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Digital academic entrepreneurship: The potential of digital technologies on academic entrepreneurship

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ABSTRACT

Today's digital technologies, such as social media, business analytics, the Internet of Things, big data, advanced manufacturing, 3D printing, cloud and cyber-solutions and MOOCs, permeate every private and public organization. However, even if this phenomenon has been analyzed for entrepreneurship in general, to the best of our knowledge, the impact of digital technologies on academic entrepreneurship remains ~~not~~ only slightly addressed. With the aim of filling this gap, this paper proposes a novel contribution regarding the emerging concept of Digital Academic Entrepreneurship. Based on a qualitative literature review, an interpretative framework for Digital Academic Entrepreneurship is deductively proposed that is composed of the following components: the rationale for the adoption of digital technologies for academic entrepreneurship (why), the emerging forms of digital academic entrepreneurship (what), the stakeholders involved through the digital technologies to achieve the academic entrepreneurship goal (who), and the processes of academic entrepreneurship supported by digital technologies (how). The discussion section provides a conceptualization of Digital Academic Entrepreneurship. The paper closes with the identification of a research agenda for this promising and under-researched field.

1. Introduction

Universities in developed countries have become increasingly entrepreneurial (Mowery and Sampat, 2005; Siegel, 2006). In the early 1980s, the entrepreneurial university become an accepted concept, and the literature debating the role of higher education institutions in economic growth and social development raised the attention of prominent scholars (Clark, 1998; Etzkowitz, 1983; Gibb and Hannon, 2006; Guerrero et al., 2016; Klofsten and Jones-Evans, 2000; Röpke, 1998). Studies have shown that, over time, the regional impact of universities on new business creation, knowledge transfer, and influx of well-educated people is considerable (Etzkowitz and Klofsten, 2005). Various activities, such as research collaborations with industry, patent applications, idea spinoffs into new firms, entrepreneurial education of highly skilled individuals and business incubators, are the tools universities use to achieve their entrepreneurial configuration (Shane, 2004; Siegel and Wright, 2015; Somsuk and Laosirihongthong, 2014). These activities are known as *academic entrepreneurship* (Grimaldi et al., 2011; O'Shea et al., 2004; Rasmussen, 2011; Rothaermel et al., 2007; Shane, 2004; Wright, 2007).

Academic entrepreneurship has attracted major attention both within the academic literature and in the policy community where it is considered to be an important element in the movement to become a knowledge society (Audretsch and Kayalar-Erdem, 2005; Davey et al., 2016; Rothaermel et al., 2007). An increase in university licensing, patenting and start-up creation has also been observed in many countries, starting in the USA with the Bayh-Dole Act and moving to Europe and Asia as well as Australia, Canada and Israel (Grimaldi et al., 2011), where the study of *academic entrepreneurship* has received increasing attention (e.g., Chrisman et al., 1995; Zucker et al., 2002).

Moreover in parallel to the evolution of academic entrepreneurship, another interesting phenomenon is the rapid acceleration of digital technologies that in the past 10 years are reshaping the markets and society globally (Nambisan et al., 2017). The digital technologies of today, such as social media, mobile, business analytics, the Internet of Things, big data, advanced manufacturing, 3D printing, cloud and cyber-solutions, MOOCs, artificial intelligence, permeate every organization, manufacturer and service as well as private and public organizations (Fischer and Reuber, 2011; Fitzgerald et al., 2014; Greenstein et al., 2013). This wave of digital technology enables the departure from established systems of production and opens new channels and connections to markets, users and other stakeholders (Abernathy and Clark, 1985). Digital technologies are opening up fascinating innovation opportunities for entrepreneurs (Cohen et al., 2017; Yoo et al.,

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2010) and could also become the dominant source for innovation in academic entrepreneurship. Today, Joseph Schumpeter's (1912) ideas about how innovative entrepreneurs provoke creative destruction are more relevant than ever.

However, while this phenomenon has been analyzed for organizations in general, we suggest the rise of a new category of entrepreneurship, Digital Entrepreneurship, which is defined as a relevant socio-economic and technological phenomenon that can be considered as the leveraging of digital technologies to shift the traditional mode of creating and doing business in the digital era (Cohen et al., 2017; Giones and Brem, 2017; Nambisan, 2017; Nambisan et al., 2017). To the best of our knowledge, the existing research has largely neglected the potential of digital technologies in the academic entrepreneurship process. The underlying assumption behind our research is that digital technologies could leverage the way academia in which pursues the entrepreneurship process with a pervasive effect on the rationale, processes and forms of academic entrepreneurship as well as on the stakeholders involved in the achievement of university entrepreneurship goals.

Specifically, moving from a deductive research approach (Bryman and Bell, 2015, p. 23), this research aims to analyze the potential intersection of academic entrepreneurship with digital technologies to highlight a novel conceptualization of *Digital Academic Entrepreneurship*. The deduction starts with the definition of general assumptions and is then based on broadly accepted theories and concepts, which are presented in the qualitative literature review with a focus on academic entrepreneurship and digital technologies, and more specific conclusions (Ketoviki and Mantere, 2010, p. 316) are developed with regard to the potential impact of emerging digital technologies on academic entrepreneurship. This represents the background for the achievement of new findings by means of deduction (Bryman and Bell, 2015). A framework of the novel conceptualization of Digital Academic Entrepreneurship is provided and discussed, organized as follows: the rationale for the adoption of digital technologies for academic entrepreneurship (why), the support of digital technologies for new forms of digital academic entrepreneurship (what), the stakeholders involved through the adoption of digital technologies to achieve the goal of academic entrepreneurship (who), and, finally, the processes activated by digital technologies for academic entrepreneurship (how).

The paper is organized as follows: Section 2 will review the potential of the digital technologies that have emerged in the last 10 years, followed by an excursus about the perspectives of the academic entrepreneurship literature in Section 3. Section 4 describes and discusses the potential intersection between Digital Technologies and Academic Entrepreneurship. Section 5 proposes an interpretative framework for the conceptualization of Digital Academic Entrepreneurship. Finally, Section 6 concludes the paper by presenting a future research agenda for this promising field.

2. The emerging potential of digital technologies

It is almost impossible to miss the impact of digital technologies in our day-to-day activities. Digital technologies are drastically reshaping markets and society, and several authors have analyzed the impact and future challenges deriving from digitization: the impact of digitization on innovation (Nambisan et al., 2017; Yoo et al., 2012), on entrepreneurship (Cohen et al., 2017; Nambisan, 2017), on technology entrepreneurship (Giones and Brem, 2017) and on new venture creation processes (von Briel et al., 2018). In the last two decades, digital technologies have extensively modified all aspects of organizational life (Yoo, 2010). Digital technologies support the new phenomenon of generativity (the ability of technology to support the creation of new products, Wikipedia, 2018) whereby individuals, groups and organizations co-create services, applications, and content. This creates opportunities for radically new business models, and new opportunities are continuously triggered by new forms of social infrastructure (Tilson et al., 2010).

