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Abstract

In this research review we analyse digital platforms through the lens of sociomateriality. Sociomateriality integrates the material features of the technology and the goals of the human agencies which mutually interact to enrich the features of the technology further. Digital platforms are characterised by their unique layered modular architecture which constitutes the materiality. Sociality consists of user goals and user behaviour in association with platforms. In this review we analyse how each component of a platform and the goals of the platform users are interlocked. This review identifies three areas for future research which can be studied through the sociomateriality lens i) The governance of platforms by understanding the IS capabilities of the complements ii) Exploration on the concept of platform forking iii) Identifying design choices for digital nudging in the case of user interface design.

Keywords: Digital platforms, Sociomateriality, Layered Modular architecture.

1 Introduction

The term 'platform' has been proliferating in a wide variety of literature including Economics, Marketing, Information Systems, and Industrial Organizations. It refers to diverse things in different domains - for example in economics platforms may refer to products and services that bring together groups of users in a two-sided network (Eisenmann, 2008), whereas in information systems it is generally understood as IT infrastructure. As multiple groups of people are brought together by platforms they create network externalities (Katz and Shapiro, 1994). Even though the term spans across different fields, the common thread to the notion of platform, is a low variety stable core component and a high variety unstable periphery. Furthermore, platforms have also been understood as sociomaterial. For example digital platforms have been conceptualized as sociomaterial because they integrate hardware, software, organizational processes and standards (De Reuver et al., 2018). However, it is not clear what characteristics of platforms qualify them as sociomaterial, and what sociomaterial characteristics of platforms have been dispersed in several studies. A research review is imperative to analyse previous studies on platforms from a sociomaterial perspective to understand how platforms embed and evolve on materiality and human agency.

From a social interaction perspective, it could be argued that materiality, which is the intrinsic material property of platforms independent of people who use them (Orlikowski, 2007 ;Leonardi, 2013), enable or facilitate the interaction between the two sides and the interactions serve to enrich the features of the platforms further: For example, considering the case of videogames, a collaboration occurs when a player buys a game developed by a game publisher, and the platform enabled by the publisher is used to play the game. In the example of payment cards, an interaction occurs when a customer, uses his

card for making payment with a seller. Similarly, for an operating system, collaboration occurs when the computer user buys an application designed by the platform developer (Rochet and Tirole, 2003).

Information systems research has dealt with platforms spanning two eras: non-digital platforms in period starting from 1980's (Rochet and Tirole, 2003) and digital platforms in period from 2002 (Asadullah et al., 2018). Asadullah et al., (2018) have done a systematic review of digital platforms and classified prior research on digital platforms into three streams: the design, development and scalability of digital platforms, the adoption and use of digital platforms and outcomes of digital platforms. Platforms have also demonstrated pervasive influence in various domains such as agriculture (e.g. Jha et al., 2016), healthcare (e.g. Agarwal et al., 2010), and energy (e.g. Watson et al., 2014). However, there is little understanding about the elements of technology and human behaviour that shapes platforms' recursive interactions that lead to impactful influence of platforms in various domains.

This review seeks to understand how social practices shape the materiality of platforms and their effects and conversely how materiality of platforms impacts human interactions. This two way reflexive relationship between materiality of platforms and human interactions with them form the focus of this research review. This paper contributes to the growing body of platform literature where there is still lack of clarity in the conceptualization of digital platforms from a sociotechnical perspective as pointed out by the recent research articles (De Reuver et al., 2018; Asadullah et al., 2018). Moreover, we also analyse digital platforms at different architectural levels by reviewing studies through the lens of sociomateriality. The purpose of this review is to foster research focusing on the evolution of digital platforms in various domains by understanding the affordance and constraints posed by the components of the platform to each of its stakeholders. The paper proceeds as follows: Section 2 describes the methodology through which this review was carried out, Section 3.1 describes the most consistent and relevant topics in digital platforms some of which need more academic attention, Section 3.2 describes the sociomaterial perspective which serves as the base for section 3.3 which integrates substantialist perspective in sociomateriality to digital platforms.

