

DESIGN AND GOVERNANCE OF PLATFORM ECOSYSTEMS – KEY CONCEPTS AND ISSUES FOR FUTURE RESEARCH

Research

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Abstract

The purpose of this paper is to give an overview of current research in IS on the design and governance of platform ecosystems. To this end, we conduct a literature review of relevant journals and conferences. We show that platform ecosystems have been analysed from two different perspectives: technology- and market-oriented. Thereby, most studies take on the viewpoint of the platform owner. Furthermore, we summarize key concepts on the design and governance of platform ecosystems that have been discussed in literature. As most relevant concepts we identify the definition of roles, pricing, boundary resources and openness. Based on this analysis, we derive issues for future research: the integration of market- and technology-oriented perspectives, an individual level of analysis to include complementors and end-users and the role of data as boundary resource in platform ecosystems. This paper contributes to the understanding of platform ecosystems in IS literature by structuring existing research with regard to different perspectives and concepts and by providing starting points for future work. In addition, it lays out which concepts practitioners need to consider when designing and governing platform ecosystems.

Keywords: Platform ecosystem, platform governance, boundary resource, literature review.

1 Introduction

“Proliferating digital platforms will be at the heart of tomorrow’s economy, and even government”, *The Economist* stated last year, referring to the dominance of platform ecosystems in today’s economy (“Something to stand on,” 2014). In a broad sense, platforms can be defined as “foundational products, services, or technologies upon which additional complementary products, services or technologies can be developed” (Gawer, 2009b). The term platform ecosystem refers to the platform and all stakeholders interacting on the platform (Gawer & Cusumano, 2013). The dominance of platform ecosystems can be underlined by two numbers: six out of ten of the most valuable brands in the Interbrand index have platform-based business models (“Best Global Brands,” 2014) including Apple and Google with their platform ecosystems dominating the market of smartphones. At the same time, all ten start-ups included in the list of the most trending start-ups in 2015 are, to a certain extent, based on platforms (“SpotRocket - Quantitative rankings of the world's hottest startups,” 2015). The list includes for example Uber, Airbnb and Spotify as platforms connecting providers and consumers of services, and cloudera, a technological platform for processing big data.

Platform ecosystems need to attract and coordinate two or more different target groups also referred to as sides (Gawer, 2009b) – in most cases complementors and customers (Tiwana, 2014) – for example drivers and passengers in the case of Uber or developers and end-users in the case of an app store. The right design and a suitable governance concept are therefore key to orchestrating a successful platform ecosystem with all stakeholders (Smedlund & Faghankhani, 2015). As described by Tiwana, Konsynski, and Venkatraman (2013) in a special issue of the *Journal of Management Information Systems* on IT governance, new organizational forms enabled by IT such as platform ecosystems raise the questions “Who is governed?”, “What is governed?” and “How is it governed?”. Answering these questions in the right way is crucial for platform owners – especially in view of the fierce competition between ecosystems (Mantena & Saha, 2012). The owners of platform ecosystems constantly compete with others to gain market share both in the group of end-users and complementors. For example, Amazon is trying to gain ground in the market for mobile device applications which is dominated by Google and Apple. Amazon has just launched the program “underground” as an attempt to undermine the Google Play Store on Android as marketplace for mobile applications (Dillet, 2015).

Since the late 1990s, motivated by Microsoft’s unprecedented success with its operating system platform Windows, IS research tries to understand how successful platform ecosystems in the IT industry need to be designed and governed (Bakos, 1998; Messerschmitt & Szyperski, 2003; Selander, Henfridsson, & Svahn, 2010). Researchers analysed the technical requirements of software platforms (Baldwin & Woodard, 2008), characteristics of successful platforms (Tan, Pan, Lu, & Huang, 2015), optimal pricing for platform-based businesses (Lin, Li, & Whinston, 2011) and control mechanisms applied on platforms (Goldbach & Kemper, 2014). These aspects all relate to how platform ecosystems are designed and governed (Hein, Schreieck, Wiesche, & Krcmar, 2016; Tiwana, Konsynski, & Bush, 2010). However, the growing base of literature builds on different understandings of the term platform and different perspectives on platform ecosystems. While some researchers view platforms as an IT artefact (Baldwin & Woodard, 2008), others define it as an abstract construct that brings together different parties (Bakos & Katsamakos, 2008). As a result, findings on the design and governance of platform ecosystems lack conceptual consensus.

Several authors have already contributed to structuring the research field of platforms. Thomas, Autio, and Gann (2014) provide a comprehensive review from a management research point of view that not only includes platform ecosystems but also organizational platforms, product family platforms and market intermediaries. This analysis needs to be concretized for the IS field. Existing literature reviews on platform ecosystems in IS provide a focus on specific concepts related to platform ecosystems and do not provide an overview of concepts (Porch, Timbrell, & Rosemann, 2015; Smedlund & Faghankhani, 2015). In order to understand the role of design and governance in platform ecosystems,

it is necessary to structure existing contributions based on their perspectives on platform ecosystems and the various concepts of design and governance they focus on. We thereby build on the framework developed by Tiwana et al. (2010) which is the first to integrate concepts of design and governance of platform ecosystems.

