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ORIGINAL ARTICLE

Three layers of abstraction: a conceptual framework for theorizing digital multi-sided platforms

Martin Poniatowski[1] · Hedda Lüttenberg[1] · Daniel Beverungen[1] · Dennis Kundisch[1]

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Abstract
The digital economy has brought about multi-sided platforms as superior configurations for value co-creation. However, the academic discourse on platforms is scattered across academic disciplines—including management, information systems, and economics. Based on a systematic literature review of 140 papers from nine disciplines, we inductively develop a framework that provides a conceptual point of reference for conducting boundary-spanning research on digital multi-sided platforms. Systematizing the identified concepts, we introduce three layers of abstraction: conceptualizing platforms as information systems, as systems for actor engagement, or as ecosystems. Our framework conceptualizes digital multi-sided platforms as nested hierarchies of systems that are shaped by, and in interaction with, their environment. This view focuses on designing IT artifacts, governance mechanisms, and strategies for platforms in terms of how they interact with their environment. Practitioners can use our insights to analyze, design, and manage platforms aimed at establishing a sustainable competitive advantage.

Keywords Multi-sided platform · Digital platform · Conceptual framework · Literature review

1 Introduction

Driven by digitalization, the competitive environment of digital platforms has changed substantially over recent years, and their importance and relevance has grown ever since. New forms of digitally enabled interactions and information exchanges have given rise to innovative and disruptive platform-based business models. Additionally, new actors establish platforms that act as intermediaries,

✉ Dennis Kundisch
dennis.kundisch@wiwi.uni-paderborn.de

[1] Department of Information Systems, Paderborn University, Paderborn, Germany

substituting dyadic interactions among market players (e.g., Airbnb successfully established a platform that matches providers and consumers of apartments). Digital multi-sided platforms are enabling different groups of participants not only to exchange information, goods, and social content, but also to create new services, business models and markets (Eisenmann et al. 2006; Parker and Van Alstyne 2012). Widely used across different branches (e.g., industry, tourism, and e-commerce), platform-based offerings encompass a diverse range of digital services (e.g., AXOOM, 365FarmNet), applications (e.g., Google Play Store, Microsoft Store), shared commodities (e.g., Uber, Airbnb), social media (e.g., Facebook, YouTube), and products (e.g., Amazon, Alibaba). Conventional market dynamics have been fundamentally disrupted by the ubiquity of platforms, their rapidly evolving and growing variety, and the new roles and business models they have helped to create (e.g., Parker and Van Alstyne 2018; Tiwana 2015a, b).

While two-sided markets and their mechanisms have been researched for a long time—focusing on non-digital markets matching two groups of actors, e.g., workers and companies, or sellers and buyers (Jones 1962; Shapley and Shubik 1971)—the disruptive effects of digital multi-sided platforms require new theorizing as well as greater consideration in managerial practice. Understanding how and by which dynamics digital multi-sided platforms shape competitive environments and their participants can generate valuable insights for analyzing and designing platform-based business models and the platform ecosystem. Identifying the structural concepts of platforms and their interactions might also enable us to better understand and manage dynamic effects in the platform ecosystem.

While platforms have received considerable scholarly attention, multi-sided platforms are often researched separately in different disciplines, each applying their own foci and investigating different phenomena, while boundary-spanning research is scarce (Gawer 2014). In information systems (IS), for instance, research has addressed the evolution (e.g., Fu et al. 2018; Tiwana et al. 2010), design (e.g., Bakos and Katsamakas 2008; Spagnoletti et al. 2015), and governance of multi-sided platforms and their ecosystems (e.g., Huber et al. 2017; Song et al. 2018). While in management a wide range of topics is researched applying four perspectives—focused on the product, technological systems, transactions (Baldwin and Woodard 2009), or platform ecosystems (Thomas et al. 2014)—the technical aspects of platforms are predominantly researched from a strategic perspective (e.g., Boudreau 2010). Research in economics focuses on market mechanisms and dynamics (e.g., Rochet and Tirole 2003). To develop consistent theory that spans boundaries between these disciplines, research has called for further reviewing the body of knowledge, structuring it, and providing conceptual clarifications concerning digital multi-sided platforms (de Reuver et al. 2018). A systemic perspective on digital multi-sided platforms is required to reveal the interactions, and resolve any contradictions, involved in investigating platforms as IT artifacts, as mechanisms for the engagement of third parties, or as environmental dynamics that endogenously affect a platform's success.

Taking up this call for action, we set out to develop a conceptual point of reference that bridges boundaries between disciplines involved in researching digital multi-sided platforms, posing the following research question:

What concepts and relations constitute a digital multi-sided platform?

We start with performing a comprehensive literature review, resulting in eight main concepts, which we detail with 18 sub-concepts originating in nine academic disciplines. Based on these insights, we inductively develop a conceptual framework that defines three layers of abstraction that structure the identified concepts. The framework offers a fresh conceptual point of reference (de Reuver et al. 2018), which is much needed to inspire and guide boundary-spanning research on digital multi-sided platforms.

The remainder of this paper is structured as follows. Section 2 reviews different perspectives and research foci on digital multi-sided platforms. Section 3 describes and justifies our research method. Section 4 presents our concept hierarchy, concept matrix, and conceptual framework. We conclude the paper in Sect. 5 by discussing limitations and outlining avenues for future research.

2 Related research

Building upon de Reuver et al. (2018) and Van Alstyne et al. (2016), we conceptualize digital platforms as consisting of three parts: A *platform periphery,* a *platform core*, and a *platform infrastructure* (cf. Fig. 1). The platform infrastructure is used as a foundation for the platform core (for this reason, it is enclosed by the core) and controlled by the platform sponsor. The core forms the part of the platform that is managed by the platform owner, and which third parties can interact with. The platform owner might also take on the role of the platform's sponsor in some cases (e.g., Amazon). The platform owner also controls the platform periphery, which comprises the contributions provided by third parties. In particular, we focus on digital multi-sided platforms that "enable interactions between multiple groups of surrounding consumers and 'complementors'" (Boudreau and Hagiu 2009, p. 163) based on functionalities supplied by the platform owner.

Research foci and, by implication, perspectives on digital multi-sided platforms have evolved differently in various disciplines. As we will show below, some of the disciplines do intersect, while they also implement specific idiosyncratic perspectives and define similar concepts differently. In this paper, we focus mainly on the

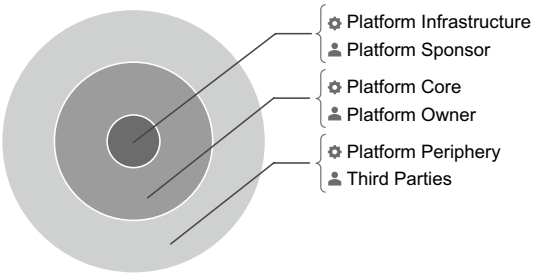

Fig. 1 Roles and their scope of activities within a digital multi-sided platform (de Reuver et al. 2018; Van Alstyne et al. 2016)

intersections between management, economics, and IS—three disciplines that represent a significant share of research about multi-sided platforms.

