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Research Article

The digital platform: a research agenda

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Abstract

As digital platforms are transforming almost every industry today, they are slowly finding their way into the mainstream information systems (ISs) literature. Digital platforms are a challenging research object because of their distributed nature and intertwinement with institutions, markets and technologies. New research challenges arise as a result of the exponentially growing scale of platform innovation, the increasing complexity of platform architectures and the spread of digital platforms to many different industries. This paper develops a research agenda for digital platforms research in IS. We recommend researchers seek to (1) advance conceptual clarity by providing clear definitions that specify the unit of analysis, degree of digitality and the sociotechnical nature of digital platforms; (2) define the proper scoping of digital platform concepts by studying platforms on different architectural levels and in different industry settings; and (3) advance methodological rigour by employing embedded case studies, longitudinal studies, design research, data-driven modelling and visualisation techniques. Considering current developments in the business domain, we suggest six questions for further research: (1) Are platforms here to stay? (2) How should platforms be designed? (3) How do digital platforms transform industries? (4) How can data-driven approaches inform digital platforms research? (5) How should researchers develop theory for digital platforms? and (6) How do digital platforms affect everyday life?
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Introduction

Researchers within the information systems (IS) field and beyond are seeking to understand the omnipresent digital platforms in today's industries (Tiwana, 2014; Parker *et al.*, 2016). Social media platforms like Facebook have changed how people interact and share experiences. Operating system platforms like Android and iOS have become the centre of gravity in the mobile telecommunications industry. Payment platforms like PayPal, Apple Pay and Square are disrupting the financial industry. The emergence of peer-to-peer digital platforms such as Uber, Airbnb and TaskRabbit has created a so-called sharing economy. Competition no longer revolves around how to control the value chain but around attracting generative activities associated with a platform. Disruptive crossovers from digital technologies to finance (e.g. Kickstarter), mobility (e.g. Uber) and health care (e.g. PatientsLikeMe) are all fuelled by a digital platform logic.

Outside IS, scholars have long discussed platform concepts from a non-digital worldview. Nobel Prize winner Jean Tirole has with Rochet studied market power in two-sided markets since the 1980s (Rochet and Tirole, 2003, 2006). Gawer and Cusumano published an influential business book in 2002 on how companies could organise activities and compete through platforms (Gawer and Cusumano, 2002). Moore *et al.* (1997) advocated a radical shift in strategy thinking from competition towards coopetition around a shared niche. More recently, books by Tiwana (2014), Evans and Schmalensee (2016) and Parker *et al.* (2016) provide multiple perspectives on how platforms are shaping business and organisational models and in fact are transforming entire economies. Platform-related research is maturing as fundamental assumptions are increasingly formalised both within the industrial innovation management literature (Gawer, 2014; Thomas *et al.*, 2014) and the

economics literature (Parker and Van Alstyne, 2005). However, while concepts and notions can be borrowed from these streams of platform literature, *digital* platforms are notably different in several ways (Yoo *et al.*, 2010).

Digital platforms are changing phenomena over the entire IS landscape. User interactions with organisations are changing as digital platforms facilitate online communities of consumers (Spagnoletti *et al.*, 2015). Inter-organisational relations of IS development are changing as traditional principal–agent relationships for software development are replaced by arms' length relations between app developers and platform providers (Tiwana and Konsynski, 2010; Ghazawneh and Henfridsson, 2013; Eaton *et al.*, 2015). Architectures of IS artefacts are changing as the modularity of digital platforms is replacing traditional monolithic approaches (Tiwana and Konsynski, 2010).

While studying digital platforms is already challenging as a consequence of their distributed nature (Henfridsson *et al.*, 2014), developments in the business environment pose even larger research challenges for IS researchers. As platforms are mashed up into larger digital infrastructures, digital platforms are becoming increasingly complex research objects (Evans and Basole, 2016). The generativity of digital platforms produces exponentially growing app developer ecosystems, thereby creating research objects that are several orders of magnitude larger than any traditional IS system (Sørensen and Landau, 2015). As digital platforms are competing on multiple levels of the technical architecture, for instance the operating system and browser in the mobile domain (Pon *et al.*, 2014), specifying the appropriate unit of analysis is becoming increasingly difficult. Platform providers such as Google, Facebook, Amazon and eBay are carving up the Internet into de facto closed domains, implying that all relevant interactions take place outside the view of researchers (Eaton *et al.*, 2015). As platforms are emerging in highly diverse industries like banking (de Reuver *et al.*, 2015), health care (de Reuver *et al.*, 2013), energy (Kiesling, 2016) and transportation (Svahn *et al.*, 2015), the scope and diversity of scientific discourse are growing rapidly.

This paper develops a research agenda for digital platforms for dealing with these trends and research challenges. We elicit research challenges by scrutinising the literature on platforms, ecosystems, infrastructures and two-sided markets. Next, we draw upon the elicited research challenges combined with trends in the business domain to specify yet unanswered research questions for the digital platforms discourse.

The following section conceptualises non-digital and digital platforms. Next, we elicit conceptual, scoping and methodological issues in the current literature and provides recommendations for digital platforms' scholars. The discussion section confronts the elicited challenges with trends in the digital platforms domain to specify research questions for future research. The conclusion section concludes the paper with summary statements on the challenges ahead.

Conceptualisations of digital platforms

In this section, we conceptualise digital platforms. First, we introduce core concepts from the literature on non-digital platforms ("Non-digital platforms"). Next, we explain how digital platforms are different from non-digital platforms as well as digital infrastructures, with specific focus on governance arrangements ("How are digital platforms different?").

Non-digital platforms

Industrial innovation management scholars see platforms as a stable core and a variable periphery (Baldwin and Woodard, 2009). This conceptualisation stipulates opportunities for distributed development and recombinant innovation through modularisation (Henderson and Clark, 1990; Baldwin and Clark, 2000). Within this perspective, a platform can be categorised in terms of its production process scope: (1) internal platforms, enabling recombination of sub-units within the firm; (2) supply-chain platforms coordinating external suppliers around an assembler; and (3) industry platforms where a platform leader pools external capabilities from complementors (Gawer, 2014). In the latter two types, platforms not only provide a stable core but also mediate between different groups of users.

A platform mediating different groups of users, such as buyers and sellers, is typically denoted as a multisided platform (Boudreau and Hagiu, 2009). In the 1990s, analyses of US credit card antitrust cases triggered ideas of two-sided markets (Rochet and Tirole, 2003). Two-sided markets bring together (or match) two distinct groups in a relationship where the value for one group increases as the number of participants from the other group increases (Evans, 2003; Eisenman *et al.*, 2006). Evans (2003) emphasises the necessity of an intermediary for internalising externalities created by one group for the benefit of the other. The economics literature on two-sided markets studies a variety of phenomena, ranging from credit card merchants and holders to the health sector with patients and doctors. Multi-sided markets denote arrangements where multiple groups interact (Rochet and Tirole, 2003; Boudreau and Hagiu, 2009; Evans and Schmalensee, 2013).

As platforms bring together multiple user groups, they create the so-called network effects or network externalities. Network externalities imply that a technology's usefulness increases as its installed base of users increases (Katz and Shapiro, 1985; Shapiro and Varian, 1998). Increasing adoption levels can trigger positive feedback cycles that further increase the usefulness of the technology (Arthur, 1989). Typically, network externalities (Katz and Shapiro, 1985) are *direct* if the value of the platform depends on the number of users in the same user group, i.e. the value of the product increases by others buying, connecting or using the same platform or services provided via the platform. Examples of direct network effects are social media, which become more valuable if more end-users join the platform. Externalities are *indirect* when the value of the platforms depends on the number of users in a *different* user group. For instance, video game consoles become more valuable for consumers if there are more developers creating games for that console. Indirect network effects may also be negative, as illustrated in the context of advertising, where more advertisers on a search engine platform decrease its value for searchers of independent advice. Once the adoption of a product or technology has commenced, these network externalities provide benefits to both new and existing users such as reduced price, lower uncertainty about future versions of platforms and complementary services, communities of users, higher-quality products and new market opportunities (Dew and Read, 2007).

