RECOMBINATION IN THE OPEN-ENDED VALUE LANDSCAPE OF DIGITAL INNOVATION

Ola Henfridsson
Warwick Business School
University of Warwick
Coventry CV4 7AL
United Kingdom
e-mail: ola.henfridsson@wbs.ac.uk

Joe Nandhakumar
Warwick Business School
University of Warwick
Coventry CV4 7AL
United Kingdom
e-mail: joe.nandhakumar@wbs.ac.uk

Harry Scarbrough
Cass Business School
City University of London
London EC1Y 8TZ
United Kingdom
e-mail: harry.scarbrough.1@city.ac.uk

Nikiforos Panourgias
University of Leicester
Leicester LE1 7RH
United Kingdom
e-mail: **np220@le.ac.uk**

RECOMBINATION IN THE OPEN-ENDED VALUE LANDSCAPE OF DIGITAL INNOVATION

Abstract. Digital innovation introduces a new open-ended value landscape to anyone seeking to generate or capture new value. To understand this landscape, we distinguish between design recombination and use recombination, explore how they play out together, and redirect the attention from products and services toward digital resources. Digital resources serve as building-blocks in digital innovation, and they hold the potential to simultaneously be part of multiple value paths, offered through design recombination and assembled through use recombination. Building on this perspective, we offer the value spaces framework as a tool for better understanding value creation and capture in digital innovation. We illustrate the framework and offer the early contours of a research agenda for information systems researchers.

INTRODUCTION

Recombination is at the heart of innovation. The idea that novel products and services derive from the carrying out of new combinations of components is enduring across disciplines. This is also the case in information systems, where recent and well-cited work on digital innovation such as Yoo et al. (2010) broadly follows Schumpeter's (1934) view on innovation as recombination. While a significant assumption in seminal innovation research is that firms carry out the recombination, however, the emerging digital innovation literature recognizes that firms are not the only actors mixing and matching. In fact, firms are increasingly anticipating that their design will be recombined at the point of use.

At a time when digital resources are readily editable (Kallinikos et al. 2013), re-programmable (Yoo et al. 2010), and functionality can be procrastinated until the point of use (Eaton et al. 2015; Henfridsson et al. 2014), it makes considerable sense to extend the firm-centric view on recombination to include recombination performed in use. Consider that use is no longer defined by products with clear and pre-defined boundaries (Yoo et al. 2010), but hosts digital resources that come together and assemble a whole from the ground-up (cf. DeLanda

2006). For instance, a user in need of cloud services does not need to adopt Google's offer as a whole but can conveniently combine Google Drive with Microsoft Office apps, and services on Amazon's AWS platform. We use the term "use recombination" to refer to this activity of generating an individual value path by connecting digital resources in use. Individuals carry out use recombination but so do firms and sometimes software agents such as bots. We contrast this type of recombination from design recombination, which denotes the activity of generating a value path by connecting digital resources as a value offer to users. Design recombination is typically done by firms[1], operating as stand-alone entities or recombining on top of other actors' digital platforms.

We argue that this distinction between design recombination and use recombination is pivotal to addressing the call for new perspectives on the business value of digital innovation (Kohli and Grover 2008). In particular, it supports our ability to map an 'open-ended' value landscape in which the value of a specific digital innovation needs to be viewed not as fixed but as fluid over time, dependent both on connections to assemblages of digital resources and on the relative engagement of individuals, firms, and bots. A focal point in such an analysis is defined by 'digital resources'; that is, entities that serve as building blocks in the creation and capture of value from information. Instead of notions such as products (Yoo et al. 2010) or services (Barrett et al. 2015; Lusch and Nambisan 2015), the notion of digital resources increases the granularity by which the creation and capture of value can be studied in digital innovation.

Such granularity is needed since the digital resource is not a self-contained unit with fixed meaning and relations. It rather hosts the potential to simultaneously be part of multiple value paths, as offered through design recombination and assembled through use recombination.

[1] We refer to firms in a broad way here. Examples are service innovators, third-party developers, and platform-based businesses.

Future business value research needs to better understand the meeting-points of both these types of recombination, thereby making digital resources a new and much needed level of analysis which contrasts with the conventional focus on products or services. In addition, this shift in attention to digital resources and their connections is also necessary because of their product-agnostic nature. Digital resources are agnostic in the sense that their meaning in the use situation is largely defined by their relationships to other resources. Rather than being defined by logically necessary relations (cf. modularity: Baldwin and Clark 2000; Garud et al. 2003), the agnosticism of digital resources makes these relations obligatory in a contingent fashion (DeLanda 2006; Um 2016).

Existing perspectives such as the layered-modular architecture (Yoo et al. 2010), digital controls (Lee and Berente 2012), architectural frames (Henfridsson et al. 2014), service innovation (Barrett et al. 2015; Lusch and Nambisan 2015), the cocreation of value (Grover and Kohli 2012; Sarker et al. 2012), and network effects (Parker et al. 2016), all offer valuable insights on how to address the open-ended value landscape of digital innovation. However, as we will argue in this paper, it is essential to think of recombination in design and use in digital innovation concurrently, rather than tilting too much towards the design or use end of value. To this end, we develop a new perspective, which we term *the value spaces framework*, which can be applied to better understand value creation and capture in digital innovation. We illustrate the framework and outline the early contours of a research agenda with the purpose of both stimulating intellectual debate on this important topic and providing some initial conceptual apparatus for future research.

THE OPEN-ENDED VALUE LANDSCAPE

Economists often refer to technologies as means of production (Arthur 2009). In this vein, Schumpeter viewed innovation as the recombination of means of production (see Langlois 2007). Technologies process something in order to achieve an end, and innovation as recombination therefore involved the idea of rethinking how different functions could be reintegrated in ways that create novelty (Arthur 2009; Galunic and Rodan 1998). This view of innovation has been adopted in influential theories of modularity and competition (Baldwin and Clark 2000; Garud et al. 2003; Sanchez and Mahoney 1996).

The view on recombination adopted in this research differs from the classic view of recombination in at least one important way. Recognizing the agnostic nature of digital technology (Yoo et al. 2010), we adopt a non-essentialist view of the nature of digital resources. Consistent with the view of ontology proposed by DeLanda (2006), a digital resource can be seen as characterized by relations of exteriority, meaning that its function and significance is influenced by its relations to other digital resources in the form of value paths[2]. If a digital resource is part of multiple value paths, it can then assume different functions depending on the way it relates to other resources. Compared to the modular system in which a part relates to the whole in terms of a logically necessary relationship (DeLanda 2006), such as in a hierarchy-of-parts frame (Henfridsson et al. 2014), the relationships between digital resources are only contingently obligatory (DeLanda 2006; Um 2016).

Necessary relationships between the parts and the whole imply a bounded product where each part exhibits certain qualities that necessitate its place and function in the design hierarchy (cf. Clark 1985). It has a ready-made shape offered by a firm as a discrete entity to a customer

[2] DeLanda's (2006) more encompassing term is "assemblages".

adopting or rejecting it in use. Novelty, which might increase the number of users adopting it, is achieved through changes to the product through recombination done by the firm. However, while "the relationships between the product and its components are nested and fixed" in a modular architecture (Yoo et al. 2010, p. 728), the agnosticism of digital resources makes such relations only contingently obligatory (DeLanda 2006; Um 2016). Contingently obligatory relationships imply that any digital resource, when provided as part of a firm's offering, may become a constituent of many different user value paths as it is recombined and made meaningful by different users. Novelty thus emerges around the digital innovation through recombination of digital resources performed by both firms and the users.

This reasoning paves the way for making a distinction between design recombination and use recombination.

