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Digital Academic Entrepreneurship: A structured literature review and avenue for a research agenda

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ABSTRACT

This paper reviews the Academic Entrepreneurship literature according to the emergence of powerful Digital technologies, providing an overview of the state of research and outlining a future research agenda about Digital Academic Entrepreneurship. One hundred and sixty-five journal papers were initially extracted from Scopus and their content was analysed for the paper selection process by two researchers in parallel, plus a third one in case of uncertainty. Finally, fifty-nine papers dealing with digital academic entrepreneurship and published in a variety of academic journals have been analyzed through a content and a bibliometric analysis. Findings show that literature on Digital Academic Entrepreneurship is really scant and dominated by unrelated research. Content analysis provides the emergence of four major research streams: 1) Digital Technologies for Entrepreneurship Education; 2) The "maker space movement" for Academic Entrepreneurship; 3) Digital technologies for discovering entrepreneurial opportunities; 4) Creating entrepreneurial competences in the Digital "University-based" Entrepreneurial ecosystems. The paper presents the first attempt to provide a comprehensive structured literature review of the disruptive role of digital transformation for the Academic Entrepreneurship. Despite the growing literature on Digital Entrepreneurship, this research area is still fragmented and under-theorized. More systematic and holistic studies, considering both the technological, economic and the social aspects of Academic Entrepreneurship are required.

1. Introduction

Academic entrepreneurship, has attracted major attention both within the academic literature, policy community as well as business community (Teixeira and Nogueira, 2016) where it is considered as being an important element in the evolution toward a knowledge society (Audretsch and Lehmann, 2005; Davey et al., 2016; Anand and Singh, 2011; Rothaermel et al., 2007). Defined as the process universities adopt to achieve their entrepreneurial configuration (O'Shea et al., 2004; Shane, 2004; Wright et al., 2007; Grimaldi et al., 2011; Rasmussen et al., 2015), academic entrepreneurship includes activities such as University's research collaborations with industry, patent applications, idea spin-offs into new firms, entrepreneurial education of highly skilled individuals and business incubators (Shane, 2004; Siegel and Wright, 2015; Somsuk and Laosirihongthong, 2014).

In parallel to this, it is not possible to forget the rapid acceleration of digital transformation that through digital technologies is reshaping society globally (Nambisan et al., 2017; Kraus et al. 2018). Digitalization is opening up fascinating innovation opportunities for innovators, creators and entrepreneurs (Carayannis et al., 2006; Yoo et al., 2010; Cohen et al., 2017; Nambisan, 2017; Ramaswamy and Ozcan, 2018), and governments have a role in stimulating technological development (Dolfsma and Seo, 2013). The disruptive role of digital technologies cannot also be neglected in the academic context where the threefold missions, i.e. education, research and "third mission" (Dalmarco et al, 2018; Etzkowitz, 2016; Secundo et al., 2017) could benefit from the generative potential on several activities. As far as the latter is concerned, the impact of digital technologies is intense on different activities of academic entrepreneurship (Rothaermel et al., 2007) such as research collaborations with industry, patent applications, transformation of innovative ideas in spin-offs, entrepreneurial education of highly skilled individuals, technology transfer or business incubators (Birtchnell, et al 2016; Good et al., 2019; Shane, 2004; Mian et al., 2016; Horta et al., 2016; Somsuk and Laosirihongthong, 2014).

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Recent developments in the scenario of digital transformation call for a revision and the advancement of the academic entrepreneurship concept towards a digital focus, i.e. digital academic entrepreneurship recently coined (Rippa and Secundo, 2019). The possible combinations of digitalization in the university ecosystem results in a diversity of phenomena with significantly different characteristics and socio-economic impacts (Giones and Brem, 2017), overhauling the traditional mission of commercializing academic research (Siegel and Wright, 2015; Holley and Watson, 2017; Kalar and Antoncic, 2015). *Digital Academic Entrepreneurship* has been defined 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 a broader range of innovation development that goes beyond the region (Rippa and Secundo, 2019). Digital Academic Entrepreneurship engages more stakeholders through novel digital technologies for the identification of entrepreneurial opportunities and more in general for the development of the entrepreneurial process in the University Ecosystem.

The implications of digital revolution for academic entrepreneurship can be addressed with reference to a variety of issues. So far, how digital technologies are affecting the way individuals face innovation processes and, eventually, new academic firms' creation, remains an issue yet to be addressed. Following the call from Siegel and Wright (2015) for future research on academic entrepreneurship, we acknowledge the complexity and richness of digital academic entrepreneurship issues. We would like to understand the phenomenon from different perspectives, trying to contribute to theory, practices and policy makers by providing new theories, frameworks, models and cases to foster its development. This new wave of digital academic entrepreneurship will introduce substantial challenges on how to handle technology, management, government policies and stakeholders' engagement in the academic entrepreneurship process. A holistic perspective about the emerging research stream of Digital Academic Entrepreneurship is indeed required to posit new directions for research about the impact of digital technologies on the academic entrepreneurial process.

Even if Structured Literature Review (SLR) about Academic Entrepreneurship and Digital innovation exist separately, such as University Entrepreneurship (Rothaermel et al., 2007) University and Technology Transfer (O'Shea et al., 2004), Academic engagement and commercialisation (Perkmann et al., 2013), Technology Transfer Ecosystem (Good et al, 2019) to our best knowledge no SLR exists regarding the new concept of Digital Academic Entrepreneurship. According to Massaro et al. (2016), an SLR "is not the end of the road, but the beginning of new journeys". The main goal of this paper is therefore to investigate the effects of digital technologies on academic entrepreneurship activities, bridging and combining two consolidated streams of literature, digitalization and academic entrepreneurship to form digital academic entrepreneurship. The final purpose is to identify the relationships, connectivity and interdependencies between digitalization and academic entrepreneurship. This motivates the need for our study.

Interestingly, the findings show the focus of the extant literature primarily on four research areas: 1) Digital Technologies for Entrepreneurship Education; 2) The "maker space movement" for Academic Entrepreneurship; 3) Digital technologies for discovering entrepreneurial opportunities; 4) Creating entrepreneurial competences in the Digital "University based" Entrepreneurial ecosystems. These results highlight the partial comprehension of the phenomenon observed and are an useful baseline for academic and practitioners implications about the evolution of the Digital technologies for the Academic Entrepreneurship. Additionally, the paper is aimed to identify lessons learnt and research gaps, and by this to provide an agenda for future researches.

The remaining of the paper is structured as follows: after the introduction, in Section 2 the methodology is illustrated. The Section 3 presents the findings in terms of descriptive statistics, content and thematic analysis. Moreover, the research streams emerging from the cluster analysis are described and discussed. In the final sections, conclusions and implications are detailed.

2. Methodology

This paper is founded on a structured literature review (SLR) approach to analyse the state of the art on the topic investigated (Massaro et al., 2016; Petticrew & Roberts, 2006; Tranfield et al., 2003). According to (Massaro et al., 2016) a SLR is a rigorous and relevant approach that produces knowledge, contributes to identifying research trends and paths, as well as potential future research. An "SLR offers an empirical grounding that avoids missing seminal articles and reduces researcher bias" (Tranfield et al., 2003). More in details, according to (Tranfield et al., 2003), our structured review method is based on manual filtering for its replicable process that allows minimizing bias in the findings. Compared to automatic filtering, this method allows authors to identify and synthesise all relevant contributions using a transparent review process and provide an overview of both quantitative and qualitative issues. According to (Centobelli et al., 2018), theoretical and content analysis are conducted using a hybrid inductive and deductive approach for the identification of the research areas.

In this section we summarise the main methodological steps suggested by previous studies (Dumay, 2010; Massaro et al., 2015a; Massaro et al., 2015b) in order to develop a **5D** systematic, transparent and replicable literature review methodology:

1 **D**efine the research questions
2 **D**esign a review protocol
3 **D**etermine the articles to include and carry out a comprehensive material search
4 **D**evelop a coding framework
5 **D**iscuss the results.

Firstly, as for the definition of the research questions, according to (Massaro et al., 2016) this is the preliminary step to conduct a SLR. In this study, we identified three research questions:

RQ1. How is the impact of digital technologies for academic entrepreneurship literature developing?
RQ2. What is the focus of the literature within digitalisation for the entrepreneurial (process of) universities?
RQ3. What are the implications of our research for the field of Digital Academic Entrepreneurship?.

Secondly, the research protocol was designed to determine the source of information, the methods to use, the studies to analyse and the tools for analysing and synthesizing these studies (Petticrew and Roberts, 2006). In this study, it was chosen to perform both a SLR and a bibliometric analysis in order to minimize mistakes in interpreting findings of collected studies. The approach of crossing SLR and bibliometric analysis was chosen in this study to enhance the value of the literature review findings and minimize mistakes in interpreting them (Fahimnia et al., 2015; Feng et al., 2017).

Thirdly, regarding the determination of articles to include, we focused on Scopus database to retrieve all the relevant material. This choice was based on the previous studies that have shown that the overall Scopus database coverage of academic journals is higher than other databases and there is only a small percentage of relevant journals not indexed in Scopus (Mishra et al., 2017; Thelwall, 2018; Waltman, 2016). The search string used for searching articles useful to be included in this study were firstly identified by querying a set of relevant keywords. The material search phase was conducted in May

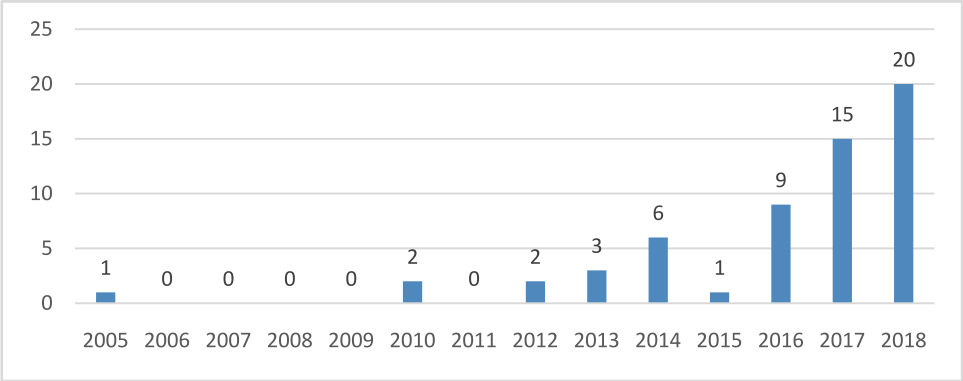

Fig. 1. Distribution of papers over time.