Towards this end, we conducted a literature review, condensing different perspectives on platform ecosystems in the first step. We determine that platform ecosystems have been analysed from two different perspectives: technology- and market-oriented. Thereby, most studies take on the viewpoint of the platform owner. In the second step, we present key concepts of the design and governance of platform ecosystems identified in literature. By discussing these concepts, our review reveals major open issues related to the design and governance of platform ecosystems: the integration of the two perspectives on platform ecosystems when discussing design and governance concepts, an individual level of analysis to consider characteristics of the actors in platform ecosystems and the role of data as boundary resource in platform ecosystems. Addressing these open issues will significantly contribute to our understanding of platform ecosystems and in particular of the key concepts of design and governance. The results will prove useful for practitioners that set up or run platform ecosystems and lack a structured overview of influencing factors on and within the platform ecosystem.

In the remainder of the paper, we first describe the process of literature search. Then, we present the results by structuring contributions according to different perspectives on platform ecosystems and by presenting the compiled concepts for the design and governance of platform ecosystems. Based on these findings, we discuss themes for future research.

2 Design of the Literature Review

In this review, we looked for publications that (a) focus on the platform ecosystem as unit of analysis and (b) derive explicit or implicit insights on how to design and govern platform ecosystems. Towards this end, we screened relevant outlets drawing on the guidelines by Webster and Watson (2002) and vom Brocke et al. (2009) and subsequently coded the studies with regard to their key results on platform ecosystems.

First, we conducted an all-field search (title, abstract, keywords, references) with the key word “platform” in the journals included in the Senior Scholars’ Basket of Journals of the Association for Information Systems. We screened the abstract of all 367 articles and identified 30 publications that matched both search criteria (a) and (b). If the match to our search criteria was unclear after reading the abstract, we read the full text to decide on the inclusion of the respective articles. Second, we performed a forward and backward search based on the publications gathered so far. This resulted in 40 additional articles from a variety of outlets. The sample includes books, such as the textbook “Platforms, Markets and Innovation” by Gawer (2009a), dissertations, e.g. from Qiu (2013), and articles from economic journals as long as they are related to the field of IS. Third, we extended our search to the leading IS conferences to include the most recent research topics. We focused on contributions published at the following conferences since 2013: International Conference on Information Systems (ICIS), European Conference on Information Systems (ECIS), Hawaii International Conference on System Sciences (HICSS), Americas’ Conference on Information Systems (AMCIS) and Wirtschaftsinformatik (WI). We restricted the search to title, abstract and keywords and excluded research-in-progress papers. Compared to the search in journals, we used the more specific search term “platform AND (ecosystem OR architecture OR governance OR control)” in order to end up with a manageable amount of hits. Again, the articles that resulted from the search were screened and selected according

to the criteria defined above. This step yielded another 27 articles (Table 1). Finally, 6 articles were added to the sample based on suggestions by the reviewers¹, leading to a total of 103 articles.

We then coded the selected articles along three main coding dimensions, using an explorative coding process which was repeated iteratively to develop conclusive coding constructs for each of the categories (Lacity, Khan, Yan, & Willcocks, 2010). The first dimension represents the research method used in the articles. An overview of the predominant methods in a field of research helps to assess its maturity and to identify methods for future studies that complement existing research (Edmondson & McManus, 2007). The second dimension covers the articles' perspectives on platform ecosystems. This builds on previous literature reviews that have identified different streams of literature on platforms and helps to take a holistic perspective on platform ecosystems. The perspective also includes whether the studies focus on the platform owner, the complementors or the end-users. The third dimension comprises all concepts related to the design and governance of platform ecosystems that are discussed in the respective article. In addition to the main coding dimensions, we gathered information on the cases and examples used in the studies. By summarizing the insights along the coding dimensions, we can carve out the focal points of existing research and identify issues for future research.

Outlet	Search	Hits	Selected
Top journals	MISQ	52	8
	JAIS	35	1
	ISR	59	8
	JMIS	76	3
	ISJ	12	4
	JIT	60	4
	EJIS	45	0
	JSIS	28	2
Top conferences	ICIS	99	5
	ECIS	89	8
	AMCIS	150	6
	HICSS	33	4
	WI	21	4
Other	Other journals	-	22
	Other conferences	-	2
	Dissertations	-	3
	Books / book chapters	-	6
	Other	-	7
Total		728	97

Table 1. Summary of the literature search process. Six additional articles were added during the review process.