Economics research on two-sided markets is primarily concerned with the financial dynamics of competition between platforms and cross-subsidisation (Rochet and

Tirole, 2003), their pricing dynamics and the intense competition to be the dominant platform (Eisenman *et al.*, 2006). The overarching focus of the economics view is how economic forces render multi-sided markets different from other market arrangements. The interest in pricing strategies and financial dynamics is at the core of economics research into platforms rather than innovation dynamics. While contributing greatly to understanding issues of pricing and financing, this strand of research does not facilitate an opening of the technological black box necessary to understand platform generativity and other innovation dynamics.

Platforms are closely related to ecosystems. Iansiti and Levien's work explores the strategic options for enterprises in becoming a keystone actor (i.e. platform) cultivating an ecosystem (Iansiti and Levien, 2004a, b). Their work, building on Moore *et al.* (1997) idea of a changing competitive environment, thus applies the biological ecosystem metaphor to describe business ecosystems. While Iansiti and Levien's conceptualisation does not involve a platform construct, much other management research on ecosystems does. Some scholars use ecosystems to denote the organisational form associated with an industry platform (Gawer, 2014) or as an unspecific notion of a collection of assets (Thomas *et al.*, 2014). Within management research, platforms are sometimes treated separately from and sometimes intimately related to the ecosystem construct or metaphor.

How are digital platforms different?

While the industrial innovation management literature on platforms typically assumes modularisation governed by an over-arching design hierarchy (Clark, 1985), this assumption does not necessarily hold for digital platforms. Digital technologies imply homogenisation of data, editability, reprogrammability, distributedness and self-referentiality (Yoo *et al.*, 2010; Kallinikos *et al.*, 2013). Such characteristics of digitality can lead to multiple inheritance in distributed settings, meaning there is no single owner that owns the platform core and dictates its design hierarchy (Henfridsson *et al.*, 2014). Furthermore, when combining the modularity of physical goods with the layered architecture of software, the resulting architectures are loosely coupled through standardised interfaces, leading to products open for new meanings after manufacture (Yoo *et al.*, 2010, p. 729). For example, allowing for the separation of form and function, a smartphone keyboard can be software-defined and dynamically adapt to the specific application need for input. Also, users may adapt the default keyboard configuration. Postponing decisions on product features and rendering these decisions, the subject of subsequent generativity as the result of a distributed innovation process can be described as the late binding of capabilities by third-party developers (Svahn and Henfridsson, 2012). App developers combine existing layered-modular resources from the operating systems, the various hardware elements, the software development kits and a variety of public application programming interfaces (APIs) into novel apps not considered when the smartphones and associated software were conceived.

Various conceptualisations of digital platforms exist. Digital platforms can be defined as purely technical artefacts where the platform is an extensible codebase, and the ecosystem comprises third-party modules complementing this codebase (Tiwana *et al.*, 2010; Boudreau, 2012). A digital platform can, however, also be characterised as a sociotechnical assemblage encompassing the technical elements (of software and hardware) and associated organisational processes and standards (Tilson *et al.*, 2012). Ghazawneh and Henfridsson (2015) build on Tiwana *et al.* (2010) by defining digital platforms as: "software-based external platforms consisting of the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate".

A digital platform incorporates various modules that extend the functionality of the software product (Sanchez and Mahoney, 1996; Baldwin and Clark, 2000). These modules can be seen as "add-on software subsystems" (Tiwana and Konsynski, 2010, p. 676), often in the form of applications designed and developed by third-party developers. We define such applications as "executable pieces of software that are offered as applications, services or systems to end-users" (Ghazawneh and Henfridsson, 2013, p. 175).

The issue of how to govern digital platforms has been a continuing subject of study. Darking *et al.* (2008) argue for the importance of designing the governance of digital ecosystems, balancing the different interests. Wareham *et al.* (2014) study the governance of ecosystems in terms of dialogical relationships. As an example, the recombinability of digitised elements through digital convergence, and the associated generativity, raises paradoxical relationships of change and control (Tilson *et al.*, 2010). The paradox of change implies the need for digital platforms to simultaneously remain stable to form a solid foundation for further enrolment, and yet to be sufficiently flexible in order to support seemingly unbounded growth (Tilson *et al.*, 2010). The paradox of control presents the opposing logic of digital platforms simultaneously being governed by centralised and distributed control. The development of the iOS and Android platforms and associated ecosystems of apps and stakeholders illustrates the control paradox as varying control arrangements have both hindered and fuelled generativity. The ability to facilitate a rapid self-serviced process of continuous automatic updates of apps and operating systems resources has provided stable yet constantly evolving platforms. This challenges existing notions of the speed of change in large distributed technical arrangements. As an example, Apple reported after less than one week from the launch of the iOS operating system upgrade a 50% adoption rate amongst its global user-base (Tracy, 2015).

Henfridsson and Bygstad (2013) suggest that in order to better understand digital platform dynamics, the core unit of analysis should not be the core of the platform but its boundary resources. Boundary resources are made up of software tools and regulations facilitating the arms' length relationships between platform provider and app developers. Eaton *et al.* (2015) build on this idea by conceptualising platform dynamics in terms of distributed actors that collectively tune boundary resources. These alternative units of analysis mark a departure from ownership-centric views in the traditional innovation management literature that focuses on the platform owner as a keystone organisation that manages a number of complementors (Iansiti and Levien, 2004a, b).

While openness has been discussed in relation to non-digital platforms (Eisenman *et al.*, 2006), digitality also makes a fundamental difference here. For digital platforms,

openness does not merely relate to organisational arrangements like entrance and exit rules but also to openness of technologies such as APIs and software development kits (SDKs). Different levels of openness are found in practice for mobile platforms like iOS and Android (Benlian *et al.*, 2015), digital marketplaces (Ghazawneh and Henfridsson, 2015) and payment platforms (Ondrus *et al.*, 2015).

Digital platforms can be seen as a less complex subtype of digital infrastructure with specific control arrangements (Hanseth and Lyytinen, 2010). Research on information infrastructures largely began by exploring the intersection between existing work on physical infrastructures and the characteristics of networked information technology (Arthur, 1990; Hanseth *et al.*, 1996; Shapiro and Varian, 1998). Ciborra *et al.*'s (2001) research on global corporate infrastructures provides an early signposting of abandoning ideas of direct managerial control in these complex distributed arrangements. Such lack of control is echoed in a current debate within IS, relating to the specific characteristics of digital technologies, hence, focusing specifically on the dynamics of digital infrastructures (Tilson *et al.*, 2010; Henfridsson and Bygstad, 2013). Overall, what set digital platforms apart from digital infrastructures are the control arrangements, which may be anchored in an organisation or consortium of firms that owns the core platform technologies.

The definitions developed in this section are summarised in Table 1.

Building a research agenda on digital platforms

The established strands of platform and ecosystem research within management, economics, IS and telecommunications literature point towards common themes for a research agenda into digital platforms. We argue that all streams of the literature provide important yet partial understanding of the issues at hand. The following outlines the key challenges: stronger clarity of the core concepts; better scoping of the discourse; and clarity on methodological issues.