2019 and, using as keywords "academic entrepreneurship" OR "entrepreneurial universit*" in combination with "digital technolog*" OR "digital transformation" OR "digitalization", 165 journal papers were initially extracted from Scopus. Furthermore, the search string was validated comparing our keywords with additional keywords used by the individual papers identified in the initial list. Specific digital technologies (i.e., augmented reality, internet of things, 3D printing, blockchain) emerged as frequent keywords and it was included in the string as a validation criterion. The asterisk after the keywords "universit*" and "technolog*" was used to retrieve also papers including, for example, "universities" and "technologies". In addition, the inclusion of the terms "augmented reality", "internet of things", "3D printing", "blockchain" allowed us to retrieve additional papers dealing with digitalization issues affecting entrepreneurial universities, but not directly reporting the word "digital technology", "digital transformation" or "digitalization". According to (Gunasekaran et al., 2015) only articles published in peer-reviewed journals have been included in the review process (excluding conference proceedings and book chapters).

Fourthly, in order to focus on the research products closer to the topic under investigation, the one hundred and sixty-five journal papers extracted from Scopus were analysed by two researchers in parallel, plus a third one in case of uncertainty (Centobelli et al., 2018). This classification was based on the entire manuscript and not merely on the evaluation of the abstract or specific paragraphs. When the concept of digitalization or academic entrepreneurship was not considered simultaneously, the paper was excluded from the sample. At the end of this process, fifty-nine papers were selected and three researchers were employed in classifying the papers belonging to the final sample.

Fifthly, the final step consisted in developing the coding framework based on similar research frameworks. In this research, the selected papers were analysed considering the following perspectives: 1) time evolution; 2) authors' country; 3) journals; 4) bibliographic-coupling of authors and documents; and 5) common keywords and focus topics. As for the keywords analysis we used the author keywords occurrences to identify the most relevant and used ones. Another relevant category of coding consisted of the distribution of articles among countries, aimed to underline how literature supports the development of a scientific discourse within specific national settings (Massaro et al., 2015c).

Among the different software packages used to analyse and map the state of the art of digitalisation in academic entrepreneurship, in this paper we used VOSviewer software to conduct such analyses for its focus on the graphical representations of the maps (Castillo-Vergara et al., 2018). VOSviewer allows researchers to cluster and analyse the relationships among papers, authors, institutions and countries (van Eck and Waltman, 2010) through bibliographic coupling analysis, co-citation analysis, and co-occurrence of keywords. Bibliographic coupling occurs when a paper is cited by two other papers (Li et al., 2017). Co-citation occurs when two papers are cited by a third one. Co-occurrence of keywords occurs when a group of keywords co-occur in at least two different papers. Some papers reported in the literature conduct longitudinal co-citation and co-occurrence analysis to investigate the evolution of a field of research over time (Glänzel and Schubert, 2004; Liang and Liu, 2018). In doing that, the clustering technique is already set as appropriate for bibliometric analysis by VOSviewer developers (Van Eck and Waltman, 2014). Clustering refers to distances between nodes, and the groups are determined by minimizing such distances. This is the starting point of the clustering process defined by (Waltman, et al., 2010). Finally, to provide an overview of emerging trends, research gaps and future directions, content analysis was conducted. In the next section, the main findings of this research are presented and discussed. Furthermore, for all statistical computations and for designing topic dendrograms and thematic maps we took advantage of the free software R (R Development Core Team, 2009).

3. Research findings: insights and critique

This section aims to present the results obtained from the analysis that answers to the first two research questions of this study: RQ1. How is the impact of *digital technologies for academic entrepreneurship* literature developing? RQ2. What is the focus of the literature within *digitalisation for the entrepreneurial (process of) universities*?

3.1. Descriptive analysis

Following the coding framework, this section explores articles by *evolution on time,* geographic distribution, author and citation analysis, journals, common keywords of the articles and focus topics.

The figures and tables that follow present the main evidence resulting from the structured literature review and offer a comprehensive reading of the trends characterizing the advancement of the debate on Digital Academic Entrepreneurship from 2005 so far.

3.1.1. Articles evolution in time

Fig. 1 describes the trend of the research papers developed over the years. A growing interest by scholars and researchers in the investigation of the research topics at the intersection of the debates on Digital Technologies and Academic Entrepreneurship can be identified since 2014, even if a first paper had been published in 2005. The peak year for relevant publications in journals was 2018, presenting a positive trend of increase started in 2010. This means that the relationship between Digitalization and Academic Entrepreneurship is a novel issue in the literature that is now receiving more attention, after the years 2006–2009 when no articles have been found. The first paper, published in 2005 by Human, S. E., Clark, T., & Baucus, M. S. ("Student online self-assessment: Structuring individual-level learning in a new venture creation course" published in Journal of Management Education) provides a first attempt to connect the importance of Digital Technologies, such as MOOCs, to create the required competence of

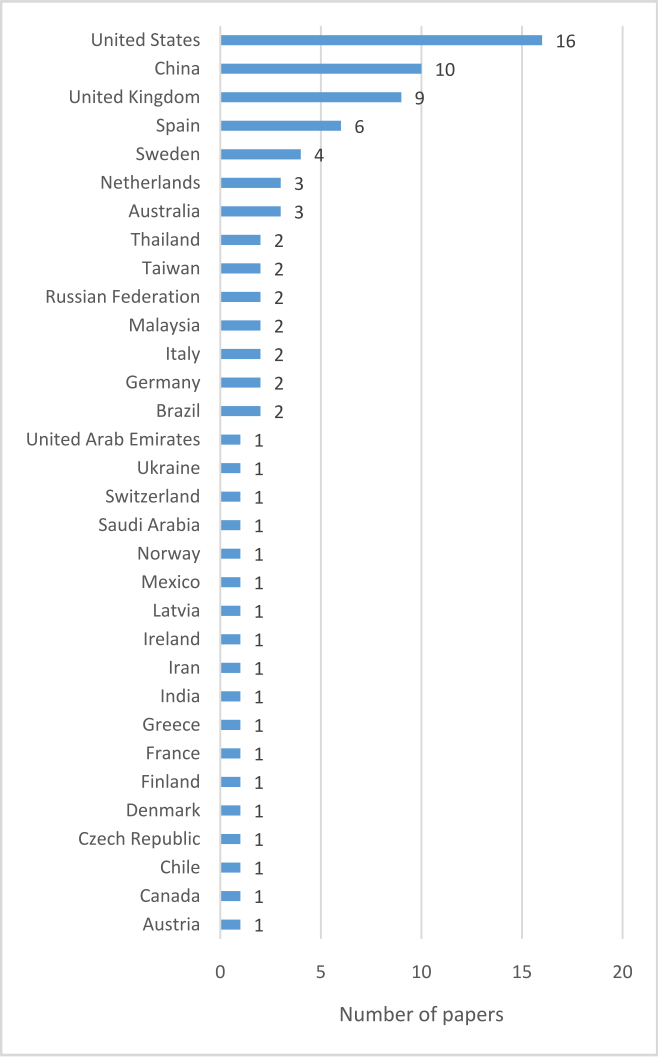

Fig. 2. Number of papers per country.

university students for Academic Entrepreneurship. After this, the published papers have started to be focused on the other processes of academic entrepreneurship, such as the collaboration between University and Industry, the spin –off creation, to understand the supporting role of the digital technologies.

The shape of the curve in Fig. 1 seems to follow the classical trend of diffusion of innovation theory (Rogers, 2010). In this review of the literature, universities are considered an organization that are successively adopting digital technologies.

3.1.2. Geography of articles

The geographical distribution of the articles as indicated in Fig. 2, immediately reveal that countries with the highest number of the articles are USA, China and UK (with 16, 10 and 9 articles respectively), followed by Spain (6), and Sweden (4). Looking at the position of the other countries, It is possible to note that the issue of Digital academic Entrepreneurship doesn't present an interest for a specific country because several other countries spanning from Europe, Canada to Asia are emerging with the publishing of scientific contributions. Although the number of papers in these countries is low (just one paper per country), the bar chart allows identifying a diffused interest at a global level.

Considering the citation trend of countries (Fig. 3), it could be easily understood that the contribution offered by USA as a country with higher productivity is also confirmed as the country most cited. This reveals the USA leadership position in the phenomenon of Academic Entrepreneurship and also for the adoption of digital technologies. On the other side, the citations' analysis provides a different position of other countries (compared to that of Fig. 2): e.g. Sweden, goes up with one position from the fifth place for the production to second place for the citations received; while, China, goes down to the fifth place from the second into the previous Fig. 2.

Furthermore, Figs. 4 and 5 respectively highlight how authors belonging to different countries and institutions interact with each other (Garfield, 1970; van Raan, 1996; Aria and Cuccurullo, 2017).

3.1. 3 Journals

The fragmentation of the scientific community on the topic of Digital Academic Entrepreneurship is also evident looking at the journals where the articles in our sample have been published. It is not worth to note that only 5 journals (out of 53) have published more than one article related to the theme and include: *Technical Bulletin* (with 4 articles) followed by *Entrepreneurship: Theory And Practice, Eurasia Journal Of Mathematics, Science And Technology Education; Technological Forecasting And Social Change and Kuram Ve Uygulamada Egitim Bilimleri* that are home for 2 articles each. It's clear that these journals are characterized by different perspectives publishing paper with a specific focus on technology, education or Entrepreneurship. This means that so far, the concept of Digital Academic Entrepreneurship could be deepened from several angles.

If these are the journal with the highest number of records publishes, the remaining 48 journals published just one article, even if in some cases they presented a high number of citations (Information Systems Research, with one article and 563 citations, and *Organisation Science* with 435 citations). The journals *Entrepreneurship: Theory And Practice, Technovation, Advances In Engineering Education* are ranked at the third, fourth and fifth position in terms of citations' number (106, 39 and 38 respectively) after the first two mentioned journal. This could be easily noticed from Table 1, which presents the top 15 journals per number of citations.

This analysis demonstrates that there is a high fragmentation of the researches in the exploration of topics of Digital Academic Entrepreneurship, and also the lack of structured and mature research on the field. Indeed, it is possible to note that the most influential journals for the number of records and citations are *Entrepreneurship: Theory And Practice* and *Technological Forecasting and Social Change*.

3.4. Citations and most influential authors

The value of citations for 2010 and 2012, the highest registered in the period observed (as showed in Table 2), allows deriving a positive recognition of these works also into the papers that followed. This circumstance clearly allows to understand that the scientific community interested to the exploration of the Digital Technologies adoption into the context of for Academic Entrepreneurship is refereeing to the seminal works of 2010, 2012, 2014 into their new contributions.

The trends characterizing the number of citations received by each paper, as described into Table 2, demonstrate the relevance that the papers published in the first period, and specifically in 2010 and 2012 and 2017, have consolidated into the community of scholars interested in. It's not possible to derive a general trend in the citations since the situation changes every year.

Fig. 6 presents the citations' trends associated with the papers for the year. The bar chart depicts a trend that is similar to the evidence highlighted in Table 2 and related to the advancement of productivity of paper, due to the circumstance that in the period with larger number of works published there is a direct implication in terms of citations' growth.

Regarding the most cited authors and papers, Table 3 discerns the rank of total citations and the relative CPY for the first 3 most cited authors. As it could be noted Yoo et al. (2012) ("Organizing For Innovation In The Digitized World") is the most cited paper followed by

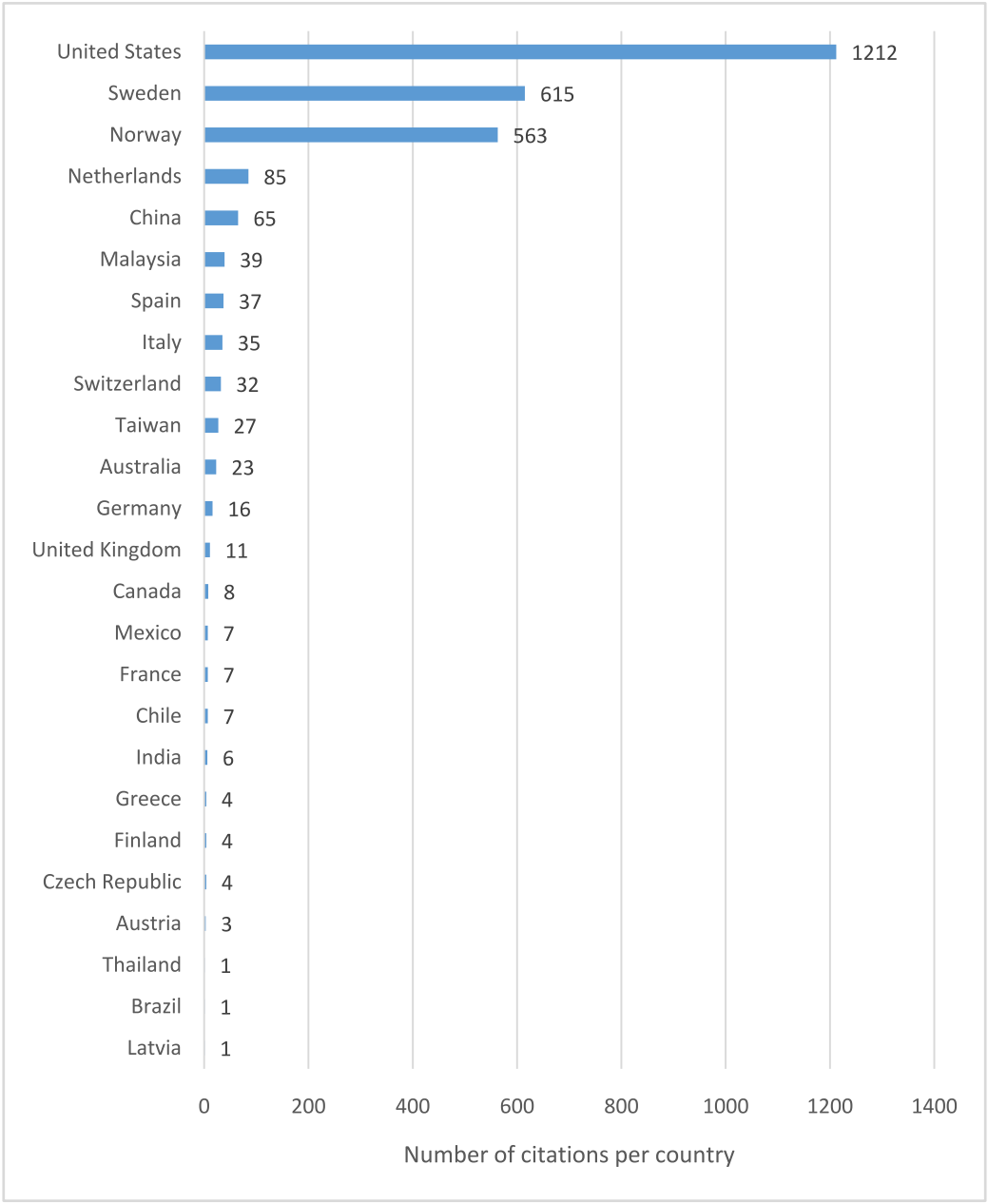

Fig. 3. Number of citations per country.

another paper of the same Author Yoo et al. (2010). To better evaluate the citations trend of authors it is relevant to consider the CPY, being that it has been argued as a large number of articles published impact on decreasing the CPY value (Massaro and Dumay, 2015). In addition, articles published in recent years "have not had sufficient time to garner citations" (Dumay, 2014, p.22). Also in relation to CPY, our analysis reveals that the papers with the highest CPY are those published in 2010 and 2012, that corresponds to earlier years of contribution on the theme of Digital Academic Entrepreneurship. Interestingly, the maximum CPY is 80,42 while the minimum CPY of the ten most cited one is 0,2 showing in general as well as wide difference among values that are five times lower the most cited one.

These results suggest that prospective authors who want to publish on these topics should "think carefully about how their research is transformational [. . .]" (Dumay, 2014, p. 20), and consider not only popular research frameworks and methods already utilized in previous research but also propose new ones.

3.5. Topics and keywords

This section defines the main keywords covered by the 59 articles analysed. Keywords are used by authors, editors and publishers to signal important themes in articles. According to Silverman (2013, p. 275), keyword analysis "is a method that allows you to analyse very large amounts of text without losing touch with focusing on small amounts of the material in considerable depth". In this paper, keywords are classified and analysed through social network analysis. While, Booker et al. (2008, p.240.), argues that "practitioners search for articles based on topics or keywords as they are needed". Similar to the study performed by Ribiere and Walter (2013), keywords were extracted from the articles and a dictionary of terms was created by aggregating similar keywords (e.g. "Entrepreneurial university", "Entrepreneurial university", "Academic entrepreneurship" "University Entrepreneurship" are all connected with the "university" dimension). Table 4 presents the occurrences of different keywords found in our

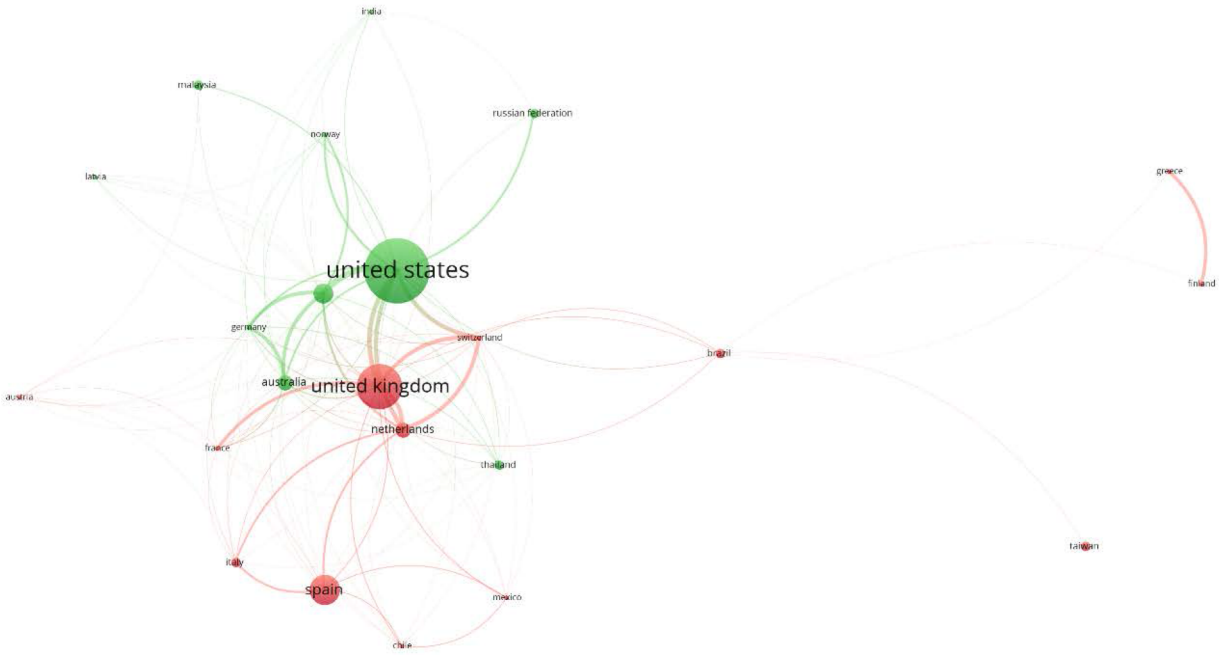

Fig. 4. Country collaboration.

