THE CREATION AND DEVELOPMENT OF UNIVERSITY-BASED COMPANIES

Evidence from Spain

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DOCTORAL THESIS DISSERTATION

Business Economics Department
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Doctoral Thesis Dissertation

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DOCTORAL DISSERTATION INTRODUCTION

1. Interest of this doctoral dissertation: The research universities and the phenomenon of university-based companies (UBC)

"The research university fulfils a role in the Information Society analogous to that of the factory in the Industrial Society. It is the key institution around which growth occurs, and it determines the direction of that growth."

(Rogers, 1986: 172)

"Given that they are situated at the crossroads of research, education and innovation, universities in many respects hold the key to the knowledge economy and society."

European Commission (2003: 4-5)

"*Nowadays, the efforts of governments, universities and industries are specially focused on promoting university NTBF creation. Society is demanding from universities a more active role and effective commitment in economic growth and development issues."*

Del Palacio et al. (2006: 163)

"*Modern universities contribute by generating research and consultancy income, embedding knowledge in students and employees, upgrading regional business environments, and potentially improving the process of regional value capture.*"

Sanchez-Barrioluengo (2014: 1769)

"*Research Centers and Universities are leaving their traditional role of being mere fosters of knowledge, to become important agents of technology transfer to society through promotion and creation of Technology-based* companies"

Mendez et al. (2014: 380)

"*Universities are widely recognized as a critical source of technological innovation and are heralded for the entrepreneurial ventures cultivated within their walls. ... Such firms - and the societal and economic benefits they create - are an important contribution of modern universities.*"

Shah and Pahnke (2014: 780)

The rapid rate of technological change, shorter product life cycles and more intense global competition has radically transformed the current competitive position of many regional economies (O'Shea et al., 2007; Van Looy et al., 2011; Epure et al., 2014). In this sense, a growing policy debate has led governments to increase pressure to develop regional innovation systems and a pro-active entrepreneurial culture in order to foster socio-economic development (Del Palacio et al., 2006; Rodeiro et al., 2010; Van Looy et al., 2011; Algieri et al., 2013; Berbegal et al., 2013; Huyghe and Knockaert, 2015).

Consequently, academics and policy-makers have emphasized the role of research universities as key agents of knowledge and technology transfer to the markets (Rogers, 1986; Bozeman, 2000; European Commission, 2003; Etzkowitz, 2003; Aceytuno and Paz, 2008; Guerrero and Urbano, 2012; Iglesias et al., 2012; Algieri et al., 2013; Berbegal et al., 2013; Guerrero et al., 2014; Mendez et al., 2014; Ortin and Vendrell; 2014; Sanchez-Barrioluengo, 2014; Shah and Pahnke, 2014; Kalar and Antoncic, 2015).

Trying to exploit their potential as tools for regional development, during the last three decades, most research universities around the world has started to include in their mission statements the transfer of knowledge and technology to the industry; the so called "*third mission*" of universities (Guerrero and Urbano, 2012; Algieri et al., 2013; Astebro et al., 2013; Guerrero et al., 2014; Mendez et al., 2014; Ortin and Vendrell, 2014; Sanchez-Barrioluengo, 2014; Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015).

In this sense, research universities willing to commercialize the knowledge generated in-house began to develop support programmes and measures to foster technology transfer and entrepreneurial practices among university members (Beraza and Rodriguez, 2011; D'Este et al., 2012; Guerrero and Urbano, 2012; Algieri et al., 2013; Astebro et al., 2013; Guerrero et al., 2014; Mendez et al., 2014; Ortin and Vendrell, 2014; Sanchez-Barrioluengo, 2014; Huyghe and Knockaert, 2015).

In the past, the route to transfer knowledge and technology from university to the markets was mainly through two means: (i) licensing the rights of university owned patents and (ii) research contracts between universities and the private sector (Bozeman, 2000; Serarols et al., 2011; Epure et al., 2014). But in recent years, university-based companies (UBC) have become an alternative way to commercialize potentially valuable research and knowledge generated at universities (Rodeiro et al., 2010; Iglesias et al., 2012; Karnani, 2013; Swamidass, 2013; Treibich et al., 2013; Mendez et al., 2014; Ortin and Vendrell, 2014; Shah and Pahnke, 2014).

For example, Ortin and Vendrell (2014: 101) argue that: "*University spin-off companies, those new technology-based firms created with the support of a university by some of its members, have received increasing attention in the last two decades by policy makers and managers of higher education institutions, particularly in the US and Europe.*" In this line, Iglesias et al. (2012: 240) argue that: "*University Spin-Off has*

become one of the most effective mechanisms for technology and research results transfer from academic research centres to the productive sector."

Indeed, the creation of new ventures based on some knowledge generated at the parent university (PU) is gaining terrain compare to more traditional knowledge-transfer mechanisms as research contracts or patents and licensing rights (Siegel et al., 2003; Markman et al., 2004; Lockett and Wright, 2005; Powers and McDougall, 2005; O'Shea et al., 2007; Wright et al., 2007; Nosella and Grimaldi, 2009; Iglesias et al., 2012; Treibich et al., 2013; Huyghe and Knockaert, 2015). In this sense, Wright et al. (2007: 1) argue that: "*Traditional emphasis has been upon the licensing of innovations ... but greater attention is now being addressed internationally to the creation of new ventures that involve the spinning-off of technology and knowledge generated at universities.*"

Furthermore, university-based companies (UBC) have proven to be in the long-run a more profitable knowledge transfer activity for universities than other more traditional ways of commercializing universities' technological innovations (Bray and Lee, 2000; Shane, 2004). In this sense, UBC are especially interesting for commercializing new technologies that are far away from the markets (in terms of customers needs) or cannot be commercialized without further development (Thursby et al., 2001; Lockett et al., 2003; Shane, 2004; Lockett and Wright, 2005; Landry et al., 2006; Migliorini et al., 2010; Karnani, 2013).

Moreover, while codified knowledge can be protected by intellectual property rights and then licensed to third parties, tacit knowledge in the form of know-how is difficult to protect and therefore to commercialize through licensing rights (Lockett and Wright, 2005; Wright et al., 2008; Karnani, 2013). Therefore, in many cases, non-patentable tacit knowledge generated at universities find in UBC the only way of commercialization (Thursby et al., 2001; Pirnay et al., 2003; Migliorini et al., 2010; Karnani, 2013; Swamidass, 2013; Shah and Pahnke, 2014).

In the same line, Swamidass (2013: 788) say that: "*A recent National Research Council (NRC) report (2011) recommends that universities must craft policies and allocate resources to enable more university start-ups because some university technologies will never be commercialized unless licensed to a startup*." Moreover, Swamidass (2013: 789) also argue that: "*A startup may be the best or the only option for commercializing nearly 75% of university inventions that are never licensed to commercial entities. History shows, unless licensed to a new startup, many university inventions will remain on the shelf indefinitely, benefiting no one; all the investments made in the research leading to the inventions may never be recovered fully or partially.*"

Thus, in environments with scarce and weak entrepreneurial and technological resources where the majority of the university-based research is not patentable, it is easier and more profitable for universities to commercialize their research through the

creation of UBC (Lockett and Wright, 2005; Wright et al., 2008; Migliorini et al., 2010; Rodeiro et al., 2010; Karnani, 2013; Swamidass, 2013; Shah and Pahnke, 2014).

From the previous argument, we can conclude that research universities located in *mid-range* environments, with limited access to technological resources, low R&D budgets, few R&D facilities and equipment, few technological innovations or patentable intellectual property; may largely benefit from UBC (Degroof and Roberts, 2004; Wright et al., 2008; Migliorini et al., 2010; Rasmussen and Borch, 2010; Karnani, 2013; Swamidass, 2013; Shah and Pahnke, 2014).

Moreover, UBC are proven to be significant tools to increase the financial resources of state-owned universities (Bray and Lee, 2000; DiGregorio and Shane, 2003; Shane, 2004; Beraza and Rodriguez, 2011; Algieri et al., 2013; Sanchez-Barrioluengo, 2014). In the same line, it is also proven that UBC have positive effects over the local and regional environment generating wealth and spilling over knowledge and technology to other firms (DiGregorio and Shane, 2003; Shane, 2004; Audretsch et al., 2005; O'Shea et al., 2008; Iglesias et al., 2012; Treibich et al., 2013; Mendez, 2014; Rolf, 2014; Shah and Pahnke, 2014).

In addition, through the creation of UBC university researchers may find a way to further develop their investigations inside the university but with private sources of financing (Migliorini et al., 2010; Van Looy et al., 2011; Abramo et al., 2012). University academics may also find in UBC a way to introduce practical issues into their research and teaching curricula (Roberts and Malone, 1996; Lockett and Wright, 2005; Migliorini et al., 2010; Van Looy et al., 2011; Abramo et al., 2012).

In this sense, Harrison and Leitch (2010: 1246) argue that: "*As well as being viewed by some commentators as an efficient means by which to transfer technology from universities to industry, the creation and growth of spin-off companies can also provide employment for a university's graduates and in some cases can also contribute to university revenue*." The authors also add that: "*Attention has thus been focused on commercialization activities, including the development of spin-off companies, as a means of generating alternative sources of income.*"

Furthermore, UBC are usually highly performing companies showing a higher average rate of survival compared to other new technology-based firms (O'Shea et al., 2005; Ortin et al., 2008; Vendrell and Ortin, 2010; Criaco et al., 2014; Epure et al., 2014; Ortin and Vendrell, 2014). In this sense, Ortin et al. (2008) argue that the average mortality rate of UBC in Spain is around 8,5%, while the average mortality rate of all firms in Spain is around 40%. In the same line, Epure et al. (2014) found in their sample of UBC from Catalonian universities that: "*The survival rate of these firms at the end of 2011 was of approximately 73%, a very promising figure for the support programme considering the well-known financial distress endured during 2008-11*."

In his book entitled "Academic Entrepreneurship. University spin-offs and wealth creation", Shane (2004) devotes a whole chapter to describe why UBC are important. Based on chapter two of Shane's (2004) book, we show in **Table 1** the reasons why UBC merits the attention of scholars and policy makers.

Table 1: Why do university-based companies matter?

Encourage economic development	Generate significant economic value
	Create highly qualified jobs
	Induce investments in university technologies
	Promote local economic development
Enhance the commercialization of university technologies	Facilitate the commercialization of uncertain technologies
	Encourage inventor involvement
Help universities with their mission	Support additional research
	Attract and retain faculty
	Help to train students
They are high performing companies	
They are more profitable than licensing technologies to established companies	

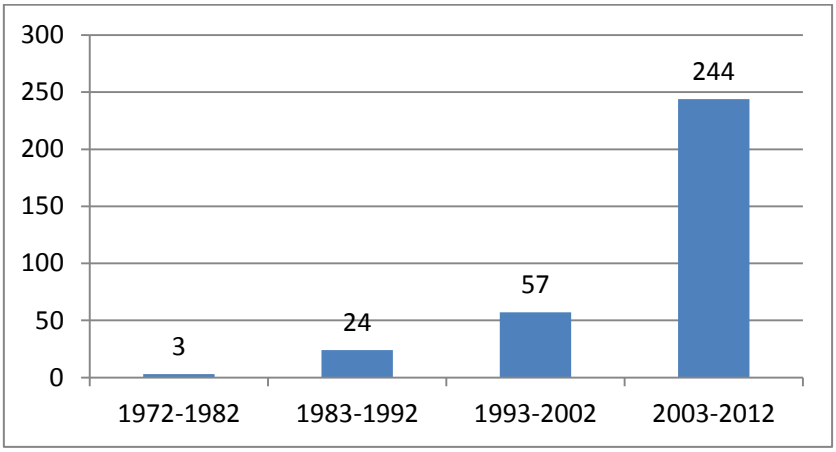
Source: Shane (2004:15-39).

All these factors have attracted the attention of scholars willing to better understand the UBC phenomenon (Djockovic and Souitaris, 2008; Ortin et al., 2008; Yusof and Jain, 2010; Abramo et al., 2012). In this sense, many academic publications have recently analysed the UBC phenomenon and the entrepreneurial transformation of public research institutions (Criaco et al., 2014; Epure et al., 2014; Guerrero et al., 2014; Lehoux et al., 2014; Lundqvist, 2014; Mendez, 2014; Nelson, 2014; Ortin and Vendrell, 2014; Rasmussen et al., 2014; Rolf, 2014; Sanchez-Barrioluengo, 2014; Shah and Pahnke, 2014; Wright, 2014; Goel et al., 2015; Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015; O'Kane, 2015).

In fact, since the beginning of this century we have seen a rampant increase in the number of academic publications treating the University Entrepreneurship phenomenon and in particular the creation and development of UBC (Rothaermel et al., 2007; Djockovic and Souitaris, 2008; Yusof and Jain, 2010). In this sense, in **Figure 1** we anticipate the general results of the extensive University Entrepreneurship literature review done in chapter one of this dissertation. **Figure 1** reveals that the number of publications concentrating in the University Entrepreneurship phenomenon has increased by a ratio of ten during the last two decades.

On the other hand, most of the University Entrepreneurship and UBC literature focuses on PU generally located near highly developed techno-clusters (Degroof and Roberts, 2004; Vohora et al., 2004; Ortin et al., 2008; Wright et al., 2008; Rasmussen and Borch, 2010; Beraza and Rodriguez; 2011; Marion et al., 2012; Swamidass, 2013; Lundqvist, 2014). While no explicit detailed definition or characterization of the term is provided, this body of research has emphasized important differences between research universities labelled as *top-range*, *elite*, *eminent*, *successful*, *entrepreneurial*, *leading* or *high-performing* and other research universities not gaining the same status or qualification.

Figure 1: Number of academic publications treating the University Entrepreneurship phenomenon



Source: Results of the literature review done in chapter one of this dissertation.

Moreover, the majority of the studies treating the University Entrepreneurship phenomenon concentrate in countries as US, Canada, UK or Sweden with abundant technological and entrepreneurial resources (Vohora et al., 2004; Vendrell and Ortin, 2008; Beraza and Rodriguez; 2009; Vendrell and Ortin, 2010; Beraza and Rodriguez, 2011; Ortin and Vendrell, 2014).

In this sense, in a study identifying potential lines of future research in the field of Technology Transfer and University Entrepreneurship, Vendrell and Ortin (2008: 67) argue that: "*Most of these lines still remain without analysing and the existing evidence comes basically from US and UK. The empirical research should foment new advances in the theoretical approach.*" Vendrell and Ortin (2008: 77) concluded that: "*there is scarce evidence about the UBC creation process and outcomes outside the Anglo-Saxon world. Evidence from other countries and especially from Spain, could provide robustness to the propositions made based in diverse types of environments*."[1]

[1] Translated from the Spanish language. I would like to apologize for any mistaken or misleading translation I may have done.

In the same line, Wright et al. (2008) argue the necessity of complementing cases' characteristics in highly developed environments with other lesser developed ones. These authors wonder how relevant are the insights obtained from these contexts to environments where there is less demand for innovation or that do not possess a world-class research base. Moreover, as stated in Wright et al. (2008), if universities have demonstrated an impact on their regional/industrial environment they should be regarded, described and framed in such. However, very few works deal with such a complementary, but meanwhile necessary process.

We understand the importance of studying highly-successful University Entrepreneurship cases as possible role models for other less *entrepreneurial* universities. But in order to have a holistic view of the phenomenon under study, we believe that researchers and policy-makers should also pay attention to cases of Parent Universities (PU) located in more discrete technological and entrepreneurial environments. Thus, it seems that the University Entrepreneurship literature has forgotten to study the UBC phenomenon in environments where most of the knowledge generated at PU is tacit and non-patentable.

To conclude, UBC is a complex phenomenon and its analysis from different perspectives - academic, practitioner and policy maker- is far from being systematic. In concrete, our understanding of the UBC phenomenon outside technologically and entrepreneurially developed environments remains limited. Therefore there is a need for greater knowledge about this particular entrepreneurial process and about the resulting companies. In this sense, explaining the academic entrepreneurial behaviour and how UBC are created and developed has become an important topic in academic research (Wright, 2014).

2. Objectives and research questions

The aim of this doctoral dissertation is:

- To increase our understanding of the university-based companies' (UBC) phenomenon outside the most commonly studied and technologically developed *top-range* environments.

Thus, the general objective of this research is:

- To improve our knowledge about the characteristics, the creation, the development and the survival of UBC located outside *top-range* environments.

Therefore, the general research question of this doctoral dissertation could be summarized as:

- Which are the factors influencing the creation, development and survival of UBC from Parent Universities (PU) located outside *top-range* environments? Are these factors different between PU located in *top* and *mid-range* environments?

The chapters' specific objectives and research questions of this doctoral dissertation may be seen in **Table 2**.

Table 2: Chapters' objectives and research questions

CHAPTER	OBJECTIVE/S	RESEARCH QUESTION/S
1	To review, synthesize and classify the existing UBC literature.	How has the UBC field of study evolved? What is the state of the art and what are the research gaps in the UBC literature?
2	To develop a coherent UBC definition and taxonomy. To characterize the profile of different UBC types.	What is a UBC? What are the existing types of UBC? What are the characteristics of each UBC type?
3	To identify the parent organizational determinants of UBC creation outside *top-range* environments.	Which are the parent organizational determinants that significantly influence UBC creation outside *top-range* environments?
4	To disentangle the UBC development process outside *top-range* environments.	How do UBC located outside *top-range* environments overcome critical junctures in their development process?
5	To identify founders' human capital characteristics that significantly influence UBC survival outside *top-range* environments.	Which are the founders' human capital characteristics that significantly influence UBC survival outside *top-range* environments?

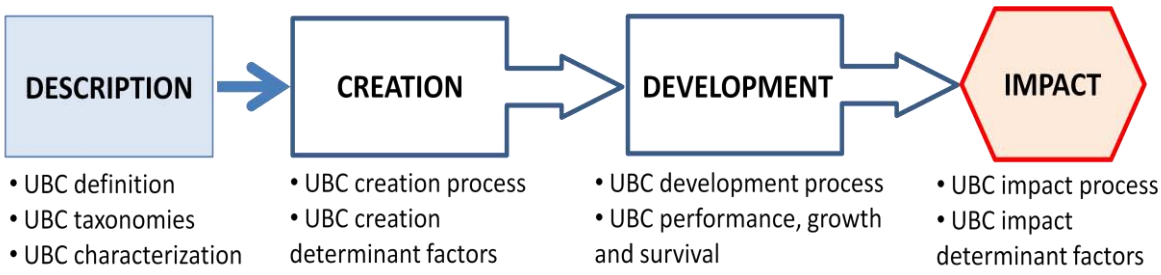
The objectives of the chapters were developed based on the research gaps found in the literature. In this sense, Vendrell and Ortin (2008) identify ten potential lines for future research in the area of Technology Transfer Offices (TTO) and University Entrepreneurship. In this study we try to give answer to the research lines identified in Vendrell and Ortin (2008). In particular the research line four in Vendrell and Ortin (2008) is covered in chapter three of this dissertation; research line five is covered in chapter five; research line nine is covered in chapter four and the research line ten is included in chapters four and five of this doctoral dissertation.

3. Studying university-based companies (UBC)

The UBC phenomenon may be studied from different angles and perspectives. In particular, we have found in the University Entrepreneurship literature academic studies treating four different aspects of the UBC phenomenon: (i) the UBC description, (ii) the creation of UBC, (iii) UBC development and (iv) the impact of UBC. In **Figure 2** we can see the four main subtopics in the UBC literature.

The first subtopic includes studies willing to define, characterize and provide a classification of UBC and their founders (McQueen and Wallmark, 1982; Smilor et al. 1990; Carayannis et al., 1998; Steffensen et al., 2000; Pirnay et al., 2003; Mustar et al., 2006; Iglesias, et al., 2012; Karnani, 2013; Treibich et al., 2013; Epure et al., 2014; Ortin and Vendrell, 2014; Shah and Pahnke, 2014).

Figure 2: Main subtopics in UBC literature



The second group of research concentrate in explaining the process and determinant factors of UBC creation (Roberts and Malone, 1996; Franklin et al., 2001; Ndonzuau et al., 2002; DiGregorio and Shane, 2003; Meyer, 2003; Vohora et al., 2004; Lockett and Wright, 2005; O'Shea et al., 2005; Ortin et al., 2008; Fini et al., 2009; Nosella and Grimaldi, 2009; Rasmussen and Borch, 2010; Clarysse et al., 2011; Karlsson et al., 2012; Marion et al., 2012; Algieri et al., 2013; Swamidass, 2013; Mendez et al., 2014; Nelson, 2014; Rolf, 2014; Goel et al., 2015; Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015; O'Kane, 2015).

The third subtopic in the UBC literature includes studies willing to disentangle the UBC development process and to better understand UBC performance (Shane and Stuart, 2002; Vohora et al., 2004; Grandi and Grimaldi, 2005; Gübeli and Doloreux, 2005; Lawton Smith and Ho, 2006; Walter et al., 2006; Clarysse et al., 2007; Zhang, 2009; Vendrell and Ortin, 2010; Serarols et al., 2011; Criaco et al., 2014; Lehoux et al., 2014; Lundqvist, 2014; Ortin and Vendrell, 2014; Rasmussen et al., 2014).

Finally, subtopic four includes studies willing to better understand the effect or impact of UBC over university entrepreneurs, parent universities and the local environment (Benneworth and Charles, 2005; Libaers et al., 2006; Meyer, 2006; Jain et al., 2009; Harrison and Leitch, 2010; Van Looy et al., 2011; Abramo et al., 2012; Astebro et al., 2013; Wright, 2014).

Moreover, each of the UBC subtopics may be studied from three different levels of analysis: micro (individuals and firms), meso (parent universities) and macro (environments) (Djokovic and Souitaris, 2008; Wright, 2014; Huyghe and Knockaert, 2015). In this sense, while micro-level studies in the first UBC subtopic (description) concentrate in characterizing UBC and their founders, meso-level studies concentrate in defining and characterizing Parent Universities (PU) and macro-level studies focus on characterizing the local environment where UBC are created.

In **Table 3** we can see that along this doctoral dissertation we shall cover subtopics one (description), two (creation) and three (development) of the UBC phenomenon. In this sense, chapter two of this research concentrates in subtopic one at a meso level of analysis (UBC definition, UBC types and UBC characterization). Chapter three covers subtopic two from a meso level of analysis (PU's determinant factors of UBC creation) and chapter four covers subtopic three from a meso level perspective (the UBC development process). Finally, chapter five is also related to UBC development but specifically at a micro level of analysis (effect of founders' human capital characteristics over the probability of UBC survival). Subtopic four, the impact of UBC, exceeds the scope of this doctoral dissertation.

Table 3: Location of chapters of the dissertation in the UBC literature

	DESCRIPTION	CREATION	DEVELOPMENT	IMPACT
MACRO				
MESO	Chap. 2	Chap. 3	Chap. 4	
MICRO			Chap. 5	

Studies in each of the 12 categories of the UBC literature explained before may adopt a variety of theories and conceptual perspectives to frame their researches. In this sense, we have found that the more commonly adopted conceptual perspectives to study the UBC phenomenon are: the Resource-Based View of the firm (Lockett and Wright, 2005; Powers and McDougall, 2005 Walter et al., 2006; Shah and Pahnke, 2014; Lundqvist, 2014), the Dynamic Capabilities Perspective (Lockett and Wright, 2005; Rasmussen and Borch, 2010; Clarysse et al., 2011), the Institutional Economic Theory (DiGregorio and Shane, 2003; Karlsson et al., 2012; Treibich et al., 2013; Rasmussen et al., 2014), Social Capital or Networks Theory (Karlsson et al., 2012), the Theory of Knowledge (Agrawal, 2001; Karnani, 2013), the Human Capital Theory (Karlsson et al., 2012; Marion et al., 2012), the Business Model and life-cycle Perspective (Iglesias et al., 2012; Lehoux et al., 2014), the Process Approach and the Stage-Based Models of Firm Development (Vohora et al., 2004; Swamidass, 2013; Treibich et al., 2013).

In particular, in this research we adopt different conceptual approaches depending on the research objectives of each of the chapters. In chapter three we draw on the Resource-Based View of the firm (RBV), the Dynamic Capabilities Perspective and the Institutional Economic Theory to identify the Parent University (PU) determinant

factors of UBC creation. Although the RBV and Dynamic Capabilities Perspective was originally developed for better understanding firms and differences in firms' performances, both conceptual approaches have proven to be appropriate frameworks to study the creation and development of UBC (Shane and Stuart, 2002; DiGregorio and Shane, 2003; Lockett and Wright, 2005; O'Shea et al., 2005; Walter et al., 2006; Rasmussen and Borch, 2010; Clarysse et al., 2011; Beraza and Rodriguez, 2011; Shah and Pahnke, 2014).

Moreover, chapter three also draws on the Institutional Economic Theory which has been specifically developed to understand the environmental or macro-level restrains to business and economic performance. Thus, in chapter three our specific research question would be: which are the Parent University's resources, capabilities and institutions that significantly influence the rate of UBC creation? In this sense, we make a parallelism between the firm and the Parent University, where the measure of performance is the number of UBC created per year (Berbegal et al., 2013).

In chapter four we also adopt the RBV, the Dynamic Capabilities and the Institutional Economic Theory but in this case to better understand the UBC development process from a meso level perspective. Thus, in chapter four we want to identify which are the resources, capabilities and institutions used/applied by UBC in order to overcome critical junctures[2] in their development process. Furthermore, in chapter four we also adopt a Process Approach and in particular the Stage-Based Models of Firm Development to conceptually frame the analysis. Stage-Based Models of Firm Development are particularly useful for describing and analysing the UBC creation and development process (Nlemvo et al., 2002; Vohora et al., 2004).

Finally, in chapter five we adopt a micro level perspective to identify the founders' human capital characteristics that significantly affects the probability of UBC survival. In this chapter we draw on the Human Capital Theory (Becker, 1975) as the logical conceptual framework to analyse the significance of the human factor over firm continuity/closure. Moreover, in this chapter, we extend the Threshold Model of Entrepreneurial Exit developed in Gimeno et al. (1997) to empirically assess the influence of the human factor over the probability of firm closure.

4. University entrepreneurship and new venture creation

i. The University Entrepreneurship paradigm

The University Entrepreneurship paradigm is based on the Triple Helix model developed during the nineties by Etzkowitz and Leydesdorff (Leydesdorff and Etzkowitz, 1998; Etzkowitz and Leydesdorff, 1999; Etzkowitz and Leydesdorff, 2000).

[2] Critical junctures are defined as the obstacles and difficulties found by the UBC when willing to pass from one stage of development to the next one (Vohora et al., 2004).

The Triple Helix model requires the collaboration of three key socio-economic agents of regional development: (i) the government, in particular regional agencies of socio-economic development; (ii) the industry, particularly regional markets of goods and services and (iii) the university, as the key agent for regional knowledge creation and transfer (Etzkowitz and Leydesdorff, 2000; Etzkowitz, 2002).

Following Etzkowitz Triple Helix model of regional development, many research universities in the United States and Occidental Europe started to undertake different types of entrepreneurial activities (Wright et al., 2007; Van Looy et al., 2011; Guerrero et al., 2014; Ortin and Vendrell, 2014; Sanchez-Barrioluengo, 2014). By becoming more entrepreneurial, universities could help to accomplish the Triple Helix objective of regional development. Thus, the University Entrepreneurship paradigm was adopted by most universities willing to commercialize their research and improve regional development (Etzkowitz, 1998; Etzkowitz and Leydesdorff, 2000; Wright et al., 2007; Van Looy et al., 2011; Guerrero et al., 2014; Sanchez-Barrioluengo, 2014).

On the other hand, universities may show an entrepreneurial behaviour through other activities apart from firm creation (Klofsten and Jones-Evans, 2000; Landry et al., 2006; Abreu and Grivenich, 2013; Huyghe and Knockaert, 2015). For example patenting, licensing, industry-funded research projects or remunerated technical consulting are also considered entrepreneurial activities (Klofsten and Jones-Evans, 2000; Wright et al., 2008; Huyghe and Knockaert, 2015). In this sense and drawing on Abreu and Grivenich, (2013), Huyghe and Knockaert (2015: 139-140) define university entrepreneurship as *any activity that occurs beyond the traditional roles of teaching and research, which is innovative and compromises an element of risk, and may lead to financial rewards for the individual or the institution.*

Thus, in addition to new venture creation (the focus of this research), the University Entrepreneurship paradigm includes other topics of analysis as ***Technology/Knowledge Transfer*** from the university to the industry (Bozeman, 2000; Agrawal, 2001; Siegel, 2003; Wright at el., 2004; Anderson et al., 2007; Geuna and Muscio, 2009) or the characteristics of an ***Entrepreneurial University*** (Etzkowitz, 1983; Clark, 1998; O'Shea et al., 2007; Van Looy et al., 2011; Guerrero and Urbano, 2012; Guerrero et al., 2014; Sanchez-Barrioluengo, 2014; Kalar and Antoncic, 2015)**.**

ii. Definition and types of university-based companies

Drawing on the UBC literature reviewed we propose the following definition of a university-based company (UBC): ***UBC are firms recently created inside the spatial and institutional context of a Parent University (PU), which draw upon knowledge generated or identified at the PU and with at least one member of the PU in their founding teams*** (McQueen and Wallmark, 1982; Smilor et al. 1990; Steffensen et al., 2000; Klofsten and Jones-Evans, 2000; Pirnay et al., 2003; Druilhe & Garnsey, 2004; Vohora et al., 2004; Wright et al., 2004; Fini et al., 2009; Bathelt et al., 2010; Müller,

2010; Bonardo et al., 2011; Iglesias et al., 2012; Treibich et al., 2013; Ortin and Vendrell, 2014; Shah and Pahnke, 2014).

From the literature reviewed we have also identified two dimensions to classify university-based companies (Pirnay et al., 2003; Bathelt et al., 2010; Bonardo et al., 2011; Karnani, 2013; Epure et al., 2014). The first dimension is related to the UBC founders' status towards the PU (i.e. academic, student or staff). In this sense, we call *academic* UBC those firms founded by former or current PU's academics (Pirnay et al., 2003). Firms founded by other members of the PU are called *non-academic* UBC (Bonardo et al., 2011).

The second dimension to classify UBC is related to the nature of the knowledge transferred (codified or tacit) and the way this knowledge is transferred from the PU to the UBC (formally or informally). We call *spin-offs* new ventures drawing on a codified piece of knowledge originally developed at the PU and formally transferred to the UBC. On the other hand, we call *start-ups* new ventures drawing on some type of tacit knowledge originally identified at the PU and informally transferred to the UBC (Pirnay et al., 2003; Wright et al., 2008; Bathelt et al., 2010; Müller, 2010; Karnani, 2013; Shah and Pahnke, 2014).

Following a two-dimensions classification matrix we conclude that there are four types of university-based companies: (i) ***academic spin-offs*** (firms with at least one academic in their founding teams and formal transfer of codified knowledge from the PU to the new venture), (ii) ***academic start-ups*** (with an academic in the founding team but informal transfer of tacit knowledge), (iii) ***non-academic spin-offs*** (with no academic in the founding team but formal transfer of codified knowledge), (iv) ***non-academic start-ups*** (with no academic in the founding team and informal transfer of tacit knowledge).

iii. The creation of university-based companies

In the literature we have found studies mainly concentrating in two subtopics around the general research field of UBC creation. One group of studies deals with the process of UBC creation (Ndzondau et al., 2002; Vohora et al., 2004; Kirwan et al., 2006; Vanaelst et al., 2006; Müller, 2010; Vendrell and Ortin, 2010; Rasmussen, 2011; Swamidass, 2013). This group of studies usually adopt a process approach using stage-based firm development models. In this sense, Vohora et al. (2004) identify five stages of UBC development with four *critical junctures* between consecutives stages that have to be overcome by the UBC in order to progress from one stage of development to the following.

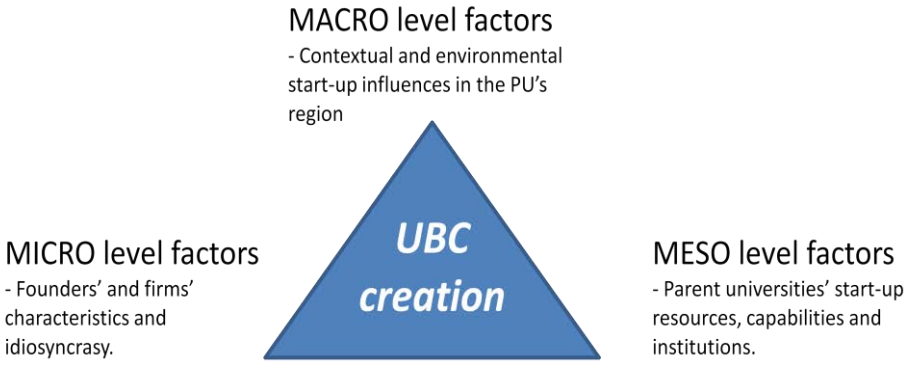
The second group of studies dealing with the UBC creation topic concentrates in the analysis of the determinant factors that significantly influence the rate of UBC creation by parent universities (Roberts and Malone, 1996; Franklin et al., 2001; DiGregorio and Shane, 2003; Lockett et al., 2003; Markman et al., 2004; Link and Scott, 2005; Lockett and Wright, 2005; O'Shea et al., 2005; Powers and McDougall, 2005; Landry et al.,

2006; Ortin et al., 2008; Rasmussen and Borch, 2010; Clarysse et al., 2011; Haeussler and Colyvas, 2011; Goel et al., 2015; Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015).

As said before, UBC creation factors may be divided into three categories following their level of analysis: micro level factors, meso level factors and macro level factors (Djokovic and Souitaris, 2008; Huyghe and Knockaert, 2015). Micro level UBC creation studies assess the effect of individual characteristics of UBC and their founders over university start-up activity (Ortin et al., 2008; D'Este et al., 2012; Karlsson et al., 2012; Marion et al., 2012; Goel et al., 2015).

Meso level studies focus on the effect of parent universities' (PU) resources, capabilities and institutions over university start-up activity (Ortin et al., 2008; Algieri et al., 2013; Berbegal et al., 2013; Swamidass, 2013; Mendez et al., 2014; Nelson, 2014; Wright, 2014; Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015; O'Kane, 2015). Finally, macro level studies evaluate the significance of environmental-related factors over UBC creation (Wright et al., 2008; Rolf, 2014; Wright, 2014). In **Figure 3** we can see a graphic representation of the different determinant factors significantly influencing UBC creation grouped by level of analysis.

Figure 3: Location of chapters of the dissertation in the UBC literature



5. The Spanish university start-up context and outcomes

Willing to characterize the Spanish research university system Sanchez-Barrioluengo (2014: 1764) argued that: "*Lack of recognition of the political and economic relevance of science and technology and the absence of efficient patterns of action for the management of a science and innovation system, have for long characterized the Spanish Research System*."

Moreover, Berbegal et al. (2013: 2052) affirm that: "*Spanish policies and the changes in the universities' regulatory framework strive to achieve greater knowledge transfer results. However, considerably difficulties still remain and these difficulties mainly*

relate to the lack of incentives and the limited capacity of faculty to own spin-offs' equity. These barriers diminish universities' potential to effectively engage in knowledge transfer activities. Also, the relative scarce entrepreneurial culture among Spanish faculty and the presence of formal mechanisms, such as business incubators affiliated to the university with blurred strategies, may contribute to explain the dissimilar effectiveness of universities in commercializing their research outcomes.

Analysing Spanish universities' efficiency in terms of knowledge transfer activities, Berbegal et al. (2013: Table 4) found that only 47% of Spanish PU are efficient knowledge transfer agents. In this sense, Berbegal et al. (2013: 2055) argue that: "*inefficiency may come from a lack of institutional support given to their activities.*" Berbegal et al. (2013: 2057) concluded that: "*the Spanish regulatory framework for the creation of spin-offs attempts to foster spin-off creation. Nevertheless, the effects of this directive are far from those of other European countries, as some constraints limiting researchers' access to the spinoff's equity still exist, as well as legal impediments for universities to benefit from the impact of technology transfer activities.*"

In the same line, in a study comparing Spanish universities' support programs for UBC creation with programs in other European countries, Beraza and Rodriguez (2011: 112) concluded that: "*the existence of UBC support programs recently exists among Spanish universities and that the number of persons advocated to this task is reduced. Thus, the success and scope of the UBC support programs developed by Spanish universities remain limited*." The authors also concluded that: "*Spanish universities have fewer resources to support UBC and they are less committed in UBC development than other European universities*."[3] Finally, Iglesias et al. (2012: 214) also characterize the Spanish start-up context as *a relatively new phenomenon, either in the research context as in the practical reality.*[4]

Therefore, in contrast with other countries as the US, Canada, UK, France, Germany, Belgium or Sweden; UBC creation is a recent phenomenon in the Spanish university system (del Palacio, 2006; Rodeiro et al., 2010; Beraza and Rodriguez, 2011; Iglesias et al., 2012; Sanchez-Barrioluengo, 2014). While most universities in the US expanded their entrepreneurial activities and began to spin-off new ventures with the approval of the Bayh-Dole Act in 1980 (Shane, 2004; Shane 2004(a); Link and Scott, 2005; Wright et al., 2007), it is not until the beginning of the XXIth century that the UBC creation phenomenon spread among Spanish research universities (Rodeiro et al., 2008; Beraza

[3] Extracted and translated from Beraza and Rodriguez (2011:112). It was directly translated from Spanish to English language by the author of this doctoral dissertation. Thus, I apologize for any incorrect or misleading translation I could possibly made.

[4] Extracted and translated from Iglesias et al. (2012: 241). It was directly translated from Spanish to English language by the author of this doctoral dissertation. Thus, I apologize for any incorrect or misleading translation I could possibly made.

and Rodriguez, 2009; Migliorini et al., 2010; Beraza and Rodriguez, 2011; Iglesias et al., 2012; Sanchez-Barrioluengo, 2014).[5]

This relative time backwardness in Spanish university start-up activity could be explained by the high degree of centralization and low degree of competition among academics in many state-owned European universities (Nosella and Grimaldi, 2009). Moreover, differently from world-class universities located in the US or UK, in Spain and other southern European countries as Italy, Portugal or Greece, there is a lack of technological resources available for Parent Universities (PU) to facilitate start-up activity (Fini et al., 2009; Nosella and Grimaldi, 2009; Migliorini et al., 2010; Beraza and Rodriguez, 2011; Berbegal et al., 2013).

In this sense, Spanish universities present a scarce research base, with a limited scope and usually far from its commercialization in the markets (Migliorini et al., 2010; Beraza and Rodriguez, 2011). Moreover, the number of patents, innovation disclosures or new ventures generated by Spanish universities is behind the rest of Europe (Beraza and Rodriguez, 2011; Berbegal et al., 2013).

Furthermore, the Spanish university system is characterized by a limited access to financing sources for UBC creation (Migliorini et al., 2010; Beraza and Rodriguez, 2011; Berbegal et al., 2013). In particular, there is a lack of venture capital firms or other private financial institution willing to make equity investments in high-risk ventures as UBC. This fact is important because it has been empirically proven that the availability of venture capital investments in the university hosting region is a key factor determining university start-up activity (Powers and McDougall, 2005).

In this sense, Beraza and Rodriguez (2011) undertook a detailed comparison study between UBC support programs of Spanish universities and UBC support programs from universities in UK and other European countries. Their results show that:

- Spanish universities have started to provide UBC support programs with some delay compare to the rest of Europe.
- European universities give a greater attention to foster an entrepreneurial culture than Spanish universities.
- UK universities give a greater attention to the assessment of business ideas than Spanish universities.
- The number of business ideas to assess is significantly lower in Spanish universities than in the rest of Europe.
- European universities are more successful identifying business opportunities than Spanish universities.

[5] There are few exceptions to this fact (i.e. the Polytechnic University of Valencia, the University of Santiago de Compostela and the University of Granada).

- Spanish universities dispose of a reduced number of people to support UBC creation compare to other European universities.
- The external networks for UBC support are less developed in Spanish universities compare to other European universities.
- The use of external resources to evaluate and promote business projects is significantly less common in Spanish universities than in the rest of Europe.
- The use of facilities and productive infrastructure by university members willing to create UBC is much less common in Spain than in the rest of Europe.
- Differently from the rest of Europe, Spanish universities rarely finance UBC using their own funds.

The outcome of the university start-up activity in Spain also shows signs of underdevelopment compare to US or UK. In this sense, the UBC phenomenon started later and is reduced comparing to other countries in North America or Europe (Rodeiro et al., 2008; Beraza and Rodriguez, 2009; Migliorini et al., 2010; Beraza and Rodriguez, 2011; Iglesias et al., 2012; Sanchez-Barrioluengo, 2014).

For example, in a study willing to characterize Spanish UBC, Ortin et al. (2008) and Vendrell and Ortin (2008) found that before the year 2001 there were only 18 UBC in Spain. Therefore, Ortin et al. (2008) argue that almost the totality of Spanish UBC was created after the year 2001. In this line, Epure et al. (2014) found that in their sample of 94 UBC generated at Catalonian universities, more than 86% were created after 2002.

Moreover, Ortin et al. (2008) and Vendrell and Ortin (2008) also found that by the year 2003 Spanish universities have created a total of 209 UBC. On the other side, in the book entitled Academic Entrepreneurship in Europe, Wright et al. (2007: Table 1.1) show that by the year 2003 US universities have created 4543 UBC, UK universities have created more than 1650 UBC, French universities have created 1230 UBC, and Canadian universities have created 1100 UBC. Furthermore, Wright et al. (2007: Table 1.1) also show that by the end of the 90s Sweden had already created more than 3000 UBC and Germany more than 1000 UBC.[6]

Indeed, due to the scarcity of a high-quality research base together with insufficient technological and financial resources, the Spanish university system generates a reduced number of UBC compare to other universities in the US or Europe that are located near world-class technological clusters (Siegel et al., 2003; Ortin et al., 2008; Rodeiro et al., 2008; Beraza and Rodriguez, 2009; Harrison and Leitch, 2010; Rodeiro et al., 2010; Berbegal et al., 2014). In this sense Ortin et al. (2008) argue that: "*the probability of creating new technology-based companies is significantly higher in environments where more technology and new knowledge is produced.*"

[6] These figures are very difficult to estimate for Sweden and Germany because of differences in the UBC definition and therefore which firms should be included in the statistic.

In the same line, Harrison and Leitch (2010: 1255/6) argue that: "*In regional environments, which are characterized by weakly functioning entrepreneurial systems there may well be a need for the development of a much more highly supportive business development infrastructure.*" In fact, the reduced number of firms created by the Spanish university system (compared to US, Canada, UK and other European countries) is due to both factors: (i) the weak entrepreneurial and technological environment where most Spanish universities operate and (ii) the scarcity of *highly supportive* measures and programs to foster UBC creation.

Furthermore, the type of UBC that is created by Spanish PU usually presents a low degree of technological innovation and in many cases cannot be considered a technology-based firm (Wright et al., 2008; Migliorini et al., 2010). Following the UBC typology previously described, most of the companies created in the Spanish university system are *start-ups*; tacit knowledge informally transferred from PU to UBC, instead of *spin-offs*; codified knowledge or technology formally transferred from PU to UBC (Wright et al., 2008).

In the same line, Nosella and Grimaldi (2009) affirmed that "*In the USA, spin-offs based on university licensed technologies are very frequent.*" "*In Europe, and in particular in Italy, there are few companies founded on the basis of technologies protected by university patents.*" "*In Europe, the most common type of academic spin-off is represented by companies based on a technological knowledge developed within academia and not formally covered by a university patent, which is transferred into the new venture by academics themselves.*" (Nosella and Grimaldi, 2009: 681).[7]

In this line, Epure et al. (2014) found that in their sample of 81 companies created with the support of Catalonian universities, only 45% of them had formal technology transfer agreements with their parent universities (PU). On the other side, Harrison and Leitch (2010: 1255) argue that: "*in the UK, the vast majority of university spin-off companies are small business new technology-based firms, set up to exploit limited portfolios of technological/intellectual assets.*" In this sense, Harrison and Leitch (2010) confirm that most UBC in the UK are companies that commercially exploit a technology or any piece of intellectual asset originally developed at the parent university.

Finally, Degroof and Roberts (2004) argued that companies generated by universities located in *mid-range* environments usually lack the growth potential when comparing to UBC created by universities located in *top-range* environments. In particular, the authors of this study emphasized "*the fact that academic spin-off ventures in regions outside established high tech clusters tend to stay small boutiques.*" (Degroof and Roberts, 2004: 328).

Following all previous academic references and also supporting these arguments with our own research experience we argue that, in most of the cases, Spanish parent

[7] This argumentation is especially true for the Spanish case. On the contrary, may not seem totally adequate for the case of UK.

universities (PU) are located in environments showing little entrepreneurial culture, with few start-up resources, underdeveloped start-up capabilities and with a recent set of institutions regulating start-up activity at PU. In this sense, we may consider that the Spanish university system is immersed in an environment not highly propitious for university start-up activity when comparing to US, Canada, UK or other Western European countries. We may call this type of innovation and entrepreneurial context, *mid-range* environments (Wright et al., 2008).

6. Methodologies and diffusion of chapters

This research is a compound of five independent but highly-related studies. Each chapter is a self-contained study that serves as a whole academic publication in its own. Chapter one starts with a comprehensive bibliometric study based on Google Scholar database and Publish or Perish software application to retrieve citation metrics and be able to rank UBC-related documents, authors and journals. The bibliometric study includes 328 UBC-related documents from a variety of sources (journals' articles, working or research papers, books and books' chapters, research reports, doctoral dissertations, etc.).

In the second part of chapter one, we review and make a content analysis of 72 empirical articles concentrating in the UBC phenomenon. Moreover, we use Multiple Correspondence Analysis (MCA) and other quantitative techniques to classify the UBC literature into homogenous categories. This chapter has not been diffused yet but we believe it fits the publication interests of the International Journal of Management Reviews or the interests of the European Management Review.

In chapter two we first draw on the UBC literature reviewed in chapter one to develop a coherent and comprehensive UBC definition and taxonomy. Chapter two continues with a detailed characterization of each of the UBC types identified before. This part of the chapter draws on an empirical and descriptive analysis of 94 UBC created with the support of ten Catalonian Parent Universities. Chapter two was included as part of my doctoral research work defended in February 2010. Moreover, this chapter has been published as a competitive research report by CIDEM/COPCA Generalitat de Catalunya (Serarols et al., 2009). The descriptive nature of this chapter limits its probabilities of being published in JCR-ranked academic journals.

In chapter three we undertake a longitudinal study of Parent Universities (PU) determinant factors of UBC creation. The database includes 16 PU from different Spanish regions and seven years of analysis (2004 to 2010). Thus, in this study we run a negative binomial regression over a panel data consisting of 112 year/observations to identify PU determinant factors of UBC creation.

Chapter three has not been diffused yet but we believe it fits the publication interests of Technovation, R&D Management, Journal of Technology Transfer or Science and

Public policy. We shall focus our efforts to publish this chapter at Technovation or R&D Management. As a second level option we may publish this chapter at the International journal of Technology Transfer and Commercialization (not ranked in JCR). On the other hand, we believe that the database limitations of this chapter may hinder the probabilities to publish it at highly-ranked journals as Research Policy, Journal of Business Venturing or Entrepreneurship Theory and Practice.

Chapter four is a multiple case study of eleven UBC created with the support of two Catalonian Parent Universities: the Autonomous University of Barcelona (UAB) and the University of Girona (UdG). This chapter was presented at the UAB "Jornadas de Precomunicaciones a Revistas Económicas" and at UAB "Entrepreneurship Workshop" both in the year 2009. Moreover, chapter four was included as part of my doctoral research work defended in February 2010. Finally, this chapter was presented at the RENT International Conference of 2009 held in Covilha, Portugal and has been selected for publication in the RENT Anthology book of 2010.

Thus, chapter four is already published in the book "Theory and Practice of Entrepreneurship. Frontiers in European Entrepreneurship Research" edited by Smallbone, Leitao, Raposo and Welter, Edward Elgar Publishing Ltd. (Migliorini et al., 2010). Moreover, we expect to publish the reviewed version of this chapter (the one present in this doctoral dissertation) at JCR-ranked journal as Technovation or R&D Management. Due to the qualitative nature of this study we shall also target more accessible JCR journals as the Journal of Management and Organization, the European Journal of International Management or the International Journal of Technology Management.

Finally, in chapter five we run a binary logistic regression model to test the impact of explanatory variables on the dependent variable. This chapter draws on the data collected from 80 UBC created with the support of Catalonian Parent Universities. Chapter five was presented at the ICSB George Washington University Global Entrepreneurship Research and Policy Conference (October 2011, Washington DC), at the Cisalpino Institute for Comparative Studies in Europe (CCSE) Doctoral Workshop (March 2012, Bergamo) and at the International Symposium on Entrepreneurship and Innovation (ISEI) (May 2012, Venice). The chapter has finally been published by the Journal of Technology Transfer in an online version in June 2013 (Criaco et al., 2013) and the paper edition in August 2014 (Criaco et al., 2014).

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CHAPTER ONE

UNIVERSITY-BASED COMPANIES

A PROMINENT FIELD OF SCHOLAR RESEARCH

1. Introduction

Through the transfer of knowledge to the industry and the creation of new ventures, universities may increase their income, allow their members to develop profitable businesses, attract more and better members, improve the quality of faculty and researchers, further develop and commercialize technological innovations and foster regional and national economic performance (Rogers, 1986; Roberts, 1991; Roberts and Malone, 1996; Etzkowitz et al., 2000; Shane, 2002; Shane, 2004; Lockett and Wright, 2005; O'Shea et al., 2005; O'Shea et al., 2008; Wright et al., 2008; Nosella and Grimaldi, 2009; Colombo and Piva, 2012; Iglesias et al., 2012; Algieri et al., 2013; Treibich et al., 2013; Mendez, 2014; Shah and Pahnke, 2014; Goel et al., 2015).

All these factors have fostered an increase in the amount and impact of the academic literature treating the university entrepreneurship phenomenon and in particular the case of university-based companies (Rothaermel et al., 2007; Djockovic and Souitaris, 2008; O'Shea et al., 2008). Moreover *"research on university entrepreneurship appears to be moving at a faster rate in terms of citations garnered from mainstream journals than strategy research and other entrepreneurship research have historically, controlling for the stage of the development.*" (Rothaermel et al., 2007: 696).

On the other hand, the literature about UBC is dispersed and is usually elusive to identify (Rothaermel et al., 2007; Djockovic and Souitaris, 2008). Thus, it is a difficult task to provide a classification of the UBC literature (Pirnay et al., 2003; Mustar et al., 2006). Moreover "*As the field of university entrepreneurship progresses, future research is invited to provide a more fine-grained analysis of productivity and impact of scholars* (Rothaermel et al., 2007: 701, note 9). In this sense, there is a lack of university entrepreneurship studies using documents, authors and journals impact factors to measure research productivity or to describe the field's evolution.

Thus, in this study we undertake an impact factor bibliometric study and a content review analysis following a quantitative methodology to rigorously classify the UBC academic literature. Therefore, the objective of this study is to review and critically synthesize the fragmented and dispersed literature about university-based companies (UBC) with the aim of increasing our understanding of the UBC phenomenon and facilitate the task of incoming researchers trying to publish in this relatively recent field of academic inquiry.

Following this objective, the research questions are: how has the UBC field of study evolved over time? Which/who are the documents, journals and authors that have had the highest impact in the UBC field of inquiry? Who/which are the most active authors and journals publishing UBC studies? What is the state of the art, which are the unexploited gaps and what are the future lines in UBC research? How can we classify the fragmented UBC literature in order to facilitate the study of the UBC phenomenon by incoming researchers?

To give an answer to our research questions we divide this study in two stages. In the first stage we pursue a comprehensive bibliometric study to identify and rank the publications, authors and academic journals with the highest impact in the UBC field of research. We also present the yearly evolution of the UBC field of study from its beginnings until mid 2011. In the second step we undertake a methodologically-based review and quantitative classification of the UBC literature using optimal scaling and multiple correspondence analyses (MCA) procedures.

Our results show that since its beginnings in the seventies the University Entrepreneurship field of research has strongly increased the attention from scholars and academic journals. In this sense, we have found that the number of UBC related documents published and the number of citations these documents received has radically increased in the last forty years. Moreover, the results from the MCA suggest three main streams or categories in UBC literature: (i) seminal UBC articles, (ii) mainstream UBC literature and (iii) new avenues in UBC research.

We believe to contribute to business science in several ways. This study develops the first detailed bibliometric study based on citation metrics to rank publications, authors and journals in the University Entrepreneurship field of research. Moreover this research is the first in the UBC field of study to use Google Scholar database as data source; thus considering in the analysis any type of academic document (i.e. articles, books, working or research papers, doctoral dissertations, conference proceedings), coming from a variety of authors, countries, journals and other sources. This broader research approach limits the academic endogeneity suffered in previous university entrepreneurship and technology transfer reviews (Bozeman, 2000; Agrawal, 2001; O'Shea et al., 2004; Mustar et al., 2006; Rothaermel et al., 2007; Djokovic and Souitaris, 2008; O'Shea et al., 2008; Yusof and Jain, 2010).

Furthermore and different from previous university entrepreneurship and technology transfer reviews, this study solely focuses on the UBC phenomenon, filtering-out any document treating UBC but indirectly (O'Shea et al., 2004; Djokovic and Souitaris, 2008; O'Shea et al., 2008) or treating other topics, as technology transfer or the entrepreneurial university (Bozeman, 2000; Agrawal, 2001; Mustar et al., 2006; Rothaermel et al., 2007; Yusof and Jain, 2010).

We also believe that this study makes a methodological contribution to the field of research by undertaking a quantitative classification of the UBC literature using optimal scaling procedures and Multiple Correspondence Analysis (MCA) techniques. In this sense, this is the first study to combine a review of the academic literature concentrating in UBC but with a broader research approach allowing new sources, authors and documents to intervene in the results and based on a quantitative methodology. In the following section we present the research design and the methodology of the study. Section three shows the empirical findings and discusses them under the light of previous studies. We conclude by giving answer to the research questions and by highlighting some limitations of the study.

2. Research design and methodology

2.1. Bibliometric study

We use Google Scholar® as the data source for the bibliometric study. Google Scholar® is a freely accessible web search engine that indexes the full text of scholarly literature across an array of publishing formats and academic disciplines. Google Scholar® includes most peer-reviewed online journals of Europe and North America plus other non-peer reviewed journals, working or research papers, books, conference proceedings, research reports, doctoral dissertations or any other type of academic document. Google Scholar® functioning is similar to the freely available Scirus from Elsevier, CiteSeerX and getCITED and is also similar to the subscription-based tools, Elsevier's Scopus and Thomson ISI's Web of Science.

The major advantage of Google Scholar® when compare to Thomson ISI's Web of Science or Elsevier's Scopus is that is free to use. One can access bibliometric data and sometimes the full text of the document without having to pay any fees or subscription.[8] Google Scholar® is freely available to anyone with an Internet connection and is praised for its speed (Bosman et al., 2006). The ISI Web of Science is only available to those academics whose institutions are able and willing to bear the subscription costs of the ISI Web of Science. Moreover, Google Scholar® provides an avenue for more transparency in tenure reviews as it allows citation counts to be performed and duplicated by anyone. The fact that any study using Google Scholar® can be replicated by anyone, adds a methodological advantage to the use of this database (Pauly & Stergiou, 2005).

Another important factor for choosing Google Scholar® is that it includes any type of academic document published and available through internet. In this sense while Web of Science General Search is limited to ISI-listed journals and articles, Google Scholar® searches are not. In addition Web of Science Cited Reference is limited to citations from ISI-listed journals and counts citations to non-ISI journals only towards first author. Thus while the ISI Web of Science provides a substantial underestimation of an individual academic's actual citation impact, Goggle Scholar does not (Pauly & Stergiou, 2005).

In order to collect the bibliometric data from Google Scholar® database we used Harzing's publication search engine Publish or Perish, in its version 3.7.4631 updated on 04/09/12.[9] Publish or Perish is a free software program that retrieves and analyzes academic citations.[10] It uses Google Scholar® to obtain the raw citations, then analyzes these and calculates a series

[8] The use of Google Scholar does not automatically grant searchers access to publications. The full texts of articles in Google Scholar are not necessarily available freely to all searchers. Searchers with access through an institution such as a research laboratory or university may be able to access select articles freely. Some articles found through Google Scholar are hosted by sites that allow searchers to subscribe or purchase the full text of their articles.

[9] This was the final version updated at the end of the field work. We have also used several previous versions of the application.

[10] PUBLISH or PERISH is available at http://www.harzing.com/pop.htm.

of citation metrics as the total number of papers, the total number of citations, the average number of citations per paper or per author, the average number of papers per author and the average number of citations per year among others.

To identify UBC published documents and retrieve their bibliometric data we undertake a keywords search on the *General Citation Search* menu under the *All of the Words* selection box. We also limited our search to the subjects of *Business, Administration, Finance and Economics* and we checked the box *Titles words only* to look-up our keywords only over the documents' titles and not over the whole text of the document. The search was done for the years ranging from 1900 until 2011 inclusive (in concrete until May 2012).[11]

The list of keywords for the publication search is based in a frequency analysis made by the authors over the keywords used in 28 articles identified by the authors as papers treating the UBC phenomenon. We have then grouped all the keywords used in these 28 UBC papers into homogeneous categories and counted the number of times that the keywords in each group are used. Finally we have decided to use for the publications' search any keyword that was at least used twice in the 28 papers reviewed.[12] In **Table 1** we list the 35 groups of keywords, for a total of 135 individual keywords that were finally used in the publications' search. In the second column of **Table 1** we can see the number of publications (entries) retrieved for each of the keywords groups. We came-up with an initial database including 7293 entries or publications that we had to filter out for repetitions and publications not treating the UBC phenomenon.

The first step in the filtering process was to select those publications with at least 10 citations in total or at least 1 citation per year.[13] This was done to ensure that the publications included in the study have had at least a minimum impact in the academic arena. In this way we narrow down our initial database from 7293 publications to 1049 and a total of 36524 citations received by them. In the second step of the filtering process we take out the repeated entries.[14] Following this procedure the database was once again narrow down from 1049 entries to 834 individual publications and 27057 cites received. Finally we have reviewed the titles of each of the 834 publications to filter-out anyone not treating the topic of UBC or UBC founders. Indeed we have found many publications that even though they have any of the keywords in their title, do not treat the UBC topic. Examples of this are the publications treating the topic of entrepreneurship education at universities. These publications may have one or more of the keywords in their title but do not treat the UBC topic. We also had to manually complete the database due to missing values or blanks in the information.

[11] Due to the fact that the UBC literature review (subject of this chapter) was done at the first phase of my doctoral research, I have been able to update the literature review analysis until May 2012. On the other hand, in the rest of this doctoral dissertation I have included bibliographic references until February 2015.

[12] The list of papers reviewed for the keywords selection is available from the authors.

[13] We selected this base number because the median was in eleven citations per publication.

[14] Entries may be repeated because small differences in the writing of the publication title, generating two or more entries while actually being the same publication. In this case we had to sum the total number of citations that the different entries of the same publication have.

Table 1: List of keywords used in the publication search

Nº	GROUP of KEYWORDS	# keywords in group	# of entries base search
1	UNIVERSITY/IES ENTREPRENEUR/S/SHIP	6	1.580
2	UNIVERSITY/IES FIRM/S	4	1.294
3	UNIVERSITY/IES SPIN-OFF/S or SPINOFF/S	6	266
4	UNIVERSITY/IES COMPANY/IES	4	1.740
5	UNIVERSITY/IES START-UP/S or STARTUP/S	6	143
6	UNIVERSITY/IES SPIN-OUT/S or SPINOUT/S	6	63
7	UNIVERSITY/IES VENTURE/S	4	485
8	ACADEMIC/S ENTREPRENEUR/S/SHIP	6	494
9	ACADEMIC/S FIRM/S	4	143
10	ACADEMIC/S SPIN-OFF/S or SPINOFF/S	6	166
11	ACADEMIC/S COMPANY/IES	4	217
12	ACADEMIC/S START-UP/S or STARTUP/S	6	48
13	ACADEMIC/S SPIN-OUT/S or SPINOUT/S	6	14
14	ACADEMIC/S VENTURE/S	4	92
15	FACULTY ENTREPRENEUR/S/SHIP	3	88
16	FACULTY FIRM/S	2	24
17	FACULTY SPIN-OFF/S or SPINOFF/S	4	6
18	FACULTY COMPANY/IES	2	79
19	FACULTY START-UP/S or STARTUP/S	4	10
20	FACULTY SPIN-OUT/S or SPINOUT/S	4	-
21	FACULTY VENTURE/S	2	21
22	CAMPUS ENTREPRENEUR/S/SHIP	3	37
23	CAMPUS FIRM/S	2	21
24	CAMPUS SPIN-OFF/S or SPINOFF/S	4	3
25	CAMPUS COMPANY/IES	2	74
26	CAMPUS START-UP/S or STARTUP/S	4	4
27	CAMPUS SPIN-OUT/S or SPINOUT/S	4	-
28	CAMPUS VENTURE/S	2	17
29	RESEARCH-BASED ENTREPRENEUR/S/SHIP	3	20
30	RESEARCH-BASED FIRM/S	2	28
31	RESEARCH-BASED SPIN-OFF/S or SPINOFF/S	4	32
32	RESEARCH-BASED COMPANY/IES	2	69
33	RESEARCH-BASED START-UP/S or STARTUP/S	4	9
34	RESEARCH-BASED SPIN-OUT/S or SPINOUT/S	4	-
35	RESEARCH-BASED VENTURE/S	2	6
	TOTAL OF 35 KEYWORDS' GROUPS	**135**	**7293**

We ended up with a database including 328 publications with a total of 15596 cites and 2213 cites/year. Once we have our UBC publications database in order we proceed to make two analyses. First we analyze the annual evolution for different variables of the study (number of publications, number of cites, number of authors and number of journals). In the second step we rank all 328 UBC publications following the number of citations that each publication has received. At this step, we also rank the authors and journals by the number of UBC publications issued and by the number of cites received in these publications.

2.2. Literature review

In the second stage of this research we review and critically synthesize the content of a sample of 72 empirical articles concentrating in the UBC phenomenon and published in academic journals. The selected papers have received more than two citations per year or more than ten citations in total and have been available through the online library and journals database subscription of the Universitat Autònoma de Barcelona.

We have reviewed the content of these 72 papers according to a set of commonly used variables which are described in **Table 2**. The variables AUTHORS, JOURNAL and YEAR are directly taken from the paper. The variable CITES/YEAR is equal to the total number of citations that a paper has received divided by the life-time in years of the paper and is taken from the bibliometric study done in the first stage of this research.

We draw on the results obtained in O'Shea et al. (2004 and 2008) to subscribe the TOPIC variable of the UBC papers to the following four: (i) UBC description, (ii) UBC creation, (iii) UBC development and (iv) UBC impact. Subtopic one includes the definition, typology and characterization of UBC and UBC founders (McQueen and Wallmark, 1982; Smilor et al. 1990; Carayannis et al., 1998; Steffensen et al., 2000; Pirnay et al., 2003; Mustar et al., 2006). Subtopic two includes papers studying the UBC creation process or UBC creation determinant factors (Nlemvo et al., 2002; DiGregorio and Shane, 2003; Lockett and Wright, 2005; O'Shea et al., 2005).

Moreover, subtopic three includes papers studying the UBC development process, UBC performance, UBC growth and UBC survival (Shane and Stuart, 2002; Vohora et al., 2004; Grandi and Grimaldi, 2005; Gübeli and Doloreux, 2005; Lawton Smith and Ho, 2006; Walter et al., 2006; Clarysse et al., 2007; Zhang, 2009). Finally subtopic four includes papers studying the impact of UBC over individual entrepreneurs, parent universities, local markets or the environment (Benneworth and Charles, 2005; Libaers et al., 2006; Meyer, 2006; Jain et al., 2009).

Table 2: Variables used in the content analysis of the UBC literature

VARIABLE	DESCRIPTION
AUTHORS	**The name of the authors:** same order than in the paper
JOURNAL	**The name of the journal or review where the paper has been published**
COUNTRY	**Country of the first author of the paper:** country where first author did his/her research
YEAR	**The year of publication of the paper**
CITES/YEAR	**The number of papers' citations divided by the number of years from publication**
TOPIC	**The subtopic or focus of the paper**: 1) UBC description, 2) UBC creation, 3) UBC development or 4) UBC impact.
TYPE	**The type of study**: quantitative versus qualitative, exploratory versus explanatory and cross-sectional versus longitudinal.
PERSPECTIVE	**Theoretical framework and research approach:** managerial, sociological, economic and psychological approach.
LEVEL - UNIT	**The level or unit of analysis:** micro (individual or team), meso (firm) and macro (university, region, country or industry).
SIZE	**The sample size:** number of observations or cases included in the analysis.
SCOPE	**The sample scope:** number and country of the universities of the sample.
METHOD	**The methodology of analysis:** case study, descriptive statistics, regression analysis, hazard models, parametric tests, etc.

In **Table 2**, The PERSPECTIVE variable describes the theoretical framework used and thus the conceptual approach assumed in each study. Different theoretical frameworks are grouped under one of the four research approaches described at Veciana (2007): the managerial, the sociological, the economic and the psychological approach. The managerial approach includes theories as the resource and knowledge-based view of the firm, dynamic capabilities, initial endowments or contingency theory among others. The sociological approach is

composed by networks theory, social capital perspective, institutional theory and population ecology theory. In the economic approach we include studies based on process approach, stage-based models of venture development, financial and market-based perspective, regional innovation systems, technology clusters and absorptive capacity. Finally the psychological approach includes individual decision models and the human capital perspective.

In **Table 3** we have a summary of the content analysis performed. All bibliometric variables (AUTHORS, JOURNAL, YEAR, CITES/YEAR and COUNTRY) and general variables (TOPIC, TYPE, PERSPECTIVE, LEVEL, UNIT, SIZE, SCOPE and METHOD) are described for each of the 72 papers included in the analysis.

Finally, **Table 4** shows the pair-wise Pearson correlation matrix of these variables. We have no missing values, with 72 observations for each of the variables in the analysis. CITES/YEAR is negatively correlated with AUTHORS-COUNTRY. This means that a paper whose first author is from the US, UK or Canada is generally related with a higher impact in the academia than papers whose first authors come from other countries. TYPE 1 is highly and negatively correlated with the variable SIZE because of the variables' definitions. LEVEL and UNIT are mainly the same variables grouped differently (see **Table 2**); this is why they are almost linearly correlated.

Once we have our database of articles and variables in place, we develop an analysis of the time evolution of some of the variables presented in **Table 2**: CITES/YEAR, TOPIC, PERSPECTIVE, TYPE 1, TYPE 2 and LEVEL. In this way we can see how the categories of each variable evolve over time. We then continue to use quantitative and explorative techniques to classify the reviewed UBC literature. At this step of the analysis we draw on O'Shea et al. (2008) and Djokovic and Souitaris (2008) to a priori classify the UBC literature in a two-dimension matrix where we locate quantitative and qualitative papers.

O'Shea et al. (2008) proposed to classify the UBC literature in six streams that captures the determinants and consequences of spin-off activity.[15] Moreover, Djokovic and Souitaris (2008) propose to classify the UBC literature according to the level of analysis of the research and distinguish among three groups of UBC papers: micro, meso and macro level studies. Therefore, we have taken both discriminant variables from O'Shea et al. (2008) and Djokovic and Souitaris (2008), to develop a two-dimension matrix to easy a priori categorize the UBC literature.

In the second step of the review, we use optimal scaling procedure to run a Multiple Correspondence Analysis (MCA) in order to classify the UBC literature into homogenous categories.

[15] In the group of literature that captures the determinants of UBC activity, O'Shea et al. (2008) included papers treating the causes of UBC creation at the different level of analysis (i.e. individual, organizational, institutional or external determinants). In the consequences of UBC activity group of papers O'Shea et al. (2008) included in one hand articles treating the development and performance of UBC and in the other hand papers treating the regional impact that UBC may produce.

Table 3: Results of the literature review content analysis

Table 3

Authors	Journal	Year	Cites / year	Country	Topic	Type	Perspective	Level	Unit	Size	Scope	Method
H. Bathelt, D. Kogler & A. Munro	Technovation	2010	6,5	Canada	Descrip	Quali, Explora & Longi	Knowledge-Based View + regional dynamics	Meso	Firm	18	Canadian universities	Case Study
D. Bonardo, S. Paleari & S. Vismara	Entrepreneurship Theory & Practice	2011	10	Italy	Develop	Quanti, Explana + Explora, Cross & Longi	Financial (market-based) + RBV + capabilities	Micro	Individual (academic patents)	131	International universities	GMM + logit + OLS + desc. Statistics + param. Tests
M. Brennan & P. McGowan	Journal of Small Business and Enterprise Development	2005	3,3	UK	Creation	Quali + Cuanti, Explora + Explana & Cross	Knowledge-Based View + Institutional Theory	Micro	Individual	12 (case study) + 54 (survey)	1 UK university	Case Study (12) + Descriptive Statistics (54)
E. Carayannis, E. Rogers, K. Kurihara & M. Allbritton	Technovation	1998	13,1	USA	Descrip	Quali, Explora & Cross	0	Meso	Firm	7	International universities	Case Study
V. Chiesa & A. Piccaluga	R&D Management	2000	16,3	Italy	Descrip	Quanti, Explora & Cross	0	Micro	Individual	48	National universities	Descriptive Statistics
J. Chrisman, T. Hynes & S. Fraser	Journal of Business Venturing	1995	6,1	Canada	Descrip	Quanti, Explora & Cross	0	Micro + Meso	Individual + Firm	374	One university	Descriptive Statistics
B. Clarysse & Nathalie Moray	Journal of Business Venturing	2004	25,6	Belgium	Creation + Develop	Quali, Explana + explora & Longi	Process Approach + socio-demographic perspective	Meso	Firm	1 (team)	One university	Case Study
B. Clarysse, M. Wright, A. Lockett, P. Mustar & M. Knockaert	Industrial and Corporate Change	2007	10,2	Belgium	Develop	Quanti, Explana & Cross	Resource-Based View + Financial perspective	Micro	Individual	135	International universities	Generalized Least Squares regression GLS
M. Colombo, D. d'Adda & E. Piva	Journal of Technology Transfer	2010	9	Italy	Develop	Quanti, Explana & Longi	RBV + Dynamic Capabilities	Meso	Firm	487	Italian universities	Augmented Gibrat Law Panel Data Model
R. de Coster & C. Butler	Technovation	2005	6,4	UK	Descrip	Quanti, Explora & Cross	Firm Decision Models	Micro	Individual	28	2 UK universities	Descriptive Statistics + Parametric Tests
J. Degroof & E.	Journal of	2004	14,9	USA	Develop	Quali, Explana	Stage-based	Micro	Individual	9	National	Case Study

Roberts	Technology Transfer					+ explora & Cross	venture models				universities	
I. del Palacio Aguirre, F. Solé Parellada & H. Montiel Campos	International Entrepreneurship & Management Journal	2006	3,3	Spain	Creation	Quali + Cuanti, Explora + Explana & Cross	Process Approach	Micro	Individual	20 (firms) & 37 (universities)	UPC (firms) + Spanish universities	Case Study (firms) + Descriptive Statistics (universities)
D. DiGregorio & S. Shane	Research Policy	2003	68,3	USA	Creation	Quanti, Explana & Longi	Resource-Based View + Institutional Theory	Macro	University	457 (101unis)	National universities	Panel PA GEE Negative Binomial Regression
J. Doutriaux	Journal of Business Venturing	1987	3,4	Canada	Develop	Quanti, Explora & Longi	0	Micro + Meso	Individual + Firm	38	National universities	Descriptive Statistics
C. Druilhe & E. Garnsey	Journal of Technology Transfer	2004	23,8	UK	Descrip	Quali, Explora + explana & Longi	Resource-Based View	Meso	Firm	9	One university	Case Study
M. Ensley & K. Hmieleski	Research Policy	2005	16,6	USA	Descrip	Quanti, Explora + explana & Cross	Institutional Theory	Macro	University	102	National universities	PLS + Discriminant Analysis + param tests
R. Fini, R. Grimaldi & M. Sobrero	Journal of Technology Transfer	2009	10,7	Italy	Creation	Quanti, Explana & Cross	Organizational Behaviour (Incentive Theory)	Micro + Meso	Firm + Individual	88	National universities	Descriptive Statistics + PCA + ANNOVA
S. Franklin, M. Wright & A. Lockett	Journal of Technology Transfer	2001	21,4	UK	Creation	Quanti, Explora & Cross	0	Macro	University	57	National universities	Non-parametric tests
A. Grandi & R. Grimaldi	Small Business Economics	2003	7,8	Italy	Develop	Quanti, Explana & Cross	Networks Theory + Social Capital	Meso	Firm	40	National universities	OLS regression
M. Gübeli & D. Doloreux	European Journal of Innovation Management	2005	3,9	Switzerland	Creation + Develop	Quali, Explora & Cross	Stage Models + Networks Theory	Micro	Individual	3	1 Swedish university	Case Study
C. Haeussler & J. Colyvas	Research Policy	2011	12	Germany	Creation	Quanti, Explana & Cross	Human Capital + Social Capital	Meso	Firm	2294	International universities	Ordered Probit regression
D. Hsu, E. Roberts & Ch. Eesley	Research Policy	2007	13,4	USA	Descrip	Quanti, Explora + Explana & Longi	Entrepreneurial entry/exit decision models	Micro	Individual	1631	One university	Cox Hazard regression

S. Jain, G. George & M. Maltarich	Research Policy	2009	18,7	USA	Impact	Quali, Explana & Longi	Social-psychology (Role-identity)	Micro	Team	20	One university	Case Study
P. Kirwan, P. van der Sijde & A. Groen	International Entrepreneurship & Management Journal	2006	3,7	Holland	Creation + Develop	Quali, Explana & Cross	Stage Models + Social System Theory + Networks	Meso	Firm	22	6 european universities	Case Study
M. Klofsten & D. Jones-Evans	Small Business Economics	2000	13	Sweden	Creation	Quanti, Explora & Cross	0	Meso + Macro	Firm & University	1857	International universities	Descriptive Statistics + Parametric tests
H. Kroll & I. Liefner	Technovation	2008	9,8	Germany	Descrip	Quanti, Explora & Cross	National Innovation Systems	Micro	Individual	82	3 chinese universities	Descriptive Statistics
R. Landry, N. Amara & I. Rherrad	Research Policy	2006	14,2	Canada	Creation	Quanti, Explana & Cross	Resource-Based View	Micro	Individual	1554	National universities	Logit regression + parametric tests
H. Lawton Smith & K. Ho	Research Policy	2006	6,8	UK	Descrip	Quanti, Explora & Longi	National Innovation Systems	Meso	Firm	114	2 UK universities	Descriptive Statistics
D. Libaers, M. Meyer & A. Geuna	Journal of Technology Transfer	2006	5,3	USA	Impact	Quanti + Quali, Explora + Explana & Cross	Economic approach (industrial sector)	Micro	Individual	121 (firms) + 1 (industry)	UK universities	Descriptive Statistics + Case Study
A. Link & J. Scott	Research Policy	2005	12,9	USA	Creation	Quanti, Explana & Cross	Resource-Based View	Micro	Team	51	National universities	Tobit regression
A. Lockett, M. Wright & S. Franklin	Small Business Economics	2003	21,7	UK	Creation	Quanti, Explora + explana & Cross	Strategic Management	Meso	Firm	57	National universities	Non-parametric tests
A. Lockett & M. Wright	Research Policy	2005	35,1	UK	Creation	Quanti, Explana & Cross	Resource-Based View + Dynamic Capabilities	Meso	Firm	48	National universities	Poisson + Negative Binomial Regression
H. Lofsten & P. Lindelof	Technovation	2005	12,1	Sweden	Develop	Quanti, Explora & Cross	Networks Theory + Resource-Based View	Macro	University	74	National universities	Parametric tests
G. Markman, P. Phan, D. Balkin & P. Gianiodis	Journal of Business Venturing	2005	29,7	USA	Creation	Quali + Quanti, Explana & Cross	Strategic Management	Meso	Firm	128	National universities	Case Study + Descriptive Statistics
M. McAdam & R. McAdam	Technovation	2008	13	UK	Develop	Quali, Explora & Longi	Resource-Based View + Life Cycle Perspective	Meso	Firm	18	National universities	Case Study

W. McMullan, W. Long & J. Graham	Journal of Business Venturing	1986	1,4	Canada	Creation	Quanti, Explora & Cross	0	Micro	Team	50	1 Canadian university	Descriptive Statistics
D. McQueen & J. Wallmark	Technovation	1982	1,5	Sweden	Descrip	Quanti, Explora & Cross	0	Meso	Firm	38	1 Swedish university	Descriptive Statistics
M. Meyer	R&D Management	2003	18,1	Belgium	Creation	Quali, Explora & Cross	Organizational Behaviour (Incentive Theory)	Macro	University	4	International universities	Case Study
M. Meyer	Journal of Technology Transfer	2006	6,5	Finland	Impact	Quanti, Explora & Cross	0	Meso	Firm	243	Finish universities	Descriptive Statistics
S. Mosey & M. Wright	Entrepreneurship Theory & Practice	2007	21,4	UK	Develop	Quali, Explana & Longi	Networks Theory + Social Capital	Macro	University	24	National universities	Case Study
K. Müller	Research Policy	2010	8,5	Germany	Creation	Quanti, Explana & Longi	Process Approach	Meso	Firm	1810	German universities	Hazard Models + Cox Regression
F. Murray	Research Policy	2004	27,9	USA	Develop	Quali, Explora & Cross	Networks Theory + Social Capital	Meso + Macro	Firm & University	12	National universities	Case Study
F. Nlemvo, F. Pirnay & B. Surlemont	Technovation	2002	3	Belgium	Creation + Develop	Quali, Explora & Longi	Stage-based venture models	Micro	Individual	15	International universities	Case Study
A. Nerkar & S. Shane	International Journal of Industrial Organization	2003	13,4	USA	Develop	Quanti, Explana & Cross	Contingency Theory + Human Capital	Meso	Firm	128	One university	Event-history Hazard model
N. Nicolau & S. Birley	Management Science	2003	13,6	UK	Creation	Quanti, Explana & Cross	Networks Theory + Social Capital	Micro	Individual	89	One university	Logit regression
J. Niosi	Journal of Technology Transfer	2006	6,2	Canada	Develop	Quanti, Explora + Explana & Cross	0	Meso	Firm	65	Canadian universities	Desc. Statis. + Crosstabulation + Regression + pier correlation
R. O'Shea, T. Allen, A. Chevalier & F. Roche	Research Policy	2005	38,4	USA	Creation	Quanti, Explana & Longi	Resource-Based View + Dynamic Capabilities	Meso + Macro	Firm & University	987 (141x7)	National universities	Panel RE Negative Binomial Regression
M. Pérez & A. Martínez	Technovation	2003	13,3	Spain	Develop	Quali + Quanti, Explora & Cross	Networks Theory + Social Capital	Macro	University	10	One university	Case Study + Descriptive Statistics

J. Powers & P. McDougall	Journal of Business Venturing	2005	27,2	USA	Creation	Quanti, Explana & Cross	Resource-Based View	Macro	University	120	National universities	Negative Binomial Regression
E. Rasmussen & O.J. Borch	Research Policy	2010	8	Norway	Creation	Quali, Explana & Longi	Dynamic Capabilities + Process Approach	Meso	Firm	4 (firms) & 2 (universities)	2 universities from Norway	Case Study
E. Rasmussen	International Small Business Journal	2011	5	Norway	Creation	Quali, Explora & Longi	Process Approach	Meso	Firm	4	2 universities from Norway	Case Study
C. Renault	Journal of Technology Transfer	2006	11,2	USA	Creation	Quanti, Explana & Cross	Individual Decision Models + Institutional Theory	Meso	Firm	98	National universities	Logit regression
E. Roberts & D. Malone	R&D Management	1996	17,3	USA	Creation	Quali, Explora & Cross	0	Meso	Firm	8	International universities	Case Study
F. Rothaermel & M. Thursby	Research Policy	2005	20,4	USA	Develop	Quanti, Explana & Longi	Resource-Based View + Absorptive capacity	Meso	Firm	79	One university	Logit regression
F. Rothaermel & M. Thursby (a)	Research Policy	2005	18,7	USA	Develop	Quanti, Explana & Longi	Resource-Based View + Networks Theory	Meso	Firm	79	One university	OLS & Logit regression
K. Samsom & M. Gurdon	Technovation	1993	6,5	Holland	Creation	Quali, Explora & Longi	0	Meso	Firm	22	International universities	Case Study
S. Shane & T. Stuart	Management Science	2002	62,9	USA	Develop	Quanti, Explana & Longi	Initial Endowments + RBV + Social Capital	Meso	Firm	134	One university	Event-history Hazard model
R. Smilor, D. Gibson & G. Dietrich	Journal of Business Venturing	1990	10	USA	Descrip	Quanti, Explora & Cross	0	Meso	Firm	23	One university	Descriptive Statistics
M. Steffensen, E. Rogers & K. Speakman	Journal of Business Venturing	2000	20,8	Norway	Descrip	Quali, Explora & Cross	0	Meso	Firm	6	One university	Case Study
T. Stuart & W. Ding	American Journal of Sociology	2006	39,7	USA	Creation	Quanti, Explana & Cross	social influence and status dynamics	Meso	Firm	5120	National universities	Hazard models , Cohort Cox regression
A. Toole & D. Czarnitzki	Journal of Economic Behaviour & Organization	2007	12,4	USA	Creation + Develop	Quanti, Explana + Explora &	Financial Perspective (Real Options)	Meso + Macro	Firm + UK nano tech sector	1 (SBIR) + 337 (individuals) + 2855 (firms)	National universities	Probit regression + negative binomial

						Longi + Cross						
A. Toole & D. Czarnitzki	Management Science	2009	8,3	USA	Develop	Quanti, Explana & Cross	Human Capital	Meso	Firm	213 (individuals) 169 (firms)	National universities	Probit + Negative Binomial Regression
P. van der Sijde & J. van Tilburg	Entrepreneurship and Innovation	2000	1,9	Holland	Creation + Develop	Quali, Explora & Cross	Process Approach	Macro	University	2	3 European universities	Case Study
M. van Geenhuizen & D. Soetanto	Technovation	2009	5	Holland	Develop	Quanti + Quali, Explora & Cross + Longi	Stage models + RBV	Meso	Firm	58 (firms) + 1 (university)	1 university from Holland	Descriptive Statistics + Parametric Tests + case study
I. Vanaelst, B. Clarysse, M. Wright, A. Lockett, N. Moray & R. S'Jegers	Entrepreneurship Theory & Practice	2006	14	Belgium	Creation + Develop	Quali, Explora & Longi	Stage-based venture models	Macro	University	10	National universities	Case Study
A. Vohora, M. Wright & A. Lockett	Research Policy	2004	47,3	UK	Creation + Develop	Quali, Explora & Cross	Stage-based venture models	Macro	University	9	National universities	Case Study
A. Walter, M. Auer & T. Ritter	Journal of Business Venturing	2006	30,7	Germany	Develop	Quanti, Explana & Cross	Dynamic Capabilities	Meso	Firm	149	National universities	Regression analysis
K. Wennberg, J. Wiklund & M. Wright	Research Policy	2011	9	Sweden	Develop	Quanti, Explana & Longi	Knowledge-Based View	Meso	Firm	528 * 5 years = 2670	Swedish universities	Panel regression + event history analysis (Cox Regression)
M. Wright, A. Vohora & A. Lockett	Journal of Technology Transfer	2004	12,4	UK	Creation + Develop	Quali, Explana & Longi	Resource-Based View	Micro	Team	4	National universities	Case Study
M. Wright, A. Lockett, B. Clarysse & M. Binks	Research Policy	2006	23	UK	Develop	Quanti, Explora + Explana & Longi	Financial Perspective (pecking order theory)	Meso	Firm	124	International universities	Descriptive Statistics & Parametric Tests
S.A. Zahra, E. Van de Velde & B. Larrañeta	Industrial and Corporate Change	2007	6,2	USA	Develop	Quanti, Explana & Cross	Knowledge-Based View + Dynamic capabilities	Micro	Individual	78	National universities	Mancova + OLS
J. Zhang	Journal of Technology Transfer	2009	10,3	USA	Descrip	Quanti, Explora & Cross	Financial Perspective (Venture Capital)	Macro	University	704	National universities	Descrip. Statis. + OLS + Logit + parametric tests

Table 4: Correlation matrix of the variables included in the content analysis

	Cites / year CAT	Authors - country	Journal - country	Year CAT	Topic	Type 1	Type 2	Type 3	Pers pective	Level	Unit	Size	Scope	Method
Cites / year	1	-,359**	,040	-,127	-,076	-,153	-,141	-,134	-,192	-,069	-,102	,050	-,066	,164
Aut-country	-,359**	1	-,034	,187	,129	,129	0,000	,135	,107	,035	,097	-,092	,195	-,064
Jou-country	,040	-,034	1	,018	-,109	-,078	-,038	-,126	-,067	,058	,065	,026	,103	-,121
Year	-,127	,187	,018	1	,129	-,030	-,145	-,140	-,379**	-,013	,016	,266*	,154	,336**
Topic	-,076	,129	-,109	,129	1	,260*	-,030	-,043	,007	,064	,095	-,232*	,115	,094
Type 1	-,153	,129	-,078	-,030	,260*	1	,282*	-,003	,022	,232*	,240*	-,556**	-,039	,105
Type 2	-,141	0,000	-,038	-,145	-,030	,282*	1	,188	,173	,096	,134	-,186	-,010	-,151
Type 3	-,134	,135	-,126	-,140	-,043	-,003	,188	1	,115	,173	,143	,157	,091	,110
Perspec t	-,192	,107	-,067	-,379**	,007	,022	,173	,115	1	-,106	-,088	-,102	-,139	-,230
Level	-,069	,035	,058	-,013	,064	,232*	,096	,173	-,106	1	,979**	-,009	,159	,162
Unit	-,102	,097	,065	,016	,095	,240*	,134	,143	-,088	,979**	1	-,046	,139	,137
Size	,050	-,092	,026	,266*	-,232*	-,556**	-,186	,157	-,102	-,009	-,046	1	,016	,280*
Scope	-,066	,195	,103	,154	,115	-,039	-,010	,091	-,139	,159	,139	,016	1	-,015
Method	,164	-,064	-,121	,336**	,094	,105	-,151	,110	-,230	,162	,137	,280*	-,015	1

MCA requires categorical variables with mutually exclusive categories. Thus we had to codify the categories of each of the variables and set-up a new database with numerical categories of variables instead of text chains. In **Table 5** we can see the procedure undertaken in order to codify the categories of the variables included in the MCA. We run the Multiple Correspondence Analysis (MCA) using IBM SPSS Statistics package software in its version 20.

Table 5: Procedure to codify the categories of the variables included in the MCA

	CATEGORY					
VARIABLE	**1**	**2**	**3**	**4**	**5**	**6**
YEAR	Before year 2001	Between year 2001 and year 2005	Between year 2006 and 2009	After year 2009		
CITES/YEAR	Between 1 and 5	Between 6 and 10	Between 11 and 20	More than 20		
COUNTRY	US, UK & Canada	Rest of Europe	Rest of the world			
TOPIC	Description	Creation	Development	Impact	Creation & Development	
TYPE 1	Quantitative	Qualitative	Both			
TYPE 2	Explanatory	Exploratory	Both			
TYPE 3	Longitudinal	Cross-sectional	Both			
PERSPECTIVE	Managerial	Sociological	Economic	Psychological	A combination	None
LEVEL	Micro	Meso	Macro	A combination		
SIZE	Less than 10	Between 10 and 29	Between 30 and 100	More than 100		
SCOPE	One university alone	Several universities from the same country	Several universities from several countries			
METHOD	Descriptive Statistics, PCA, cluster and parametric tests	Case Study	Regression Analysis and non-parametric tests	A combination		

3. Research results and discussion

3.1. General results of the bibliometric study

In **Table 6** we have a summary of the general results of the bibliometric study. The number of publications is the total number of UBC documents published and retrieved in the search (328 publications). The number of cites is the total number of citations received by these publications during their total life (15.596 cites). From **Table 6** we can see that in average each UBC publication received 48 citations during its lifetime and an average of 7 citations per year of life (a total of 2.213 cites/year).

Table 6: General results of the bibliometric study

Total number of publications	328
Total number of cites	15.596
Total number of cites/year	2.213
Average number of cites per publication	48
Average number of cites/year per publication	7
Year of first publication	1.972
Year of last publication	2.012
Publication year range	40
Average number of publications per year	8,2
Average number of cites per year	390
Total number of authors	425
Average number of publications per author	0,8
Average number of cites per author	37
Average number of cites/year per author	5
Average number of authors per year	11
Average number of authors per publication	1,3
Total number of journals	90
Average number of papers per journal	2,6
Average number of cites per journal	149
Average number of cites/year per journal	21
Average number of journals per year	2,3

The first publication we found treating the UBC phenomenon and considering our filtering process, dates from the year 1972. On the other extreme, we have found several documents published in the year 2012 (the last year of this study). Thus the time range of the publications included in this study is forty years with an average of 8,2 UBC documents published in each year. We have knowledge about previous articles treating the UBC phenomenon but that are not included in the analysis because of our keywords' search limitations.[16]

From **Table 6** we can also see that this study includes 425 different authors, publishing on average 0,8 UBC documents and receiving a total of 37 citations or five citations per year each author. We have also an average of eleven new or different authors publishing UBC documents each year and in average each UBC publication has 1,3 authors. Moreover we can see in **Table 6** that this study includes 90 different journals publishing an average of 2,6 papers and receiving in average 149 citations or 21 citations per year. Considering our time range of forty years, we have an average of 2,3 new journals publishing UBC papers each year.

Table 7 shows the distribution of the publications by type or format. As we can see, papers from journals or reviews constitute the vast majority of the publications retrieved in the search (234 papers or 71,3%), followed by books or books' chapters and by working papers. In terms of cites and cites per year received by each type of publication, we can see that more than 85% of them correspond to journals' papers. We can also see that journals' papers have the highest rate of cites per publication with 57,3 cites per paper compare to 11,1 cites of working papers or 44,7 if it is a book or book chapter. As we can see in **Table 7** this study also includes 15 proceedings from conferences and six published doctoral dissertations. We also have two published research reports and one forthcoming paper (to be published soon).

It is interesting to compare these first results with previous reviews in the field of University Entrepreneurship. In this sense, in an extensive review of this field of study Rothaermel et al. (2007) included a total of 173 academic articles published in 28 different journals from 232 different authors. In contrast, our review includes 234 articles published in 40 different journals from 425 different authors.

More recent reviews of the University Entrepreneurship (UE) literature have also included a smaller number of articles. For example, Yusof and Jain (2010) included in their review of *university-level entrepreneurship* 72 papers related to UE topics. In this line, Djokovic and Souitaris (2008) identified 102 papers directly or indirectly treating the UBC phenomenon.

The broader approach adopted in this research allowed us to include in this review a larger number of papers from a larger number of different journals and authors. Furthermore, while previous UE reviews have only included articles from journals in their studies, our bibliometric search also retrieved 94 academic documents treating the

[16] In particular we know about the existence of E. Roberts (1968) and A. Cooper (1971) seminal articles.

University Entrepreneurship phenomenon but that are not journals' articles (i.e. books and books' chapters, working or research papers, research reports, doctoral dissertations or conference proceedings).

Table 7: Distribution of the publications included in the bibliometric study by type

TYPE OF PUBLICATION	Publications		Cites		Cites per year		cites / publication	cites/year/ publication
	nº	%	nº	%	nº	%		
Journal-Review Article	234	71,3%	13404	85,9%	1933	87,3%	57,3	8,3
Book or Book Chapter	35	10,7%	1564	10,0%	177	8,0%	44,7	5,1
Working-Research-Discussion Paper	35	10,7%	387	2,5%	61	2,7%	11,1	1,7
Conference Proceeding	15	4,6%	153	1,0%	27	1,2%	10,2	1,8
Doctoral Dissertation	6	1,8%	45	0,3%	8	0,4%	7,5	1,3
Research Report	2	0,6%	42	0,3%	5	0,2%	21,0	2,7
Forthcoming Journal-Review Article	1	0,3%	1	0,0%	2	0,1%	1,0	2,0
Total	**328**	100,0%	**15596**	100,0%	**2213**	100,0%	**47,5**	**6,7**

3.2. The evolution of University Entrepreneurship research

In **Figure 2(a)** we can see the annual distribution in the number of new UBC academic documents published. We found the first UBC document to be published in the year 1972 dating the start of the field of research (Lamont, 1972).[17] Ten years later two more UBC publications appeared (Doutriaux, 1982; McQueen and Wallmark, 1982). During the eighties a total of 21 UBC publications came into the scene with a partial peak of six academic documents published in the year 1986 (i.e. McMullan et al., 1986; Rogers, 1986 or Stankiewicz, 1986).

From **Figure 2(a)** we can see a decrease in the intensity of UBC publications until the year 1996 when only one UBC document was published (Balázs, 1996). From 1997

[17] We have not included this observation of 1972 in figures 6, 7, 8 and 9 because of graphic limitations.

onwards we witness a vigorous increase in the number of UBC publications with a partial peak in the year 2005 (29 publications) and again in 2010 (34 publications).

The number of UBC publications decreases to 30 documents in the year 2011 (i.e. Bathelt et al., 2011; Bonardo et al., 2011; Grimaldi et al., 2011; Haeussler and Colyvas, 2011; Rasmussen et al., 2011 or Wennberg et al., 2011) and to 19 in 2012 (i.e. Audrestch et al., 2012; Colombo et al., 2012; Rasmussen and Gulbrandsenb, 2012; Wright et al., 2012). The sharp apparent decrease shown in year 2012 is due to the fact that our analysis includes data until June 2012. It also takes time for a publication to be indexed in Google Scholar®, thus underestimating even further the number of UBC documents published in the year 2012.

In **Figure 2(a)** we can see the annual evolution in the number of authors publishing UBC documents. Here we count the number of non-repeated names of the authors involved in the 328 UBC publications retrieved in our search. In this sense if a person is the author of more than one UBC publication in the same year, he/she would be counted just once. Every author of a UBC publication is weighted the same (with a factor of one) independently of their position of appearance in the published document.

The first chronological author in our analysis is Dr. Lamont with his article entitled "Entrepreneurship, technology and the university", published at R&D Management in the year 1972. During the eighties several UBC authors came into the scene (i.e. Doutriaux, McQueen, Wallmark, Stankiewicz, Rogers, Allen) as well as in the nineties (i.e. Smilor, Chiesa, Chrisman, Mustar, Carayannis, Jones-Evans, van der Sijde).

On the other hand, more recent UBC authors include academics as Rasmussen, Bathelt, Bonardo, Colombo, Djokovic, Fini, Müller, Soetanto, Toole or Zhang. We also want to point out some authors whose names appear repeatedly along the years: Clarysse, Lockett, Mustar, O'Shea, Shane, Siegel or Wright. Considering our sample limitations (data until June 2012 and the time taken to be indexed in Google Scholar®), we believe that the number of authors involved in UBC publications is also underestimated for the year 2012.

Moreover, in **Figure 2(a)** we have the evolution in the number of journals publishing UBC papers each year since the beginning of the field in the early seventies. We can see at **Figure 2(a)** that in the year 1972 *R&D Management* published the first UBC paper (Lamont, 1972). Ten years later, *Technovation* published another UBC paper (McQueen and Wallmark, 1982) followed by a paper published in 1984 by the *International Journal of Social Economics*.

Three years later the *Journal of Business Venturing* and the *Journal of Small Business and Entrepreneurship* published a UBC paper. The journal *Technology and Culture* published a UBC article in the year 1988 and in the following year two new journals appeared in the scene, *Entrepreneurship & Regional Development* and the *Journal of Higher Education*.

In the year 1997 *Entrepreneurship Theory and Practice* published its first UBC paper. In the year 2001 The *Journal of Technology Transfer* published the first special issue related to UBC: "Organizational issues in University-Industry Technology Transfer". From this special issue we retrieved one paper focusing on UBC (Franklin et al., 2001). In 2002 *Management Science* also published a special issue related to UBC: "University Entrepreneurship and Technology Transfer".

From this special issue we found one paper with a UBC focus published by the editors of this special issue (Mowery and Shane, 2002). *Research Policy* (the most prominent journal as we shall see in the next point of this section) published a special issue about "Technology Entrepreneurship" in the year 2003. We have retrieved two UBC papers published at this special issue that concentrate in the UBC phenomenon (DiGregorio and Shane, 2003; Etzkowitz, 2003). Again we consider that due to sample data limitations, the number of journals publishing UBC papers is underestimated for the year 2012.

Comparing these results with previous reviews in the UE field of study, we can see that our research includes UBC-related documents that are older. For example, Rothaermel et al. (2007) include articles treating the UE phenomenon from the year 1981 onwards. Moreover, the first UE document included in Yusof and Jain (2010) dates from the year 1989. In the same line, Djokovic and Souitaris (2008) include articles from the year 1990 onwards. Once more the broader approach adopted in our study allowed us to include older documents in the review.

In terms of the impact that these publications had in the academic arena we sum the total number of citations per year received by the publications.[18] In **Figure 2(b)** we have the distribution of the number of cites/year received. Until the year 2002, cites/year has followed a similar path compare to the number of publications; but then, in 2003 we see a sharp increase reaching an absolute maximum of 309 cites/year. After 2005 we witness a steady decrease in the number of cites/year received by UBC publications.

This result suggests that UE documents with the highest impact in the academic arena were published around the year 2003. This is consistent with the results found in Rothaermel et al. (2007). In this study the authors found that due to special issues related to UE the number of papers related to this phenomenon has largely increase during the first years of the XXI century. Following these results, we may deduct that UE papers published in special issues receive more citations that UE papers published in regular issues.

[18] We believe that using the total number of citations received instead of citations per year would mislead the analysis results because older publications would generally show a higher number of citations than the newer ones. Thus, we believe that cites/year is a better proxy of the impact a publication have in a research field.

Figure 2(a): Annual evolution in the total number of UBC documents published, total number of authors (divided by two) and total number of journals publishing UBC articles and documents

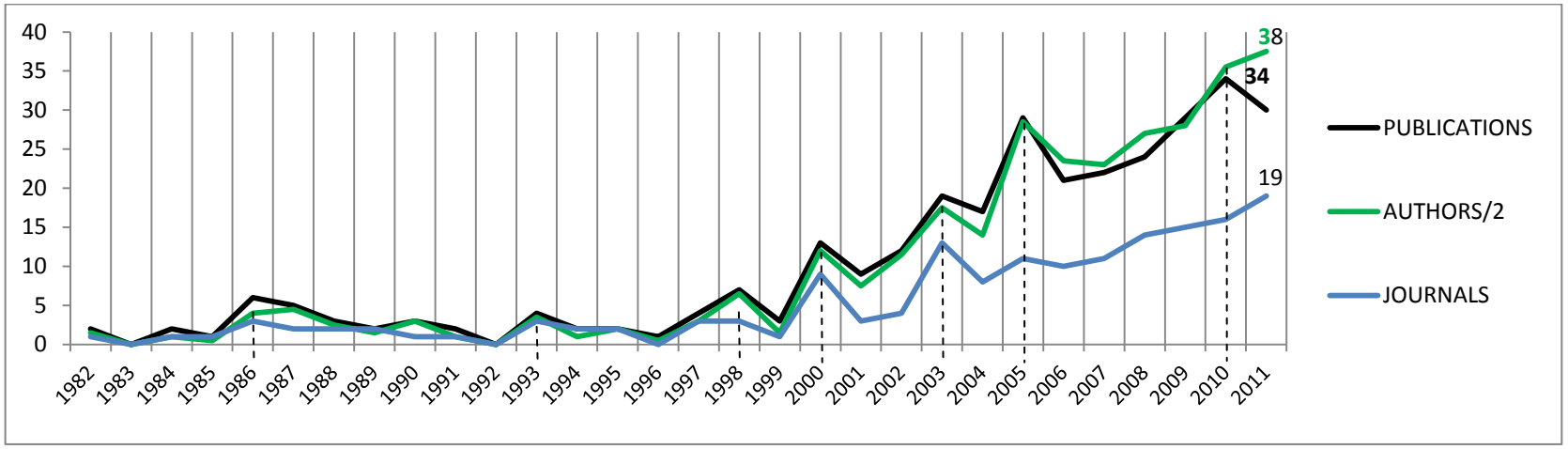
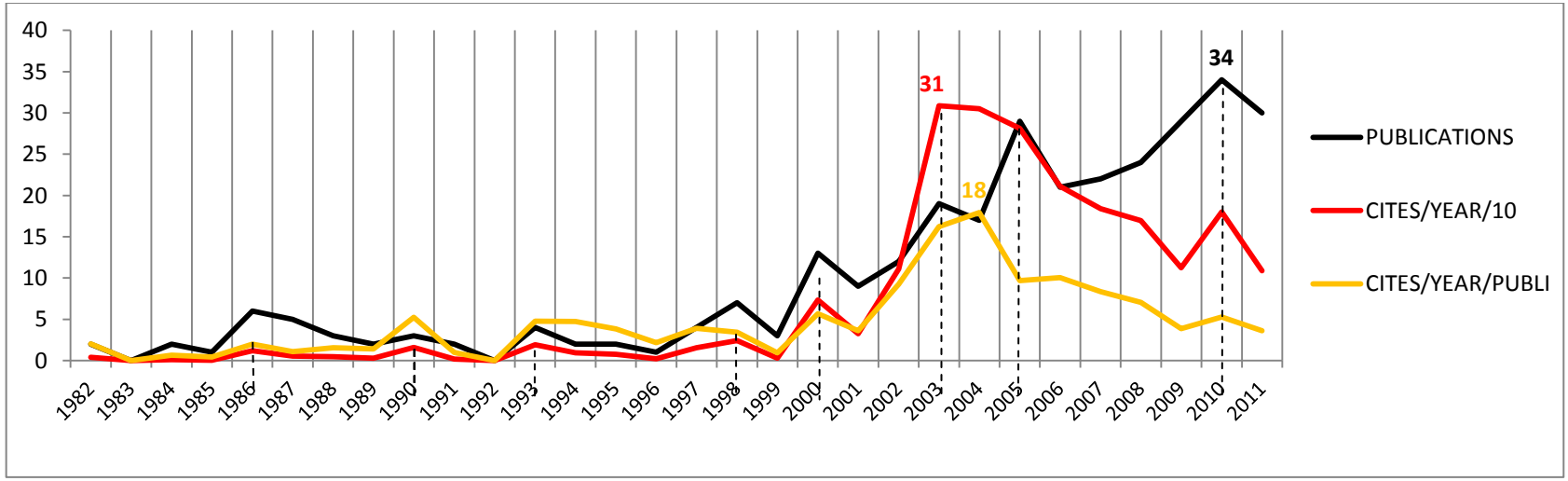


Figure 2(b): Annual evolution in the total number of UBC documents published total number of cites per year (divided by ten) and average number of cites per year received by each publication



3.3. Who is who in the University Entrepreneurship field of study?

Table 8 shows the top 50 publications ranked by the average number of cites per year received. The UBC publication showing the highest impact is a book written by Scott Shane and published in the year 2004 entitled "Academic entrepreneurship. University spinoffs and wealth creation" With 79,4 cites/year Shane's book seems to be the most influential publication in the UBC field of research. This book summarizes various decades of Dr. Shane's research about UBC in the context of the Massachusetts Institute of Technology (MIT) in Boston, United States.

There is another book in the 9th position called "Academic entrepreneurship in Europe" edited by Wright, Clarysse, Mustar and Lockett and published in the year 2008. This book includes several contributions studying the UBC phenomenon in Europe. All other publications in the top 50 are articles from academic journals or reviews.

In second position in terms of cites/year, we find an empirical article written by DiGregorio and Shane and published at Research Policy in 2003 (DiGregorio and Shane, 2003). In this research the authors empirically test some hypotheses about the determinant factors of UBC creation. In the third position of the impact ranking we find a comprehensive review of the university entrepreneurship literature written by Rothaermel, Agung and Jiang, published at Industrial and Corporate Change (Rothaermel et al., 2007). In the fourth position of the ranking we find a publication written by Shane and Stuart about organizational endowments as determinant factors of UBC performance. This article was published at Management Science in the year 2002 (Shane and Stuart, 2002).

We cannot compare this result with previous literature reviews in the University Entrepreneurship (UE) field of study because we have not found any other UE review using citation metrics to rank UE publications. It would be interesting that future research compare the rank of UE papers found in this study but using ISI Web of Knowledge Journal Citation Report (JCR) metrics of impact to rank them.

In **Table 9** we can see the list of the top 50 authors ranked by the total number of citations received in their UBC publications. The number of UBC publications and citations counts the same for different authors independently of their order of appearance in the document. In this sense, some publications may be counted more than once overstating the total number of citations received by the top 50 authors of **Table 9**.

From **Table 9** we can see that Dr. Scott Shane from the US occupies the first position with only six UBC publications but a total of 2246 citations received. Thus, following the results of this study, Dr. Scott Shane seems to be the most influential author in the UBC field of research.

Table 8: Top 50 UBC publications by the number of cites per year received

Nº	Cites/ year	First Author	Title	Year	Type
1	79,4	Shane	Academic entrepreneurship: University spinoffs and wealth creation	2004	Book
2	68,3	Di Gregorio	Why do some universities generate more start-ups than others?	2003	Paper
3	65,6	Rothaermel	University entrepreneurship: a taxonomy of the literature	2007	Paper
4	62,9	Shane	Organizational endowments and the performance of university start-ups	2002	Paper
5	47,3	Vohora	Critical junctures in the development of university high-tech spinout companies	2004	Paper
6	39,7	Stuart	When Do Scientists Become Entrepreneurs? The Social Structural Antecedents of Commercial Activity in the Academic Life Sciences	2006	Paper
7	38,4	O'shea	Entrepreneurial orientation, technology transfer and spinoff performance of US universities	2005	Paper
8	37,8	Bercovitz	Academic entrepreneurs: Organizational change at the individual level	2008	Paper
9	36,5	Wright	Academic entrepreneurship in Europe	2007	Book
10	35,1	Lockett	Resources, capabilities, risk capital and the creation of university spin-out companies	2005	Paper
11	30,7	Walter	The impact of network capabilities and entrepreneurial orientation on university spin-off performance	2006	Paper
12	29,7	Markman	Entrepreneurship and university-based technology transfer	2005	Paper
13	28,8	Mustar	Conceptualising the heterogeneity of research-based spin-offs: A multi-dimensional taxonomy	2006	Paper
14	27,9	Murray	The role of academic inventors in entrepreneurial firms: sharing the laboratory life	2004	Paper
15	27,7	Powers	University start-up formation and technology licensing with firms that go public: a resource-based view of academic entrepreneurship	2005	Paper
16	25,6	Clarysse	A process study of entrepreneurial team formation: the case of a research-based spin-off	2004	Paper
17	25,6	Lockett	The creation of spin-off firms at public research institutions: Managerial and policy implications	2005	Paper
18	23,0	Wright	University spin-out companies and venture capital	2006	Paper
19	22,5	Djokovic	Spinouts from academic institutions: a literature review with suggestions for further research	2008	Paper
20	21,7	Lockett	Technology transfer and universities' spin-out strategies	2003	Paper
21	21,4	Mosey	From human capital to social capital: A longitudinal study of technology-based academic entrepreneurs	2007	Paper
22	21,4	Franklin	Academic and surrogate entrepreneurs in university spin-out companies	2001	Paper
23	20,9	Shane	Encouraging university entrepreneurship? The effect of the Bayh-Dole Act on university patenting in the United States	2004	Paper
24	20,8	Steffensen	Spin-offs from research centers at a research university	2000	Paper

25	20,5	O'Shea	Determinants and consequences of university spinoff activity: a conceptual framework	2008	Paper
26	20,4	Rothaermel	University–incubator firm knowledge flows: assessing their impact on incubator firm performance	2005	Paper
27	19,2	Nicolaou	Academic networks in a trichotomous categorisation of university spinouts	2003	Paper
28	18,9	Nlemvo	A stage model of academic spin-off creation	2002	Paper
29	18,7	Rothaermel	Incubator firm failure or graduation?: The role of university linkages	2005	Paper
30	18,7	Jain	Academics or entrepreneurs? Investigating role identity modification of university scientists involved in commercialization activity	2009	Paper
31	18,1	Meyer	Academic entrepreneurs or entrepreneurial academics? Research–based ventures and public support mechanisms	2003	Paper
32	17,9	Pirnay	Toward a typology of university spin-offs	2003	Paper
33	17,4	Wright	Entrepreneurship and university technology transfer	2004	Paper
34	16,6	Ensley	A comparative study of new venture top management team composition, dynamics and performance between university-based and independent start-ups	2005	Paper
35	16,3	Chiesa	Exploitation and diffusion of public research: the case of academic spin-off companies in Italy	2000	Paper
36	16,0	Rasmussen	The Evolution of Entrepreneurial Competencies: A Longitudinal Study of University Spin-Off Venture Emergence	2011	Paper
37	15,8	Massa	Innovation and SMEs: Misaligned perspectives and goals among entrepreneurs, academics, and policy makers	2008	Paper
38	15,6	Lowe	Faculty entrepreneurs and research productivity	2007	Paper
39	14,9	Degroof	Overcoming weak entrepreneurial infrastructures for academic spin-off ventures	2004	Paper
40	14,2	Landry	Why are some university researchers more likely to create spin-offs than others? Evidence from Canadian universities	2006	Paper
41	14,0	Vanaelst	Entrepreneurial team development in academic spinouts: An examination of team heterogeneity	2006	Paper
42	13,8	Heirman	How and why do research-based start-ups differ at founding? A resource-based configurational perspective	2004	Paper
43	13,6	Nicolaou	Social networks in organizational emergence: The university spinout phenomenon	2003	Paper
44	13,4	Nerkar	When do start-ups that exploit patented academic knowledge survive?	2003	Paper
45	13,4	Hsu	Entrepreneurs from technology-based universities: Evidence from MIT	2007	Paper
46	13,3	Pérez Pérez	The development of university spin-offs: early dynamics of technology transfer and networking	2003	Paper
47	13,1	Carayannis	High-technology spin-offs from government R&D laboratories and research universities	1998	Paper
48	13,0	Klofsten	Comparing academic entrepreneurship in Europe: the case of Sweden and Ireland	2000	Paper
49	13,0	McAdam	High tech start-ups in University Science Park incubators: The relationship between the start-up's lifecycle progression and use of the incubator's resources	2008	Paper
50	12,9	Link	Opening the ivory tower's door: An analysis of the determinants of the formation of US university spin-off companies	2005	Paper

In the second position we find Dr. Mike Wright from UK with 22 UBC publications (so being the most active author in terms of the number of UBC publications) and a total of 1796 citations received. From the top ten UBC authors five are from US (Shane, Stuart, Di Gregorio, Rothaermel and Rogers) and five from Europe (Wright, Lockett, Clarysse, Mustar and Vohora).

This result is similar to the findings in Rothaermel et al. (2007). In this study the authors also found that Mike Wright is the most active researcher publishing UE papers. The authors also found that Andy Lockett and Scott Shane are among the most active authors in the UE field of study.

On the other hand, differently from our study, it seems that in Rothaermel et al. (2007) Bart Clarysse is not among the most active UE authors. This could be explained by the fact that while Rothaermel et al. (2007) include papers until the year 2005, our review includes articles until the year 2012.[19].

The variable CITES/YEAR/PUBLI (citations per year divided by the number of UBC publications) represents the relative *efficiency* of the authors to generate impact in the academic arena. In this sense, authors with higher number of CITES/YEAR/PUBLI are more *efficient* in generating impact than authors with low CITES/YEAR/PUBLI.[20]

Following this criterion and selecting only authors with at least two UBC publications, we can develop an authors' ranking by the level of efficiency they have. In this sense, we have found that Shane is the most *efficient* researcher in terms of the number of citations per year received divided by the number of documents published. Dr. Shane averages 42 citations per year per document published. Stuart, Rothaermel, O'Shea or Bercovitz are also highly efficient researchers in the UE field of study.

On the other hand and following our results, other highly active and relevant authors in the UE field of study do not seem to present a good efficiency ratio. For example, Clarysse received 11, Wright received 14 and Lockett received 16 cites/year/document.

To end the point about rankings we show in **Table 10** the top 10 academic journals ranked by the total number of citations received. Research Policy is the journal that has published more UBC papers and received more citations. In this sense Research Policy is the most active and the most influential academic journal in the UBC field of research. In the second range of journals we find The Journal of Business Venturing, The Journal of Technology Transfer and Technovation. Another relevant journal for the field of study is R&D Management with 11 UBC papers published and 569 citations received. These five journals sum a total of 97 UBC papers published (42% of the sample) and 8776 citations received (66% of the sample).

[19] Most of Clarysse's articles in the UE field of study are published after the year 2004.
[20] This is due to the fact that *efficient* authors need less UBC publications to receive the same amount (or more) citations per year.

Table 9: Top 50 authors by number of total citations received

#	Author's family name	Publi-cations	Cites	Cites / year	Cites / year/publi
1	**Shane**	6	2246	253	42
2	**Wright**	22	1796	301	14
3	**Lockett**	14	1610	229	16
4	**Stuart**	3	873	105	35
5	**Clarysse**	13	818	138	11
6	**Mustar**	8	638	105	13
7	**Di Gregorio**	1	615	68	68
8	**Rothaermel**	3	602	105	35
9	**Rogers**	3	495	36	12
10	**Vohora**	3	490	61	20
11	**Franklin**	2	430	43	22
12	**Allen**	4	407	61	15
13	**Birley**	3	378	41	14
14	**O'shea**	2	351	59	29
15	**Pirnay**	2	350	37	18
16	**Surlemont**	2	350	37	18
17	**Agung**	1	328	66	66
18	**Jiang**	1	328	66	66
19	**Roche**	2	321	45	22
20	**Stankiewicz**	2	308	15	7
21	**Nicolaou**	2	295	33	16
22	**Feldman**	5	278	90	18
23	**Thursby**	3	275	41	14
24	**Chevalier**	1	269	38	38
25	**Waddock**	1	255	32	32
26	**Speakman**	1	249	21	21
27	**Steffensen**	1	249	21	21
28	**Chiesa**	2	243	18	9
29	**Piccaluga**	2	243	18	9
30	**Meyer**	4	241	37	9
31	**Renault**	2	240	40	20
32	**Ding**	1	238	40	40
33	**Piva**	6	237	52	9
34	**Colombo**	6	232	51	9
35	**Murray**	1	223	28	28
36	**Dietrich**	1	220	10	10
37	**Gibson**	1	220	10	10
38	**Smilor**	1	220	10	10
39	**Bercovitz**	3	209	83	28
40	**Balkin**	1	208	30	30
41	**Gianiodis**	1	208	30	30
42	**Markman**	1	208	30	30
43	**Phan**	1	208	30	30
44	**Powers**	2	207	29	14
45	**Moray**	2	206	28	14
46	**Roberts**	3	202	30	10
47	**Bania**	1	198	10	10
48	**Eberts**	1	198	10	10
49	**Fogarty**	1	198	10	10
50	**Jones-Evans**	3	195	16	5

This result is highly consistent with Rothaermel et al. (2007) and Yusof and Jain (2010). