

Evolving Entrepreneurial Universities: A Bibliometric Analysis

Abstract

Research on entrepreneurial universities as a key driver of innovation and economic growth has witnessed increasing interest in recent years. The study aims to review the current state of research on entrepreneurial universities. Employing both the co-citation and bibliographic coupling approaches, we review and analyze 178 scientific articles published in refereed journals over the 27 years (1983 – 2016), our study advances the understanding of the entrepreneurial university literature by identifying the core domains and their intellectual structures, as well as establishing current and emerging trends.

Keywords: Entrepreneurial Universities, Bibliometric analysis, Co-citation analysis, Bibliographic coupling,

INTRODUCTION

Growing out of their traditional mission, universities have emerged as key institutions in the entrepreneurial society by generating new knowledge and facilitating spillovers that spur innovation, economic growth, job creation and competitiveness (Acs, Audretsch and Lehmann, 2013). Termed *entrepreneurial universities* (EUs), such universities are defined as having the ability to innovate, recognize and create opportunities, work in teams, take risks and respond to challenges, on its own, seeks to work out a substantial shift in organizational character to arrive at a more promising posture for the future (Guerrero et al., 2006: 6).

EUs are now recognized to play an important role as both a knowledge producer and a disseminating institution (Guerrero et al., 2012). They serve as natural incubators that endeavor simultaneously to fulfill their missions of teaching, research and entrepreneurial activities while providing an adequate atmosphere in which the university communities can identify, explore and exploit innovative and creative ideas that could be transformed into new ventures (Kirby, 2011). Faced with environmental uncertainties, universities have been forced to become relevant and responsive to their society or region through utilizing entrepreneurship as a critical force in stimulating economic growth and social development (Audretsch, 2014). Thus, it becomes relevant and important to examine the ability of universities to enhance performance by harnessing the entrepreneurial decision-making processes that enhance their performance.

As a result, EU as a field of study is drawing significant attention in the past decade with more than 100 publications published since 2010 and a special issue on EU (Small Business Economics, 2016). Evolving from research that focused on technology commercialization, industry-university engagement and academic entrepreneurship, EU has emerged as an area that

has its distinct identity. Much of the research on EU has captured the transition of universities over the past few decades – driving innovation through commercialization, transforming inventions into innovations through industry and government partnerships, contributing to regional and national development, and promoting an entrepreneurial culture in their strategic actions that allow them to adapt to environmental challenges. Although the prior studies have helped improve the theoretical understanding of EUs and signaled how universities operate, collaborate, make decisions, identify benefits, or transform their roles is still an interesting research area (Cunningham and Link, 2015), the literature remains fragmented with few review articles (e.g. Guerrero, 2012; Kirby 2011). In general, systematic literature reviews provide a list and qualitative assessment of scholars' areas of interest along with corresponding suggestions about the areas that need a greater research focus. While these systematic reviews are critical to any field's development, they often suffer from general problems of subjectivity and hence are inherently biased.

To address the gaps in the literature, we conduct a comprehensive literature review on 178 articles using the co-citation and bibliographic coupling techniques. To our best knowledge, no quantitative review to date has been conducted to understand the flourishing EU domain. These bibliometric analysis approaches aim at identifying the most influential documents and analyzing the relational links between them while objectively examining the core tenets of EUs. In addition to the quantitative analysis, a qualitative content analysis on the identified articles will follow to further generate nuanced insights into relevant future research directions. Such emergent approaches have been encouraged in the literature (e.g., Tsai & Wu, 2010) and have the potential to offer an objective overview of the field's current status as well as the new directions for future evolution.

The results of the co-citation analysis imply that the EU research field is currently based on five thematic clusters focused on the following: (1) *social and economic contribution* of EU's, (2) *academic entrepreneurship* and the role of academic researchers, (3) *triple-helix framework* and the leveraging of academic knowledge, (4) *regional innovation focus* and industry-university interface and (5) *local- global axis* and the global trends.

In addition, the bibliographic coupling analysis suggests emerging trends in the form of three thematic clusters. The first cluster formed by the bibliographic coupling analysis is the *Knowledge Spillover* perspective. The knowledge spillover is formed by the aggregate of a number of clusters that resulted out of the co-citation analysis and thus represents the foundation on which the EU research field is situated on. Cluster 2 encompasses the newer wave of research that captures the role of the universities beyond technology transfer, namely, the *Multifaceted Entrepreneurial University* perspective. Finally, cluster 3, *Universities and the Region*, represents the response of universities to the changing urban/regional landscape.

This paper offers a new perspective into the strength of the foundational knowledge production and transfer role of universities to regional growth and economic stability through the incorporation of both the co-citation and bibliometric analysis. As universities continue to evolve and grow as key drivers of the socio-economic landscape, they have to build on existing strengths while consciously embracing an entrepreneurial focus in every aspect of their functioning.

The Emergence of Entrepreneurial Universities

Over the last 30 years, researchers across the country have been documenting the shifts in university policies and practices enabled in no small part by the Bayh-Dole legislation of the mid-1980s, and the establishment and growth of the Small Business Innovation Research (SBIR)

Program (Walshok & Shapiro, 2015). The changes ushered in commercialization incentives to universities by granting them ownership of intellectual property arising from their research (D'este & Perkmann, 2011). Following this, the period from 1983 -2000 witnessed identification, creation and commercialization of intellectual property become institutional objectives of academic systems. Universities were increasingly being called upon to contribute to economic development and competitiveness (Feller, 1990). The entrepreneurial university began encompassing a 'third-mission' of economic development in addition to research and teaching, though the precise shape this takes varied such that different scenarios of academic development were being projected (Readings, 1996).

By the turn of the century, technology commercialization as a derivative of academic research had become an essential characteristic of engineering research and academic institutions hosting this research (Etzkowitz & Leydesdorff, 2000; Kenney & Goe, 2004; Phan & Siegel, 2006). Though the increased involvement of universities in technology transfer and commercialization warrants questions about their nature and mission (Deiaco, Holmén, & McKelvey, 2009), their involvement in socio-economic development has created an enhanced role for universities. Increasingly the university system has expanded to include activities outside the "ivory tower" with the goal of transforming inventions into innovations for the betterment of society and to enhance the university's revenues and philanthropic contributions. Increasingly the university system has expanded to include activities outside the "ivory tower" with the goal of transforming inventions into innovations for the betterment of society and to enhance the university's revenues and philanthropic contributions. This new role has stemmed from several specific developments – ability to keep the talent pipeline for workforce with new ideas, skills and entrepreneurial talent and to generate technology through transfer.

Before we review the field of EU research, it is essential to understand that EU's engage in multifaceted efforts to ensure that they succeed in their three-fold mission. A key result of this diverse range of operations becomes visible from the fact that there exist numerous definitions of EU in literature. Table 2 provides some of the key definitions that emerge from publications included in the bibliometric analysis.

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RESEARCH DESIGN

Data Source and Collection

The articles for the review was identified from the Thomson Reuters Web of Science database which is recognized widely to cover a broad range of relevant journals and peer reviewed articles of high quality (Skute et al., 2017). Duly acknowledging the availability of other databases, we adopt the methodological approach from the prior research (Meyer et al., 2014, Skute et al., 2017) and focus on investigating patterns of indicators.