3 Research on Platform Ecosystems

In this part of the literature review, we summarize the insights from the selected and coded articles on platform ecosystems in IS following the three main coding dimensions: research method, perspectives on platform ecosystems, and concepts of design and governance of platform ecosystems.

¹ Articles suggested by the reviewers: Wareham, Fox, and Cano Giner (2015), Boudreau (2012), Tiwana (2015), Liu, Au, and Choi (2014), Selander, Henfridsson, and Svahn (2013), Kude, Dibbern, and Heinzl (2012)

3.1 Research Methods

Research interest in platforms in IS has constantly increased since the late 1990s (see Figure 1). First platform ecosystems such as IBM's hardware-based personal computer platform and especially Microsoft's tremendously successful software-based Windows platform attracted the interest of IS research. We analysed which research methods are used in the publications and found that the majority of contributions is based on qualitative research.

67 publications apply qualitative methods, whereof 36 are based on case studies. These cases mostly focus on the successful platform ecosystems of the last decades: Microsoft with its Windows ecosystem (Eurich, Giessmann, Mettler, & Stanoevska-Slabeva, 2011) as well as Google and Apple with their app store ecosystems (Manner, Nienaber, & Schermann, 2013). Another 25 studies apply various qualitative approaches such as theory building based on qualitative insights (Grover & Kohli, 2012) or expert interviews (Bergvall-Kåreborn & Howcroft, 2014). Quantitative insights are presented in 28 studies. Researchers apply data analysis (Basole & Karla, 2011), experiments (Goldbach & Benlian, 2014), surveys (Goldbach & Benlian, 2015), simulations (Butler, Bateman, & Gray, 2014) as well as mathematical models to understand the formation of prices (Bakos & Katsamakos, 2008) or to understand processes and relationships in platform ecosystems.

Plotting the data over time reveals that the share of quantitative research has increased over the last decade (see Figure 1). According to Edmondson and McManus (2007) who evaluate the maturity of research fields, this increase in the share of quantitative studies shows that the topic "platform" in IS is currently evolving from a nascent to an intermediate field of research.

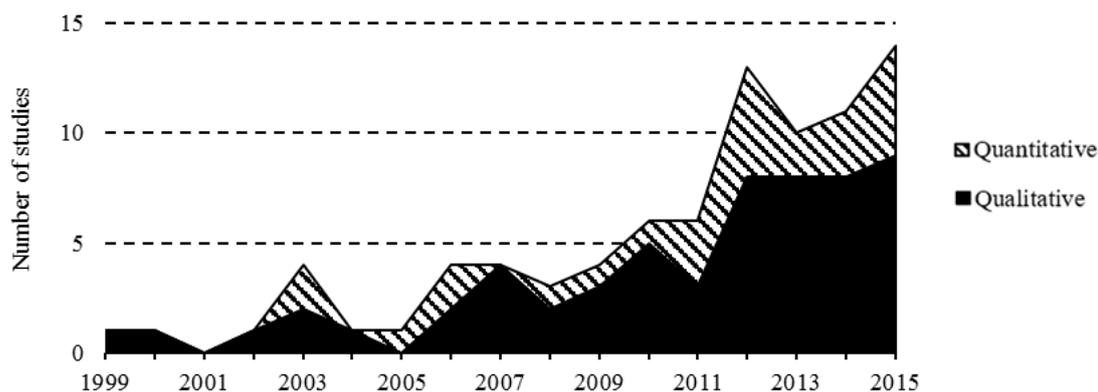


Figure 1. Number of quantitative and qualitative studies on platforms in IS over time (results from conference proceedings excluded, as the search was restricted to 2013-2015).

3.2 Perspectives on Platform Ecosystems

Our iterative coding process revealed two important dimensions along which studies take on different perspectives on platform ecosystems. First, studies have a different understanding of the platform ecosystem as unit of analysis. We therefore identify different perspectives on platform ecosystems by bringing together definitions and viewpoints from various studies. Second, studies focus on different stakeholders of the platform ecosystem, the platform owner, the complementors or the end-users. Both dimensions are discussed below. Regarding the understanding of the platform ecosystem, we identified more than 20 different definitions of the term "platform" referring to the core of the platform ecosystem. Based on these definitions and on existing attempts to cluster them, we derived two characteristics that can be used to differentiate platforms: technology- vs. market-oriented (Dibia & Wagner, 2015; Gawer, 2014; Thomas et al., 2014) and internal vs. external (Gawer, 2014; Porch et al., 2015). As we focus our literature review on platform ecosystems, we can assume that the underlying platforms are external, i.e. they bring together different actors to enable interactions that would not be

possible without the platform (Ghazawneh & Henfridsson, 2011). We therefore focus on the characteristic technology- vs. market-oriented (see Table 2). The analysis suggests that the characteristic technology- vs. market-oriented is not mutually exclusive. An app store, for example, is a marketplace for apps, enabled by the underlying technology, i.e. the mobile device's operating system and its application programming interfaces (APIs). We therefore see technology- and market-oriented as two perspectives on platform ecosystems. To a certain extent, all platform ecosystems need underlying technology and will exhibit characteristics of a market.