In the management discipline, four overlapping research streams emerged, focusing on products, technological systems, transactions (Baldwin and Woodard 2009), and platform ecosystems (Thomas et al. 2014), respectively. The first stream takes a combined strategic and technical perspective on planning and managing a product as a platform. Based on a modular design and the standardized interfaces of a physical product, third parties can contribute other goods to complement the product. Thus, a product's features can be adapted to meet customers' needs (Baldwin and Woodard 2009). A strategy-driven perspective on a platform's technical design and applied technologies intersects with some streams in IS research (e.g., Tiwana et al. 2010).

The second perspective in management research focuses on platforms as technological systems (e.g., Microsoft Windows) and their strategies for succeeding in a competitive environment, based partly on technological advancements (Baldwin and Woodard 2009). Research on platform technologies and a platform's governance (e.g., granting access or devolving control (Boudreau 2010; West 2003)) intersects with IS research (e.g., Ghazawneh and Henfridsson 2013; Nielsen and Aanestad 2006), while research on competition between platforms (e.g., Economides and Katsamakas 2006) intersects with research in economics (e.g., Rochet and Tirole 2003). Gawer (2014) introduced an integrative framework, which bridges an economic and a technical perspective on multi-sided platforms, focusing on innovation and competition between platform owners and third parties.

The third perspective in management applies an economic lens to digital multi-sided platforms, investigating transactions and behavior on platforms (e.g., Eisenmann et al. 2006, 2011; Parker and Van Alstyne 2005; Rochet and Tirole 2003, 2006). It closely refers to economic concepts and theories that explain market effects that are also found in digital multi-sided platforms (e.g., network externalities (Choi 1994)). Recent research in economics investigates market mechanisms and their influence on digital platform markets (e.g., Rochet and Tirole 2003, 2006). To further expand the generalization and applicability of the results, research in this discipline adapts the existing knowledge base to digital multi-sided platforms (e.g., Armstrong and Wright 2007). This stream also intersects with the marketing discipline. Here the focus is on contributions made by third parties and extends beyond the traditional offline marketing to consider new channels for interacting with customers and publishing opinions about companies' products and services enabled by multi-sided platforms, for example, social media posts, online reviews (e.g., Fang et al. 2015).

The fourth stream of management research focuses on the platform ecosystem, based on research in the other three research streams. It takes on a strategic technology and innovation management perspective (Thomas et al. 2014) and intersects with the economics discipline with regard to market dynamics such as competition (Armstrong 2006; Katz and Shapiro 1994). Additionally, it intersects with the IS discipline by addressing technological aspects, e.g., the architectural design of the platform and its interfaces with complementors and consumers (Cennamo et al. 2018; Tiwana et al. 2010).

The economics discipline researches multi-sided platforms with a focus on market mechanisms and market dynamics (Rochet and Tirole 2003). For example, research addresses network effects as a phenomenon from an abstract and theoretical perspective (e.g., telephones and their network value) (Hagiu 2006). It is adaptable to the digital as well as the non-digital context (Katz et al. 1985), while research in IS examines network effects on digital platforms and their interdependencies with technological aspects (e.g., platform updates) or governance policies (e.g., app review) (Song et al. 2018).

The IS discipline investigates digital platforms from a socio-technical perspective, including IT artifacts, human users, and organizations. IS research usually does not consider platforms as physical products, but as digital platforms (e.g., matching platforms like Airbnb or Uber, or software platforms like Android or iOS). Here, complements are offerings (e.g., products and services) or software applications requiring communication or programming interfaces to be established for interacting with the platform, i.e., application programming interfaces (API) (Ghazawneh and Henfridsson 2013; Huang et al. 2018) instead of electrical or mechanical interfaces to fit with a product platform (Sawhney 1998). In particular, research in IS focuses on the evolution (e.g., Fu et al. 2018; Tiwana et al. 2010), design (e.g., Bakos and Katsamakas 2008; Spagnoletti et al. 2015), and governance of digital multi-sided platforms and their ecosystems (e.g., Huber et al. 2017; Song et al. 2018). Research questions address how a platform's openness to third-party contributions influences innovation (e.g., Yaraghi et al. 2015), or how third parties impact a platform's governance (e.g., Huber et al. 2017).

Since each discipline is rooted in a different school of thought, even overlapping research topics address different aspects, or take different perspectives (cf. Fig. 2). For example, openness is researched from a strategic perspective based on granting access or devolving control (Boudreau 2010), or from a technical perspective

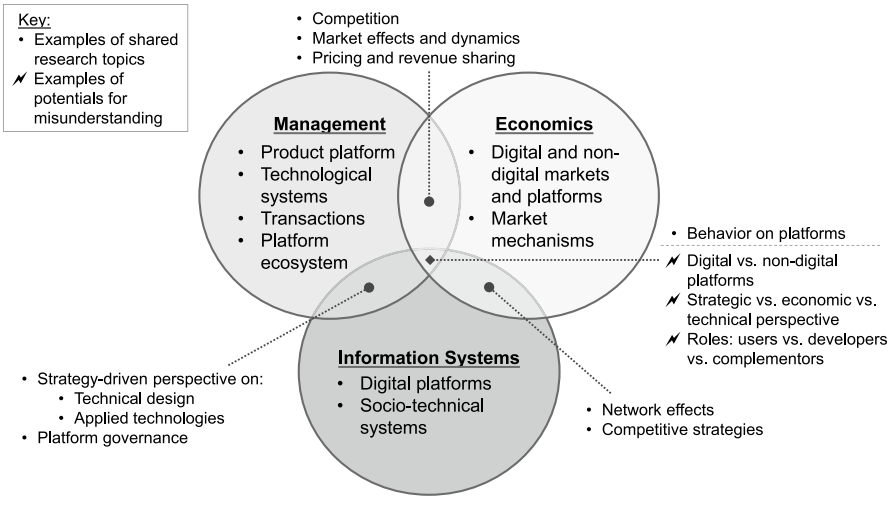

Fig. 2 Foci in research on multi-sided platforms in management, economics, and IS

addressing interfaces and standards (Simcoe et al. 2009). Disciplines also use different terminologies, such as cross-network effects versus indirect network effects, or users versus developers (Ye and Kankanhalli 2018). This paper adopts a holistic, cross-disciplinary perspective on digital multi-sided platforms, by providing a common conceptual point of reference.