We use the search terms “Entrepreneurial Universities” and “Entrepreneurial university*” to allow for variations of the terms used in prior literature. This keyword combination allows to grasp the EU literature scope and minimizes the risk of including false positive items that do not compliment the actual thematic EU literature, which can result in misleading interpretations of the state of knowledge (Kovacs et al., 2015). Additionally, we refrained from adding other key terms such as *academic entrepreneurship* and *technology commercialization* as the intent of this study is to gain an in depth understanding of the evolution of entrepreneurial universities as a field of its own that has grown out of the shadows of these concepts. While these three research categories, have been used interchangeably at time, (O'Shea et al., 2004, Powers and McDougall

2005), articles on EUs are mainly centered and touched on institutional-level issues such as institutional policy, policy on higher education (Gibb and Hannon, 2006), the triple-helix model (Etzkowitz & Leydesdorff, 2000; Etzkowitz 2003), national policies, and socio-economic development (Etzkowitz and Klofsten 2005). Thus, we adopt the perspective that an entrepreneurial university is a university that strategically adapts the entrepreneurial mindset throughout the organization and practices academic entrepreneurship which also encompasses technology transfer activities (Yusof, 2010).

The search in the Thomson Reuters' Web of Science database resulted in 194 articles. Restricting the search to articles published in the English language resulted in 178 articles published between 1983(1 publication) and 2016(38 publications) with 3512 citations and 6981 references. The unit of analysis in this study is the publication and the variables include authors, journals, journal affiliations, number of citations and references.

Review Methods

We employ a couple of bibliometric techniques to analyze the scientific mapping patterns and to identify research themes in the EU literature. Bibliometrics refers to “the collection, the handling, and the analysis of quantitative bibliographic data, derived from scientific publications” (Veerbek et al., 2002: 181). Specifically, two citation-based methods--*co-citation analysis* and *bibliographic coupling* are used to understand the intertextual relationships between scientific publications that are established by the referencing behaviors of authors (Vogel and Guttel, 2013). They both assume that these relationships reflect some textual similarity between the co-cited or coupled documents.

A co-citation is defined as the frequency with which two documents are cited together in the literature (Small, 1973) – they are included in the same reference list. Thus, it is a

relationship extrinsic to the publication, and co-citation frequencies increase over time lending itself to tracing the intellectual roots of an academic work by identifying the foundational works. In contrast, bibliographic coupling is said to occur when two documents have at least one reference in common (Kessler, 1963) – their bibliographies overlap. The coupling strength is determined by the amount of overlap, and results of bibliographic coupling are independent of the point in time at which the analysis is conducted. While the co-citation approach allows us to conduct an examination of the EU literature from its roots based on the cited articles, bibliographic coupling is based on the citing articles and hence is applicable to the identification of the current state of literature and future priorities (Boyack & Klavans, 2010; Meyer et al., 2014; Kovacs et al., 2015). We employ both these methods as they are empirically proven to produce considerably different results and thus complement, rather than substitute each other (Jarneving, 2005).

Visualization of similarities (VOS) approach using an optimized algorithm of VOSviewer 1.6.5 (van Eck and Waltman, 2010) was adopted to construct the clustered bibliometric networks. Additionally, in accordance with the methodological approach adopted by prior studies (Kovacs et al. 2015; van Eck and Waltman 2007; Waltman et al. 2010), we selected association strength measure as the appropriate measure for normalizing the co-occurrence data.

RESULTS

The 178 articles included in the study present an average citation rate of 19.73%. However, 55 articles have never been cited, and 54 have been cited between 1 and 5 times. The top 30 highly cited articles are presented in Table 1. Out of the top five studies with the highest number of citations, four are first authored by Etzkowitz (1998; 2000; 2003a, 2003b). Figure 1 shows the number of articles on EU published by year and the trend. It is suggestive that in spite

of the low number of papers in 2013(11), EU as a field of research is witnessing some remarkable attention in the past decade. Compared to the time frame between 1983 and 2008, the period beginning 2009 has seen the topic of EU emerging as a field of research with 2016 being the year with the highest number of publications.

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These highly cited publications by Etzkowitz highlight the transformation occurring among universities as they have incorporated economic and social development as part of their mission. These publications have recognized that the ‘capitalization of knowledge’ is the heart of a new mission for the university that it links itself to users of knowledge, thereby establishing the university as an economic actor in its own right (Etzkowitz, 1998). We further extracted information to enable an analysis on journals as outlet for the EU publications and keywords used in these publications, represented in Figure 2. The three leading journals are Journal of Technology Transfer (16 publications), Research Policy (14 publications) and Higher Education (11 publications). Additionally, we measured the term frequency of keywords assigned to the journals to examine the most important keywords in the cited references of the EU literature. Keywords that dominate the field are identified in the density map (Figure 3). The density map highlights the words frequently co-occurring in the titles and abstracts of publications based on a term frequency analysis. The words that are in the darker shade of red such as industry, innovation, commercialization, economic development, science occur frequently suggesting that the research on EUs focus on these key topics.

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Results of Co-Citation Analysis

The results of the co-citation analysis are presented in Figure 4. Five interconnected clusters are represented in the visualized bibliometric network that was extracted based on cited references from the initial dataset of 178 publications. The original dataset consisting 178 articles published in the 1982-2016 period refers to 6981 references that were standardized to the same format for further analysis. However, in the co-citation analysis, we restricted publications with at least a minimum of ten citations to ensure only essential literature included and to avoid the potential risk of overly complicating the interpretation (Kovacs et al., 2015). The initial sample of 178 articles was thus reduced to 58 papers with at least 10 citations that were quoted 3301 times. In a next step, we deleted four articles that had no co-citations, and thus further reduced the core number to 54. Based on these 54 articles, a co-citation analysis was performed and further grouped into 5 clusters as follows. Each scientific publication depicted in the visualized co-citation network represents a unique cited reference that is clustered based on the likelihood to be cited in combination with other items.

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Cluster 1: Social and Economic Contribution

Cooke (2003) underlined the pressure on universities to lead regional economic development in addition to commercialization of research arising from the fact that they are among the few organizations in any given region with legitimate authority to speak

knowledgeably on science, technology and, it is hence believed, innovation and the policy to support it. Universities now have to be engaged in regional economic development to enable their knowledge to be relevant in terms of local employment, university spin-offs and growth (Lazzeretti & Tavoletti, 2005). Both these studies highlighted that strong entrepreneurial vision, flexible organizational and governance structures and cultural embeddedness were critical to reach both local economic relevance and international excellence.

A number of case studies help delineate the anatomy of the EU (O'Shea et al., 2007), their contribution to rebuild the regional innovation system (Benneworth, 2007), differences in institutional arrangements that help understand similarities and differences of the conditioning factors and outcomes across regions (Guerrero et al., 2014) both in UK and Japan (Yokoyama, 2006).

Kirby et al., (2011), Guerrero et al., (2012) and Urbano et al., (2013) adopted the institutional perspective to delineate formal and informal factors that can facilitate or hinder the development of EU's. This approach has turned out to be one of the most suitable frameworks for the analysis of institutional factors on the development of entrepreneurial universities (Guerrero et al. 2006; Guerrero 2008) and the changes in the tertiary educational systems (Witte, 2004) as it stresses the function carried out by institutions in economic development.

Formal factors include the development and implementation of entrepreneurial courses for students, university support for technology transfer and start-ups, flexible organizational structures, and ties to industry all can contribute to a university becoming more entrepreneurial. Informal factors comprise favorable attitudes of students and faculty toward entrepreneurship, the presence of entrepreneurial role models, and strategically aligned rewards can also contribute to a university becoming more entrepreneurial. Both these sets of factors shape human

interactions of the stakeholders and place constraints on an institution in the form of political rules, economic rules and contracts) or through impacting codes of conduct, attitudes, values, norms and conventions, societal culture.

