a gaming platform to game creators [97]. The focus on openness to complementary providers is understandable, as most platforms exhibit strong network effects. Network effects imply winner-takes-all dynamics: only one or a few platforms that dominate the market survive. Hence, to understand why strong network effects affect a platform's survival, the question is how openness affects the participation of complementary providers.

Data platforms are different, in our view. Data requires context to be valuable to data consumers [1]. As data as an exchange commodity is thus highly context-dependent, a strong need for the specialization of data platforms arises [8]. Further, as data owners have concerns over data sovereignty, they will prefer data platforms confined to specific use cases [3].

In line with these assumptions on the need for specialization, we see that so-called data spaces are emerging that provide the facilities to data owners in specific verticals to exchange data. Use cases of data spaces are often deeply rooted in a specific industry

[66]. Most data marketplaces are similarly specialized. As data trading and exchange have to comply with local regulations, data marketplaces often focus on a specific nation (e.g. German Mobility Data Marketplace) or even a city (e.g. Amsterdam Data Exchange). Hence, we expect that the current fragmentation of the data platform industry will likely sustain in the future, resulting in costly lock-in effects and data discovery challenges [8].

At the same time, there is a strong push for cross-data platform interoperability [35]. Impactful solutions for societal challenges require cutting across industries and domains. For instance, self-care solutions require healthcare platforms (e.g., electronic patient records) and Internet-of-Things platforms (e.g., consumer wearables). New European regulations, such as the Data Act, empower consumers to mandate data platform providers to exchange their data with other platforms. Initiatives such as Gaia-X provide the standards and infrastructure to achieve platform-to-platform interoperability.

In sum, we see a trend toward specialization of data platforms to specific industries or geographical areas, which leads to an increasingly complex landscape of heterogeneous and fragmented data platforms. At the same time, there are strong forces to foster interoperability between platforms from a societal, regulatory and technical perspective. Hence, the openness *between* platforms requires scholarly attention, next to the openness to complementors or users.

Conceptually, multiple ways exist to realize openness between platforms. Meta-platforms can be introduced, constituting a higher-order platform that federates or forks other platforms [59]. Third parties may create `bridges' between platforms directly, for instance, through their applications [48]. Platforms could also foster interoperability by creating direct interconnections [60]. These conceptual issues lead to the following research questions:

- What is platform-to-platform openness in the context of data platforms?
- How do we distinguish meta-platforms, forking, and platform interoperability?

The area of platform-to-platform openness is largely uncharted. It is unclear what business models could be for meta-platforms and other complex platform constellations. Similarly, exploratory studies on platform-to-platform openness suggest that there may be very different reasons (not) to open up platforms to other platforms [60]. These uncertainties lead to the following questions:

- What are business models for meta-platforms?
- What are the reasons (not) to open up platforms to other platforms?

While the openness of platforms to users and developers is often defined in universal terms, platform providers typically take one-by-one decisions when opening up to other platforms [60]. This leads to the following questions of governance:

- How are new data platforms invited to participate in platform-to-platform openness?
- How many data platforms should ideally be included to reach optimum network effects?
- How can a consensus-based structure of governance be maintained? How can governance hierarchy and decentralization be balanced?
- How to divide roles and decision rights between platform integrators and platform participants?
- How can conflicts between data platform providers be managed and resolved?

Finally, platform-to-platform openness may affect the decisions of data owners to participate in the data economy. While disclosing data on one platform is already non-trivial for most data owners due to concerns over privacy or confidentiality, these concerns are likely amplified in a cross-platform setting [3]. Hence, the question arises:

- How does platform-to-platform openness affect data owners' and consumers' intentions to participate in data platforms?

7 New risks of platform openness

Literature on digital platforms discusses several drivers, trade-offs and implications of platform openness [77]. Reasons to open up platforms are increased flexibility [71], attractiveness for adopters [38], end-user adoption [95], efficiency [56], ability to charge license fees [68], ability to learn [93], long-term `evolvability' [83], legitimacy of market entry [52], and likelihood to reach critical mass [65]. Open platforms also benefit platform providers indirectly through potential network effects [67] and cross-side network effects [74,91]. Through openness, third parties are stimulated to join a platform [7,22,53] and share their knowledge [23]. Openness thus leads to higher external innovation [14,37,76], more complementors [6], diversity of complementors [83], co-creation by third parties [18]. Openness also creates strategic advantages, for instance, by promoting platform features that benefit the strategy of the platform provider [47] or winning the market quickly [65].