The infusion of new digital technologies—such as mobile computing, cloud computing, social media, 3D printing, and data analytics—into various aspects of innovation and entrepreneurship has also transformed the nature of the uncertainty inherent in entrepreneurial processes and outcomes as well as the ways of managing such uncertainty. In turn, this has opened up a host of important research questions at the intersection of digital technologies and entrepreneurship—on digital entrepreneurship—that call for the careful consideration of digital technologies and their unique characteristics in shaping entrepreneurial pursuits.

Entrepreneurs and innovators are adopting digital technologies to develop new forms of entrepreneurial actions that move beyond the traditional industry boundaries to include networks, ecosystems and communities, thus accelerating the evolution of new ventures (e.g., Chandra and Leenders, 2012; Chang, 2017; Huang et al., 2017; Rayna et al., 2015). Using the language of Abernathy and Clark (1985), the present wave of digital technology development can be classified as an architectural innovation since it enables the departure from established systems of production, and it opens new channels and connections to markets, users and other stakeholders.

Nambisan (2017) synthesized the concept of digital technologies as the result of three distinct-but-related elements: *digital artifacts*, *digital infrastructure and digital platforms*. This classification has been proposed to highlight the role of digital technologies into entrepreneurial processes. The concept of academic entrepreneurship is not far from that of entrepreneurship (Siegel and Wright, 2015) since they are both based on the emergence of entrepreneurial opportunities in different contexts.

A *digital artifact* can be defined as 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). In the information system (IS) field, there are many researchers claiming that digital artifacts are different from their physical counterparts. Hence, digital artifacts differ from physical entities and other cultural records (e.g., paper-based files, tape recordings) of non-digital constitution in terms of editability, interactivity, reprogrammability as well as in the way they are distributed through different sources (Kallinikos et al., 2013). Thus, when organizations manage digitization (the process of converting analog signals into a digital form, and ultimately into binary digits) they need to alter their approach of doing business.

Digital infrastructure is defined as the digital technology tools and systems that offer communication, collaboration, and/or computing capabilities (Nambisan, 2017). The use of digital infrastructure is a sociotechnical process defined by Tilson et al. (2010) as *digitalization*, which imbues significance to the accompanying changes at the cognitive, social, and institutional levels. Specifically, with digitization, dependencies between entrepreneurial processes and outcomes become more complex and dynamic.

As digitalization supports basic information technologies and organizational structures, digital infrastructures are regarded as *sociotechnical systems*, consisting of more than technology components (Ciborra, 2000). Digital infrastructures depend on the pro-active involvement of different and heterogeneous group of actors in using, operating, designing and planning them. This aspect makes digital infrastructure an attractor of actors. The more the actors participate, the more the digital infrastructure will evolve and give rise to innovation. A typical mechanism of participation is *bootstrapping*, whereby early users make the infrastructure useful for their needs. This mechanism is regarded as an entrepreneurial approach to making the most out of limited available resources and allowing serendipitous design activity to lead to creative innovation (Ries, 2011). Digital infrastructure, such as cloud computing, data analytics, online communities, social-media, 3D printing, and digital makerspaces, support academic entrepreneurial activities. For example, 3D printing, also known as “additive manufacturing” or “rapid prototyping”, is the printing of solid, physical 3-D

objects. Drawing from a computer aided design (CAD) file, 3D printing makes it possible to build physical models, prototypes, patterns, tooling components or production parts.

Digital platforms refer to shared, common sets of services as well as architecture that serves 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 with which it interoperates and the interfaces through which they interoperate (e.g., Apple's iOS and Mozilla's Firefox browser) (Tiwana et al., 2010). At the same time, a module can be defined as an add-on software subsystem that connects to the platform to add functionality to it (e.g., iPhone apps and Firefox extensions). A platform's ecosystem can be defined as the collection of the platform and the modules specific to that platform (Cusumano and Gawer, 2002). Generally, platforms are designed to organize information technology capabilities into frameworks that allow the software to address a family of generic specifications that meet the needs of multiple, heterogeneous and growing user communities (Hanseth and Lyytinen, 2010). Additionally, digital platforms facilitate and promote cooperation and sharing. In the following table, we propose an expanded version of the typologies of digital technologies as proposed by Nambisan (2017).

The scope of this categorization (see Table 1) is to provide the basis for depicting how and if digital technologies influence and support entrepreneurial processes within the academic context. In the next section, we present some of the ways in which Academic Entrepreneurship has been interpreted.

3. Different interpretations of academic entrepreneurship

Recognizing that present day entrepreneurial universities with the help of their state and private sector partners are key enablers in the areas of technology, innovation and economic development, it is crucial to understand their roles as change agents for todays´ competitive society and as *entrepreneurial organizations* (Gibb et al., 2009). The idea that the knowledge spawned by university research programs can be used for commercial applications and revenue generation led Etzkowitz (1998) and Clark (1998) to coin the term *entrepreneurial university*. Several factors have facilitated the evolution of universities towards an entrepreneurial orientation. Since the early 1980s, the Bayh-Dole Act allowed a focalization of US universities along many dimensions: patenting and licensing, incubator creation, science parks, and university spin-outs, and investing equity in start-ups (Mowery and Sampat, 2005; Siegel, 2006). Moving to Europe and Asia as well as Australia, Canada and Israel (Grimaldi et al., 2011), the idea of entrepreneurial universities has become associated with the concept of '*academic entrepreneurship*' to identify all the activities and efforts undertaken by universities and their industry partners in hopes of commercializing the outcomes of faculty research (O'Shea et al., 2004). The basic premise behind academic entrepreneurship is that a wide range of scientific research takes place within universities, and some of the research results may have commercial applications capable of generating revenue for those universities (Wood, 2011). There is a need to embrace greater variety in the extent and nature of academic entrepreneurship. The most relevant research perspectives of academic entrepreneurship are analyzed below.

3.1. An evolutionary perspective of academic entrepreneurship

One of the classical interpretations of academic entrepreneurship is to consider it as a *university start-up activity* (O'Shea et al., 2004). This increased emphasis on technology-transfer from universities to industry and the need to develop more "rapid" linkages between science, technology and utilization have led to the emergence of a number of *entrepreneurial initiatives* within academic institutions, such as the launch of spinoff, of which the case of MIT (the Massachusetts Institute of Technology) is a well-known example (Etzkowitz, 2002; Roberts, 1991). Explaining spinoff behavior and why some universities are better at it has become an important research objective within the broad domain of academic entrepreneurship. This stream of research has been widened by studies about the riskier forms of entrepreneurial activity, specifically, forming start-up companies around a university-developed technology or licensing to small private firms rather than through the traditional commercialization route with large public companies (Powers and McDougall, 2005). As a result, today's universities are expected not only to provide knowledge-intensive outputs but also to contribute to economic growth and regional development through knowledge-based start-ups and spinoffs (Audretsch, 2014).