Although several literature reviews address concepts of digital multi-sided platforms and platform ecosystems (cf. Table 1), no conceptual model has been proposed to provide a comprehensive overview on digital multi-sided platforms and platform ecosystems, including their interdependencies. Also, most reviews focus on a particular research discipline. Fu et al. (2018) and Thomas et al. (2014) focus on analyzing management literature, while others cover IS (Asadullah et al. 2018) and economics research (Schreieck et al. 2016; Hein et al. 2020), too. Some authors focus on a technical perspective by including software engineering (Tiwana et al. 2010), telecommunications (de Reuver et al. 2018), or computer science (Setzke et al. 2019). Only de Reuver et al. (2018) and Schreieck et al. (2016) take a broader scope and cover IS, economics, and management research, even if neither of the two papers provides a model for structuring and explaining digital multi-sided platforms and ecosystems. Hein et al. (2020) consider IS, economics, and technology management literature, but focus on carving out three building blocks for platform ecosystems: platform ownership, value-creating mechanisms, and complementor autonomy. We conclude that, to date, neither a comprehensive overview nor a systematization of concepts has been conducted in the context of digital multi-sided platforms and ecosystems. Therefore, the aim of our paper is to provide a cross-disciplinary and, thus, comprehensive set of concepts with which to structure digital multi-sided platforms.

3 Research design

To answer our research question, we conducted a comprehensive and descriptive literature research focused on a conceptual analysis of the literature on digital multi-sided platforms originating in a range of disciplines (Paré et al. 2015). By structuring the concepts emerging from previous research, we aim to provide a foundation for further theorizing (Leidner 2018). Following Webster and Watson (2002), we started our review by selecting journals based on the Financial Times Research Rank (Ormans 2016) and the IS Senior Scholars' Basket of Journals (AIS 2011). The assignment of these journals to disciplines is based on the VHB JOURQUAL 3 journal ranking list (Hennig-Thurau et al. 2015) as well as on the descriptions found on each journal's website. We included journals of the disciplines 'Management' (comprising 'General Business Administration' and 'International Management'), 'Economics', 'Marketing', 'Operations Research', 'Production Management', 'Strategic Management', 'Technology, Innovation and Entrepreneurship', 'Information Systems', and 'Service and Trade Management'. We did not include 'Accounting', 'Business Taxation', 'Financing', and 'Organization'. Additionally, we performed a backward search to identify journals that contain seminal research on multi-sided platforms (i.e., Armstrong 2006; Parker

Table 1 Overview of literature reviews on digital multi-sided platforms and ecosystems

Author	Paper type	Focus	Scope	Model
Asadullah et al. (2018)	Literature review	Platform design, platform adoption and use, platform outcomes	96 papers from 2002–2017; IS and management	–
de Reuver et al. (2018)	Research agenda	Digital platforms and platform ecosystems in general	IS, management, economics, telecommunications	–
Fu et al. (2018)	Literature review	Platform-based service innovation and system design	187 papers from 2006–2016; management	Framework on the mechanisms of platform evolution driven by platform-based service innovation and system design; contains 11 research topics, structured by 'platform service innovation', 'platform system design', 'network effect and value co-creation activities', and 'co-evolution of a platform ecosystem'
Hein et al. (2020)	Conceptual paper	Digital platform ecosystems in general	IS, economics, technology management	Model to explain how different digital platform ecosystems vary according to three core building blocks: 'platform ownership', 'value-creating mechanisms', and 'complementor autonomy'; the building blocks comprise seven manifestations; the model is structured by 'digital platform', 'boundary', and 'ecosystem'
Schreieck et al. (2016)	Literature review	Design and governance of platform ecosystems	103 papers from 1999–2015; IS, management, economics	–
Setzke et al. (2019)	Literature review	Platform openness	73 papers; IS, management, organization science, computer science	–
Thomas et al. (2014)	Literature review	Architectural leverage	183 papers from 1992–2010; Management	Architectural leverage framework containing nine platform types, three of each are assigned to production logic, innovation logic, or transaction logic
Tiwana et al. (2010)	Research commentary	Platform evolution	IS, strategy, economics, and software engineering	Framework for studying platform evolution; based on platform architecture, governance, and environmental dynamics; comprising 16 core elements of the research problems

and Van Alstyne 2005; Rochet and Tirole 2003). The final journal list consisted of 41 journals (see Online Resource 1). Using the literature research tool "Publish or Perish" (Harzing 2007), we searched each journal (up to 01/2019) by applying the following keyword string: "platform" OR "platforms" OR "two-sided" OR "multi-sided" OR "network effect" OR "network externality", based on the Google Scholar Database. Our initial search identified 363 papers, all of which we analyzed in detail.

We applied a hermeneutic approach to develop a complete set of concepts that structure digital multi-sided platforms. A hermeneutic approach prescribes that understanding emerges from an interplay of concepts and their description across various sources and perspectives (Boell and Cecez-Kecmanovic 2014). Consistent with this approach, we started by identifying an initial set of concepts related to digital multi-sided platforms from literature reviews, research agendas and editorials. We provide an overview of the initially identified concepts in Online Resource 2. The concepts appertained to internal factors and environmental dynamics of digital multi-sided platforms. As our analysis commenced, two authors refined, restructured, and extended these concepts based on the papers analyzed. Where a paper did not match the concepts exactly, we updated the concepts accordingly. Additionally, the final concept hierarchies (i.e., assessment to concept classes, main concepts, as well as sub-concepts) were discussed by all the authors together in in several workshops until a consensus was reached.

After establishing the final set of concepts, we analyzed all papers in a two-step approach. Since our research question focuses on digital multi-sided platforms, we first reviewed each paper's title, abstract, and keywords, to make sure that all papers deal explicitly with digital multi-sided platforms that "enable interactions between multiple groups of surrounding consumers and 'complementors'" (Boudreau and Hagiu 2009, p. 163). Where a paper's abstract did not suffice to make a clear decision, we screened the entire paper. All other papers were excluded, reducing the resulting set to 206 papers. Second, by screening the remaining papers in detail, we excluded those that did not address any of the concepts already identified. We also excluded non-peer reviewed sources such as interviews, books, and book reviews from our analysis, after checking them for any mention of concept definitions or explanations (e.g., Gawer 2009). We analyzed the remaining 140 papers in detail, using our concept matrix to identify the state-of-the-art of internal factors and environmental dynamics in the ecosystem of a multi-sided platform. Also, we examined to what extent papers considered relationships between concepts and systematized these relationships in a conceptual model.

4 Results and discussion

4.1 Concepts that structure multi-sided platforms

Internal Factors and Environmental Dynamics emerged as two disjointed classes of concepts from our literature review, which is in line with the findings of Tiwana

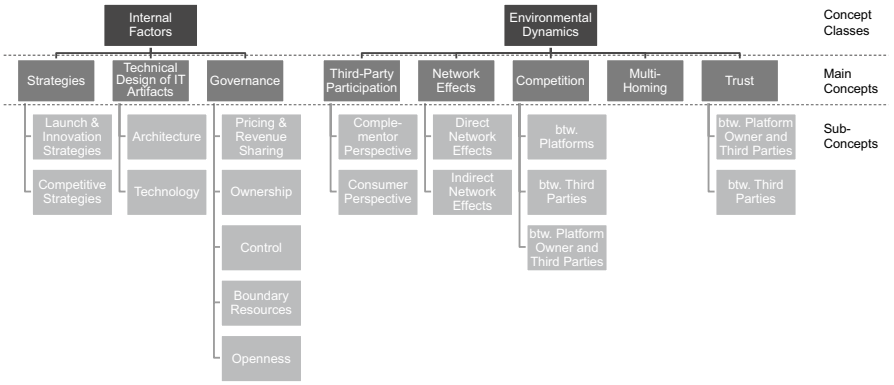

Fig. 3 Concept hierarchy for digital multi-sided platforms

et al. (2010). While a platform owner can control all Internal Factors fully, Environmental Dynamics emerge beyond the platform owner's control. Accordingly, we assigned all other concepts to these two basic classes of concepts (cf. Fig. 3).