Various motives against openness exist too. High openness potentially removes incentives for complementors to innovate [13], for instance, because of coordination costs [24] or fear of competition [63]. Too high openness can also limit platform growth [58]. Other scholars generally question the impact of openness on platform participation [15]. Open platforms can attract low-quality complements that free-ride on the platform's reputation [21], threatening the platform's integrity [94]. Control mechanisms to mitigate low-quality complements are costly [92] and can reduce the motivations of third parties to contribute [42], thus reducing the benefits of openness.

Openness can also create financial disadvantages for platform sponsors. Openness creates costs from setting up open interfaces [41] and control mechanisms [44,92], especially as usage grows [5]. Open platforms can reduce revenues and profits if third parties directly compete with the platform provider [31,67].

Strategically, reduced openness can help lock in customers and create entry barriers [57,92]. Closed platforms also allow higher margins [31,95]. Open platforms are vulnerable to exploitation by competitors [51], e.g. through `forking' [50] or absorption into other platforms [41,69].

Whether openness is beneficial depends on the context of the platform provider: the for-profit status [92], maturity [14,92], market position [31], absorptive capacity [62] and market share [31]. The context of the market plays a role, too: availability of compatibility standards [86], the dominance of compatibility standards [14,95], the timing of opening up [85] and the degree of vertical integration [45]. Contextual factors interact; for instance, low market power and dominant standards justify high openness levels [52].

Studies show that the factors above motivate businesses to change platform openness. For instance, tensions between conflicting goals may be resolved by changing the governance regime of the platform [92], which can significantly impact third parties [25]. Businesses also tend to open up their platforms gradually over time [75,81].

For data platforms, novel risks of openness emerge, depending on the type of data being exchanged. For business data, openness creates new risks related to competitiveness. For instance, competitors could use business data to reverse engineer critical processes or break a competitive advantage [70]. For industrial data (e.g., from Internet-of-Things), similar risks of reverse engineering apply. Further, a new class of safety risks emerges when data platforms are linked to actuators and AI models. For personal data, openness implies risks for privacy and regulatory compliance. Even if anonymization is applied, risks exist of de-anonymization if sufficient data points are re-combined.

In general, new risks are difficult to foresee and anticipate because platform resources are generative: how third parties use them is difficult to predict [17]. The characteristics of data, as derived in Section 3, increase the unpredictability: Because data can be re-contextualized and re-combined in new ways, the qualitative risks that may emerge are principally uncertain until they materialize.

The new and unpredictable risks of opening up data platforms create new questions. These questions involve understanding the implications of openness as well as ways in which stakeholders can deal with these implications reflectively and responsibly:

- What are the novel (negative) implications of opening up data platforms?
- How can reflexivity in design help providers to resolve the negative implications of openness?

An open question is if the societal and external implications of platform openness play a role in the decisions of platform providers to (not) open up their platforms. As discussed in this section, existing literature mainly considers business motives in explaining openness decisions. One potential explanation could come from the theory on socio-political legitimacy, which explains why business actors take into account external pressures [79]. While legitimacy perceptions of platform users have been studied before [80], the role of broader societal concerns is hardly being studied.

- How do societal/external implications of platform openness (e.g. privacy, safety) affect platform openness decisions?
- Do negative implications of data platform openness affect the perceived legitimacy of data platform providers?
- What is the role of legitimacy tensions in deciding upon data platform openness?

8 Conclusions

The data economy brings a new generation of digital platforms, for which data is no longer a side product but the main dish. Data platforms are fundamentally different from conventional platforms due to the importance of context for data, the fragmentation of data platforms across industries, and the new business and societal risks that their openness creates. Therefore, we cannot simply transfer the insights from conventional platforms to understand the governance and openness of data platforms. Yet, visions of the data economy as a free market for data are only possible when data platforms are open.

In this paper, we laid down a research agenda, calling for more research in four main areas: (1) new objects of openness of data platforms should be studied, such that the specific characteristics of data as an artefact are covered; (2) new mechanisms to realize openness should be conceptualized, specifically privacy-enhancing technologies which may break the traditional tension between openness and control; (3) new units of analysis should be adopted in platform openness studies, specifically platform-to-platform openness; and (4) reasons to (not) open up platforms should be revisited, in light of the new risks that data platforms create when opened up.