2 Methodology

For this review, we followed the principles of systematic literature review to search, screen and review literature related to digital platforms from sociotechnical and sociomaterial perspectives. Keyword based search in eight leading IS journals (senior scholars' basket) was conducted. Proceedings from three leading IS conferences namely International Conference on Information Systems, European Conference on Information Systems and Pacific Asia Conference on Information Systems have also been included in the search. Moreover, for the sake of inclusiveness, we also searched general management journals such as Organization Science, Management Science, Research Policy, California Management Review etc. Platform competition and pricing were reviewed by referring to economic journals such as Journal of European Economic Association and Journal of Economic perspectives. Our search for articles pertaining to digital platforms and sociomateriality was restricted to the period of 2005-2018. However, we identified and referred to articles before 2005 for conceptual discussion on sociomateriality, sociotechnical systems and platforms. We conducted search in the databases of AISeL IEEE, EBSCO and Google Scholar for accessing relevant publications, using key words such as *platforms, digital platforms, two-sided markets, sociotechnical and digital platforms, socio materiality and digital platforms* which resulted in over 5000 articles. The papers were first shortlisted on the basis of title, following abstract relevance which resulted in a set of 90 papers. We found different meanings for the term *platform* in different articles as mentioned in the introduction. We included research papers and commentaries focusing on the core issues of digital platform and specific case studies which directly dealt with any of the platform components and social aspects. We selected publications describing intended characteristics of the platform which distinguished it from non-digital platforms. This resulted in a set of 40 publications. We read these final 40 articles and used them for writing a review on digital platforms from a sociomaterial perspective.

3 Review and Discussion

In the following sections, we provide a review of literature described in the previous section. We first review papers related to digital platforms, and then introduce the sociomaterial perspective. Further, we use the sociomaterial perspective as a lens to analyse previous research on digital platforms.

3.1 Digital platforms

Platforms could be broadly classified into non-digital and digital based on the underlying technology used to build them. Non-digital platforms, mainly studied by industrial innovation management scholars consist of a stable core and a variable periphery (Baldwin and Woodard, 2007) and facilitate recombination of subunits such as i) internal platforms, ii) supply chain platforms which synchronize external suppliers around an assembler and iii) industry platforms where platform leader pools external capabilities from complementors (Gawer, 2014). For this study we follow the definition of a digital platform as "*an extensible codebase to which complementary third-party modules can be added*" by De Reuver et al. (2018, p.126). A good discussion on the distinction between digital and non-digital platforms is available in the same article. Modular architecture followed by a design hierarchy is the overreaching principle in non-digital platforms (Clark, 1985), which makes them product specific whereas digital platforms have a layered modular architecture which extends the modular architecture of physical products by integrating four loosely coupled layers created by digital technology namely devices, networks, services and contents (Yoo et al., 2010). The layered modular architecture gave rise to distributed architecture, which means that there is no single owner which dictates its design hierarchy making them product agnostic. However, digital technology is not constrained to geographical boundaries which is one of its key difference from non-digital technologies (Constantinides et al., 2018). As a result, collective expertise can be gathered from different sources, which is important in domains like healthcare and agriculture. For example, farmers could reach a range of markets through digital trading platforms, and sell to buyers who offer them best price.

Properties of digital objects	Description	Literature
Homogenization of data	Same digital devices and networks can be used to store, transmit and process digital data.	Yoo et al. (2010)
Editability	Digital objects are modifiable. E.g. we can modify software libraries, digital repositories etc.	Kallinkos et al.(2010)
Reprogrammability	Allows separation of semiotic function-al logic from the physical embodiment which executes it.	Yoo et al. (2010)
Self referentiality	Creates positive network effects as digital innovation requires the use of digital technologies.	Yoo et al. (2010)
Addressability	RFID chips, barcodes, microprocessors etc. make digital objects uniquely iden-tifiable.	Yoo et al.(2010)

Table 1: Properties of digital objects

Digital platforms built on digital objects have a set of features which distinguishes them from non-digital objects. Digital objects refer to devices, digital artefacts and technologies such as videos, music and images. Yoo et al. (2010) have clearly demarcated digital platforms from non-digital platforms, IT

innovation as innovation in process and digital innovation as product innovation. The key characteristics of digital objects outlined by the authors are: i) Homogenization of data ii) Editability iii) Self-Referentiality iv) Reprogrammability and v) Addressibility. Table 1 lists the key technical characteristics of digital objects, which are also the key constituents of digital platforms.

