

Digital Technology Entrepreneurship: A Definition and Research Agenda

Ferran Giones and Alexander Brem

“Entrepreneurship is the key to emerging technologies.”

James H. Clark

Entrepreneur and computer scientist

Technology entrepreneurship is an established concept in academia. However, recent developments in the context of digital entrepreneurship call for revision and advancement. The multiple possible combinations of technology and entrepreneurship have resulted in a diversity of phenomena with significantly different characteristics and socio-economic impact. This article is focused on the identification and description of technology entrepreneurship in times of digitization. Based on current examples, we identify and describe characterizations of technology entrepreneurship, digital technology entrepreneurship, and digital entrepreneurship. With this new delineation of terms, we would like to foster discussion between researchers, entrepreneurs, and policy makers on the impact of digitization on entrepreneurship, and set a future research agenda.

Introduction

Do we need another definition in entrepreneurship research? We argue that at least technology entrepreneurship deserves a revision. Indeed, Mosey, Guerrero, and Greenman (2017) have stated that, after two decades of interest and research contributions in the field, we all can now take stock of what has been achieved, what needs to be revisited, and what is still missing. We have reached a consolidation stage in technology entrepreneurship research.

A seminal contribution to the definition of technology entrepreneurship as a field was made by Tony Bailetti. His definition highlights that technology entrepreneurship is “an investment in a project that assembles and deploys specialized individuals and heterogeneous assets that are intricately related to advances in scientific and technological knowledge for the purpose of creating and capturing value for a firm” (Bailetti, 2012). Around the time when Bailetti’s article was published, the largest ever initial public offering (IPO) from a technology company took place: Facebook raised over \$16 billion USD upon becoming listed in the stock market (Rusli & Eavis, 2012). In subsequent five years after Facebook became a public company, we have witnessed a mobile and social media revolution (Hanna et al., 2011). This revolution has not only changed how organizations connect with customers, but it has also transformed the meaning of technology entrepreneurship.

To make sense of how much digitization has changed technology entrepreneurship, we propose to examine the topic from three different angles: the underlying technological opportunity, the entrepreneurship process, and the resource acquisition. Prior research has highlighted the entrepreneur–opportunity nexus, suggesting that the type and nature of a technology opportunity can be a determining factor in the activation of the entrepreneurial process (Davidsson, 2015; Gruber et al., 2012). Similarly, the entrepreneurial activities and their sequence (Brush et al., 2008; Lichtenstein, 2015) or the acquisition and timing of resources affect survival and the likelihood of growth (Bhawe et al., 2016; Klyver & Schenkel, 2013). These complementary perspectives allow us to identify and describe entrepreneurship cases where we can observe how digitization has permeated technology entrepreneurship.

We follow the approach of MacInnis (2011) to identify and describe characterizations of the concept, and then determine and differentiate the theoretical and practical implications. First, we describe the different types of technology entrepreneurship and their characteristics. Based on that, we propose and discuss a conceptual differentiation. Finally, we identify the implications for researchers, entrepreneurs, or other actors active in the promotion of technology entrepreneurship.

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New Forms of Technology Entrepreneurship

The absence of a detailed characterization of technology entrepreneurship makes it difficult to determine whether we are still inside the original concept boundaries. In their recent systematic literature review, Ferreira and colleagues (2016) opt for a broad conceptualization of technology entrepreneurship, suggesting that it is a combination of entrepreneurship and technology-based innovation. Similarly, Beckman and colleagues (2012) wrote in their special issue on technology entrepreneurship that it is a type of entrepreneurship that aims to exploit opportunities related to advances in science and engineering. Both conceptualizations are broad and are rather consistent with Bailetti's (2012) approach.

An unexpected challenge to this conceptualization has evolved through the meaning of "technology". Although most of technology entrepreneurship research started by studying new entrants in high-tech industries (Gans & Stern, 2003), much attention has been given to the technology commercialization efforts of new firms such as academic spin-offs (Fryges & Wright, 2014; Mosey et al., 2017; Wright et al., 2007). As a result, the phenomenon under study was usually characterized as a technology-push situation (Brem & Voigt, 2009), where the

entrepreneur had the mission to find an application and create a market for a new and complex technology (Giones et al., 2013). But how much does this perspective fit with entrepreneurial activity using digital technologies? As recently discussed by Nambisan (2016), the digitization of the "technology" not only changes its properties but also impacts the overall technology entrepreneurship process. Apparently, this has also major impacts on entrepreneurial processes in general.

To explore the potential differences between alternative characterizations, we first present potentially different, but related forms, of technology entrepreneurship, as shown in Table 1.

Instead of looking for an exhaustive characterization, Table 1 offers a first impression of the diversity of forms that technology entrepreneurship can take. Even in the extreme case of pure digital entrepreneurship, it can be argued that it rarely fits within a technology-push perspective, being instead much closer to concepts such as recombinant innovation or demand-driven approaches to technological innovation in the understanding of market-pull (Brem & Voigt, 2009; Priem et al., 2011). From a research perspective, digital entrepreneurship is much closer to the information systems' concepts of artefacts, platforms, and information infrastructure

Table 1. Alternative forms of technology and digital entrepreneurship

Typology	Technology Behind the Opportunity	Key Activities in the Process	Access to Resources and Funding
Technology Entrepreneurship	New products based on breakthroughs in research; science-based advances through specific knowledge in an academic field Example: Graphene	Technology proof of concept: first customer validation; activate a global but niche market (Clarysse et al., 2011)	Public research grants and other soft money sources Venture capital attracted by promising intellectual property (Audretsch et al., 2012; Giones & Miralles, 2015)
Digital Technology Entrepreneurship	New products based on ICT technologies only; making smart devices using the possibilities of Internet of Things Example: Smartphone	Use of existing technologies: market validation, traction, and growth, scalability	Business angels; seed and venture capital; stock market Crowdfunding; reward and equity (Gedda et al., 2016)
Digital Entrepreneurship	New products and services based on the Internet. Services running only in the cloud; using big data or artificial intelligence. Example: Snapchat	Technology as an input factor: high growth ambitions (Wallin et al., 2016); stay ahead of competitors; be the dominant player in the category	Business angels; seed and venture capital; stock market Equity crowdfunding (Tomczak & Brem, 2013)

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(Nambisan, 2016). Digital entrepreneurs often do not really care about the specific technology behind their business idea, they simply focus on the service that is based on it. Hence, technology here is an input factor only. Digital technology entrepreneurship refers to the technology: its products are technological.

To further clarify this potential divide, in Table 2 we present some examples of entrepreneurial firms that could help reveal the existing differences across the types of technology entrepreneurship.

As the examples in Table 2 illustrate, the type of technology that triggers the entrepreneurship story behind the cases is different. It is not only a discussion about whether we are talking about software or hardware firms, or whether these entrepreneurs aim to only offer services or combine products and services. The typologies we propose aim to connect the traditional science-based technology entrepreneurship coming from university intellectual property (Hartmann, 2014) to the new and rapidly evolving Internet-based digital startups (Drori et al., 2009).

