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The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes

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ABSTRACT

The emergence of novel and powerful digital technologies, digital platforms and digital infrastructures has transformed innovation and entrepreneurship in significant ways. Beyond simply opening new opportunities for innovators and entrepreneurs, digital technologies have broader implications for value creation and value capture. Research aimed at understanding the digital transformation of the economy needs to incorporate multiple and cross-levels of analysis, embrace ideas and concepts from multiple fields/disciplines, and explicitly acknowledge the role of digital technologies in transforming organizations and social relationships. To help realize this research agenda, we identify three key themes related to digitization—openness, affordances, and generativity—and, outline broad research issues relating to each. We suggest that such themes that are innate to digital technologies could serve as a common conceptual platform that allows for connections between issues at different levels as well as the integration of ideas from different disciplines/areas. We then summarize the contributions of the 11 papers presented in this Special Issue relating them to one or more of these themes and outlining their implications for future research.

1. Introduction

In the last decade or so, the emergence of a diverse set of novel and powerful digital technologies, digital platforms and digital infrastructures has transformed both innovation and entrepreneurship in significant ways with broad organizational and policy implications (Nambisan, 2017; Nambisan et al., 2017; Yoo et al., 2010). Indeed, the phrase *digital transformation* has come into wide use in contemporary business media to signify the transformational or disruptive implications of digital technologies for businesses (new business models, new types of products/services, new types of customer experiences) (e.g., Boulton, 2018; Boutetiere and Reich, 2018), and more broadly, to indicate how existing companies may need to radically transform themselves to succeed in the emerging digital world (e.g., McAfee and Brynjolfsson, 2017; Rogers, 2016; Venkatraman, 2017).

Recent research in innovation and entrepreneurship has tried to unpack these implications in more specific or concrete terms. For example, studies have shown how digital technologies fuel new forms of innovation and entrepreneurial initiatives that cross traditional industry/sectoral boundaries, embrace networks, ecosystems and communities, integrate digital and non-digital assets, and accelerate the

inception, scaling and evolution of new ventures (e.g., Fischer, and Reuber, 2011; Huang et al., 2017; Lyytinen et al., 2016; Rayna et al., 2015; Srinivasan and Venkatraman, 2018; von Briel et al., 2018a, b; Younkin and Kashkooli, 2016). Similarly, studies have also documented the ways by which established large companies (such as GE, Volvo, Johnson Controls, Caterpillar, and Boeing) have tried to redefine themselves and radically restructure their innovation strategies and practices to respond to digitization (e.g., Fitzgerald et al., 2014; Svahn et al., 2017). More broadly, studies (Nambisan, 2017; Nambisan et al., 2017; Yoo et al., 2012) have noted that the infusion of new digital technologies transforms the nature of uncertainty inherent in innovation and entrepreneurship—in terms of both processes and outcomes—thereby, encouraging a radical rethink of how individuals, organizations, and collectives may pursue creative endeavors.

Importantly, digitization of innovation and entrepreneurship also holds implications at a broader regional/national and societal levels with the potential to inform policy making entities and other stakeholders. For example, studies have indicated how digitization can translate into innovation productivity gains, increased regional entrepreneurial activity, and broader economic and social gains (e.g., Brynjolfsson, 2011; Burtch et al., 2018; Katz et al., 2014; Kenney and

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Zysman, 2016). Similarly, digital infrastructures and platforms have allowed for the emergence of new work structures that redefine industry/sectoral boundaries and shape local and regional economic health (Malone, 2018; Sundararajan, 2016). Digitization has also compelled government agencies and other public institutions to rethink the laws, regulations, and policies related to a wide range of issues including intellectual property rights, data privacy and security, consumer rights, worker skills and training, entrepreneurial financing and securities, incubator/accelerator programs, and regional/local economic development (e.g., Agrawal et al., 2014; Bruton et al., 2015; Greenstein et al., 2013; Goldfarb et al., 2014; Goldfarb and Tucker, 2012; Martin, 2018; Sorenson et al., 2016; Varian, 2018; Zysman and Kenney, 2018).

Three broad issues are evident from the ongoing discourse on the digitization of innovation and entrepreneurship. First, digitization not only holds implications at different levels of analysis (individual, organization, ecosystem/community, regional/societal), but importantly, across levels too—an aspect that has arguably received limited attention. For example, consider data privacy and security. Clearly, new digital infrastructures and platforms such as social media, mobile computing and cloud computing raise important privacy and security concerns for individual users or consumers; however, importantly, these concerns also create ripple effects that cross over to firm-level issues (e.g., firm-consumer relationships, firm reputation) and societal issues (e.g., social media as a surveillance tool, lack of trust in media and democratic institutions) (e.g., Allcott and Gentzkow, 2017; Grinberg et al., 2019; Martin, 2018; Martin et al., 2017; Trottier, 2016). While conducting such studies that examine phenomena across levels of analysis continues to be complicated and challenging (Aguinis and Edwards, 2014; Eckardt et al., 2018; Zhang and Gable, 2017), the themes and concepts that underlie digitization may open up newer conceptual bridges and empirical possibilities.

