



Digital transformation shaping structural pillars for academic entrepreneurship: A framework proposal and research agenda

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Abstract

Digital technology always accelerates change, altering organisations culturally, socially and technically. These modifications are known as “digital transformation” (DT). On a much greater scale than DT, the world was changed in 2020 by the COVID-19 pandemic, which re-organised society in the way of thinking, acting, producing, consuming and creating new business. Higher Education Institutions (HEIs) were no different, since these institutions had to make changes to the student–lecturer interaction; teaching–learning, where DT had a relevant role, above all in academic entrepreneurship. Therefore, this study aims to propose a framework showing the structural pillars of the link between digital transformation (DT) and academic entrepreneurship (AC) (DT-AC Framework). This framework identifies the new patterns, methods, skills and other discoveries in aspects such as management, information systems and culture sciences. The intention is not to analyse how the COVID-19 pandemic imposed global structural changes, but because of it, lecturers and students found their DT accelerated and intensified, and so it is necessary to investigate the pillars supporting academic entrepreneurship. The results show that DT was already emerging as a basic element of academic entrepreneurship before the pandemic, but the process has speeded up. This bibliometric study indicates the structural pillars that support entrepreneurship following the Covid19 pandemic, as created from DT in universities, providing an extensive systematic review that indicates the cause and effect of the academic entrepreneurship process.

Keywords Covid19 pandemic · Digital transformation · Academic entrepreneurship · SLR

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1 Introduction

The rapid acceleration of digital technology in the last ten years has permeated all organisations (Nambisan, 2017), due to progress in communication, computing and connectivity technology (Bharadwaj et al., 2013), which have stimulated changes in actors, structures, practices, values and beliefs. According to Hinings et al. (2018), this has modified, threatened or complemented existing rules in organisations.

Digital technology accelerates changes, altering organisations culturally, socially and technically. This phenomenon is known as "digital transformation" (DT) (Hess et al., 2016). In 2020, due to the COVID-19 pandemic, digital transformation was stimulated, re-organising society in its way of thinking, acting, promoting, consuming and creating new business (Haefner & Sternberg, 2020). This disturbance to systems has changed the concept of uncertainty in the market, stimulating advances in the entrepreneurial process (Nambisan, 2017), as it has modified the complexity of consumption and social trends (Hracs et al., 2013).

For Higher Education Institutions (HEIs), the situation was no different (Sá & Serpa, 2020), since these institutions changed the student–lecturer and teaching–learning interaction, with digital transformation having a relevant role, above all in academic entrepreneurship (Ratten, 2020).

This context has given an even greater stimulus to research in the field of digital entrepreneurship. This topic faces some challenges, since the entrepreneurship phenomenon and digital technology affect various disciplines and there is little clarity or consensus as to the boundaries of research fields, a situation which makes the terminology used extremely dynamic (Zaheer et al., 2019a). It also hinders consistency in the literature with the use of more systematic methods, despite recent developments in research having provided more opportunities.

Based on emerging knowledge about the nature and characteristics of digital technology (Kallinikos et al., 2013; Lyytinen et al., 2016; Yoo et al., 2010), the editable, re-combinable, re-programmable and generating nature of digital technology is understood to have an impact on many aspects of innovation and processes and entrepreneurial results. This technology allows the development of ecosystems in different geographical locations (Autio et al., 2018) and requires different business competences (Nambisan & Baron, 2013), innovation processes (Nambisan et al., 2017) and governance structures (Sussan & Acs, 2017). In this context, the disruptive role of digital transformation for academic entrepreneurship (Secundo et al., 2020a) is important, since this situation can potentialize digital academic entrepreneurship (Rippa & Secundo, 2019).

Digital technology creates new paradigms by changing the relations between individuals, industry and society (Vial, 2019). This change is supported through use of the internet and digital technology (Lasi et al., 2014), and is known as Digital Transformation (DT) (Vial, 2019). When that DT is associated with entrepreneurship, the phenomenon of Digital Entrepreneurship is created, seeking business results (Nambisan, 2017).

In the context of universities and other higher education institutions, digital entrepreneurship takes the form of "Digital Academic Entrepreneurship", which

results from the intersection of digital transformation and digital entrepreneurship in the academic context (Secundo et al., 2020a).

In this study, Digital Academic Entrepreneurship is understood as entrepreneurship carried out from digital capacities and skills developed in the university environment, irrespective of the associated digital technology, considering the product/service created by the academic, i.e., it is the result of making use of the digital technology taught and developed at universities that can transform the environment.

In this context, the level of digital academic entrepreneurship should permeate the need to enhance existing business theories, from the relations between digital transformation and the entrepreneurial process, and multiple levels of analysis should be incorporated in that relation. Of all the quantitative and considering the multiple concepts of fields/disciplines, it is easier to recognise the role of digital technology in entrepreneurial transformation (Nambisan, 2017). This scenario encourages debate around new skills for digital academic entrepreneurship, adopting a holistic perspective of this phenomenon (Rippa & Secundo, 2019).

Despite social science scholars' attempts to understand digital entrepreneurship, findings are fragmented and scattered over different disciplines and do not seem to converge on a clear image (Cortellazzo et al., 2019; Nambisan, 2017). There is still a clear lack of studies correlating entrepreneurship and digital evolution (Hsieh & Wu, 2019; Grégoire & Shepherd, 2012) in the HEI context. According to Akhter (2017), there is evidence that digital academic entrepreneurship can have a positive impact on HIEs. Therefore, this study aims to understand the bases for digital academic entrepreneurship, what they are, how they are formed and how they are related, through a systematic literature review (SLR).

Studies exist in various disciplines with multiple theoretical models (Nambisan et al., 2019; Rippa & Secundo, 2019; Schwarzmüller et al., 2018) of academic entrepreneurship, but the contributions are fragmented. Therefore, this study contributes to present the structural pillars for digital academic entrepreneurship, considering that DT has speeded up in the HEIs context. The methodology used to build the framework was based on an extensive bibliometric analysis which identified two significant relations: digital technology (hard skills), the logic of business and the entrepreneurial process and (soft skills) digital technology and socio-cultural modifications. A research agenda for further studies in this area is also presented.