Conceptual issues

Our literature review shows a wide variety of conceptualisations on digital platforms. One specific concern is that management research on platforms does not consider the specific characteristics of digitality. All technological platforms are treated as a homogeneous group and classifications are merely based on organisational arrangements (Gawer, 2014; Thomas *et al.*, 2014). While having paved the way for digital platform research, management scholars generally do not consider that technology in general, or indeed digitality in particular, is theoretically relevant. Thomas *et al.* (2014) do emphasise the essential element of technology, but not digital technologies, as foundational for platform ecosystems. Gawer (2014) does not conceptualise technology in relation to the platform or ecosystem concept, but exemplifies industry platform types exclusively through examples such as Facebook, Google and Apple.

Our first recommendation is therefore for scholars to provide clear definitions of what is meant by the terms "digital platform" and "digital ecosystem". Specifically, scholars should make explicit whether they refer to platforms as technical or sociotechnical concepts. Platforms that merely mediate between different user groups but offer no extensible codebase should not be considered digital platforms in the IS discourse.

In contrast to non-digital platforms, digital platforms contain components on different levels, e.g. the device, the operating system and the applications. The innovation dynamics of a digital platform often depend on its dependencies with platforms on different levels of the technical architecture. For instance, in the context of mobile platforms, the iOS operating system is closely linked with the Apple iTunes app store platform. Google's mobile wallet only functions as a platform as it builds upon the Android operating system with its ability to emulate payment cards. An open data platform on smart cities for app developers may contain a diversity of platform components, such as

Table1 Definitions of core concepts on digital platforms

Concept	*Definition*
Multisided platform	Mediating different groups of users, such as buyers and sellers
Multisided markets	Bring together (or match) distinct groups, whereas the value for one group increases as the number of participants from the other group increases
Direct network externalities	The value of the platform depends on the number of users in the same user group
Indirect network externalities	The value the platform depends on the numbers of users in a different user group
Digital platform (technical view)	An extensible codebase to which complementary third-party modules can be added
Digital platform (sociotechnical view)	Technical elements (of software and hardware) and associated organisational processes and standards
Ecosystem (technical view)	A collection of complements (apps) to the core technical platform, mostly supplied by third-party
Ecosystem (organisational view)	Collection of firms interacting with a contribution to the complements.
Applications	Executable pieces of software that are offered as apps, services or systems to end-users
Boundary resources	Software tools and regulations facilitating the arms' length relationships between the involved parties
Platform openness	The extent to which platform boundary resources support complements

databases, semantically enriched databases, app development kits or even reusable application components (de Reuver *et al.*, 2015). Depending on which components are considered to be part of the digital platform, dynamics may be considerably different. In the case of the open data platform, specifying the platform as merely a knowledgebase implies platform competition with for instance data on city points of interest from Google, while specifying the platform as reusable application components implies platform competition with the APIs from TripAdvisor. We recommend digital platform scholars to specify the unit of analysis, including which technical components are considered to be part of the platform (Eaton *et al.*, 2015).

In sum, we recommend that scholars (1) provide clear definitions of digital platforms, drawing upon previous research; (2) identify the unit of analysis including its boundary and the components that comprise the digital platform; and (3) specify whether the perspective on digital platforms is technical or sociotechnical in nature.

Scoping

Due to the dynamic nature of digital platforms, the relevant unit of analysis for scholars shifts over time. Vertical scoping issues relate to choosing the appropriate level of the technical architecture for studying platforms. As one illustrative example of this scoping issue, consider the case of mobile platforms. Here the operating system and associated app store are often studied as the focal platform (e.g. Basole and Karla, 2011). However, new platforms are currently emerging on top of the mobile operating system (e.g. Pon *et al.*, 2014). Cross-platform development enables application developers to utilise multiple operating systems without noticing a difference. HTML5 enables applications to run in the browser of the smartphone, making the browser the main platform to be analysed. Hybrid apps can embed HTML5 into native iOS or Android container apps, and through this provide mixtures of native and web-based apps. Apps can become the dominant platform as for instance Facebook's app allows browsing within the application to content from third-party newspapers. Such shifting units of analysis across the different levels of the technical architecture complicate comparing the results of studies that may on first sight have a similar focus.

Also horizontally, scoping issues are relevant, i.e. the variety of application domains covered by the platform to be taken into consideration in the study. The rapid penetration of sensors and wearables (i.e. the Internet of Things) leads to a wide variety of data sources that can be used to build applications. Platforms are emerging that integrate devices and data sources and make them available to application developers (Nikayin and de Reuver, 2013). Consequently, digital platforms are also emerging in specific application domains, such as financial and health care industries. The fundamental question here is whether these platforms on different levels of the technical architecture and in specific sub-domains should in fact be considered within the scope of the digital platform literature? Should these phenomena be framed within the digital platform literature or are they separate phenomena? How will this impact the completeness and consistency of the discourse? The trade-off is here between achieving comparability of studies (implying narrowing the focus of studies) with the ultimate relevance and sustainability of a field of study (implying broadening its scope).

When combined, vertical and horizontal scoping issues lead to even larger complexity and lack of comparability across studies. For instance, in the mobile payment domain, platform components are found on different levels of the architecture: the secure element on the device layer for authenticating users, the trusted service manager in the banking infrastructure layer for handling authentication and transaction handling, and the mobile wallet in the application layer for storing multiple payment apps. For each of the three platform components, different institutional and market-related factors play a role. For instance, for the SIM card-based secure element on the device layer, the main strategic driver is to sustain the competitive position of telecom operators, while the main strategic driver for a trusted service manager from a bank is to create defensive mechanisms to scare off new entrants. To complicate matters further, the platform components are shifting across the layers of the architecture over time. The secure element used to be located on the SIM card of the mobile device, but is now increasingly implemented in the mobile phone motherboard or even the operating system (de Reuver and Ondrus, 2017). The trusted service manager used to be the domain of telecom operators but is increasingly offered by banks and over-the-top providers (de Reuver *et al.*, 2015). Considering the intertwined nature of platforms with other digital artefacts, their multilevel characteristics and dynamic nature, we need theories on digital platform architectures that are contextualised based on deep understanding of the domain in which they are embedded.

Methodological issues

As we observe when conceptualising digital platforms and ecosystems, these are by their very nature interconnected and comprise multiple levels of analysis. Platforms compete with other platforms, and ecosystems around different platforms are often partly overlapping as complementary providers utilise multiple platforms (i.e. multi-homing, for example, when an app developer publishes their apps on both iOS and Android). Cross-platform development and the browser as platform are technological developments that will accelerate this trend. Such complexity of an object of study renders obsolete traditional reductionist approaches that dominate the IS literature (Yoo, 2013). Comparability of research units is difficult as the complexity of digital platforms makes each of them unique in their own right. Embedded case study approaches are required that take into account the full network of participants engaging in distributed innovation arrangements (Tilson *et al.*, 2010). By comparing cases within the same larger ecosystem, internal validity of platform studies can be enhanced.

As we typically study platforms as a snapshot in time, the understanding of platform dynamics is generally lacking. The dynamics of digital platforms and ecosystems can only be observed within a sufficiently long time horizon. Studies on digital infrastructure dynamics show that changes may only be observed in the long run (Tilson *et al.*, 2010). Germonprez and Hovorka (2013) argue that the generative principles of a platform imply that the effect of design choices on the platform in the long run cannot be reliably predicted at its inception. Longitudinal studies on the evolution of digital platforms and ecosystems are, therefore, required.

