



Digital entrepreneurship ecosystem: How digital technologies and collective intelligence are reshaping the entrepreneurial process



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ABSTRACT

Digital technologies have nowadays a significant impact on how new business ventures are imagined and created. The arising technology paradigm is leveraging the potential of collaboration and collective intelligence to design and launch more robust and sustainable entrepreneurial initiatives. However, although the topic of digital entrepreneurship is relevant and timely, there is a limited literature discussion on the real impact of digital technologies and collaboration on the entrepreneurial process. Further research is needed to describe the nature and characteristics of the entrepreneurial ecosystem enabled by the new socio-technical paradigm. Based on extant literature, this article proposes a definition of digital entrepreneurship ecosystem by highlighting the integrated *digital-output* and *digital-environment* perspectives. A collective intelligence approach is then adopted to define a descriptive framework and identify the distinguishing genes of a digital entrepreneurship ecosystem. Four dimensions associated to *digital actors* (who), *digital activities* (what), *digital motivations* (why), and *digital organization* (how) are defined and discussed. The framework was also applied to describe 9 real cases of companies and initiatives, which are analyzed as digital entrepreneurship ecosystems along the four key dimensions presented. The article ends with a discussion about the results and a research agenda for future studies.

1. Introduction

In the last ten years, technology trends such as mobile services, social media, cloud computing, Internet of things, big data and robotics (European Commission, 2017) supported new ways of collaborating, organizing resources, designing products, matching complex demand and offer, and developing new standards and solutions (Markus and Loebecke, 2013). Such rapid development has profoundly changed the competitive environment and reshaped traditional business strategies, models and processes (Bharadwaj et al., 2013).

Digital technologies enabled the creation of new business ventures and digital start-ups, which incorporate novel technology as a vital component of their business models and operations. In this sense, digital technologies are enablers of the entrepreneurial activity (von Briel et al., 2018) and they manifest in various forms such as digital products or services (Lyytinen et al., 2016), digital platforms (Tiwana et al., 2010), digital tools or infrastructure (Aldrich, 2014), digital artefacts (Ekbia, 2009), or Internet-enabled service innovations (Kuester et al., 2018). Examples of such transformation are online ventures able to engage with customers and stakeholders through new channels (e.g. Netflix), connect multivariate demands and highly personalized offerings (e.g. Uber and Airbnb), use social media to outsource activities and

collect money (e.g. Upwork and Kickstarter), or test the potential of a business idea (e.g. Quirky). Moreover, digital technologies support the creation of new contexts where a constellation of actors with diverse goals and motives interact dynamically to undertake business and innovation processes (e.g. LinkedIn). The diffusion of digital technologies has thus created new avenues for the development of entrepreneurial projects by leveraging collaboration and collective intelligence (Anderson, 2014).

Such relentless convergence between entrepreneurship and digital technologies is giving rise to a new breed of entrepreneurs that use digital technologies and Internet to execute most of the processes required to launch a new venture (Giones and Brem, 2017). However, despite the relevance of the trend, there is still limited discussion in literature on how these technologies, and the collaborative dynamics enabled by the same, are really changing and transforming the overall entrepreneurial process, including the aspects related to the regulatory environment (Dong, 2018). In particular, the community or ecosystem dimension needs to be more formally described to understand how digital technologies may influence the nature and interactions among actors for identifying resources and partners of the entrepreneurial process. Entrepreneurship research has partially ignored the impact of digital technologies and the role that users and agents play in digital

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entrepreneurship. There is a critical need for novel theorizing on digital innovation management that draws on the rapidly emerging research on digital technologies (Nambisan et al., 2017). A significant gap exists therefore in the definition of entrepreneurship in the digital age since research has yet to contextualize within the digital economy (Sussan and Acs, 2017). In particular, although digital ecosystems play an important role as accelerators, extant studies on digital innovation and digital entrepreneurship mainly focus on firm and organization-level analysis (Bharadwaj et al., 2013; Sambamurthy et al., 2003), whereas studies at the ecosystem level are limited (Du et al., 2018). The term ecosystem is widely used to explain the birth-boom of entrepreneurship, but as a theoretical concept, entrepreneurial ecosystem is underdeveloped (Spigel, 2015), and there is little understanding of interdependencies between the components of the ecosystem and their evolutionary dynamics (Mack and Mayer, 2016).

In the above-described scenario, this paper is thus focused on how digital technologies and knowledge digitalization are changing the overall technology entrepreneurship and new venture creation processes. Indeed, the impact of digital transformation is today widespread and pervasive into most industries and types of companies, and only very traditional businesses are not completely affected yet. Besides, the development of open innovation and participation are associated to the development of digital communities able to streamline crucial entrepreneurial activities. More than a new type of entrepreneurship, the concept of digital entrepreneurship is thus delineating the emergence of a new entrepreneurial paradigm, which possesses two main features. First, it is strongly focused and/or enabled by the adoption of Internet and digital technologies; second, it is leveraging the innovation potential embedded into large and dispersed groups of individuals with heterogeneous background that participate into the entrepreneurial activities.

This article attempts to unbundle the concept of digital entrepreneurship ecosystem into its founding constructs, and provide a conceptual interpretative framework of the ecosystem using a collective intelligence perspective. The rest of the article is structured as follows: Section 2 presents the theory background on digital technologies, entrepreneurship and ecosystems; Section 3 uses literature definitions to identify the founding constructs of a digital entrepreneurship ecosystem and propose an integrative definition of the same; Section 4 presents an interpretative framework of the digital entrepreneurship ecosystem as a collective intelligence system; Section 5 uses real cases with the purpose to show the application of such framework; Section 6 provides discussion and a research agenda, along with the main limitations of the study.

2. Digital technologies, entrepreneurship and ecosystems

Digital technologies are giving rise to the so-called fourth industrial revolution (World Economic Forum, 2016) and digital transformation (European Commission, 2017) as they are allowing or enhancing an unprecedented convergence of computing, communications, contents, and networking of humans (Brynjolfsson and McAfee, 2014; Tapscott, 2014). The concept of digital technologies was described as the result of three distinct but related elements, i.e. digital artifacts, digital infrastructures and digital platforms (Nambisan, 2016).

A *digital artifact* represents a digital component, an application, or media content that is part of a new product or service, and offers a specific functionality or value to the end-user (Ekbia, 2009; Kallinikos et al., 2013) such as Amazon Dash Button or Nike+ Sensor. A digital artifact extends physical products or services to support innovation, like those companies that use social networking sites to develop social capital and identify new business opportunities (Sigfusson and Chetty, 2013), or experiment sharing economy models (Richter et al., 2017).

A *digital infrastructure* is the set of digital technology tools and systems that offer communication, collaboration, and computing

capabilities. The use of digital infrastructure is a sociotechnical process defined by Tilson et al. (2010) as digitalization. Amazon Web Services or Microsoft Azure are cases of digital infrastructure specialized in cloud computing. MIT Fab Central and Stanford FabLearn Labs are cases of digital infrastructure for digital prototyping and mockups. Online communities like Eclipse or Quirky, crowdsourcing portals like Amazon Mechanical Turk, Upwork or Innocentive, and crowdfunding systems like Kickstarter or Indiegogo are further examples of digital infrastructures that make entrepreneurs able to engage with potential partners and suppliers, customers and investors, and acquire varied resources on a global scale (Kim and Hann, 2013).