Second, existing research on the digitization of innovation and entrepreneurship has largely been contained within specific fields or disciplines (e.g., marketing, economics, information systems, operations, strategy) and arguably, limited effort has been spent so far on adopting a more interdisciplinary view of the underlying issues. For example, consider crowdfunding. Clearly, crowdfunding represents an alternate source of venture financing and, as such, is of interest to entrepreneurial finance scholars (e.g., Drover et al., 2017; Harrison, 2017; Wright et al., 2016); however, importantly, the crowdfunding context also has sociological underpinnings as crowd behavior can shape both the processes and the outcomes. Similarly, the crowdfunding platform—a digital platform—has unique technological characteristics that can shape the nature and structure of interactions among participants, and thereby, the outcomes. Despite all this, most of the research on crowdfunding seems to fall into functional silos, and studies that have tried to bring together ideas and concepts from venture financing, sociology, information systems, and other related fields are limited.

Third, digitization is not merely a context for innovation and entrepreneurship—increasingly, digital technologies can assume the role of an *operant* resource, i.e. serve as an active ingredient in fueling innovative initiatives (Lusch and Nambisan, 2015; Nambisan, 2013). From such a perspective, it then becomes imperative that studies incorporate characteristics innate to digital technologies as key explanatory factors in theorizing on the nature and process of innovation and entrepreneurship (Kallinikos et al., 2013; Nambisan, 2017; Yoo et al., 2010). However, scholarship on digital innovation and digital entrepreneurship that lie beyond the information systems field have failed to incorporate such an expansive approach. This implies not only lost opportunities to develop more nuanced understanding of how digital technologies facilitate innovation and entrepreneurship but also findings that place undue significance on non-digital factors.

This special issue was initiated to promote research that would help address the above three issues—research that incorporates issues at multiple or cross levels of analysis, embraces ideas and concepts from

multiple fields/disciplines, and explicitly acknowledges the role of digital technologies—and contribute to a broadened understanding of the implications of digitization for innovation and entrepreneurship. The 11 articles selected for this special issue accomplish the above to varying degrees and help illustrate the promise and potential for such an interdisciplinary and cross-level research agenda on the digitization of innovation and entrepreneurship. In the remainder of this essay, we articulate such a research agenda in more concrete terms by focusing on three broad themes related to digitization—*openness*, *affordances*, and *generativity*. We suggest that identification of such digitization related themes will enhance the coherence of future research efforts and help realize the promise of interdisciplinary and cross-level research to inform innovation and entrepreneurial practice in an increasingly digital world.

2. Themes in the digital transformation of innovation and entrepreneurship

We propose that a focus on themes that are native to digital technologies and at the same time are amenable to broader interpretations could potentially serve as the basis for a broader research agenda – one that helps ensure the central role of digital technologies, connects issues across different levels of analysis, and integrates concepts from different fields/areas in the service of examining those issues. Here, we consider three such themes—openness, affordances, and generativity; these are themes that have been considered in the digital technology literature (e.g., Majchrzak and Markus, 2013; Nambisan et al., 2017; Tiwana, 2014; Wareham et al., 2014; Yoo et al., 2010), and at the same time, have gained some attention among innovation and entrepreneurship researchers, and as such, serve our purpose here well. However, these themes are by no means the only ones that are relevant in the context of digital innovation and entrepreneurship. Further, our objective is not to provide an exhaustive analysis or commentary on these themes and their related issues; rather, we hope to demonstrate the value of developing a research agenda built on common themes that are innate to digital technologies. Next, we define each of these themes and discuss some of the associated research issues and questions (see Table 1). We start with openness.

2.1. Openness of innovation and entrepreneurship

The notion of openness has a relatively long history in the area of innovation. The early SAPPHO studies (Rothwell, 1972; Rothwell et al., 1974) as well as research on user innovation (von Hippel, 1986) and customer co-creation (Prahalad and Ramaswamy, 2004) have all indicated that a firm can advance its innovation performance by being open to ideas from users and customers. Similarly, studies on open innovation have focused on the sharing and flow of knowledge and technological assets across organizational boundaries in pursuit of innovation and entrepreneurship (e.g., Chesbrough, 2003; Dahlander and Gann, 2010; West and Bogers, 2014).

Digital technologies promote openness in varied ways, and consequently, digitization has radically changed the notion of openness in terms of degree, scale and scope. For example, digital resources (artifacts/objects) are open “in the sense of being, in principle (if not in practice), accessible and modifiable by a program (a digital object) other than the one governing their own behavior” (Kallinikos et al., 2013, p359). Similarly, openness of the technological architecture that underlie a digital platform allows for external entities to build on (and complement) one another’s contributions (innovation outputs) (e.g., Tiwana, 2014). Openness of the ecosystem or community implies that collectives (of individuals or organizations) can pursue innovation/entrepreneurship collaboratively and importantly participate in joint decision making and governance (e.g., Wareham et al., 2014). Thus, more broadly, digitization has transformed the nature and degree of openness in innovation and entrepreneurship—in terms of who can

Table 1
Key Themes in the Digital Transformation of Innovation and Entrepreneurship.