Addressing these areas is crucial to gain insights into why, how and when providers open up their data platforms. These fundamental insights are also needed to build a basis for a new generation of platform studies in the emerging area of the data economy. Truly advancing these fundamental questions requires interdisciplinary work by (A) digital platform scholars that bring in the conceptual language and toolsets to theorize platform openness and (B) data economy scholars that bring in a deep understanding of the technologies and market structures of data platforms. Scholarly fora are needed that are open to such interdisciplinary and cumulative efforts, of which the inaugural workshop on the data economy hopefully sets an example.

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10 References

[1] Aleksi Ville Aaltonen, Cristina Alaimo, and Jannis Kallinikos. 2021. The making of data commodities: data analytics as an embedded process. *Journal of Management Information Systems* 38, 2 (August 2021), 401–429.

[2] Antragama Ewa Abbas, Wirawan Agahari, Montijn Van de Ven, Anneke Zuiderwijk, and Mark De Reuver. 2021. Business Data Sharing through Data Marketplaces: A Systematic Literature Review. *Journal of Theoretical and Applied Electronic Commerce Research* 16, 7 (December 2021), 3321–3339. DOI:https://doi.org/10.3390/jtaer16070180

[3] Antragama Ewa Abbas, Hosea Ofe, M De Reuver, and Anneke Zuiderwijk. 2022. Preparing future business data sharing via meta-platform for data marketplaces. In *35th Bled eConference*.

[4] Wirawan Agahari and M De Reuver. 2022. Rethinking consumers' data sharing decisions with the emergence of multi-party computation: An experimental study. In *ECIS 2022 Research-in-Progress Papers*, Timisoara, Romania.

[5] E. Almirall and R. Casadesus-Masanell. 2010. Open versus closed innovation: A model of discovery and divergence. *Academy of Management Review* 35, 1 (2010), 27–47. DOI:https://doi.org/10.5465/amr.35.1.zok27

[6] Joey van Angeren, Carina Alves, and Slinger Jansen. 2016. Can we ask you to collaborate? Analyzing app developer relationships in commercial platform ecosystems. *Journal of Systems and Software* 113, (March 2016), 430–445. DOI:https://doi.org/10.1016/j.jss.2015.11.025

[7] M. Anvaari and S. Jansen. 2010. Evaluating Architectural Openness in Mobile Software Platforms. In *Proceedings of the Fourth European Conference on Software Architecture: Companion*, 85–92. DOI:https://doi.org/10.1145/1842752.1842775

[8] SA Azcoitia and N Laoutaris. 2022. A Survey of Data Marketplaces and Their Business Models. Retrieved September 22, 2022 from https://arxiv.org/abs/2201.04561

[9] Alexander Benlian, Daniel Hilkert, and Thomas Hess. 2015. How open is this platform? The meaning and measurement of platform openness from the complementors' perspective. *Journal of Information Technology* 30, 3 (2015), 209–228.

[10] Romy Bergman, Antragama Ewa Abbas, Sven Jung, Claudia Werker, and Mark De Reuver. 2022. Business model archetypes for data marketplaces in the automotive sector. *Electronic Markets* (2022).

[11] Daniel Beverungen, Thomas Hess, Antonia Köster, and Christiane Lehrer. 2022. From private digital platforms to public data spaces: implications for the digital transformation. *Electron Markets* 32, 2 (June 2022), 493–501. DOI:https://doi.org/10.1007/s12525-022-00553-z

[12] K. J. Boudreau. 2010. Open platform strategies and innovation: Granting access vs. devolving control. *Management Science* 56, 10 (2010), 1849–1872. DOI:https://doi.org/10.1287/mnsc.1100.1215

[13] K. J. Boudreau. 2012. Let a thousand flowers bloom? An early look at large numbers of software app developers and patterns of innovation. *Organization Science* 23, 5 (2012), 1409–1427. DOI:https://doi.org/10.1287/orsc.1110.0678

[14] Kevin J. Boudreau. 2010. Open Platform Strategies and Innovation: Granting Access vs. Devolving Control. *Management Science* 56, 10 (October 2010), 1849–1872. DOI:https://doi.org/10.1287/mnsc.1100.1215

[15] Sabine Brunswicker and Aaron Schecter. 2019. Coherence or flexibility? The paradox of change for developers' digital innovation trajectory on open platforms. *Research Policy* 48, 8 (October 2019), 103771. DOI:https://doi.org/10.1016/j.respol.2019.03.016