4.1.1 Internal factors

Internal Factors comprise Strategies, Technical Design of IT Artifacts, and Governance (Tiwana et al. 2010) (Fig. 4). The main concept – Strategies – goes beyond the framework for platform evolution developed by Tiwana et al. (2010) and adds aspects which enable the alignment of the Technical Design of IT Artefacts and Governance in accordance with an overall strategy.

Strategies comprise Launch & Innovation Strategies and Competitive Strategies.

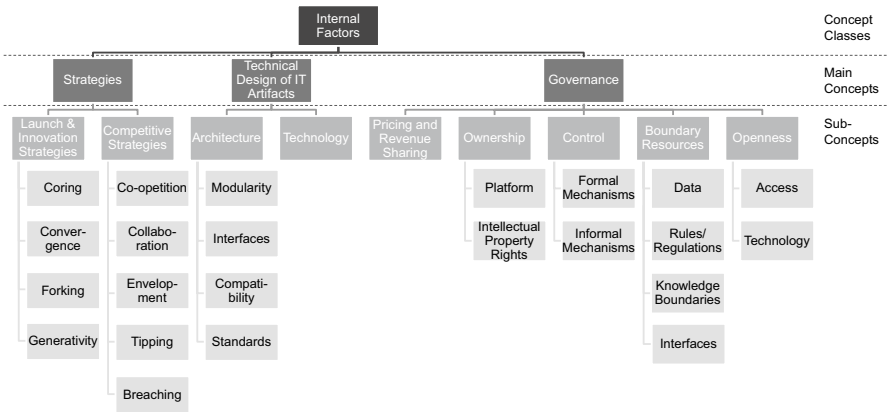

Fig. 4 Internal factors of digital multi-sided platforms

Launch & Innovation Strategies include activities that establish a new multi-sided platform or innovation, e.g., by coring (Gawer and Cusumano 2015), forking (Karhu et al. 2018), using convergence (Tiwana et al. 2010), or enabling generativity (de Reuver et al. 2018). Coring describes activities that identify elements that can be used to develop a platform, and to solve any problems concerning the majority of third parties within a particular platform ecosystem (Gawer and Cusumano 2015). The purpose of forking is to exploit existing platforms by building on the resources they provide (i.e., accessible within the platform core and the periphery) and thereby establish a new platform (Karhu et al. 2018). Convergence refers to the merging of technologies from adjacent application areas to further develop a platform (e.g., mobile phone combined with a camera) (Tiwana et al. 2010). Convergence can either be driven by a platform owner or by third parties (mostly complementors) enabled by the platform owner. In contrast, generativity is about enabling third parties to autonomously develop the platform within a defined scope as well as update their contributions (de Reuver et al. 2018).

Competitive Strategies include activities to expand a platform's market share in the form of envelopment (Eisenmann et al. 2011), breaching (Ozer and Anderson 2015), tipping (Gawer and Cusumano 2015; Katz and Shapiro 1994), 'co-opetition', or collaboration (Ondrus et al. 2015). Envelopment is focused on incorporating a competitive platform's functionality step-by-step into one's own platform. Thereby, third parties are wangled from the competitive platform and redirected to the own platform (Eisenmann et al. 2011). Breaching can be seen as the opposite of envelopment, as the objective of this strategy is to breach into the competitive platform and offer functionalities in the rival's immediate environment (Ozer and Anderson 2015). Tipping can be built upon envelopment or breaching and additionally includes competitive measures through pricing as well as marketing strategies (Gawer and Cusumano 2015; Katz and Shapiro 1994). As a more general term, tipping can be understood as a set of activities intended to decrease the popularity of a competitor's platform's in favour of one's own and, thereby, increase one's market share (Gawer and Cusumano 2015; Katz and Shapiro 1994). Alternatively, instead of direct competition with another platform, co-opetition or collaboration could also be considered (Ondrus et al. 2015). Co-opetition describes an interplay between platforms, where competitive platforms with the same functionalities reach different sets of third parties that are dependent upon each other (e.g., streaming Netflix content over Amazon Fire-TV hardware), whereas collaboration corresponds to a situation where platforms with different functionalities work together to benefit at least one third party (e.g., the food delivery platform Delivery Hero collaborating with the payment processing platform PayPal in order to facilitate orders and payment processes simultaneously for customers) (Ondrus et al. 2015).

Technical Design of IT Artifacts comprises Architecture and Technology. By including *Architecture* as a sub-concept, we adapt the concept definition offered by Tiwana et al. (2010), comprising the "conceptual blueprint" on how to integrate complements of third parties, for example by providing interfaces to the platform core (Tiwana 2015b), supporting modularity (Gawer 2014), building on established standards (Simcoe et al. 2009), or ensuring compatibility, e.g., with legacy systems (Edelman 2015). Interfaces as well as standards ensure the interoperability and

compatibility between third party-contributions (Tiwana 2015b; Simcoe et al. 2009). By providing interfaces, a variety of modular contributions extends the platform's periphery, resulting in a modular platform architecture (Gawer 2014). Interfaces are software-based and might include specifications of hardware elements. These interfaces might either apply to only one platform or, by being standardized, they are accepted across an entire industry (Tiwana 2015b; Simcoe et al. 2009). Compatibility (e.g., with legacy systems) refers to whether new complements are compatible with an older version of the platform. This applies to consoles, for example, where newer consoles are no longer compatible with older games (Edelman 2015). *Technology* denotes a platform's technological foundation and the different technologies that enable activities for third parties (Niculescu et al. 2018) or provide functionalities to third parties (Mantena and Saha 2012).

Governance refers to governing activities and interactions on the platform (Bresnahan and Greenstein 2014), such as setting prices or sharing revenues with third parties (i.e., *Pricing & Revenue Sharing* (Zhang et al. 2018)), as well as shifting and changing intellectual property rights of their contributions to the platform (i.e., *Ownership* (Parker and Van Alstyne 2018)). Governance also refers to designing the formal and the informal *Control* mechanism concerning third-party behavior on a platform (Song et al. 2018; Tiwana 2015a), and to determining which types of *Boundary Resources* (e.g., knowledge, data, interfaces, rules and regulations) can be accessed by third parties (Ghazawneh and Henfridsson 2013; Foerderer et al. 2018b). The degree of *Openness* can be used to restrict or enable access to a platform (Cusumano and Gawer 2002; West 2003). Among the Governance sub-concepts, platform ownership has special relevance as it has a strong impact on how all other sub-concepts of Governance are implemented (Bresnahan and Greenstein 2014). This ownership can range between proprietary and dispersed (or open) (Nocke et al. 2007).