Theme	Description	Sample Research Issues and Questions
<i>Openness</i>	Nature and degree of openness facilitated by digital technologies in innovation and entrepreneurship—in terms of who can participate (actors), what they can contribute (inputs), how they can contribute (process), and to what ends (outcomes).	How do the motives and goals, related to openness in innovation and entrepreneurship, that operate at different levels (individual, firm, industry, community/region) conflict with one another? How do digital technology related factors and digitization-based mechanisms help address these tensions across multiple levels and shape innovation/entrepreneurial outcomes? How does digitization-enabled openness promote innovative and entrepreneurial pursuits among individuals, firms and at the community/regional levels? What are the contingent factors—digital and non-digital—that allow for such pursuits at one level to support/promote those at another level? What are the ensuing organizational and public policy implications? How can digitization facilitate collaboration and co-creation among actors at different levels to resolve complex societal level challenges? How do openness related policies at the ecosystem/industry/government levels (e.g., architecture, data, IP, privacy) shape the effectiveness of such initiatives?
<i>Affordances</i>	Action potential or possibilities offered by an object (e.g., digital technology) in relation to a specific user (or use context) in innovation and entrepreneurship – for example, digital affordances, spatial affordances, institutional affordances, social affordances	How do the affordances associated with economic/regional, institutional, organizational and digital infrastructures interact with one another and shape the ways by which innovation and entrepreneurial initiatives unfold in different contexts? To what extent does digitization compensate for weakening spatial and institutional affordances to facilitate firms' geographically and institutionally distant interactions (e.g., in foreign markets)? What is the role of digital technology affordances in fueling firms' internationalization initiatives? How, and under which conditions, do digital technology affordances stimulate/facilitate the formation of regional innovation and entrepreneurial ecosystems? How do the affordances associated with new digital technologies and infrastructures (e.g. IoT, blockchain) help redefine ecosystem boundaries and the behaviors of the actors that inhabit them? What are the ensuing policy and regulatory implications?
<i>Generativity</i>	Capacity exhibited by digital technologies to produce unprompted change (through 'blending' or recombination) by large, varied, unrelated, unaccredited and uncoordinated entities/actors	What are the potential (negative) consequences of technology generativity (associated with digital platforms and infrastructures) for individuals and for the larger society? How should an understanding of these potential consequences inform firm-level and ecosystem-level digital strategies and policies? How does our extant understanding of the sources and mechanisms of (digital) technology generativity inform on the potential interaction effects among technological structures, governance processes, and individual/firm behaviors and their impact on varied outcomes across multiple levels? To what extent (and when) does the technology generativity emanating from new generations of digitization (e.g., IoT) require incremental or wholesale changes to regulatory regimes? How can regulatory mechanisms be designed to trade-off the positive and negative aspects of technology generativity for consumers and for society?

participate (actors), what they can contribute (inputs/resources), how they can contribute (process/governance), and to what ends (outcomes).

Prior research has focused on the implications of openness at different levels. For example, at the individual level, studies have examined individuals' motivations to participate in (or contribute to) as well as to embrace ideas in collaborative, ecosystem/community-based, and/or crowd-based innovation and entrepreneurship (e.g. Antons and Piller, 2015; Jeppesen and Frederiksen, 2006; Liang et al., 2018; Nambisan and Baron, 2010). Similarly, at the organization level, studies have focused on firms' decisions on how open it wants its innovation or entrepreneurial initiatives to be—for example, the openness of a digital platform architecture and the boundary resources (e.g., APIs) a platform owner wants to share with complementors, the openness of the inflows and outflows of knowledge in a product development project, and the specific phases of the innovation/entrepreneurial process that should be opened up for external participants (crowd) to contribute (e.g., Drechsler and Natter, 2012; Ghazawneh and Henfridsson, 2013; Karhu et al., 2018; Lazzarotti and Manzini, 2009; West, 2003). Finally, at the community and societal levels, studies have focused on how openness in innovation and entrepreneurship promote economic and social wellbeing—for example, how open innovation initiatives in government promote citizen engagement and democratic values, and how open data policies facilitate finding solutions to 'wicked' social problems (e.g., Gurin, 2014; Mergel, 2015).

At the same time, most of these research streams have either neglected or only tangentially considered issues related to openness that cross multiple levels of analysis (Bogers et al., 2017). Such issues help lead to a more nuanced understanding of how openness related factors that promote innovation/entrepreneurship at one level might prove to be less beneficial (or even a hindrance) at another level. Further, connecting issues across multiple levels of analysis may also usefully inform policies to promote innovation and entrepreneurship initiatives in ways that benefit individuals, organizations as well as the broader society. Importantly, such issues also provide a conduit to integrate theoretical perspectives and concepts from different disciplines.