[16] Maja Hojer Bruun, Astrid Oberborbeck Andersen, and Adrienne Mannov. 2020. Infrastructures of trust and distrust: The politics and ethics of emerging cryptographic technologies. *Anthropology Today* 36, 2 (2020), 13–17. DOI:https://doi.org/10.1111/1467-8322.12562

[17] B. Bygstad. 2017. Generative Innovation: A Comparison of Lightweight and Heavyweight IT. *Journal of Information Technology* 32, 2 (2017), 180–193. DOI:https://doi.org/10.1057/jit.2016.15

[18] Marco Ceccagnoli, Chris Forman, Peng Huang, and D. J. Wu. 2012. Cocreation of Value in a Platform Ecosystem! The Case of Enterprise Software. *MIS Quarterly* 36, 1 (2012), 263–290. DOI:https://doi.org/10.2307/41410417

[19] Javier Cenamor and Johan Frishammar. 2021. Openness in platform ecosystems: Innovation strategies for complementary products. *Research Policy* 50, 1 (January 2021), 104148. DOI:https://doi.org/10.1016/j.respol.2020.104148

[20] C. Cennamo and J. Santaló. 2013. Platform competition: Strategic trade-offs in platform markets. *Strategic Management Journal* 34, 11 (2013), 1331–1350. DOI:https://doi.org/10.1002/smj.2066

[21] Carmelo Cennamo and Juan Santaló. 2019. Generativity Tension and Value Creation in Platform Ecosystems. *Organization Science* 30, 3 (May 2019), 617–641. DOI:https://doi.org/10.1287/orsc.2018.1270

[22] Goya Choi, Changi Nam, and Seongcheol Kim. 2019. The impacts of technology platform openness on application developers' intention to continuously use a platform: From an ecosystem perspective. *Telecommunications Policy* 43, 2 (March 2019), 140–153. DOI:https://doi.org/10.1016/j.telpol.2018.04.003

[23] Goya Choi, Changi Nam, Seongcheol Kim, Hyun Ju Jung, and Chul Ho Lee. 2020. Where does knowledge-sharing motivation come from? The case of third-party developer in mobile platforms. *Journal of Knowledge Management* 24, 7 (January 2020), 1681–1704. DOI:https://doi.org/10.1108/JKM-08-2019-0449

[24] G. Choia, C. Nam, and S. Kim. 2017. The Impacts of Mobile Platform Openness on Application Devel-opers' Intention to Continuously Use a Platform: From an Ecosystem Perspective. Passau, Germany. Retrieved from https://www.econstor.eu/handle/10419/169455

[25] Jörg Claussen, Tobias Kretschmer, and Philip Mayrhofer. 2013. The Effects of Rewarding User Engagement: The Case of Facebook Apps. *Information Systems Research* 24, 1 (March 2013), 186–200. DOI:https://doi.org/10.1287/isre.1120.0467

[26] Panos Constantinides, Ola Henfridsson, and Geoffrey G. Parker. 2018. Introduction—Platforms and Infrastructures in the Digital Age. *Information Systems Research* 29, 2 (June 2018), 381–400. DOI:https://doi.org/10.1287/isre.2018.0794

[27] Michael A. Cusumano and A. Gawer. 2002. The Elements of Platform Leadership. *MIT Sloan Management Review* 43, 3 (2002), 51. DOI:https://doi.org/10.1109/EMR.2003.1201437

[28] V Dal Bianco, Varvana Myllärniemi, M Komssi, and M Raatikainen. 2014. The Role of Platform Boundary Resources in Software Ecosystems: A Case Study. Retrieved September 21, 2022 from https://ieeexplore-ieee-org.tudelft.idm.oclc.org/abstract/document/6827094

[29] M. De Reuver and J. Ondrus. 2017. When technological superiority is not enough: The struggle to impose the SIM card as the NFC Secure Element for mobile payment platforms. *Telecommu-nications Policy* 41, 4 (2017), 253–262. DOI:https://doi.org/10.1016/j.telpol.2017.01.004

[30] M De Reuver, C Sørensen, and R C Basole. 2018. The digital platform: A research agenda. *Journal of Information Technology* 33, 2 (2018), 124–135. DOI:https://doi.org/10.1057/s41265-016-0033-3

[31] Thomas R. Eisenmann, Geoffrey Parker, and Marshall W. Van Alstyne. 2009. Opening Platforms: How, When and Why? In *Platforms,market and innovation*. Edward Elgar Publishing Ltd., 131–162. DOI:https://doi.org/10.2139/ssrn.1264012

[32] Thomas R. Eisenmann, Geoffrey Parker, and Marshall W Van Alstyne. 2006. Strategies for two-sided markets. *Harvard business review* 84, 10 (2006), 92.