2 DT-AC framework—construction methodology

To achieve the aim defined for this study, the methodology used was the systematic literature review (SLR), through a pre-pandemic bibliometric analysis to help build a guiding framework to link Digital Transformation (DT) and Academic Entrepreneurship (AC) following the covid-19 pandemic. Specifically on this subject, due to the lack of guidance on systematic literature reviews, the researchers decided to apply a critical review (Xiao & Watson, 2019). The methodology adopted to build the DT-AC framework is shown in Fig. 1.

Thus, the researchers decided to carry out exploratory qualitative research (Cortellazzo et al., 2019) as presented here.

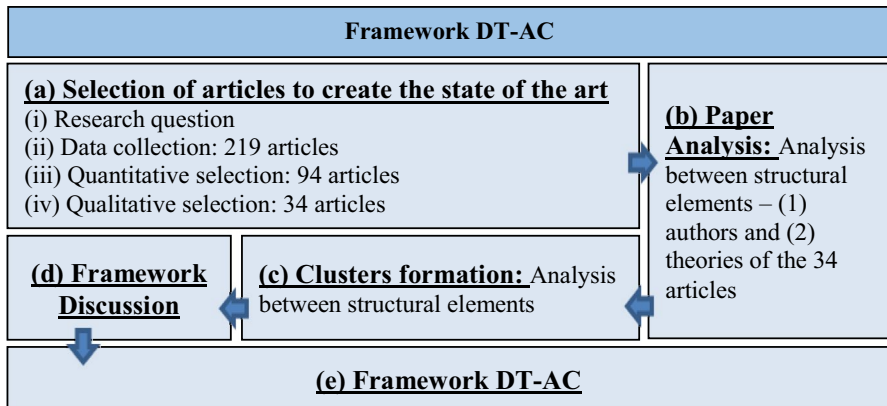


Fig. 1 DT-AC Framework—construction methodology

a) **State-of-the-Art:** The survey of the state-of-art intended to identify how scientific studies are related to Digital Transformation and Digital Entrepreneurship in Universities, pre-COVID-19, to structure the research field, namely Academic Entrepreneurship post-pandemic.

- (i) **Research question:** To serve as a guide to the research, a research question was created: What are the existing links between DT and Academic Entrepreneurship?
- (ii) **Data collection.** To form a set of reliable data giving a solid basis for construction of the DT-AC framework, a quanti-qualitative approach was adopted, structured from the coding standard used and proposed by various authors such as Cortellazzo et al. (2019), Mazzarol (2015) and Zupic and Čater (2015).

To identify articles, the Web of Science (WoS) database was used, since this is the most commonly used database for bibliometric studies in management and because it provides bibliographic data such as indexed documents, including article title, article type, authors, authors' institutional affiliation, key-words, abstract, number of citations, journal name, publisher's name and address, year of publication, volume and issue number, and a list of cited references is available for analysis (Zupic & Čater, 2015).

Only journal articles were included in this research, since these sources contain validated scientific knowledge (Podsakoff et al., 2005). The search terms used were: "digital transformation" or "digital technolog*" or "digitalization" and "entrepreneur*" added to the key-words: Digital Entrepreneurship; Digital Economy; Innovation; Academic Entrepreneurship.

The selection criteria were the title, key-words or abstract and peer-reviewed articles published in English, without restrictions regarding the

study domain, due to the relevance in a wide range of disciplines. Other authors such as Secundo et al., (2020a, b) have used this procedure.

To prevent the research from being based on only the number of citations, recent conference articles, between 2019 and 2020, were added, as these might not have had time to pass through the whole publication process, and this resulted in 219 articles.

- (iii) **Quantitative Selection:** The articles were also selected according to data parameters; number of citations and journal’s impact factor, which meant eliminating articles prior to 2017 without citations and articles published in journals with no impact factor. These criteria were defined so as to select articles with a strong relation between the variables studied (Jayasekara & Abu, 2018) and with a strong scientific basis, as well as aiming to establish precise classification criteria (Acedo et al., 2006) representative of the population. Concluding this stage left 94 articles.

When the criterion was analysis of citations (Figure 2), the USA stands out, followed by Denmark and China.

Observation of Fig. 2 reveals the USA in a leading position as regards entrepreneurship and transformation in digital technology. This reflects the initiatives created by that country in stimulating entrepreneurship, for example by attracting global entrepreneurial talent to instigate high-tech undertakings such as eBay (founded in 1995 by Pierre Omidyar, an Iranian businessman born in France) and PayPal (founded by the German Peter Thiel and Ukrainian Max Levchin) (Li, 2018).

Also analysed was the number of citations per year, per author (Table 1) and per journal (Table 2), showing that the scientific community interested in exploring the adoption of digital technology in the context of entrepreneurship, from 2017 to 2020, cited more than 750 times seminal work from 2010, 2012 and 2014 in their new contributions (Tables 1 and 2 only show the 10 most cited).