Table 2. Examples of different types of technology and digital entrepreneurship

Typology	Example	
Technology Entrepreneurship	Fractus (www.fractus.com)	Started as an academic spin-off, Fractus was a pioneer in the development of internal antennas for smartphones. They first attempted to commercialize their new antenna designs as a finished product, but then realized that it made more sense to just focus on R&D, patenting, and licensing their technology to manufacturers and OEMs such as Nokia, Samsung, or Motorola.
	Oryzon Genomics (www.oryzon.com)	Founded by bio-pharmaceutical researchers, Oryzon's first decade of operations was focused in offering genomics diagnostics. The company took-off in 2008 when it shifted its focus on developing proprietary drug candidates and licensing to large pharmaceutical companies such as Roche.
	Rust Patrol (www.rustpatrol.com)	The technology was invented by a chemistry professor, and it offered a potential alternative solution to address metal corrosion. A decade later, in 2014, two students joined the researcher to successfully start commercializing anti-corrosion products for industrial and consumer needs.
Digital Technology Entrepreneurship	Go Pro (www.gopro.com)	Founded by a surfer frustrated with the limited options he had to take nice action shots, Go Pro became a manufacturer of action cameras and created a new category in the market. It is a good example of user entrepreneurship (Shah & Tripsas, 2007).
	Fitbit (www.fitbit.com)	Started by a team of IT professionals that identified the untapped potential of sensors and wireless technologies, it transformed from being a consumer electronics to a digital healthcare company. Created and dominated the wearable tech category in the market.
	Tesla (www.tesla.com)	First a hobby electric car, it was one of the rare successful attempts to build an electric sports car from scratch. In a few decades, it has become a disruptor in the automotive industry, challenging the innovation pace and accelerating the technological development of electric vehicles.
Digital Entrepreneurship	AirBnb (www.airbnb.com)	What started as an idea to make a bit of money by renting space in an apartment, quickly became a popular site for people to share and find accommodation. After failing to attract business angels, it was only after being part of an acceleration program in 2009 that it started to gain traction as an accommodation-sharing platform.
	Just Eat (www.just-eat.com)	An attempt to make takeaway ordering an option for all types of restaurants in 2001 was the birth of one of the largest networks of international restaurants that offers online ordering in an increasing number of countries around the world.
	Dropbox (www.dropbox.com)	The idea of having a user's files synchronize in the cloud was behind the digital storage company that has successfully competed with the largest software firms. Since 2009, when the competitive threat of the iCloud arose, they have managed to keep growing what was once a feature into a full product line for consumers and businesses.

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The typologies and examples in Tables 1 and 2 are provided to group together similar evolution paths and growth trajectories. This comes as a response to the diversity of technology origins and outcomes that make it unfeasible to extract homogeneous insights from them if treated as a sole category. We argue instead that it might be a much more fruitful avenue to explore how some of these organizations have benefited from lean startup approaches (Frederiksen & Brem, 2017) or how they have activated a global niche for their products (Tanev, 2012).

Furthermore, each of these types of firms might respond to specific entrepreneurial motivations in their founders. Some might be driven by the idea to address a social problem, whereas others might be excited by the ambition to build a firm that makes an economic impact and becomes a respected institution. These motivations can reflect a combination of multiple entrepreneurial identities or a specific dominant identity (Fauchart & Gruber, 2011). The social identity of the entrepreneur behind each of these firms has implications for the goals they set, as well as for the exit routes that they might be able to define (Dehlen et al., 2014). However, digital entrepreneurs expect to be able to sell their firms to a larger player, resulting in the effective transfer of their user base to a new firm. Pure technology or digital technology entrepreneurs carry with them technology assets that can either be the focus of interest of the acquirer or a costly asset that makes the acquisition price unattractive.

In the following section, we aim to suggest promising directions to further explore technology entrepreneurship considering the different shapes and forms that digital technologies have triggered.

Implications for Digital Technology Entrepreneurship Theory and Practice

The digital transformation of most of the input technologies that entrepreneurs use to propose their new innovative ventures has extended the types of technology entrepreneurs we can observe. Instead of proposing a clear-cut conceptualization between digital and technology entrepreneurship, we propose to describe the change in meaning of “technology” as a continuum between the extremes represented by the commercialization of the latest scientific breakthroughs (e.g., a new material like graphene) and the latest application for smartphones (e.g., a new food delivery app). Figure 1 shows the overlap between these concepts.

As a result, the concept of digital technology entrepreneurship necessarily combines elements of technology and digital entrepreneurship. Thus, we propose to enrich Bailetti’s (2012) definition of technology entrepreneurship to include specific aspects related to this specific form of entrepreneurship: digital technology entrepreneurship is focused on the identification and exploitation of opportunities based on scientific or technological knowledge through the creation of digital artefacts. Digital technology entrepreneurs build firms based on technologies on the one hand, and on services on the other hand.