Cluster 2: Academic Entrepreneurship

As universities transformed into engines of economic growth, the debate on the entrepreneurial universities shifted to its micro-foundations (Jain et al. 2009). Understanding the individual motivational drivers for university-industry relations became important for judging the ultimate organizational and societal implications of the entrepreneurial university (Siegel et al. 2007). D'este and Perkmann (2011) found that though there were differences in channels of engagement, academics engaged with industry to further their research rather than to commercialize their knowledge. Further, patenting and spin-off company formation were found to be motivated exclusively by commercialization whilst joint research, contract research and consulting was strongly informed by research-related motives. Etzkowitz (2003) mapped the transition of the research university to the entrepreneurial university and highlighted how the internal organization of the Research University consists of a series of research groups with firm-like qualities. He further demonstrated that the working under competitive funding pressures, the “inner logic” of research groups worked like start-up firms as they behaved entrepreneurially to succeed in academic entrepreneurial initiatives. Ankrah et al., (2013) extended the understanding of the “black box” of university industry knowledge- sharing. They established that extent of correspondence and differences in motives (and outcomes) of individual academic and industry actors suggesting that modification in agendas were needed for the partnership to be successful.

Cluster 3: Triple-Helix framework

Following the Bayh–Dole Act, academic entrepreneurship received increasing attention from scholars and practitioners (Mowery et al. 2001). Advocates of the ‘triple helix’ theory suggested that universities embraced economic and social development as a new mission in addition to their traditional missions of teaching and research (Etzkowitz, 1998) and transformed from ivory towers to engines of economic growth (Feller 1990). In accepting this new mission, universities became part of a coherent system that included industry and government and underpins innovation and economic progress (Etzkowitz and Leydesdorff, 2000). Rather than concentrating on ‘blue-skies’ research, academics were seen increasingly to be eager to bridge the worlds of science and technology, in an entrepreneurial way, by commercializing the technologies that emerge from their research (Clark 1998; Shane 2004; Etzkowitz 2003). As the field matured, researchers continued to explore the nuances and variations across fields such as experimental biology, mathematics and physics (Hong, 2009) and in university hospitals (French, 2012). These studies emphasized the increased pressure created by competitive funding climate as well as differing commercial ethos in health care and health research.

Cluster 4: Regional Innovation Focus

Etzkowitz et al., (2000) utilized the triple helix model to explain the mechanism and emergent structures to development Entrepreneurial Universities (Guerrero et al., 2006). Developing a model for knowledge-based regional development, Etzkowitz & Klofsten (2005) identified four stages of development - inception, implementation, consolidation and renewal. They further identified that the key event is the creation of an entrepreneurial university, whether from an existing academic base or a new foundation, which takes initiatives together with government and industry to create a support structure for firm formation and regional growth.

Etzkowitz's model accounted for the new role of universities in the advancement of national economic prosperity and paved the way for a number of studies that captured the variations and similarities across regional and national contexts such as in the United Kingdom (Goddard et al., 2012; Harrison et al., 2010; Lam, 2010). Goddard et al., (2012) highlighted the critical importance of long-term strategy and clarity of mission through the study of a relatively bold but short experiment initiated by the Regional Development Agency in the older industrial region of the North-East of England. Tuunainen (2013) questioned the applicability of Etzkowitz's model to other kinds of universities in other countries where new hybrid entities that were evolving. These were entities either had close collaboration networks between different actors or were hybrid firms that operated within the academic setting where the boundaries separating the firm from the university were blurred.

Cluster 5: Local- global axis

Deem (2001) extended the topic of entrepreneurialism in universities and introduced the local-global axis as an important metric that enabled a better understanding of their response to growing external pressures and demands including globalization (Stromquist, 2007). As the traditional discipline-based basic research evolved into transdisciplinary, problem-oriented project research carried out with external funding, the changes were found to profoundly affect the core values and basic beliefs of academic work (Ylijoki, 2005), especially among junior researchers (Hakala, 2009). Studying shifting trends in the newly industrialized economies in Asia, Wong et al., (2007) analyzed the contribution of the National university of Singapore to its national economic development while Sidhu et al., (2011) evaluated the complexities and unanticipated outcome of the university's partnership with Massachusetts Institute of

Technology. Wong et al., (2007) found significant shifts from the university's primary role as manpower provider in the pre-2000 era to playing a visible role in knowledge commercialization through increased patenting, licensing, spin-offs.

We summarize the key statistical details of the identified clusters in Table 3. The statistical comparison indicated different evolution patterns of the identified thematic clusters and their relative importance. The three clusters – Socio- Economic Contribution, Academic Entrepreneurship and Triple Helix Model and the dominate the field of research with almost an equal number of publications. But, in terms of total and average number of citations, the Triple Helix Model (Cluster 3) suggests that it covers the seminal articles in the area that have shaped the field of EU research as also reflected in it being the oldest cluster (12.25 years in existence). The socio-economic contribution (cluster 1) and academic entrepreneurship (cluster 2) clusters have surpassed the triple-helix cluster in number of publications by building on the university-industry engagement model. They evaluation of the contribution of EU's to the economic development and also explore the micro-foundations of EU's by understanding the motivations of scientists engaging in academic entrepreneurship.

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Results of Bibliographic Coupling Analysis

The results of the bibliographic coupling outline the current and emerging research perspectives in the field of EU. We limited the search to articles with at least one citation. From the total of 178 articles, 119 were clustered and is included in the bibliographic network. Excluded articles represent a sample of publications with no shared references with other articles in the dataset and therefore cannot be connected. Three clusters emerged comprising one large

cluster (technology commercialization perspective) of 104 articles and two smaller clusters with 10 (multifaceted entrepreneurial university perspective) and 5 (Globalization of entrepreneurial universities perspective) articles respectively. By application of the visualization of similarities (VOS) approach and the bibliographic coupling technique, the existing research was divided into three thematic clusters based on additional review of the publications in each cluster.

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Cluster 1: Knowledge Spillover perspective

The key tenet of this cluster vests on the technology commercialization metric as a primary output of an EU. This cluster under bibliographic coupling encompasses three of the clusters under the co-citation analysis- Triple-Helix, Academic Entrepreneurship and Industry University Interface in Regional Innovation. In sum, the articles capture the essence of the university's response to expectations that universities should contribute both to the generation of knowledge and the transfer to the business world for commercialization and good of the society (Mian, 2012). Etzkowitz (2000) highlighted four processes related to major changes in the production, exchange and use of knowledge- internal transformation within each of the helices: a) influence of one institutional sphere on another bring about transformation, creation of new overlay of trilateral linkages, networks and organizations among the three helices, and finally the recursive effect of these inter-institutional networks representing academia, industry and government on their originating sphere and the larger society. The knowledge spillover perspective captured the external and internal forces (eg. Deem, 2001; Philpott, 2011) that influenced the extent of interaction and successes). There seemed increasing level of agreement universities should be more entrepreneurial and should contribute directly to economic development through business activities such as the formation of spin-off companies, and the

patenting and licensing of technology (O'Shea et al. 2007; Martinelli et al., 2008). A number of studies focused on testing the effectiveness of the knowledge transfer/ spillover process through a number of case studies set in the US (Ranga et al., 2003), UK (O'Shea et al., 2007; Tuunainen,2005), Netherlands (Lazzeretti, 2005), Sweden (Jacob et al., 2003), Singapore (Wong et al., 2007) to name a few.

