

INSIGHTS AND PERSPECTIVES FROM A LITERATURE REVIEW ON UNIVERSITY SPIN-OFFS

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Abstract

The need for innovation and the ability to transfer knowledge to society and industry are essential for the development of current economy. In this sense, universities play a crucial role in this mission, and university spin-offs have become one of the most popular mechanisms of academic knowledge transfer. The purpose of this paper is to perform a literature review in the field of university spin-offs. The adopted methodology starts by creating a conceptual map of the various research areas around university spin-offs, followed by the identification of the most predominant studies in the field taking into account the number of citations. The findings indicate that the main explored dimensions in the university spin-offs research include the process of technology transfer, the role of university in the society, the regional context of the university and the impact of university spin-offs considering several dimensions. On the other side the least explored dimensions include the analysis of the founders' background, and the establishment of public policies to support the activities of university spin-offs.

Keywords: university spin-offs, knowledge transfer, technology transfer, activities; academic entrepreneurship; entrepreneur university.

1. INTRODUCTION

The role of universities has been changing in these last decades, assuming today as a basilar pillar in the construction of knowledge societies. As a result of the combination of diverse factors, universities have been assuming an increasing emphasis in any discussion about the production, diffusion and conversion of knowledge in economic and social value. In fact, the increasing globalization of the economy and the intensification of competition have made knowledge one of the factors of competitiveness in modern economies, reinforcing the role of the institutions responsible for their production.

Although academic entrepreneurship has been a phenomenon that has existed throughout history, only recently has taken a prominent place in the political agendas of governments. Nowadays, the race to knowledge, to innovation, and to science and technology is global and has a direct impact on the economic performance, growth and prosperity of all regions. Many EU policies focus on building an entrepreneurial culture, and the attention to new enterprise creation is clearly expressed in the priority areas of intervention defined by the EU (Mărcuț, 2016). These situation results from the ability of university spin-offs to create knowledge, to attract companies to settle in their environment and foster the creation of some qualified job through the creation of new companies.

University spin-offs are a particular type of new innovation-driven enterprises, characterized by high human capital and technology intensive production processes, often aiming at developing into high-growth businesses in the industry and services sectors. According to Ensley and Hmieleski (2005) and Fackler et al. (2016) university spin-offs have some specific characteristics: independence, small size, youth, high academic qualifications of their founders, a strong and systematic investment in R&D, a commitment to innovation and connection with knowledge production centers, such as universities, higher education institutions and R&D centers.

The phenomenon of university spin-offs is complex, multidimensional, high risk and influenced by factors of diverse nature that include factors related to the production, transfer of knowledge, financing, the founding teams, or the support provided by the institution of origin, among others. However, despite the great diversity of scientific articles in this field, there are difficulties in finding studies that clearly and concisely organize the different components and dimensions of analysis of a university spin-off. Therefore, we propose the development of a study that identifies in the literature the most predominant studies in the field and characterizes the different dimensions and analysis components of these studies. The paper is organized as follows: First, we perform a review of the state of the art in the field of university spin-offs. Then, we present the adopted methodology, followed by the comparison of the most predominant studies considering the several research dimensions of university spin-offs. Finally, we draw the conclusion of our work.

2. LITERATURE REVIEW

Rothaermel et al. (2007) were the first authors to perform a literature review in the field of university entrepreneurship. They identified four streams in this area of study: (i) entrepreneurial research university, (ii) productivity of technology transfer offices, (iii) new firm creation, and (iv) environmental context including networks of innovation. Van Burg et al. (2008) adopted a science-based design approach to establish a set of rules that universities should adopt to effectively promote the creation of university spin-offs. Geuna and Muscio (2009) also performed a literature review in the field of university knowledge transfer by looking to intellectual property rights and spin-offs. Pattnaik and Pandey (2014) presented a concise overview about the main concepts associated to university spin-offs and proposed a multi-stage holistic model. Siegel and Wright (2015) revisited the concept of academic entrepreneurship and identified two changes since 2012: first, the involvements of more stakeholders in the process of academic entrepreneurship; second, universities have become more strategic in their approach to this activity. More recently, Fini et al. (2016) performed a longitudinal and multi-level cross country study (i.e., Italy, Norway, and UK) to test whether the national and university level initiatives have an influence on the number and quality of those created spin-offs.