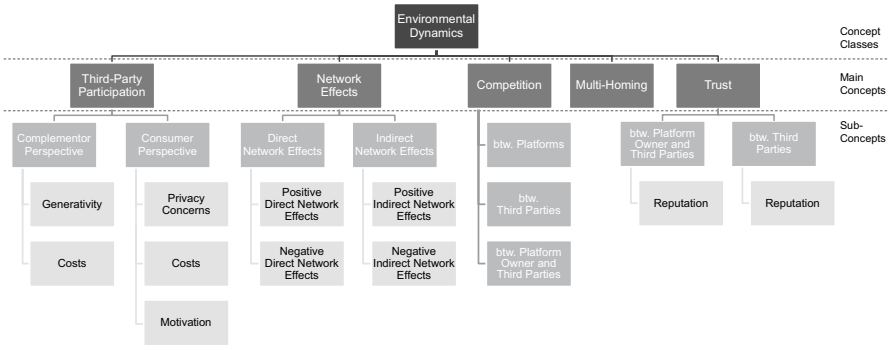

Fig. 5 Environmental dynamics of digital multi-sided platforms

4.1.2 Environmental dynamics

Environmental Dynamics encompasses Third-Party Participation, Network Effects, Competition, Multi-Homing, and Trust, where Multi-Homing and Third-Party Participation are partially based on the Framework for Studying Platform Evolution provided by Tiwana et al. (2010) (cf. Fig. 5). The other main concepts were derived during the literature review process.

Third-Party Participation presents concepts dealing with different types of actors engaging on a platform. We distinguish between the *Complementor perspective* (i.e., including developers (Tiwana 2015b) and sellers (Nielsen and Aanestad 2006)) and the *Consumer perspective* (Albuquerque et al. 2012). However, a complementor can take a consumer perspective and vice versa. The complementors' contributions to the platform include, among others, (smartphone) apps, online and offline services and products, social media posts, reactions, or reviews. Consumers might use complementors' contributions in various ways, for example by reading social media posts or buying products from online marketplaces. Also, in the sense of generativity (de Reuver et al. 2018), whole new functionalities might be contributed to the platform (e.g., by adding a camera functionality to a mobile phone). However, the contribution depends on the costs of participating from the perspective of third parties (e.g., Lam 2017). Especially from the third-party perspective, the motivation (e.g., gaining a specific status) as well as privacy concerns (e.g., disclosing sensitive data as well as the way the data is processed) might influence the decision to participate (e.g., Levina and Arriaga 2014; Khern-am-nuai et al. 2018; Gal-Or et al. 2018).

Network Effects designate the size of the stakeholder groups that give rise to Direct and Indirect Network Effects. *Direct Network Effects* occur, "if the value of the platform depends on the number of users in the same group" (de Reuver et al. 2018, p. 125), for example in telephone networks. *Indirect Network Effects* occur if the number of users in the other group of stakeholders affects the platform's value proposition of the first group (Katz et al. 1985). For example, online marketplaces like Amazon or Alibaba are only attractive to consumers when enough complementors offer their products. Complementors, in turn, participate only if they can reach enough consumers. Both types of network effects can either be positive or negative (Eisenmann et al. 2006; Evans and Schmalensee 2016).

Competition can emerge on different levels (Armstrong 2006; Rochet and Tirole 2003): *Competition between Platforms* (Rochet and Tirole 2003), *between Platform Owner and Third Parties* (Hagiu 2009), and *between Third Parties* (Armstrong 2006). For example, Ebay and Amazon are competitors on the platform level (marketplaces). Complementors within those marketplaces (here, sellers) compete for consumers, which reflects the competition between third parties. As platform owners have information on product sales of each seller and products within the platform, the owner might enter the platform as complementor and compete with the other complementors (competition between platform owner and third parties). This scenario also applies to Google's Play Store and Apple's App Store, as marketplaces for applications.

Multi-Homing occurs if third parties participate in at least two different platforms (Armstrong and Wright 2007) and use them alternately as substitutes. This concept

might be considered from two different perspectives: the complementor or the consumer. From the complementor's perspective, smartphone's operating systems (e.g., Android, iOS) are platforms that might be seen as substitutes, but despite providing the same functionality to consumers, often one of these systems is preferred by the consumer. Nevertheless, complementors build upon these platforms to provide mobile apps. Due to the high dissemination of both systems, complementors might multi-home to provide their application in different application marketplaces. However, from the consumer perspective, there are cases, in which the consumer is active on multiple platforms with similar functionalities (e.g., LinkedIn and Xing).

Trust is essential to stimulate activity on a multi-sided platform (Constantinides et al. 2018), particularly for Peer-to-Peer (*between Third Parties*) funding or when handling personal data (e.g., Airbnb (Gal-Or et al. 2018)). Third Parties have to trust that *Platform Owners* will continuously support and develop the platform (Ye and Kankanhalli 2017), since their specific investments would otherwise be lost. Trust in these subjects is influenced by the reputation of the third party as well as of the platform (owner), based on reviews and ratings, for example (e.g., Li et al. 2019).

4.1.3 Conceptual analysis of research on multi-sided platforms

As recommended by Webster and Watson (2002), we used a concept matrix to guide our literature review, based on the final set of concepts (cf. Table 2), and identified which research methods (theoretical or empirical) the authors used. The resulting concept matrix, reporting on all 140 papers, cannot be reported here in full. Instead, Table 2 illustrates our main findings, while the full matrix is available as Online Resource 3.

Our analysis of the whole concept matrix reveals that twenty papers address Internal Factors only, while thirty focus on Environmental Dynamics. Ninety papers refer to both categories, underlining the importance of investigating their intersections.

As expected, the majority of papers on multi-sided platforms are published in either of the three disciplines, respectively IS (i.e., 28 in six journals), management (MGMT; 26 in nine journals), and management and (applied) economics (MGMT/ECON; 26 in two journals). The Journal of Economics & Management Strategy (17), Information Systems Research (16), and Management Science (12) occur frequently in our dataset, too.