Cluster 2: Multifaceted Entrepreneurial University perspective

This cluster captured the changes in the role of the university as the economy evolved from being driven by physical capital to knowledge. While the EU was a response to generate technology transfer and knowledge based startups, the role of the university in the entrepreneurial society has broadened to focus on enhancing entrepreneurship capital and facilitating behavior to prosper in an entrepreneurial society (Audretsch, 2014). This cluster corresponds mostly to the socio-economic contribution cluster under the co-citation analysis. The primary thought process of articles under this cluster are focused around the institutional perspective that identifies formal and informal factors that enhance or diminish the role of the EU in contributing to economic development (eg., Kirby et al., 2011; Guerrero et al., 2012; Urbano et al., 2013).

Cluster 3: Universities and the Region

Studies on regional development has stressed the role of key economic actors in less favored regions, particularly in high-technology sectors, in making those regions more attractive to outside investors (Benneworth, 2007). This cluster highlights articles that follow specific cases of universities that contribute to building their regional innovation system. These include the study of Newcastle university's role as part of the hub and spoke regional innovation system in the north east of England (Benneworth, 2007). Continuing with this theme of study of

the university's contribution to less successful regions or impoverished urban areas, Bose (2015) analyzed the involvement of universities in redevelopment projects and specifically analyzed the case of the Ohio State University located in Columbus, Ohio. Ho (2014) extended this focus by evaluating the regional impact of growing international student migration in East Asia and the relationship between the university and industry, showing how such collaborations represent university products and knowledge spillovers that connect the university to the metropolitan economy in Singapore.

The results of the bibliographic coupling suggest a dynamic evolution of different perspectives. Cluster 1 focused on the knowledge spillover perspective with the highest number of publications, citations and average citations is still the dominant perspective (table 4). The average years of existence of 6 years draws attention as the concept of entrepreneurial university if well over 30 years old. This suggests that researchers are continuing to focus on the knowledge spillover perspective. Cluster 2 represents the evolving focus on the larger socio-economic contribution of the universities. Finally, cluster 3 focuses on a closer to home regional focus and emphasizes that universities are increasingly finding unique ways to become relevant to the region in which they are embedded.

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DISCUSSION AND FUTURE DIRECTIONS

Entrepreneurial Universities play an important role as both knowledge producers and disseminating institutions (Guerrero and Urbano, 2012). In the present day, universities are seen as a central force that drives innovation, creativity and economic growth (Audretsch, 2014). At the core of the EU concept is the connection between the “ivory tower” and the “real world”

(Redford & Fayolle, 2014). As EU's seek to become stand-up organizations that are significant actors in their own terms, they need five elements in order to transform 'a traditional university' into an 'entrepreneurial university: a strengthened steering core, an expanded developmental periphery, a diversified funding base, a stimulated academic heartland and an integrated entrepreneurial culture(Clark,1998). Our bibliometric analysis reveals that this vision of Clark holds good to date. While the co-citation analysis highlights that one of the most efficient ways to accomplish collaboration is the Triple- Helix model that enables knowledge spillovers through university- industry-government interrelationships (Etzkowitz and Leydesdorff, 1998). This transfer of knowledge generated through innovation to commercial applications creates new market opportunities fueling job and wealth creation and eventually enhances the country's competitive advantage. Thus, there is a necessity to involve national and regional governments in vision setting and policy making. Universities have recognized the need to utilize a more comprehensive framework that extends beyond commercialization. This is reflected in the emergence of socio-economic contributions (cluster 1: co-citation analysis; figure 6) and the evolving multifaceted university perspective (cluster 2 – bibliographic coupling; figure 7). The increased number of publications in the EU field (111 articles out of 178) published since 2010 demonstrates that researchers are closely analyzing the changes and strategies of EUs.

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The analysis also reflects that aspects of the inner-workings of the universities that will help spread of the entrepreneurial culture to aspects beyond technology commercialization are yet to be incorporated under the larger scope of functioning of EUs. These areas include entrepreneurship education, and university venture development organizations. A central feature

of the transition to an EU is the development of entrepreneurship education programs (Blok et al., 2016) as universities are natural incubators providing support structures for teachers and students to initiate new ventures (Etzkowitz, 2003) and entrepreneurship education is one of key missions (Guerrero, 2008). University venture development organizations, both accelerators and university based incubators contribute to entrepreneurship education, technology commercialization, and venture creation on campus. In addition, business incubators seek to boost regional development by fostering business and employment creation (Phan, Siegel, & Wright, 2005). Thus, it is key to integrate both these perspectives within the EU literature to get a wholesome understanding of the impact of EUs.

Finally, the EU phenomenon brings some changes to university routines, culture and policies(Tijssen,2006), resulting in the formation of an entrepreneurial orientation within the University (Todorovic et al.,2011). Yet, despite the growing awareness of the entrepreneurial university, little is still known about the entrepreneurial orientation within the university and how such an orientation there may influence the performance of EUs (Todorovic et al.,2011; Kalar and Antocic, 2015; Balasubramanian et al., 2015).

Research Limitations

This study is not without limitations thereby paving the way for additional extensions and modifications of bibliometric analysis of the EU research field. First, the study investigates a specific dataset focused on the EU research field. However, the results show that each of the identified clusters could be investigated independently. Thus, the scope of the EU literature among the identified sub-fields. The study is limited to the use of specific EU related keywords. Using additional keywords may lead to broader research directions. Our dataset is focused on most recent publications and therefore the weight of the publications used for creating clusters

will change according to their citation patterns. Imposing different thresholds for co-citation analysis will result in other patterns of clusters. Finally, the VOS methodology adopted allows limiting cluster sizes and variations in constraints placed in the bibliographic coupling analysis can provide other clustering patterns.

CONCLUSION

The study examined the nature of the EU research field using bibliometric analyses concluding that the field is currently undergoing explosive growth as universities strive to become relevant to their local, regional and national economy. They are significant differences and similarities among how universities embed themselves and contribute to being a key player in their landscape. Based on the co-citation analysis, we analyzed the evolution of the field and identified that the EU research field has its foundation in the Triple-Helix system but is adapting dynamically to building on the framework to reap larger benefits. By using the bibliographic coupling method, we were able to investigate current and emerging topics of interest in the study of EU. This comprehensive analysis has helped identify linkages between the diverse focal areas of the EU literature – focused both on the micro-foundations as well as the macro level outcomes of EU. The findings suggest that EUs are striving hard to achieve internal self-sufficiency as well as a create and maintain an entrepreneurial culture that enables them to adapt to macro-economic and global pressures.