Bercovitz and Feldmann (2006) proposed a framework composed by three pillars (economic, social and political) to understand the role of universities in systems of innovation. Philpott et al. (2011) performed an exploratory study

using case studies that intended to analyze how the concept of the entrepreneurial university is being implemented. Farsi et al. (2012) propose a conceptualization framework for entrepreneurial universities in developing countries composed of four elements: (i) resources; (ii) capabilities; (iii) mission; and (iv) impeding elements. Walker (2012) intended to determine what processes, procedures and organizations are critical in terms of creating an environment that encourages entrepreneurship. This study established that incentives, as provided by government and the university, play a decisive role in influencing researchers' decisions. Kretz and Sá (2013) discussed the role of the university in promoting entrepreneurship and look to the fourth mission of higher education institutions. Trencher et al. (2013) explored this new emerging function of the university and its articulation with other entities, such as government, industry and civil society. Kochenkova et al. (2016) suggested the classification of public policy measures in supporting technology transfer activities based on two dimensions: (i) the type of policy measure (i.e., legislative reforms, financial support, and competence development); and (ii) the focus of the study (i.e., considering just one variable dimension, or two variables together).

González-Pernía et al. (2013) conducted an assessment of the determinants of university technology transfer. They used data from Spanish territory and concluded that technology transfer offices with more experienced staff teams and universities with well established quality management policies are more likely to obtain better university technology transfer results. Bradley et al. (2013) also looked to university technology transfer activities and advocated that the linear model of technology transfer is no longer sufficient. Instead, they proposed an alternative model that could better capture the progression of the university towards an entrepreneurial and dynamic institution. Rasmussen et al. (2014) analyzed the influence of university departments on the evolution of entrepreneurial competencies in spin-off ventures and concluded that this kind of support provided significant differences in early venture performance. Avnimelech and Feldman (2015) examined the cross-university variation in spin-off activity by faculty members using 124 US academic institutions and found that the local cluster size and university quality both increase the probability of spin-offs, but the same doesn't happen when the relative quality of the institution is higher than the relative quality of the cluster. In this case, the probability of academic spin-offs decreases.

Leisyte (2011) discussed the institutionalization linkages between universities and industrial firms. She explored how the US and Dutch governments are commercially exploring their research projects and activities conducted at universities and R&D centers. Rasmussen and Wright (2015) proposed several policies to foster and facilitate the creation of academic spin-offs. They considered that a university should be seen as one uniform entity in relation to spin-offs, considered its internal departments, offices, research groups, scientists and students. Berbegal-Mirabent et al. (2015) used also data from Spanish university spin-offs to conclude that there isn't a unique receipt that fosters spin-offs. Instead, the findings of this study demonstrated that there are several strategies that can successfully lead to academic entrepreneurship.

Müller (2008) analyzed the length of time between the founder's leaving of academia and the establishment of the spin-off and concluded that exists three factors that typically decrease this time, which is the intensity of technology transfer, the access of founders to university infrastructure and the access to informal support by former colleagues. Astebro et al. (2012) provided an evidence from the US region that demonstrated that the gross flow of start-ups created by recently graduated students was more significant rather than those created by faculty and staff. Bigliardi et al. (2013) identified a set of indicators that contribute for the success of university spin-off companies. Among them, we highlight the access to qualified entrepreneurial skills, competent staff in technology transfer offices, founder's motivation, and financial involvement of the parent. Those indicators emerged from the literature and the national context of Italy, such as industry characteristics, regional infrastructure, seed and venture capital availability. Hayter (2015) explored the economic factors that are associated with the success of university spin-off, and concluded that the spin-off success is dependent on both the type and size of the academic entrepreneur's social network. Wooley (2016) used data from nanotechnology firms founded between 1981 and 2002 to understand the roles of spin-off founders and intellectual property in high technology venture outcomes. This study showed that both intellectual property and founder background influenced the outcome of those companies, even considering that type of firm origin has provocative distinctions.