A closer inspection of the papers, however, reveals that each discipline investigates different aspects of multi-sided platforms. IS research focuses on Technical Design, Governance, and Third-Party contributions, emphasizing the implementation and use of a platform. Management (MGMT) predominantly addresses Network Effects, as well as Governance mechanisms. Economics (ECON) is less broadly diversified than management, but focuses on similar concepts (i.e., Governance Mechanisms, Network Effects). All but one of the economics papers apply theoretical research methods, while in MGMT almost half of the papers are empirical. A chronological analysis shows that the number of ECON articles peaked early (i.e., in around 2006) and is now decreasing slightly, while the number of MGMT papers is still increasing, with peaks in 2013 and 2018. This increase could indicate

Table 2 Concept matrix for analyzing the state of research on digital multi-sided platforms

Authors	Year	Discipline	Internal factors											
			Strategies	Competitive Strategies	Launch & Innovation Strategies	Technical Design	Technology	Architecture	Governance	Pricing and Revenue Sharing	Ownership	Control	Boundary Resources	Openness
Rochet and Tirole	2003	ECON							X	X			X	
Armstrong	2006	ECON							X	X				
Rochet and Tirole	2006	ECON							X	X				
Armstrong and Wright	2007	ECON	X	X										
Hagiu	2006	ECON							X	X				
Ceccagnoli et al	2012	IS				X	X	X	X		X			
Ghazawneh and Henfridsson	2013	IS							X			X	X	X
Ondrus et al	2015	IS	X	X		X	X		X					X
Song et al	2018	IS							X			X		
Thies et al	2016	IS												
Gawer and Cusumano	2014	MGMT	X	X		X		X	X		X			
Eisenmann et al	2006	MGMT	X	X					X	X				
Parker and Van Alstyne	2005	MGMT							X	X				
Boudreau	2010	MGMT				X	X		X			X		X

Table 2 (continued)

Authors	Year	Discipline	Internal factors											
			Strategies	Competitive Strategies	Launch & Innovation Strategies	Technical Design	Technology	Architecture	Governance	Pricing and Revenue Sharing	Ownership	Control	Boundary Resources	Openness
Economides and Katsamakas	2006	MGMT							X	X				X
Gawer and Henderson	2007	MGMT/ ECON	X	X	X									
Hagiu	2009	MGMT/ ECON							X	X				
Choi	2010	MGMT/ ECON	X	X										
Simcoe et al	2009	MGMT/ ECON				X	X	X	X		X			
Lee	2014	MGMT/ ECON												
Albuquerque et al	2012	MARKET							X	X				
Constantinides et al	2018	OR, IS	X			X			X					
Zhang et al	2018	PROD MGMT							X	X				
Eisenmann et al	2011	STRAT MGMT	X	X										
Gawer	2014	TIE				X		X	X			X	X	X
		Sum presented	8	7	1	7	4	4	17	8	3	4	3	5
		Sum total	32	25	7	30	11	15	83	54	9	13	10	20

Table 2 (continued)

Environmental dynamics														Research	
Network Effects	Direct Network Effects	Indirect Network Effects	Third-Party Participation	Complementor Perspecitve	Consumer Perspective	Competition	Competition btw. Platforms	Competition btw. Third Parties	Competition btw. Platform Owner and Third Parties	Multi-Homing	Trust	Trust btw. Platform Owner and Third Parties	Trust btw. Third Parties	Theoretical	Empirical
						X	X			X				X	
X		X				X	X	X		X				X	
X		X												X	
X		X								X				X	
X		X				X	X			X				X	
X		X	X	X											X
			X	X										X	X
														X	X
X		X	X	X											X
			X		X						X		X		X
			X	X											X
X		X								X				X	
X		X												X	
			X	X											X
X		X	X	X		X	X							X	
			X	X											X
						X		X		X				X	
						X	X			X				X	
															X

Table 2 (continued)

Environmental dynamics														Research	
Network Effects	Direct Network Effects	Indirect Network Effects	Third-Party Participation	Complementor Perspecitve	Consumer Perspective	Competition	Competition btw. Platforms	Competition btw. Third Parties	Competition btw. Platform Owner and Third Parties	Multi-Homing	Trust	Trust btw. Platform Owner and Third Parties	Trust btw. Third Parties	Theoretical	Empirical
						X	X			X				X	
			X		X									X	X
X						X				X	X				X
						X		X							X
						X	X							X	X
X			X	X		X	X							X	
11	0	9	10	7	2	10	7	3	0	8	2	0	1	16	13
48	6	28	59	42	17	51	32	12	8	14	9	2	5	81	70

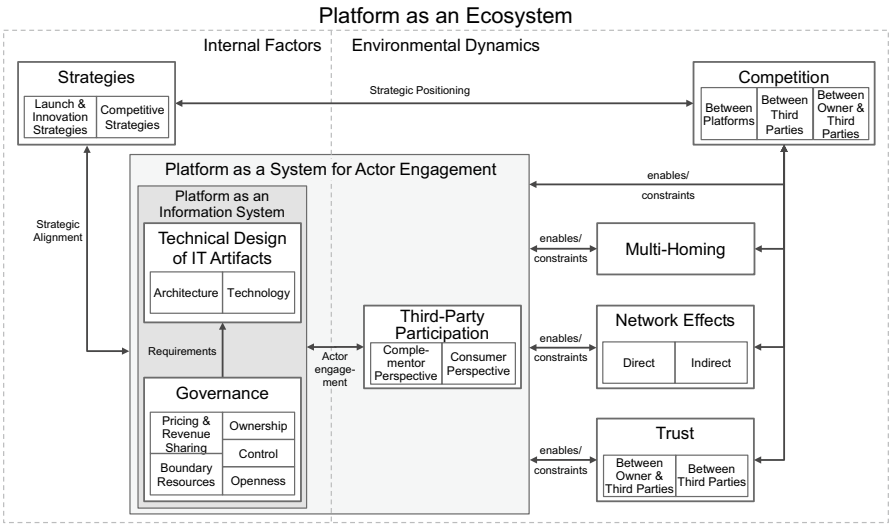

Fig. 6 Three layers of abstraction for theorizing digital multi-sided platforms

that MGMT might validate theories developed by the economics community with a focus on the digital environment. Marketing (MARKET) focuses on Third-Party Participation and Network Effects, while it also considers Pricing & Revenue Sharing. Production Management (PROD MGMT) also investigates Pricing & Revenue Sharing, but considers Competition, too. As can be expected, Strategy Management (STRAT MGMT) focuses on Strategies and Competition. In contrast, Technology, Innovation, and Entrepreneurship (TIE) have no identifiable predominant focus.

Our data reveal that research in digital multi-sided platforms is carried out in different disciplines that overlap to some extent, but without having established a consistent set of shared theoretical concepts. Therefore, we set out to provide a conceptual reference point that can serve to integrate different views on digital multi-sided platforms in the spirit of boundary-spanning research on platforms.

4.2 Three layers of abstraction on multi-sided platforms

Based on our literature analysis, we develop a conceptual framework providing three layers of abstraction on digital multi-sided platforms that bridge discipline-specific perspectives: Platforms as an Information System, as a System for Actor Engagement, and as an Ecosystem (Fig. 6). These layers form a nested structure, rooted in General Systems Theory premise to distinguish systems from their environments (Luhmann et al. 2013).

As an *Information System*, platforms refer to the *Technical Design of IT Artifacts* and their *Governance*, based on the notion that a platform owner controls both aspects, subject to a *Strategy*. In this sense, a platform can be viewed as an IT artifact that needs to be designed and managed by an organization. As information systems, platforms have structures that are coupled with their environment. With

a Platform as an Information System, a platform owner offers third parties a value proposition—reaching participants on other sides of the market.