While the layered modular architecture leads to structural complexity, the platform governance is associated with the behavioural complexity of platforms. Several studies have highlighted the significance of platform governance, which determines decisions and decision rights of a platform (Tiwana et al., 2010). It has been recommended that governance structure should be a subtle equilibrium between control and generativity in the platform (Yoo et al., 2012). The role of IS capabilities in the development of a multisided platform has been discussed in detail by Barney et al. (2015). The platform openness which is too wide may lead to strategic exploitation by the competitor thus giving rise to an unfavourable outcome to the platform owners. In this connection the term *forking* has been coined which is defined as "a hostile firm, i.e., a forker, bypassing the host's controlling boundary resources thereby exploiting the platform's shared resources, core and complements, for creating a competing platform business" (Karhu et al., 2018). The case study of forking on Google's Android platform and subsequent fate of five Android forks were discussed in this study.

Having introduced the main attributes of digital platforms, in the next section we discuss the sociomaterial perspective, followed by section 3.3 where we bring out the sociomaterial perspective of digital platforms.

3.2 The sociomaterial perspective

The sociotechnical systems approach arose in the middle of the last century (Trist and Bamforth, 1951). It is termed both as a precursor and foundation for sociomateriality (Cecez-kecmanovic et al., 2014). From an ontological perspective, researchers have followed two approaches, relational (Orlikowski, 2007) and substantialist (Leonardi, 2013) views. Building upon the concept of relational ontology, in which entities and human beings are brought together through relations (Latur, 2005; Orilkowski, 2007; Latham and Sassen, 2009), there emerged a whole new sociotechnical relations and domains - digital formations - which need to be constructed as objects of study. These "sociodigitized" structures "exhibit dynamics of their own that derive from technological capacities that enable specific patterns of interaction" (Latham and Sassen, 2009, pp. 3–5). The focus on the epistemological and ontological perspectives of sociomateriality has produced a large amount of literature. A recent special issue of MIS Quarterly focussed on the sociomaterial perspective in IS research (Cecez-kecmanovic et al., 2014). However, there is still scanty research which focuses on the practical implications associated with appreciating the co-constitution of social, material and performative role of technologies (Cecez-kecmanovic et al., 2014).

The substantialist ontology which is the dominant view in Information Systems (IS) and Management research (Cecez-kecmanovic et al., 2014), assumes the inherent separation of social and material aspects which via interaction affect each other. Leonardi (2013) proposes sociomateriality grounded on the substantialist ontology wherein the human and the material produce substantial outcomes when they are mutually interlocked. Relational ontology has certain disadvantages over the substantialist ontology as shown by Leonardi (2013). It is difficult to perform empirical studies in order to demonstrate sociomateriality by the theoretical framework followed in relational ontology. Furthermore, it overlooks the temporal aspects of practices such as how the platforms changed over time. These limitations constrain understanding of the evolution of digital platforms in various domains, by identifying the role of different stakeholders. Therefore, in this review we approach digital platforms from the substantialist ontology of the sociomaterial perspective. Figure 1 provides the schematic representation of this approach. In the following section we explain the relationship between each component of the platform architecture and user goals.

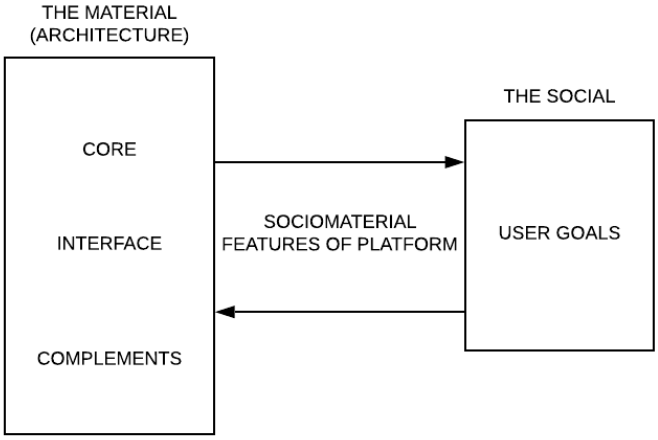

Figure 1: Substantialist sociomaterial view of digital platforms

3.3 Digital platforms: A sociomaterial perspective

The main components of a platform are core (with low variations), complements (with high variations) and interfaces. Several scholars have discussed the architectural features of digital platforms and highlighted how the architecture has enabled wide adoption of the platform in certain domains leading to major benefits to stakeholders (e.g. Tiwana et al., 2010). In this section we identify features of technology (e.g. architectural) and human attributes (e.g. usage related) along with sociomaterial characteristics (relational attributes). Table 2 provides a summary of our findings.