Table2 Main issues, risks and recommendations for digital platform scholars

	Issue	*Risk*	*Recommendation*
Concepts	Conceptual ambiguity	Platform concept becomes a fad	Provide clear definitions of platforms and ecosystems, drawing upon previous research
	Differing units of analysis across studies	Lack of comparability between studies	Identify the unit of analysis and its boundary
	Differing framing of platforms		Specify whether the perspective on platforms is technical or sociotechnical in nature
	Importance of digitality	Lack of understanding how digitality affects platforms	Make digitality an integral aspect of the definitions
Scoping	Digital platforms appear on multiple levels of technical architecture (vertical scoping)	Sacrificing comparability across studies or relevance and sustainability of discourse	Widen scope of digital platform research
	Platforms are emerging for specific application categories such as payment, share economy, media and health (horizontal scoping)	Lack of understanding how intertwinement of digital platforms with systems and institutions affects outcomes	Develop contextualised theory on digital platforms
Methodology	Difficult to isolate unit of analysis	Lack of comparability between studies	Conduct embedded case study approaches to compare platforms within the same larger ecosystem
	Digital platform and ecosystem dynamics have long time horizon	Snapshot research methods do not provide understanding of causalities	Conduct longitudinal studies on platform dynamics
	Bias towards successful cases, studied ex-post	Lack of design knowledge on digital platforms	Study failure cases Employ a design science approach to digital platform research
	Digital platforms are large, complex, and dynamic	Small-scale methods do not lead to holistic understanding	Conduct data-driven approaches, including network analysis Visualise structure and dynamics of digital ecosystems Conduct computational modelling of ecosystem behaviour

Digital platform concepts have, in general, so far been largely developed based on ex-post studies of successful cases such as Apple (Ghazawneh and Henfridsson, 2013; Eaton *et al.*, 2015) and Google (Tilson *et al.*, 2012). Failure cases where digital platforms did not succeed (or have evolved negatively) are largely lacking, with some exceptions like RIM, Ericsson or Nokia (Tilson *et al.*, 2011; Selander *et al.*, 2013; West and Wood, 2013). Moreover, research on digital platforms has so far not revealed much direct design knowledge. The secrecy of all the major platform-owners makes reliable first-hand data on governance and design decisions almost impossible to ascertain. Furthermore, due to the distributed nature of digital platforms and ecosystems, such access would likely be insufficient to fully understand the phenomenon. Broader data-driven approaches, such as data-mining of platform data (Pon, 2016), network analysis of ecosystem dynamics (e.g. Basole, 2009; Karhu *et al.*, 2014) or secondary analysis of publicly available blogs (Ghazawneh and Henfridsson, 2013; Eaton *et al.*, 2015), are viable approaches.

Summary

Table 2 summarises the main issues in the digital platform and ecosystem literature and how we recommend they should be dealt with.

Discussion: what we don't know about platforms

In this section, we discuss how the elicited challenges from the research agenda section, combined with ongoing trends in the business world, lead to new unanswered questions in the digital platforms discourse.

Are digital platforms here to stay?

It can be questioned whether we will see more or less of platforms in the future. For instance, for Internet-of-Things (IoT) or mobile cloud computing, one may argue that the fragmentation of connected devices and data on those devices raises a need for platforms that shield this complexity. But one may similarly argue that digitality affords further decentralisation (Tilson *et al.*, 2010; Kallinikos *et al.*, 2013).

In the end, it is a question about where to locate the intelligence: in centralised platforms or peripheral devices (Tiwana *et al.*, 2010).

From a technical perspective, the open standards applied in the Internet domain reduce the need for platforms. If components can interact based on open and common standards, there is no need to harness complexity through a platform. However, at the same time, platform providers like Google, Facebook, Amazon and eBay are carving up the Internet into *de facto* closed domains. So while open standards enable open interactions without intermediating platforms, they also facilitate creating *de facto* monopolies through those digital platforms (Eaton *et al.*, 2015). This ongoing tension is likely to continue as new kinds of technologies and new patterns of organisational and human behaviour co-evolve.

One of the paths digital platforms are developing along is increased integration between platforms. For instance, Facebook and many other platforms offer open authorisation (OAuth) identity service for logging into other services. The use of Facebook OAuth implies that on-line shopping platforms are accessing Facebook data on the user's friends and likes. This means that platforms are transforming into components being integrated into more extensive digital infrastructures. APIs are combined and mashed together to create entirely new digital services and products (Evans and Basole, 2016). Another example is the operating system, which is being displaced by the browser to access third-party content (Pon *et al.*, 2014). As such, digital platforms are becoming increasingly complex constructs, which amplifies the conceptual, scoping and methodological challenges elicited in this paper.

Several ongoing developments outside the typical realm of app stores and operating systems can only be understood when framed from a platform perspective. For instance, the difficulties telecom operators and banks face when introducing mobile payment systems are best understood from a platform perspective (de Reuver *et al.*, 2015). While telecom operators see mobile payment systems as a generative platform that can be rented out to third-party payment providers, banks see them as internal platforms that have to be controlled in order to harness competitive threats.

How should digital platforms be designed?

Understanding of what causes a (digital) platform to succeed while others fail is still lacking. Prior studies have predominantly focused on success stories. Studying the conditions in which some platforms thrive and grow while others fail is of value to both research and practice. Decomposing these conditions into a spectrum from "necessary" to "nice-to-have" can accelerate platform design.

A more fundamental research issue is: How do digital platforms actually emerge? There are many examples of accidental digital platforms (e.g. iTunes, Airbnb). Do products and services (or perhaps applications) evolve into platforms as "accidental results" or can they be consciously designed? To answer these questions, scholars should examine digital platform genesis and dynamics. While innovation management literature can inform a discussion on platform genesis, digitality affects these dynamics. For example, the paradoxical relationships between generativity and control, or between stability and growth in digital infrastructures, lead to different and quicker innovation trajectories as compared to non-digital systems (Tilson *et al.*, 2010).

From a design science research perspective, core questions are concerned with applying digital platform insights into practice. This requires understanding the design practices of platform leaders, i.e. to what extent are trade-offs like evolvability and sustainability informing design practices? Moreover, within design cycles, a core concern is how and when to tackle platform issues, and for instance how design choices early in a design cycle impact the platform's evolution in the long run (c.f. Germonprez *et al.*, 2011). Digital platforms must also be generative and evolvable in order to survive in the long run. Some platform strategies are aimed at infrastructuralising the digital platform, as in the case of the Facebook OAuth authentication platform. Design science studies should thus shed light on how digital platform providers can shape platforms such that they meet these dynamic criteria.

Evaluation of digital platforms in design studies presents methodological challenges. Typical evaluation criteria for IS design such as user acceptance or system quality do not necessarily suffice for platforms. Technologically superior products with large user appeal are not enough to win platform competition, as the case of Nokia has dramatically shown (Tilson *et al.*, 2011). Evaluation approaches for platforms are difficult to develop since platforms in and of themselves are of little value for end-users without the services running on top. In practice therefore, design studies often use services running on top of digital platforms as a proxy for evaluating the platform artefact, but the validity of doing so can be questioned. From an app developer or complementor perspective, similar concerns apply, especially since the appeal of a platform depends as much on technical performance as on the envisioned network effects and intangible aspects like trust in platform providers.

A final issue for design studies on digital platforms is how to deal with the multi-actor setting in which they are being developed. Given that digital platforms comprise multiple components that are distributed among the control of different actors, there is not one single platform provider. Instead, multiple actors try to influence and shape the design of a platform jointly. Even application developers of greatly varying size have been shown to have an impact on the design and redesign of platforms through leveraging the collective power of the blogosphere and through the power of digitality to circumvent control points (Eaton *et al.*, 2015). As such, we need design theories that take into account the iterative shaping and redefinition of what is the platform by multiple distributed actors with divergent goals. Action design research (Sein *et al.*, 2011) provides a promising approach to such highly situated multi-actor design settings but has not been applied to digital platforms.

How do digital platforms transform industries?

The emergence of platform thinking and the resulting "platform economy" demands research into the transformative and disruptive impact of digital platforms on organisations and their business models and the business

environment as a whole (Parker *et al.*, 2016). How do platforms change the power structure and the relationship between participants in the ecosystem? How do various organisations adapt to emerging digital platforms? If not developed internally, what types of digital platforms do incumbents adopt? How many platforms can successfully co-exist or is there a maximum number? How do service providers and device manufacturers strategise in a platform environment? Are there sectoral and geographic differences in digital platform assimilation? And do geographic boundaries even matter? These questions are still poorly understood within the context of rapid digital generativity.