Recombination as Design: Massive Recombination and Resource Integration

Recombination is typically viewed as an activity performed by the firm as it innovates digitally. This emphasis on design is an implicit assumption in much of the work focused on technological development and infrastructure, including studies of the architecture of digital innovations (Henfridsson et al. 2014; Kallinikos et al. 2013; Lee and Berente 2012; Yoo et al. 2010). However, this firm-centric, design emphasis also pervades IS research on cocreation (Grover and Kohli 2012; Sarker et al. 2012), where recombination, consistent with a service-dominant view (Lusch and Nambisan 2015), is understood as "resource integration".

First, in the case of the architecture of digital technology and how it relates to innovation (Henfridsson et al. 2014; Lee and Berente 2012; Yoo et al. 2010), existing work suggests how firms can better govern digital innovation through understanding the unique properties of digital technology (Kallinikos et al. 2013; Shapiro and Varian 1999; Yoo et al. 2010), tensions between control and generativity (Tilson et al. 2010; Svahn et al. 2017; Wareham et al. 2014), digital

controls (Lee and Berente 2012), digital infrastructure mechanisms (Henfridsson and Bygstad 2013), boundary resources design (Eaton et al. 2015; Ghazawneh and Henfridsson 2013), and procrastinated binding of functionality (Eaton et al. 2015; Henfridsson et al. 2014). The idea of 'massive recombination' underpins the literature (cf. Flath et al. 2017), attributing to digital architecture much leverage in the formation of a new value landscape. Firms are essentially able to expand the number of possible value paths in innovation, not least by expanding their reach horizontally along the layers of digital technology (cf. Yoo et al. 2010). Such expansion involves non-existent, or nascent, markets and presents new opportunities for value creation (Bharadwaj et al. 2013), which cannot be easily identified *ex ante*. It therefore requires new forms of governance (Tiwana 2016; Tiwana et al. 2010), entrepreneurship (Nambisan 2017), and digital innovation management (Nambisan et al. 2017).

This tendency to equate recombination with design also pervades the cocreation literature. The emerging literature on service innovation (Barrett et al. 2015; Lusch and Nambisan 2015), including work on value cocreation (Grover and Kohli 2012; Sarker et al. 2012), underlines how value is created in use by many actors, suggesting that digital innovation is a collaborative effort of integrating resources (see Malhotra et al. 2005). For instance, Kohli and Grover (2008) calls for closer examination of "multiple firms using open architectures that raise interesting issues for symbiotic resource sharing and co-creation of value" (p. 28), and Sarker et al. (2012) note "researchers seem to have ignored the fact that, in many contexts, the business model involves vendors selling, extending, and delivering packaged software through partners, who contribute to value addition for the customer firms" (p. 318). In other words, the cocreation literature puts much emphasis on the collaborative aspect of innovation, and views such collaboration as a process in which firms integrate resources to create an attractive offering. Such resources can be

both tangible and intangible, where operant resources, that is, "resources that act on other resources to produce effects" (Lusch and Nambisan 2015, p. 159), are particularly distinctive in digital innovation.

Recombination in Use: Market-based Views and Beyond

An important viewpoint in the service innovation literature holds that "a firm's offerings are not embedded with value (value-in-exchange), but rather value occurs when the offering is useful to the customer or beneficiary (value-in-use)" (Lusch and Nambisan 2015, p. 159). However, our analysis suggests that this view of how the value of digital innovation is constituted in use does not exhaust the need to understand how it is both created and captured at the point of use. In fact, it can be argued that the most elaborated views in this regard are to be found among economists of information. Thus, with a focus on demand economics of scale (Shapiro and Varian 1999) and scope (Gawer 2014), consider how the notion of network effects (Parker and Van Alstyne 2005) has had a profound impact on how we understand the value of users. In particular, how it pins down "the impact that the number of users of a platform has on the value created for each user" (Parker et al. 2016). This notion serves as an important ingredient in explanations of rapid scaling and winner-takes-it-all behavior (Eisenmann et al. 2006; Schilling 2002), as well as the phenomena related to multi-sided markets. Consistent with the idea of demand economies of scale and scope (Gawer 2014; Shapiro and Varian 1999), network effects demonstrate the role of technological improvements (including digital technology) on the demand side (Parker et al. 2016).

However, network effects are not independent of reflective users seeking to create and capture value. Since users are reflective agents who situate themselves in the open-ended value landscape (Garud and Karnøe 2001; Henfridsson and Yoo 2014), we may be able to better understand their activity in generating individual value paths by focusing on the way in which

they connect digital resources in use. Drawing on the flexibility and malleability of digital technology (Germonprez et al. 2007; Kallinikos et al. 2013; Yoo et al. 2010), we propose that such "use recombination" deserves attention as a separate type of recombination. Use recombination's importance ultimately follows from the breakdown of product boundaries (Yoo et al. 2010), where "use" is no longer a discrete act, but is about actively selecting resources of an offering and configuring them with other resources, or even rethinking their usages and purpose.

It is therefore vital to develop a more detailed understanding of value in the context of digital innovation. While this is important for further extending the research related to recombination as design (e.g., Grover and Kohli 2012; Lusch and Nambisan 2015; Sarker et al. 2012), it may be equally important to the recombination in use side of digital innovation. In doing this, we draw on the non-essentialist view of digital resources (cf. DeLanda 2006) to think of the meeting point between design recombination and use recombination as a multi-dimensional space of possible value. The meaning and significance of a digital resource need to be considered in view of its relations to other resources in terms of the value paths created. Concurrent design recombination and use recombination are the processes by which such value is created and captured.

In what follows, we further elaborate on the ways that design recombination and use recombination play out together. We develop "the value spaces framework" and outline its implications for future work.

THE VALUE SPACES FRAMEWORK

The value spaces framework, including its key constructs (Table 1), is intended to serve as an orientation for understanding value in digital innovation. In what follows, we describe its key

constructs and how they hang together as a basis for understanding the setting, activities, and outcomes of value creation and capture in digital innovation. We also illustrate the constructs using examples from cloud services, home entertainment, and digital maps settings (see Table 2 for comprehensive examples).

The Setting: Spaces, Resources, and Connections

The open-ended value landscape of digital innovation is made up of multiple spaces, where each space hosts a multitude of possibilities for value creation and capture. As outlined in Figure 1, these spaces map onto the four loosely coupled layers of digital architecture (Benkler 2006; Yoo et al. 2010), namely: contents, service, networks, and device. We define a *value space* as an evolving network of digital resources interlinked through connections established (and dissolved) by actors seeking to generate and appropriate value.[3]

[3] The notion of value space has been used in prior research (El Sawy and Pereira 2013; Nandhakumar et al. 2013), although in slightly different fashions.