Ortín-Ángel and Vendrell-Herrero (2010) found that typically university spin-offs attract more venture capital than other technological start-ups. They concluded that this fact is explained mainly by the lack of managerial skills among the founders. Becsky-Nagy (2013) looked how venture capital is being used by university spin-offs in Hungary. She concluded that the three main obstacles are: (i) information gap between demand and supply side, (ii) the lack of entrepreneurship willingness; and (iii) the low quality of the financial environment. Rodríguez-Gulías et al. (2016) conducted a study to demonstrate whether venture capital influences university spin-offs using a longitudinal dataset of 212 Spanish spin-offs. The results of this study showed that venture capital partners have a positive effect on the spin-offs growth.

Elpida et al. (2010) built a conceptual framework called the "spin-off chain", which integrates the regional and national context into the main university-based entrepreneurial process. Bathelt et al. (2010) developed an insightful conceptualization of the spin-off processes, and applies it to a regional case study in Canada. Oscarina (2013) used a dataset of 327 Portuguese research based spin-offs to investigate the intensity of spin-offs creation across several regions of Portugal. The findings suggested that the prestige of the university and the existence of local incubators and science parks have a positive impact on the intensity of spin-offs creation. Sternberg (2014) analyzed the impact of regional government support and regional environment in the success of a university spin-off. The results suggested that the regional context of a firm has more impact than the government support given to the company. Prencipe (2014) investigated, on a regional level, the development of university spin-offs in favorable and non favorable regional contexts over the Italian territory using meso and macro factors.

Vincett (2010) analyzed the economic impact of academic spin-off companies and their implication for public policy. This study demonstrated that spin-offs causes incremental GDP, much larger than the government funding directly attributed to it. Additionally, Vincett (2010) states that spin-offs offer long-term benefits that are more important than the direct economic impact, but those benefits are less quantifiable. On the other side, Harrison and Leitch (2010) used data from UK universities to advocate that university spin-offs tend to appear to start and remain small. They advocate that the impact of university spin-offs has been overestimated.

Pitsakis et al. (2015) addressed the peripheral halo effect, namely questioning if academic spin-offs influence the income received by universities to their research activities. This study revealed that spin-offs portfolios can generate direct income (e.g., equity positions) and indirect income (e.g., reputational benefits) for universities. This study also revealed that this effect is more prominent for higher-status than for low-status organizations. Corsi and Prencipe (2015) proposed a model for measuring the performance of academic spin-offs. The results of this study revealed that the number of ventures created by the university is the most adequate measure, followed by the asset evaluation. On the other side, profitability measurement was considered unsuitable. The same authors, used data of 621 Italian university spin-offs to demonstrate that the positive impact of the university context is more crucial compared with those of the regional context (Corsi and Prencipe, 2016). Still to mention the study conducted by Jelfs (2016) that analyzed the performance of university spin-off companies created by the University of Birmingham in UK.

Bchini (2012) analyzed the factor of growth and entrepreneurial success of spin-offs in the Tunisian context. They adopted a qualitative approach based on case studies and they concluded that extrapreneurship is the most successful form of spin-off. Bolzani et al. (2014) analyzed a vast sample of 935 university spin-offs from Italian public universities to understand the growth strategies and performance of these companies. Motoyama and Watkins (2014) examined the connection within the start-up ecosystem by using the St. Louis area in US as case study. They identified that cooperation between support organizations in the city played a key role in the evolution of the ecosystem by connecting entrepreneurs with the types of support they need. Wright and Fu (2015) provided an overview of the trends in spinouts from universities in the UK considering the last fifteen years. Mosey et al. (2017) analyzed three empirical studies located in different European countries (i.e., Spain, Italy and UK) and proposed an agenda for further research using multi-level approaches to understanding the technology entrepreneurship process.