[33] Thomas R. Eisenmann, Geoffrey Parker, and Marshall W. Van Alstyne. 2009. Opening Platforms: How, When and Why? In *Gawer, A. (eds) Platforms,market and innovation*. Edward Elgar Publishing Ltd., 131–162. DOI:https://doi.org/10.2139/ssrn.1264012

[34] Martin Engert, Julia Evers, Andreas Hein, and Helmut Krcmar. 2022. The Engagement of Complementors and the Role of Platform Boundary Resources in e-Commerce Platform Ecosystems. *Inf Syst Front* (January 2022). DOI:https://doi.org/10.1007/s10796-021-10236-3

[35] European Commission. 2020. The European Data Strategy. Retrieved December 13, 2021 from https://ec.europa.eu/commission/presscorner/detail/en/fs_20_283

[36] Samuel A. Fricker and Yuliyan V. Maksimov. 2017. Pricing of Data Products in Data Marketplaces. In *Lecture Notes in Business Information Processing*, Karl Werder, Arto Ojala and Helena Holmström Olsson (eds.). Springer International Publishing, Cham, 49–66. DOI:https://doi.org/10.1007/978-3-319-69191-6_4

[37] Annabelle Gawer. 2014. Bridging differing perspectives on technological platforms: Toward an integrative framework. *Research Policy* 43, 7 (2014), 1239–1249. DOI:https://doi.org/10.1016/j.respol.2014.03.006

[38] Selam Abrham Gebregiorgis and Jörn Altmann. 2015. IT Service Platforms: Their Value Creation Model and the Impact of their Level of Openness on their Adoption. *Procedia Computer Science* 68, (January 2015), 173–187. DOI:https://doi.org/10.1016/j.procs.2015.09.233

[39] A. Ghazawneh and O. Henfridsson. 2015. A paradigmatic analysis of digital application marketplac-es. *Journal of Information Technology* 30, 3 (2015), 198–208. DOI:https://doi.org/10.1057/jit.2015.16

[40] Ahmad Ghazawneh and Ola Henfridsson. 2013. Balancing platform control and external contribution in third-party development: the boundary resources model. *Information Systems Journal* 23, 2 (2013), 173–192. DOI:https://doi.org/10.1111/j.1365-2575.2012.00406.x

[41] Ahmad Ghazawneh and Ola Henfridsson. 2013. Balancing platform control and external contribution in third-party development: The boundary resources model. *Information Systems Journal* 23, 2 (2013), 173–192. DOI:https://doi.org/10.1111/j.1365-2575.2012.00406.x

[42] Tobias Goldbach, Viktoria Kemper, and Alexander Benlian. 2014. Mobile Application Quality and Platform Stickiness under Formal vs. Self-Control—Evidence from an Experimental Study. Auckland.

[43] Robert Wayne Gregory, Ola Henfridsson, Evgeny Kaganer, and Harris Kyriakou. 2022. Data Network Effects: Key Conditions, Shared Data, and the Data Value Duality. *AMR* 47, 1 (January 2022), 189–192. DOI:https://doi.org/10.5465/amr.2021.0111

[44] R Gulati, P Puranam, and M Tushman. 2012. Meta-organization design: Rethinking design in interorganizational and community contexts. *Strategic Management Journal* 33, 6 (2012), 571–586.

[45] Andrei Hagiu and Julian Wright. 2015. Multi-Sided Platforms. *International Journal of Industrial Organization* 43, (2015), 162–174. DOI:https://doi.org/10.1016/j.ijindorg.2015.03.003

[46] Daniel Heinz, Carina Benz, Marcel Fassnacht, and Gerhard Satzger. 2022. Past, Present and Future of Data Ecosystems Research: A Systematic Literature Review. 19.

[47] Ola Henfridsson, Joe Nandhakumar, Harry Scarbrough, and Nikiforos Panourgias. 2018. Recombination in the open-ended value landscape of digital innovation. *Information and Organization* 28, 2 (June 2018), 89–100. DOI:https://doi.org/10.1016/j.infoandorg.2018.03.001

[48] Susan Hilbolling, Hans Berends, Fleur Deken, and Philipp Tuertscher. 2020. Complementors as connectors: managing open innovation around digital product platforms. *R&D Management* 50, 1 (2020), 18–30. DOI:https://doi.org/10.1111/radm.12371

[49] Matthias Jarke, Boris Otto, and S Ram. 2019. Data sovereignty and data space ecosystems. *Business & Information Systems Engineering* 61, 5 (2019), 549–550.

[50] Kimmo Karhu, Robin Gustafsson, and Kalle Lyytinen. 2018. Exploiting and defending open digital platforms with boundary resources: Android's five platform forks. *Information Systems Research* 29, 2 (2018), 479–497.

[51] Kimmo Karhu and Paavo Ritala. 2021. Slicing the cake without baking it: Opportunistic platform entry strategies in digital markets. *Long Range Planning* 54, 5 (October 2021), 101988. DOI:https://doi.org/10.1016/j.lrp.2020.101988

[52] S. Khanagha, S. Ansari, S. Paroutis, and L. Oviedo. 2020. Mutualism and the dynamics of new platform creation: A study of cisco and fog computing. *Strategic Management Journal* 43, (2020), 476–506. DOI:https://doi.org/10.1002/smj.3147

[53] S. Koch and M. Kerschbaum. 2014. Joining a smartphone ecosystem: Application developers' moti-vations and decision criteria. *Information and Software Technology* 56, 11 (2014), 1423–1435. DOI:https://doi.org/10.1016/j.infsof.2014.03.010

[54] Pantelis Koutroumpis, Aija Leiponen, and Llewellyn D W Thomas. 2020. Markets for data. *Industrial and Corporate Change* 29, 3 (June 2020), 645–660. DOI:https://doi.org/10.1093/icc/dtaa002

[55] F Lauf, S Scheider, J Bartsch, P Herrmann, M Radic, M Rebbert, A.T. Nemat, C Schlueter Langdon, R Konrad, and A Sunyaev. 2022. Linking Data Sovereignty and Data Economy: Arising Areas of Tension.

[56] Changjun Lee, Daeho Lee, and Junseok Hwang. 2015. Platform openness and the productivity of content providers: A meta-frontier analysis. *Telecommunications Policy* 39, 7 (August 2015), 553–562. DOI:https://doi.org/10.1016/j.telpol.2014.06.010

[57] Karan Menon, Hannu Kärkkäinen, and Thorsten Wuest. 2020. Industrial internet platform provider and end-user perceptions of platform openness impacts. *Industry and Innovation* 27, 4 (April 2020), 363–389. DOI:https://doi.org/10.1080/13662716.2019.1673150

[58] Jan Mikolon, David Hoffmann, Malte Greulich, and Matthias Werner. 2019. To row together or paddel one's own canoe? Simulating strategies to spur digital platform growth. Retrieved from https://aisel.aisnet.org/ecis2019_rp/75

[59] J Mineraud, O Mazhelis, X Su, and S Tarkoma. 2016. A gap analysis of Internet-of-Things platforms. *Computer Communications* 89–90, (2016), 5–16. DOI:https://doi.org/10.1016/j.comcom.2016.03.015

[60] Lars Mosterd, Vladimir C.M. Sobota, Geerten van de Kaa, Aaron Yi Ding, and Mark de Reuver. 2021. Context dependent trade-offs around platform-to-platform openness: The case of the Internet of Things. *Technovation* 108, (December 2021), 102331. DOI:https://doi.org/10.1016/j.technovation.2021.102331

[61] Tomasz Mucha and Timo Seppala. 2020. *Artificial Intelligence Platforms – A New Research Agenda for Digital Platform Economy*. Social Science Research Network, Rochester, NY. DOI:https://doi.org/10.2139/ssrn.3532937

[62] M F Niculescu, D J Wu, and L Xua. 2018. Strategic Intellectual Property Sharing: Competition on an Open Technology Platform Under Network Effects. *Information Systems Research* 29, 2 (2018), 498–519.

[63] Fatemeh Nikayin, M De Reuver, and Timo Itälä. 2013. Collective action for a common service platform for independent living services. *International journal of medical informatics* 82, 10 (2013), 922–939.

[64] Hosea Ofe, M De Reuver, B Nederstigt, and M.F.W.H.A. Janssen. 2023. Data Analytics Platforms: Value Propositions and Adoption Challenges for Small Hospitality Businesses.