The extension of the definition implies that this profile of entrepreneurs do not only experience the challenges of engineering or scientific development, but also the complex dynamics of digital platforms and infrastructures (Nambisan, 2016). Digital technology entrepreneurs do not only rely on an innovation ecosystem as digital entrepreneurs do. They strategically combine technological product knowledge (“technology push”) with consumer know-how (“market pull”). But why introduce these terms – are there not already enough definitions in the area of entrepreneurship, as mentioned earlier? From an academic perspective, researchers could use the different classifications of entrepreneurship to learn more about the personal motivations of entrepreneurs and their founding behaviours, financing preferences, etc. One may further argue that such labels might not be relevant to the entrepreneurs themselves. However, we believe that, when it comes to entrepreneurs aspiring to start a business, it might help them to make a conscious decision on what type of technology entrepreneur they want to be.

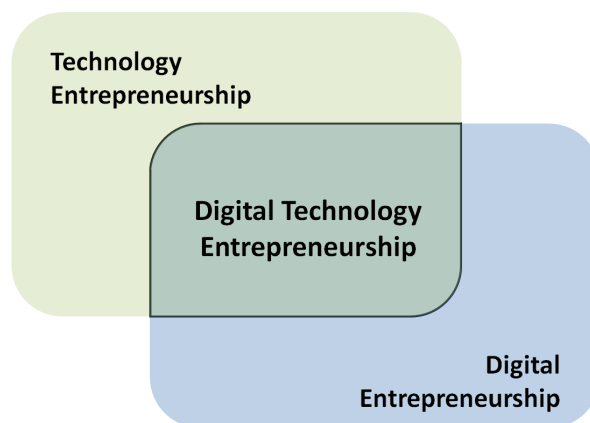


Figure 1. Conceptual representation of a new type of technology entrepreneurship: digital technology entrepreneurship

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Indeed, the introduction of digital technologies as an input for entrepreneurship opens further opportunities for researchers, entrepreneurs, and policy makers. Below, we discuss the implications of our new characterizations of technology entrepreneurship, digital technology entrepreneurship, and digital entrepreneurship for each of these groups.

Researchers

In traditional forms of technology entrepreneurship, the key decision of the entrepreneur was to select whether to aim for licensing their technology or engage in the full commercialization of their product (Gans & Stern, 2003). In contrast, digital technology entrepreneurs are embedded in an interconnected system when they aim to commercialize their solutions; it is a context where platforms and network effects matter (Kyprianou, 2016; Srinivasan et al., 2004) and standards or dominant designs (Brem et al., 2016) can define the boundaries and scalability of products. As a result, there are opportunities to update what we know about growth patterns in technology entrepreneurship (Hesse & Sternberg, 2016) to include digital technology entrepreneurs. Related research questions include:

- What are the implications of building a new venture on a digital artefact? What is different in resource acquisition, team dynamics, or funding strategies?
- What are the implications of growth in digital technology entrepreneurship? How is it different from technology entrepreneurship or digital entrepreneurship? When does growth stop being a desirable outcome for entrepreneurs? How do valuation, user, and revenue growth translate into different entrepreneurship processes and perceptions of success?

Further research could also study the co-evolution between digital technology entrepreneurship and the digital platforms or infrastructure governance (Wareham et al., 2014), as well as the impact of regulation (Gurses & Ozcan, 2015) to explore when this enables or constrains entrepreneurial activity. Related research questions include:

- How do platform dynamics impact entrepreneurial activity in emerging ecosystems? When does too much dynamism reduce the ecosystem attractiveness to new potential entrants? When does entrepreneurial activity generate new innovations, and when does it not?

- When do entrepreneurs engage in transforming the digital platforms where they operate? How does regulation by code and by law explain the different evolutionary paths in different markets?
- What strategies do entrepreneurs use to protect their positions in unstructured ecosystems? What is different in digital infrastructures? When do digital entrepreneurs use regulation to their advantage?