Indubitably, the study of digital platforms requires examining the ecosystems that surrounds them. While there is some work on mobile ecosystems, as outlined above, there remains the need for a deeper scholarly understanding of the structure, dynamics, and strategy/behaviour of platforms and associated organisations in the ecosystems around digital platforms. Prior work has shown that ecosystemic thinking is becoming particularly important for decision makers (Basole, 2014) due to increasingly global, complex and interconnected business environments. Firms are not isolated anymore, and value is co-created and co-delivered by multiple contributing entities. New theories and models that capture, explain and predict the potentially disruptive nature of digital platforms are needed.

How can data-driven approaches inform digital platforms research?

In the recent past, data to inform digital platform and ecosystem research were resource intensive to obtain and use. To large degree, data were either proprietary or had to be commercially licensed. Today, we have a wide spectrum of data available through numerous open and socially curated data sources, such as Crunchbase,[1] Mesh,[2] or ProgrammableWeb,[3] just to name a few. These emerging data sources can provide important digital platform and ecosystem information for different levels and scopes of analysis.

Conceptually, and drawn from systems thinking, it is critical how to effectively specify the boundaries of ecosystems based on digital platforms (Basole *et al.*, 2015). From a networked economy perspective, virtually all business segments are related to each other to some degree. Including all segments is resource intensive and may not necessarily provide the desired insight. While excluding segments from analysis could reduce the problem space, it may also mask important complexities needed to truly understand the ecosystem. Prior work has suggested that the boundary of the ecosystem is determined/guided by the type of insight sought and the anticipated decision processes that will take place (Basole and Bellamy, 2014). Data-driven studies focused on the ICT ecosystem, for instance, have shown that the ecosystem is converging at a rapid pace with hardware and software companies collaborating closely and media companies gaining importance (Basole *et al.*, 2014).

Once we have specified the system boundary of digital platforms and ecosystems, it is equally important to determine how to effectively describe the underlying structure and topology. If modelled as networks, graph theoretic measures can be used. With the increasing availability of digital data about digital ecosystem companies and the relationships between them, we have an increased ability to apply data-driven analysis and visualisation approaches to generate novel insights into ecosystems and the role of platforms. One illustrative example of a data-driven visualisation approach is provided by Evans and Basole (2016) who, leveraging publicly available data on API mashups, examine sectoral differences in the global API ecosystem and diverging enterprise strategies. In another study, Um *et al.* (2015) use source code data on Wordpress.org plug-ins to describe the evolution and generative nature of platforms in digital ecosystems.

However, many research issues remain with data-driven analysis. When studying ecosystems, how can researchers differentiate all the activities and distinguish between true signal and noise? Moreover, how can researchers effectively manage the intense velocity and scale at which data on platforms and ecosystem is generated? And how can researchers develop computational capabilities and insights that allow greater understanding of changes in the ecosystem and the resulting impact on ecosystem players? One possible path of addressing these research issues is stronger interaction between the IS and computer science research communities, which will facilitate fusion of domain expertise with integration of relevant techniques from data mining, machine learning and visualisation.

How should researchers develop theory for digital platforms?

As argued in the section conceptualising digital platforms, most existing research on platform innovation takes as its unit of analysis either the technical components, i.e. the core platform artefact and the associated software complements as constituting the ecosystem (Tiwana *et al.*, 2010), or the organisational elements, i.e. the contributing organisations typically divided into a platform owner or keystone organisation (Iansiti and Levien, 2004a), and complementors or third-party developers (Ghazawneh and Henfridsson, 2013). However, scholars should adopt other units of analysis to push theory development beyond traditional mid-range theories (Grover and Lyytinen, 2015). The units of analysis chosen must allow for the theoretical treatment of the fundamental characteristics of digital platform characteristics and innovation arrangements. This can lead to the development of new insights informing the deeper theoretical inquiry into digital innovation. Doing so will allow digital platform research to establish new theoretical categories rather than exclusively adopt existing categories (Tilson *et al.*, 2010; Alaimo and Kallinikos, 2016).

The boundary resource concept could be such unit of analysis, used in the context of highly distributed arrangements where independent actors pragmatically engage in innovations utilising the opportunities and limitations of digital or layered-modular arrangements (Yoo *et al.*, 2010; Eaton *et al.*, 2015). Participants can each engage in localised optimisation of basic technologies, own intellectual property, and adapt boundary resources in distributed and recursive tuning arrangements (Eaton *et al.*, 2015). Such digital innovation arrangements will be both bounded by and leverage: (1) digital artefacts (Tilson *et al.*, 2010; Leonardi *et al.*, 2012; Kallinikos *et al.*, 2013); (2) the exponential growth in computational power, faster networks, cheap storage and the development of increasingly capable middleware layers allowing for rapid development of fundamentally

new services (Brynjolfsson and McAfee, 2014); and (3) distributed architectures without central control, which allow more complex behaviour by independent actors with emergent side-effects, such as the challenging of existing social categories and control points, by the emergence of new ones (Tilson *et al.*, 2010).

The challenge of exploring and theorising on digital platforms brings with it the methodological challenges of gaining access to empirical data. However, there are so far only very few examples of intimate studies of digital platforms from the inside (for exception, see Alaimo, 2014), and so far most work is conducted by interviewing complementors (Selander *et al.*, 2013), or by collecting data from an outside perspective (Eaton *et al.*, 2015). The inherent complexity of digital platform dynamics implies that they exhibit emergent behaviour (Hanseth and Lyytinen, 2010). Empirical research should therefore employ holistic approaches, uncovering the generative mechanisms that lead to change (Henfridsson and Bygstad, 2013). There is need for further research from within the digital platform and adopting processual accounts and taking advantage of the large amounts of data produced through use. Analysing diverse sets of data on platform activities – found in sources such as press releases, tech blogs and developer forums – using emerging sequence mining techniques can also provide important additional insights into the process dynamics and evolution of digital platforms.

Platform sustainability is one important further research agenda. How do we ensure that all sides of the platform participate? How are developers incentivised to develop on a single or on multiple platforms? Does widespread adoption of multi-sided digital platforms raise significant issues of power, engagement, and surveillance all specific to the digital capabilities of these platforms (Zuboff, 2015)? This begs the need to understand and critically assess the role of platform governance and incentives. Some work has already begun on this, for example, by Wareham *et al.* (2014). Our current thinking on successful governance is limited and primarily drawn from success stories. Another important related future research area is the emerging block-chain phenomenon, for example allowing new types of platformisation through distributed ledgers for identity validation (Mainelli and Smith, 2015). How will digital platforms and ecosystems evolve when there is no central governing node/core, but rather a distributed model of organisation? Methodologically, researchers can develop computational/synthetic platform "markets" to mimic and explore rules and outcomes of the ecosystem and use the insights gained to inform design. Similarly, there are also substantial data created by online communities, including online forums and social Q&A sites that may reveal what types of developers participate as well as the nature of their participation and interaction in ecosystems across digital platforms. Adopting non-traditional platform and ecosystem contexts and multi-disciplinary lenses may lead to novel theoretical extensions.

How do digital platforms affect everyday life?

Digital platforms can support new and flexible means for inter-organisational relations through a variety of distributed boundary resources facilitating highly distributed and automated coordination of activities at arm's length. The architecting of technology itself can to a higher degree be done through apps, micro-services and other modular elements rather than in monolithic arrangements, which raises the issue of how to architect these interrelationships. An example of this includes the possible approaches of enterprises organising interrelationships through devising a micro-services architecture with independent services, all the way to the extreme solution adopted by Google of painstakingly maintaining interrelationships between elements by keeping all its source-code in one directory structure (@Scale, 2015).