To illustrate this point, consider data openness facilitated by digitization and how it relates to innovation and entrepreneurship in the healthcare industry. The increasing number of digital health trackers or monitoring devices (e.g. Fitbit) have enabled consumers to acquire personal health data that they could use for self-health management. Several companies have established digital platforms for consumers to share such data with peers, employers and trainers (e.g., Fitbit Care; Garmin Connect), promising advanced data analysis capabilities, virtual care, and health coaching services. Access to such consumer 'big data' clearly allows companies to develop more innovative offerings (for example, using machine learning) (Mooney and Pejaver, 2018). However, policies that enhance the benefits for individuals (consumers) (for example, freedom to choose what data and with whom to share) may run counter to those that enhance the benefits that companies

derive from such sharing (for example, exclusive access to and control on consumer data), and vice versa. This also relates to the tension between value creation and value appropriation or the ‘paradox of openness’ (e.g., Arora et al., 2016).

From a societal perspective, openness in digital health platforms may allow data from different consumer health settings to be mined collectively leading to more entrepreneurial approaches and innovative solutions that address common public health issues (Mooney and Pejaver, 2018). However, the openness needed for such initiatives, may run counter to individuals’ need for privacy and/or companies’ need to protect their data platforms (and associated data assets) (Bader et al., 2016; Xafis, 2015).

All of these imply that a narrow focus on open data related issues at one level is unlikely to be useful as the prescriptions from such research would either be deemed impractical or find resistance at other levels (Poikola et al., 2015). On the other hand, research that incorporates factors that operate at multiple levels of analysis may not only help reveal the potential conflicts (across levels) but also lead to policy and managerial prescriptions that could bridge such divides. For example, Foege et al. (2019) illustrate this promise in the context of crowdsourcing. Research on digital health platforms that examine the areas of overlap and conflict in incentives/benefits at individual, firm and societal levels may inform on specific concepts/constructs that might form the underpinning for novel business models and public policies. Such concepts/constructs may be drawn from different fields including information systems, strategy, economics, health, psychology and sociology.

Similarly, openness may play a critical role in providing access to different types of actors and resources needed to resolve complex societal challenges—for example, achieving smart energy usage in social housing (De Silva and Wright, 2019). Addressing such a challenge, however, will require developing a deeper understanding of the tensions that underlie the goals and motives of actors at different levels and how digitization-based mechanisms, in conjunction with non-digital approaches, might enable resolution of such challenges—which, in turn, brings a sharp focus on concepts and constructs that are innate to digital technologies. More broadly, while openness (due to digitization) allows for novel forms of partnerships, sharing resources, and co-creating knowledge, it has become imperative to adopt a broader multi-level perspective and examine how these novel mechanisms may help address the conflicting forces that operate at different levels. The sample issues and questions discussed here and listed in Table 1 indicate the promise of such multi-level research, framed by the concept of openness, to inform on the digitization of innovation and entrepreneurship.

2.2. Affordances for innovation and entrepreneurship

The notion of affordances, that emerged from the design community (Gibson, 1979; Norman, 1999), has in recent years been adopted by innovation scholars to examine how innovation tools and infrastructure facilitate the innovation process in specific use contexts. An affordance is defined as action potential (i.e. action possibilities or opportunities for action) offered by an object (e.g., digital technology) in relation to a specific user (or, use context), i.e. “what an individual or organization with a particular purpose can do with a technology” (Majchrzak and Markus, 2013, p832). A constraint, on the other hand, refers to the ways by which a technology limits the actor from accomplishing specific goals. Thus, as originally noted by Gibson, affordances (and constraints) represent relationships (e.g., interactions) between an object (e.g., technology with some features) and an actor (individual/firm with some goals). By considering digital technology use as ‘sets of affordances and constraints’ for particular sets of actors (innovators, entrepreneurs), one could potentially explain how and why the same digital artifact, digital platform, or digital infrastructure (for example, crowdfunding system) may lead to different innovation or

entrepreneurial outcomes in different use contexts (Nambisan, 2017).

Research employing the affordance perspective has focused on different levels of analysis. For example, Ingram et al. (2014) focused on individual entrepreneurs’ use of a crowdsourcing system and found that their prior cognitive norms and biases (related to existing institutional logics for venture funding) shaped their perceptions regarding the features of the crowdfunding system (and their affordances), and thereby, the nature of usage and the entrepreneurial outcomes. Similarly, at a firm-level, Tan et al. (2016) examined the competitive actions afforded by the technology features of a digital (multi-sided) platform in pursuit of specific organizational goals. More recently, Autio et al. (2018), adopted an affordance perspective to consider how entrepreneurial ecosystems facilitate an economy-wide redesign of value creation, delivery and capture processes. Specifically, they set out a framework to examine how affordances associated with digital technologies and infrastructures (digital affordances) and those associated with spatial (proximity-based) mechanisms (spatial affordances) together “support a distinctive cluster dynamic that is expressed through the creation and scale-up of new ventures” (Autio et al., 2018, p74). All of these (and related) studies indicate the promise of the affordances lens to help us understand how digital technologies redefine innovation and entrepreneurship practices and outcomes for specific sets of actors (or participants).