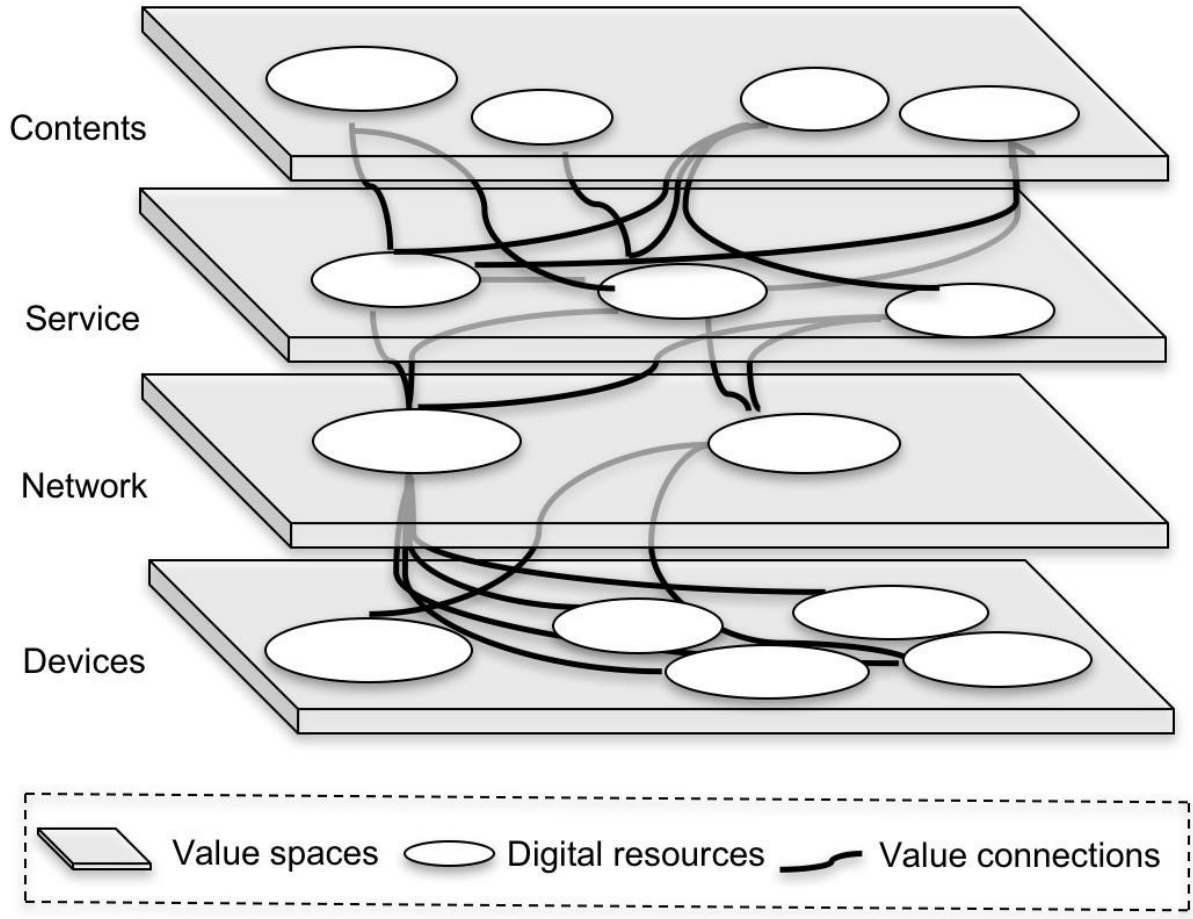

Figure 1: Spaces, Resources, and Connections

We furthermore view *digital resources* as entities that serve as the building blocks in the creation and capture of value from information in digital innovation. A digital resource (1) belongs to a specific value space, (2) hosts the potential to simultaneously be part of multiple value paths, and (3) is typically product-agnostic. First, a particular digital resource belongs to one of the four value spaces: devices, network, services, or contents. For instance, the contents value space consists of digital data resources commonly recognized as information, such as maps, music, news, and video; the services value space includes functional software-based resources such as heart monitors, social media applications, weather services, smart lighting, and

media browsers; the network value space includes logical transmission software and the physical transport resources; and lastly, the device value space consists of hardware and software resources that enable storing and processing capabilities. In the case of a boundary resource (Ghazawneh and Henfridsson 2013) such as an application programming interface (API), an API for allowing access to the camera of a smartphone can be classified as a device layer digital resource, while an API for allowing access to map data from services like Google Maps can be classified as a contents layer digital resource.

Second, a specific digital resource may be part of several different value paths (see Figure 2). For instance, the value of digital map contents may be realized in different contexts (navigation, traffic, education, search, entertainment, and so on) guided by its combination with other digital resources. In addition, multiple actors may decide to release offerings where the same map contents are used. For instance, as of February 2012, ProgrammableWeb listed 2,337 mashups that used the Google Maps API, meaning that the same contents are part of many offerings. Third, digital resources are agnostic in that their use is not pre-determined (Yoo et al. 2010). Compared to a component in a modular architecture where variation is accomplished within the scope of an architectural scheme (Baldwin and Clark 2000), a digital resource exhibits relations of exteriority (DeLanda 2006). This implies that the meaning, or function, of a specific digital resource changes in tandem with its relations to the other resources of a value path. If the digital resource is detached from the value path and plugged into a different value path, its interactions and meaning will be different. Consider how the use of Google maps in the context of a ride-sharing service such as Uber evokes different meanings to its use in, say, a property-listing service.

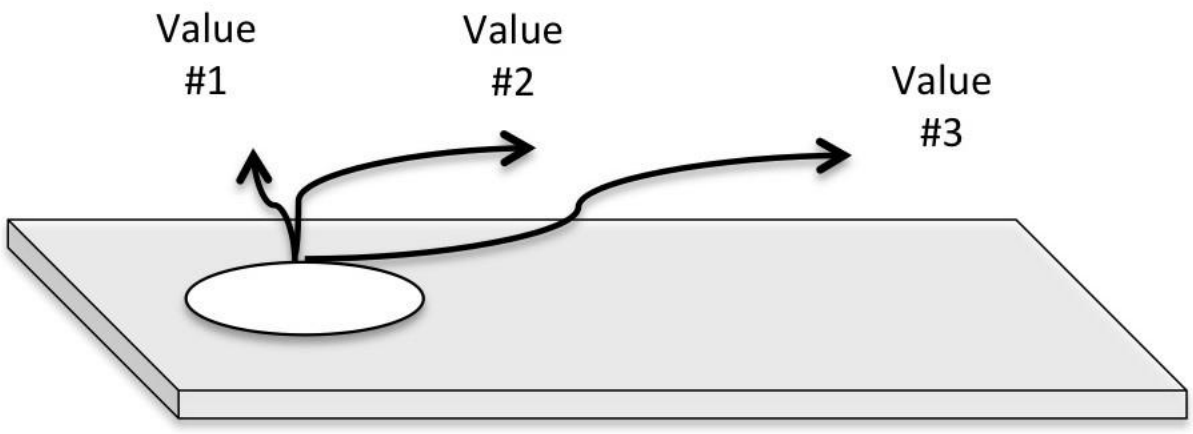

Figure 2: The Multiple Value Paths of a Digital Resource

Value connections are associations between digital resources. A value connection within the same value space (see Figure 1) may involve a horizontal (i.e. within the same space) standard that pools digital resources in a way that creates value. For instance, a particular standard for geographical data may create an association between two map contents resources. Consider how property-listing services such as Rightmove have created new value by connecting map data (using Google Map API) with their database of properties for sale. User value is thereby created as prospective homebuyers can more easily explore a particular geographical area for properties.

Value connections can also be made across value spaces. The Rightmove app for iOS, which is an example of a digital resource in the service value space, creates additional value for users. A value connection across value spaces (see Figure 1) may also involve a platform that enables a service to be distributed and used. For instance, if an activity tracking application such as 'Moves', is created for a platform such as Facebook, this creates a value connection by not only giving Moves a large potential audience, but also potentially increasing the value of the

Facebook platform. The myriad of value connections made between digital resources thus collectively generate multiple value paths, either as unfolding value offers or as value in use at a particular time.

The Process: Actors, Recombination, and Channeling

Actors perform value creation and capture activities within and across value spaces. We distinguish between three relevant actors: firms, individuals, and bots. We use the notion of bots broadly to refer to software agents such as scripts and algorithms, which are designed and configured to act on behalf of firms or individuals. These actors engage in at least three types of activities: design recombination, use recombination, and paths channeling.

First, we refer to *design recombination* as the activity of generating a value path by connecting digital resources as a value offering to users. For instance, Microsoft offers OneDrive as an online storage system with collaborative features to work with its Office applications such as Microsoft Word. By closely connecting its email and calendar applications, Microsoft seeks to offer a comprehensive value path as a proposition to cloud users to collaborate on document creation and editing.

Second, another relevant activity is *use recombination*. We refer to use recombination as the activity of generating an ideographic value path by connecting digital resources in use. This involves making connections between digital resources in the moment of use. This may follow one or many value paths offered by actors doing design recombination. However, in many cases, the use value is quite ideographic, where a particular value path offer may be adopted in part, or in combination with other digital resources. For instance, in the above example of cloud-based collaborative document creation and editing, users might partially adopt the comprehensive value path offered by Microsoft by using the online storage but then combine it with digital resources such as Google Drive and Facebook Messenger to share their work with collaborators.