The platform debate should also seek to address the broader issue of how digital platform innovation directly relates to issues of societal and global interest. One such issue is the possibilities for direct influence on and societal regulation of digital platforms, which in turn may play a critical role in civil society. The paradox of influence is that given the right leverage on the blogosphere, even a single developer can make the mighty Apple blink (Eaton *et al.*, 2015), yet it is generally very difficult to see any openness being fostered for the main digital platforms. This raises a number of critical issues regarding the power dynamics and the direct impact of these digital innovations on everyday life, for example, in terms of surveillance, labour market relations and the distribution of wealth beyond a simplistic argument based on technical rationality (Zuboff, 2015; Morozov, 2016). Some of the public debate as well as academic research focuses on the wealth of opportunities offered by digital platforms. Digital platforms support new ways of interacting within communities and through mediated co-creation. They allow ordinary citizens to share their spare resources in a so-called sharing economy, although any equity gains resulting from all such sharing are not necessarily shared (Morozov, 2016).

The traditional technologically oriented discourse mainly focuses on what is provided at very low or no direct cost to the consumers, or how the digital platforms help smooth out operational inefficiencies. The new digital platforms can be presented as benevolent servants extracting and analysing data, providing new forms of contracting through monitoring, and personalising and customising their services to match the changing user-needs (Varian, 2010). Such arguments are popular but are also receiving push-back from wider analyses, for example, of the effects on civil society though illegible mechanisms of commodification and control (Zuboff, 2015), or on how the battle for a large installed base of users is financed by venture capital (Morozov, 2016). Facebook may not only offer uniquely new opportunities for sociality to be rendered into computed categorisations (Alaimo and Kallinikos, 2016), but may indeed also support the displacement of co-present interaction (Putnam, 2000; Turkle, 2011).

In terms of the technological and industrial development, then platformisation will likely play a role in replacing some traditional firms and sectors with new ones, and challenge the role of some categories of work with others, for example, to the extent that platforms provide mechanisms for the automated self-service of business relationships previously conducted more directly by those job categories (Susskind and Susskind, 2015). This can, for example, be in terms of the possible outlook on what may constitute work with the possibility for digital platforms supporting the micro-

coordination of the tiniest of effort (Malone *et al.*, 2011). It also raises the issue of possible wider consequences for paid work (Brynjolfsson and McAfee, 2011; Sørensen and Pillans, 2012), and for our understanding of how competition may be reshaped, for example, in winner-takes-all digital markets (Brynjolfsson and McAfee, 2014; Pon, 2016).

The open-ended character and malleability of digital platforms support some degree of independent strategic action by distributed actors with possible side effects for the entire platform – an aspect of generativity (Zittrain, 2006). This can both lead to highly useful complements, but also represent challenges for the organisation(s) responsible for cultivating the platform and for society more generally. As an example, Airbnb is designed based on the notion of private individuals sharing their extra space with strangers and making a modest income from this. However, Airbnb has been struggling with users in effect setting up shop as commercial room rental companies with multiple listings with less risk and less oversight than traditional hotels who work in a context of significant more regulatory and taxation pressure (Kaplan and Nadler, 2015).

Perhaps one way of framing this challenge of participation and democratic oversight is as global drift. For Ciborra *et al.* (2001), the widespread diffusion of large-scale organisational information systems resulted in the loss of direct executive control as the complexity across services and business contexts led to "drift". Similarly, it can be argued that global digital platforms introduce complexity resulting in globalised drift where even national states find it difficult to engage and regulate. The European Union directive to ensure the right to be forgotten has not only raised principled debates but also turned out to be a practical headache – especially since the indexing is automated processing of distributed unstructured data produced by independent agents and therefore not easily managed using one simple ontology (Bennett, 2012; Wikipedia, 2015).

Conclusions

The diffusion and importance of digital platforms operating as multi-sided markets are rapidly increasing, for example, facilitating social networks, smartphone app stores or the so-called sharing economy. Unquestionably, digital platforms are going to be an intrinsic part of IS research and we are just in the middle of the maturity curve. Digital platforms form uniquely new sociotechnical artefacts that force IS scholars to engage in conceptual and methodological innovation. While insights from other academic disciplines, such as economics, strategy, and telecommunications, can provide an important foundation to understanding digital platforms and ecosystems, there are many fundamental differences that must be considered.

This paper seeks to identify and synthesise a series of possible contributing strands of research to advancing our understanding of digital platforms. We suggest a research agenda to deal with conceptual, scoping and methodological challenges, including concrete recommendations to scholars. Our analysis explores and outlines three main concerns. Firstly, the discourse will need to engage in further conceptual clarification of the digital platform concept and, for example, delineate the platform and ecosystem constructs in a digital context. The second main issue is concerned with the scoping of digital platforms, for example, developing a typology expressing the variety of digital platforms. Thirdly, critical methodological issues are to be resolved in the study of digital platforms – many of which are common to the challenges of studying digital infrastructures.

These research challenges and recommendations are ever more relevant since ongoing developments in the business domain lead to new unanswered research questions regarding the longevity of digital platforms as an architectural pattern as well as creating design knowledge. By studying questions such as how digital platforms disrupt industries and shape everyday life, the digital platform discourse provides an opportunity for IS research to re-establish its relevance for other fields. While the aim of this paper has been to raise awareness and stimulate discussion, it is our hope that it also will contribute to some initial conceptual clarity facilitating the further work on populating the concept of the digital platform with meaning, precision and depth. We definitely do see an urgent need for much more research exploring a range of emerging phenomena best classified as belonging under the heading of digital platform innovation.

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Notes

1 www.crunchbase.com.
2 meshing.it.
3 www.programmableweb.com.

References

@Scale (2015). Why Google Stores Billions of Lines of Code in a Single Repository. https://www.youtube.com/watch?v=W71BTkUbdqE&feature=youtu.be.

Alaimo, C. (2014). Computational Consumption: Social Media and the Construction of Digital Consumers. London School of Economics. https://www.researchgate.net/profile/Cristina_Alaimo/publication/266701936_Computational_consumption_social_media_and_the_construction_of_digital_consumers/links/5437dbf30cf2027cbb20502d.pdf.

Alaimo, C. and Kallinikos, J. (2016). Encoding the Everyday: Social Data and Its Media Apparatus, In: S.R. Cassidy, H.R. Ekbia, and M. Mattoli (eds). *Big Data is not a Monolith: Policies, Practices, and Problems*, Cambridge, MA: The MIT Press.

Arthur, W.B. (1989). Competing Technologies, Increasing Returns, and Lock-in by Historical Events, *The Economic Journal*, **89**: 116–131.

Arthur, W.B. (1990). Positive Feedbacks in the Economy, *Scientific American* **262**(2): 92–99.

Baldwin, C.Y., and Clark, K.B. (2000). *Design Rules, Vol. 1: The Power of Modularity*, Cambridge, MA: MIT Press.

Baldwin, C.Y., and Woodard, C.J. (2009). The Architecture of Platforms: A Unified View, In A. Gawer (Ed.), *Platforms, Markets and Innovation* (pp. 19–44). Cheltenham: Edward Elgar.

Basole, R.C. (2009). Visualization of Interfirm Relations in a Converging Mobile Ecosystem, *Journal of Information Technology* **24**(2): 144–159.

Basole, R.C. (2014). Visual Business Ecosystem Intelligence: Lessons from the Field, *IEEE Computer Graphics and Applications,* **5**: 26–34.

Basole, R.C., and Bellamy, M.A. (2014). Visual Analysis of Supply Network Risks: Insights from the Electronics Industry, *Decision Support Systems,* **67**: 109–120.