Importantly, the above studies also imply the potential for the affordance perspective to inform on issues and outcomes across multiple levels of analysis. Different types of digital affordances might operate or assume relevance at different levels—for example, affordances associated with social media may hold implications for different types of actors (individuals, organizations, and communities) in different innovation (use) contexts (e.g., Cabiddu et al., 2014; Fischer and Reuber, 2011; Majchrzak et al., 2013; Treem and Leonardi, 2013). Similarly, affordances associated with different types of ‘objects’ may assume relevance in innovation and entrepreneurship—for example, social affordances (Sileno et al., 2014), institutional affordances (van Dijk et al., 2011), and spatial affordances (Autio et al., 2018). A focus on the potential interaction effects among the affordances associated with economic/regional, institutional, organizational and digital infrastructures may offer valuable insights on how similar innovation/entrepreneurial initiatives unfold in distinctly different ways in different contexts leading to different outcomes.

For example, consider the growth and internationalization of platform-based digital ventures (Nambisan et al., 2019). Clearly, technology affordances (those related to the features of the digital platform or infrastructure) can help firms pursue and attain growth related goals (for example, common technology standards may help a firm’s international expansion). Such technology affordances may also enable the firm to realize goals related to offering consistent customer experiences across national borders. At the same time, spatial and institutional affordances that fueled the venture’s growth in its ‘home’ country may weaken as it navigates foreign markets (for example, preferential access to knowledge and resource flows from universities, accelerator, etc. may assume less relevance in the foreign market). Similarly, affordances associated with regional infrastructures (for example, tax laws, quality of skilled workforce) may dissipate thereby further constraining venture’s pursuit of its growth agenda. On the other hand, digitization may or may not help overcome these constraints, i.e., interactions between digital technology affordances and other types of affordances may assume significance. Thus, a joint consideration of these different factors, that operate at different levels, from an affordance perspective, may help provide a more coherent and holistic explanation of venture growth and internationalization. Importantly, such an approach, aided by the affordance perspective, would also facilitate drawing on and integrating concepts from different areas/disciplines—for example, regional economics, international business, strategy, and digital technology—to develop more powerful insights.

Similarly, studies might usefully explore how the interactions

between digital affordances and institutional affordances (at the level of national and regional governments) help stimulate and coordinate innovation and entrepreneurial ecosystems, shape what type of keystone actors they rely on, or whether such ecosystems emerge in a more organic manner. As new digital technologies such as the Internet of Things (IOT) and blockchain help redefine relationships among objects and entities, the affordance lens might be particularly valuable to understand the implications of these newly defined relationships in the broader context of regional innovation ecosystems and the actors and institutions that inhabit them. Table 1 lists these and other issues, related to the digitization of innovation and entrepreneurship, that could be viewed from an affordance perspective and involve multiple levels of analysis.

2.3. Generativity in innovation and entrepreneurship

The concept of generativity has its roots in psychology where it has been defined as “the general ability to form multipart representations from elementary canonical parts” (Donald, 1991, p71).¹ As such, generativity represents combinatorial skills or the cognitive process of “blending” or conceptual integration (Turner and Fauconnier, 1997). As Turner and Fauconnier (1997) note, “there is new meaning in the blend that is not a composition of meanings that can be found in the inputs” (p398), i.e. generativity leads to consequences that are not always linear or predictable from the inputs.

Borrowing on these ideas, Zittrain (2006) considered the inherent generativity facilitated by the Internet (and related technologies)—technology generativity—which he defined as technology’s “overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences” (p.1980). A number of characteristics innate to digital technologies—for example, their openness, distributedness, editability, recombining, accessibility, and transferability (Kallinikos et al., 2013; Yoo et al., 2010; Zittrain, 2008)—make them particularly amenable to generative processes. As Zittrain (2006, 2008) has noted, such technology generativity can both ignite creative and entrepreneurial endeavors (or, form “complex wakes of innovation” - Boland et al., 2007) as well as lead to security, privacy and other threats to individual consumers, firms/organizations as well as the broader society (or, what Baumol (1990) referred to as destructive entrepreneurship).

Although the concept of technology generativity has proven difficult to operationalize in empirical studies, existing research on digital innovation has amply recognized its significance. One set of studies has focused on the sources of such digital technology generativity. For example, as noted previously, studies have tried to identify the attributes or characteristics of digital technologies, artifacts and infrastructures that promote such generativity (e.g., Bygstad, 2017; Kallinikos et al., 2013; Lyytinen et al., 2017; Tilson et al., 2010; Yoo et al., 2012). Another set of studies have examined the mechanisms of such generativity—specifically, the behaviors of the ecosystem actors and the change processes they undertake that lead to generative outcomes (e.g., Eaton et al., 2015). Related to this, studies have also focused on factors related to digital platforms—specifically, aspects related to platform architecture and ecosystem governance—that shape the extent of generativity allowed (e.g., Foerderer et al., 2014; Um et al., 2013). For example, a rich set of heterogeneous APIs, that underlie a digital platform architecture, enable generative actions by heterogeneous third-party developers leading to new breeds of digital artifacts or innovation. And, as Weitzman (1996) noted, the greater the number of such re-combinable assets (here, digital assets), the more opportunities there are for innovation (here, the creation of new digital artifacts).