If the creation of startups and spinoffs has been considered among the initial forms of academic entrepreneurship outcomes, a wider conceptualization of the phenomenon should be based on the evolving mission of the university (Martin, 2012). Recently, university missions of education and research have evolved towards the so-called third mission, which, according to Laredo (2007), entails a variety of activities including not only (applied) research, development and innovation but also social engagement with the surrounding society. Furthermore, although there is no general definition, third-mission activities comprise three dimensions performed by universities in relation to the external environment: technology transfer and innovation, continuing education and social engagement (E3M, 2010). Such activities also specifically address the entrepreneurial aspect of universities that focus on socio-economic development (Etzkowitz and Leydesdorff, 2000; Jongbloed et al., 2008; Laredo, 2007). As stated by Etzkowitz (2003), the "triple helix" principles based on the relationships among university-industry-government represent a key aspect for the promotion of innovation in a knowledge based society; this concept allows us to define *Academic entrepreneurship* as all the university's activities related to the third mission.

Among the other relevant scholars in the field, Rothaermel et al. (2007) purposefully define *university entrepreneurship* broadly to include any *entrepreneurial activities* in which a university could be involved, including, but not limited to the following: patenting, licensing, creating new firms, facilitating technology transfer through incubators and science parks, and facilitating regional economic development. Rothaermel et al. (2007), analyzing 173 articles, identified four research areas in the field of Academic entrepreneurship: (i) entrepreneurial research universities, (ii) the productivity of TTOs (technology transfer offices), (iii) new firm creation, and (iv) environmental context including innovation networks. The development of such a framework is a worthwhile exercise because a field cannot advance to a stage of theory-building without an agreed-upon categorization scheme (Christensen et al., 2002). Even Rothaermel et al.'s (2007) review is among the most comprehensive, it lacks an understanding of a practical process model to guide the potential stakeholders in the application of successful academic entrepreneurship.

Wood (2011) provided a process perspective with a focus on how universities can pursue more entrepreneurialism based on the premise that Academic entrepreneurship is not a single event but rather a continuous process comprised of a series of events (Friedman and Silberman, 2003). According to Wood (2011), this perspective requires an understanding of how universities engage in academic entrepreneurship, and she proposed a process-based model of academic entrepreneurship that is composed of the following stages: a) *Innovation disclosure and intellectual property protection;* b) *Awareness and securing industry partnerships;* c) *Commercialization mechanism selection, realized through the use of technology licensing agreements* or the launch of a completely new business, typically called a '*spinoff*.' The final stage of the academic entrepreneurship process is d) *Commercialization*, during which the university and its industry partners decide to attempt commercialization of the innovation through a license agreement or the creation of a spinoff. Although the advantage of this model is the

Table 1
The emerging digital technologies categories.

Categories of digital technologies	Typologies of digital technologies	Description
Digital Artifact	Digital storytelling	Channel for telling stories with digital multimedia, such as images, audio, video, and animations. These stories bring together a mixture of digital graphics, video, audio narration, text, and music to present information on a given topic.
	Digital business portfolio	Collections of artifacts (text documents, Web pages, presentations, research papers, assessment instruments, original projects) used to validate claims made by the creator. These digital portfolios encourage the business student and professional populations to look critically at their work and to analyze it objectively.
	Virtual and augmented reality	Immersive technologies that transform the way in which individuals interact with one another and with software systems (virtual reality).
	Conversational system	Focused on chatbots and microphone-enabled devices. The device mesh moves beyond the traditional desktop computer and multiple devices to encompass the full range of endpoints with which humans might interact.
	Blockchain	A digital ledger in which transactions made in bitcoin or another cryptocurrency are recorded chronologically and publicly. Blockchains are opening new entrepreneurial opportunities as alternative forms of disintermediated financial services that can generate semi-formal financial services that bring people closer to their financial aspirations.
Digital platform	Intelligent apps	Perform some of the functions of a human assistant making everyday tasks easier and more effective (virtual customer assistant, smart advisors).
	Mesh app and service architecture (MASA)	Mobile apps, web apps, desktop apps and IoT apps link to a broad mesh of back-end services to create what users view as an "application". The MASA enables users to have an optimized solution for targeted endpoints.
	Big data and learning analytics	Big data can be defined as large data volumes and large data variety in an unstructured (or, more correctly, semi-structured) form. Big data analytics refers to the process of applying algorithms to analyze sets of data to extract useful and previously unknown patterns, relationships and information.
	Cloud computing	A type of Internet-based computing that provides shared computer processing resources and data to computers and other devices on demand. It is a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources.
	Social media	Social media are computer-mediated technologies that facilitate the creation and sharing of information, ideas, career interests and other forms of expression through virtual communities and networks. Examples include Facebook, Linkedin, and Twitter.
Digital infrastructure	Artificial Intelligence (AI) and advanced machine learning	Composed of many technologies and techniques. Applied AI and advanced machine learning give rise to a spectrum of intelligent implementations including physical devices as well as apps and services (deep learning, neural networks, natural-language processing).
	Intelligent things	Intelligent things refer to physical things that go beyond the execution of rigid programming models to exploit applied AI and machine learning to deliver advanced behaviors and to interact more naturally with their surroundings and with people (drones, autonomous vehicles, smart appliances).
	3D printing	3D printing (or additive manufacturing) refers to processes used to create a three-dimensional object in which layers of material are formed under computer control to create almost any shape or geometry of object, produced using digital model data from a 3D model or another electronic data source.
	Internet of things	Physical objects in which are embedded electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. It will enable radical change in existing business process as well as contribute to reductions in both loss and waste.
	Drone Technology	Technically known as unmanned automatic aerial vehicle, drone technology is a vehicle without a human pilot aboard. This technology is inspiring new wave of entrepreneurial startups.

identification of the activities, actors, and key success factors associated with each stage of the academic entrepreneurship process, there are some limits given the need to focus on the organizational forms that support the entrepreneurship process within the academic context.

This limit was further explored by Etzkowitz (2016, p. 1) who supported the idea that academic entrepreneurship enhances "the research university by joining a reverse linear dynamic moving from problems in industry and society, seeking solutions in academia, to the classic forward linear model, producing serendipitous innovations from the meandering stream of basic research". The key activities include the following: (1) the organization of group research, (2) the creation of a research base with commercial potential, (3) the development of organizational mechanisms to move research out of the university as protected intellectual property, (4) the capacity to organize firms within the university and "graduate" them, and (5) the integration of academic and business elements into new formats, such as university–industry research centers. The relationship between industry and the academic world is widely accepted in the ideology of the entrepreneurial university as defined by Zhou and Peng (2008), who sustain that Academic entrepreneurship includes entrepreneurship and technology transfer based on R&D in high-tech.

Finally, questioning how universities should engage in academic entrepreneurship, Siegel and Wright (2015) argue that academic entrepreneurship needs to be rethought. An emerging perspective of academic entrepreneurship includes wider social and economic benefit to the *university ecosystem* overcoming the traditional goal of economic revenue from research commercialization. Today the creation of students and alumni start-ups, entrepreneurially equipped students, and job creation in the local region or state have become the priority. In addition to the traditional modes to facilitate academic entrepreneurship (TTOs and science parks), the key elements of the university ecosystem facilitating academic entrepreneurship include the following (Siegel and Wright, 2015): (1) the rise of property-based institutions, such as incubators/accelerators and science/technology/research parks, to support technology transfer and entrepreneurship; (2) substantial growth in the number of entrepreneurship courses and programs on campus; (3) the establishment and growth of entrepreneurship canters; (4) a rise in the number of 'surrogate' entrepreneurs on campus to stimulate commercialization and startup creation; and (5) a rapid increase in alumni support of various aspects of this

Table 2
The main perspectives of academic entrepreneurship (the literature listed is not meant to be exhaustive).