The paper “The industrial dynamics of Open Innovation—Evidence from the transformation of consumer electronics”, exploring the dynam-

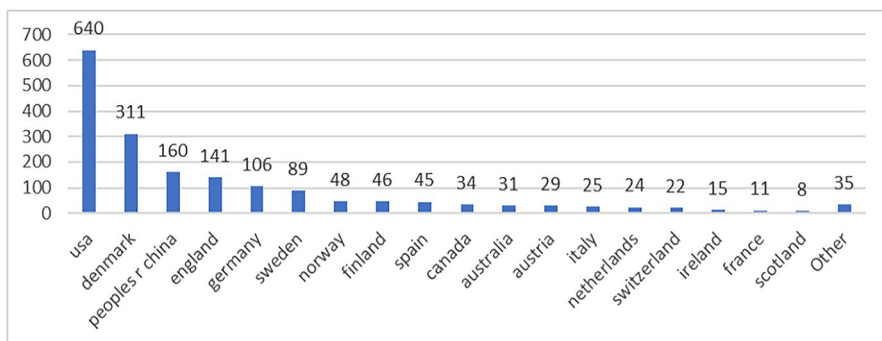


Fig. 2 Number of citations by country involving work on DT and Entrepreneurship from 1990 to 2020. Source: Research data

Table 1 Citations per most influential authors

Author – Title	Citation	Journal	Year	Area
1 Christensen, JF; Olesen, MH; Kjaer, JS <i>The industrial dynamics of Open Innovation—Evidence from the transformation of consumer electronics</i>	286	Research Policy	2005	Business & Economics
2 Nambisan, S; Lyytinen, K; Majchrzak, A; Song, M <i>Digital Innovation Management: Reinventing Innovation Management Research In A Digital World</i>	126	Mis Quarterly	2017	Computer; Information; Science Business & Economics
3 Rosenblat, A; Stark, L <i>Algorithmic Labor and Information Asymmetries: A Case Study of Uber's Drivers</i>	125	International Journal of Communication	2016	Communication
4 Nambisan, S <i>Digital Entrepreneurship: Toward a Digital Technology Perspective of Entrepreneurship</i>	102	Entrepreneurship Theory And Practice	2017	Entrepreneurship
5 Li, L <i>China's manufacturing locus in 2025: With a comparison of "Made-in-China 2025" and "Industry 4.0"</i>	96	Technological And Social Change	2018	Digital transformation
6 Henfridsson, O; Yoo, YJ <i>The Liminality of Trajectory Shifts in Institutional Entrepreneurship</i>	43	Organization Science	2014	Business & Economics
7 Li, L; Su, F; Zhang, W; Mao, JY <i>Digital transformation by SME entrepreneurs: A capability perspective</i>	33	Information Systems Journal	2018	Digital transformation
8 Hraacs, BJ; Jakob, D; Hauge, A <i>Standing out in the crowd: the rise of exclusivity-based strategies to compete in the contemporary marketplace for music and fashion</i>	32	Environment And Planning A-Economy And Space	2013	Environmental Sciences & Ecology; Geography
9 Hinings, B; Gegenhuber, T; <i>Digital innovation and transformation: An institutional perspective</i>	26	Information And Organization	2018	Digital transformation
10 Giones, F; Brem, A <i>Digital Technology Entrepreneurship: A Definition and Research Agenda</i>	21	Technology Innovation Management Review	2017	Digital transformation

Source: Research data

Table 2 Citations per most influential journals

Ranking	Journal	N° articles	Citations
1	Research Policy	3	296
2	Mis Quarterly	1	126
3	International Journal of Communication	1	125
4	Entrepreneurship Theory and Practice	2	120
5	Technological Forecasting and Social Change	6	110
6	Organization Science	1	43
7	Information Systems Journal	1	33
8	Environment and Planning A-Economy And Space	1	32
9	Technology Innovation Management Review	8	31
10	Information and Organization	1	26

Source: Research data

ics of innovation as a factor of transformation, is the most cited article with 286 citations, but the most cited paper whose title focuses on Digital Entrepreneurship is “Digital Entrepreneurship: Toward a Digital Technology Perspective of Entrepreneurship”, by Nambisan (2017) with 102 citations.

- (iv) **Qualitative Selection.** An exploratory qualitative study was also carried out by reading the abstracts and conclusions of the 94 articles selected, from inductive and interactive criteria related to the research question presented in Stage (i), i.e., it was determined whether there was: (1) Discussion about the relation between digital technology, business logic and consequently the entrepreneurial process, and (2) Discussion about the relation between entrepreneurship, digital transformation and entrepreneurial skills. These articles were accepted as relevant to the subject, to establish the state-of-the-art.

If there was no clear relation between these matters in the abstracts and conclusions, the articles were read completely to determine their irrelevance, and if this was confirmed, they were rejected (conf. Fig. 3).

- b) **Paper analysis:** In this phase, an analysis between structural elements was made: (1) authors and (2) theories of the 34 articles selected, in order to understand how these relate and influence, to represent the research structure of the selected data (Zupic & Čater, 2015), seeking to identify in the articles the themes influencing research most. In this analysis, the co-citation analysis method was used, through VOSviewer software. This choice is justified due to it being a method that can determine the nuclear structural knowledge of a specific domain (Small, 1973), being relevant for evidence, paradigm changes and schools of thought (Zupic & Čater, 2015). After various trials with different cut-off points, it was decided to set this at 5 citations.

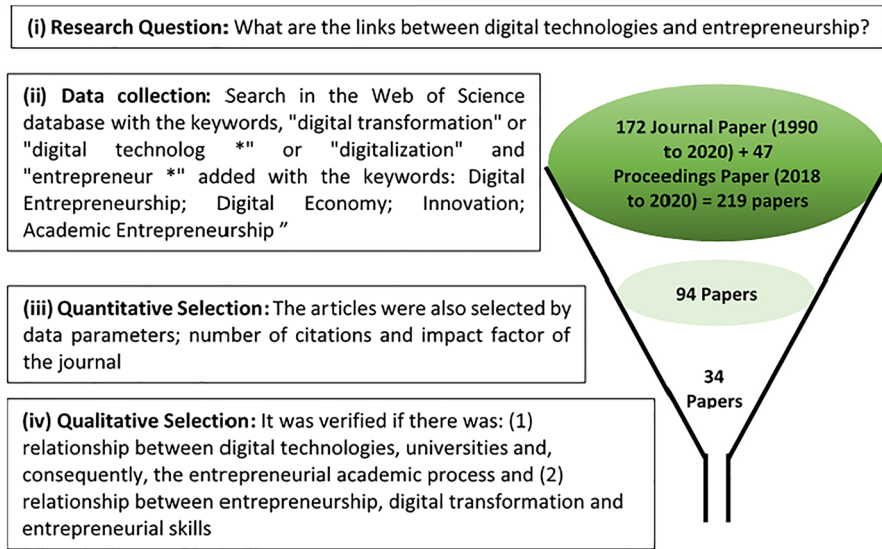


Fig. 3 Process of choosing the papers establishing the state-of-the-art. Source: Research data

The reliability of the study was achieved by all articles presenting the strongest link (Nambisan, 2017), due to its seminal contribution to the debate on digital transformation and the uncertain nature of business processes and results.