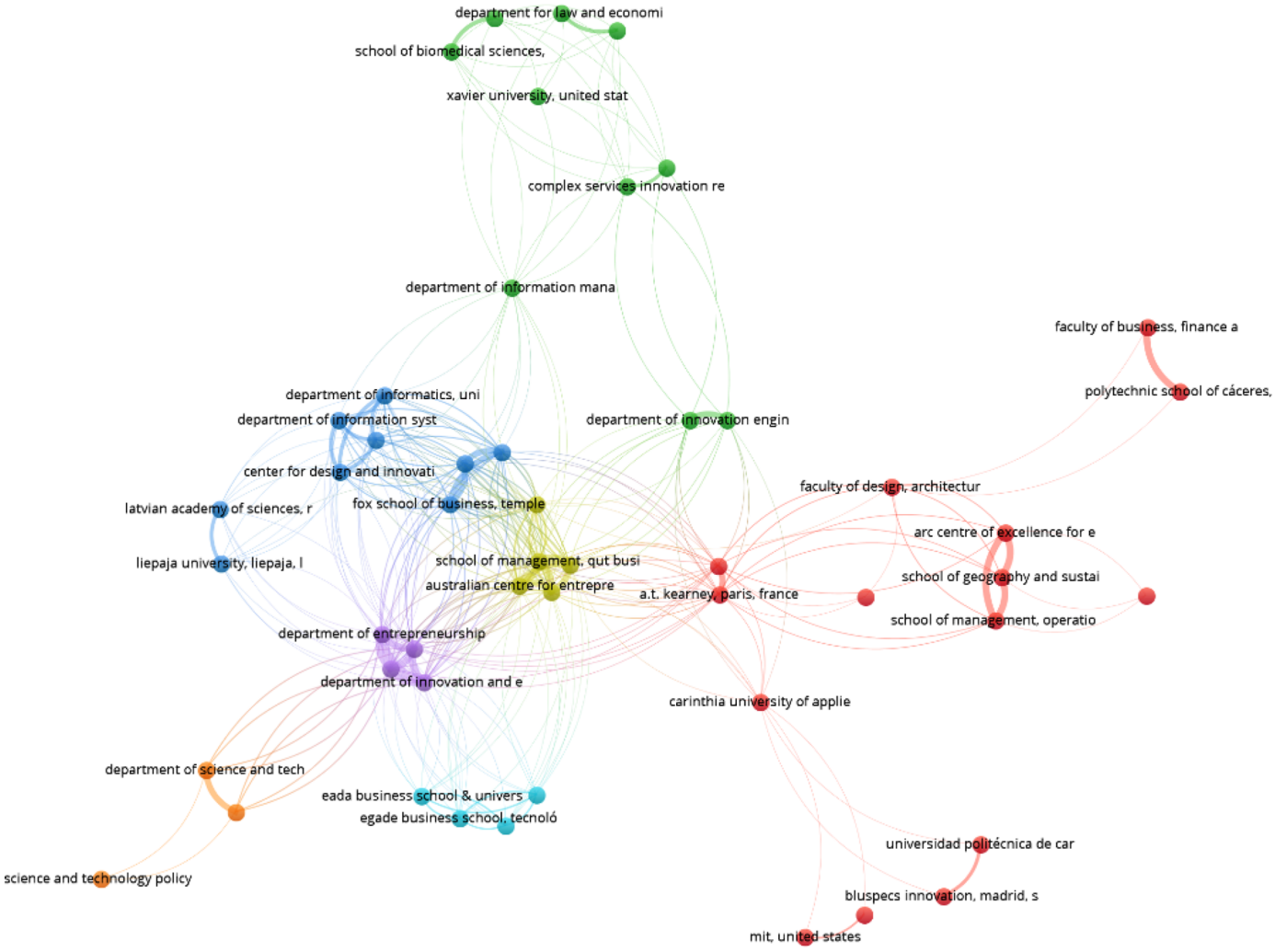

Fig. 5. Institution collaboration.

Table 1
Top 15 Journals per N° per Citations.

Journal	No. of records	Citations
Information Systems Research	1	563
Organization Science	1	435
Entrepreneurship: Theory And Practice	2	106
Technovation	1	39
Advances In Engineering Education	1	38
Information Research	1	36
Strategic Entrepreneurship Journal	1	32
Computers And Education	1	24
Entrepreneurship And Sustainability Issues	1	18
International Journal Of Entrepreneurial Behaviour And Research	1	18
Entertainment Computing	1	17
International Journal Of Emerging Technologies In Learning	1	10
Journal Of Management Education	1	10
Technological Forecasting And Social Change	2	9
Educational Media International	1	8

Table 2
Citations Trends.

Publication year	No. of records	Citations
2005	1	10
2010	2	437
2012	2	568
2013	3	9
2014	6	109
2015	1	3
2016	9	78
2017	15	147
2018	20	57

sample that appear simultaneously at least 3 times, as well as the interrelationship and networking among them.

This analysis reveals that Entrepreneurship is the most recurrent keyword (7 times) followed by entrepreneurship education, Innovation and University. The technologies most recurrent are 3D printing and additive manufacturing as they represent other recurrent keywords. These findings are interesting as they indicate that the most recurrent academic entrepreneurship process considered in the studies related to digitalization is the process of entrepreneurship education as the foundation to create the adequate competence in university to develop more entrepreneurial ability, and to a lesser extent to other types of processes connected to the research and third missions of the academy (Pena et al, 2014). This is aligned with the conceptualization of Digital Academic Entrepreneurship as provided by Rippa and Secundo (2019). Specifically, *Digital Academic Entrepreneurship* is a process characterised by a high level of utilization of new digital technologies to improve the emerging forms of academic entrepreneurship, such as the development of digital spin-offs and alumni start-ups, the creation of entrepreneurial competence supported by digital platform and a more wide 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.

Interestingly, analyzing the clustering of the keywords, the results show 4 main clusters as depicted in Fig. 7. The size of the spheres in Fig. 7 represents their relative importance (larger circles have connections to more articles) calculated using the degree centrality measure. As argued by McCulloh et al. (2013) the degree centrality specifies the agents with the major number of straight links to and from other agents.

A topic dendrogram was designed to observe the hierarchical relationship between keywords that generates from hierarchical clustering (Fig. 8). Dendrograms are used to allocate the objects to clusters by measuring the height of the different objects joined together in branches. The topic dendrogram highlights that the body of literature is divided in two main research branches: a technology-driven digital academic entrepreneurship and an education-driven digital academic entrepreneurship. Technology-driven digital academic entrepreneurship combined digital manufacturing topics focusing on Industry 4.0 enabling technologies (e.g., additive manufacturing, 3d printing) and topics related to a technology-based extension of do it yourself (DIY) culture involving 'makers' and 'makerspace' that revels in the creation of new products and devices as well as tinkering with existing ones. Education-driven digital academic entrepreneurship combines education topics (e.g., higher education, university, engineering education) and entrepreneurship topics (e.g., entrepreneurship, new venture, entrepreneurship education).

3.2. Clustering and content analysis

The content analysis phase has been conducted starting from the

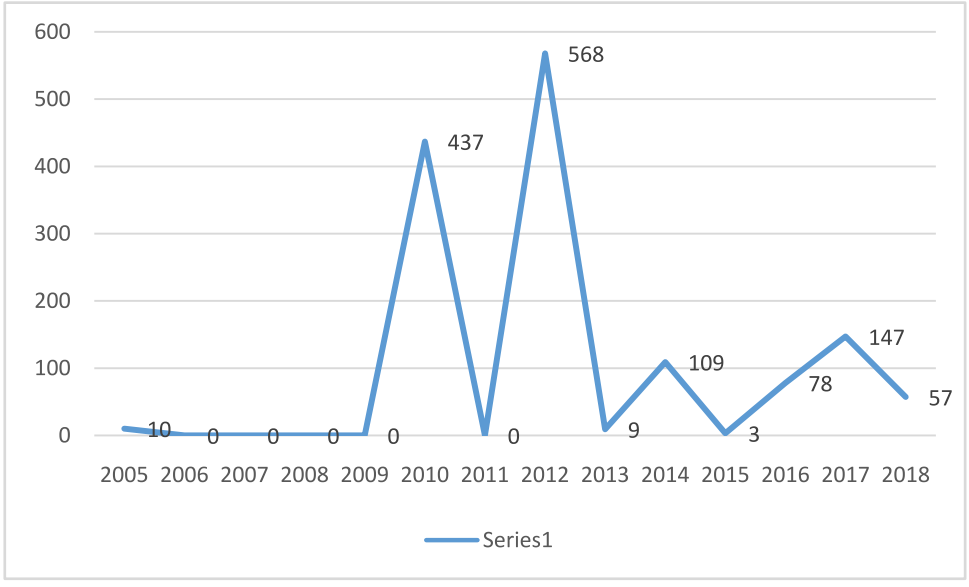

Fig. 6. Trend of paper's citations for year.

Table 3
Top 10 authors and papers per Citation and Citation per Year (CPY).

Authors		Title	Journal	Citations	CPY
Yoo, Y., Boland Jr, R. J., Lyytinen, K., And Majchrzak, A.	2012	Organizing For Innovation In The Digitized World	Organization Science	563	80.42
Yoo, Y., Henfridsson, O., And Lyytinen, K.	2010	The New Organizing Logic Of Digital Innovation: An Agenda For Information Systems Research	Information Systems Research	435	48.33
Nambisan, S.	2017	Digital Entrepreneurship: Toward A Digital Technology Perspective Of Entrepreneurship	Entrepreneurship Theory & Practice	90	45
Autio, E., Nambisan, S., Thomas, L. D., & Wright, M.	2018	Digital Affordances, Spatial Affordances, And The Genesis Of Entrepreneurial Ecosystems	Strategic Entrepreneurship Journal	32	32
Von Briel, F., Davidsson, P., Recker, J.	2018	Digital Technologies As External Enablers Of New Venture Creation In The It Hardware Sector	Entrepreneurship Theory And Practice	16	16
Hammarfelt B; Derijcke S; Rushforth Ad	2016	Quantified Academic Selves: The Gamification Of Research Through Social Networking Services	Information Research	36	12
Chang, S. H.	2017	The Technology Networks And Development Trends Of University-Industry Collaborative Patents	Technological Forecasting And Social Change	24	12
Secundo G; Del Vecchio P; Schiuma G; Passiante G	2017	Activating Entrepreneurial Learning Processes For Transforming University Studentsâ €™ Idea Into Entrepreneurial Practices	International Journal Of Entrepreneurial Behaviour And Research	18	9
Al-Atabi, M., And Deboer, J.	2014	Teaching Entrepreneurship Using Massive Open Online Course (Mooc)	Technovation	39	7.8
Forest Cr; Moore Ra; Jariwala As; Fasse Bb; Linsey J; Newstetter W;Ngo P; Quintero C	2014	The Invention Studio: A University Maker Space And Culture	Advances In Engineering Education	38	7.6

Table 4
Keywords occurrences.

Keyword	Frequency
entrepreneurship	7
entrepreneurship education	6
innovation	4
university	4
3d printing	3
additive manufacturing	3
higher education	3
students	3
universities	3

Bibliographic coupling (Kessler, 1963) using the 59 papers included in the data sample. As explained in the methodological section, the unit of analysis were documents and sources, and the relatedness is evaluated by considering the articles that mainly share the same references (Boyack and Klavans, 2010). The result of this analysis produced 4 clusters. We considered this clustering to avoid the fragmentation of results as well as the unpacking of same topic to different areas. The clusters considered bring together those articles that may mark a specific topic/approach. To guide the content analysis of the papers included in the sample, we performed the clustering algorithm proposed by (Van Eck and Waltman, 2014; 2017). The modularity class has been used to find nodes of the network that are more densely connected and identify clusters of papers (Fig. 9).

Fig. 9 shows the clusters based on the strength of the closeness by considering the number of common bibliography appearing in the article. Therefore, the cluster technique of VOSviewer software works out after running 10 interactions.

Starting from bibliographic coupling, four main research areas have been identified by carefully reading the clustered papers, in order to synthetize the body of knowledge. The main research areas along with their focus, details and description are listed in Table 5 as follows:

- *Research area 1 (blue cluster): Digital Technologies for Entrepreneurship Education*
- *Research area 2 (green cluster): The "maker space movement" for Academic Entrepreneurship*
- *Research area 3 (red cluster): Digital technologies for discovering entrepreneurial opportunities*
- *Research area 4 (yellow cluster): Creating entrepreneurial competences in the Digital "University based" Entrepreneurial ecosystems.Research area 1: Digital Technologies for Entrepreneurship Education* with a specific focus on the "Entrepreneurially equipped students: models and tools" in terms of new experiential learning processes (Gupta and Bharadwaj, 2013), toolkits for entrepreneurial education (Watts and Wray, 2012; Smith and Paton, 2010), self-assessment tools (Human et al., 2005). Nowadays, the Experiential Learning Theory (Kolb, 1984) represents one of the forms of learning typically used in educational contexts. It is characterized by the fact that the educational method is based on the role played by experience in the learning process. This theory contrasts with the two classic types of learning theories, namely cognitive and behavioral theories. The main difference lies in inducing in the student a concrete experience during learning, rather than relying on cognitive aspects or related to the student's perceptions. The experience refers not to the results of an experiment, but to the reflection that derives from the experience itself. This theory is experiencing a flourishing period due to digital technologies, which allow the reproduction of a physical environment or a risky experience in a protected mood. Augmented reality, additive manufacturing, social networks, are some examples of how technologies are revolutionizing aspects related to learning, and how education methods are changing. Even in the field of entrepreneurship education, conceptual frameworks and educational tools such as those represented by this research area

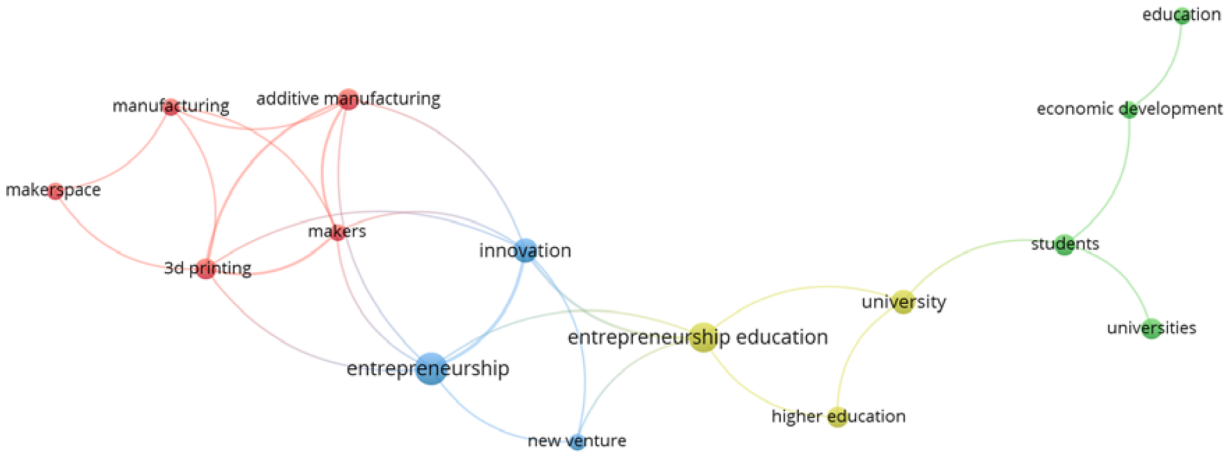

Fig. 7. Clusters of Keywords.

are being developed. Gupta and Bharadwaj (2013) have developed a general framework for approaching entrepreneurship education in a business school through the use of augmented reality and social networks. The proposed conceptual model aims to develop the concept of entrepreneurial agility through education. Watts and Wray (2012) proposed a toolkit based on the use of commercial software to increase attitudes towards entrepreneurship by STEM students. The toolkit is essentially based on the use of simulation software, a type of tools that in the field of pedagogy make them find a high consensus on the part of the students who use them. Among the different technologies, even the

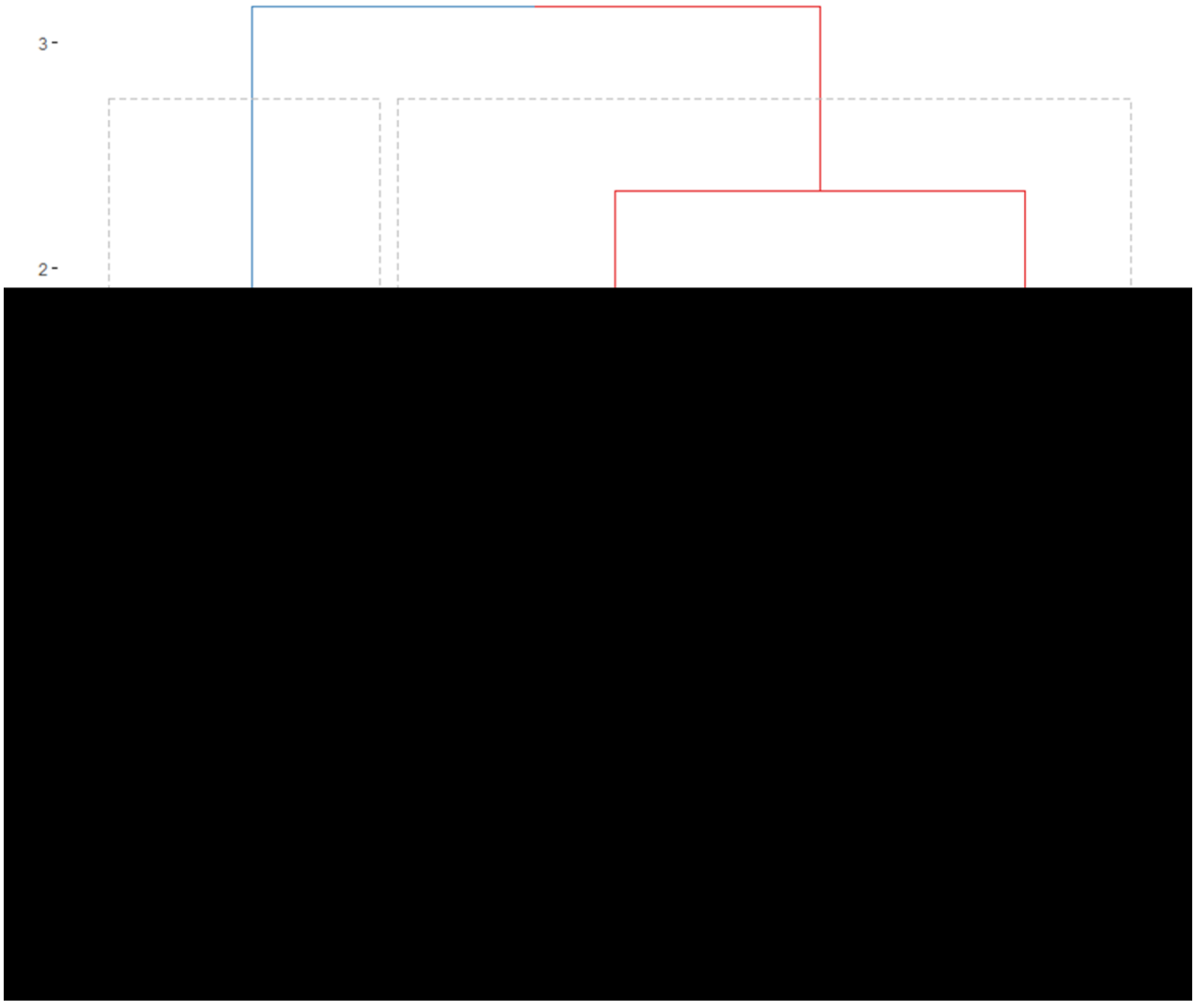

Fig. 8. Topic Dendrogram.

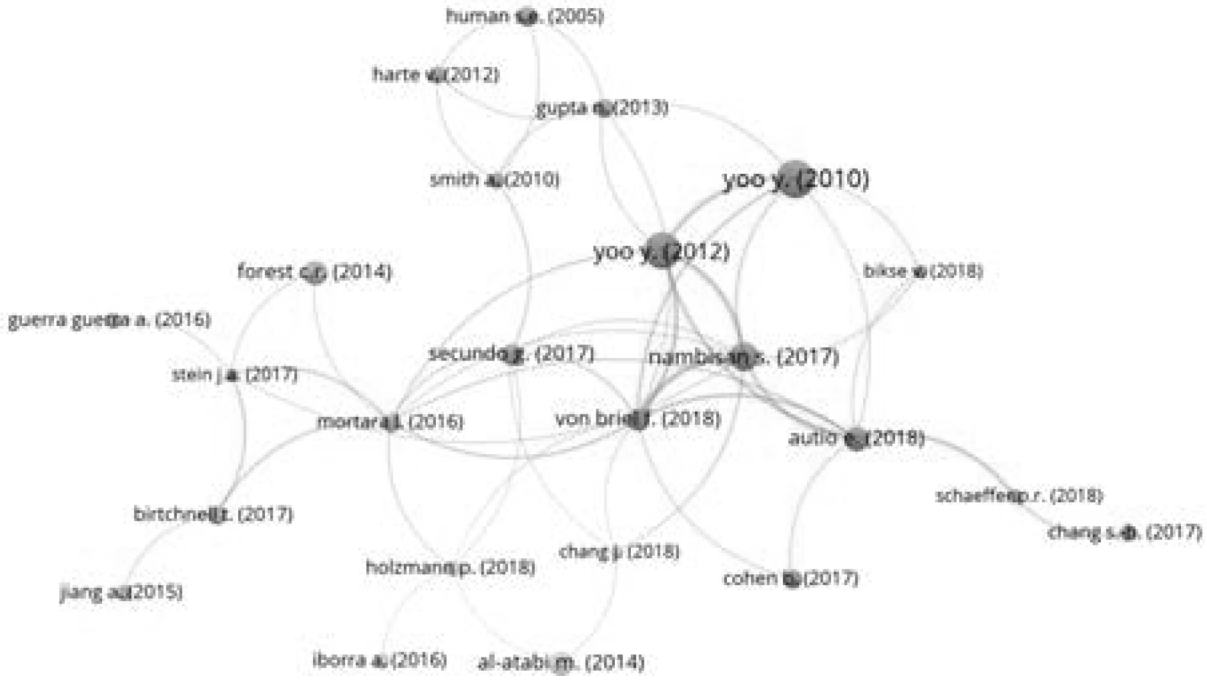

Fig. 9. Bibliographic clustering of documents and authors.

web-based ones can allow greater effectiveness of the educational process in the field of academic entrepreneurship as demonstrated by Human et al., (2005). The development and use of a web-based system to provide a diagnostic tool for the activities carried out by students in a new venture creation course at a British university, demonstrate how students are able to significantly improve their learning experience. Finally, another work included in this area reports the experience of the EDGE (Encourage Dynamic and Global Entrepreneurs) project (Smith and Paton, 2010). Developed at a Scottish university, EDGE uses social network technologies and electronic systems portfolio. All these resources offer the student a technological connectivity capability that enables learning and knowledge acquisition to be greater than the sum of the parts.