Academic entrepreneurship perspectives	Academic entrepreneurship: Definition	Authors
Third mission activities	Academic entrepreneurship refers to all a university's activities related to the third mission according to the perspective of the triple helix. The third mission includes commercially oriented activities and addresses the entrepreneurial aspect of universities.	Etzkowitz and Leydesdorff (2000); Etzkowitz (2003)
University start-up activity	*Academic entrepreneurship* identifies all activities and efforts undertaken by universities and their industry partners in hopes of commercializing the outcomes of faculty research through the creation of start-ups and spinoffs.	O'Shea et al. (2004)
University start-up companies	Academic entrepreneurship is the riskier form of entrepreneurial activity, specifically, forming start-up companies around a university-developed technology or licensing to small private firms rather than through the traditional commercialization route with large public companies.	Powers and McDougall (2005)
University entrepreneurship	University entrepreneurship refers to any entrepreneurial activities in which a university could be involved, including, but not limited to the following: patenting, licensing, creating new firms, facilitating technology transfer through incubators and science parks, and facilitating regional economic development.	Rothaermel et al. (2007)
Entrepreneurial University activities	Academic Entrepreneurship entails the development of entrepreneurship in higher education institutions; an entrepreneurial university is considered to be an entrepreneurial organization.	Gibb et al. (2009)
Industry - University relation for regional development	Academic entrepreneurship is widely accepted in the ideology of the entrepreneurial university; government and managers support it in a systematic way, and organizational mechanisms are available in university-industry relations. Academic entrepreneurship includes entrepreneurship and technology transfer based on R&D in high-tech.	Zhoa and Peng (2008)
University Spinoffs	A university spinoff is defined as a new venture initiated in a university setting and based on technology developed at a university. These new ventures often commercialize research results, and the commercialization process is initiated inside the university.	Rasmussen (2011)
Academic entrepreneurship as a process	Academic entrepreneurship is a continuous process composed by the following stages: a) Innovation disclosure and intellectual property protection; b) Awareness and securing industry partnerships; c) Commercialization mechanism selection, realized through the use of technology licensing agreements or the launch of a completely new business, typically called a 'spinoff'; and d) Commercialization.	Wood (2011)
Modes for academic entrepreneurship	Many new opportunities for developing Academic Entrepreneurship include the following: the development of accelerators, entrepreneurship garage, students' business plan competitions, collaborative networks with industry and alumni, employee mobility, and public-private incubators.	Siegel and Wright (2015) (Audretsch, 2014)
Academic entrepreneurship as research university	Academic entrepreneurship enhances research universities by linking them to a reverse linear dynamic that moves from problems in industry and society to seeking solutions in academia.	Etzkowitz (2016)

entrepreneurial ecosystem, including alumni commercialization funds and student business-plan competitions. These shifts reflect the policy developments that focus on the need for universities' knowledge transfer to make a wider contribution to society. Siegel and Wright's (2015) academic entrepreneurship conceptualization allows for the embrace of a greater variety in the extent and nature of academic entrepreneurship that allows it to be linked to the changing role and purpose of universities.

To conclude, Table 2 highlights the evolution of the most relevant contributions of academic entrepreneurship, organized chronologically around the insights that have emerged from the literature. (See.)

Moving from the qualitative literature review about the discussed perspectives of academic entrepreneurship, it is possible to understand that academic entrepreneurship is sometimes defined as a process; in other cases, it is focused on the entrepreneurial output of the university, or it regards the finalized activities to develop a more entrepreneurial evolution of the university. Common to all these perspectives is the evidence that the influence and the potential impact of digital technologies remain largely uncovered.

3.2. Research gap

As discussed in Section 2, digital technologies are breaking down the boundaries of innovation and entrepreneurship, leading to more porous and flexible outcomes and activities of entrepreneurial processes. Meanwhile, digital technologies have greatly expanded the set of actors involved in innovation and entrepreneurial processes. Several authors are analyzing the impact and future challenges deriving from the adoption of digital technologies with regard to innovation (Nambisan et al., 2017; Yoo et al., 2012), entrepreneurship (Cohen et al., 2017; Nambisan, 2017), technology entrepreneurship (Giones and Brem, 2017), new venture creation processes (von Briel et al., 2018) and entrepreneurial ecosystems (Autio et al., 2018). For example, new types of digital infrastructures—such as crowdfunding systems (Mollick, 2014), digital 3D printing systems and digital makerspaces (Mortara and Parisot, 2016; Rayna et al., 2015), and social media platforms (Fischer and Reuber, 2011)—have led to more collective ways of pursuing entrepreneurship (Aldrich, 2014).

Despite this relevance, surprisingly few studies of academic entrepreneurship have focused on the analysis of digital technologies in the whole spectrum of academic entrepreneurship.

Moving into this digital technology perspective, we inquire as to the challenges posed by digital technologies on the activities, forms and processes of academic entrepreneurship, such as technology transfer offices (TTOs), incubators and science parks, entrepreneurship teaching and training activities, stakeholder collaboration, and the development of spinoff firms.

Our research aims to shed light on the following questions: *why are universities adopting digital technologies, and how does this affect academic entrepreneurship; who are the new stakeholders engaged in academic entrepreneurship due to the adoption of digital technologies; how can digital technologies support the processes of academic entrepreneurship development; and what new forms of academic entrepreneurships are emerging due to the support of new digital technologies*.

Research efforts in this regard can support extending the understanding of the individual pieces of the academic entrepreneurship puzzle towards a more holistic view of this complex and multifaceted process to further the thinking about the impact of digital technologies on the rationale, processes, activities and stakeholders characterizing the academic entrepreneurship phenomenon.

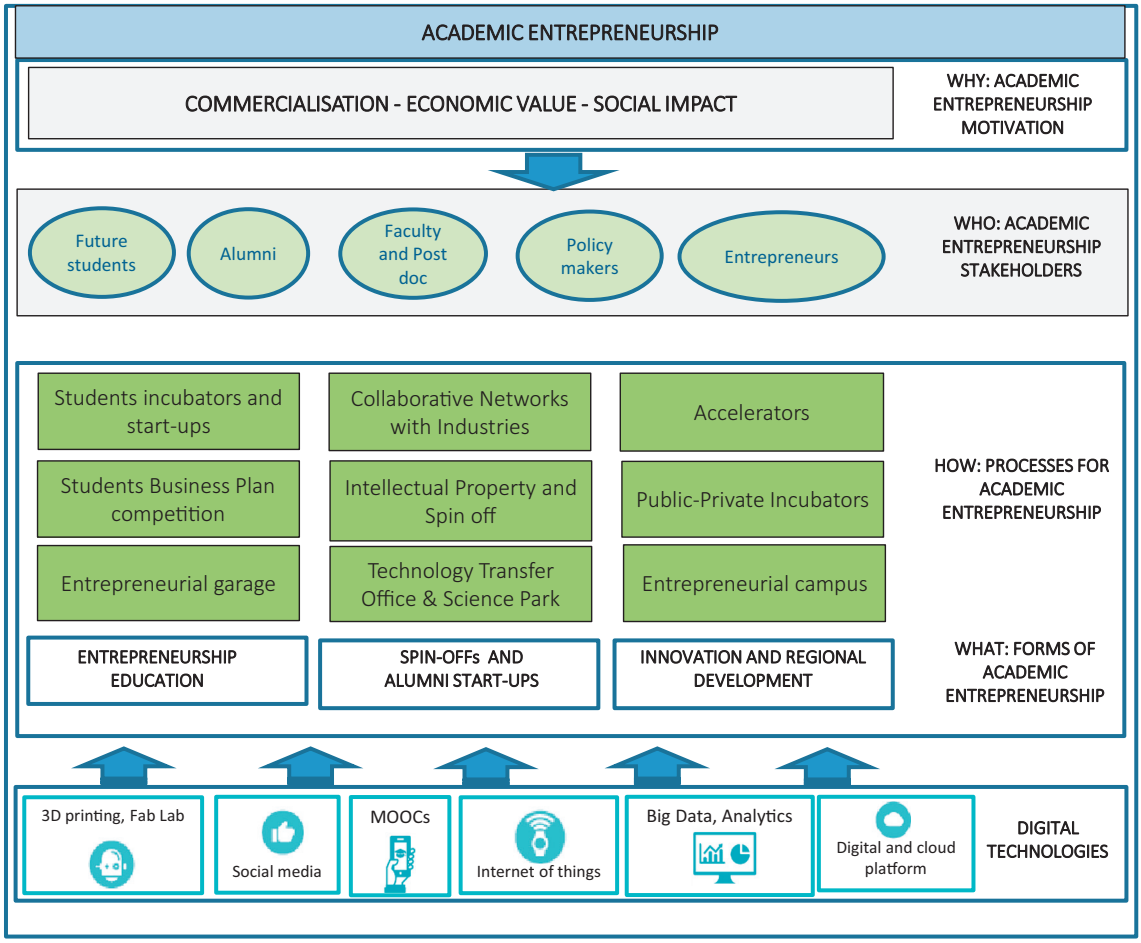

Fig. 1. The impact of digital technologies on academic entrepreneurship. (Source: Own elaboration).

4. Digital technologies and academic entrepreneurship: The missing link

Moving from the holistic conceptualization of Academic Entrepreneurship as proposed by prominent scholars in the field (Siegel and Wright, 2015), we discuss the potential impact of digital technologies on Academic Entrepreneurship, investigating the following aspects (Fig. 1): the rationale for adopting digital technologies for academic entrepreneurship (why), the stakeholders involved through the digital technologies to achieve the academic entrepreneurship goal (who), the processes activated by digital technologies for academic entrepreneurship (how) and, finally, the new forms of digital academic entrepreneurship (what). For each component (why, who, how and what), the impact of digital technologies is discussed.

This framework around the above-mentioned categories finds its justification in Whetten (1989) suggestions for using the questions of what, how, why and who to scrutinize the process of theory development. These questions reveal the elements embedded in a typical theory. In sum, in his views, (i) "Why" involves the underlying economic or social dynamics that justify the selection of factors and their proposed causal relationships; (ii) "What" refers to the factors (variables, constructs, concepts) that should logically be considered as part of the explanation of the phenomenon; (iii) "Who" is the condition or the context that limits the theory development; and (iv) "How" addresses the way in which these sets of factors are related. Two of these questions, i.e., what and how, constitute the subject of a typical theory.

In the following sub-sections, the impact of some digital technologies on each aspect of academic entrepreneurship is introduced and discussed to develop the basis about the novel conceptualization of *Digital Academic Entrepreneurship*, as presented in Section 5.

4.1. Why: Rationale for digital academic entrepreneurship

Digital technologies can support the shift of the traditional motivation behind academic entrepreneurship, from the pure economic value derived from the commercialization of university research, to wide social and democratic value generated through the involvement of more university stakeholders. Digital technologies contribute to achieve a more collective way of pursuing entrepreneurialism through a wide inclusion of different stakeholders. New digital technologies enlarge the potential users of digital products and services. As technologies are becoming continuously more accessible, they increase the process of democratization. Technologies such as social media, MOOCs and virtual platforms democratize access to high-quality entrepreneurial experiences and cultivate a greater number and widespread potential for stakeholders in academic entrepreneurship.

Stakeholders' engagement is essential to create value by improving the socioeconomic environment (Fayolle and Redford, 2014). Social value and innovation precisely emerge through joint collaborative endeavors in which different internal and external stakeholders bring together their assets, competences, and know-how for sustaining the development of academic entrepreneurship. For example, through the use of new social media tools, such as Facebook, university researchers are able to identify and exploit new entrepreneurial opportunities moving from their research and prototypes towards market opportunities; social media allows academics to exploit populations worldwide

and thus their studies can more easily enter into the entrepreneurial world (Malita, 2012). In this way, the traditional economic and social value of academic entrepreneurship can be completed based on the value of the democratization concept and due to the free diffusion of university research within the entrepreneurs' world and through wide diffusion within the local technological research community.

4.2. What: Forms of digital academic entrepreneurship

Academies are increasingly adopting digital technologies to transfer technology and knowledge or to create spinoffs and start-ups. New forms of academic entrepreneurship are emerging, such as digital entrepreneurship education, digital spinoffs and digital alumni start-ups, or glocal innovation and regional development.

The massive evolution of MOOCs on the topic of entrepreneurship, such as Coursera (University of Maryland), EDX-Babson X MOOCs, audio, interactive simulations, and games, has been particularly useful for delivering digital content both in and out of the classroom for students involved in entrepreneurial initiatives (Cirulli et al., 2016). Free online courses on entrepreneurship also allow faculty and students far removed from vibrant entrepreneurial ecosystems to gain access to a wide range of support, enablers and content (Al-Atabi and DeBoer, 2014; Ripiye, 2016; Yepes-Baldó et al., 2016). Scholars have studied in-depth the phenomenon to understand the positive effects of *social media* engagement on learner motivation, achievement, course participation and completion in MOOCs (Ripiye, 2016).

Other emerging forms of academic entrepreneurship are the *alumni start-ups and spinoffs* that can be supported by digital technologies, such as *fabrication spaces* (fab-spaces); these technologies provide (students) entrepreneurs with access to numerous types of manufacturing equipment (including additive manufacturing) to carry out different types of projects starting from users who have an entrepreneurial intention (Mortara and Parisot, 2016). An example is offered by the MIT Fablab and the Stanford Fab lab. Virtualizing structures provide analogous functions and operations of real companies, and *simulated enterprises* provide a learning environment where learners acquire professional entrepreneurial knowledge and practical skills. Collaborative networks for simulated enterprises allow participants to perform management functions, virtual transactions or production simulations and to develop entrepreneurial behaviors in a collaborative professional environment. This environment can be adopted by academic entrepreneurship for practicing in virtual enterprises in which actors such as students, universities and real companies (Patic et al., 2013) are involved to achieve a common entrepreneurial goal.