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APPENDIX

	Authors	Total Citations
1	Etzkowitz et al., (2000)	450
2	Etzkowitz (1998)	316
3	Etzkowitz (2003)	285
4	Etzkowitz (2003)	192
5	Deem (2001)	138
6	Etzkowitz (1983)	110
7	Cooke (2005)	107
8	Etzkowitz & Klofsten (2005)	103
9	D'Este & Perkmann (2011)	99
10	Jacob & Hellsmark (2003)	91
11	Bramwell & Wolfe (2008)	87
12	Meyer (2006)	72
13	Boardman & Ponomariov(2009)	59
14	Martinelli et al., (2008)	57
15	O'Shea et al., (2007)	56
16	Van Looy et al., (2011)	49
17	Philpott et al., (2011)	48
18	Lam (2011)	47
19	Stromquist (2007)	47
20	Meyer & Utecht (2003)	43
21	Mian (1994)	43
22	Ylijoki (2005)	41
23	Czarnitzki et al.,(2009)	38
24	Wong et al.,(2007)	38
25	Chang et al.,(2009)	35
26	Tuunainen (2005)	35
27	Ranga et al., (2003)	34
28	Guerrero & Urbano (2012)	32
29	Sidhu et al., (2011)	30
30	Leydesdorff & Meyer (2011)	30

Table 1: Most cited articles in the field of entrepreneurial universities

Author	Definition
Etzkowitz (1983)	Universities that are considering new sources of funds like patents, research under contracts and entry into a partnership with a private enterprise.
Subotzky (1999)	The entrepreneurial university is characterized by closer university-business partnerships, by greater faculty responsibility for accessing external sources of funding, and by a managerial ethos in governance, leadership and planning.
Etzkowitz (2003)	Just as the university trains individual students and sends them out into the world, the Entrepreneurial University is a natural incubator, providing support structures for teachers and students to initiate new ventures: intellectual, commercial and conjoint.
Jacob et al. (2003)	An Entrepreneurial University is based on both commercialization (customs made education courses, consultancy services and extension activities) and commoditization (patents, licensing or student owned start-ups).
Kirby (2005)	An entrepreneurial university could be defined as a survivor of competitive environments with a common strategy oriented to being the best in all its activities (e.g., having good finances, selecting good students and teachers, producing quality research) and tries to be more productive and creative in establishing links between education and research.
Guerrero et al. 2006; Guerrero 2008	Universities involved in entrepreneurial initiatives such as science parks and incubators, teaching programs and courses in entrepreneurship, or interdisciplinary centers and co-operation networks.
Yusof, 2010	An entrepreneurial university is a university that strategically adapts the entrepreneurial mindset throughout the organization and practices academic entrepreneurship which also encompasses technology transfer activities.

Table 2: Definitions of Entrepreneurial Universities

	Number of Publications	Total Citations per cluster	Average Citations per publications	Average Existence of publications (in years)	Three most cited articles
Cluster 1: Socio-Economic Contribution	14	540	38.6	8.07	Cooke (2005); Jacob et al., (2003); Bramwell et al., (2003);
Cluster 2: Academic Entrepreneurship	13	577	44.4	7.39	D'Este & Perkmann (2011); Meyer (2006); Boardman et al., (2009)
Cluster 3: Triple Helix Model	12	1063	88.6	12.25	Etzkowitz (1998); Etzkowitz (2003); Etzkowitz (2003)
Cluster 4: Regional Innovation Focus	9	716	79.6	9.67	Etzkowitz et al.,(2000), Etzkowitz & Klofsten (2005), Lam (2010)
Cluster 5: Local- Global Axis	6	316	52.7	9.27	Deem (2001); Stromquist (2007); Ylijoki (2005)

Table 3: Key statistical indicators of the clustered publications, based on the co-citation technique

	Number of Publications	Total Citations per cluster	Average Citations per publications	Average Existence of publications (in years)	Three most cited articles
Cluster 1: Knowledge Spillover perspective	104	3246	31.2	6.04	Etzkowitz (1998); Etzkowitz (2000); Etzkowitz (2003);
Cluster 2: Multifaceted Entrepreneurial University perspective	10	144	14.4	3	Guerrero et al., (2012); Audretsch (2014); Kirby et al., (2011)
Cluster 3: Globalization of EU perspective	5	60	12.0	5.2	Sidhu et al., (2011); Benneworth et al., (2007); Benneworth (2007)

Table 4: Key statistical indicators of the clustered publications, based on the bibliographic coupling technique