[65] Jan Ondrus, Avinash Gannamaneni, and Kalle Lyytinen. 2015. The impact of openness on the market potential of multi-sided platforms: A case study of mobile payment platforms. *Journal of Information Technology* 30, 3 (September 2015), 260–275. DOI:https://doi.org/10.1057/jit.2015.7

[66] Boris Otto and Matthias Jarke. 2019. Designing a multi-sided data platform: findings from the International Data Spaces case. *Electron Markets* 29, 4 (December 2019), 561–580. DOI:https://doi.org/10.1007/s12525-019-00362-x

[67] G. Parker, M. Van Alstyne, and X. Jiang. 2017. Platform Ecosystems: How Developers Invert the Firm. *MIS Quarterly* 41, 1 (2017), 255–266.

[68] Geoffrey Parker and Marshall W. Van Alstyne. 2018. Innovation, Openness, and Platform Control. *Management Science* 64, 7 (2018), 3015–3032. DOI:https://doi.org/10.1287/mnsc.2017.2757

[69] Bryan Pon, Timo Seppälä, and Martin Kenney. 2014. Android and the demise of operating system-based power: Firm strategy and platform control in the post-PC world. *Telecommunications Policy* 38, 11 (December 2014), 979–991. DOI:https://doi.org/10.1016/j.telpol.2014.05.001

[70] Fabian de Prieëlle, G. A. de Reuver, and J. Rezaei. 2020. The Role of Ecosystem Data Governance in Adoption of Data Platforms by Internet-of-Things Data Providers: Case of Dutch Horticulture Industry. *IEEE Transactions on Engineering Management* Early Access, (2020). DOI:https://doi.org/10.1109/TEM.2020.2966024

[71] Mark de Reuver, Harry Bouwman, Guillermo Prieto, and Alex Visser. 2011. Governance of flexible mobile service platforms. *Futures* 43, 9 (November 2011), 979–985. DOI:https://doi.org/10.1016/j.futures.2011.06.007

[72] Mark de Reuver, Edgar Verschuur, Fatemeh Nikayin, Narciso Cerpa, and Harry Bouwman. 2015. Collective action for mobile payment platforms: A case study on collaboration issues between banks and telecom operators. *Electronic Commerce Research and Applications* 14, 5 (September 2015), 331–344. DOI:https://doi.org/10.1016/j.elerap.2014.08.004

[73] Jean-Charles Rochet and Jean Tirole. 2003. Platform competition in two-sided markets. *Journal of the european economic association* 1, 4 (2003), 990–1029.

[74] Fatemeh Saadatmand, Rikard Lindgren, and Ulrike Schultze. 2019. Configurations of platform organizations: Implications for complementor engagement. *Research Policy* 48, 8 (October 2019), 103770. DOI:https://doi.org/10.1016/j.respol.2019.03.015

[75] T. Saarikko. 2016. Platform Provider by Accident: A Case Study of Digital Platform Coring. *Busi-ness & Information Systems Engineering* 58, 3 (2016), 177–191. DOI:https://doi.org/10.1007/s12599-016-0426-4

[76] Maximilian Schreieck, Manuel Wiesche, and Helmut Krcmar. 2021. Capabilities for value co-creation and value capture in emergent platform ecosystems: A longitudinal case study of SAP's cloud platform. *Journal of Information Technology* 36, 4 (December 2021), 365–390. DOI:https://doi.org/10.1177/02683962211023780

[77] David Soto Setzke, Markus Böhm, and Helmut Krcmar. 2019. Platform Openness: A Systematic Literature Review and Avenues for Future Research. *Wirtschaftsinformatik 2019 Proceedings* (March 2019). Retrieved from https://aisel.aisnet.org/wi2019/track07/papers/9

[78] M Spiekermann. 2019. Data Marketplaces: Trends and Monetisation of Data Goods. *Intereconomics* 54, 4 (2019), 208–216. DOI:http://dx.doi.org/10.1007/s10272-019-0826-z

[79] Mark C. Suchman. 1995. Managing Legitimacy: Strategic and Institutional Approaches. *AMR* 20, 3 (July 1995), 571–610. DOI:https://doi.org/10.5465/amr.1995.9508080331

[80] Karl Taeuscher and Hannes Rothe. 2021. Optimal distinctiveness in platform markets: Leveraging complementors as legitimacy buffers. *Strategic Management Journal* 42, 2 (2021), 435–461. DOI:https://doi.org/10.1002/smj.3229

[81] B. Tan, S. Pan, X. Lu, and L. Huang. 2015. The Role of IS Capabilities in the Development of Multi-Sided Platforms: The Digital Ecosystem Strategy of Alibaba.com. *Journal of the Association for Information Systems* 16, 4 (2015), 248–280. DOI:https://doi.org/10.17705/1jais.00393

[82] David Tilson, Kalle Lyytinen, and Carsten Sørensen. 2010. Digital infrastructures: The missing IS research agenda. *Information Systems Research* 21, 4 (December 2010), 748–759. DOI:https://doi.org/10.1287/isre.1100.0318

[83] Amrit Tiwana. 2013. *Platform Ecosystems: Aligning Architecture, Governance and Strategy*. Morgan Kaufmann Publishers, Burlington, MA.