In a platform conceptualized as a *System for Actor Engagement*, third parties can engage in the value proposition offered by the platform owner by using the *Information System* to interact (Boudreau and Hagiu 2009) and co-create mutual value, e.g., by offering complements, products, or user-generated content, or consuming offers. This value co-creation—enabled by *Third Party Participation*—can manifest in two different types: transaction and innovation (Hein et al. 2020). To enable transactions, the *Platform as an Information System* takes the role as an intermediary between complementors and consumers (Parker et al. 2005) and matches the latter's intent to consume with a supply offered by a complementor (Van Alstyne et al. 2016). Innovation results from complements to the platform core (within the platform's periphery) that are provided by complementors and that extend the platform's functionality (de Reuver et al. 2018). To enable one or both types of value-creation, the design of the Platform as an Information System is crucial to make the occurrence of valuable contributions more likely, while discouraging any contributions that are not valuable. Through governance mechanisms, a platform owner can control the participation of third parties by setting incentives or restrictions. The platform's technical design can either increase or reduce the options, or strengthen or diminish the impact of governance mechanisms (Tiwana et al. 2010).

While the *Platform as a System for Actor Engagement* limits the perspective to one platform and the value-creation taking place on that platform, the *Platform as an Ecosystem* expands this perspective by additionally incorporating environmental dynamics that endogenously affect and are affected by the *System for Actor Engagement* (Tiwana et al. 2010). An *Ecosystem* comprises the *Internal Factors* and the *Environmental Dynamics* of platforms. *Internal Factors* are controlled by a platform owner directly, with the owner defining *Strategies*, *Technical Design of IT Artifacts*, *Governance* mechanisms, and processes. In contrast, *Environmental Dynamics* lie outside of the provider's direct control, since they result from performances of actors situated in the Platform's Ecosystem (Tiwana et al. 2010). Therefore, the strategies of the platform owner and the environmental dynamics within the Platform Ecosystem affect the value-creation in a positive or negative way. The strategies of the platform owner must adapt to changes in the ecosystem and might cause modifications of the Platform as an Information System, and vice versa.

4.2.1 Platform as an information system

The identified concepts impact each other in various ways. Regarding *Platforms as an Information System*, the *Technical Design of IT Artifacts* is closely intertwined with a platform's *Governance*. For instance, the desired degree of *Openness* and *Boundary Resources* will leave its mark on a platform's implementation (e.g., West 2003). *Control* relates to technology or formal control comprising the output and processes of module developers (e.g., Nielsen and Aanestad 2006; Tiwana et al. 2010). On the one hand, platform owners can decide to devolve control over

technology to complementors, allowing them to design, implement, and operate information structures (Nielsen and Aanestad 2006) and thereby extend the platform's technology architecture (i.e., generativity (de Reuver et al. 2018)). On the other hand, platform owners can prescribe processes that complementors have to perform, and can check the fulfillment of criteria for evaluating complements and rewarding or penalizing complementors (e.g., Tiwana et al. 2010). Informal mechanisms are less strict, and are enforced by the complementors themselves (e.g., common values and beliefs (Tiwana et al. 2010)).

4.2.2 Platform as a system for actor engagement

A *Platform as a System for Actor Engagement* considers the technical and governance features that incentivize, regulate, and control *Third-Party Participation* by granting, limiting, or facilitating access based on rules and regulations, technical interfaces, and access to information (e.g., de Reuver et al. 2018; Schreieck et al. 2016). Therefore, *Control*, *Openness*, and *Boundary Resources* strongly influence *Third-Party* engagement by either providing or restricting access to the platform. According to Ghazawneh and Henfridsson (2013), *Boundary Resources* can be designed for resourcing, which in turn supports complementors to extend and diversify the platform by their complements, while *Boundary Resources* can also be designed to secure or control the platform and its complements. Platform owners can apply different forms of *Pricing & Revenue Sharing* to attract and incentivize the participation of third parties (e.g., Hagiu 2006), for example through promotional activities to influence third parties in their choice to visit a platform, to create or purchase content (e.g., Albuquerque et al. 2012). Of course, the properties of Platforms as Information System can also promote or limit the engagement of external complementors, since they determine the required investment and coordination costs (e.g., Gawer and Cusumano 2015; Tiwana 2015b). For instance, complementors need to establish sufficient knowledge (e.g., based on knowledge boundaries provided by the platform (Foerderer et al. 2018b)) and technologies to enable their contribution and ensure profitability (e.g., Gawer and Cusumano 2015). For platform owners, it is essential to attract a large number of complementors (reaching a *Critical Mass* of users and establishing *Network Effects*), since their complements are essential to the innovativeness and competitive performance of their platform (e.g., Gawer 2014). The more standardized and compatible the interfaces of a platform are, the more decision rights complementors have, and the easier it is for third parties to contribute, which reduces their coordination costs (e.g., Tiwana 2015b; West 2003).

4.2.3 Platform as an ecosystem

On the *Platform Ecosystem layer*, the platform owner can make strategic decisions (*Strategies*) on how to launch and innovate or manage a platform to generate a competitive advantage over rivals (e.g., Eisenmann et al. 2006).

Environmental Dynamics affect the Platform as a System for Actor Engagement, since environmental factors make contributions from third-party stakeholders more

or less likely. *Network Effects* work by enhancing actor engagement (e.g., Katz and Shapiro 1994; Parker and Van Alstyne 2005). In some cases, *Network Effects* influence a constellation of several factors and dynamics. For example, according to Hann et al. (2016), the backward compatibility of a platform (*Technical Design of IT Artifacts*) affects the degree of participation by complementors and consumers, depending on the intensity of *Network Effects* that prevails on the platform. Complementors and consumers might leave the platform in case its owner decides to no longer support backward compatibility (i.e., quality, security, and technical support across platform generations). Additionally, removing former platform generations reduces the market size and, in order to persist on the market, complementors might decide to change their strategy to a *Multi-Homing* approach to persist on the market (e.g., Hann et al. 2016). Further, the platform owner's *Governance* decisions might result in *Network Effects*, while *Network Effects* can in turn affect *Governance* decisions (e.g., Eisenmann et al. 2006; Rochet and Tirole 2006). For example, a *Pricing & Revenue Sharing* strategy implemented by a platform owner might include the offer of a digital good (e.g., a pdf reader) for free. Due to *Indirect Network Effects*, the demand for complementary goods (e.g., a pdf writer) increases and defrays the cost of the free good (e.g., Parker and Van Alstyne 2005). In the context of a web browser (as digital multi-sided platform) the *Technical Design of the IT Artifact* can affect *Indirect Network Effects*, since an increase in the number of consumers leads to an increase in the number of complementors, whereas an increase in the number of complementors leads to a growing consumer group (e.g., Song et al. 2018).

Multi-Homing is linked to the Platform as an Information System and *Competition between platforms* (e.g., Choi 2010; Hagiu 2006, 2009). *Competition between platforms* considers influences from other platforms on a particular one but does not extend the framework by including them. Therefore, it represents an interface towards other platforms' ecosystems. For complementors, *Multi-Homing* allows to increase their market share across different platforms and markets. *Multi-Homing* behavior by third parties (e.g., game developers, gamers) mostly depends on the *Technical Design of the IT Artifact* (e.g., gaming devices). Unless a platform is based on a complex *Architecture* and *Technology* that are similar to others, the barrier of *Multi-Homing* for complementors is very high due to adaptation costs (e.g., training, technical requirements) (e.g., Cennamo et al. 2018), which gives rise to winner-takes-all markets (Evans and Schmalensee 2016).