Another innovative environment to sustain aspiring entrepreneurs in turning their ideas into real start-ups is represented by the *experimental lab*, which is intended to be a network of entrepreneurial individuals from universities, research labs, financial markets and industry who become part of an innovative ecosystem to sustain entrepreneurship (Iscaro et al., 2015). Moreover, this technology can be completed by platforms such as the Guichet.lu patents management platform for patent management in some countries (i.e., Luxemburg), which contributes to the development of spinoffs, or Patsnap (www.patsnap.com), which facilitates search and analysis of documents—including 120+ million patents—containing data on how companies worldwide are innovating.

Digital academic entrepreneurship can have an impact in regions where entrepreneurship does not arise spontaneously, providing the availability of methodologies to develop among students the values and skills of entrepreneurship using available the technological (open platforms, virtual simulators, MOOCs, social media).

Generally, among the other forms of academic entrepreneurship, there are indirect effects, such as the impact on *glocal innovation* and *regional development* (Secundo et al., 2015).

4.3. Who: The stakeholders involved into digital academic entrepreneurship

Different stakeholders play varied roles in the missions of universities (Freeman, 1984; Jongbloed et al., 2008). It is possible to distinguish between internal stakeholders (alumni, professors and university staff) and external stakeholders (industry, government and local community) (Redford and Fayolle, 2014). The democratization induced by the adoption of new digital technologies enables new stakeholders to collaborate with universities with entrepreneurial purposes: a younger generation of faculty and post-doctoral fellows, federal agencies that support entrepreneurship programs and alumni who are more comfortable working with industry than the previous generation (Secundo and Moustaghfir, 2016).

Lameras et al. (2015) argue that there is an unprecedented need to stimulate creative capacities towards entrepreneurship to university students and young researchers; a smart learning ecosystem is the most suitable environment for encouraging creative thinking and stimulating the entrepreneurial opportunities of university-student entrepreneurs. At ITMO University (St Petersburg, Russia), social media has been successfully integrated into the entrepreneurship education to enable students to develop the entrepreneurial spirit and motivation for social engagement and civic impact. Students' commitment to social engagement and civic entrepreneurship is significantly enhanced (Pavlova et al., 2016).

Another example is the use of Web-2.0-based learning that may involve the use of blogs, wikis, online social communities (e.g., Facebook, Twitter), file synchronization and client software, online video sharing (e.g., YouTube), online video, audio conferencing tools, and virtual social environments (e.g., Second life). All these technologies support the engagement of nascent and future student entrepreneurs and improve their performance (Aaijaz et al., 2013). All of the above-mentioned digital technologies allow for the engagement of new stakeholders with an entrepreneurial orientation. Stakeholders who are engaged in academic entrepreneurship activities can thus begin to act in accordance with entrepreneurial values, translating concept into action (Fayolle and Redford, 2014).

4.4. How: Processes for digital academic entrepreneurship

New processes of digital academic entrepreneurship comprise virtual learning, social media environments, 3D virtual labs, fablabs and spaces, digital accelerators.

Entrepreneurship education equips student-entrepreneurs with all of the skills they require to launch spinoffs and start-ups (Elia et al., 2017). Entrepreneurship education includes innovation supported by digital technologies to engage students. Social media technologies for developing creativity and presentation skills training, team work and gamification features to improve the student learning experience, and research activities to support effective community outreach are implemented within entrepreneurship courses (e.g.,: Universidad Loyola Andalucia, Spain. In Galan, 2013).

Moreover, other scholars have focused their studies to assess student-learning outcomes in entrepreneurship courses offered as MOOCs. The results suggest that the MOOC is a suitable platform to teach entrepreneurship as it provides tools to enable students' collaborative learning as well as improve individuals' key affective entrepreneurial aspects, such as opportunity recognition and resource acquisition (Al-Atabi and DeBoer, 2014). To promote entrepreneurial activities among student entrepreneurs using social media as a business platform, programs and policies should focus on improving cyber security and value-added services (Nawi et al., 2017). An example of these technologies is Liveplan (www.liveplan.com), which is one of the world's leading business plan software and was developed to inspire entrepreneurs. The development of entrepreneurial ability in the local community has also been successfully implemented at Huainan Normal University in China, where a virtual entrepreneurship simulation center, an

Table 3
Current and digital perspectives of academic entrepreneurship.

Theme	Current academic entrepreneurship perspective (Siegel and Wright, 2015)	Digital perspective of academic entrepreneurship (own elaboration)
Why	To provide a wider social and economic benefit to the university ecosystem	To democratize the access to university ecosystem
What	Student and alumni start-ups; entrepreneurially equipped students; job creation in the local region or state	Digital Entrepreneurship Education, Digital Spinoffs and Digital alumni startups, Glocal Innovation and Regional development
Who	Students; alumni; on-campus industry-collaborations; surrogate entrepreneurs; Academic faculty; post-docs	Citizens; students' entrepreneurs; students contamination;
How	Accelerators; entrepreneurship garages; student business plan competitions; collaborative networks with industry and alumni; employee mobility; public-private "incubators"	Digital accelerators; Virtual Business game competitions; 3D virtual labs; fab labs and spaces; MOOCs; virtual/simulated enterprises; experimental labs; social media technologies

entrepreneurship simulation experiment platform, and an e-commerce training platform have been built to cultivate the development of new skills to increase entrepreneurial awareness within the society (Bai and Yang, 2015).

For example, an acceleration program has been designed to create *university startups* (Iborra et al., 2016). Using cutting edge technologies, such as 3D printing and laser cutting, library services in some universities could make learning more challenging. According to Birtchnell et al. (2016), universities should realize their third mission in a presently unforeseen way by harnessing their existing entrepreneurial activities in 3D printing. They argue that 3D printing will be 'disruptive' and 'revolutionary' for the material- and knowledge economies. For example, Birtchnell et al. (2016) recommend that Raspberry Pi and Arduino, useful applications that are not only for academics, should be made available to local communities to increase the entrepreneurial spirit within these communities. Robotic technology can promote more STEAM (science, technology, engineering, arts, mathematic) education on campus utilizing its tools to become incubators and cultivate entrepreneurs or start-ups on campus (Jiang et al., 2015).

A successful example of this technology was developed within a university research commercialization systems-development project (called *MarkIT*), which utilizes a 3D digital ecosystem for both promotion and implementation (Dreher et al., 2009).

5. Digital academic entrepreneurship: an interpretative framework

As discussed in the sections above, digital technologies are changing the way people conduct business and start new ventures (Nambisan, 2017) as well as the initiatives being undertaken by universities to realize new forms of academic entrepreneurship. The debate around academic entrepreneurship should encompass a holistic perspective of this emerging phenomenon according to the dimensions of why, what, who and how digital technologies will change the academic entrepreneurship processes.