3. METHODOLOGY

The adopted methodology starts by creating a conceptual map of the surveyed studies in the field of university spin-offs. Four search keywords were used at the title level: (i) university spin-offs; (ii) university entrepreneurship; (iii) academic spin-offs; and (iv) academic entrepreneurship. This initial strategy allows us to mapping several

studies to a common framework, which will turn easier to compare each approach, detect trends and evolutions. For each surveyed study, we captured its main features, which were mapped onto different criteria and, then, we represent them using a mind map (fig. 1).

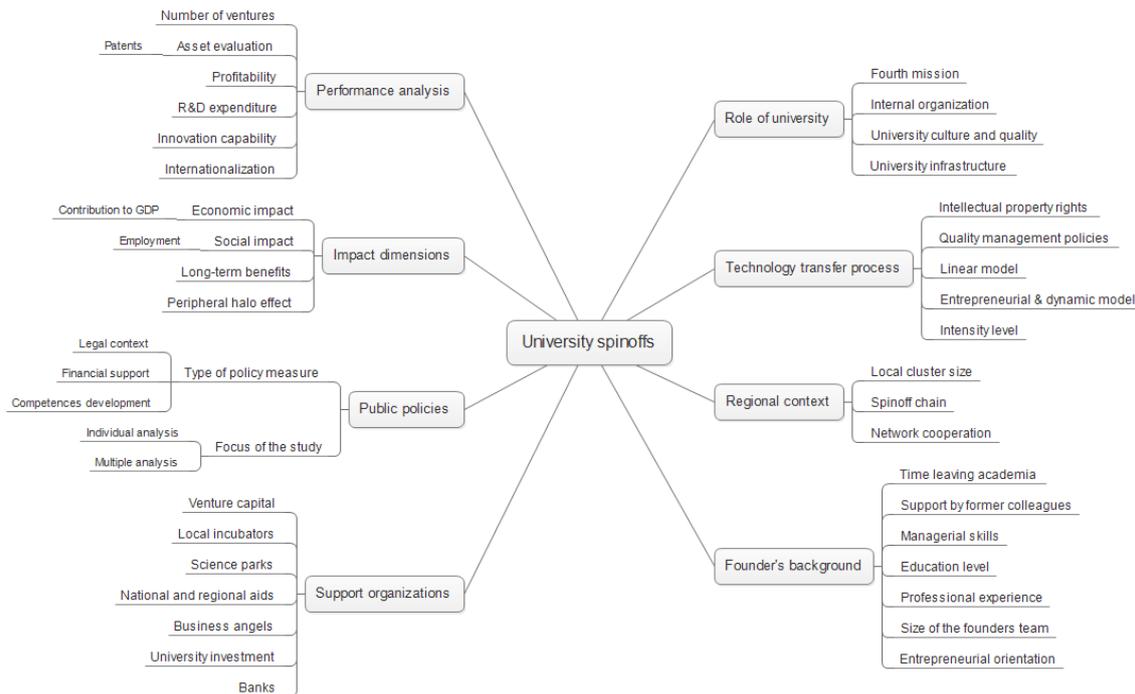


FIGURE 1 - MIND MAP REPRESENTATION OF UNIVERSITY SPIN-OFF STUDIES

In order to determine the most relevant studies conducted along the last year we analyzed the impact of these publications using the Thomson ISI Web of Science (WOS) and Scopus citations up to the end of March 2017. Lopez Illescas et al. (2008) advocated that the journals indexed in WOS and Scopus databases offer higher impact factors (IFs). However, Web of Science only includes citations to journal articles published in ISI listed journals, and hence does not include books, book chapters, conference papers, and journal articles published in non-ISI journals. Therefore, and in order to complement our source of information, we also incorporate Google Scholar, which can occasionally provide a more nuanced view of the importance of scholarly articles in social sciences (Levine-Clark and Gil, 2009). The simultaneous use of these three indexes allows us to provide a more comprehensive depiction of the extent of international and interdisciplinary nature of our research topic.