¹ Note that the term ‘generativity’ has a broader set of meanings with roots in other fields/areas such as linguistics, complexity theory, learning, and philosophy.

Another set of studies have considered the managerial paradoxes involved in the context of generativity. For example, a number of studies have considered the paradox of control vs autonomy in the context of digital platforms and how they shape generativity (e.g., Eaton et al., 2015; Ghazawneh and Henfridsson, 2013; Foerderer et al., 2014; Wareham et al., 2014). Related to this is the tension between the need to share knowledge to enhance generativity in crowdsourced platforms and the need to protect firms’ IP (or minimize IP leakage). Another associated paradox is the tussle between stability and change in technology architectures and the impact on the extent of generativity realized (Lyytinen et al., 2017). These and other such issues acknowledge the need for firms to navigate the delicate balance between promoting and constraining technology generativity in order to realize their organizational or business goals.

As is evident, the extant set of studies on technology generativity has largely focused on issues at two levels of analysis: (a) at the technology level, by informing our understanding of how digital technologies (artifacts, platforms, infrastructures) facilitate or promote generativity, and (b) at the firm/ecosystem level, by examining how specific strategies, behaviors, and practices shape the nature and extent of technology generativity. Arguably, there has been relatively limited focus on the consequences (both positive and negative) of generativity for individuals and for the larger society. More importantly, few studies have considered the potential connections between generativity-related technological structures, organizational behaviors and the varied outcomes across multiple levels and their policy/regulatory implications.

This is surprising since Zittrain’s (2006) intent in introducing the notion of technology generativity was to raise the concern that negative consequences of (Internet) generativity for consumers “will compel undesirable responses from regulators and markets and, if unaddressed, could prove decisive in closing today’s open computing environments” (p1975)—which will in turn, inhibit future creative and entrepreneurial endeavors. Recent evidence related to consumer security issues on social media platforms (e.g., phishing and other security threats unleashed through apps on social media platforms; illegal sharing of consumer data with app developers) and the associated potential for “regulatory backlash” (Zittrain, 2006) (as illustrated by EU’s GDPR laws) indicate that we have limited understanding of the broader implications of the generativity unleashed by digital technologies and platforms, and as such, are ill-equipped to develop sound policies and regulations.

Table 1 lists some of the issues that future research could consider to develop valuable insights on the consequences and implications of technology generativity. For example, going beyond the current focus on the benefits due to technology generativity for platform owners, complementors and other firms, future studies could examine how the same set of strategies and decisions may also shape the nature and extent of benefits for individual customers (e.g., security/privacy, user experience) as well as those at a collective/societal level (for example, innovations that address neglected users/markets, data usage transparency, etc.). Importantly, in pursuing such an agenda, it may be possible to build on extant research on the sources and mechanisms of technology generativity and incorporate factors related to digital technology, platform architecture, and ecosystem governance in ways that reveal their interaction effects at multiple levels of analysis. And, in doing so, it may also be possible to connect with related existing concepts in innovation and entrepreneurship—for example, effectuation, improvisation, and bricolage (Baker et al., 2003; Garud and Karnøe, 2003; Sarasvathy, 2001). Another set of studies could consider how government policies and regulations shape how individuals and organizations exercise the generative capacity of digital technologies. Such policies and regulations may be on different fronts (data security, privacy, IP rights, etc.) and at different levels (regional, national, etc.).

The three themes discussed here are also interdependent to certain extent and imply additional research opportunities. For example, both openness and affordances may promote generativity—while openness

Table 2
Summary of Articles.