Third, in addition to design recombination and use recombination, channeling is an important activity for capturing value. We refer to *paths channeling* as the activity of steering value connections, and ultimately value paths, through one particular, or a combination of, resource/s to provide the potential for capturing value as it becomes more center-stage in a particular value space. After generating a value offering through design recombination, paths channeling works as a competitive strategy to capture connections from other actors. For instance, consider Google's attempt to tap into the value paths dominated by Microsoft in the context of word processing. Offering users of Microsoft Word plug-ins to make Word to work directly from Google Drive, Google seeks to channel value paths through their own digital resources. Similarly, Google might seek to offer other plug-ins to tap into other powerful value paths by channeling users through its digital resource. As another example, consider how Amazon's Echo integrates voice-control and third-party devices such as lights, switches, and thermostats such as Philips Hue, Samsung SmartThings, and Google's Nest. It also controls music services such as Spotify. As path channeling is successfully achieved, the chances that a firm's digital resource turns into a platform, that is, an "evolving organizations or meta-organizations composed of agents who can innovate and compete" (Gawer 2014, p. 1240), increases. The growth of users is accompanied by network effects (Parker and Van Alstyne 2005), that is, it increases the marginal value for new users to join.

Even when path channeling does not lead to the emergence of a platform, it builds assets that can be monetized. First, path channeling promises to build information assets by obtaining user information at different stages such a sign-up to use a particular digital resource. Such information assets can be used to improve the precision by which advertising is targeting specific

users. The information can also be put on sale to third-parties. Second, the value of path channeling can be monetized more directly, as firms charge for the use of their digital resources.

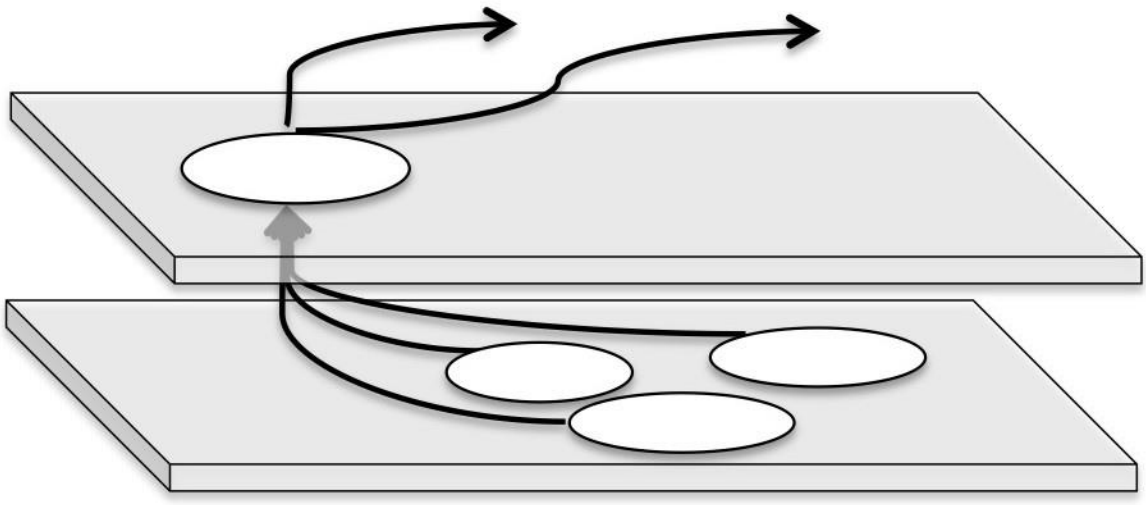

Figure 3: Path Channeling

Digital Innovation Outcomes: New Digital Resources and Generative and capture Potential

We think of a digital innovation as the outcome of the activities by which a set of digital resources are recombined in both design and use through connections across value spaces. Because of the loose coupling between digital resources, there is little point thinking of a digital innovation in terms something fixed with ready-made boundaries. In fact, the common perception of digital innovation as "the carrying out of new combinations of digital and physical components to produce novel products" (Yoo et al. 2010, p. 725) reflects a view where the offering generated through design recombination is made central. Yet, the value of the digital

innovation is not pre-determined by the original designer but extends beyond the initial proposition (Tilson et al. 2010; Wareham et al. 2014; Yoo et al. 2010). This leads us to view the value of a digital innovation as a change in state desired by an actor in a particular use context resulting from the value paths offered by actors doing design recombination and the value paths built by connecting digital resources in use (use recombination). Value unfolding extends over time and across value space as new value connections and value paths evolve in the open-ended landscape. With this in mind, actors in an open-ended value landscape will seek to develop the attractiveness of their digital resource for actors seeking new value connections and generating value paths.

One way to measure the value outcome of digital innovation would be to closely examine its *value intensity*. We refer to value intensity as the amount of value connections channeled through a digital resource over a defined time period, such as the number of hits on a web-page or an app making use of a digital resources such as maps. For the actor controlling a particular digital resource, this provides a rough estimate of how successful they have been in generating value in use for actors consuming that resource. The greater the amount of value connections *channeled* through that resource (i.e., value intensity), the greater their opportunity for value capture. In many start-ups, this measure of scaling is important for putting a value on the company (Huang et al. 2017), since it indicates a value capture potential. One way to increase the value intensity would be to decrease the threshold for a making a connection through the digital resource. Such support can be facilitated by designing support resources, such as boundary resources (Ghazawneh and Henfridsson 2013), that improve access and make the resource more attractive. Google's offer of a plug-in for Microsoft Word users mentioned above would be one example of an attempt to increase value intensity.

Another way to measure the outcome of digital innovation would be to closely examine its *value scope*. We consider this as the number of qualitatively different uses (via value connections) that the digital resource helps to mediate. This will indicate both the digital resource's degree of agnosticism (Yoo et al. 2010), and its potential to branch out into different functional areas. The greater the latitude for different uses through value connections, the greater their generative potential.

Boundary resources, such as APIs, can be purposefully designed to have a broader appeal so as to increase scope beyond the original functional area of the innovation.

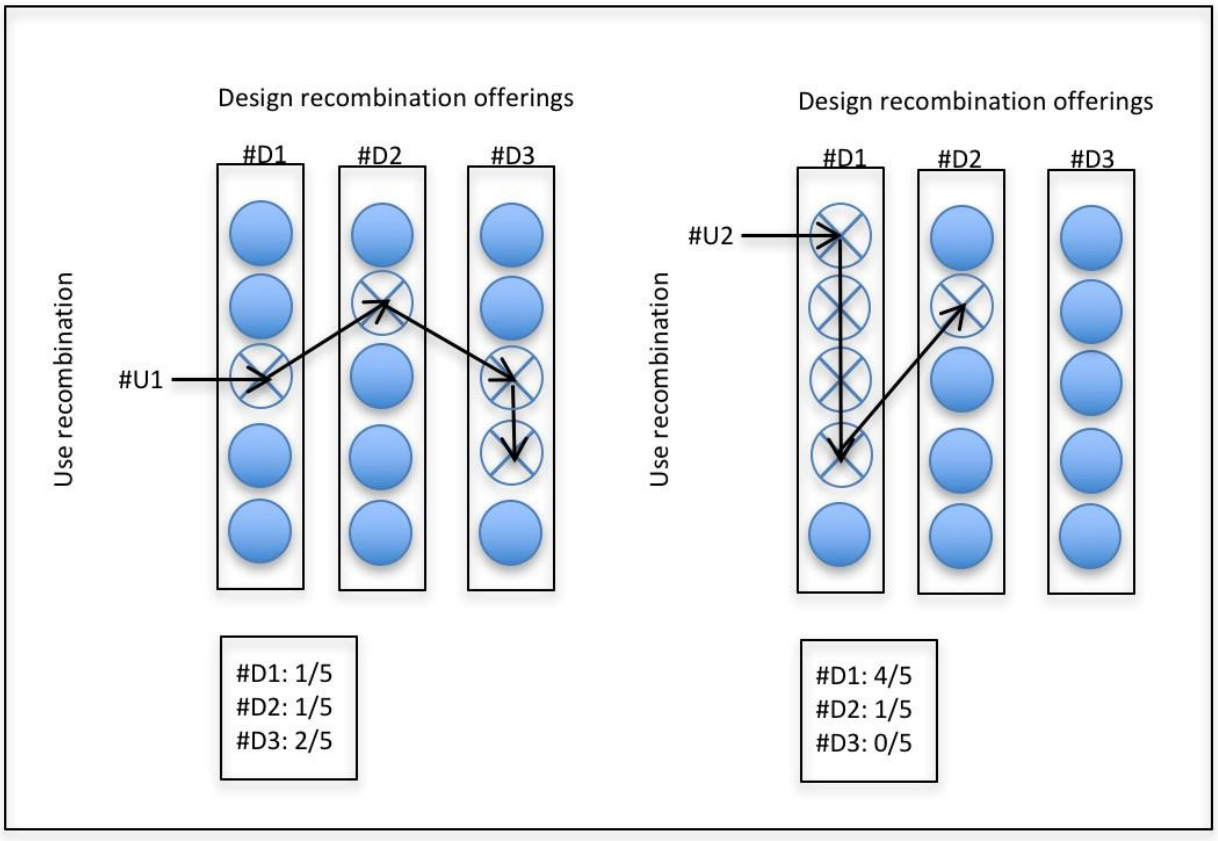

Figure 4: Design-Use Value Paths Overlap

Third, outcome could also be measured in terms of *design-use value paths overlap*, that is the degree to which an offered value path created through design recombination is adopted as actors engage in use recombination (see Figure 4). This measure provides a more detailed look at a digital service (as a combination of digital resources) and the way in which its adoption is actually distributed across its digital resources. For a given user, the proportion of digital resources offered through design recombination that were employed in use recombination would give an indication of the extent to which an offering is valued by the user in the use context. In the example in Figure 4, the first use recombination (U1) had 0.2 overlap with the first design recombination (D1), while it had 0.2 and 0.4 with D2 and D3, respectively. In this case, the use recombination was a result of the cherry-picking of digital resources across different offerings produced through design recombination. In the second use recombination (U2), the overlap with the first design recombination (D1) was much higher than in the other cases (D1: 0.8; D2: 0.2; D3: 0). In this second case, the firm behind the #1 design recombination was successful in realizing almost its entire offer in the use context, with only one of its digital resources not being incorporated into the user's value path. Given an explicit strategy for distinguishing digital resources in an offer, this measure gives us a more precise view of the user uptake for a specific digital innovation. For instance, in the case of the offer exemplified by D2, a simplistic analysis would suggest that the user base is 2 (U1 and U2). Using this notion, the user base (0.2+0.2/2) is adjusted by the range of overlap in use, which in D2 was 0.2 for both U1 and U2.

In addition, it should be added that a particular offering through design recombination has a one-to-many relationship to the use recombination side (in Figure 4, for instance, 2 use recombinations); a relationship that would need to be taken into consideration when the idea of overlapping design-use paths is progressed further. This could be done by identifying aggregated

measures, where many users' use recombinations are collected into a single measure. For instance, treating each use recombination as a string of binary variables, it would be possible to do a recombinatorial investigation of #D1 in Figure 4. Considering that users can recombine resources included in #D1 in 32 ways (2^5) (two ways exemplified in Figure 4: [0,0,1,0,0] and [1,1,1,1,0]), it can be useful to determine the most common use combinations of digital resources in the offering. Such analysis can be further expanded to include how recombination is done with resources belonging to other actors' offerings.

Table 1: Key Constructs

Setting	
Value space	An evolving network of digital resources interlinked through connections established and dissolved by actors seeking to generate and appropriate value.
Digital resources	Entities that serve as building blocks in the creation and capture of value from information in digital innovation. A digital resource (1) belongs to a specific value space, (2) hosts the potential to simultaneously be part of multiple value paths, and (3) is typically product-agnostic.
Value connection	An association between two digital resources. Such association can be established (1) between digital resources within the same value space, or (2) between digital resources belonging to different value spaces.
Process	
Actors	Actors perform value generating and appropriating activities within and across value spaces. Actors can be firms, individuals, and software agents such as robots, scripts, and algorithms.
Design recombination	The activity of generating a value path by connecting digital resources as a value offer to users.
Use recombination	The activity of generating an individual value path by connecting digital resources in use.
Paths channeling	Activities designed to steer value paths through one particular, or a combination of, digital resource/s and appropriate value as it becomes more center stage in a particular value space.
Outcomes	

Value	Desired change in state of the actor (user) in a particular context.
Value intensity	The amount of value connections channeled through a digital resource over a period of time.
Value scope	The scope of value connections channeled through a digital resource.
Design-use value paths overlap	The degree to which an offered value path created through design recombination is adopted as actors engage in use recombination.

Table 2. Example Cases

Key constructs	**Cloud services**	**Home entertainment**	**Digital Maps**
Design recombination	Microsoft provides OneDrive as an online storage system with collaborative features compatible with its Office applications such as Microsoft Word. In doing this, the firm seeks to offer a comprehensive value path as a proposition to cloud users to collaborate on document creation and editing.	Amazon offers Echo as a voice-operated software agent embedded in a connected speaker device for playing music at home from Amazon's online music library. Combining Amazon Echo with its other services such as audio books and online news, Amazon seeks to offer a strong value path for home entertainment users.	Google provides Maps as a digital maps application for a chosen location. Combining this digital resource with other data, such as real-time traffic conditions and services, the company offers a comprehensive value path for mobile users, from planning their route and finding points of interest, to creating reminders associated with specific locations.
Use recombination	Users might partially adopt the comprehensive value path offered by using the online storage based collaborative document creation and editing, but also by combining it with digital resources such as Google Drive and Facebook Messenger to share their work with collaborators. User might pick-and-match offerings from different firms to generate innovative individual value paths, for instance, for a knowledge document management service, by connecting Microsoft documents, scanning, and visualizing services with GoogleDrive's services to store, distribute,	Users of music services such as Spotify, Pandora, and TuneIn might combine these services with Amazon Echo, or even replace Amazon's default music library in the Echo. User might also generate new individual value paths by combining Echo with 'unsupported music libraries' such as Apple iTunes music, or Google Play music, by pairing Echo via Bluetooth to stream music through their Echo. Further, users might generate unexpected value paths by adding software capabilities (referred to as 'skills' by Amazon) to Echo as to	Users might partially adopt the value path offered by Google Maps for transportation, for instance, using Uber/Google to find a ride and pay faire, but also choose a different maps app, such as TomTom for navigation at the point of use. Alternatively, users might create an individual value path by choosing and combining Google Maps at point of use, for instance replacing default Microsoft's Bing Maps in the Microsoft Outlook contacts app, which displays a particular contact's address on Bing