[84] Amrit Tiwana, Benn Konsynski, and Ashley A. Bush. 2010. Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics. *Information Systems Research* 21, 4 (December 2010), 675–687. DOI:https://doi.org/10.1287/isre.1100.0323

[85] C.-L. Tsai. 2018. The timing of fostering complementary innovation: Exploring the antecedent of in-dustry platform emergence. *Technology*

Analysis & Strategic Management 30, 10 (2018), 1121–1135. DOI:https://doi.org/10.1080/09537325.2018.1442924

[86] Simon Den Uijl. 2015. *The emergence of de-facto standards*.

[87] Marshall W. Van Alstyne and Alisa Lenart. 2020. Using data and respecting users. *Commun. ACM* 63, 11 (October 2020), 28–30. DOI:https://doi.org/10.1145/3423998

[88] Marshall W. Van Alstyne, Georgios Petropoulos, Geoffrey Parker, and Bertin Martens. 2021. "In situ" data rights. *Commun. ACM* 64, 12 (December 2021), 34–35. DOI:https://doi.org/10.1145/3491270

[89] Fernando N Van der Vlist and Anne Helmond. 2021. How partners mediate platform power: Mapping business and data partnerships in the social media ecosystem. *Big Data & Society* 8, 1 (January 2021), 20539517211025060. DOI:https://doi.org/10.1177/20539517211025061

[90] B Van Loenen, Anneke Zuiderwijk, G Vancauwenberghe, FJ Lopez-Pellicer, I Mulder, C Alexopoulos, R Magnussen, M Saddiqa, M Dulong de Rosnay, J Crompvoets, A Polini, B Re, and C Casiano Flores. Towards value-creating and sustainable open data ecosystems: A comparative case study and a research agenda. *eJournal of eDemocracy and Open Government (JeDEM)* 13, 2 .

[91] N. Venkatraman and C.-H. Lee. 2004. Preferential linkage and network evolution: A conceptual model and empirical test in the U.S. video game sector. *Academy of Management Journal* 47, 6 (2004), 876–892. DOI:https://doi.org/10.5465/20159628

[92] Jonathan Wareham, Paul B. Fox, and Josep Lluís Cano Giner. 2014. Technology Ecosystem Governance. *Organization Science* 25, 4 (August 2014), 1195–1215. DOI:https://doi.org/10.1287/orsc.2014.0895

[93] Niklas Weiss, Manuel Wiesche, Maximilian Schreieck, and Helmut Krcmar. 2020. Learning to be a Platform Owner: How BMW Enhances App Development for Cars. *IEEE Transactions on Engineering Management* Early Access, (2020). DOI:https://doi.org/10.1109/TEM.2020.3017051

[94] M. Wessel, F. Thies, and A. Benlian. 2017. Opening the Floodgates: The Implications of Increasing Platform Openness in Crowdfunding. *Journal of Information Technology* 32, 4 (2017), 344–360. DOI:https://doi.org/10.1057/s41265-017-0040-z

[95] J West. 2003. How open is open enough? Melding proprietary and open source platform strategies. *Research Policy* 32, 7 (2003), 1259–1285. DOI:https://doi.org/10.1016/S0048-7333(03)00052-0

[96] J West. 2003. How open is open enough? Melding proprietary and open source platform strategies. *Research Policy* 32, 7 (2003), 1259–1285. DOI:https://doi.org/10.1016/S0048-7333(03)00052-0

[97] Michael A. Zaggl, Tim G. Schweisfurth, and Cornelius Herstatt. 2020. The Dynamics of Openness and the Role of User Communities: A Case Study in the Ecosystem of Open Source Gaming Handhelds. *IEEE Transactions on Engineering Management* 67, 3 (August 2020), 712–723. DOI:https://doi.org/10.1109/TEM.2019.2897900