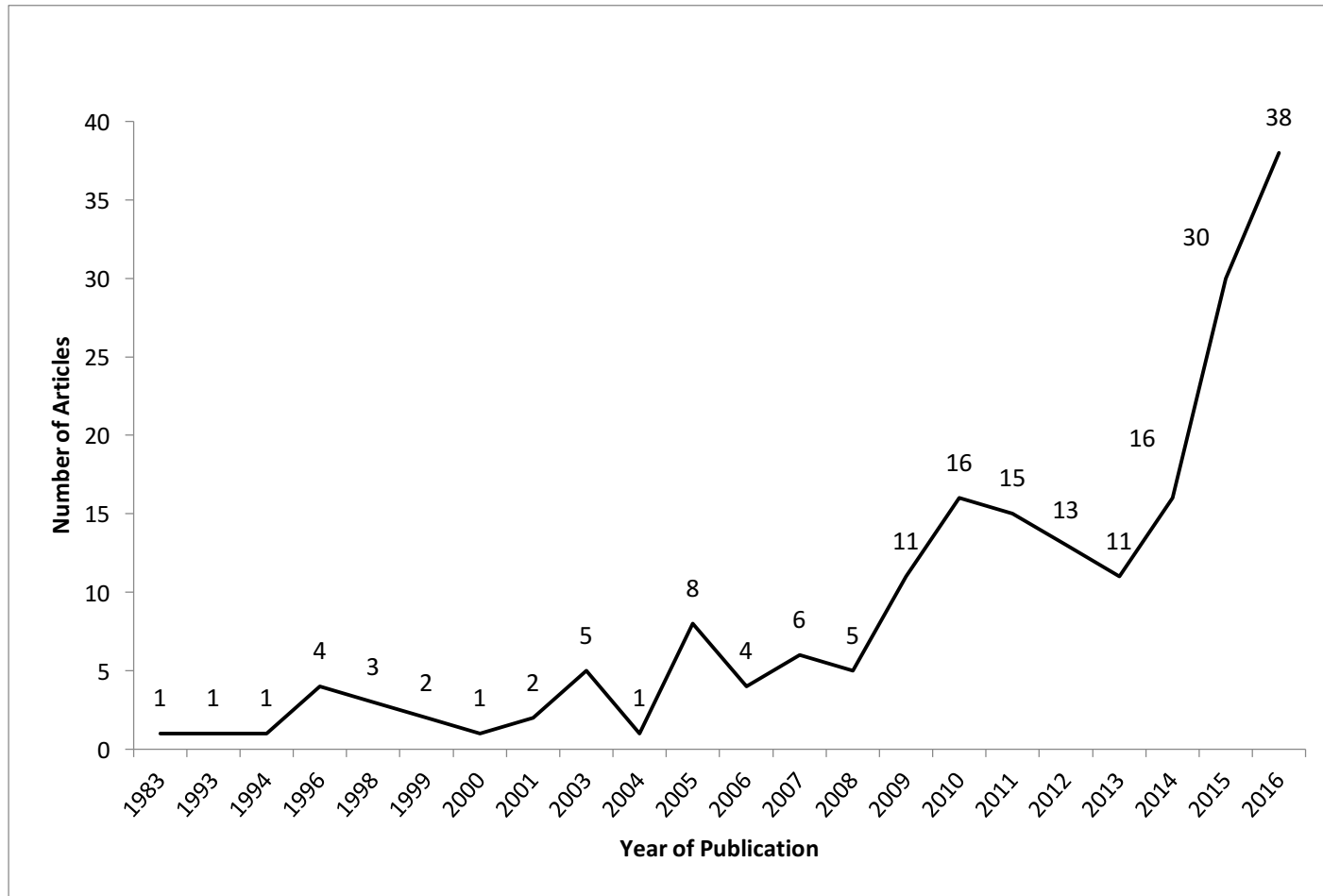


Figure 1: Number of articles by year of publication

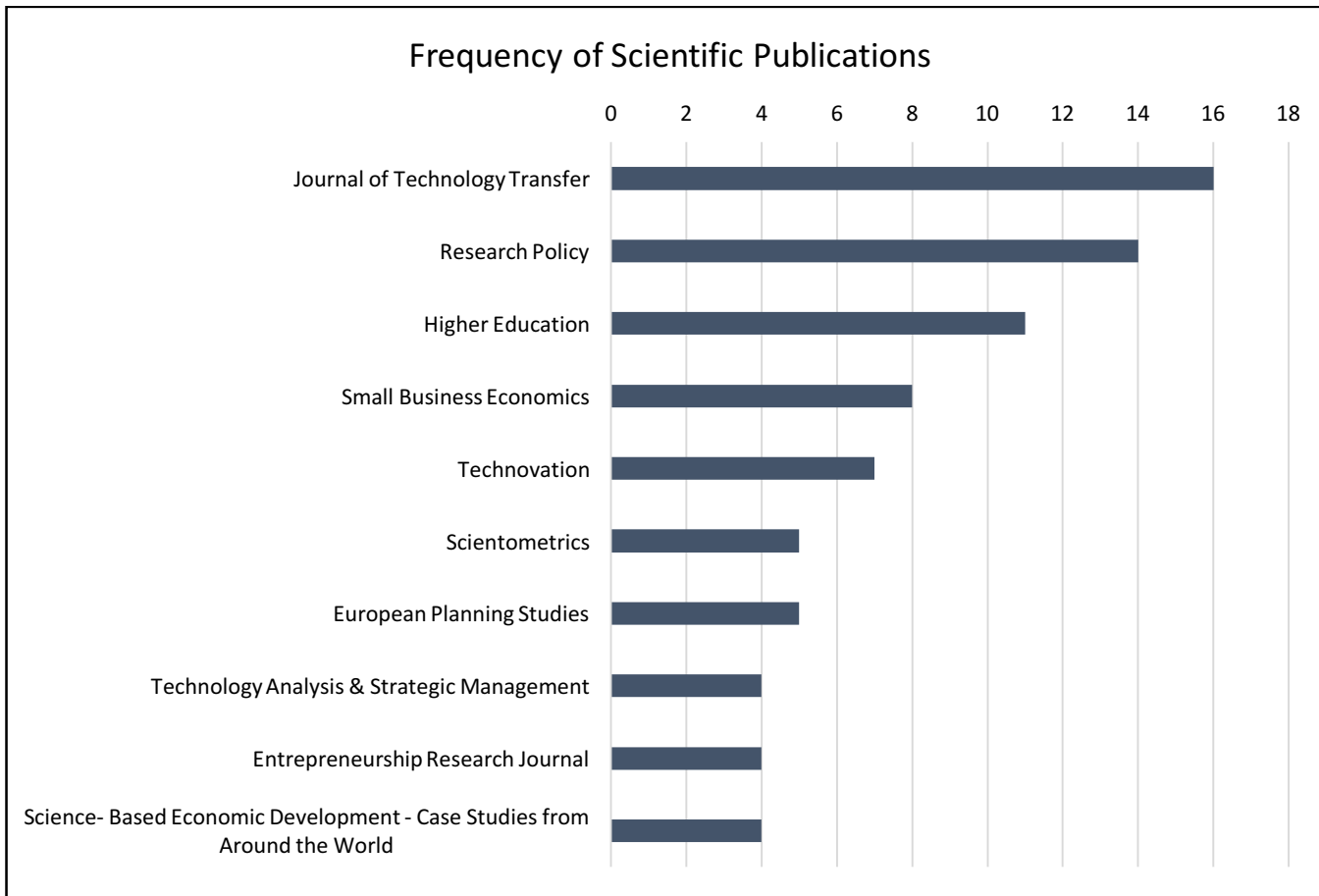


Figure 2: Overview of the most popular journals that EU related articles have been published