	connect, sync, indexing, and retrieve	integrate it with many of the third-party digital resources such as thermostats and lighting switches in different parts of their home, along with playing music.	Maps, with Google maps to create a different value.
Paths channeling	Google offers users of Microsoft Word plug-ins to make Word to work directly from Google Drive. In this way, Google seeks to channel value paths through their own digital resource. Similarly, Google might seek to offer different plug-ins to tap into other powerful value paths. In response, Microsoft provides boundary resources for other developers to integrate third-party apps such as photo and pdf edit/sharing to work directly from OneDrive and thereby link a range of digital resources and channel value paths through OneDrive.	Amazon's Echo offers users easy options to use services such as Spotify and Pandora. Further, Amazon adds software features to its Echo to integrate and voice-control exiting third-party devices such as lights, switches, and thermostats (e.g., Philips Hue, Samsung SmartThings, Google's Nest) in order to tap into other value paths of users of other digital resources in smart home. For new smart home appliances, Amazon offering users a 'Skills kit' (a collection of self-service APIs, tools, documentation, and code samples) to easily write programs and include them in Echo to channel more uses (via value connections).	Google seeks to steer value paths through Maps by allowing users to not only request Uber cars, but also other local ride-sharing services directly from Google Maps (for users with the ride-sharing apps installed on their devices). Google's powerful APIs enable Maps resources to be easily combined and overlaid with other services to attract and channel value connections through Google Maps. In response, competitors such as Apple Maps might offer plug-ins to tap into value paths created by Google Maps, for instance to read recent searches from Google Maps to combine with Apple Maps.
Value intensity	Many value connections channeled through OneDrive provides higher value intensity and potential for Microsoft to capture value.	The increasing take-up of Amazon's Echo and its integration with numerous online music services and digital appliances could drive large amount of value connection through its digital devices and offer opportunity for value capture.	Multiple actors making use of the Google's digital maps resources as a 'universal' standard maps help growing the number of value connections through its digital maps.
Value scope	Microsoft OneDrive can be used together with Office apps. By offering API's/software development kit for other developers to integrate their apps with OneDrive, Microsoft may stimulate an increase of	Amazon Echo can be used for music, shopping, information seeking, and so on, making the value scope high.	Google Maps' powerful APIs enables a very high value scope in that it can be used as a stand-alone service, property listing, services, and so on.

	qualitatively different uses.		

DISCUSSION AND IMPLICATIONS FOR INFORMATION SYSTEMS RESEARCH

Recombination is essentially about creating and capturing new value by weaving components together in new ways. In view of the increased flexibility which digital technology allows for such recombination (Henfridsson et al. 2014; Kallinikos et al. 2013; Yoo et al. 2010), there is an increased interest in the information systems community and beyond in new business values that arise from the pervasiveness of digital technology. Yet, this interest has been clearly tilted towards the design side of recombination. In prior work, such as the literatures on cocreation in the business value of IT (Grover and Kohli 2012; Sarker et al. 2012) and digital architecture (Kallinikos et al. 2013; Shapiro and Varian 1999; Yoo et al. 2010), there is a clear focus on design and recombination being performed by the firm. Even in the service innovation literature (Barrett et al. 2015; Lusch and Nambisan 2015), where value-in-use is emphasized, and in the platform and network effects literature (Gawer 2014; Parker et al. 2016), where demand and user adoption are important, there is a lack of a vocabulary and coherent framework for dealing with use recombination and how it relates to value creation and capture in digital innovation. Having laid-out our outline for such a vocabulary framework, in what follows, we discuss a number of the implications that flow from our research with a focus on process (the Two Sides of Recombination and Competitive Strategies: The Role of Paths Channeling) and outcomes (Outcomes: Intensity, Scope, and Overlap).

The Two Sides of Recombination

We propose the value spaces framework as a tool with which to understand the new open-ended landscape of digital innovation. At the heart of the framework, we make a distinction between

design and use recombination. This distinction comes with a number of significant implications. First, it offers a starting-point for detailed analysis of the meeting-point of offerings and use in digital innovation. Prior literature has observed how traditional product boundaries are effectively dissolved in this context. Indeed, digital innovation "in a layered modular architecture is not derived from a single design hierarchy of a given product" but is "inductively *enacted* by orchestrating an ensemble of components from a set of heterogeneous layers" (Yoo et al. 2010, p. 728). Our framework extends the research on layered modular architecture by offering a straightforward terminology to describe and explain the emergence of such ensembles in terms of interaction between design recombination and use recombination. In particular, it accommodates the fact that a particular digital resource ("component" in Yoo et al.'s (2010) terminology) can be part of many users' different value paths. This is something that Yoo et al. (2010) imply without providing a terminology with which to express such value multiplicity. In this regard, we unpack existing notions of use and the user and seek to locate use recombination within the "massive recombination" that follows from digital innovation (cf. Yoo et al. 2010). This makes it possible for us to build a bridge between the work on digital innovation and theories of network effects and of platform competition (Parker et al. 2016). Viewing use, and the value derived from use, not as symmetrical with designed products or services but as involving enacted recombinations of digital resources has important implications for network effects in the context of digital innovation. In particular, where the existing platform literature tends to focus on the network effects in terms of scale, and especially demand economies of scale, our focus on use recombination provides novel insights into the way in which the growth in use creates value both for other users (termed 'same-side' network effects) and for product/service providers (cross-side network effects). Indicative research questions arising from

this discussion are as follows: *How does the interaction between design recombination and use recombination shape digital innovations and their value? What are the conditions under which use recombination leads to the kind of massive recombination made possible by digital technology? What are the implications of situating use at the level of digital resources (rather than as symmetrical with design products or services) for the analysis of network effects and platform competition?*

Contributing to the service innovation literature (Barrett et al. 2015; Lusch and Nambisan 2015), the value spaces framework offers a significant direction for investigating use value in digital innovation. With its emphasis on resource integration, the service innovation literature tends to equate recombination with design. Acknowledging the two sides of recombination, however, helps us better characterize diversity in use value among different users. For instance, with a particular offering in mind, differences in perceived use value can be analyzed (and even visualized) in terms of data about which combinations of digital resources (of the offering) are valued and by whom, and how such combinations of digital resources are combined with resources belonging to other actors' offerings. This will significantly improve the possibility to decide upon pricing and ways to monetize digital innovations. Important research questions that follow from our analysis are: *What are the factors that diversify the use value of digital resources across users? What are the conditions under which particular digital resources of an offering exhibit high use value compared to other resources of the same offering? How can decisions on pricing of digital innovations be taken in view of the analysis of configurations of digital resources?*

The distinction between design recombination and use recombination also offers a way to of understanding user innovation as a particular form of digital innovation. While a particular use

recombination may not represent user innovation in itself, it may lead to such innovation when an idiographic value path is taken up by other users and then repackaged or recognized as an offering or a widely shared practice. Existing research suggests that the ability to generalize an idiographic value path in this way is dependent on several factors, including; the existence of an active user community (Di Gangi and Wasko 2009), the motivation of the user (Von Hippel and Von Krogh 2003), and the receptiveness of producer organizations to such innovations (Di Gangi and Wasko 2009). However, we know little about the process by which use recombination, facilitated by the malleability of digital technology (Kallinkos et al. 2013), actually leads to user innovation. One indicative research question, related to the relationship between use recombination and user innovation, is as follows: *What is the process by which a particular use recombination, originally idiographic, becomes a user innovation, offered as a value path to other users?*

Competitive Strategies: The Role of Path Channeling

We developed the notion of path channeling to denote activities designed to steer value paths through one particular, or a combination of, digital resources. If successful, such channeling makes a digital resource more center-stage in a particular value space, which supports significantly the firm's ambitions to capture value. In particular, it can be seen as a competitive strategy to capture value from value paths offered by other actors. Since relations between digital resources are only contingently obligatory (Delanda 2006; Um 2016), such attempts to capture value from someone else's user base are not only possible, but have emerged as an important aspect of competitive strategies. Indeed, once a firm has offered a value path, it becomes important to identify ways to attract users engaged in use recombination to include parts, or ideally the entire, offering in their value path based on some other actors' offering(s). Such ways include the use of boundary resources (Ghazawneh and Henfridsson 2013) such as plug-ins

(recall the example of Google offering users of Microsoft Word plug-ins to make Word to work directly from Google Drive).