According to the technology-oriented perspective, a platform is defined as “a set of stable components that supports variety and evolvability in a system by constraining the linkages among the other components” (Baldwin & Woodard, 2008). This definition comprises software platforms such as operating systems (e.g. Apple's iOS) and hardware platforms such as IT infrastructure or computing hardware (e.g. wireless networks) (Fichman, 2004). The purpose of technological platforms is to enable co-creation of value in the platform ecosystem by complementors, for example the creation of applications for an operating system platform. Accordingly, studies taking on a technology-perspective, focus on study variables that influence the intensity of the co-creation of value such as openness (Benlian, Hilbert, & Hess, 2015) or the provision of boundary resources (Bianco, Myllarniemi, Komssi, & Raatikainen, 2014).

Following the market-oriented perspective, platform ecosystems can be seen as “markets, where users' interactions with each other are subject to network effects and are facilitated by a common platform provided by one or more intermediaries” (Eisenmann, Parker, & Van Alstyne, 2011). This definition comprises e-commerce marketplaces where goods and services are exchanged (e.g. Ebay) as well as communities where information is exchanged (e.g. Facebook). Intermediaries bring together different parties to enable a transaction between these parties (Thomas et al., 2014). While Ebay connects buyers and sellers, Facebook connects providers and consumers of information. The market perspective on platform ecosystems is rooted in economics, where characteristics of multi-sided markets have been an ongoing research topic (Weyl, 2010). The purpose of market platforms is to match supply and demand on a digital marketplace. Therefore, studies taking on the market-oriented perspective focus on study variables such as the number of market sides (Economides & Tåg, 2012) or the competitive strategy (Armstrong, 2006) to understand price formation and the success of intermediaries.

	Technology-oriented perspective	Market-oriented perspective
Definition	“A set of stable components that supports variety and evolvability in a system by constraining the linkages among the other components” (Baldwin & Woodard, 2008)	“Markets, where users' interactions with each other are subject to network effects and are facilitated by a common platform provided by one or more intermediaries” (Eisenmann et al., 2011)
Sub-categories	Software platform, hardware platform	Marketplace, community
Examples	Google Play, Apple App Store, SAP HANA Cloud Platform, IBM Watson	Airbnb, Uber, Spotify, Facebook
Purpose	Co-creation of value, innovation	Matching of supply and demand, exchange of information
Selected independent variables	Perceived openness Boundary resources Availability of complementary products Control mode	Number of market sides Network effects Centrality Competitive strategy
Selected dependent variables	Number of third-party applications Rate of innovation Platform adoption Platform stickiness	Welfare Equilibrium price Platform adoption

Table 2. Summary of the technology- and market-oriented perspective on platform ecosystems.

The contributions considered in this literature review by the majority focus on one of the perspectives (Table 3). Over all outlets, only 10 studies explicitly cover both perspectives.

Article	Perspective (Platform Ecosystem)				Perspective (Stakeholder)		
	Technology		Market		Owner	Comple-mentor	End-user
	Soft-ware	Hard-ware	Market-place	Commu-nity			
Top journals							
Anderson, Parker, and Tan (2014)	X		X		X		
Avgerou and Li (2013)			X	X		X	
Bakos and Katsamakos (2008)			X		X		
Benlian et al. (2015)	X					X	
Bergvall-Kåreborn and Howcroft (2014)	X					X	
Bock, Ahuja, Suh, and Yap (2015)				X	X		X
Butler et al. (2014)				X	X	X	
Ceccagnoli et al. (2012)	X					X	
Claussen, Kretschmer, and Mayrhofer (2013)	X		X		X	X	
Eaton (2015)	X				X	X	
Fichman (2004)	X				X		
Ghazawneh and Henfridsson (2013)	X				X		
Gnyawali, Fan, and Penner (2010)	X			X	X		
Grover and Kohli (2012)	X				X		
Hackney, Burn, and Salazar (2004)			X		X		
Koch and Schultze (2011)			X		X		
Koh and Fichman (2012)			X				X
Kuk and Janssen (2013)	X	X			X		
Lin et al. (2011)			X		X	X	
Lindgren, Eriksson, and Lyytinen (2015)	X					X	
Liu et al. (2014)	X		X			X	
Lusch and Nambisan (2015)	X				X	X	
Mantena and Saha (2012)			X		X		
Markus and Loebbecke (2013)				X	X		
Ondrus, Gannamaneni, and Lyytinen (2015)	X	X			X		
Rai and Tang (2014)	X				X		
Sambamurthy and Zmud (2000)	X				X		
Selander et al. (2013)	X					X	
Shaw and Holland (2010)			X		X		
Spagnoletti, Resca, and Lee (2015)	X			X	X	X	
Tiwana (2015)	X				X	X	
Tiwana et al. (2010)	X				X		
Yaraghi, Du, Sharman, Gopal, and Ramesh (2015)			X	X	X		X
Top conferences and others							
70 articles	40	3	22	2	60	17	7
Total	61	5	34	9	85	31	10

Table 3. Perspectives on platforms in IS research.