Besides reliability through the “strongest link”, the validity of this study is due to (a) the use of various sources of evidence in relation to the phenomenon analysed, as well as triangulation of sources in searching for more than one bibliographical reference; and (b) being peer-reviewed (one Ph.D. student and one post-Ph.D. researcher).

In this case, the results are supported by socio-material theory (Orlikowski, 1996), which assumes that social and material are considered inseparable terms, i.e., the assumption that there is no social without also being material, and no material that is not also social (Orlikowski, 2007).

Table 3 presents the articles with co-citation frequency above 5 articles, the grouping of relations and the strength of the link between these and the articles at the source of the co-citation. Here, two relations were identified: R1: Digital technology, business logic and entrepreneurial process, and R2: Digital Technology and Digital Entrepreneurship. Therefore, the article selection criterion was supported by the analysis of co-citations presented in Table 3.

Table 4 presents the evidence of how the correlations between R1 and R2 are contextualized, showing that these papers have greater theoretical maturity, as their structure refers to articles relating R1 and R2.

- c) **Cluster formation:** the following structural elements were crossed: (1) digital technology; (2) unit of analysis of the 34 articles selected; (3) co-citations, (4) results and (5) future research, aiming to understand how digital technology alters entrepreneurship and its impacts. Here, an inductive approach was adopted, i.e.,

Table 3 Co-citation relation ≥ 5

Co-cited	Relationship	Strength	Citation	Article
Kallimikos et al. (2013)	1	24	7	(Elia et al., 2020; Henfridsson & Yoo, 2014; Nambisan, 2017; Nambisan et al., 2019; Rippa & Secundo, 2019; Song, 2019; Zaheer et al., 2019a, b)
Tiwana et al. (2010)	1	19	5	(Elia et al., 2020; Nambisan, 2017; Rippa & Secundo, 2019; Schiavone et al., 2019; Tumbas et al., 2018)
Yoo et al. (2010)	1	18	8	(Arvidsson & Mønsted, 2018; Cenamor, et al., 2019; Mancha & Shankaranarayanan, 2020; Nambisan, 2017; Nambisan et al., 2019; Rippa & Secundo, 2019; Song, 2019; Tumbas et al., 2018)
Parker et al. (2016)	1	19	5	(Cenamor et al., 2019; Elia et al., 2020; Nambisan, 2017; Rippa & Secundo, 2019; Song, 2019)
Hull et al. (2007)	2	15	5	(Beliaeva et al., 2019; Elia et al., 2020; McAdam, 2020; Tontolo, et al., 2020a, b; Zaheer et al., 2019a, b)
Nambisan (2017)	2	27	10	(Beliaeva et al., 2019; McAdam, 2020; Monllor & Soto-Simeone, 2019; Nambisan et al., 2019; Pergelova, et al., 2019; Rippa & Secundo, 2019; Schiavone et al., 2019; Song, 2019; Tontolo et al., 2020a, b; Zaheer et al., 2019a, b)
von Briel et al. (2018)	2	25	7	(Elia et al., 2020; McAdam, 2020; Monllor & Soto-Simeone, 2019; Nambisan et al., 2019; Rippa & Secundo, 2019; Schiavone et al., 2019; Song, 2019)
Giones and Brem (2017)	2	19	8	(Beliaeva et al., 2019; Elia et al., 2020; Ivanović-dukic et al., 2019; McAdam, 2020; Monllor & Soto-Simeone, 2019; Schiavone et al., 2019; Tontolo et al., 2020a; Zaheer et al., 2019b)

Source: Research data

Table 4 Co-citation relation ≥ 5

Article	Correlation between R1 and R2
Elia et al. (2020)	Digital technology has an impact on how new undertakings are imagined and created. From four dimensions: (1) digital actors (who), (2) digital activities (what), (3) digital motivations (why) and (4) digital organisation (how)
Monllor and Soto-Simeone (2019)	Practical experience with digital technology in universities can have a positive impact on students' business self-efficacy and on their entrepreneurial intentions
Nambisan et al.(2019)	Showing the need to study digital entrepreneurship incorporating multiple levels of analysis, covering ideas and concepts from multiple fields/disciplines, and recognising the role of digital technology in transforming all organisations and social relations
Rippa and Secundo(2019)	Setting out from an interpretative framework, presenting justifications for the adoption of digital technology (why), emerging forms of digital academic entrepreneurship (what), stakeholders (who), and processes of academic entrepreneurship (how)
Schiavone et al (2019)	From the socio-material perspective of digital entrepreneurship, exploring how business-people create firms
Tumbas et al. (2018)	Studying Chief Digital Officers' search for legitimacy in the institutional environment
Zaheer et al., (2019a, b)	Exploring the factors that contribute to successful digital academic entrepreneurship, presenting the factors that shape the performance of digital academic start-ups

Source: Research data

there was no preconception of categories. Instead of this, there were observations and assessments, in order to identify patterns.

Table 5 shows the cluster grouping, after various classification cycles:

d) **DT-AC Framework**

The results of all the quantitative and qualitative analyses carried out, as per the authors selected, are found to be interlinked, which allowed construction of the structural clusters, as grouped in Fig. 4.

e) **Presenting the Framework:** Structural pillars of digital academic entrepreneurship.

Table 5 Formation and interconnection of clusters

Current Relationship Cluster	New Relationship after analysis of structural elements
Relationship 1: <i>Digital technology, business logic and entrepreneurial process</i>	(1) Management Tools; (2) Digital Processes and (3) Digital Products
Relationship 2: <i>Digital technology and socio-cultural modifications</i>	(4) Individual Characteristics; (5) Cultural Characteristics and (6) Knowledge Sharing

Source: Research data

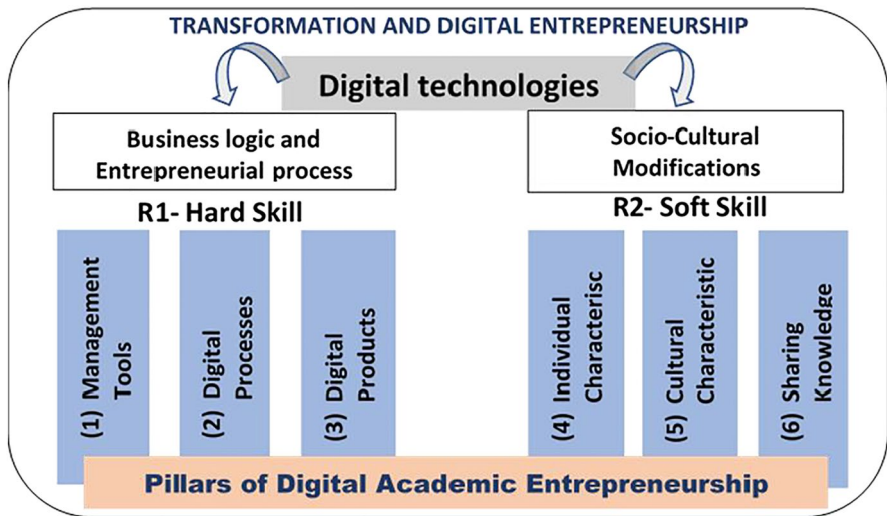


Fig. 4 Logic of the Structural Pillars of Digital Academic Entrepreneurship. Source: Research data

The results of the quantitative and qualitative analyses of the data allow formation of the structural pillars linking “Digital Technology” and “Academic Entrepreneurship” post-Covid19, presenting potential directions for coupling, and for future lines of research.

Above any existing relation, the bibliometric analysis and content analysis of the articles led to identification of two pillars, namely Nambisan (2017) and Nambisan et al. (2019). Based on these two articles and the whole study made, the following is underlined:

Relation 1 (R1): Digital technology, business logic and entrepreneurial process. The whole body of articles studied clearly indicates how digital technology affects business logic and the entrepreneurial process. This digital technology alters how objects are perceived. For example, a work routine written on paper can be digitalized, and consequently a digital object is easier to edit than a physical one. This means that information can be eliminated or added according to individuals’ choice (Kallinikos et al., 2013; Tiwana et al., 2010). Digital objects are interactive, as they accept actions of a contingency nature (depending on individuals’ choice), and they are flexible (Kallinikos et al., 2013).

Indeed, as digital objects are flexible (or malleable), they can radically transform entrepreneurship (Nambisan, 2017; Nambisan et al., 2019). Drones, for example, were created for a military application, but are currently used in the real estate sector (aerial videos to show houses), logistics (parcel delivery), agriculture (monitoring crops) and other areas (Nambisan, 2017).

One of universities' roles is to stimulate the use of digital objects, in business ecosystems and society (Toniolo et al., 2020a, 2020b), enabling individuals to use digital tools, such as digital platforms, cloud computing, social networks, 3D printing and data analysis. The aim is to encourage processes of digital innovation (Rippa & Secundo, 2019), from the creation of new services and products, as well as results of academic research, and contribute to changing the traditional way of doing business in the digital era (Toniolo et al., 2020a, 2020b).

2.1 R1 and support pillar 1: management tools

Pillar 1 emerges from the articles (Arvidsson & Mønsted, 2018; Brydges & Sjöholm, 2019; Cenamor et al., 2019; Vorbach et al., 2019) showing the obstacles to measuring the benefits of using management tools (Arvidsson & Mønsted, 2018), but when used correctly these management tools can create new types of professional activities (Brydges & Sjöholm, 2019); improve organisational performance (Cenamor et al., 2019); and stimulate education for entrepreneurship (Vorbach et al., 2019), concluding that Management Tools are one of the pillars supporting R1.

Digital tools (e.g., blogs, social media, management systems—MRP) provide new aspects of organisational competitiveness for entrepreneurship. For example, Arvidsson and Mønsted (2018) show how employees in a Norwegian hospital (intra-entrepreneurs), with the support of a digital application, developed time planning and resource analysis, raising competitiveness.

Beliaeva et al. (2019) investigated the client-supplier relation in a firm commercializing management systems, showing the importance of strategic partners in the ecosystem of business innovation.

Studying entrepreneurial SMEs, Cenamor et al. (2019) concluded that the lack of resources and skills hindered their growth. In this context, digital platforms have a positive, indirect effect on these firms' performance.

For Brydges and Hrac (2019), the mobility of the creative fashion industry (setting out from independent entrepreneurs who use digital technology and their creative work) allows greater freedom towards self-organisation, as they are freer to decide where, when and how they will live and work. In this connection, Brydges and Sjöholm (2019) study how these digital entrepreneurs in fashion use blogs and social networks to transform their personal style in online business and transform their way of working.

In this context, an opportunity for future research would be to understand how digital academic entrepreneurs manage their personal and professional lives, as well as the need to carry out longitudinal research, to track the evolution of these blogs over time (Brydges & Sjöholm, 2019); and the possible relation between the organisational life-cycle and the use of digital technology in universities (Beliaeva et al., 2019).