Table 1 shows the total number of citations distributed by each bibliometric index for each study presented in the state of the art section.

In order to focus our analysis on the most predominant studies, we established a minimum cut line of ten studies and we assure that at least 25% of the considered studies have been published in the last 3 years. This approach intends to ensure a good trade-off between the studies that present larger IFs and its recent relevance, in order to

avoid excluding from this analysis many recent empirical papers. Moreover, we only cover the most recent study conducted by each author.

TABLE 1 - NUMBER OF CITATIONS FOR EACH STUDY ABOUT UNIVERSITY SPIN-OFFS

Study	Web of Science	Scopus	Google Schola	Total
Rothaermel et al., 2007	345	444	1071	1860
Bercovitz and Feldmann, 2006	0	0	587	587
Geuna and Muscio, 2009	104	132	315	551
Philpott et al., 2011	58	80	228	366
Van Burg et al., 2008	38	59	151	248
Bathelt et al., 2010	33	48	140	221
Astebro et al., 2012	34	45	120	199
Rasmussen et al., 2014	29	37	83	149
Harrison and Leitch, 2010	31	0	105	136
Trencher et al., 2013	22	27	80	129
Vincett, 2010	24	28	66	118
Müller, 2008	0	30	87	117
Sternberg, 2014	11	16	58	85
Bradley et al., 2013	0	0	74	74
González-Pernía et al., 2013	9	12	32	53
Leisyte, 2011	7	12	26	45
Siegel and Wright, 2015	0	0	39	39
Bigliardi et al., 2013	0	9	26	35
Ortín-Ángel and Vendrell-Herrero, 2010	0	8	19	27
Rasmussen and Wright, 2015	0	0	26	26
Motoyama and Watkins, 2014	0	0	26	26
Kretz and Sá, 2013	3	4	12	19
Kochenkova et al., 2016	2	2	14	18
Bolzani et al., 2014	0	5	13	18
Berbegal-Mirabent et al., 2015	0	0	17	17
Elpida et al., 2010	0	0	15	15
Hayter, 2015	0	0	8	8
Walker, 2012	0	0	6	6
Pitsakis et al., 2015	0	0	6	6
Pattnaik and Pandey, 2014	0	0	5	5
Avnimelech and Feldman, 2015	1	1	2	4
Corsi and Prencipe, 2016	0	2	2	4
Bchini, 2012	0	0	4	4
Fini et al, 2016	0	0	2	2
Rodríguez-Gulías et al., 2016	0	0	2	2
Conceição et al., 2013	0	0	2	2
Wright and Fu, 2015	0	0	2	2
Mosey et al., 2017	0	0	2	2
Becsky-Nagy, 2013	0	0	1	1
Wooley, 2016	0	0	0	0
Prencipe, 2014	0	0	0	0
Corsi and Prencipe, 2015	0	0	0	0
Jelfs, 2016	0	0	0	0

4. COMPARISON OF APPROACHES

In this section, we present a detailed summary of the main characteristics of each spin-off study. Approaches surveyed and considered only include studies inside the cut line defined in Table 1. Rows correspond to criteria introduced in the mind maps showed in the methodology section and columns correspond to each study. A given cell contains information about an approach for a certain criterion. Most of the criteria are evaluated as yes/no, but others have alternatives. Acronyms used to represent these alternatives may be found in Table 2. However, two general alternatives can be found for any criterion: "-" means that this criterion does apply for that given methodology whereas "none" means that none of the alternatives are considered.