Research area 2: The maker space movement for Academic Entrepreneurship with a specific focus on the "Entrepreneurially equipped Fablabs and maker spaces: models and experiences" in terms of new disruptive and transformative force in the knowledge economy (Birtchnell et al., 2017), providers of knowledge and production competencies (Mortara and Praisot, 2016), a more student centered experiential practice (Forest et al., 2014), new possibilities of creating value for practical education (Guerra Guerra and De Gomez, 2016). This is in line with the maker movement, described as the fifth industrial revolution (Anderson, 2012; Pettis, 2009; Vance 2010) because it seeks to democratize invention (Aldrich, 2014) through providing technology tools in social spaces that lead to "ever-accelerating entrepreneurship and innovation with ever-dropping barriers to entry"(Anderson, 2012). Maker movement has come about in part because of people's need to engage passionately with objects in ways that make them more than just consumers. Nowadays, makerspaces have emerged as shared fabrication facilities, where makers of all types gather to invent, tinker, build, learn, and iterate using a range of manufacturing technologies.

All this is in line with the third dimension of the third mission of University focused on opening up the boundaries to technology transfer activities. The paper included in this research area are strictly linked to the evolution of 3D printing (additive manufacturing) technologies. Several experiences are described and models to enlarge the diffusion of FabLab are proposed based on such experiences. Countries like US, UK, Germany are surely advanced in terms of FabLabs experiences into a University context. Britchnell et al. (2017) converge to the idea that harnessing the existing activities in 3Dprinting and capitalizing on their existing regional presence as local providers of employment, investment and growth, universities stand to realize their third mission in a presently unforeseen way. In a wider recognition of existing fab-spaces all over the world, Mortara and Parisot (2016) clustered public or university libraries as spaces with access to low-end 3D printers and low-end design software. In this type of space, users (students) pay a low price, proportional to the number of materials used. The Invention Studio is a fabspace created by Georgia Tech where facilities, infrastructure, and cultural transformation are demonstrating the value and sustainability of hands-on, design-build education to stimulate innovation, creativity, and entrepreneurship in engineering undergraduates. In general, many authors recognize the value that a University FabLab can create in order to subsequently use this value as a vehicle for practical education in values and technical abilities in relation to the management of 21st century organizations (Guerra Guerra and De Gomez, 2016).

Research area 3: Digital technologies for discovering entrepreneurial opportunities, with a focus on the impact of digital technologies for innovation (Nambisan, 2017) digital technologies and infrastructures (called digital affordances) to support entrepreneurial ecosystem (Autio, 2018), properties and architecture of digital technology for organising innovation (Yoo, 2010 and Yoo, 2012), digital technologies for new venture creation in the IT hardware sector (Von Briel, 2018), the innovative technologies for building startups by students (Bikse et al., 2018) the emerging transformational technologies for disruptive innovation and entrepreneurial opportunities (Cohen, 2017), the emerging technology network for the development of patents (Chang, 2018).

The seminal contribution of Nambisan (2017) discusses the key pillars of the transformations provided by the new digital technologies and the nature of uncertainty inherent in entrepreneurial processes and outcomes as well as the ways of dealing with such uncertainty. As a consequence, the entrepreneurial process became less bounded and the outcomes are less predefined. An explicit theorizing of the impact of

Table 5
key aspects about Digital Academic Entrepreneurship.

Focus/research area	Details	Authors and quotations
Digital technologies for entrepreneurial education	Entrepreneurially equipped students: models and tools	"Besides the pressure of delivering the aforementioned business skills to business school students, business schools today are facing a number of pressing issues. They include: […] (3) the effects of information and communication technologies on teaching and learning methods (Gupta and Bharadwaj, 2013) "Findings from this qualitative field research with three case studies fundamentally differing in their design reveals how universities' actions are aimed at enhancing knowledge dissemination in local value networks" (Birtchnell, 2017) "[…] The experience made by the Euro-Mediterranean Incubator (EMI) at University of Salento (Italy) allows deriving a set of guidelines useful for creating a successful learning environment supporting the entrepreneurial attitudes in scientists and engineers. These guidelines can be summarised as follows: […] encouraging prototyping and experimentation of business ideas and technological archetypes" (Secundo et al., 2017) "[…] A large amount of pedagogy in the area of simulation suggests that students are very comfortable with this format and that large numbers can experience the same learning environment remotely, albeit promoting independent learning rather than teamwork. " (Watts and Wray, 2012) "[…] students contemplating careers as entrepreneurs need to assess their skills to identify both strengths and weaknesses, […], introduction of a web-based self-diagnostic tools into undergraduate New Venture Creation Class […]" (Human et al., 2005).
The maker space movement for academic entrepreneurship	Entrepreneurial equipped Fablabs and maker spaces: models and experiences	"[…] explore the possibilities of creating value in a university FabLab in order to subsequently use this value as a vehicle for practical education in values and technical abilities in relation to the management of 21st century organisations […]". (Guerra Guerra and De Gomez, 2016) "[…] Using the business applications students have created within the support desk, utilizing its tools, can we become incubator and cultivate entrepreneurs or start-ups on campus? We are at a time when technology has made innovation and creation available to many; it is just at the end of our fingertips". (Jiang et al., 2015) "[…] By harnessing their existing activities in 3D printing and capitalizing on their existing regional presence as local providers of employment, investment and growth universities stand to realize their third mission in a presently unforeseen way". (Birtchnell et al., 2017) "[…] Case-study evidence indicates that entrepreneurs, who successfully have progressed towards the launch of their products with Fab-spaces support, have dynamically moved from one Fab-space to another to outsource the resources required to overcome the key entrepreneurial barriers […]". (Mortara and Parisot, 2016) "[…] The Invention Studio's (a university maker space) facilities, infrastructure, and cultural transformation are demonstrating the value and sustainability of hands-on, design-build education to stimulate innovation, creativity, and entrepreneurship in engineering undergraduates […]". (Forest et al., 2014) "[…] the real and imagined capacity of 3Dprinting has catapulted design into mainstream understandings of the world […] 3D printing's ability to escite thepublic imagination allows us to understand the significance of design in relation to the worlds that we make […]". (Stein, 2017)
Digital technologies for discovering entrepreneurial opportunities	Impact of digital technologies for innovation and new venture creation within the Academy	"[…] we expect knowledge-intensive entrepreneurial activity to be significantly influenced by the local presence of academia within innovation ecosystems in emerging economies following recent evidence" (Shaeffer et al., 2018) "[…] a conceptual model of entrepreneurial ecosystems as a distinct type of cluster that specializes in harnessing technological affordances (…) created by digital technologies and infrastructures (which we call digital affordances) and combines them with spatial (i.e., proximity-related) affordances to support a distinctive cluster dynamic that is expressed through the creation and scale-up of new ventures". (Autio et al., 2018) "[…] The technology policies in various countries are currently in a transitional stage. In addition to conventional research-oriented technology projects, policies should also focus on expanding the application of research achievements. Thus, universities began to seek industrial collaboration and reinforce the association between technology research and socioeconomic issues […]". (Chang, 2017) "[…] to highlight emerging transformational technologies and their capacity to serve as generative mechanisms for disruptive innovation and entrepreneurial opportunities […]". (Choen et al., 2018) "[…]Our theory development started with conceptualizing how digital technologies enable venture creation processes. We identified two conceptual dimensions that characterize digital technologies and linked them to six mechanisms that describe how digital technologies enable venture creation processes […]". (von Briel et al., 2017) "[…]Digital technologies herald a new era in entrepreneurship, one in which the traditional ways and forms of pursuing entrepreneurial opportunities are increasingly questioned and refashioned […]". (Nambisan, 2017) "[…] As much as the potential benefits of digital technology are real, so too are the risks and complexity that ride with them. Entrepreneurs and technologists will continue to invent more powerful tools and better products using more powerful, more intelligent, and smaller digital technologies […]" (Yoo et al., 2012) "[…]We now create digitized products with loose couplings across devices, networks, services and contents in an irrevocable way. So far, we have only seen the early forms of such digitized products, and therefore can only dimly observe the forms of the emerging organizing logic of digital innovation […]". (Yoo et al., 2010)
Digital technologies for creating entrepreneurial competences in the "university based" entrepreneurial ecosystem		"[…] opportunity management theories should take a more prominent role in the higher education entrepreneurship curriculum. Educators also need to provide a better means of facilitating students to learn about, and practice, a greater repertoire of opportunity management behaviours than is currently the case." (Chang and Rieple, 2018) "[…]When students discovered our programme was focused on a particular domain (IoT) their interest in the program was much greater. Specialised accelerators are able to attract a more talented and focused entrepreneur than acceleration programmes with a general purpose […]". (Iborra et al., 2016) "[…]It seems as if entrepreneurship education is finally starting to attract significant attention from policy makers and education institutions. Students in general and engineering students in particular have been identified as promising candidates for entrepreneurship education […]" (Holzmann et al., 2018)

digital technologies into the very core of the products, services, and operations of many organizations and the radically change the nature of product and service innovations is provided by Autio (2018). Specifically, the author defines the concept of digital affordance (as digital technologies and infrastructures) as having a key role in supporting an economy-wide redesign of value creation, delivery, and capture processes within the Entrepreneurial ecosystems. The technology affordance, combined with the spatial affordance typical of the entrepreneurial ecosystem, allows them to increase the creation and scale-up of new ventures. Furthermore, the support of digital technologies for new venture creation in the IT hardware sector is discussed by Von Briel (2018). They develop a theory about how and when digital technologies enable new venture creation processes through the identification of two fundamental properties of digital technologies, specificity and relationality. Continuing in this perspective, Bikse et al. (2018) analysed the innovative startups in Latvia, through a comparative analysis of University and High School students that associated their entrepreneurship prospects with innovative ideas, new skills and new technologies available. The authors indicated that the foundation of start-up enterprises in Latvia led to positive results and gave an impulse to increasing economic activities as there were the necessary preconditions for their development. Cohen (2017) highlighted the potential of emerging transformational technologies to serve as generative mechanisms for disruptive innovation and entrepreneurial opportunities in other several contexts. An analysis of convergence and generativity observed in innovations with pervasive digital technologies reveals three traits: (1) the importance of digital technology platforms, (2) the emergence of distributed innovations, and (3) the prevalence of combinatorial innovation (Yoo, 2012). Finally, an Information System research agenda for digital strategy strategies and the creation and management of corporate IT infrastructures is defined by Yoo (2100).

Another perspective about ecosystem is represented by the contribution of Schaeffer at al. (2018). The authors assessed the role of universities in shaping the dynamics of innovation ecosystems within the context of a particular developing country, Brazil. Findings demonstrate that the presence of a research university within an ecosystem is relevant non only for structuring successful ecosystem but also for contributing to the socioeconomic development at the local level. Coherently with these findings, the development of technology network is crucial with the recent efforts of various countries in promoting technology enhancements. Japan and United Stated served a crucial role in University-Industry collaborations technology networks, as expressed in the study of Chang (2017). According to the author, collaborative patents among countries allowed to reveal the more recent development of technologies over time, especially in that filed characterized as basic science and with a cross-disciplinary trait.