2.2 R1 and support pillar 2: digital processes

Pillar 2 was based on the articles by Brydges and Hrac (2019); Hrac et al. (2013); Pergelova et al. (2019); Rippa and Secundo (2019) and Tumbas et al. (2018), who show how the use of digital technology changes the logic of organisational processes

(Tumbas et al., 2018), and how goods are produced, promoted, distributed and consumed (Hracs et al., 2013).

These studies also show that, in the internationalization process, digital processes were accelerated (Pergelova et al., 2019), giving individuals greater freedom to define: where, when and how to work and live (Brydges & Hracs, 2019). This aspect allows acceleration of the process of educating for entrepreneurship (Rippa & Secundo, 2019), allowing the conclusion that Digital Processes is one of the pillars supporting R1.

Digital technology creates new processes and changes business logic, such as how the cultural product market was reconfigured (Hracs et al., 2013), similarly to the market of young activists and business-people in Russia (Suleymanova, 2018), where new organisational functions emerged.

Furthermore, academic entrepreneurship is being sub-categorized as digital academic entrepreneurship (Rippa & Secundo, 2019), and new forms of SME internationalization are being created as a consequence of digital processes (Pergelova et al., 2019).

This gives rise to several opportunities for future research, such as: (i) studying the sustainability and effectiveness of producers' exclusiveness strategies in virtual environments (Hracs et al., 2013); (ii) exploring the digital logic, of the digital entrepreneur in the various organisational roles (Tumbas et al., 2018); (iii) how digital platforms can be tools to democratize academic research, setting out from the socio-technical process (Rippa & Secundo, 2019); (iv) mapping and categorizing all the new, emerging forms of digital academic entrepreneurship, and (v) examining the effect of digital technology in different models of internationalization (Pergelova et al., 2019).

2.3 R1 and support pillar 3: digital products

Pillar 3 emerges from several articles (e.g., Ho & Lee, 2015; Ivanović-đukić et al., 2019; Rippa & Secundo, 2019; Schiavone et al., 2019) showing that adaptive strategies are created from digital technology, to meet market needs (Ho & Lee, 2015). In this context, new, innovative digital products are being created (Ivanović-đukić et al., 2019), from simple products developed by digital users (Schiavone et al., 2019) to the whole structure of digital academic entrepreneurship (Rippa & Secundo, 2019).

Digital technology creates changes in products, above all mediated by junior firms in universities, generating new paradigms and disturbing the existing industrial organisation, as it changes customers' needs. For Ho and Lee (2015), this relation is clear, since an empirical analysis of the photographic industry revealed how the technological transition from analog to digital occurred, supported by the internet and corporate intranets, for audio and video transmission, radically transforming and expanding the environment.

New digital products have created opportunities for entrepreneurs, from creative destruction, providing radically new digital solutions. In this context, Ivanović-đukić et al. (2019) studied 21 European countries and showed economic development to be the main focus of innovative, digital entrepreneurs. So opportunities for future

research emerge, in analysing strategies for paradigmatic change, setting out from new digital products created from universities (Ho & Lee, 2015) and research to analyse the impact on new, innovative, digital firms (Ivanović-đukić et al., 2019).

Relation 2 (R2): Digital Technology and Socio-Cultural Modifications. In this other consolidated field of research, digital technology has changed how the university student becomes a digital entrepreneur. This change is characterised as a socio-economic and technological phenomenon (Giones & Brem, 2017; Nambisan, 2017), causing cultural modifications. These modifications are supported by the internet, through open-code software and cloud computing (von Briel et al., 2018), which has accelerated in the Covid19 pandemic with the creation of functional strategies, processes and services, reformulating traditional market models and processes.

2.4 R2 and support pillar 4: individual characteristics

Pillar 4 resulted from various articles (Luckman, 2008; Mancha & Shankaranarayanan, 2020; Monllor & Soto-Simeone, 2019; Wallin & Fuglsang, 2017) showing how individuals with digital perception can break with institutional agreements (Wallin & Fuglsang, 2017). Indeed, digital literacy (Luckman, 2008) together with exposure to digital technology, can develop business self-efficacy in individuals (Monllor & Soto-Simeone, 2019), as well as developing entrepreneurial intention (Mancha & Shankaranarayanan, 2020), allowing the conclusion that Individual Characteristics are one of the pillars supporting R2.

Digital technology has broken down barriers at the individual level, transforming university academics in digital entrepreneurs and changing how the users of digital technology present their cultural perceptions and personal preferences (Luckman, 2008), allowing these users to become entrepreneurs (Schiafone et al., 2019). In addition, the commercialization of blogs and/or social media (McIntyre, 2020) make work different and significant (Symon & Whiting, 2019).

This has happened for new entrepreneurs in the health sector (Wallin & Fuglsang, 2017) and in the development of digital start-up entrepreneurs based at universities (Zaheer et al. 2019b). Here, the relation between each entrepreneur's individual characteristics and digital technology merge, with the potential to create digital entrepreneurial ecosystems (Song, 2019).

In this context, digital academic entrepreneurs develop and regenerate themselves through a virtuous cycle setting out from the individual, accessing the network which includes other institutions and a wider ecosystem (Toniolo et al., 2020a, 2020b). Therefore, it is necessary to study the individual characteristics of the digital academic entrepreneur, namely: entrepreneurial orientation, digital literacy, business self-efficacy and self-efficacy of digital technology (Mancha & Shankaranarayanan, 2020) and self-efficacy (Mancha & Shankaranarayanan, 2020; Monllor & Soto-Simeone, 2019).

Future research should: (i) test the role of experimental learning in a simulated environment in universities, changing individual characteristics with the aim of

raising the level of digital innovation (Mancha & Shankaranarayanan, 2020); (ii) analyse the impact of teaching in an academic environment (Mancha & Shankaranarayanan, 2020); (iii) explore how digital academic entrepreneurship emerges and evolves in different contexts (Toniolo et al., 2020a, 2020b); (iv) accompany how students with entrepreneurial intentions really become entrepreneurs (Monllor & Soto-Simeone, 2019); (v) study the socio-material relation of digital entrepreneurship (Schiavone et al., 2019), and (vi) show how new undertakings in the area of health are created (Wallin & Fuglsang, 2017).