Finally, *digital platforms* are shared, common sets of services as well as architectures that serve to host complementary offerings, including digital artifacts (Parker et al., 2016; Tiwana et al., 2010). They can be defined as software based platforms created by the extensible codebase of a software-based system that provides the core functionality shared by the modules and interfaces with which it interoperates (e.g., Apple's iOS and Mozilla's Firefox browser). Services of a digital platform support real-time matching between multivariate demands and highly personalized offerings (Parker et al., 2016), and perform activities that need digital engagement but may refer to both digital and physical assets (Sussan and Acs, 2017), like Uber and Airbnb. Digital platforms have enabled a relevant industry transformation and created new foundations for industry leadership and ecosystem innovation (Gawer and Cusumano, 2014).

The impact of IT and digital technologies on business innovation and entrepreneurship is thus multifaceted as they can be a facilitator, mediator or outcome of entrepreneurial operations, or the overall business model (Steininger, 2018). The concept of *digital entrepreneurship* was thus introduced to refer to the creation of new ventures and transformation of existing businesses by developing new digital technologies or experimenting a novel usage of the same (European Commission, 2015; Zhao and Collier, 2016; Shen, et al., 2018). It is also known as cyber-entrepreneurship since it refers to the use of Internet and technology platforms to manage and execute the business operations with customers, intermediaries, or partners (Shabbir et al., 2016; Ismail et al., 2012), and sell digital products or services across electronic networks (Guthrie, 2014). Digital entrepreneurship represents a critical pillar for digital economic development (Shen et al., 2018) and underlines the need to pursuit the opportunities based on digital media and technologies (Hosu and Iancu, 2016) through a pivotal business model framework leveraging three key components such as marketing, transaction and back-office (Standing and Mattsson, 2018). By adopting a knowledge-based perspective, it facilitates the exchange, transfer and acquisition of knowledge while also initiating new ways of doing business (Geissinger et al., 2018), and refers to how startups leverage digital technologies and human agents to accomplish the overall entrepreneurial process (Le Dinh et al., 2018).

According to the intensity of digital technologies, digital entrepreneurship can be *mild* (a supplement to more traditional models), *moderate* or *extreme* (the entire venture is digital) (Hull et al., 2007). Kraus et al. (2018) identified six streams of research dealing with digital entrepreneurship such as digital business models, digital entrepreneurship process, platform strategies, digital ecosystem, entrepreneurship education, and social digital entrepreneurship.

The foundation of digital entrepreneurship can be recognized in concepts such as *Internet-driven business models* and *Internet-networked Businesses* (Tapscott, 1996, 2014), *Extended* or *Virtual Enterprise* (Martinez et al., 2001), and *Business Webs* (Tapscott et al., 2000). All these concepts have in common the goal to use digital technology to create open innovation communities (Chesbrough et al., 2014; von Hippel, 2005) and networks able to generate value and benefits over those of a single firm or market transaction (Möller and Rajala, 2007). Digital technologies lead to the democratization of entrepreneurship (Aldrich, 2014) and tools such as social media, open

Table 1
Concepts useful to build up the composite concept of digital entrepreneurship ecosystem.

Concepts	Illustrative definitions
<i>Entrepreneurship</i>	<ul style="list-style-type: none"> • Process of identifying potential business opportunities and exploiting them through the recombination of existing resources or the creation of new ones to develop and commercialize new products and services (Hitt et al., 2001) • Dynamic process of vision, change, and creation through application of energy and passion toward the design and implementation of innovative ideas and solutions (Kuratko, 2016)
<i>Digital Entrepreneurship</i>	<ul style="list-style-type: none"> • Subcategory of entrepreneurship in which some or all of what would be physical in the traditional settings has been digitized based on the use of digital media and technologies (Davidson and Vaast, 2010) • Creation of new ventures and transformation of existing businesses by developing novel digital technologies or experimenting a novel usage of such technologies (European Commission, 2015; Zhao and Collier, 2016).
<i>Digital Ecosystem</i>	<ul style="list-style-type: none"> • Self-organizing, scalable and sustainable system composed of heterogeneous digital entities and their interrelations to increase system utility, cooperation and innovation (Li, Du and Yin, 2017) • System including a static part represented by the digital technologies and people, and a dynamic component of interactions forming the behavior of the ecosystem (Dini, Iqani and Mansell, 2011; Li, Du and Yin, 2017)
<i>Entrepreneurship Ecosystem</i>	<ul style="list-style-type: none"> • Set of entrepreneurial actors including potential customers and suppliers, universities and research centers, social and cultural operators, institutions and policy makers, large companies, innovative startups and entrepreneurs, experts and professionals, investors, and a pool of talented people (Isenberg, 2010) • Self-organized, scalable, sustainable, and interactive environments involving entrepreneurial attitudes, abilities and aspirations of individuals, which are committed to carry out the entrepreneurial action (Autio and Levie, 2015)

source software, crowdsourcing and crowd-funding platforms, online reputation assessment algorithms, 3D printers and digital imaging processors are empowering potential entrepreneurs and contributing to reduce the barriers between invention and new venture creation (Kelly, 2016).

The success of an entrepreneurial project relies not only on the characteristics of the venture but also on the environment or ecosystem in which it is imagined, developed and nurtured. The *entrepreneurship ecosystem* is an important area of research (Borissenko and Boschma, 2016; Isenberg, 2010; Isenberg, 2011) and is gaining increasing attention from policy-makers, academicians and practitioners, even if the phenomenon itself remains under-theorized (Autio et al., 2018; Li, Du and Yin, 2017). Moreover, there is little understanding of interdependencies between the several components of the ecosystem and their evolutionary dynamics (Mack and Mayer, 2016). With conceptual roots on the *Digital Ecosystem* (Dini et al., 2011; Li et al., 2012) and *Digital Business Ecosystem* (Iansiti and Levien, 2004), the entrepreneurship ecosystem is a highly variegated, multi-actor and multi-scalar phenomenon (Brown and Mason, 2017), which includes a number of interacting stakeholders engaged in networking, learning and execution of business-oriented processes that may occur both in physical and digital settings.

Virtuous entrepreneurship ecosystems allow creating fruitful connections among key private players such as large corporations, innovative high-growth firms, and microenterprises (Auerswald, 2014), which are open to establish an entrepreneurial culture and new relationships with other entrepreneurial individuals, resource providers, and connectors (Brown and Mason, 2017). The range of actors involved into an entrepreneurial ecosystem include potential customers and suppliers, universities and research centers, social and cultural operators, institutions and policy makers, large companies, innovative startups and entrepreneurs, experts and professionals, investors, and a pool of talented people (Isenberg, 2010; Cohen, 2006). Based on the driving force and role of the main actor engaged, ecosystems can be industry-driven, university driven, entrepreneur-driven, or public-driven (Elia et al., 2016).

Entrepreneurship ecosystems arise from dynamic, institutionally embedded interactions between entrepreneurial attitudes, ability and aspirations by individuals, which drive the allocation of resources through the creation and operation of new ventures (Acs et al., 2014). The architectural design of the entrepreneurship ecosystems includes aspects such as markets accessibility, human capital availability, financial support, presence of professional supporting services, existence of an explicit regulatory framework, a diffused culture, and a sensibility towards the importance of education, innovation and research (Drexler et al., 2014; Hwang and Horowitz, 2012).

The above contributions highlight the importance to investigate the role of digital technologies in activating and supporting the entrepreneurial process within ecosystems by identifying and accessing to resources and potential partners, by stimulating interactions, by developing competencies and sharing information.