In addition to the different perspectives on platform ecosystems, we coded which stakeholder the studies in our review focus on – the platform owner, the complementor or the end-user (Table 3). The platform owner runs the platform and orchestrates the involved parties and processes on the platform. In most cases, the platform owner initiated the opening of the platform to enable the co-creation of value from third-parties (Ceccagnoli, Forman, Huang, & Wu, 2012) or to establish an exchange platform he can benefit from. In the example of the Apple App Store, Apple itself is the platform owner, running the App Store as integrated part of the operating system iOS. The complementor is an external party

not directly related to the platform owner that contributes to the platform ecosystem (Eisenmann, Parker, & Van Alstyne, 2008). App developers who publish apps on the Apple App Store can therefore be referred to as complementors. The end-user or customer accesses the platform to consume a service available on the platform (Tiwana et al., 2010). The user of an Apple device is likely to visit the Apple App Store to download and install applications.

Of those articles, that exhibit a clear focus, 85 take the platform owner's perspective while only 31 consider the complementor, as for example Goldbach and Benlian (2015), and only 10 consider the end-user as for example Koh and Fichman (2012) (Table 3). This observation needs to be taken into account for the discussion of concepts for the design and governance of platform ecosystems as well as for the deduction of open issues for future research.

3.3 Design and Governance of Platform Ecosystems

Our results show that researchers' main interest has been to understand why and how platform ecosystems in the IT industry arise and become successful in order to identify the underlying mechanisms of successful platforms. Ultimately, guidelines how practitioners can design and govern successful platform ecosystems are derived (Benlian et al., 2015; Ondrus et al., 2015; Spagnoletti et al., 2015; Yaraghi et al., 2015). The success of platforms is usually measured by its size, e.g. number of users, complementors or complementary products or services (Ghazawneh & Henfridsson, 2013). For commercial platforms, size alone is not sufficient but has to be complemented by a profitable business model. While for example the success of the non-profit knowledge platform Wikipedia is measured by the number of articles, the success of an e-commerce platform such as Ebay also includes the revenue and profit Ebay generates as platform owner.

To contribute to our understanding of platform ecosystems, we aggregate insights on the design and governance of platform ecosystems across all studies identified as relevant in our literature search. Following Tiwana (2014), we differentiate insights on architecture and governance of platform ecosystems. However, we replace the term architecture by design, broadening the rather technical definition by Tiwana. He defines the architecture of a platform ecosystem as "a conceptual blueprint that describes how the ecosystem is partitioned into a relatively stable platform and a complementary set of apps that are encouraged to vary, and the design rules binding on both", whereas our understanding of the design of a platform ecosystem refers to a conceptual blueprint of the whole ecosystem, including the partners and processes interacting on the platform and that includes both the technology- and market-oriented perspective. Governance, the "partitioning of decision-making authority between platform owners and app developers, control mechanisms, and pricing and pie-sharing structures" (Tiwana, 2014), covers tactical decisions that impact the processes within the platform ecosystem. Governance is related to both the technology- and market-oriented perspective as it covers technological aspects such as providing APIs and market-related aspects such as setting prices.

We identified eight key concepts focusing on the design and governance of platform ecosystems (Table 4). Some concepts are relevant for both design and governance of platform ecosystems; some primarily affect either design or governance. Furthermore, as depicted in the last three columns of the table, the concepts have been discussed from a technology- or market-oriented perspective, in some cases both. In the remainder of this section we will briefly present these concepts.

The definition of **roles** within a platform ecosystem is an important factor of ecosystem design and covers for example the number of sides it connects (Gnyawali et al., 2010), the ownership regimes (Bakos & Katsamakos, 2008), the distribution of power which can be centralized or decentralized and the relationship to stakeholders of the platform ecosystem (Bullinger, Rass, & Moeslein, 2012). For example, a platform ecosystem for mobile payment must balance ownership and power of three sides in the ecosystem (banks, dealers and customers) and establish relationships to partner companies that can increase its popularity (as airlines and hotels do for credit cards). Roles in platform ecosystems are

discussed from both a technology- and market-oriented perspective, but few studies have integrated the perspectives.