Authors	Research Question	Theory	Data & Method	Findings & Conclusions
Brunswick & Schecter	How does the tension between coherence and flexibility affect a developer's digital innovation trajectory on open evolving platforms?	Problem solving	Relational event modelling; 480 developers involved in creating more than 700 complementary apps in an open platform, nanoHUB, in the field of nanotechnology	Complementary and contradictory logic exists in how developers try to resolve the tension between coherence (with the past) and flexibility (for the future) in innovation on open digital platforms. Coherence leads to a greater degree of change, flexibility leads to more stable outcomes. Digital technology usage is organized in collectives, which perform combinations of reflecting and configuring-in-use in order to realize collective-level goals. Configurational usage is a process of collective affordance enactment. Contingency framework of firm-community alliance partner selection based on outcome interpretability and process manageability leads to four metrics: community's friendliness to corporations; ecosystem health; community viability; firm's value from community's product and services. Open ecosystem considerations, and not just partner-specific metrics, featured prominently in alliance partner evaluation. Variations in the strength and intensity of different kinds of social interaction ties, reciprocity and identification with the crowdfunding community affect venture interactions with backers. Policy makers should couple public funding schemes for innovation with private reward-based crowdfunding platforms.
Verstegen, Houkes & Reymen	How do individual actors use digital technology, how do these actors organize its use in collectives, and how do they organize their work with that of other actors in order to realize collective-level goals?	Affordance perspective	Qualitative research, Interview, observation, archival data from two architectural firms on the use of a new digital technology, Building Information Modelling	
Shaikh & Levina	How do organizational decision makers select an open innovation community as their alliance partner?	Contingency theory	Grounded theory method; Semi-structured interviews with 39 managers across two technology-based firms	
Eiteneyer, Bendig & Brettel	Is the social capital of crowdfunding ventures related to the involvement of backers as information sources and co-developers? Does backer involvement translate into increased new product innovativeness?	Social capital theory; Consumer involvement	Primary survey and secondary platform data from 710 crowdfunding ventures on reward-based platform Startnext; structural equation modelling	
Wang, Mahmood, Sismeiro & Vulkan	Do business angels "crowd out" crowd investors, or help reduce information asymmetries? Does platform domination by angels mean that digitization only benefits large investors and perpetuates funding imbalances associated with conventional funding?	Signalling theory	Data for 50,999 unique investors and 1,151 unique campaigns from July 2012 to August 2017 on a leading UK equity crowdfunding platform	
Acar	How do crowd member's motivation affect solution appropriateness in crowdsourcing? Or, what are the differential effects of intrinsic, internalized and extrinsic motivations on solution appropriateness?	Self-determination theory	Primary survey and secondary platform data from 644 'solvers' who participated in InnoCentive's crowdsourcing platform; OLS regression analysis	Intrinsic and extrinsic motivations enhance solution appropriateness, internalized motivations either reduce or have no impact on solution appropriateness Organizers should employ diverse extrinsic rewards, incorporate elements that enhance participants' sense of autonomy, and adopt platform design elements that deemphasize learning and prosocial benefits A horizontal platform organization leads to high engagement of complementors, whereas vertical and modular platform organizations produce lower levels of such engagement Formal protections, such as patents, copyrights and trademarks are infrequently used relative to informal protections, such as lead time and versioning. Larger firms use a combination of formal and informal protections, while smaller firms predominantly rely on informal protections. Higher separation between ownership and control rights lowers the probability of offering success, likelihood of
Saadatmand, Lindgren & Schultze	How does the interplay between technological architecture and governance mechanisms generate platform organizations that produce different levels of complementor engagement?	Socio-materiality (imbrication)	Action research; data generated from a 12-year (2002-2013) shared platform initiative within the Swedish road haulage industry	
Miric, Boudreau & Jeppesen	What appropriability strategies do large and small app developers adopt to capture value on digital platforms?	Appropriability strategy	Survey of mobile app developers on the Apple App Store; Regression techniques	
Cumming, Meoli & Vismara	Do the findings of ownership and control studies on traditional stock markets hold in the loosely regulated	Agency theory (alignment of interest and entrenchment)	491 offerings on Crowdfunder, the UK equity crowdfunding platform, from 2011 to 2015	

(continued on next page)

Table 2 (continued)

Authors	Research Question	Theory	Data & Method	Findings & Conclusions
Balsmeier & Woertter	context of digital financing (equity crowdfunding) platforms? How does the adoption of new digital technologies influence job creation and destruction?	Economics on the impact of innovation on employment growth	Survey data; firm digitalization activities in Switzerland and their employee background in 2016 merged with Swiss Innovation Survey (SIS) 2015	attracting professional investors, and long-run prospects. The negative effects are mitigated with experienced founders; Family firm offerings have lower probabilities of failure. Voting rights' thresholds enhance the attractiveness for professional investors, but small investors often are unable to achieve voting rights. Investment in digitalization increases employment of high-skilled people and reduces employment of low-skilled people. Main effects are entirely due to use of machine-based digital technologies (e.g., IoT, robotics), whereas no employment effects are found for non-machine-based digital technologies.
Forman & Zeebroeck	Under what conditions does digital technology adoption increase cross location knowledge flows within firms?	Geography of Innovation	Econometric analysis of a large data set of Internet adoption and patent citations among dyadic pairs of firm-locations between 1992-1998.	Internet adoption increases the citation likelihood between pairs of R&D locations within firms. The effect is larger when the pair is working in similar research areas or the research is less specialized.

offers greater levels of access to assets for actors to engage in generative behavior, affordances enable different actors to pursue different innovation trajectories, thereby enhancing generativity. Similarly, openness and the ensuing generativity may also lead to new digital technology affordances. While more careful theorizing is obviously needed, all of these potential interdependencies indicate not only intriguing research possibilities but also the centrality of the constructs underlying the above three themes for developing a deeper understanding of how digitization redefines innovation and entrepreneurship.

3. Articles in this special issue

This special issue includes 11 articles that successfully negotiated the standard Research Policy review process, from among the 77 manuscript submissions we received following a general call for papers. Table 2 provides a summary of these 11 articles. While they are quite diverse in terms of topics, theoretical perspectives, fields/disciplines and methodologies, they also relate to one or more of the themes we identified earlier.