3. A new concept: the digital entrepreneurship ecosystem

Whereas digital entrepreneurship and entrepreneurship ecosystem are well-developed topics in the extant innovation and entrepreneurship literature, the concept of *digital entrepreneurship ecosystem* is mostly new and very few attempts exist to provide an autonomous definition. Sussan and Acs (2017) integrated contributions on digital ecosystem (Dini et al., 2011; Li et al., 2012) and entrepreneurial ecosystem (Acs et al., 2014; Stam, 2015) to provide a framework of four concepts, i.e. digital infrastructure governance, digital user citizenship, digital entrepreneurship, and digital marketplace. Du et al. (2018) defined digital entrepreneurial ecosystem as the combination of elements within a region that supports the development and growth of innovative start-ups pursuing new opportunities presented by digital technologies. This conceptualization separates the digital entrepreneurial ecosystems from those entrepreneurial ecosystems built on digital platforms like e-commerce marketplace (Avgerou and Li, 2013; Leong et al., 2016) and crowdfunding platforms (Burtch et al., 2013; Zheng et al., 2014). Li et al. (2017) and Du et al. (2018) introduced the idea of digital entrepreneurship ecosystem as a collective and collaborative effort among “digital species”, which allows overcoming the resource limitation of a single firm and accelerate the creation of digital startups.

To provide an integrative definition of *digital entrepreneurship ecosystem*, it is useful to firstly identify the definitions of single concepts which build up the composite construct and then attempt to realize a “qualitative synthesis” (Saini and Shlonky, 2012) of such definitions. Since “digital” and “ecosystem” are too wide concepts if not specifically contextualized, four key concepts to consider are thus *entrepreneurship*, *digital entrepreneurship*, *digital ecosystem* and *entrepreneurship ecosystem*. Table 1 reports the concepts and some descriptions of the same, which are not meant to provide an exhaustive range of definitions present in literature but rather a sample of illustrative characterizations from which it is possible to extract some key insights.

A number of key considerations can be extracted from the definitions above in order to characterize a digital entrepreneurship ecosystem:

- View of *entrepreneurship as a dynamic process* aimed to convert opportunities into innovative *solutions* and *ventures*;

- Pervasive role of *digital technologies as both object and domain* where creating value proposition through product development and organizational transformation;
- Impact of digitization in *connecting entrepreneurial actors* and supporting a new *environment* for entrepreneurial processes, as well as for the emergence of a digital entrepreneurial *community*;
- Presence of a system of parts and stakeholders, which *interact* and are correlated by a number of *flows*.

Digital technologies can represent the “output” or object of the venture creation and operational processes, as well as the “environment” or context where such processes are conducted. It is thus possible to discuss two integrative interpretations of digital entrepreneurship ecosystem as *digital-output ecosystem* and *digital-environment ecosystem*. The *digital-output ecosystem* includes or is based on a network of entrepreneurial actors (e.g. entrepreneurs, investors, incubators and accelerators, service providers, research institutes) which interact to create digital enterprises, i.e. organizations focused on the exploitation of digital technologies to design, produce and deliver innovative digital artifacts or services. An exemplary case of digital-output entrepreneurship ecosystem is the Silicon Valley, which is home to many of the world's largest technology corporations, including the headquarters of 39 businesses in the Fortune 1000, and thousands of digital startups. Silicon Valley also accounts for one-third of all of the venture capital investment in the United States, which has helped it to become a leading hub and startup ecosystem for high-tech innovation and scientific development. It was in the Valley that the silicon-based integrated circuit, the microprocessor, and the microcomputer, among other technologies, were developed. As of 2013, the region employed about a quarter of a million information technology workers. Silicon Valley is a good example of a self-organizing community or ecosystem of interdependent entrepreneurial agents and companies able to capture technology-based opportunities through the conceptualization, development and launch of novel digital products, solutions and ventures.

The entrepreneurship ecosystem can be at the same time a *digital-environment ecosystem* since it uses digital technologies as facilitating structure or general-purpose technology to aggregate a wide network of heterogeneous and geographically dispersed stakeholders in the final aim to provide an end-to-end support to the process of design and formation of a startup, including the case of digital platforms that allow other entrepreneurs to start their own small or micro ventures. In such a view, the roadmap of converting an entrepreneurial idea into a new venture happens through a virtually-supported process enabled by digital technologies. An illustrative case is Startup Compete, which is a global networking site and competition platform powered by the Global Entrepreneurship Network. The platform allows aspiring entrepreneurs, mentors and advisors to connect and develop potential business ideas, bringing them to the market. Startup Compete offers an articulated system of digital services and interactive tools that enable actions and interactions among entrepreneurial agents, which can communicate, collaborate, exchange information and know-how, transfer resources, and take decisions throughout the entire entrepreneurial process. A similar case is the “Google for Startups” initiative, which offers the innovative Google's products, the wide network of relationships, and best practices to enable entrepreneurial teams to startup and grow-up their companies.

Fig. 1 schematizes the two complementary “dimensions” of a digital entrepreneurship ecosystem, showing the role and impact of digital technologies on the “object” or domain of the entrepreneurial process (*digital-output ecosystem*) and new venture creation, as well as on the “context” or community (*digital-environment ecosystem*) in which the process is conducted. Of course, most digital-output ecosystem are also digital-environment, and the two dimensions are thus overlapping.

Nevertheless, it is possible to say that some ecosystems are significantly addressed to produce digital outputs (e.g. Apple) versus some other ecosystems that use digital technology to produce non-digital services (like Uber) although they generate also digital results (e.g. apps) which are only functional to the core business rather than representing the same. It could thus be reasonable to separate ecosystems (and companies) providing digital output from ecosystems (and companies) that act as digital environment to provide non-digital output. At the “intersection” of the two, a hybrid space lies of digital-output and digital-environment initiatives and ecosystems. The digital entrepreneurship ecosystem includes a “living” component of actors and agents, and a non-living component represented by the digital infrastructure (Henfridsson and Bygstad, 2013).

Next section aims to identify one potential framework useful to interpret the digital entrepreneurship ecosystem as complex socio-technical system in which technology-based participation and collaboration among distributed and heterogeneous actors are conducted to successfully undertake digital entrepreneurship projects.

4. An interpretative framework of the digital entrepreneurship ecosystem

One crucial aspect of an entrepreneurial ecosystem is the predominant “self-organization” nature and the absence of a controlling or orchestrating entity. Stakeholders are thus mostly autonomous and are not governed by any formal authority (Li et al., 2017), activities are not coordinated by bureaucracy but rather by emergence, and decisions are not driven by hierarchy but rather by collective interaction and mutual adjustment. However, considering the digital entrepreneurship ecosystem as a meta-organization (Gulati et al., 2012) whose stakeholders form a coordinated network, it is possible to include some design elements (Gulati et al., 2012) about the organization of labor and the integration of distributed efforts (Du et al., 2018).

Moreover, the existence of a complex set of objectives and motivating factors that drive the participation of actors into the ecosystem, together with the presence of a set of interconnections among agents that could benefit from the adoption and usage of digital technologies, give to the ecosystem the typical features of a collective intelligence system.

The concept of collective intelligence is not new as it has been present in literature for a long time. Some preliminary or precursory “ideas” may be traced back to 1785 with the Marquis de Condorcet and his “jury theorem” on group voting, to 1910 with the entomologist William Morton Wheeler and his observation on how seemingly independent individuals (ants) can cooperate so closely, and to Herbert George Wells's concept of “world brain”. More recently and more explicitly, the concept of collective intelligence was defined by Pier Levy (1994) in the book “*L'intelligence collective: Pour une anthropologie du cyberspace*”.