Basole, R.C., and Karla, J. (2011). On the Evolution of Mobile Platform Ecosystem Structure and Strategy, *Business & Information Systems Engineering,* **3**(5): 313–322.

Basole, R.C., Park, H., and Barnett, B.C. (2014). Coopetition and Convergence in the ICT Ecosystem, *Telecommunications Policy* **39**: 537–552.

Basole, R.C., Russell, M.G., Huhtamäki, J., Rubens, N., Still, K., and Park, H. (2015). Understanding Business Ecosystem Dynamics: A Data-Driven Approach, *ACM Transactions on Management Information Systems (TMIS)* **6**(2): 6.

Benlian, A., Hilkert, D., and Hess, T. (2015). How Open is This Platform? The Meaning and Measurement of Platform Openness from the Complementors' Perspective, *Journal of Information Technology,* **30**(3): 209–228.

Bennett, S.C. (2012). Right to be Forgotten: Reconciling EU and US Perspectives, *Berkeley Journal of International Law,* **30**: 161.

Boudreau, K.J. (2012). Let a Thousand Flowers Bloom? An Early Look at Large Numbers of Software App Developers and Patterns of Innovation, *Organization Science* **23**(5): 1409–1427.

Boudreau, K.J., and Hagiu, A. (2009). Platform Rules: Multi-sided Platforms as Regulators, In A. Gawer (Ed.), *Platforms, Markets and Innovation* (pp. 163–191), Cheltenham, UK: Edward Elgar Publishing Limited.

Brynjolfsson, E., and McAfee, A. (2011). *Race Against The Machine*, Lexington: Digital Frontier Press.

Brynjolfsson, E., and McAfee, A. (2014). *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*, New York City: WW Norton & Company.

Ciborra, C.U., Braa, K., Cordella, A., Dahlbom, B., Failla, A., Hanseth, O., et al. (Eds.). (2001). *From Control to Drift. The Dynamics of Corporate Information Infrastructures*, New York: Oxford University Press.

Clark, K.B. (1985). The Interaction of Design Hierarchies and Market Concepts in Technological Evolution, *Research Policy* **14**(5): 235–251.

Darking, M., Whitley, E.A., and Dini, P. (2008). Governing Diversity in the Digital Ecosystem, *Communications of the ACM,* **51**(8): 137–140.

de Reuver, M., and Ondrus, J. (2017). When Technological Superiority is not Enough: The Struggle to Impose the SIM Card as the NFC Secure Element for mobile payment platforms. *Telecommunications Policy*. doi:10.1016/j.telpol.2017.01.004.

de Reuver, M., Bouwman, H., and Haaker, T. (2013). Business Model Roadmapping: A Practical Approach to Come from An Existing to a Desired Business Model, *International Journal of Innovation Management* **17**(01): 1340006-1–1340006-18.

de Reuver, M., Verschuur, E., Nikayin, F., Cerpa, N., and Bouwman, H. (2015). Collective Action for Mobile Payment Platforms: A Case Study on Collaboration Issues Between Banks and Telecom Operators, *Electronic Commerce Research and Applications* **14**(5): 331–344.

Dew, N., and Read, S. (2007). The More We Get Together: Coordinating Network Externality Product Introduction in the RFID Industry, *Technovation* **27**(10): 569–581.

Eaton, B.D., Elaluf-Calderwood, S., Sørensen, C., and Yoo, Y. (2015). Distributed Tuning of Boundary Resources: The Case of Apple's iOS Service System, *MIS Quarterly: Special Issue on Service Innovation in a Digital Age* **39**(1): 217–243.

Eisenman, T., Parker, G., and Van Aystyne, M.W. (2006). Strategies for Two-Sided Markets, *Harvard Business Review* **84**(10): 92–101.

Evans, D.S. (2003). Some Empirical Aspects of Multi-Sided Platform Industries, *Review of Network Economics* **2**(3): 191–209.

Evans, P.C. and Basole, R.C. (2016). Revealing the API Ecosystem and Enterprise Strategy using Visual Analytics, *Communications of the ACM* **59**(2): 23–25.

Evans, D.S. and Schmalensee, R. (2013): The Antitrust Analysis of Multi-sided Platform Businesses. Paper No. 623. The Law School, The University of Chicago. http://www.law.uchicago.edu/Lawecon/index.html.

Evans, D. S. and Schmalensee, R. (2016). *The Matchmakers: The New Economics of Multisided Platforms*, Boston: Harvard Business Review Press.

Gawer, A. (2014). Bridging Differing Perspectives on Technological Platforms: Toward an Integrative Framework, *Research Policy* **43**(7): 1239–1249.

Gawer, A., and Cusumano, M.A. (2002). *Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation*, Brighton: Harvard Business School Press.

Germonprez, M., and Hovorka, D.S. (2013). Member Engagement Within Digitally Enabled Social Network Communities: New Methodological Considerations, *Information Systems Journal 23*(6): 525–549.

Germonprez, M., Hovorka, D., and Gal, U. (2011). Secondary Design: A Case of Behavioral Design Science Research, *Journal of the Association for Information Systems* **12**(10): 662–683.

Ghazawneh, A., and Henfridsson, O. (2013). Balancing Platform Control and External Contribution in Third-Party Development: The Boundary Resources Model, *Information Systems Journal* **23**(2): 173–192.

Ghazawneh, A., and Henfridsson, O. (2015). A Paradigmatic Analysis of Digital Application Marketplaces, *Journal of Information Technology* **30**(3): 198–208.

Grover, V., and Lyytinen, K. (2015). New State of Play in Information Systems Research: The Push to the Edges, *MIS Quarterly* **39**(2): 271–296.

Hanseth, O., and Lyytinen, K. (2010). Design Theory for Dynamic Complexity in Information Infrastructures: The Case of Building Internet, *Journal of Information Technology* **25**(1): 1–19.

Hanseth, O., Monteiro, E., and Halting, M. (1996). Developing Information Infrastructure: The Tension Between Standardisation and Flexibility, *Science, Technologies, and Human Values* **21**(4): 407–426.

Henderson, R.M., and Clark, K.B. (1990). Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms, *Administrative Science Quarterly* **35**: 9–30.

Henfridsson, O., and Bygstad, B. (2013). The Generative Mechanisms of Digital Infrastructure Evolution, *MIS Quarterly* **37**(3): 907–931.

Henfridsson, O., Mathiassen, L., and Svahn, F. (2014). Managing Technological Change in the Digital Age: The Role of Architectural Frames, *Journal of Information Technology* **29**: 27–43.

Iansiti, M., and Levien, R. (2004a). *The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation, and Sustainability*, Brighton: Harvard Business Press.

Iansiti, M., and Levien, R. (2004b). Strategy as Ecology, *Harvard Business Review* **82**(3): 68–81.

Kallinikos, J., Aaltonen, A., and Marton, A. (2013). The Ambivalent Ontology of Digital Artifacts, *MIS Quarterly* **37**(2): 357–370.

Kaplan, R.A., and Nadler, M.L. (2015). Airbnb: A Case Study in Occupancy Regulation and Taxation, *The University of Chicago Law Review,* **82**: 103.

Karhu, K., Tang, T., and Hämäläinen, M. (2014). Analyzing Competitive and Collaborative Differences Among Mobile Ecosystems Using Abstracted Strategy Networks, *Telematics and Informatics* **31**(2): 319–333.

Katz, M.L., and Shapiro, C. (1985). Network Externalities, Companition and Compatibility, *American Economic Review* **75**: 424–440.

Kiesling, L.L. (2016). Implications of Smart Grid Innovation for Organizational Models in Electricity Distribution, In C.-C. Liu (Ed.), *Wiley Handbook of Smart Grid Development*, Hoboken: Wiley.