To explore this and related research questions, researchers might take advantage of methods and theoretical perspectives from information systems' research, where we have seen similar research fields' interconnections in the last years between innovation and information systems (Majchrzak & Malhotra, 2013). Promising approaches include:

- Introducing heuristics theorizing to build design theories in entrepreneurship research (Gregory & Muntermann, 2014).
- Bringing multilevel perspectives (Shepherd, 2010) that capture the complexity of digital technology entrepreneurship, or different angles such as real options to understand how stakeholders see and make decisions in technology entrepreneurship (Rasmussen & Mathisen, 2016).

Entrepreneurs

The introduction of digital elements in the technology entrepreneurship process also reveals a bright side for entrepreneurs. For example, the digital aspects of the technology favour the adoption of born-global approaches (Kraus et al., 2017; Tanev, 2012). These firms can quickly scale up their products and aim for a global audience. Furthermore, the digitization of the production processes makes it possible to be both a lean and global company at the same time (Frederiksen & Brem, 2017; Rasmussen & Tanev, 2015), blurring the traditional boundaries of technology entrepreneurship. Activities in the entrepreneurship process, such as resource acquisition, are also changing; digital technologies offer the possibility to bring forth early working prototypes that can be used in reward crowdfunding campaigns, completely changing the technology innovation management process in the new firm (Giones & Oo, 2017). With so many possible futures, the ability to design and innovate the business model makes a difference (Doganova & Eyquem-Renault, 2009; Westerlund et al., 2014).

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There is also a dark side to the digital potential of technology entrepreneurship. Fast growth and forward leaps often mean higher failure risks for the ambitious digital entrepreneurs stepping into emerging ecosystems, where the role of each of the players is still unclear and the technology base is still evolving. Westerlund, Leminen, and Rajahonka (2014) describe the example of new entrants in the Internet of Things (IoT) ecosystem, where the lack of structure and solid standards (Brem et al., 2016) in the ecosystem increase the complexity of entrepreneurs' decisions.

To sum up, the digital artefact at the core of the entrepreneurship process might require or call for additional information management capabilities in the entrepreneurial team, but it also opens new doors to accelerate learning and growth in the new venture.

Policy makers

The consequence of digitization goes beyond the dynamics of the entrepreneurship process. An example of how digital technology entrepreneurship is also activating new policy and support mechanisms is the successful I-Corps program (<http://www.nsf.gov/i-corps>) run by the National Science Foundation in the United States. The digital core of new technologies makes it possible to run accelerated approaches to market validation and early-stage growth.

As a result, the model of the university incubator for technology entrepreneurship (Amezcuca et al., 2013; Gerlach & Brem, 2015) no longer fits with the characteristics of digital technology entrepreneurship. Instead, we observe how an increasing number of research centres and universities are starting to partially or fully introduce entrepreneurship-supported models that follow the accelerator program design (Pauwels et al., 2016). The transition from incubation to acceleration models requires specific knowledge, dynamic markets, and an investor ecosystem; done in isolation, it is likely to end up in the black-box of failed policies (Brown & Mason, 2014).

Conclusion

The unprecedented digital revolution has transformed the meaning and forms of entrepreneurship across the globe. The emerging field of technology entrepreneurship research has not been able to keep pace with the fast changes in the digitization of our society and economy. In this article, we aim to help entrepreneurs and researchers interested in further exploring the possibilities that new technologies and entrepreneurship generate. We propose a conceptualization and characterization of three different phenomena: technology entrepreneurship, digital technology entrepreneurship, and digital entrepreneurship. Each of them has a different origin and different emergence dynamics, and in most cases, they generate rather different trajectories for growth and technology evolution. The uniqueness and novelty of the phenomena also open multiple research opportunities. We have proposed a research agenda that hopefully motivates further research and provides valuable insights to entrepreneurs and policy makers alike.

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