TABLE 2 - CLASSIFICATION AND COMPARATIVE ANALYSIS OF UNIVERSITY SPIN-OFFS STUDIES

	ROT07	BF06	GM09	PHI11	VB08	BAT10	AST12	RAS14	HL10	TRE13	STE14	SW15
Role of university												
Fourth mission	-		None		None	None		None		Yes		Partial
Internal organization	-		Yes		Yes	Yes		Yes		Yes		Yes
University culture and quality	-		Yes		Yes	Yes		Yes		Yes		Yes
University infrastructure	-		Yes		Yes	Yes		Yes		Yes		Yes
Technology transfer process												
Intellectual property rights	Partial	None	Yes	Partial	Partial	Yes		None		Yes		Yes
Quality management policies	Partial	None	None	None	Partial	None		Partial		Partial		Yes
Linear model	Yes	Partial	Yes	None	Yes	Yes		Partial		Yes		Yes
Entrepreneurial & dynamic model	Yes	Partial	Yes	Yes	Partial	Yes		Partial		Yes		Yes
Intensity level	Yes	Partial	Partial	None	Partial	Yes		Partial		Yes		Yes
Regional context												
Local cluster size	Partial	Partial				Yes			Yes	Partial	Partial	
Spin-off chain	Partial	Partial				Yes			Yes	Partial	Partial	
Network cooperation	Yes	Yes				Yes			Yes	Yes	Partial	
Founders background												
Time leaving academia						Partial	Yes					
Support by former colleagues						Partial	Yes					
Managerial skills						None	Partial					
Educational level						None	Yes					
Professional experience						None	Partial					

	ROT07	BF06	GM09	PHI11	VB08	BAT10	AST12	RAS14	HL10	TRE13	STE14	SW15
Size of the founders team						Yes	Yes					
Entrepreneurial orientation						Yes	Yes					
Performance analysis												
Number of ventures							Yes		Yes			
Asset evaluation							Yes		Yes			
Profitability							Yes		Yes			
R&D expenditure							Yes		Yes			
Innovation capability							Partial		None			
Internationalization							None		None			
Impact dimensions												
Economic impact		Yes					Yes		Yes	Yes		Yes
Social impact		Yes					Yes		None	Yes		Yes
Long-term benefits		Yes					Yes		None	Yes		Yes
Peripheral halo effect		None					None		None	None		No
Public policies												
Type of policy measure											Yes	
Focus of the study											Yes	
Support organizations												
Venture capital											Partial	
Local incubators											None	
Science parks											None	
National and regional aids											Yes	
Business angels											None	
University investment											Partial	
Banks											None	

The main identified themes addressed by the studies in the field of university spin-offs are: (i) role of the university; (ii) technology transfer process; (iii) regional context; (iv) founder's background; (v) performance analysis; (vi) impact dimensions; (vii) public policies; and (viii) support organizations.

The technology transfer process is the main theme addressed by the foremost bibliographic studies. In the literature it is possible to identify two models of transfer of technology and knowledge: (i) the more academic or linear model; and (ii) the more entrepreneurial model, which reflects a strong dynamism and connection to the industry. Other topics covered include: (iii) intellectual property rights, (iv) quality management policies; and (v) intensity level. Intellectual property refers to the knowledge the creator hold of how to produce his creation. The studies essentially

cover protection with reference to copyright and industrial property. The quality management policy is an essential dimension that allows universities to fulfil their mission and vision in order to ensure their commitment to quality in their activities in the areas of teaching, research and the transfer of scientific and technological knowledge. Most of the studies only partially address this issue, because quality management is a very broad area that covers several functional areas of a university. Finally, the intensity level is referred by some studies as being a relevant aspect in the success of the technology transfer process.