The notion of path channeling adds to our understanding of competitive strategy, including recent insights related to platform envelopment (Eisenmann et al. 2011). Platform envelopment is described in the literature as a firm leveraging the shared relationships created by overlapping user bases to envelop the service offered by an existing provider by, for example, replicating the functionality of their existing platform as part of a multiplatform bundle. Viewing such strategies in terms of the recombination of digital resources, however, provides a new vocabulary and tools for analysis. In particular, envelopment can be seen as involving a particular form of path channeling in which the positioning of new digital resources affords new value paths for users. These resources seek to substitute a value path currently dominated by a competitor with an alternative value path which is linked to a wider array of resources and therefore enjoys greater value scope than the competitor's path. Conversely, path channeling may also be incorporated within a defensive strategy by exploiting the contingent association of a specific digital resource with existing highly used and complementary digital resources and thereby increasing its value intensity.

Extending our discussion of paths channeling also provides new insights into the emergence of platforms themselves. Much attention has been given in the existing literature to the dominant role played by platforms in digital innovation and their grounding in different types of network effects. However, the 'chicken or egg' question of how such platforms emerge and achieve dominance remains a challenging one (Parker et al. 2005). The network effects associated with platforms ultimately flow from use. They operate most strongly when the numbers of producers and users are high. Network effects cannot be an explanation for the initial

growth in usage when a network does not exist. Here, our analysis of path channeling complements existing work on platforms by providing an insight into their nascent emergence as a market. It suggests that the growth in usage of a particular digital resource can be achieved by strategically exploiting its contingently obligatory relations (DeLanda 2006; Um 2016) with other digital resources. Influencing the value paths available for use recombination helps to secure greater usage (value intensity as we have termed it) for a particular digital resource.

Indicative research questions are as follows: *How can a firm increase the value of its offering by channeling value paths originating with other actors through their own digital resources? How can boundary resources be used to capture value paths that otherwise would remain outside the firm's offering? How can we explain the formative stages of a platform through the notion of path channeling?*

Outcomes: Intensity, Scope, and Overlap

The value spaces framework offers a set of concepts for assessing the outcomes of digital innovation: value intensity, value scope, and design-use value paths overlap. This set of measures of the outcome of digital innovation flow from the distinction and interplay between design recombination and use recombination. They come with important implications for the literature and with significant promise for future research in the area.

Consider, for instance, how important implications for the analysis of network effects can be derived from our earlier analysis of the overlap between design and use recombination. That analysis suggests that simply pursuing larger numbers of users as a way of creating network effects, or using such numbers as a metric of success, may be profoundly misleading. Instead, the value spaces framework suggests that more attention needs to be given to the value paths which such users are able to access by recombining with other complementary resources. Thus, one implication is that network effects are likely to be secured not only by the standardization of a

particular service (or digital resource in our case) (Katz and Shapiro 1985; Farrell and Saloner 1986), but also by the quality of the value connections between that resource and a plurality of complementary digital resources. While standardization helps to increase *value intensity* for a particular resource, its links with other resources provide *value scope*, enabling multiple different value paths for users around that standardized resource.

Moreover, detailed analysis of the meeting-point of an offering and the many uses of the digital resources in the offering opens up the possibility of new forms of valuation for digital innovation. The notion, described earlier (Figure 4), of design-use value paths overlap offers significant traction for anyone intending to conduct a detailed assessment of a digital innovation as a combination of digital resources. In particular, it allows for a more forensic examination of how the innovation's adoption is distributed across digital resources, by facilitating analysis of the one-to-many relationship for any design recombination. Such analysis can be conducted within the scope of the offering itself, or extend to the value paths offered by other actors.

In addition, while accepting that particular user recombinations involve idiographic value paths, our focus on resource recombination may help to reveal in a more systematic way not only the *overlap* between design and use recombinations (as discussed previously), but also the *gap* between such recombinations. By exposing the existence of clear disjunctures between what firms have designed and what users have pursued to create value, we may be better able to identify both the conditions of, and potential for, user innovation than is currently the case. Conversely, the *overlap* of value paths created through design recombination with use may also reveal the potential for value capture. Such an overlap effectively signals points at which the access to user value paths by different actors (users and firms) could be monetized.

Lastly, in contrast to, for instance, the service-dominant view, the digital spaces framework takes digital resources rather than actors as a starting-point in exploring the outcomes of digital innovation. The idea of focusing on the artifacts rather than actors should not be taken as an attempt to downplay the social dimension of these spaces. Rather, this represents a research-pragmatic standpoint, which demands straightforward units of analysis for research and inquiry into digital innovation and related value creation. As digital innovation spans organizational, and even industry, boundaries and involves multi-vectored value paths, there is a strong case for viewing the digital resource, or the artifact, not only as a key object of value connections but as a crucial point for data collection. This case is also being steadily reinforced by the advance of computational methods in our field. While still in its early stages, research using sequence analysis (Gaskin et al. 2014), for instance, epitomizes this advance, as it seeks to import new theoretical backdrops from evolutionary theory and complexity science (Yoo 2012). The value spaces framework seeks to stimulate further thinking in this direction by providing an artifact-centered vocabulary that nevertheless offers explanatory potential for models of digital innovation.

Indicative research questions following from the discussion above are: *How can the value of digital innovations be measured on the digital resources level? How can we explain the distribution of use recombination across users? How can be understand the balance between value intensity and value scope in the emergence of a digital innovation? How to locate the optimal digital resource that will capture value from use recombination originating in external value offerings? How can digital trace data be used to make sense of the overlap between design recombination and use recombination?*

CONCLUSION

In this paper, we have articulated the idea that it is important to make a distinction between recombination in design and recombination in use, and to explore how they interact. The value spaces framework leverages this distinction to meet both theoretical and practical concerns, as a growing range of actors now find themselves in a new but also often disorienting and complex open-ended value landscape of digital innovation. In fact, even actors in extant industries such as the automotive sector, characterized by established models of value creation and capture, confront troubling valuation challenges. To this end then, we have sought to identify a number of important constructs for understanding value in a situation when products and services lack clear and pre-defined boundaries. Using digital resources as the unit of analysis, the value spaces framework helps to make clear how such resources come together and assemble a whole from the ground-up. As a stimulus to thinking we have developed new constructs that seek to better capture the settings, process, and outcomes of value generation for digital innovations. At the same time, we have put forward a small number of research questions with the aim of catalyzing further exploration of these issues.

The research direction posed by this research commentary complements existing thinking on massive recombination (Flath et al. 2017; Yoo et al. 2010; Yoo et al. 2012) and resource integration (e.g. Lusch and Nambisan 2015). It does so by adopting a vocabulary that allows a more granular and combinatorial understanding of value. At a time when both the promise and consequences of digital technology are more prominent than ever, we believe that IS researchers are well equipped to take on the challenge of further research and theorizing on the emerging vistas of value creation and capture that arise from digital innovation. This will certainly entail new methodological thinking (see El Sawy et al. 2010), with such methods needing to be able to

describe and handle the many different paths along which value is constructed and how these can be appropriated. However, as we have sought to address in this paper, it also demands urgent and creative thinking (and re-thinking) of what we mean by, and how we can better assess, the value potential of digital innovation.

REFERENCES

Arthur, W. B. 2009. *The Nature of Technology: What It Is and How It Evolves*. New York: Free Press.

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

Barrett, M., Davidson, E., Prabhu, J., and Vargo, S.L. 2015. "Service Innovation in the Digital Age: Key Contributions and Future Directions," *MIS Quarterly* (39:1), pp 135-154.

Benkler, Y. 2006. *The Wealth of Networks: How Social Production Transforms Markets and Freedom*, Yale University Press.

Bharadwaj, A. El Sawy, O. A, Pavlou, P. A. and Venkatraman, N., 2013. Digital Business Strategy: Toward a Next Generation of Insights. *MIS Quarterly*, 37(2), pp.471–482.

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

DeLanda, M. 2006. *A New Philosophy of Society*. London: Continuum.

Di Gangi, P. M., & Wasko, M. 2009. Steal my idea! Organizational adoption of user innovations from a user innovation community: A case study of Dell IdeaStorm. *Decision Support Systems, 48*(1), 303-312.