In the recent years, thanks to the relevant advances and

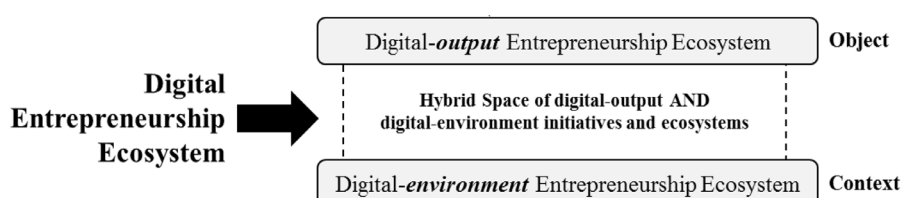


Fig. 1. Integrative dimensions of a digital entrepreneurship ecosystem.

developments in technology, and to the global evolution and proliferation of the web and Internet access, new forms of collective intelligence are today possible, driven by global communities of individuals that use digital infrastructures to communicate information, exchange resources, and coordinate activities. Radical changes in information production gave rise to a social phenomenon that is reshaping markets, while offering new opportunities to enhance individual freedom, cultural diversity, political discourse, and justice. Patterns of information, knowledge, and cultural production are changing and this can either limit or enlarge the ways people can create and express themselves, thus generating important effects based on the decisions we make today (Benkler, 2006). Open source communities, with crowdsourcing and collaborative filtering, are great examples of how collective intelligence can shape new forms of digitally enabled ecosystems that foster innovation and entrepreneurship.

In its broad sense, collective intelligence studies how people and computers can be connected each other so that, collectively, they act more intelligently than any individuals, groups, or computers have ever done before (Malone et al., 2010; Malone et al., 2008). A collective intelligence system allows thus the harvesting of knowledge, experience and resources of potentially thousands of individuals through an interactive process that represents new forms of knowledge acquisition (Boder, 2006; Bonabeau, 2009; Laubacher, 2012; Surowiecki, 2005), with the ultimate goal to solve a complex problem or face challenging issues. This aggregation results in decisions and actions that are often better than could have been made by any single member.

It is of relevance to distinguish between collective intelligence mainly driven by human physical connections over a limited geographical region, and forms of collective intelligence that are global as enabled and augmented by information technology and digital services. Examples are systems for ratings, reviews and recommendations (e.g. Trip Advisor and Amazon), user-generated content (e.g. Wikipedia and YouTube), bookmarking and voting (e.g. Tumblr and Del.icio.us), tag cloud navigation (e.g. Flickr), problem solving (e.g. Innocentive), money collection (e.g. Kickstarter), ideation (e.g. Spigit), design (e.g. Quirky), and due diligence (e.g. Seedups). In the specific field of entrepreneurship development (Laubacher, 2012), examples of collective intelligence applications to undertake single steps of the entrepreneurial process are the access to crowdsourcing platforms to execute operational tasks (i.e. TopCoder, Innocentive, Elance, oDesk or BootB), or idea screening and selection (i.e. Spigit, Imaginatik, or VenCorps), or crowd-funding (i.e. Kiva, Kickstarter, GrowVC, Indiegogo, Springboard Ventures, Profounder and StartNext). By adopting a more integrated view, Startup Compete and IBridgeNetwork represent two interesting cases of collaboration, cooperation and connection among community members to conceive, refine and develop innovative ideas and transform them into successful ventures.

The key assumption in this paper is that a digital entrepreneurship ecosystem can be considered a form of collective intelligence system. A digital entrepreneurship ecosystem is a self-organizing community of interdependent entrepreneurial agents able to capture (technology-based) opportunities by leveraging the existence of a complex system of (digital) services and tools that enable actions and interactions throughout all the phases of the entrepreneurial process. The potential of adopting a collective intelligence perspective can reside into two considerations. First, the idea-to-venture process is a complex and articulated activity, which can benefit from the collaboration of individuals and systems that may contribute at a different level by sharing knowledge, joining networks, and making resources available. Second, the use of digital technologies can streamline production of innovative goods and services, and amplify the impact and scale of networking and sharing of critical knowledge and expertise useful for undertaking the different phases of the entrepreneurial process.

A collective intelligence system exhibits four key “genes” (Malone et al., 2009) or building blocks, i.e.: 1) *What*, i.e. the goal and scope of activities undertaken within the (eco)system; 2) *Who*, i.e. the

actors or agents involved or participating in the (eco)system; 3) *Why*, i.e. the motivations attracting and retaining actors into the (eco)system; and 4) *How*, i.e. the organizational model and infrastructure supporting the existence of the (eco)system. These four genes refer to peculiarities and critical attributes of systems in which crowds do a key part as they choose to respond to an open call, particularly if web-based. However, the framework is also applicable in situations where crowds and on-line communities are not being employed. For example, collective intelligence “dimensions” can be recognized both in the Silicon Valley and in systems such as Topcoder as respectively off-line or on-line entrepreneurial ecosystems. Considering that the barriers to entry on web platforms are considerably lower respect to those ones of some years ago, the main advantages to rely on web-based crowds can be identified in terms of more opportunities to involve a wide number of potential contributors, a wider heterogeneity of their background and geographical provenience, an increased frequency and richness of their contributions, an enhanced simplicity to communicate with them and maintain a relationship, and the immediacy to process huge quantity of digitized data. Next sections describe the building blocks of a digital entrepreneurship ecosystem and discuss the impact of the “digital” and collective intelligence on digital-output, digital-environment and hybrid entrepreneurship processes.

4.1. What: digital activities

A first dimension along which the digital entrepreneurship ecosystem can be described is represented by the innovation and entrepreneurial goals to be achieved, and the activities to be enabled, supported or realized within the same ecosystem. Autio et al. (2018) identified three groups of entrepreneurial processes which are realized within entrepreneurial ecosystems, i.e. “stand-up” (conceptualization), “start-up” (venture creation), and “scale-up” (business growth). Moreover, the authors explored key aspect such as motivation, knowledge cultivation and dissemination, business model experimentation, team building, and supply of specialized human capital. Sussan and Acs (2017) identified the components of an entrepreneurial ecosystem, with a focus on digital entrepreneurship as a set of entrepreneurial activities realized by users and agents. Elia et al. (2016) described different categories of *entrepreneurial projects* (i.e. independent, academic and corporate entrepreneurship) which require the execution of a *technology entrepreneurship roadmap*, i.e. a complex process including “desk”, “pre-market” and “market” stages (Byers et al., 2010; Elia et al., 2016). Whereas desk activities focus on preliminary context exploration and opportunity conceptualization to define a business plan, pre-market activities include resource organization, asset preparation and product/service development. Finally, market activities are represented by the processes aimed to ensure the operational management of the company, the creation and appropriation of value and the venture expansion.

As a digital-output entity, the entrepreneurship ecosystem convenes agents and stakeholders executing actions aimed to optimize the idea-to-venture process and maximize the market potential of digital solutions. One distinguishing feature of a digital-output (versus non-digital system) stays into the specific nature of digital technologies, which create peculiar challenges in terms of entrepreneurial activities and roadmap implementation (e.g. intellectual property protection, data privacy, replicability). Moreover, digital-output entrepreneurship ecosystems develop a systemic view of the market offering in order to design effective solutions that integrate the physical component with the digital extension through the development of ad-hoc digital artifacts, services, and interfaces.