Trust can exist between a platform owner and third parties as well as among its third parties, and is important to facilitate activity on the platform (e.g., Thies et al. 2016; Ye and Kankanhalli 2017). *Trust* between third parties and the platform might be established through clear, transparent, and legitimate processes on the platform (e.g., Ingram Bogusz et al. 2018). With increased media attention on the number of data breaches regarding data privacy and security, concerns might influence activity on the platform, and affect *Competition* between platforms depending on different privacy configuration possibilities (e.g., Gal-Or et al. 2018). Further, trust between third parties and the platform as well as between third parties might be influenced by the reputation (e.g., based on reviews and ratings) of these subjects (e.g., Li et al. 2019).

In a multi-sided platform ecosystem, *Competition* as an *Environmental Dynamic* might significantly affect platforms on different levels (e.g., Armstrong 2006; Rochet and Tirole 2003). Our analysis highlights three levels of *Competition*: Competition between Platforms, Competition between a Platform Owner and Third Parties, and Competition between Third Parties. *Competition* links *Strategies* (*Internal Factor*) with *Multi-Homing*, *Network Effects*, *Trust,* and the Platform as an Information System. *Competition*, especially on a platform level, is influenced by *Strategies* (e.g., envelopment, forking) to achieve a targeted position within the platform ecosystem, and vice versa (e.g., Eisenmann et al. 2011; Karhu et al. 2018). Moreover, Competition might also affect the Platform as an Information System (i.e., *Technical Design of IT Artifacts*, *Governance*, *Third-Party Participation*). Depending on *Competition* structure, in case of "pure competition" (Mantena and Saha 2012, p. 116), small differences in the *Technical Design of IT Artifacts* (i.e., *Technology*) might significantly influence the profitability of the platform and therefore its position in the ecosystem beside strategies like co-opetition or collaboration (e.g., Mantena and Saha 2012). Moreover, *Technical Design of IT Artifacts* might be used to tie third parties (e.g., developers) to the platform, which increases their barrier to *Multi-Homing,* and strengthens the platform's position vis-à-vis competitors (e.g., Tiwana 2018). *Third-Party Participation*, too is influenced by *Competition*, especially if a platform owner decides to enter the platform as a complementor and, thus, competes with existing complementors for consumers. By entering the complementors' competition (e.g., app developers), platform owners might induce an increase in the innovation rate for the complementors who compete for the same group of consumers (e.g., Foerderer et al. 2018a). In this way, platform owners might not achieve the desired revenue, but attract increasing attention among consumers for the complementors' products and services, which consequently increases activity on the platform. *Competition* might affect decisions on *Governance* as well. For example, *Competition* to attract complementors among platforms might emerge. *Competition* might also be influenced by *Network Effects* (e.g., Niculescu et al. 2018). For instance, positive *Network Effects* (higher value through an increased number of third parties) might affect *Competition* between platforms as well as between Third Parties. There is an interdependency between *Competition* and the *Multi-Homing* behavior of third parties (e.g., Lee 2014). A platform owner might reduce the risk of tipping by allowing third parties to approach *Multi-Homing*, which affects their *Competition* (e.g., Choi 2010). The ability to create *Trust* on a platform impacts on *Competition* (e.g., Constantinides et al. 2018). Especially in cases where consumers' privacy concerns come into play, it might be beneficial to inform consumers about the advantages of gathering their data and providing greater control to stand out among rival platforms (e.g., Gal-Or et al. 2018) as well as gain a better reputation from the platform's data handling in regard to data privacy (e.g., Li et al. 2019).

The organization structure on the platform (e.g., hierarchy relationship between platform owners and complementors like developers) might be important to understand how certain structures comprising *Ownership* regulations, *Pricing & Revenue Sharing* models, *Control* mechanism, scope of *Boundary Resources*, and accessibility granted by *Openness* to incentivize complementors to participate in the platform (e.g., Economides and Katsamakas 2006). The structure can range from a single-sided platform (i.e., proprietary), where the owner is the only complementor, to complementor

participation regulated by contracts (e.g., Windows, Apple), to a non-hierarchical structure (i.e., dispersed or open), where a profit-oriented platform owner is missing and the *Governance* on the platform is shaped by all participating groups, for example, the World Wide Web (e.g., Bresnahan and Greenstein 2014).

5 Conclusion

In this paper, we developed a comprehensive overview of research on digital multi-sided platforms – a phenomenon that increasingly shapes our digital economy – while addressing the issue of the literature being scattered across diverse academic disciplines. Based on identifying 27 theoretical concepts (eight main concepts and 18 sub concepts) originating in many different streams of research, we re-organized the concepts and propose three layers of abstraction for theorizing digital multi-sided platforms. Moreover, our detailed conceptual analysis contributes a literature-based concept hierarchy and matrix to provide a much-needed structure and order for the current body of knowledge on digital multi-sided platforms. At the same time, these results can be used to identify conceptual starting points for research initiatives that might bridge current disciplinary boundaries.

Other researchers can build on the concepts and relations outlined here to position their research more accurately. They can also identify additional constructs and relations to be included in our concept hierarchy and in the conceptual framework. Using our framework might enable them to structure and position future research agendas, and to identify further aspects requiring more in-depth interdisciplinary research. Further, since many of the economics papers on digital multi-sided platforms are conceptual in nature, we aim to stimulate empirical investigations into the identified relations or a broader analysis of theories to be adapted, extended, or validated by other disciplines. In addition, our framework might be applied to investigate specific types of platforms (e.g., sharing economy, crowdfunding, reviewing). While we do not expect individual concepts to be omitted completely for specific platform types, their relationships or sub-concepts might be re-specified and detailed to generate new insights.

For managers, our results identify and systematize the concepts and relations that constitute a digital multi-sided platform. Managers can use our results to better understand and successfully manage the interplay of platforms as information systems, platforms for actor engagement, and platforms as ecosystems. Our concept hierarchy can serve to distinguish the different concepts outlined here on an unprecedented comprehensive level of detail. Based on our concept hierarchy, the conceptual framework highlights the importance of direct and indirect consequences that are critical to implementing successful strategies in a platform economy.

Limitations of our study relate to the decisions we made regarding the selection and exclusion of specific journals. Moreover, we excluded concepts that consider not only policy decisions but also regulations (e.g., net neutrality (Bourreau et al. 2015)) and their influences on digital multi-sided platforms. Including these concepts might be an interesting avenue for future research. Moreover, our deliberate aim was to

develop generalizable results rather than focus only on particular types of platforms. Other limitations might arise from our decision to use the Google Scholar database for compiling our dataset based on the papers' titles, abstracts, and keywords. While we cannot claim completeness of our investigation in this regard, we invite subsequent research to extend our framework conceptually.

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Availability of data and material Electronic supplementary material on the results of the literature review are provided.

Code availability Not applicable.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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