Three papers relate to openness and generativity associated with digital platforms and focus on app developers or complementors (Brunswick and Schecter, 2019; Saadatmand et al., 2019; Miric et al., 2019). Importantly, all three papers also consider, in different ways, the connections between individual level (i.e. developer) strategies and behaviors and platform strategies. For example, Brunswick & Schecter examine the search mechanisms (coherent vs flexible) employed by individual developers to seek out innovation opportunities on a digital platform and provide a fine-grained explanation of platform generativity. Similarly, Saadatmand et al. show how different combinations of architectural and governance mechanisms lead to different levels of complementor engagement (participation). Thus, all of these studies imply the importance of using the theoretical lens associated with one of the themes discussed earlier (e.g., generativity) to examine the interconnections between individual level behaviors and platform/ecosystem level strategies, and thereby, inform on how innovation unfolds on digital platforms.

Three of the papers consider digital open innovation communities and collectives (Shaikh and Levina, 2019; Acar, 2019; Versteegen et al., 2019). All of these studies examine, in different ways and in different contexts, how collective or community level factors shape individual and firm -level actions and decisions. Further, in doing so, they also draw on ideas related to two of the themes discussed earlier: openness and affordance. For example, based on their empirical findings, Shaikh & Levina note that individual firms' decisions on which open innovation community to partner with, is shaped by not just partner-specific metrics but importantly, factors related to community and ecosystem health. Similarly, Versteegen et al., combine individual and collective levels of analysis of digital technology usage within a firm and explain the process by which collective affordances (i.e. possibilities for goal-directed actions of multiple members of a collective) are enacted by a set of heterogeneous actors. More broadly, these studies portend the promise of developing a more nuanced understanding of digital innovation (and digital entrepreneurship) by examining the interplay between individual level factors and community (or collective) level factors.

Three papers explore dimensions of digitization associated with crowdfunding (Cumming et al., 2019; Wang et al., 2019; Eiteneyer et al., 2019). With respect to the openness of the crowdfunding platform (which actors participate in crowdfunding), the types of firms utilizing digital finance platforms for funding are likely quite heterogeneous. These differences may vary across different types of platforms and relate to pre-start-up ventures, high tech start-ups, established family firms, etc. What is driving these differences? On the one hand, this may be related to the development stage of the venture and its associated finance needs. On the other hand, firms may have been refused other forms of finance or prefer not to approach other forms of finance.

We know that conventional funding sources have high rejection rates for applicants (Cosh et al., 2009) and that some potential borrowers may fail to seek outside funding because of a perception that they will be rejected (Fraser et al., 2015). However, there remains little analysis of the extent to which firms have recourse to digital finance platforms because it is a last resort when other forms of finance are not feasible.

While Cumming et al. show that, for investors, offerings by family firms have lower probabilities of failure as they are safer ventures, we still know little about the motivations of family firms to seek crowdfunding. In family firms, to what extent is the use of different forms of crowdfunding related to the presence of more tech-savvy next generation family members, particularly those wanting to test out new ideas beyond the family firm's core operations? Alternatively, does crowdfunding provide a means to access finance without significant dilution of control? Further analysis is also needed regarding investor behavior in terms of screening potential targets on digital finance platforms. To what extent are investors constrained regarding the hard, and especially, the soft information they would be able to access if conducting diligence as a traditional venture capital firm or business angel?

Finally, two papers relate to the impact of digital infrastructures on innovation and the broader economy (Balsmeier and Woerter, 2019; Forman and Zeebroeck, 2019). While there is general consensus that increased investments in digital technologies could lead to better employment opportunities for high-skilled workers, Balsmeier & Woerter empirically find that such effects are evident only in the case of investments in machine-based digital technologies (e.g., robots, 3D printing, IoT). The broader implication from this and other studies is the need for complementary policy frameworks (e.g. worker training & development, flexible labor market) to accompany digitization in order to achieve the purported gains for the broader economy (e.g., job creation, productivity enhancement).

4. Conclusion

In developing our framework centered on the three themes of openness, affordances and generativity, our primary objective was to articulate the potential for future research to adopt a more holistic approach to consider the implications of digitization for innovation and entrepreneurship at multiple levels and from diverse disciplinary perspectives. We believe that such research can provide important insights for policy and practice. For example, research may highlight the benefits of digitization at individual, corporate and societal level interests but also identify conflicts and tensions between these different levels and suggest how conflicts might be resolved. As noted previously, the themes that we considered here are meant to serve as a common conceptual platform to allow for connections to be made between issues at different levels as well as the integration of ideas from different disciplines/areas. We do not claim that these are the only themes. Indeed, there may be others that could equally fruitfully be employed for this purpose. However, we hope that our illustration of how such themes enable a broader interpretation of the implications of digitization for innovation and entrepreneurship, along with the 11 papers showcased in this special issue, would inspire the adoption of such perspectives in future research in this area.

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