As a digital-environment entity, the entrepreneurship ecosystem extensively benefits from the application of digital technologies to connect agents, share and exchange knowledge, execute processes, organize resources, and coordinate tasks. Traditional desk-stage activities can be improved by the use of virtual collaboration tools (e.g., to support the idea management process) or specialized digital suites and

simulators (e.g. for preparing the business plan). Pre-market activities can be supported by the access to digital databases of patents, the use of crowdfunding/crowdsourcing platforms, mobile development integrated environments, 3D printing systems, big data and cloud computing facilities, cybersecurity and Blockchain infrastructures, or MOOC platforms to support competence development and learning processes of individuals and teams engaged in the development of new products and services. Finally, market and day-by-day operations can be enhanced by ERP and CRM platforms, web content management tools, social media marketing applications, or integrated reporting and interactive dashboards.

Digital technologies can be considered as effective tools that empower goods and services, and stimulate creativity to conceive highly innovative solutions. Moreover, they allow for defining new ways of collaborating, collecting, sharing and organizing resources thus supporting the design of products and services, the execution of activities, the matching between demand and offer (Markus and Loebecke, 2013) in the final aim to provide an end-to-end support to the innovation and entrepreneurial process (Nambisan et al., 2017). Besides, the adoption of digital technologies contributes to reduce communication and coordination costs (Rippa and Secundo, 2018), and collaboration overcomes both market and hierarchy as the network provides ways to sanction opportunistic behavior. In such perspective, the digital-environment entrepreneurship ecosystem leverages the potential of digital technologies to drive or enhance a broad range of activities aimed to imagine, design and bring to reality innovation and entrepreneurial initiatives. The ecosystem adopts the principles and mechanisms of collective intelligence to enhance knowledge and actor productivity. Illustrative example are idea management system and the virtual collaboration suites, crowdfunding and crowdsourcing platforms, social media tools through which collecting opinions and comments to be analyzed for extracting strategic and operational insights.

4.2. Who: digital actors

An entrepreneurship ecosystem can be described in terms of participating actors and stakeholders/agents who, with different roles and responsibilities, contribute directly or indirectly to achieve the goals of the same ecosystem. Many contributions in literature describe such actors and their role within the ecosystem. Brown and Mason (2017) proposed a taxonomy including entrepreneurial actors (e.g. business incubators, support, accelerator programs), entrepreneurial resource providers (e.g. business angels, linkages to universities), entrepreneurial connectors (e.g. professional associations, business brokers), and entrepreneurial culture (e.g. entrepreneurship education, failure tolerance programs). Elia et al. (2016) described technology entrepreneurship actors such as banks and funders, business partners, incubators and accelerators, IP offices, government bodies, scientists and technologists, universities and venture capitalists. With a more generic focus on the generation and development of innovation ecosystems, Dedehayir et al. (2018) defined four groups of roles, i.e. leadership roles (ecosystem leader, and dominator), direct value creation roles (supplier, assembler, complementor, and user), value creation support roles (expert, and champion), and entrepreneurial ecosystem roles (entrepreneur, sponsor, and regulator). Autio and Levie (2015) specifically focused on digital entrepreneurship and discussed the relevance of stakeholders in the construction and working mechanisms of ecosystems. Stakeholder consultation and participation are indeed required to enhance the understanding of how the system works, to identify coherent policy actions, to realign stakeholders and build stakeholder commitment based on their motivations and potential power influence. Also with a specific interest on digital entrepreneurship, Sussan and Acs (2017) discussed a quadrant of *digital user citizenship*, with social norms and participation, and a *digital marketplace*, with digital infrastructure and entrepreneurial agents within.

Although a digital entrepreneurship ecosystem includes all the

agents and stakeholders that can be found into a traditional entrepreneurship ecosystem, there are some peculiarities to consider. For digital-environment entrepreneurship ecosystems, a new category of actor has to be considered which is represented by “digital entities” like software systems, web applications, and algorithms. These “agents” are able to process data in real-time, support effective matching among involved actors, provide recommendations and comments, and interact with humans to execute routine and complex tasks useful to support the entrepreneurial processes of the ecosystem. The existence and working mechanisms of such digital entities relies on collective intelligence principle in that they require the analysis of individual contributions, profiles and behavior respect to a wider and multi-perspective offering at community-based level. In the case of digital-output entrepreneurship ecosystems, most of actors are the same than a traditional entrepreneurship ecosystem but there is a stronger focus and specific expertise on digital technologies and the application of the same to create new technology ventures. Of course, the digital-output ecosystem can also be digital-environment. In such case, there is also the presence of those digital entities mentioned for digital-environment systems that support the phases of the entrepreneurial process.

4.3. Why: digital motivations

Actors bring a different spectrum of expectations and motivations when participating into a community. The third dimension for analyzing the digital entrepreneurship ecosystem as a collective intelligence system is thus related to the reasons why individuals and groups aim to participate into the ecosystem, the types of incentives needed to attract/reward them, and the different role and responsibility that they could assume. Autio and Levie (2015) discussed the importance of consultation and participation in order to enhance stakeholder commitment based on their motivations and potential power influence whereas Sussan and Acs (2017) discussed the idea of *digital user citizenship* and the social norms that enable the participation. Also Malone et al. (2009), and Elia et al. (2016) defined the fundamental categories of motivations driving individuals to participate into large (entrepreneurial) communities. These include money (financial benefits, business opportunities), love (emotional aims, passion, social impact), and glory (visibility, fame).

In the digital entrepreneurship ecosystem, it may be of relevance to distinguish among digital-output and digital-environment ecosystems. In digital-output ecosystems, the business motivation is predominant and individuals and groups mostly aim to participate into innovative entrepreneurial processes attempting to develop and market new digital solutions. On the other side, digital-environment ecosystems may host a broader spectrum of scenarios and motivations. In fact, digital-environment ecosystems may be focused on socially-relevant initiatives (such as experimenting a new therapy for children cancer or developing algorithms to evaluate the impact of climate change) for which it is easier to envision more “intangible” motivations such as social network influencing, web popularity, emotional aims and glory. Of course, visibility, personal sensitivity, and individual social motivation can be motivations also in business-oriented projects and entrepreneurial initiatives.

4.4. How: digital organization

The last dimension of analysis for the digital entrepreneurship ecosystem is related to the criteria for linking actors and processes into a proper organization model able to support both structured activities and emergent or self-organized dynamics. Li et al. (2017) defined four main objectives of organizing a digital entrepreneurship ecosystem (i.e. task division, task allocation, reward distribution, and information flow), and eight activities involved in the organization (i.e. category design, co-specialization, captain assignment, self-selection, value co-creation, entrepreneurial culture, physical collocation, and intensive

conferences). Sussan and Acs (2017) discussed the idea of *digital infrastructure governance*, with coordination, governance and legitimacy. Elia et al. (2016) discussed a roadmap or stage-based model of entrepreneurial ecosystem activities, and a model of technology entrepreneurship flows as a dynamic view of how the ecosystem works in terms of roles and interactions.

In the digital-output perspective, the ecosystem could be organized as a “traditional” ecosystem where individual entrepreneurs, organizations and other agents operate autonomously with the goal to optimize the idea-to-venture process and maximize the market potential of digital solutions. One distinguishing feature of a digital-output (versus non-digital output) stays into a significantly higher obsolescence rate of technological knowledge, products and solutions, which is typical of the digital endeavor. This creates pressures for a more effective organization of the technology development and venture creation processes, which are executed within the ecosystems. In many cases, part of the non-core activities and residual tasks can be outsourced to external people and professionals that provide their contributions to finalize the digital offering.