Digital technologies are pervasive per se, and they provide open and flexible affordances that prompt convergence and generativity. These technologies herald new organizational forms and new business models. Digital technologies mean that academic organizations can leverage more standardized tools to support academic entrepreneurial processes throughout the organization and, as a consequence, more data and processes are shared across organizational boundaries. This new way of sharing data and processes has impacts on conventional configurations or relationships among the actors involved in academic entrepreneurial processes. Researchers and students in academia may now relate to a wider audience to discover new opportunities and potentiate their ideas.

In addition, the generative power of digital technologies increasingly transforms the academic entrepreneurship process towards the horizontal dimension of the organization. The same innovation or the same idea can be applied across multiple products or scientific sectors. Academic research outputs can expedite the testing and prototypization phase due to the availability of digital technologies. Academic research groups can now more easily share their discoveries with the industrial side to better match industrial needs. Technology transfer activities are now shifting towards new organizational forms.

Moreover, digital technologies are reducing communication and coordination costs. The locus of innovation processes is moving outside organizational boundaries. Universities may now shift from closed bureaucratic organizational forms to an open and flexible one guided by the new wave of digital technologies.

Based on our literature review, we propose a novel conceptualization of *Digital Academic Entrepreneurship*, which we define as a relevant socio-economic and technological phenomenon, and which can be considered as the joining of traditional academic entrepreneurship with an emphasis on leveraging new digital technologies (such as social media, mobile, analytics, 3D printing, cloud and cyber-solutions, digital and cloud platforms, MOOCs, Fab Labs) in novel ways, all to shift the traditional modes of Academic Entrepreneurship.

Table 3 presents and summarizes a contrast between current and digital perspective of digital academic entrepreneurship.

Specifically, *Digital Academic Entrepreneurship* is characterized by a high level of utilization of new digital technologies to improve the emerging forms of academic entrepreneurship, such as the development of digital spinoffs and alumni start-ups, creation of entrepreneurial competence supported by digital platforms and broader range of innovation development that goes beyond the region. *Digital Academic Entrepreneurship* engages more stakeholders through the use of digital technologies to develop the academic entrepreneurial process.

Our definition of Digital Academic Entrepreneurship is intended to capture two important aspects:

- First, our definition of Digital Academic Entrepreneurship includes a range of entrepreneurship outcomes of university entrepreneurship, such as spinoffs and alumni start-ups, as well as different forms of entrepreneurship education development; as long as these outcomes are made possible through the use of digital technologies, such as MOOCs, big data, analytics, fab labs, the outcomes themselves do not need to be digital. This allows for the understanding that among the outputs of *Digital Academic Entrepreneurship* we include all the start-ups and spinoffs supported in their launch and development by digital technologies and not all "digital" start-ups.
- Second, our definition of Digital Academic Entrepreneurship includes a broad variety of digital technologies (i.e., Fab Labs, MOOCs, Business analytics, cloud platforms, big data, 3D printing) to make possible the different processes of Academic Entrepreneurship: student incubators and start-ups; student business plan completion; the entrepreneurial garage, which refers to entrepreneurship education; collaborative networks with industries; intellectual property and spinoffs; technology transfer offices, with entrepreneurial campuses included in the form of spinoffs and alumni start-ups; and, finally, accelerators, public-private incubators and entrepreneurial campus that support innovation and regional development as the third form of Academic entrepreneurship.

Table 4
Example of the different types of technology used in academic entrepreneurship.

Digital technology example	Digital technology description	Impact on academic entrepreneurship processes
Coursera (University of Maryland), EDX-Babson X MOOCs, iVersity by DO School, Open learning by Taylor's University	Online entrepreneurial courses that can be audited for free or for payment, where students can improve their entrepreneurial skills.	Students and researchers from different disciplines can improve their entrepreneurial knowledge and competences. In this case, entrepreneurship education is enhanced by digital technologies.
Second life (Iowa State University)	Second Life is a three-dimensional multi-user virtual environment with a vibrant economy, where avatars (virtual representations of users) can engage in innovative and unique business and collaborative activities. The immersive nature of this application creates ample authentic opportunities for teaching entrepreneurship, technology and e-commerce.	Reduction of physical assets also improves entrepreneurial opportunities within academic contexts.
Patsnap (www.patsnap.com)	PatSnap is used by R&D, IP and business intelligence teams to search and analyze documents—including 120+ million patents—containing data on how companies worldwide are innovating.	The adoption of this technology increases third-mission opportunities of research groups.
Liveplan (www.liveplan.com)	The world's leading business plan software, built for entrepreneurs.	Digital solutions enabling generativity and collaboration activities among different actors. It helps future entrepreneurs in setting their business models, pitch sessions, and technology transfer activities
Guichet.lu Patents Management Platform (www.guichet.public.lu)	A new platform for the management of patents in Luxemburg	Digital solutions that help researchers and innovators to accelerate intellectual property right applications.
Spin off world largest platform (www.spinoff.com)	Exclusive interviews with spinoff founders' dossiers of over 140.000 ultra high net-worth investor teams with 41 years of spinoff selling experience	Digital solutions to achieve technology transfer activities, search for funds and capital, and support researchers and students in finding new markets for their innovative ideas.
MIT Fablab, Stanford Fab lab (https://www.fablabs.io/)	Fab Lab is the outreach component of MIT's Center, an extension of its research into digital fabrication and computation.	Architectural features that reduce the prototypization and testing phases of research outputs to support the creation of academic spinoffs, start-ups and collaborative networks with industries.
Transformative Learning technology Lab, Stanford University (https://tltl.stanford.edu/projects/fablabschool)	The Transformative Learning Technologies Laboratory is a multi-disciplinary group designing and researching new technologies for education.	Architectural features that reduce the prototypization and testing phases of research outputs. This technology enhances new entrepreneurial education initiatives and supports the creation of new forms of entrepreneurial development, such as the entrepreneurial garage.
MarkIT (Curtin University of Technology)	3D virtual space that provides a powerful context for innovation and collaboration. MarkIT uses a Natural Language Processing algorithm (the Normalized Word Vector algorithm).	Architectural features that both reduce the prototypization and testing phases of research outputs and enable generativity, or the ability of technologies, such as the internet, to reduce transaction costs in interactions.
Google, Facebook, Twitter	The utilization of social media platforms for developing creativity, presentation skills and for identifying new business opportunities and social capital.	Digital solutions enabling generativity, or the ability of technologies, such as the internet, to reduce transaction costs in interactions.

To further clarify the potential role of digital technologies, in Table 4 we present some examples of digital platforms and technologies that could help reveal some practical solutions of how universities can support entrepreneurial processes as previously defined. As illustrated in the examples, digital technologies can support academic entrepreneurship processes in different ways. The typologies and examples in the table are provided to explore how some universities have benefited or can benefit from digital platforms and technologies.

6. Conclusion and research agenda

The rapid acceleration of digital technologies in the past 10 years has had a global impact on markets and society (Nambisan et al., 2017). Digital technologies, such as social media, mobile, business analytics, the Internet of Things, big data, advanced manufacturing, 3D printing, cloud and cyber-solutions, MOOCs, and artificial intelligence, are creating further opportunities for researchers, entrepreneurs and policy makers. Digital technologies are making more flexible the activities, processes, and outcomes of Academic Entrepreneurship as well as sustaining the development of a novel concept: *Digital Academic Entrepreneurship*.