Research area 4: Digital Technologies for creating entrepreneurial competences in the Digital "University based" Entrepreneurial ecosystems. This area recommends the strategic role of the digital technologies in shaping the entrepreneurial competences within entrepreneurial ecosystem in which the academic context has a fundamental role. Holzmann et al. (2018) describe the case of Carinthia University of Applied Sciences, Villach, Austria (CUAS) as university involved in national and international projects on e-learning and focused on technology-enhanced learning. For several years CUAS has been actively engaged in the implementation of entrepreneurial classes for providing the state-of-the-art entrepreneurship education to Engineering students. The program aims to increase the number of Technology intensive startups founded by engineering students as the most promising candidates for this typology of education. Furthermore, another contribution related to the creation of adequate competence for academic entrepreneurship is represented by Al Atabi (2014). The author focuses on the achievement of University's students in the acquisition of Entrepreneurship competences through the Massive Open Online Course (MOOC) that allow collaborative learning of students as well as the acquisition of key entrepreneurial skills, such as opportunity identification. Also in this case, the collaboration within a University based ecosystem is described as one of the most relevant factors in sustain the local development. Indeed, according to Iborra et al. (2016) the acceleration of ICTs based startups could be facilitated by in an entrepreneurial ecosystem through the creation of the entrepreneurial skills at engineering universities of countries with weaker entrepreneurial tradition in new technologies. The Authors highlight that engineering students benefit greatly from becoming part of a wider entrepreneurial ecosystem, regardless of the business success achieved. The technological solutions enable them to reach the "growth stage" of their venture in record time thanks to an acceleration program designed with the objective to create start-ups (Iborra et al., 2016). Finally, the study of Change and Rieple (2018) investigates how student entrepreneurs learn and practice in a *microcosm* of the entrepreneur's world. Specifically when, how and why students use opportunity management behaviors (causation, effectuation and bricolage) within a fundraising project is analyzed. Such a pedagogical device reveals students' use of different opportunity management behaviors over the different stages of entrepreneurship. Causation is the predominant focus for university teaching, yet our data reveal that students adopted all three behaviors at different stages of the fundraising project as they responded to different contextual forces. Findings suggest that opportunity management theories should take a more prominent role in the higher education entrepreneurship curriculum (Chang and Rieple, 2018). Table 5 lists the main evidence coming from the research included in these papers. Further investigation, contextualization and replication of the models belonging to this area, can be identified as future roots for the agenda of scholars and researchers.

3.3. Thematic Map

A thematic map was developed to further investigate the clusters presented above and analyse how networks change over time (Fig. 10). Clusters of topics were obtained and plotted according to centrality and density indices (Callon et al., 1991; He, 1999; Valentín et al., 2018). The centrality index measures how intense is the link of a cluster with others. The density characterises the tie strength between clusters (Kipper, L.M. et al.; 2019). This analysis allows us to identify five clusters of topics and classify them according to centrality and density measures. The following points provide the final list of topics included in each cluster and the related thematic area:

10- Green cluster (characterised by low centrality and medium density indices) includes the following topics: students, universities, economic development, bioscience, curricula, and engineering;
10- Blue cluster (characterised by medium centrality and high density indices) includes the following topics: additive manufacturing, 3d printing, makers, manufacturing, business models classification, cluster analysis, fablabs, fabrication spaces, hakerspaces, makerspaces, peer production, and techshops;
10- Red cluster (characterised by high centrality and low density indices) includes the following topics: entrepreneurship, entrepreneurship education, university, innovation, higher education, and new venture.

This analysis allows us to analyse how networks change over time. Firstly, consolidated themes in the evolution of the body of literature are characterised by high centrality and low density measures representing the main theoretical contributions in the field (Callon et al., 1991). Therefore, the topics included in the red cluster represent basic themes unchanged over time.

Secondly, emerging themes in the literature are characterized by low centrality measure representing the novel contributions in the field. In our case, the topics included in the green cluster represent novel subjects (e.g., bioscience, economic development, engineering) or

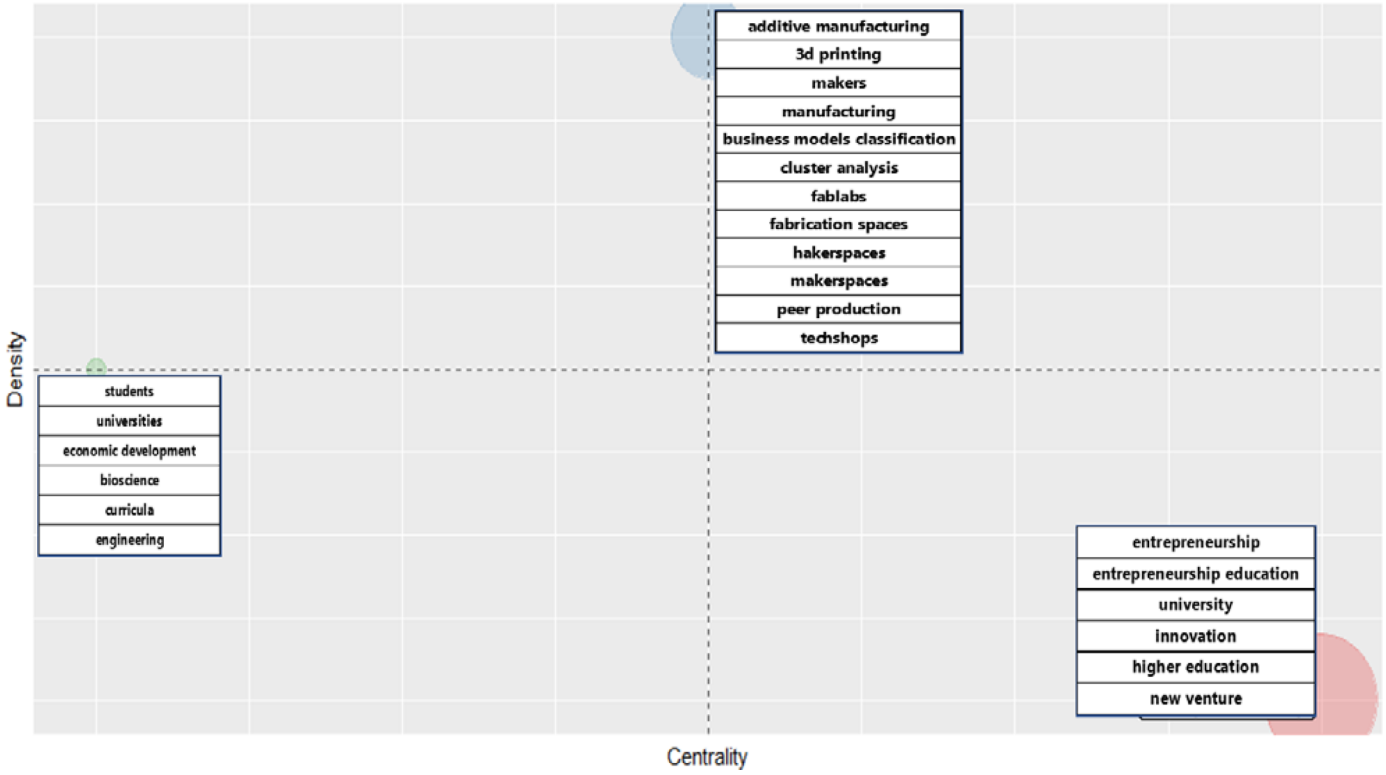

Fig. 10. Thematic Map.

perspective of analysis (e.g., entrepreneurial curricula of students, entrepreneurial university) to conduct research on digital academic entrepreneurship domain. Thirdly, specialized themes in the literature are characterised by high density measure. In this area the blue cluster includes topics focused on two main different subject areas: 1) enabling technologies and collaborative initiatives for managing the digital revolution of manufacturing; 2) new models and approaches for managing digital academic entrepreneurship. These topics represent evolutionary topics that in future years may migrate in the area of consolidated themes by exploring practical applications in various domains and, therefore, increasing their centrality.

4. Discussions and implications

The aim of this section is to discuss and critique the main findings for answering at the RQ.3 What are the implications of our research for the field of Digital Academic Entrepreneurship? The answer to this question moves toward implications organized into the following subsections.

Implication 1. Authorship' specialization on the topics, timing and individual contributions to the debate.

Digital technologies are now permeating any area of modern society, from industry to education, from education to politics. It is not exempt from this invasion the Academy, which for years has introduced some digital technologies within its own processes (mainly those related to education, e.g. the MOOCs or Academic FabLabs). Among all, also the activities of so-called academic entrepreneurship are interested in the invasion of digital technologies, and the scientific literature demonstrates, from the structured analysis of the literature, to approach with empirical cases and theoretical developments in an increasingly intensive way. If we observe the evolutionary trend of scientific articles that have dealt with the topic of digital academic entrepreneurship (theme analysed in this article), the significant growth of articles in the last three years is evident: in fact, it has gone from 15 articles in the 2005 interval – 2015 (almost a decade) to the 20 articles in 2018 only (the year in which we considered only 10 months at the time of the survey). Indeed, it must be said that digital technologies have been categorized and implemented in different contexts only in recent times.

The main geographical areas in which the greatest number of authors are present are Anglo-Saxon countries (USA and UK) and China. The US, in general, turns out to be not only the country with the greatest number of contributions, but also the country with the highest rate of citations. Undoubtedly, American universities are among the most innovative and enterprising in the world. To be noted as Scandinavian countries such as Sweden, undoubted precursors of theories in the field of entrepreneurship, climb the list of citations related to the country despite the lower number of publications compared, for example, to China or to the UK. Among the two most cited authors, we find Youngjin Yoo and Kalle Lyytinen, two researchers from Case Western Reserve University. Yoo and Lyytinen are active authors in the information system disciplinary field, which is why they have numerous citations. However, they've analysed phenomena related to the impact of digital technologies in organizational processes, with particular reference to new organizational methods for the management of digital technologies. Their purely technical contribution is a point of reference for many authors who study the impact of digital technologies from different angles, but it is also true that the publications of these authors refer to the years 2010 and 2012. Therefore the high number of citations is also attributable to this reason. These considerations do not lead us to identify two superstars in Yoo and Lyytinen, although they remain authors of undoubted value.

Implications 2. Journal specializations and impact.

The intersection between two different disciplinary areas, namely digital technologies and entrepreneurship, could not fail to generate rather uneven results in terms of types of journals. Only 5 journals have two articles, while all the remaining records return only one

publication. Of the 5 journals with two publications, only two are magazines of the A range. Of these two, one is typically a journal specialized in the field of entrepreneurship and innovation (Entrepreneurship Theories & Practices) while the second is a Journal of a more transversal nature, in which the main topic addressed is the impact of technologies and innovations on organizational change. The two most cited articles have instead been published in two of the main journals of two very different disciplinary sectors: one of the main journals on information systems, and one of the main organizing journals. However, if we analyse the top 15 journals of this analysis, only two are specialized in information systems. Six instead relate to contexts of organization and strategy, and the remaining 7 are published in journals that explicitly investigate the impacts of certain technologies in specific contexts (learning, innovation, society). In summary, there is not yet a line of demarcation on the typology of approaches to the study of the digital academic entrepreneurship. This depends on the angle from which the phenomenon is analysed. The debate, therefore, necessarily concerns the participation of two types of scholars, namely technology experts, and entrepreneurship experts.

Implication 3: A future research agenda about Digital Academic Entrepreneurship

The analysis carried out through thematic clustering, content analysis and impact citations has produced some interesting results to identify future research areas within this novel framework of the digital academic entrepreneurship. Starting from the development of the theoretical model proposed in Rippa and Secundo (2019), the identification of articles in the field of study concerning the intersection of the academic entrepreneurship field (now consolidated in literature) and that of the diffusion and implementation of digital technologies (also stabilized in the literature mainly referring to information systems) allows highlighting first of all the evident and growing interest in the topic. This evidence can be found in the growing number of articles that in the last few years have addressed the Digital Academic Entrepreneurship topic. It is the authors' belief that this trend will not cease to grow. The impact of digital technologies on academic entrepreneurship processes is certified by the numbers of articles that propose applicative examples of how digital technologies can foster entrepreneurial initiatives in university contexts. Among the main technologies analysed to date, MOOCs and 3D printing are certainly the main vehicles on which to build new organizational models for entrepreneurial universities (Yepes-Baldò et al., 2016). What is highlighted is that digital technologies are not only a lever for the growth of new businesses, but it is an opportunity to review some organizational processes within the universities to obtain more performing results in terms of patents production, technology transfer activities, spinoff creation, and everything that can considered within the academic entrepreneurship domain (Siegel and Wright, 2015). The range of toolkits identified in the research area 1 and the growing development of 3D printing laboratories within the university structures offers interesting indications on how the approach to entrepreneurship is being modified both by universities that have always been leaders in this sector (with increasingly technologically advanced structures), but above all by those universities with a less relevant entrepreneurial culture, but with a stronger “technology intensive” background. There is the certainty that more and more universities will approach digital technologies to develop workshops and experiential initiatives that will accelerate the level of competitiveness of academic entrepreneurship initiatives compared to the typical market dynamics.

Observing the results obtained in terms of research areas from another angle, in particular by analysing the research areas 3 and 4, digital technologies support academic entrepreneurial processes along the entire supply chain: from initial training (micro level: the individual) up to the development and support of innovative ecosystems (macro level: the community). The positive effects are different and give field to interesting ideas for future research areas. First, although most of the studies analysed to date refer to the STEM disciplines, where the engineering and scientific matrix seems to have predominance (Harte et al., 2012; Ramazanov et al 2018). A strong impact of digital technologies is supposed to support academic entrepreneurial processes even in the humanities side. In this context, therefore, there is wide scope for field research aimed at identifying which technologies may be of greatest interest for the humanities and cultural heritage faculties. It is not only at the micro level, however, that digital technologies are able to make their own contribution. If the analysis is extended to the innovative ecosystem, of which the academy is one of the main actors, it is possible to identify specific technologies capable of feeding virtuous circuits able to accelerate the processes of academic entrepreneurship. The technologies make it possible both to create ever wider networks between a growing number of actors, but also to make the technology transfer processes faster and more effective also in the final aim of sustainability . Future research in this area should specifically concern new organizational methods, new mechanisms for involving academic staff and students in the processes of academic entrepreneurship, new mechanisms for developing socio-economic systems even in areas and localities less skilled in terms of processes of academic entrepreneurship. The common pillar to the research areas is of course the key role covered by human capital with entrepreneurial competences. This is evident from the first paper of Human (2005)) till the most recent work of Schaeffer et al. (2018) where the development of competences for entrepreneurship is realized thanks to the collaboration of the several stakeholders belonging to the Entrepreneurial Ecosystems (Belotti et al., 2014).

Following the main themes being explored in the literature, some additional future research areas have been put forth, focusing on the possible research questions listed in Table 6.

5. Conclusions and future research

In the conclusions of this study, it is important to recall its initial motivation, based on the argument that the concept of Digital Academic Entrepreneurship represents a particular research context because of the increasing and disruptive roles of digital technologies on use within the academic context. Universities are now viewed as key economic actors within regions and are central actors in shaping and influencing entrepreneurial ecosystems: they are more and more entrepreneurial organizations (Upadhyayula et al., 2018) . This has meant that universities now have to become more entrepreneurial in offerings, commercialization of their research, and culture (Centobelli et al., in press; Miller et al., 2018; Tarabasz et al., 2018). Universities develop strategies to fulfil their historic mission of teaching and research and they also undertake a significant role in producing, creating, and diffusing new knowledge in today's ever-changing world (Olcay and Bulu, 2017; Secundo et al., 2017). Moreover, the process of Academic Entrepreneurship cannot be free from the diffusion of the digital technologies and infrastructure that could support and enhance the entrepreneurial orientation of academy (Azmi et al., 2018; Langan et al., 2016) in the same way they enhance the entrepreneurial orientation of companies and organisations more in general (Hussein Alayis, et al 2018).

The debate on Digital academic entrepreneurship has received during the last 13 years a growing attention. Despite the two topics of Digital technologies and Academic Entrepreneurship have been largely investigated separately, their intersection discloses several areas of deepening by highlighting a still fragmented debate and so requiring holistic and integrated frameworks aimed to comprehend the relevance and implications of Digital technologies on the several forms of Academic Entrepreneurship. In motivating our research to embrace a structured literature review, we have focused our attention on articles published in several journals, moving from journals with entrepreneurship focus to include journal with information system view.

Table 6
Future research agenda on Digital Academic Entrepreneurship.

Research area	Research questions
Digital Technologies for Entrepreneurial Education	How is it possible to assess the impact of digital technologies on competence acquisition? Which digital technologies better support the interplay between academia and external stakeholders such as industry, non-governmental organizations (NGOs), government institutions, investment funds, and TTOs? What forms of Entrepreneurial learning could be better supported by digital technologies (MOOCs, Social media etc..)? Which could be the rights balance between the traditional versus the innovation learning approaches for developing entrepreneurship competence?
The "maker space movement" for the Academic Entrepreneurship	How do digital technologies support knowledge sharing and opportunity recognition for academic entrepreneurship? Which digital technologies better support the interplay between academia and external stakeholders such as industry, non-governmental organizations (NGOs), government institutions, investment funds, and TTOs? Which new skills and competences are required within universities to effectively manage digital technologies labs? What are and how can be monitored impacts of digital technologies on entrepreneurial universities activities?
Digital technologies for discovering entrepreneurial opportunities	What value does academic entrepreneurship derive from the revolution of digital technologies? How can social networks (LinkedIn, Facebook, Twitter, Google+, etc.) enhance entrepreneurial students' involvement in academic entrepreneurship? How does digitalization affect ecosystems for supporting student start-ups? What emerging forms of technology transfer offices (TTOs) activities are supported by digital technologies? Who are the 'crowds' that contribute to academic entrepreneurship thanks to the adoption of digital technologies?
Creating entrepreneurial competences in the Digital supported "University based" Entrepreneurial ecosystems.	How can digital technologies enhance knowledge transfer and technology transfer between universities and industry? Why might digital technologies develop social value for academic entrepreneurship? What are the major challenges facing academic entrepreneurship ecosystem's stakeholders (faculty members, businesses and students) due to the digital technologies revolution? Which typologies of research collaboration between universities and industry are better supported by digital technologies? Who are the main stakeholders collectively contributing to the creation of a Digital Entrepreneurship Ecosystem for universities?

Findings show that despite the number of paper published on Digital Academic Entrepreneurship in the period 2005-2018 has reached a consistent volume, the analysis of their meaning, dynamics and implementation is still dominated by unrelated research. Trends observed in terms of authors' productivity, impact of their research in terms of citations, and their geographical areas has depicted a profile of community of scholars and researchers dispersed, with limited collaboration and the presence of a limited number of authors focused on the topics with outstanding performances. Despite this, the positive trends of growth registered during 2018 is promising. In the same direction, the analysis of publications' venues has allowed to identify a coherent correspondence between the thematic specialization of the journals and the scientific contributions published. However, the need of consolidating the relevance of the issues of Digital Technologies role for Academic Entrepreneurship has been found with some useful implications in terms of co-authorship with foreign authors and new empirical contexts of explorations.

Content analysis performed in the paper has allowed identifying four main thematic clusters as primary areas of specialization of the scientific debate, with related sub-areas. We categorize the main areas in: 1) *Research area 1: Digital Technologies for Entrepreneurship Education; Research area 2: The "maker space movement" for Academic Entrepreneurship; Research area 3: Digital technologies for discovering entrepreneurial opportunities; and Research area 4: Creating entrepreneurial competences in the Digital "University based" Entrepreneurial ecosystems.* The analysis of papers included in these areas allowed to derive a more robust awareness on the state of art for the debate on Digital academic Entrepreneurship in terms of conceptual and organizational models, causal mechanisms of functioning, tools and performance metrics, and impact on entrepreneurial ecosystem. Furthermore, the analysis of the temporal distribution of papers clustered into the four research areas has also offered additional implications for future studies in terms of continuous updating, areas of renewed interest, and longitudinal investigations. All findings confirm the key role of the developing and generating entrepreneurial competences in human capital starting from the graduate and post graduate course to arrive to the involvement of the other stakeholders within the while value chain of the academic entrepreneurship process (Hong et al., 2018; Simeone et al., 2017; Meng and Liu, 2017) .

The exploration of such issues, through theoretical and empirical contributions, aims to overcome the limitations that still characterize the debate on Digital Academic Entrepreneurship, and can allow to achieve a major comprehension of the meaning and implications of the disruptive and potential role of Digital technologies on the processes and activities of Academic Entrepreneurship, through holistic and multidisciplinary bases, to consolidate and increase the scientific background of a community of scholars and researchers specialized in such topics, and to identify unexplored and promising roots for scientific and practical speculations.

Some limitations and future research can be identified into nature of journals analysed as well as into the database chosen for framing the initial papers' selection. As authors we are aware that this could represent a limitation since we cannot assume that valuable researches related to our topics could have been published on different venues not listed in our database. Secondly, the validity of the evidences collected are limited to the timing frame considered. Thirdly, as every beginning of a new journey (Massaro et al., 2016), a SLR is relevant for the contribution of inspiration more than for the state of the art it is able to provide. Accordingly, we hope this work contributes to identify lacks in the debate on Digital Academic Entrepreneurship and to be of inspiration for the future works of scholars and practitioners interested into the advancement of such promising future research areas, also taking in consideration the differences between developing and developed countries (Coduras et al., 2018).

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