Digital-environment entrepreneurship ecosystems leverage the potential of the crowd in different parts of the entrepreneurial process, including some core-activities. In this case, digital technology represent an enabling factor for collecting opinions (e.g. on new products) and evaluating scenarios (e.g. algorithms assessing product sales forecast or gathering customer preferences and judgments). In such perspective, the digital-environment ecosystem operates as a collective intelligence system, which leverages knowledge, expertise and opinions of large groups of participants to support entrepreneurial decisions and actions within the ecosystem. Fig. 2 shows the collective intelligence model of the digital entrepreneurship ecosystem and its four building blocks.

4.5. Entrepreneurial flows and impact of digital

In its general view, an ecosystem is a “community” of living and non-living components interacting as a system. The concept could be applied, using an analogy between natural and creative ecosystems (Johnson, 2011), to digital entrepreneurship ecosystems in order to discuss two main points. First, the richness of the ecosystem, in terms of number and diversity of existing “species” or entrepreneurial actors, allows gathering multiple perspectives and contributions, thus creating an open environment in which individuals can collaborate and develop innovative concepts that could represent a seed of future breakthrough innovations and successful companies (Johnson, 2011). Second, the interactions and interdependence among components aim to increase the chances of success for ideas and solutions developed. The entrepreneurial actors interact with other actors to enhance the potential of success of the entrepreneurial process by maximizing market

acceptance, social relevance, technological feasibility, and economic sustainability. Such interaction can be described in terms of a number of actions or “flows” executed within the ecosystem. Building on a previous classification (Elia et al., 2016), Table 2 provides a description of such flows, along with the potential relevance of the same for the entrepreneurial process and the peculiar impact of digital technologies which distinguishes such digital-environment flows from traditional flows.

Next section presents nine cases of digital entrepreneurship ecosystems. The objective is to provide an illustrative application of the proposed framework as well as to discuss some real-life attempts to create digital-output and digital-environment entrepreneurship ecosystems. After a brief overview, each case is described in terms of the four collective intelligence “genes” of a digital entrepreneurship ecosystem, and by identifying the key flows that assume most relevance within the same.

5. Illustrative cases of digital entrepreneurship ecosystems

5.1. Cases selection

The expansion of digital entrepreneurship ecosystems requires the existence and development of open “communities” of individuals and/or digital applications involved in the transformation of technology-driven opportunities into successful business ventures. At this regard, two key elements to consider when looking at real cases is the degree of openness and the form or mode of collaboration arising within such communities. King and Lakhani (2013) proposed four archetypes based on the level of openness of the idea generation and selection processes, ranging from traditional approaches (both processes are internal) to communities and markets (both processes are external). Pisano and Verganti (2008) focused on the degree of openness of the network and on the degree of hierarchy of the governance structure. Based on such dimensions, the authors identified four basic modes, i.e. the *elite circle* (closed and hierarchical network), the *innovation mall* (open and hierarchical), the *innovation community* (open and flat), and the *consortium* (closed and flat).

With reference to the digital entrepreneurship ecosystem, a classification can be proposed among three major archetypes:

- 1 *Process-oriented ecosystem*, which has a predominant focus on supporting the execution of the innovation and venture creation process through ad-hoc services and specific tools (direct goal), although the participating actors could obtain further advantages such as bringing to the market a new product or service, or gaining access to specific resources needed to conduct an entrepreneurial activity (indirect goals);

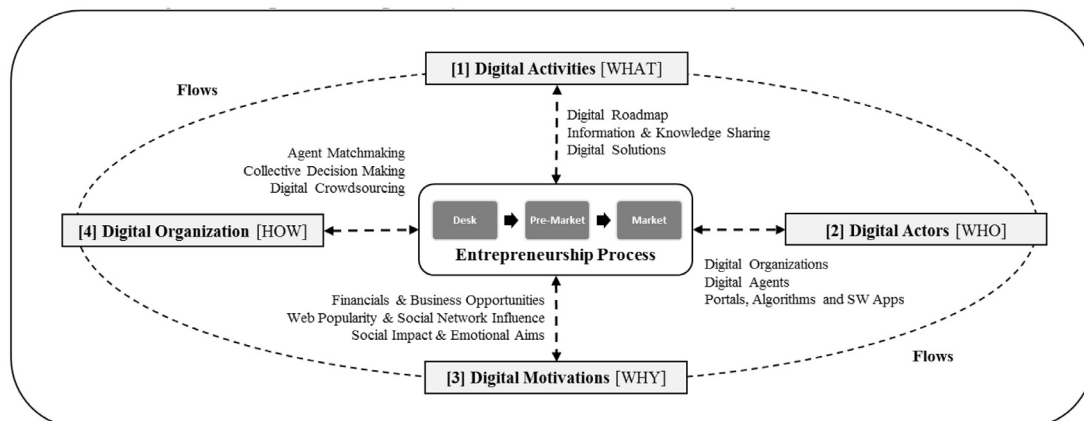


Fig. 2. Collective intelligence model of the digital entrepreneurship ecosystem.

Table 2
Flows within the digital entrepreneurship ecosystem and relevance on the entrepreneurial process.

Type of Flow	Description	Relevance for the entrepreneurial process	Impact of digital
<i>Conceptualizing</i>	Actor(s) defines a primitive and original idea about a new product, service or solution	<ul style="list-style-type: none"> ● Early idea validation ● Opportunity scanning ● Business idea pitching 	Discussion boards, online voting and selection tools allow early feedback and more robust concepts
<i>Creating</i>	Actors(s) develops an artifact or resource which has to be used or transformed	<ul style="list-style-type: none"> ● Co-design and co-development ● Early user involvement ● Partners scouting 	Virtual prototyping, online contests and collaboration improve potential impact of solutions
<i>Deciding</i>	Actor(s) selects a solution among different possible alternatives	<ul style="list-style-type: none"> ● Investment trade-off ● Team formation ● Partners and stakeholders engagement 	Matching algorithms, tradeoffs analyzer and simulators drive fact-based decisions
<i>Inspiring</i>	Actor(s) stimulates directly or indirectly the process of creation or conception	<ul style="list-style-type: none"> ● Open innovation ● Expert influencing ● Idea enrichment 	Online discussion tools (blogs, forums, wikis, social media) enhance multiple perspectives
<i>Networking</i>	Actor(s) enhances own connections and leverages the same for entrepreneurial purposes	<ul style="list-style-type: none"> ● Resource identification ● Early customer base ● Partnership development 	Professional social networks and expert directories provide variety of useful agents
<i>Recommending</i>	Actor(s) endorses one specific solution, alternative or resource developed by others	<ul style="list-style-type: none"> ● Business marketing ● Venture testimonial ● Idea promotion 	Recommendation engines and professional social networks enhance reputation and viral diffusion
<i>Requesting</i>	Actor(s) demands information or resources possessed or generated by others	<ul style="list-style-type: none"> ● Resource gathering ● Asset development ● Strategic design 	Web crawlers, collaborative design suites favor agents matching
<i>Sharing</i>	Actor(s) uses resources collectively available	<ul style="list-style-type: none"> ● Coordination mechanisms ● Critical mass of resources ● IP cooperation strategy 	Digital marketplaces and virtual communities allow synergetic behavior
<i>Suggesting</i>	Actor(s) provides advise or expertise related to open issues	<ul style="list-style-type: none"> ● Strategic consulting ● Experiences and expertise ● Knowledge spillovers 	Recommender systems and online matching tools support collective intelligence
<i>Transferring</i>	Actor(s) assigns informative or monetary resources to others	<ul style="list-style-type: none"> ● E-commerce ● Product/service distribution ● Funding 	Online merchants online tracking improve scale/scope of transactions

2 *Resource-oriented* ecosystem, which has a predominant focus on searching for tangible or intangible assets or resources needed to perform a company activity or carry on an entrepreneurial project (direct goal), although the participating actors could obtain further benefits such as bringing to the market a new product or service or executing one or more activities of the idea-to-venture process (indirect goals);

3 *Product-oriented* ecosystem, which has a predominant focus on bringing to the market a new product or service (direct goal), although the participating actors could obtain further returns such as obtaining specific resources or assets needed to perform a task or facilitating the execution of one or more activities of the idea-to-venture process (indirect goals).