Pricing and revenue sharing has been studied as a governance mechanism in platform ecosystems. Pricing and revenue sharing refers to payment flows within the platform ecosystem and how they are distributed between the different stakeholders. These concepts can be used to support network effects and to overcome the chicken-and-egg problem in the initial phase of a platform ecosystem (Suarez & Cusumano, 2009). For example, Microsoft paid software developers to create first apps on the Windows phone platform in order to attract more users. Later on, the developers had to generate revenues by selling their apps to the end-users or displaying advertisements. Pricing and revenue sharing is mostly discussed from a market-oriented perspective. However, some studies take the technology-oriented perspective, for example when pricing for hardware components is analysed (Bresnahan & Greenstein, 1999).

Boundary resources are tools, regulations or other resources that are used to govern co-creation of value in platform ecosystems (Eaton, 2015). Most of the publications that cover boundary resources focus on APIs or software development kits (SDKs) that are used to facilitate co-creation of value. However, boundary resources can also stunt co-creation of value. For example, rigid regulations for the approval of complementary products or services on a platform may decrease the complementor's motivation (Eaton, 2015). A boundary resource that is gaining importance in practice is data which is provided by the users of a platform and can be made accessible for the complementors (Gawer, 2014). While data is mentioned as boundary resource in literature, its role is not yet analysed in detail. Boundary resources are analysed from a technology-oriented perspective as they impact the technical details of contributing to a platform but also complementors' motivation. Again, only few studies integrate a technology- and market-oriented view.

Openness refers to “to the easing of restrictions on the use, development and commercialization of a technology” (Boudreau, 2010). Following Boudreau (2010), a platform ecosystem can be opened by granting access to the platform or by partially giving up control over the platform. For example, Microsoft grants access to the Windows platform for application developers but stays in control, whereas in the Linux platform, the underlying technology has been made completely available to stakeholders (Ondrus et al., 2015). While choosing the right degree of openness is part of the design of a platform ecosystem, it can also be adjusted dynamically to govern the ecosystem as shown in case studies on Android and iOS (Homscheid, Kilian, & Schaarschmidt, 2015). So far, openness is mostly discussed from a technology-oriented perspective as it is closely related to how access is granted to technology. Few studies also consider the market-oriented perspective or both perspectives.

In addition to these concepts, we identified control, technical design, competitive strategy and trust as relevant concepts discussed by several authors. **Control**, in general, is used to “direct attention, motivate, and encourage organizational members to act according to organizational goals and objectives” (Wiesche, Schermann, & Krmar, 2011) and IS play a key role to implement control mechanisms (Schermann, Wiesche, & Krmar, 2012; Wiesche, Berwing, Schermann, & Krmar, 2011). In platform ecosystems, control refers to how the platform owner governs the processes within his platform ecosystem and can be divided into formal control mechanisms (e.g. output control) and informal control mechanisms (e.g. clan control) (Tiwana, 2014). **Technical design** comprises the modular architecture of the platform (Tiwana et al., 2010), the definition of its interfaces and the compatibility to relevant systems. **Competitive strategy** describes whether competition, collaboration, or the mélange of both, co-opetition, is the most suitable strategy to establish a platform ecosystem among competing ones (Mantena & Saha, 2012). **Trust** as counterpart of power is a basic prerequisite for a platform ecosystem to succeed (Hurni & Huber, 2014). It is relevant for the relationship between platform owner and complementors as well as for the relationship between customers and the platform ecosystem as a whole. Similar to the concepts described above, only few studies integrate the technology- and market-oriented perspective when discussing control, technical design, competitive strategy and trust.

Concept	Aspects	No. of studies		
		technology-oriented	market-oriented	both
Roles	<ul style="list-style-type: none"> • Number of sides • Ownership • Distribution of power • Relationship to stakeholders 	15	14	2
Pricing and revenue sharing	<ul style="list-style-type: none"> • Achieving network effects • Barriers to market entry • Subsidizing of one or more sides 	8	16	3
Boundary resources	<ul style="list-style-type: none"> • Software tools (API, SDK) • Documentation • Data 	14	7	2
Openness	<ul style="list-style-type: none"> • Granting access to technology • Giving up control over technology 	13	3	2
Control	<ul style="list-style-type: none"> • Informal control mechanisms • Formal control mechanisms 	12	1	2
Technical design	<ul style="list-style-type: none"> • Modularity • Interfaces • Compatibility 	10	4	1
Competitive strategy	<ul style="list-style-type: none"> • Competition • Co-opetition, collaboration • Single vs. multihoming 	1	5	1
Trust	<ul style="list-style-type: none"> • Relationship complementor – platform owner • Relationship end-user – platform 	1	1	1

Table 4. Concepts of design and governance of platform ecosystems.

4 Central Issues for Future Research on Platform Ecosystems in IS

In this section, we discuss central issues for future research on the design and governance of platform ecosystems in IS based on the insights gained in the analysis of existing literature. We discuss three major issues: the integration of the different perspectives on platform ecosystems when analysing design and governance concepts, an individual level of analysis in platform ecosystems and the role of data as boundary resource in platform ecosystems. We suggest that future research on these issues will deepen our understanding of platform ecosystems and allow to derive recommendations for their implementation and management in practice.