2.5 R2 and support pillar 5: cultural characteristics

Pillar 5 emerged from various articles (e.g., Fernandes et al., 2019a, b; McAdam, 2020; Secundo et al., 2020b; Sperlich, 2011) showing that the use of digital technology potentializes female emancipation (McAdam, 2020); markets emerge, from associations between people and places (Fernandes et al., 2019a, b) and new university ecosystems are created (Rippa & Secundo, 2019). However, it can also make work precarious (Sperlich, 2011), allowing the conclusion that Cultural Characteristics are one of the pillars supporting R2.

Digital technology in universities added to academic entrepreneurship change existing cultures. For Sperlich (2011), the market of digital production of films, videos and photography in Austria saw a radical change in the cost of production means, professional functions and work methods, which allows one person alone or a small firm to carry out various or all phases of production.

Complementing this, Fernandes et al. (2019a, b) show that digital technology gives business-people working at the base of the pyramid the possibility of associations between people and places which was previously impossible, allowing a new market, especially for new university graduates who usually do not have working capital to begin in large firms.

In the same context, McAdam (2020) analysed female digital entrepreneurs in emerging economies such as Saudi Arabia, aiming to understand how they use technology to seek opportunities.

2.6 R2 and support pillar 6: knowledge-sharing

Finally, Pillar (6) also emerged from various studies (Elia et al., 2020; Henfridsson & Yoo, 2014; Li et al., 2018b; Toniolo et al., 2020a, b), which showed how constant enablement is generated in individuals, from digital technology (Henfridsson & Yoo, 2014), supported: (a) by collective intelligence (Elia et al., 2020), (b) digital ecosystems (Li et al., 2018a, b) and (c) the change in individual and institutional relations (Toniolo et al., 2020a, b), allowing the conclusion that Knowledge-Sharing is one of the pillars supporting R2.

Digital technology added to academic entrepreneurship change how knowledge is shared, both between individuals and between organisations. For Henfridsson and Yoo (2014), knowledge-sharing allows an organisation to produce innovative products, through the acquisition and implementation of digital technology. Li et al.

(2018a, b) also study how business-people in small and medium-sized firms with limited capacities and resources stimulate digital transformation in their firms, from a digital platform typical of small universities, creating wide-ranging renovation of the organisation.

In these circumstances, some suggestions for future research in this area concern the aim to understand how the process of changing the trajectory of digital institutional entrepreneurship occurs (Henfridsson & Yoo, 2014), and also understand how digital platforms can support SMEs' sustainable growth (Li et al., 2018a).

(e) **DT-AC Framework**

The results of all the quantitative and qualitative analyses carried out, as per the authors selected, are found to be interlinked, which allowed construction of the structural pillars of digital academic entrepreneurship, as grouped in the framework proposed here (Fig. 4).

3 Conclusions and contributions

This study built and proposed an innovative framework to explain the relation between Digital Transformation and Academic Entrepreneurship, during Covid19 pandemic, through an extensive literature review, based on pre-pandemic DT. This included a wide, representative set of studies on these two topics, formed of peer-reviewed articles published in journals with an impact factor.

The results obtained revealed two relations: Relation 1 (R1): Digital technology, business logic and academic entrepreneurial process, which covers the hard skill field of study, and Relation 2 (R2): Digital Technology and Digital Entrepreneurship, in the soft skill field of study.

Indeed, digital transformation (DT) caused by digital technology radically changes organisations and the world in general. In this context, universities also experienced accelerated social, environmental and even cultural changes, which require a change in attitudes, requalification and relearning on the part of academics, employees and human beings in general.

This original study contributes by providing a framework indicating and justifying the link between DT and the academic entrepreneurial process, identifying patterns, methods, skills and other discoveries in aspects such as management, information systems and culture sciences.

In addition, the framework proposed here shows the pillars supporting R1: (1) Management Tools, (2) Digital Processes, and (3) Digital Products, as well as the pillars supporting R2; (4) Individual Characteristics, (5) Cultural Characteristics, and (6) Knowledge-Sharing, something that shows the complexity of the phenomenon studied here. This study confirms the relation between digital transformation mediated by digital technology and academic entrepreneurship, in a digital economy where knowledge is intensive and also disruptive (Davidson & Vaast, 2010).

Table 6 Research agenda

Pillar	Researchers	Gap	Trends Topics
Digital Technology, Business Logic and Entrepreneurial Process			
1. Management Tools (MT)	Vorbach et al. (2019)	Show the relevance of entrepreneurial education, from MOOCs	Understand the competences, for the use of MT in education for entrepreneurship
	Arvidsson and Mønsted (2018)	Understand the obstacles to measuring the benefits of using MT in organisational innovation	Associate the use of MT with organisational innovation
	Cenamor et al. (2019)	How entrepreneurial SMEs can improve performance through digital platforms	Relate the use of digital platforms and SME performance
	Symon and Whiting (2019)	Investigate the role of MT in constituting significant work, in the context of the social entrepreneur	Explore how MT can support social entrepreneurship
	Brydges and Sjöholm (2019)	Understand the opportunities and challenges of using MT	Show how digital technology creates new types of professional activities
2. Digital Process	Rippa and Secundo (2019)	Lack of studies about the intersection of academic entrepreneurship with digital technology	Investigate how the use of DT accelerates entrepreneurship education
	Tumbas et al. (2018)	Show how new functions created by DT gain legitimacy	Analyse how the new digital logic creates new functions for the development of organisational innovation
	Hraes et al. (2013)	How the virtual space can alter how goods are produced, promoted, distributed and consumed	Show how non-digital are being adapted to digital strategies with the use of technology
	Pergelova et al. (2019)	The use of digital technology can impact on the internationalization process and whether the results suffer a gender effect	Understand how digital technology can accelerate the process of HEI internationalization
	Brydges and Hraes (2019)	In what way DT provides individuals with greater freedom to define: <i>where, when and how to work and live</i>	Show the importance of online spaces, for work and student mobility
	Suleymanova (2018)	Understand how DT can expand cultural consumption and the creation of a regional identity	Study how DT can add value in a region and spread its culture