The role of universities is a pivotal point addressed by the majority of studies. All the studies that address this topic focus their analysis on the internal organization of the departments and processes, the quality of the available infrastructure and the culture of the university. This latter aspect is considered by several studies as a distinctive element in the success of the technology transfer process and in the connection with industry. Finally, it is mentioned in some studies, highlighting the research conducted by Trencher et al. (2013), that the university's mission should not be limited to teaching, research and community service. It is argued that universities should go beyond the notion of community service and explore their fourth mission of nurturing future leader and global citizens.

Another dimension that is addressed by most studies is the regional context. At this level, it should be highlighted the emergence of technological clusters, the integration of university spin-offs in their regional and national context, and the importance of network cooperation, which is fundamental in today's context where resources are scarce from the point of view of human resources, technological or financial. This situation is also confirmed by Guerrero et al. (2014) in which they refer that human resources are the most critical element in the entrepreneurial transformation process, particularly in emergent developing countries.

The economic and social impact of university spin-offs is analyzed by 50% of the most predominant studies in the field. At this level, the main indicators are: (i) number of ventures created at national and/or regional levels; (ii) asset evaluation; (iii) innovation capability, essentially measured using the number of registered patents; (iv) internationalization; and (v) profitability measures. There is no consensus in the literature about the relative importance of each of these indicators, but it be noted that the most widely used indicators for measuring university spin-offs are based on the number of ventures and asset evaluation.

The founder's background is only analyzed in detail by two of the most predominant studies. The perspectives of analysis focus fundamentally on the following aspects: (i) time leaving academia; (ii) support by former colleagues; (iii) managerial skills; (iv) professional experience; (v) size of the founders team; and (vi) entrepreneurial orientation. Within these areas, it is essentially looked with greater emphasis if team size and team environments of dissonance and synergy have an impact in the spin-offs creation process. Furthermore, the founder's entrepreneurial capacity is mentioned, and it is pointed out that this capacity is the result of the entrepreneurs' capacity for critical thinking, initiative, responsibility, and practical approach.

Only one considered study looks to the public policies that are available to university spin-offs. Two dimensions can be found in this group: (i) type of policy measure; and (ii) focus of the study. It can be found studies that focus on an individual or multiple perspectives, where it is adopted one or multiple variables in the analysis. Apart of the focus of the study, it can be found policy measures in terms of legal context, financial support and competences development.

Finally, Sternberg (2014) is also the only one of the most cited authors to address the financial support available in this field. However, only the support from national and regional government agencies is studied in-depth. Aspects related to venture capital and university investments are only partially considered. At last, other types of support, such as bank financing, support of business angels, technology parks and local incubators are not addressed.

5. CONCLUSIONS

In a context in which universities have been playing an increasingly important role in economic and social development, university spin-offs have become a relevant mechanism for knowledge conversion and a central element in this process. In this sense, it is very important to know and understand the process of creating and managing university spin-offs, which are fundamentally characterized as companies in which academic qualifications, research results, scientific methods and other abilities play a crucial role.

The article addressed a central theme in entrepreneurship: the generation of university spin-offs. The discussion, although brief, brought important reflections, aiming to broaden the general view on the various dimensions of analysis of a university spin-off. In a first place, eight dimensions of research on university spinoffs were identified, respectively the university's role, technology transfer process, regional context, founder's background, university spinoffs performance analysis, impact analysis according to several domains, the establishment of public support policies and entities that support the creation and growth of university spinoffs. In a second phase, it was also possible to draw a profile of each of these areas, emphasizing the research areas that have aroused greater and less interest from the scientific community.

Finally, it is also imperative to consider the viability and reliability of this study. Like in any literature review study, the results obtained are valid within the considered time period and, therefore, it is important to review it within a time period of 3 to 5 years. Additionally, the use of three bibliometric indexes aims to increase the robustness of this study to include different types of scientific works like books and book chapters. However, MSc. dissertations and PhD. thesis were not included in this study, and these elements offer relevant scientific material in the context of university spinoffs.

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