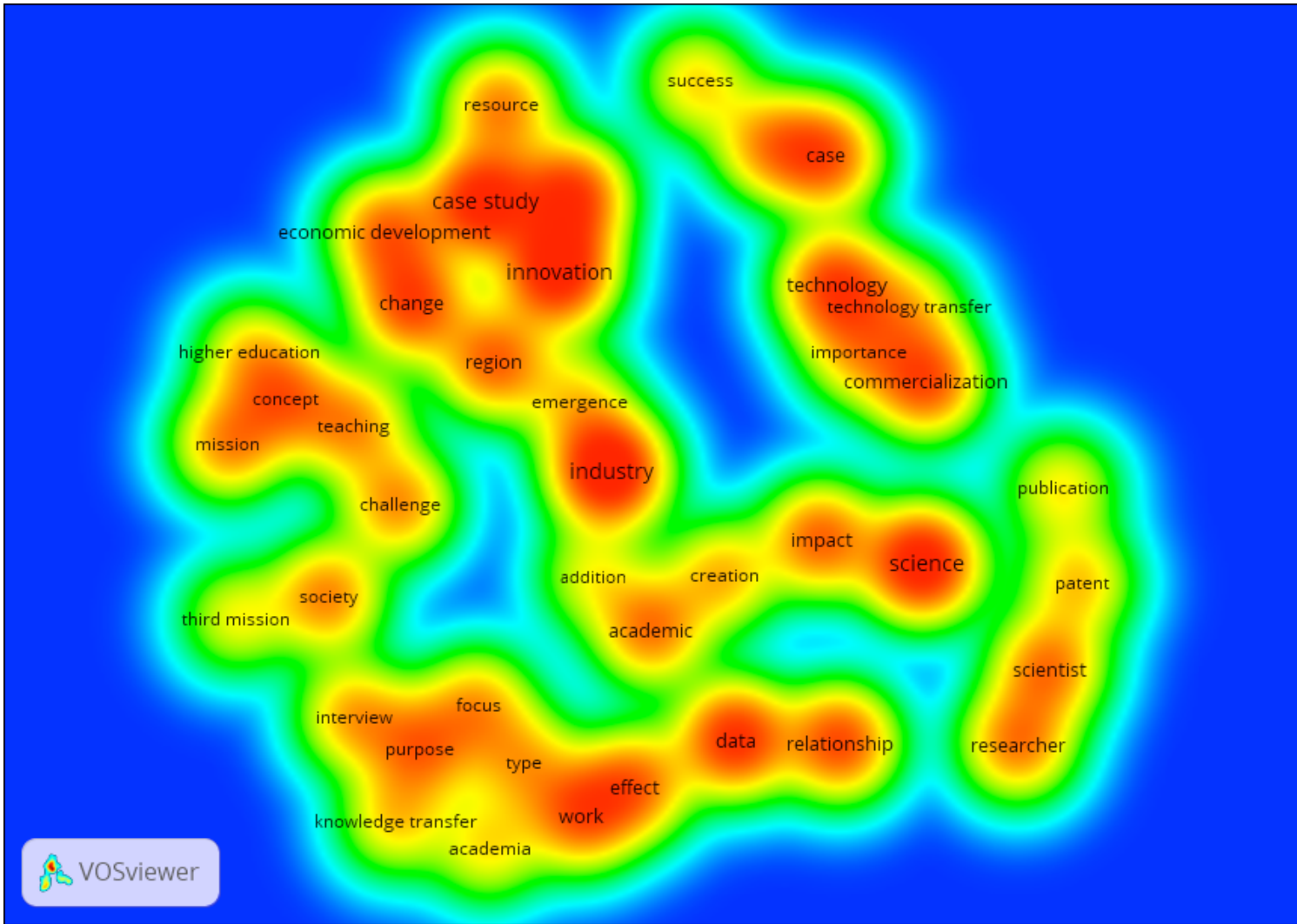


Figure 3: Density Map of Keywords in the EU Research Field

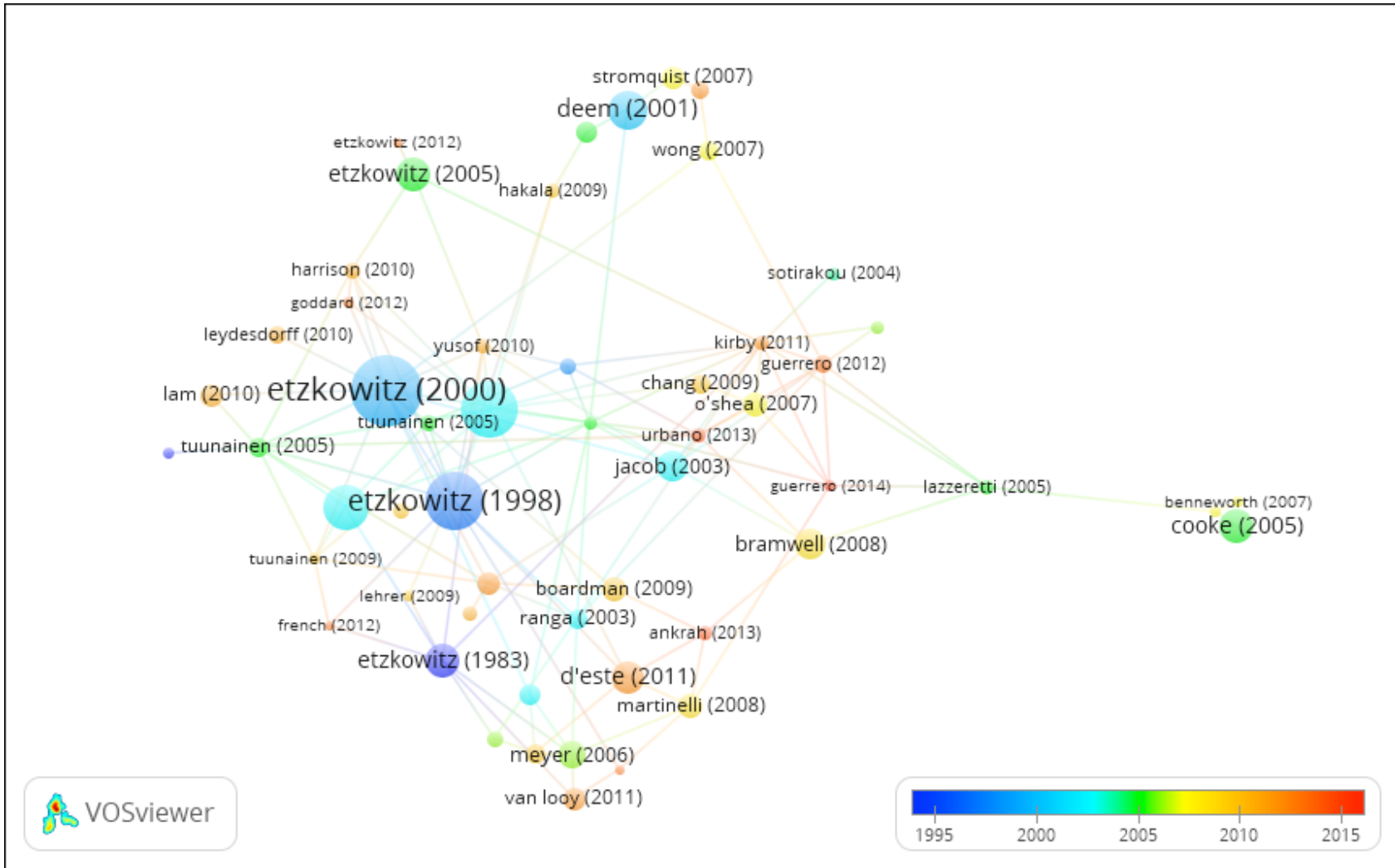


Figure 4: Co-Citation Network (54 publications in 5 clusters)

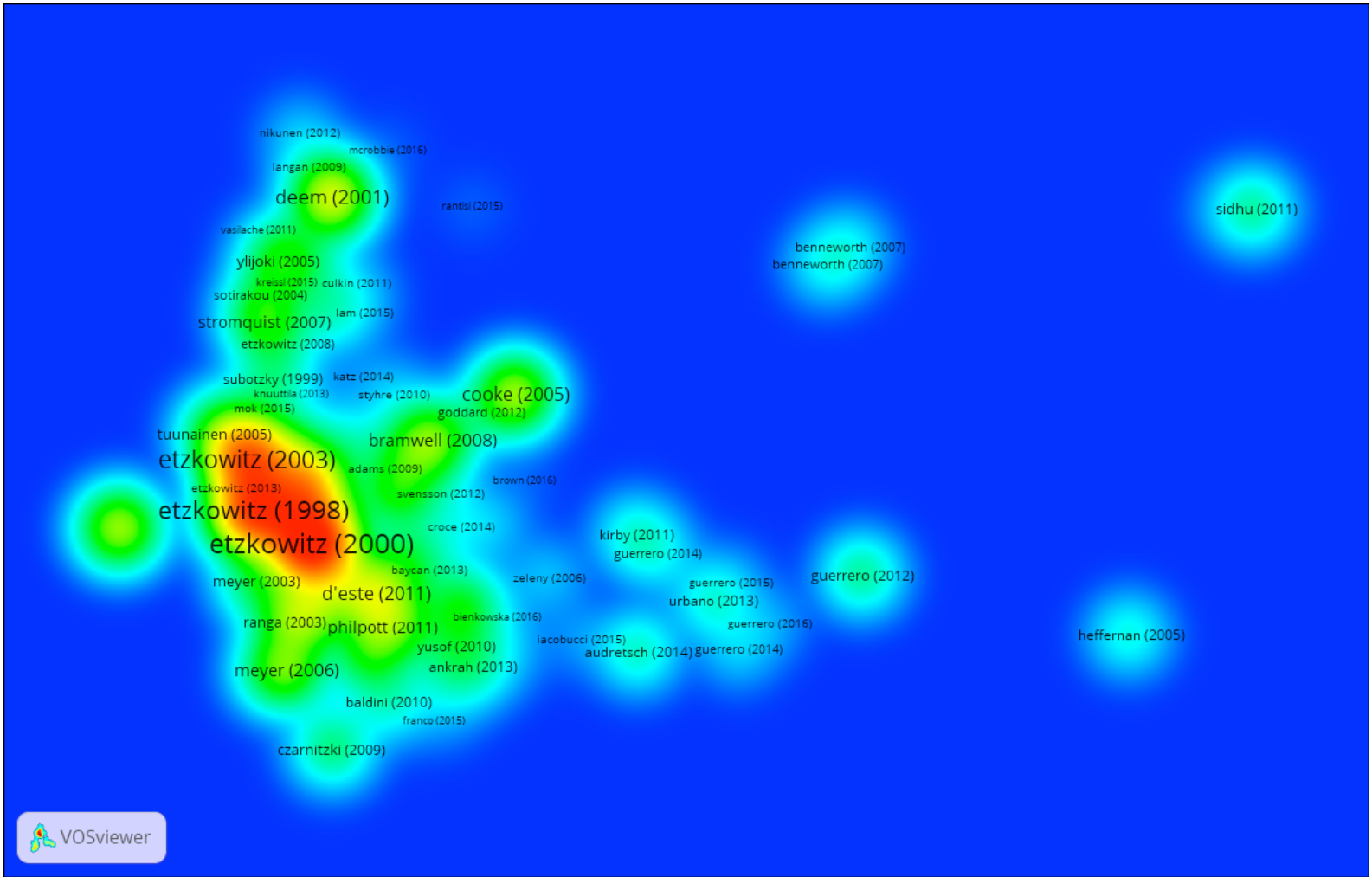


Figure 5: Bibliographic Network – Density Map (119 publications in 3 clusters)

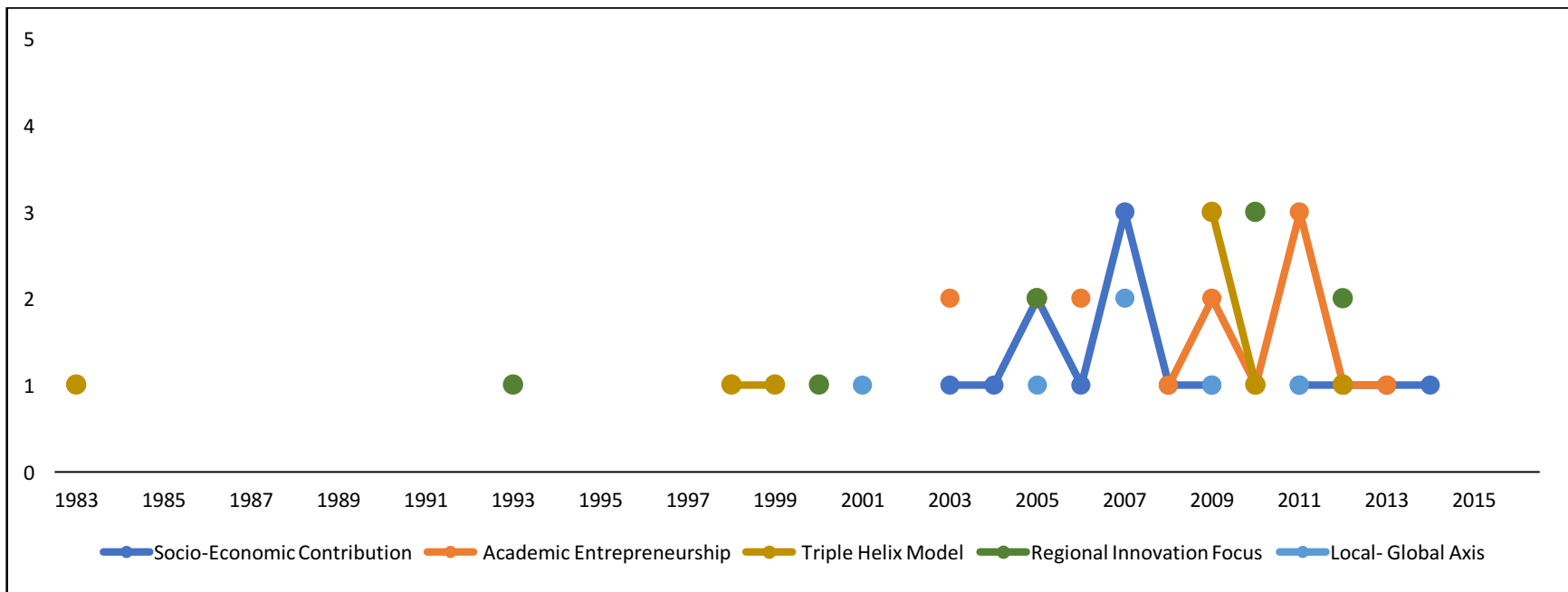


Figure 6: Overview of the evolution of 5 thematic clusters per year, representing number of articles based on the references of the initial dataset. Includes 54 articles identified using co-citation analysis.

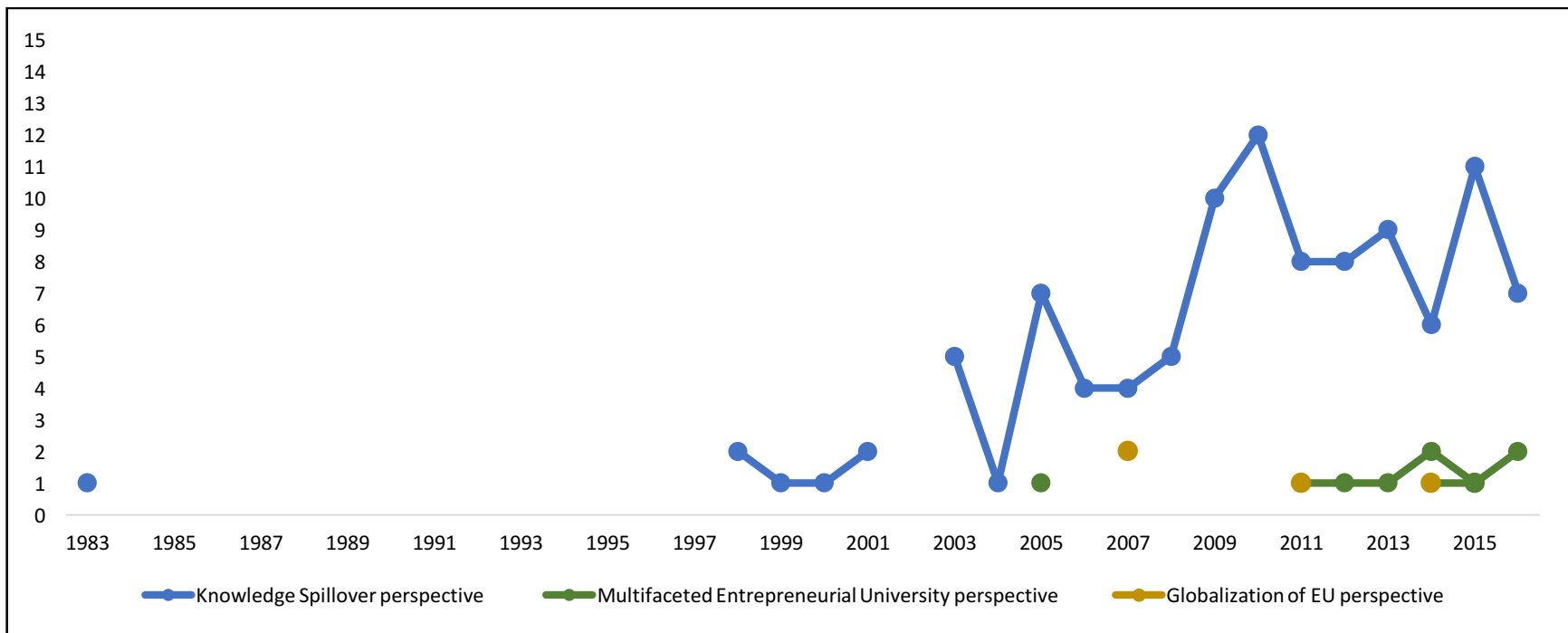


Figure 7: Overview of the evolution of 3 thematic clusters per year, representing number of articles based on the references of the initial dataset. Includes 119 articles identified using bibliographic coupling analysis.