This novel conceptualization has been characterized by a high level of utilization of new digital technologies to improve the emerging forms of academic entrepreneurship, such as the development of digital spinoffs and alumni start-ups, the creation of entrepreneurial competence supported by digital platforms and broader innovation development that goes beyond the region to embrace a “glocal” perspective. *Digital Academic Entrepreneurship* engages more stakeholders through the use of digital technologies to develop the academic entrepreneurial process with the final goal of democratizing access to the university ecosystem.

As an emergent research field, scholars should devote future debate to new possibilities for universities to perform entrepreneurial activities taking advantage of digital technologies as discussed in this paper. Our aim is to show how a new direction of research should be followed to define the boundaries, if they exist, of Digital Academic Entrepreneurship. There is a need to address whether universities should be involved in academic entrepreneurship and if more universities can be involved in such processes due to the impact of digital technologies.

Based on this premise, we propose a research agenda to open further investigation into the impact of new digital technologies on academic entrepreneurship processes.

The agenda is organized into 4 research streams that can involve scholars in the near- and far future.

Research stream 1: Why. The analysis of theoretical concepts and constructs that reflect how digital platforms' architecture can enhance democratization in the academic entrepreneurship research.

The architectures of both digital infrastructures and digital platforms must be managed to exploit researchers' and students' ability (knowledge) and willingness (motivation) to act as entrepreneurs to obtain novel opportunities, to finalize technology transfer initiatives and objectives, and to pursue research contract activities. The opportunity to make more “democratic” the access to the university ecosystem makes the motivation behind the adoption of digital technologies for academic entrepreneurship more challenging.

Table 5
An emerging research agenda for digital academic entrepreneurship.

	Main research questions
WHY (The value generated by Digital technologies for academic entrepreneurship)	o What value does academic entrepreneurship derive from the impact of digital technologies? o Do university boards understand the potential to improve academic entrepreneurship from the broader adoption of digital technologies? o How can digital technologies enhance knowledge transfer and technology transfer between university and industry? How can digital technologies develop social value for academic entrepreneurship?
WHO (The stakeholders involved in digital academic entrepreneurship)	o Who are the 'crowds' that contribute to academic entrepreneurship due to the adoption of digital technologies? o Who are the main stakeholders collectively contributing to the creation of a digital entrepreneurship ecosystem for universities? o Which digital technologies better support the interplay between academia and external stakeholders, such as industry, non-governmental organizations (NGOs), government institutions, investment funds, and technology transfer offices (TTOs)?
HOW (The processes for digital academic entrepreneurship)	o How do digital technologies support knowledge-sharing and opportunity-recognition for academic entrepreneurship? o How can social networks (LinkedIn, Facebook, Twitter, Google+) enhance students' involvement in academic entrepreneurship? o How does digitalization affect the university ecosystem to support student start-ups? o How do technological evolutions impact entrepreneurial social networks: virtual versus real network? o How can a system of digital technologies and infrastructures be used by academic entrepreneurs? o How do the generativity effects produced by digital platforms stimulate the emergence of entrepreneurial opportunities in researchers and professors? o How does the contamination and cooperation enabled by digital technologies among students, researchers and actors form outside the university boundaries shape entrepreneurial processes and outcomes? o How does the adoption of digital platforms, such as MOOCs, improve students and researchers towards different types of effectual cognition and behaviors (especially in less innovative areas)?
WHAT (The emerging digital academic entrepreneurship)	o What are the major challenges facing academic entrepreneurship stakeholders, faculty, businesses and students due to the digital technologies revolution? o Which academic entrepreneurship activities/processes are more influenced by the technological revolution? o What emerging forms of TTO activities are supported by digital technologies? o Which typologies of research collaborations between university and industry are better supported by digital technologies?

Research stream 2: Who. The incorporation of the theoretical concepts of digital infrastructures and their underlying sociotechnical processes—for example, digitalization—in the stakeholders engaged in the academic entrepreneurship research.

Digital infrastructures are regarded as socio-technical systems that involve new categories of actors and stakeholders who are now able to interact with academia. The more the actors' participate, the more the performance of digital academic entrepreneurial initiatives will evolve and give rise to innovation. However, at the same time, threats must be envisaged to reduce the uncertainty deriving from entrepreneurial activities.

Research stream 3: What. The incorporation of theoretical concepts from the information systems discipline, such as digital artifacts and platforms, and their impact on the academic entrepreneurship research. The analysis of the forms emerging in the digital academic entrepreneurship that require new investigation.

Digital artifacts and digital platforms can release their potential if they are adopted into university practices focusing on novel entrepreneurial activities. There is a need to map and categorize all the new emerging forms of digital academic entrepreneurship, such as, for example, the novel organization of technology transfer activities supported by digital technologies, the creation of spinoff activities enhanced by digital technologies, and new forms of research collaboration between universities and industries that are better supported by digital technologies.

Research stream 4: How. The incorporation of theoretical concepts and methodological approaches of digital artifacts and platforms into academic entrepreneurial initiatives.

Finally, it is also important to investigate which activities and processes are more influenced by the technological revolution. More in depth, the question is the way in which universities include digital artifacts and platforms in their routines. As a consequence, the impact of such technologies on academics' routines should be investigated to better align the competences of interested actors and to obtain insights into the boundaries of academic entrepreneurial processes.

These four research streams aim to open the door for field studies that will offer answers to the following research questions (see Table 5):

It is clear that the research focusing on university entrepreneurship must be expanded to include the literature from other disciplines, such as information systems, political science, and psychology. The contribution of the political science literature could provide the knowledge that is necessary to evaluate the governance model of the digital academic ecosystem. The research from the information system field is required to evaluate the democratization process deriving from the adoption of different digital technologies in the activities of academic entrepreneurship. Psychology studies should be devoted to understanding which competences are required to manage digital technologies within an academic environment.

This opens up a series of issues related to strategy formulation and implementation at the university level and the analysis of the new competencies that are required for the management of digital technologies. The question is whether more universities could be involved in academic entrepreneurship activities facilitated by digital technologies; and, if so, how can they be effective in this complex activity?

Two different steps need to be developed to allow the evolution of the academic entrepreneurship towards the Digital Academic Entrepreneurship framework: first, the ability to set a strategic direction towards the adoption of digital technologies, that is, those that are necessary and those that are merely sufficient; and second, a strong commitment to use the entrepreneurial knowledge developed within the university, the development of internal capabilities for technology transfer and the commercialization of research as well as playing a collaborative role, with government, business and society, in participating, establishing and implementing a strategy for digital academic entrepreneurship.

6.1. Limitations and future research

The authors are aware of the limitations of this study. First, the examined literature is not exhaustive, and a systematic literature review should be performed. Future development will involve the need to expand the base of the literature analyzed to include papers searched directly in the most renowned journals in the field of academic entrepreneurship, Technology Transfer and Information System. The novelty of the phenomena opens up multiple research opportunities, such as case studies, field analysis, and database analysis. For this reason, we have proposed a research agenda with several constructs and research questions that could motivate further research to provide evidence and insights into a promising research area.

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