Not all of the publications discussed in Table 2 are grounded on sociomateriality, but we are gleaning the social and material features in these studies. Spagnoletti et al. (2015) proposed that three different components of platform architecture namely core, interface and complements should together support a mix of collaboration, collective action and information sharing which are three distinct forms of social interaction. The validation of the proposition was done by undertaking comprehensive analysis of the European Digital Platform for the Elderly Care assistance. The main objective of the study was to generate a design theory for digital platforms supporting online communities. The authors analyse the social interaction through the lens of transaction cost theory, as the transaction cost drop due to the rise of digital platforms. The first type of social interaction is information sharing in which the users of a platform provide their contents on the net, making the contents available to all (e.g. Twitter). In collaboration, actors follow certain rules and engage in activities that require substantial group coordination (e.g. Wikipedia). In collective action, a common goal and rule will be there which will be established by group members. Decisions are made by group members, which predominate over common interests (e.g. e-participation established by political parties and government). The study also compares the three types of social interaction through the dimensions of scope congruence, type of relationship, type of admittance, informational requirements, atmosphere, coordination, goals and core institutional values. The architectural requirements of core components, interfaces and complements are also discussed in the paper (see Table 2).

The symbiotic relationship between the capabilities of the platform technology and the contextual action to be taken has been analysed through the lens of affordance (Lee, 2010; Majchrzak et al., 2013). Merolli et al.(2013) identifies six different key affordances namely self-presentation, flexibility, connection, narration, adaptation and exploration in the context of online patient engagement. Self-presentation means that users can select and control what they have to disclose. The opportunity for communication and interaction anytime and anywhere is referred as flexibility whereas connection refers to isolation mitigation and self-management of patients. Narration refers to the value the patients gain by shared experiences, adaptation refers to the convenience to access the real time information and the information seeking capability is referred as exploration. The number of design

Reference	The Material (Architecture)	The Social (User related)	Sociomateriality (Relations)
Components of platform architecture : Spagnoletti, Resca and Lee (2015)	Core (IT application services: identity management, content and knowledge management and so on), Complements (IT capabilities for consuming and generating codified and abstract information) and Interfaces (API's , Multimedia standards and Open data)	Need for information, interaction and participation	Collaboration, collective action, information sharing
Affordance perspective : Lee (2010), Majchrzak, Faraj et al. (2013), Merolli et al.(2013)	Number of design features and their types	Need to communicate anytime, anywhere , freedom from isolation, need for autonomy, need for sharing information, convenience	Self-presentation, flexibility, connection, narration, adaptation and exploration
Design of digital objects : Bernardi (2016), Markus and Silver, (2008)	Digital objects (videos, music and images etc.)	Need for engagement and empathy	Network building, learning by sharing and searching practical information, self-presentation, narration, empowerment
Architectural Design : Crawley et al.(2004), Baldwin and Woodard (2007), Yochai Benkler, (2007), Schilling, (2000), Yoo et al., (2010)	Layered modular architecture of digital platforms : devices, networks, services and contents	Need to participate from anywhere, need to respond	Generativity: ability of dispersed and uncoordinated users to bring spontaneous change to digital objects, Platform governance.
User Interface Design : Schneider and Weinmann(2018) Basole and Karla, (2011), Johnson and Goldstein, (2003)	User interface (Choice elicitation, choice presentation)	User interface plays an important role in determining usability. The designers intended behaviour of customer can be obtained through design and testing. The online and offline customer behaviour is affected by biases and heuristics.	Digital nudging, adoption

Table 2: Elements of digital platforms and user attributes contributing to sociomateriality

features and their types in a system determine the affordance of a technology (Markus and Silver, 2008).

Bernardi (2016) showed the influence of affordance relationships on patient's engagement with Twitter online communities. The sociotechnical nature of the affordance which takes into consideration the digital infrastructure and social relationships entangled in the social media is taken into consideration in this study. The twitter chats of the Great Britain Diabetes Online Community (GBDoc) were captured and analysed using the help of Chorus Analytics. The interpretation was done using the concepts drawn from literature of patient's affordances and social media engagement. These analyses revealed the importance of affordance to the members of GBDoc.

According to Crawley et al. (2004) the platform architecture includes: a set of functions, physical components necessary to accomplish the functions, detailed arrangements and interfaces inter-relating the components, and description of how the system functions with time and under diverse conditions. In a modular architecture of a platform, elements within a system are strongly connected to each other but weakly coupled to the elements of other systems. Boundaries between modules are established by interfaces. As the platform is organized as modules and modular interfaces, the cost of distributing design and production across multiple firms is easier (Baldwin and Woodard, 2007). Here modularity refers to the degree in which a product can be decomposed into components (Schilling, 2000). The underlying features of digital technology offers layered architecture which consists predominantly of four layers: devices, networks ,services and contents (Yochai Benkler, 2007). Generativity means that dispersed and uncoordinated users can bring spontaneous change to digital objects. Essentially the layered modular architecture is a hybrid arrangement between layered architecture and modular architecture a continuum is formed by the extent to which layered architecture adds generativity to the modular architecture (Yoo et al., 2010).

In the case of mobile platforms, the operating system and the associated app store have been identified as a platform (Basole and Karla, 2011). Here user interface design elements play a major role in guiding user's behaviour to make judgment in a digital choice environment (e.g. web-based form, ERP screen). The use of design elements for influencing such behaviour has been termed as digital nudging (Weinmann et al., 2016). Prior research shows that as there is no neutral way of presenting choices as simple alteration in displaying the same could impact a user's behaviour. For example a study by Johnson and Goldstein (2003) showed that simply changing the choice option from opt-in to opt-out in the case of organ donation doubled the number of people giving consent for the same. Online decision making as in the case of offline decision making is governed by heuristics and bias, therefore the concept of nudging is also applicable in platforms for e-health and social media.

Schneider and Weinmann (2018) studied the effects of nudging by analysing the results of a series of experiments conducted for crowd funding. Three main heuristics and bias effects namely decoy effect, scarcity effect and middle option bias were considered in this study. A design cycle consisting of defining the goal, understand the customer, designing and testing the nudge was proposed by the authors to design choice architecture for users. The result shows that both the online and offline behaviours of a customer were affected by heuristics and biases. By thoroughly designing and testing nudges it is possible to achieve customer behaviour intended by the designer.

4 Conclusion and future scope

Key functions and capabilities of many of the industrial products such as automobiles, books, television etc. have got digitized due to hardware miniaturization, reasonable and reliable memory, and efficient power management (Yoo et al., 2010). Majority of the literature on platform has focused on pricing strategies (Bakos & Katsamakas, 2008; Rochet & Tirole, 2003), platform competition (e.g. Gawer and Cusumano, 2014) and IS capabilities (e.g. Barney et al., 2015). Sociomateriality, promoted in the IS discipline by Wanda Orlikowski and Susan Scott (Orlikowski and Scott, 2008) and advanced by Cecez-kecmanovic et al. (2014) has given a different direction to IS research. In this paper, we attempted to review the sociomaterial properties of digital platforms dispersed in various studies based on the substantialist paradigm proposed by Leonardi (2013). Sociomateriality is exhibited by digital platforms in each of its architectural layers such as digital objects as whole, components of the

platform architecture and user interface. We tried to bring these relationships of the material and social and their intertwinement in each of these architectural layers thus providing a distinct synthesis of digital platform literature.

We identified certain key research topics pertaining to digital platforms which could guide future research in this area. Even though the effects of interface on behavioural aspects of the users have been studied in an offline context, there is no significant work on the same in an online context such as that of digital platforms (Schneider and Weinmann, 2018). Platform governance determines the behaviour complexity of digital platforms, but the research investigating IS capabilities of the platform complements, and the problem of platform forking which could adversely affect sustainability of platforms is sparse. The openness and competitive nature of platform complements may make it difficult to design common governance and incentives. One way of addressing this challenge is to make a nested hierarchy for governance in par with the layered modular architecture (Constantinides et al., 2018). The governance structure required for one digital platform will be completely different from other (e.g. Android and Uber). So more academic attention has to be there to understand the implementation of governance and incentive structure for coordinating the behaviour of multiple platform stakeholders and their distinct interests (Constantinides et al., 2018). This study viewed digital platforms through the lens of sociomateriality, which does not consider technology and sociality alone separately, but also focuses on the relational attributes and the dynamic interaction of the two, leading to affordance, adoption and social and economic benefits to stakeholders. We aim to further advance this research to empirically apply the conceptual framework derived from literature (Fig. 1) for understanding the evolution of digital platforms in agricultural domain through the lens of sociomateriality. We also hope future studies dealing with the research topics identified in this review could benefit from this integrative perspective, in design, implementation and operations of digital platforms.

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