Based on such classification, nine cases were identified as illustrative examples of digital entrepreneurship ecosystems (Table 3). Each case includes a process, a resource and a product perspective, with one of them being more specifically or purposefully addressed by the ecosystem. Next sections provide a brief overview of each case, which is described in terms of the four collective intelligence “genes” of a digital

entrepreneurship ecosystem and by identifying the key flows that assume most relevance within the same. The most of information was obtained from the websites of the companies/initiatives, as well as from specialized reports and further web sources.

5.2. Cases description and analysis

IBM Innovation Jam is a management tool for driving innovation and collaboration processes. It consists into an online event lasting a few days that brings together thousands of invited individuals who share opinions on various topics, and interact to identify themes and actions for exploring emerging concepts for new products, services and business models. IBM Innovation Jam is a platform serving IBM internal strategic purposes, but also external organizations willing to execute part of their innovation and entrepreneurship process into an online conversational environment.

Startup Compete is a global networking site and competition platform for aspiring entrepreneurs, mentors and advisors to connect with each other and bring potential business ideas to market. Powered by the Global Entrepreneurship Network, it reaches millions of people in more than 160 countries. The access to the platform can be completely open or be restricted to invited people within an organization or a network of organizations who join the platform to provide feedback, comments, suggestions, resources, and any other kind of support.

F6S is an initiative that provides startups’ founders with opportunity growth through participating in startup programs and accelerators, pitching for investment, exploring new markets, and job posting. Within F6S, a startup can search for partners, events, experts or funders that are crucial for its development and growth. On the other side, individual actors can join existing entrepreneurial team and provide services for the idea development and business planning processes.

InnoCentive is an open innovation and crowdsourcing company that enables organizations or potential entrepreneurs to put their unsolved

Table 3
Selected cases and typologies of digital entrepreneurship ecosystems.

Typology	Illustrative cases
<i>Process-oriented</i> entrepreneurship ecosystem	IBM Innovation Jam Startup Compete F6S
<i>Resource-oriented</i> entrepreneurship ecosystem	InnoCentive iBridge Network Kickstarter
<i>Product-oriented</i> entrepreneurship ecosystem	Uber Airbnb Apple Store

problems, needs and challenges out to the crowd, which can be either external (i.e. network of over 380,000 problem solvers) or internal (i.e. an organization's employees, partners or customers). InnoCentive is able to virtually aggregate organizations and potential entrepreneurs that search for solutions and resources with experts and companies that provide knowledge and technology for solving problems and exploiting new opportunities. iBridgeNetwork is a web-based mechanism for the dissemination of innovations such as research results and reports, computer software and other copyrighted works, biological research materials, and patented inventions. It is implemented as a database with web interfaces and electronic commerce capabilities through which organizations and potential entrepreneurs can search for knowledge and technology assets that could be further exploited into the market.

Kickstarter is a corporation that maintains a global crowdfunding platform focused on creativity and merchandising. The company aims to bring creative projects to life and it has received more than \$4 billion in pledges from 15.5 million backers to fund 257,000 creative projects, such as films, music, shows, comics, journalism, video games, technology, and food-related projects. Potential entrepreneurial actors and teams can join Kickstarter to validate the market potential and technical feasibility their projects, and to collect the money required for development.

Uber is a transportation network company that offers peer-to-peer ridesharing, taxicab hailing, food delivery, bike sharing and other services. It has a global operational scope and its platform is accessed via website and mobile app by more than 100 million users. Uber represents a process-oriented platform enabling entrepreneurs interested to operate in the transportation industry to launch their own businesses, simply by registering as a service provider and by accessing to a set of infrastructural and operational services provided by Uber itself.

Airbnb is a global company that operates as an online marketplace and hospitality service, which is accessible via its website and mobile app. Members can use the service to arrange or offer lodging, primarily homestays, or tourism experiences. Similarly to Uber that does not own any vehicle, Airbnb does not own any of the real estate listings, nor does it host events. Operating as a broker, it allows for matching accommodation needs and requests with hospitality services and assets, by receiving commissions from every booking.

Apple Store is a product-oriented platform realized by Apple for iPhone, iPod and iPad devices, which allows users to download applications directly from the device or on a pc. Downloading can be for free or by paying a very limited price. The Store was launched in 2008 and it hosts more than two millions applications developed by third parties, with more than 130 billion download.

For each of the nine cases, Table 4 reports the genes of the digital entrepreneurship ecosystems (“what”, “who”, “why”, “how”), whereas Table 5 shows the type of flows characterizing the nature of the exchanges within the nine cases.

Cases analyzed are examples of digital entrepreneurship ecosystems with a predominant market or business-oriented focus. However, other cases can be found in the social entrepreneurship endeavor as well as in the resolution of complex problems. An example is the Climate Colab, an initiative launched by the MIT Center for Collective Intelligence that aggregates people with different background and expertise from all over the world to create proposals for how to address the global challenges of climate change and related goals. Similarly, OpenIdeo is another initiative of social entrepreneurship that ground on a digital ecosystem of heterogeneous actors that collaborate and exchange ideas, information and knowledge to design innovative proposals, which could be transformed into effective solutions and on field experimentations.

Table 4
Selected cases and their Digital Entrepreneurship Ecosystem genes.

Ecosystem	What(Digital activities)	Who(Digital actors)	Why(Digital motivations)	How(Digital organization)
IBM Innovation Jam	innovative conceptualization, trendspotting	employees, experts, researchers, customers, users	innovation, visibility	jam contest
Startup Compete	business plan competition	investors, entrepreneurs, innovators	competition, visibility, scouting	competition, idea development, connection
F6S	entrepreneurship, networking	entrepreneurs, investors, experts, accelerators	visibility, recruitment, talent scouting, resource gathering	acceleration, meeting, job finding, benefiting
InnoCentive	open innovation, problem solving, solution building	innovators, employees, scientists	innovation, contribution, visibility, recruitment	challenge, competition, collaboration
iBridge Network	dissemination of innovative assets, networking	inventors, experts, companies, startups	innovation, market valorization	database navigation, networking
Kickstarter	crowdfunding	investors, entrepreneurs, innovators	venture financing, idea refinement, marketing, visibility, support	self-selection, digital payment, campaign building
Uber	demand-offer matching, resource sharing	car-owners	transportation, self-employment, revenues, socialization, value for money	geolocation, matching, digital contracting
Airbnb	demand-offer matching, resource sharing	property-owners	self-employment, revenues, socialization, value for money	filtering, matching, recommending
Apple Store	demand-offer matching, product distribution	software developers, app developers, users	revenues, market penetration, branding	filtering, matching, recommending

Table 5
Types of flows found in the cases of digital entrepreneurship ecosystem.