Table 6 (continued)

Pillar	Researchers	Gap	Trends Topics
3. Digital Products	Rippa and Secundo (2019)	Intersection of academic entrepreneurship with digital technology	Show the social and economic benefits of using DT, in creating new products
	Schiavone et al. (2019)	Explore how entrepreneurs using DT create and commercialize new products	Relate the socio-material nature of DT and the entrepreneurship of digital users
	Ho and Lee (2015)	How technological innovations are interlinked with changing market needs and adaptive strategies	Analyse how DT impacts on organisational strategies and the development of new products in HEIs
4. Individual Characteristics and Socio-Cultural Modifications	Ivanović-đukić et al. (2019)	Show the effect of different types of digital entrepreneurship on economic growth	Show the factors that influence the development of digital innovative organisations
	Monllor and Soto-Simeone (2019)	Investigate how exposure to digital technology can develop digital business self-efficacy and the entrepreneurial intention	Relate DT exposure to the perception of digital self-efficacy and the entrepreneurial intention
	Luckman (2008)	Identify digital literacy, which can enable people to create products using DT	How to enable more people to take advantage of the opportunities provided by DT
	Mancha and Shankaranarayanan (2020)	Explore and understand the antecedents of digital innovation	Test the role of experimental learning with DT in students' entrepreneurial intention
	Wallin and Fuglsang (2017)	Explore how new undertakings can break institutional agreements (i.e. regulations, normative rules and cultural-cognitive beliefs)	Analyse how the actors of innovation negotiate alternatives and paths to the implementation of change
	Zaheer et al., 2019b	Explore factors contributing to the success of digital education start-ups	Test the factors shaping performance in innovative digital education start-ups

Table 6 (continued)

Pillar	Researchers	Gap	Trends Topics
5. Cultural Characteristics	Rippa and Secundo (2019)	Intersection of academic entrepreneurship with digital technology	Show the social and economic benefits of using digital technology in university ecosystems
	Fernandes et al. (2019a, b)	Investigate how micro-entrepreneurs on the margin of society, from collective efforts and DT, create new markets	Understand how micro-entrepreneurs manage to make new and powerful associations between people and places, to create an entrepreneurial path from DT
	McAdam (2020)	Investigate empirically the emancipatory potential of digital entrepreneurship for women in economically rich countries with restrictive social and cultural practices	Explore how age, deficiency and social class and religion can be crossed with the liberating potential of digital entrepreneurship
	Sperlich (2011)	How DT can be a two-edged sword for entrepreneurship, as on one hand it facilitates market entry, and on the other it raises the competition and makes work precarious	Relate how the autonomy provided by DT in entrepreneurial work can bring benefits, but also costs
6. Knowledge Sharing	Toniolo et al. (2020a, b)	Understand how digital academic entrepreneurship is developed, considering individual and institutional relations	How digital academic spin-offs can contribute to spreading innovation
	Elia et al. (2020)	How DT and the digitalization of knowledge are changing entrepreneurship	Study the impact of collective intelligence on new digital projects
	Henfridsson and Yoo (2014)	Show how digital institutional entrepreneurs establish new trajectories	Explore how digital institutional entrepreneurs constantly reconfigure their identity
	Li et al. (2018a, b)	Understand how digital platforms (Alibaba) create ecosystems with competing firms	Investigate how digital platforms create and develop their digital ecosystems

The internal relation in each pillar, as well as the interconnections and overlaps between them, were not studied in this work, namely (i) the perception of self-efficacy, (ii) social cognitive theory, (iii) individuals' belief in their capacities, and other aspects that are internal characteristics and form each pillar. Work can be done in the future to expand the framework presented here. Nevertheless, this study contributes to advancing the debate on digital transformation and academic entrepreneurship post-Covid 19.

4 Limitations and future research agenda

Like any study, this one is not without limitations. The first concerns the initial selection of articles, since other valuable research related to the topics studied may have been published in other places and were therefore absent from the database used. Secondly, the validity of the evidence collected is limited considering the "new normal" post Covid-19 pandemic. However, the structured methodology of bibliometric content analysis aimed to reduce this shortcoming, as it allows other researchers to replicate the study over time. It is hoped, therefore, that this study contributes to identifying gaps in the debate on digital academic entrepreneurship and can be an inspiration for future research by academics and professionals interested in advancing these promising areas of study.

Future research should therefore make longitudinal studies post Covid-19 to capture the development of digital business behaviour in real time.

In this context, it is suggested that future work should dissect each structural pillar identified here, namely: (1) Management Tools, (2) Digital Processes; (3) Digital Products; (4) Individual Characteristics; (5) Cultural Characteristic, and (6) Knowledge-Sharing, seeking to understand what happens internally in universities in each of these pillars, how they are formed and worked on and how this is transferred to the market in the form of academic entrepreneurship.

Thus, future research about these structural pillars is necessary to explain the challenges in this research area and which trend topics require more effort from academics, as well as capturing and understanding the overlaps and circularities between pillars. Against this backdrop, Table 5 displays the gaps identified in the reviewed papers, emerging as a future research agenda.

It is also necessary to analyse how socio-material theory can affect the DT relation, via digital technology and academic entrepreneurship, something referred to by Nambisan (2017). In addition, future research can also include topics related to the perception of self-efficacy as part of Bandura's social cognitive theory, which assumes that personal beliefs in individual capacities can be an essential element in developing academic entrepreneurship (Table 6).

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