Leonardi, P.M., Nardi, B.A., and Kallinikos, J. (Eds.). (2012). *Materiality and Organizing*, Oxford: Oxford University Press.

Mainelli, M., and Smith, M. (2015). Sharing Ledgers for Sharing Economies: An Exploration of Mutual Distributed Ledgers (Aka Blockchain Technology), *The Journal of Financial Perspectives* **3**(3): 38–69.

Malone, T.W., Laubacher, R.J., and Johns, T. (2011). The Age of Hyperspecialization, *Harvard Business Review* **89**(7/8): 56–65.

Moore, J.C., Rao, H.R., Whinston, A., Nam, K., and Raghu, T.S. (1997). Information Acquisition Policies for Resource Allocation Among Multiple Agents, *Information Systems Research* **8**(2): 151–170.

Morozov, E. (2016). Cheap Cab Ride? You Must Have Missed Uber's True Cost. The Guardian. http://www.theguardian.com/commentisfree/2016/jan/31/cheap-cab-ride-uber-true-cost-google-wealth-taxation.

Nikayin, F., and De Reuver, M. (2013). Opening up the Smart Home: A Classification of Smart Living Service Platforms, *International Journal of E-Services and Mobile Applications (IJESMA)* **5**(2): 37–53.

Ondrus, J., Gannamaneni, A., and Lyytinen, K. (2015). The Impact of Openness on the Market Potential of Multi-sided Platforms: A Case Study of Mobile Payment Platforms, *Journal of Information Technology* **30**(3): 260–275.

Parker, G.G., and Van Alstyne, M.W. (2005). Two-Sided Network Effects: A Theory of Information Product Design, *Management Science* **51**(10): 1494–1504.

Parker, G.G., Van Alstyne, M.W., and Choudary, S.P. (2016). *Platform Revolution: How Networked Markets are Transforming the Economy and How to Make Them Work for You*, New York: WW Norton & Co.
Pon, B. (2016). Winners & Losers in the Global App Economy, Surrey, UK: Caribou Digital. http://cariboudigital.net/winners-losers-in-the-global-app-economy/.
Pon, B., Seppälä, T., and Kenney, M. (2014). Android and the Demise of Operating System-Based Power: Firm Strategy and Platform Control in the Post-PC World, *Telecommunications Policy* **38**: 979–991.
Putnam, R.D. (2000). *Bowling Alone*. New York: Touchstone.
Rochet, J.-C., and Tirole, J. (2003). Platform Competition in Two-Sided Markets, *Journal of the European Economic Association* **1**(4): 990–1029.
Rochet, J.-C., and Tirole, J. (2006). Two-Sided Markets: A Progress Report, *The Rand Journal of Economics* **37**(3): 645–667.
Sanchez, R.A., and Mahoney, J.T. (1996). Modularity, Flexibility and Knowledge Management in Product and Organization Design, *Strategic Management Journal* **17**: 63–76.
Sein, M.K., Henfridsson, O., Purao, S., Rossi, M., and Lindgren, R. (2011). Action Design Research, *MIS Quarterly* **35**(1): 37–56.
Selander, L., Henfridsson, O., and Svahn, F. (2013). Capability Search and Redeem Across Digital Ecosystems, *Journal of Information Technology* **28**(3): 183–197.
Shapiro, C., and Varian, H.R. (1998). *Information Rules: A Strategic Guide to the Network Economy*, Boston: Harvard Business School Press.
Sørensen, C., and Landau, J. (2015). Academic Agility in Digital Innovation Research: The Case of Mobile ICT Publications within Information Systems 2000–2014, *Journal of Strategic Information Systems* **24**(3): 158–170.
Sørensen, C. and Pillans, G. (2012). The Future of Work. The Corporate Research Forum. http://www.crforum.co.uk.
Spagnoletti, P., Resca, A., and Lee, G. (2015). A Design Theory for Digital Platforms Supporting Online Communities: A Multiple Case Study, *Journal of Information Technology* **30**: 364–380.
Susskind, R.E., and Susskind, D. (2015). *The Future of the Professions: How Technology Will Transform the Work of Human Experts*, Oxford: Oxford University Press.
Svahn, F. and Henfridsson, O. (2012). The Dual Regimes of Digital Innovation Management, In: HICSS 45, Maui, Hawai'i, IEEE, pp. 3347–3356.
Svahn, F., Lindgren, R. and Mathiassen, L. (2015). Applying Options Thinking to Shape Generativity in Digital Innovation: An Action Research into Connected Cars, In: 49th Hawaii International Conference on System Science (HICSS 49), IEEE, pp. 4141–4150.
Thomas, L., Autio, E., and Gann, D. (2014). Architectural Leverage: Putting Platforms in Context, *The Academy of Management Perspectives* **28**(2): 198–219.
Tilson, D., Lyytinen, K., and Sørensen, C. (2010). Digital Infrastructures: The Missing IS Research Agenda, *Information Systems Research* **21**(5): 748–759.
Tilson, D., Sørensen, C. and Lyytinen, K. (2011). The Paradoxes of Change and Control in Digital Infrastructures: The Mobile Operating Systems Case, In: The 10th International Conference on Mobile Business, Como, Italy.
Tilson, D., Sørensen, C. and Lyytinen, K. (2012). Change and Control Paradoxes in Mobile Infrastructure Innovation: The Android and iOS Mobile Operating Systems Cases, In: 45th Hawaii International Conference on System Science (HICSS 45), Maui, HI.
Tiwana, A. (2014). *Platform Ecosystems: Aligning Architecture, Governance, and Strategy*, Morgan Kaufmann.
Tiwana, A., and Konsynski, B. (2010). Complementarities Between Organizational IT Architecture and Governance Structure, *Information Systems Research* **21**(2): 288–304.
Tiwana, A., Konsynsky, B., and Bush, A.A. (2010). Platform Evolution: Coevolution of Platform Architecture, Governance, and Environmental Dynamics, *Information Systems Research* **21**(4): 675–687.
Tracy, A. (2015): Apple Says iOS 9 Adoption Rate Is The Fastest Ever, Running On 50% of Devices. http://www.forbes.com/sites/abigailtracy/2015/09/21/apple-says-ios-9-adoption-rate-is-the-fastest-ever/-53d242bf2727.
Turkle, C. (2011). *Alone Together: Why We Expect More from Technology and Less from Each Other*, New York: Basic Books.
Um, S., Yoo, Y. and Wattal, S. (2015). The Evolution of Digital Ecosystems: A Case of WordPress from 2004 to 2014, In: T. Carte, A. Heinzl, and C. Urquhart (eds.) *Thirty Sixth International Conference on Information Systems (ICIS 36)*, Fort Worth.
Varian, H.R. (2010). Computer Mediated Transactions, *The American Economic Review* **100**(2): 1–10.
Wareham, J., Fox, P.B., and Cano Giner, J.L. (2014). Technology Ecosystem Governance, *Organization Science,* **25**(4): 1195–1215.
West, J., and Wood, D. (2013). Evolving an Open Ecosystem: The Rise and Fall of the Symbian Platform, *Advances in Strategic Management,* **30**: 27–67.
Wikipedia. (2015). Right to be Forgotten, https://en.wikipedia.org/wiki/Right_to_be_forgotten.
Yoo, Y. (2013). The Table Has Turned: How Can IS Field Contribute to the Technology and Innovation Management? *Journal of the AIS* **14**: 227–236.
Yoo, Y., Henfridsson, O., and Lyytinen, K. (2010). The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research, *Information Systems Research* **21**(4): 724–735.
Zittrain, J. (2006). The Generative Internet, *Harvard Law Review* **119**: 1974–2040.
Zuboff, S. (2015). Big Other: Surveillance Capitalism and the Prospects of an Information Civilization, *Journal of Information Technology* **30**(1): 75–89.

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