Flows	IBM Inn. Jam	Startup Compete	F6S	Inno Centive	iBridge Network	Kick starter	Uber	Airbnb	Apple Store
Conceptualizing	X	X	X	X		X			
Creating	X	X	X	X					
Deciding	X		X	X					
Inspiring		X			X	X			
Networking	X	X	X	X	X	X			
Recommending					X			X	X
Requesting					X		X	X	X
Sharing	X				X		X	X	X
Suggesting	X	X		X	X	X			
Transferring		X		X	X	X	X	X	X

6. Discussion and conclusion

6.1. Discussion

This paper focused on the impact of digital technologies and collective intelligence on technology entrepreneurship and new venture creation processes. Digital transformation is today widespread and pervasive into most industries and companies, and a new paradigm of digital entrepreneurship emerges, which is driven by the innovation potential embedded into large groups of individuals contributing to develop innovative technology-based solutions.

The article provided a new definition of digital entrepreneurship ecosystem as *digital-output* and *digital-environment ecosystem*, and suggested how the entrepreneurial process can take advantage of the platform-based innovation ecosystem (Hsieh and Wu, 2019). The definition presented offers a more structured basis for future studies aiming to clarify the nature and distinguishing features of digital entrepreneurship ecosystems, as well as to classify and identifying peculiar traits of systems like e-commerce marketplaces, crowdfunding platforms, crowdsourcing initiatives, competition platforms, etc. (Leong et al., 2016; Zheng et al., 2014).

The research also provided an interpretative framework of digital entrepreneurship ecosystem as a collective intelligence system, and thus a virtually global and context-independent system able to favor people and machine interaction and the creation of digital startups (Li et al., 2017; Du et al., 2018). This view extends the scope and actions of the technology entrepreneurial process and ecosystem dynamics respect to the more traditional territory-based scenarios (Isenberg, 2010; Cohen, 2006). The study is also a new application of collective intelligence in the digital entrepreneurship domain (Laubacher, 2012; Elia and Margherita, 2016) and the study of nine real cases supports the investigation of static and dynamic dimensions of entrepreneurial ecosystems under the lens of collective intelligence.

This research has a twofold theory and policy/practitioner value. The article brings a new perspective on the community and system dimension of entrepreneurship, and illustrates how digital technologies may influence the nature and interactions among entrepreneurial actors and digital agents. In this perspective, the article is an answer to the call for novel theorizing on digital innovation management (Nambisan et al., 2017) and the definition of entrepreneurship in the digital age (Sussan and Acs, 2017), with a specific focus on an ecosystem perspective (Spigel, 2015). The framework proposed can also support the academic entrepreneurship process by expediting the testing and prototyping phase due to the availability and accessibility of digital technologies (Rippa and Secundo, 2018). The framework proposed can be also useful to investigate the online sharing economy (Richter et al., 2017) under a business model innovation perspective at ecosystem level (Kraus et al., 2018; Troxler and Wolf, 2017).

By a policy point of view, the article offers a checklist of elements to be addressed when constructing large-scale entrepreneurship development projects and initiatives such as incubators, accelerators, and

innovation ecosystems, whose dynamics should be deeply understood for the success of the business model of the new startups (Whittington, 2018). Since technology is not only considered as an “input” factor (Giones and Brem, 2017; Davidson and Vaast, 2010) but also an “enabling” factor (Sussan and Acs, 2017; Guthrie, 2014; Hair et al., 2012), the framework presented advances extant attempts to define and model a digital-centred entrepreneurship ecosystem. The article contributes in the discussion about the relevance of creating virtual spaces of trusted relationships that may support individuals and teams to develop their entrepreneurial projects by relying on networks of companies, customers, and stakeholders that communicate information, share data and make transactions to create new prototypes and services (Kraus et al., 2018). Such approach is also in line with the strategic need to support a triple helix view of the entrepreneurial process to enhance the performance of entrepreneurial innovations (Brem and Radziwon, 2017; Guerrero and Urbano, 2017). Finally, the findings can be useful for individuals and institutions involved into the design and implementation of virtual services or digital platforms to support entrepreneurial activities, as well as into the conceptualization of new approaches to teach entrepreneurship in digital environment (Guthrie, 2014).

6.2. Research agenda

This article stimulates a follow-up discourse and further studies aimed to investigate the emergence of a new theory of digital entrepreneurship. In particular, the following issues represent curiosities for future research on the topic, which can also offer food for thought to both practitioners and policy makers:

- 1 How digital technologies can improve the performance of the technology entrepreneurship process in terms of factors like time-to-market, idea robustness, product innovativeness, customer loyalty, and scaling of results?
- 2 What is the impact of collective intelligence (principles and tools) on the new venture design, development, and launch?
- 3 What is the impact on the business model of an actor who decides to joint and participate to a DEE?
- 4 Is it possible to develop new theories about technology entrepreneurship strategies and processes by adopting a platform economy and digital sharing perspective?

More specific research questions can be formulated along the four main dimensions (genes) of the collective intelligence framework defined in the paper:

- *Digital activities* (what): what new business and social innovation processes can be activated or enabled by a DEE? Which typologies of activities can be significantly improved by digital technologies within a DEE?
- *Digital organization* (how): what organizational principles and

technological pillars can be designed and implemented to favor the development of the ecosystem? Which kind of coordination mechanisms characterize the people-to-people and people-to-machine interactions within a DEE? How social network analysis and artificial intelligence can support the automatic reconfiguration of a DEE?

- **Digital actors (who):** what categories of individuals, groups and institutions may favor the development of successful digital entrepreneurship ecosystems? How the crowd can be actively and effectively involved into a DEE? What is the role of software agents and artificial intelligence systems to speed-up the growth of the ecosystems?
- **Digital motivations (why):** how to achieve a balance among conflicting positions or expectations while ensuring synergies of actions into a DEE? Which are the most effective motivating drivers for each category of participants within a DEE? What kind of rewards could be reserved to software agents to provide their services within a DEE?

A mix of qualitative and quantitative research methods could be applied to provide an answer to above mentioned curiosities and advance current knowledge on the impact of digital technologies on the entrepreneurial ecosystem and the relevance of collective intelligence as an approach to develop more robust and sustainable solutions and innovative ventures. Such further studies can also support the empirical validation of the study and the defined framework.

6.3. Limitations and next research

This research has some limitations. First, the definition of digital entrepreneurship ecosystem is based on a “semantic aggregation” of constructs and illustrative definitions found in literature. However, a more in-depth investigation is needed to elaborate the relevant constructs and use the same with the purpose to build a more robust and rigorous definition of digital entrepreneurship ecosystem. Second, the interpretative model defined represents an attempt to provide a descriptive framework, which needs further theoretical backing and expert validation. Nevertheless, the article offers a useful effort of synthesis and a basis to conduct further investigations around the ultimate meaning and distinguishing traits of a digital entrepreneurship ecosystem along with a sample of relevant real cases.

Next research will be addressed to validate the definition and the model also through desk-based expert feedback and the study of other initiatives of digital entrepreneurship ecosystems. Moreover, a matrix of digital-output and digital-environment dimensions could be defined to position the cases in a “space” of digital entrepreneurship ecosystem archetypes, together with the description of their distinguishing features.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.techfore.2019.119791](https://doi.org/10.1016/j.techfore.2019.119791).

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