Eaton, B., Elaluf-Calderwood, S., Sørensen, C., and Yoo, Y. 2015. "Distributed Tuning of Boundary Resources: The Case of Apple's iOS Service System," *MIS Quarterly* (39:1), pp 217-243.

Eisenmann, T., Parker, G., and Van Alstyne, M. W. 2006. "Strategies for Two-Sided Markets," *Harvard Business Review*.

Eisenmann, T., Parker, G., and Van Alstyne, M.W. 2011. "Platform Envelopment," *Strategic Management Journal* (32), pp 1270-1285.

El Sawy, O.A., Malhotra, A., Park, Y., and Pavlou, P.A. 2010. "Seeking the Configurations of Digital Ecodynamics: It Takes Three to Tango," *Information Systems Research* (21:4), pp 835-848.

El Sawy, O.A., and Pereira, F. 2013. *Business Modelling in the Dynamic Digital Space*. Heidelberg: Springer.

Farrell, J, and Sallower. G 1985. "Standardization, compatibility, and innovation." *The Rand Journal of Economics*, (16:1) pp 70-83

Flath, C. M., Friesike, S., Wirth, M., and Thiesse, F. 2017. "Copy, Transform, Combine: Exploring the Remix as a Form of Innovation," *Journal of Information Technology* (32), pp. 306-325.

Galunic, D. C. and S. Rodan 1998. "Resource Recombinations in the Firm: Knowledge Structures and the Potential for Schumpeterian Innovation." *Strategic Management Journal* 19(12): 1193-1201

Garud, R., and Karnøe, P. 2001. "Path Creation as a Process of Mindful Deviation," in *Path Dependence and Creation*, R. Garud and P. Karnøe (eds.). Mahwah, New Jersey: Lawrence Erlbaum Associates, pp. 1-38.

Garud, R., Kumaraswamy, A., Langlois, R. N., Eds. 2003. *Managing in the Modular Age: Architectures, Networks, and Organizations*. Malden, MA, Blackwell Publishing

Gaskin, J., Berente, N., Lyytinen, K., and Yoo, Y. 2014. "Toward Generalizable Sociomaterial Inquiry: A Computational Approach for Zooming in and out of Sociomaterial Routines," *MIS Quarterly* (38:3), pp 849-871.

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

Germonprez, M., Hovorka, D., and Collopy, F. 2007. "A Theory of Tailorable Technology Design," *Journal of Association for Information Systems* (8:6), pp. 351-367.

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), pp 173-192.

Grover, V., and Kohli, R. 2012. "Cocreating IT Value: New Capabilities and Metrics for Multifirm Environments," *MIS Quarterly* (36:1), pp 225-232.

Henfridsson, O., and Bygstad, B. 2013. "The Generative Mechanisms of Digital Infrastructure Evolution," *MIS Quarterly* (37:3), pp 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 (29:1), pp 27-43.

Henfridsson, O., and Yoo, Y. 2014. "The Liminality of Trajectory Shifts in Institutional Entrepreneurship," *Organization Science* (25:3), pp. 932-950.

Huang, J., Henfridsson, O., Liu, M.J., and Newell, S. Forthcoming. "Growing on Steroids: Rapidly Scaling the User Base of Digital Ventures through Digital Innovation " *MIS Quarterly*.

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

Katz, M. L., and Shapiro C. "Network Externalities, Competition, and Compatibility." *The American Economic Review* 75.3 (1985): 424-40.

Kohli, R., and Grover, V. 2008. "Business Value of IT: An Essay on Expanding Research Directions to Keep up with the Times," *Journal of Association for Information Systems* (9:1), pp. 23-39.

Langlois, R. N. 2007. *The Dynamics of Industrial Capitalism: Schumpeter, Chandler, and the New Economy*. London and New York, Routledge.

Lee, J., and Berente, N. 2012. "Digital Innovation and the Division of Innovative Labor: Digital Controls in the Automotive Industry," *Organization Science* (23:5), pp 1428-1447.

Lusch, R.F., and Nambisan, S. 2015. "Service Innovation: A Service-Dominant Perspective," *MIS Quarterly* (39:1), pp 155-175.

Malhotra, A., Gosain, S., and El Sawy, O.A. 2005. "Absorptive Capacity Configurations in Supply Chains: Gearing for Partner-Enabled Market Knowledge Creation," *MIS Quarterly* (29:1), pp 145-187.

Nambisan, S. 2017. "Digital Entrepreneurship: Towards a Digital Technology Perspective of Entrepreneurship," *Entrepreneurship Theory and Practice* (41:6).

Nambisan, S., Lyytinen, K., Majchrzak, A., and Song, M. 2017. "Digital Innovation Management: Reinventing Innovation Management Research in a Digital World," *MIS Quarterly* (in press).

Nandhakumar, J., Panagourgias, N., and Scarbrough, H. 2013. ""From Knowing It to Getting It": Envisioning Practices in Computer Games Development," *Information Systems Research* (24), pp 933-955

Parker, G., and Van Alstyne, M. W. 2005. "Two-Sided Network Effects: A Theory of Information Product Design," *Management Science* (51:10), pp. 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 and London: W. W. Norton & Company.

Sanchez, R. and J. T. Mahoney 1996. "Modularity, Flexibility, and Knowledge Management in Product and Organization Design." *Strategic Management Journal* 17(Winter): 63-76

Sarker, S., Sarker, S., Sahaym, A., and Bjorn-Andersen, N. 2012. "Exploring Value Cocreation in Relationships between an ERP Vendor and its Partners: A Revelatory Case Study," *MIS Quarterly* (36:1), pp 317-338.

Schilling, M. A. 2002. "Technology Success and Failure in Winner-Take-All Markets: The Impact of Learning Orientation, Timing, and Network Externalities," *Academy of Management Journal* (45:2), pp. 387-398.

Schumpeter, J. A. 1934. *The Theory of Economic Development*. Cambridge, MA: Harvard University Press.

Shapiro, C., and Varian, H. R. 1999. *Information Rules - a Strategic Guide to the Network Economy*.
Boston, MA: Harvard Business School Press.

Svahn, F., Mathiassen, L., and Lindgren, R. 2017. "Embracing Digital Innovation in Incumbent Firms: How Volvo Cars Managed Competing Concerns," *MIS Quarterly* (41:1), pp. 239-253.

Tilson, D., Lyytinen, K., and Sorensen, C. 2010. "Digital Infrastructures: The Missing IS Research Agenda," *Information Systems Research* (21:4), pp 748-759.

Tiwana, A. 2016. *Platform Ecosystems: Aligning Architecture, Governance, and Strategy*. Amsterdam: Morgan Kaufmann.

Tiwana, A., Konsynski, B., and Bush, A.A. 2010. "Platform Evolution: Coevolution of Platform Architecture, Governance, and Environmental Dynamics," *Information Systems Research* (21:4), pp 685-687.

Um, S. 2016. *The Co-Evolution of Digital Ecosystems*. Temple University, Philadelphia: Unpublished PhD dissertation.

Von Hippel, E., and Von Krogh, G. 2003. "Open Source Software and the "Private-Collective" Innovation Model: Issues for Organization Science," *Organization Science* (14:2), pp 209-223.

Wareham, J., Fox, P.B., and Cano Giner, J.L. 2014. "Technology Ecosystem Governance," *Organization Science* (25:4), pp 1195-1215.

Yoo, Y. 2012. "Digital Materiality and the Emergence of an Evolutionary Science of the Artificial," in: *Materiality and Organizing: Social Interaction in a Technological World*, P.M. Leonardi, B. Nardi and J. Kallinikos (eds.). Oxford: Oxford University Press, pp. 134-154.

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), pp 724-735.

Yoo, Y., Boland, R. J., Lyytinen, K., and Majchrzak, A. 2012. "Organizing for Innovation in the Digitized World," *Organization Science* (23:5), pp 1398-1408.