4.1 Integrating Different Perspectives on Platform Ecosystems with Design and Governance Concepts

Future research can gain additional insights on how to design and govern ecosystems by integrating the technology- and market-oriented perspective on platform ecosystems. None of the platform-based businesses can be described with only one of the perspectives (Basole, 2009). An app store, for example, is a marketplace that matches demand for and supply of applications on mobile devices. At the same time, the app store is the platform owner's vehicle to co-create value on his technological platform, i.e. the operating system of the mobile devices. To understand such platform ecosystems that can be interpreted as two interlaced platforms – a technology and a market platform – the technology- and market-oriented perspectives have to be integrated. Existing literature rarely adapts an integrated view, as shown in our review.

All of the constructs related to the design and governance of platform ecosystems that we have identified in our literature review, can be viewed from a technology- and a market-oriented perspective. For example, providing boundary resources such as APIs or development tools is, on the one hand, a technological aspect of governance used to incentivize developers to contribute to a platform ecosystem. On the other hand, providing boundary resources will also impact the platform ecosystem as a marketplace by increasing the competition between developers. Similarly, the agreement on decision rights for the different stakeholders within the platform ecosystem is influenced by technology- and market-oriented considerations: decision rights for developers on a platform may include the tools and frameworks used but also the prices that can be set in the market.

First contributions integrate the different perspectives with regard to specific phenomena. For example, Claussen et al. (2013) discuss incentives for developers of Facebook apps while interpreting the Facebook app store as market and technological platform. Yet, many concepts related to the design and governance of platform ecosystems still need to be evaluated against the integrated view. Cusumano (2010) stated that “[w]ho wins and who loses these competitions is not simply a matter of who has the best technology or the first product. It is often who has the best platform strategy and the best ecosystem [...]” In order to come up with the best strategy for a platform ecosystem, research and practitioners need to consider both the technology- and the market-oriented perspective.

In doing so, research should not only focus on case studies of successful platform ecosystems, as “successful [...] platforms are the exception” (Hagiu, 2014). Insights from failed platform ecosystems can enhance the field and provide additional insights. Within multiple-case studies of successful and non-successful platform ecosystems, patterns for successful design and governance strategies could emerge. As a starting point, a case survey of existing case studies as described by Jurisch, Wolf, and Krcmar (2013) could provide valuable insights.

4.2 An Individual Level of Analysis for End-users and Complementors

Our review revealed that most studies focus on the platform owner, neglecting the perspective of the end-user or complementor. For example, Table 3 shows that no study with a technology-oriented perspective takes on the end-user perspective although the end-user is also affected by technological decisions of the platform owner. The complementor’s perspective, even though adapted by several more recent publications (Bergvall-Kåreborn & Howcroft, 2014; Goldbach & Benlian, 2015; Hurni & Huber, 2014), is based on an abstract representation of the complementor, its characteristics are not considered on an individual level of analysis. Bergvall-Kåreborn and Howcroft (2014) argue that complementors and end-users need to be seen as individuals because their different characteristics can impact the relationship they establish to the platform ecosystem. Including the complementors and end-users into the analysis, will also allow to discuss a bottom-up approach in the design and governance instead of interpreting it as a top-down approach only – a gap that has recently been shown by Constantinides and Barrett (2015).

A software developer from an open source community might be incentivized by open interfaces and the freedom to decide on the tools and frameworks to use. A start up, on the other hand, might focus on reliable, documented interfaces and adequate pricing and revenue sharing. Depending on which types of complementors a platform owner wants to attract, different design and governance concepts may prove useful. To understand the role of individual complementors and end-users, future research should take on an individual level of analysis. Experiments or simulations could generate insights detached from specific cases as for example in the experiment by Goldbach and Benlian (2014) who compare different control mechanisms in platform ecosystems. Similar to Schilling, Laumer, and Weitzel (2011) who evaluate the motivation of open source software developers depending on their personality, personality traits and more specific characteristics such as a complementor’s self-efficacy or goal setting could be evaluated. In doing, so it could be worthwhile to not only analyse current

complementors and end-users of a platform but also complementors who failed with their product and end-users who have already turned their back on the platform ecosystem.

Complementors and end-users are not necessarily individuals. Especially in the case of business-to-business platform ecosystems, complementary products are created by and sold to companies. Instead of a large crowd of developers, the platform owner has to govern a group of partner companies. Some of them might be strategic partners that enhance the platform ecosystems value for customers significantly. With regard to the customer companies, a platform needs to provide firm-specific solutions that are still based on the same technological platform, a challenge that for example all ERP system providers are facing at the moment. Based on research on interfirm networks, the role of relationships and strategic partnerships could be a worthwhile area for future research.

4.3 Data as Boundary Resource in Platform Ecosystems

In our analysis of existing literature, we identified the concept of boundary resources as one of the most important governance mechanisms. At the same time, Gawer (2014) depicts the importance of data as boundary resource. However, no article explicitly analyses the role of data as boundary resource in platform ecosystems. In practice, many of today's platform ecosystems are fuelled by data. For example, Google and Facebook use the aggregated user data to sell personalized advertisements, attract developers by providing selected data streams via API (Gawer, 2014) and build additional services such as Google's real-time traffic information service based on movement data of Android users (Barth, 2009). As data is usually provided via APIs, it is also worthwhile to analyse how these interfaces define standards for data exchange and how these standards change over time. This might affect the optimal design and governance of platform ecosystems.

Data that is aggregated in a platform ecosystem can even be a threat. Developers can use the data aggregated by their own apps to strengthen its competitive position vis-à-vis the platform owner. For example, fitbit, a seller of fitness trackers, uses the data aggregated by its iOS and Android apps to establish its own ecosystem based on wearables – perhaps one reason why Apple and Google push their own fitness and health ecosystems Apple Health and Google Fit (Pressman, 2015). The way the data flow is handled in platform ecosystems is therefore an important aspect of platform governance, largely neglected in existing literature.

First publications have touched the topic of data in platform ecosystems in the context of open data (Ponte, 2015), wearables (Sun, Lou, Li, & Wang, 2015), and inter-organizational collaborations (van den Broek & Veenstra, 2015) but did not explicitly consider its role as boundary resource. A first step would be to evaluate how data is used to govern platform ecosystems in practice and to generalize the findings. This will enhance research on governance of platform ecosystems and address a topic that is highly relevant in practice.

5 Conclusion

In this paper, we summarized recent literature on platform ecosystems and derived open issues for further research based on the results. We analysed the methodology applied by the studies in our review, determined different perspectives research takes on platform ecosystems and condensed the key concepts of design and governance of platform ecosystems. In doing so, we identified three major issues for further research. First, we suggest to integrate the market- and technology-oriented perspective when discussing phenomena on platform ecosystems. This is in particular relevant for design and governance concepts such as boundary resources or openness that are implemented technically but impact the market-related processes on the platform. Second, we think that future research needs to integrate complementors and end-users into the analysis in addition to the platform owner. An individual level of analysis would further contribute to our understanding as each contributor and end-user is different. Third, we recommend to study data as boundary resource in more detail. Data has been mentioned in

several contributions as boundary resource fuelling platform ecosystems and is highly relevant in practice.

By reviewing existing literature and deriving issues for future research, our study contributes to IS governance literature in several ways. First, we provide a holistic overview on research related to the design and governance of platform ecosystems. The overview integrates contributions that were previously not related due to a heterogeneous understanding of platforms and platform ecosystems. Thereby, we provide a unified foundation for future research on design and governance of platform ecosystems. Second, we summarize concepts related to the design and governance of platform ecosystems across all studies. In doing so, we identify the key challenges relevant for all platform ecosystems and reference the current state of research regarding these challenges. Third, we derive specific issues for future research that are rooted in existing research but show how our understanding of platform ecosystems and their governance can be enhanced. Finally, our study is relevant for practice by laying out which concepts practitioners need to consider when designing and governing a platform ecosystem. Currently, digital platforms spring up like mushrooms while others are withering and practitioners try to figure out how to bring them to success. The issues we identified will provide useful in practice and will further advance the applicability of the scientific findings on platform ecosystems.

The results of our study underlie several limitations. First, the literature search might not cover all relevant studies due to the choice of outlets and keywords. For example, alternative terms for the concept of platform ecosystems such as software ecosystem, partnership network, etc. might yield additional relevant articles. Second, the coding process we conducted simplifies the results of the studies to make them comparable. Similar concepts were merged to superordinate concepts, as summarized in Table 5 in the appendix. In the course of this process, some insights might have been lost and are not represented in our results. A greater level of detail within studies that focus on specific concepts might generate additional insights. Third, our twofold perspective on platforms in IS, market- and technology-oriented needs to be concretized with further cases from practice. While the perspectives are based on existing literature on platforms, we could not clarify all communalities and differences between the perspectives within the scope of this review. Fourth, the issues for future research that we derived from our results may be influenced by the authors perspective and the topic. Further open issues might therefore exist and can be discovered by future work.

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Appendix

Omitted concept	Comment
Business model	merged with competitive strategy
Features and functionalities	merged with technical design
Information and transparency	merged with boundary resources
Decision rights	merged with roles
Resolve conflicts	merged with roles
Network effects	merged with pricing and revenue sharing
Data	merged with boundary resources

Table 5. Omitted coding constructs of governance and design of platform ecosystems.

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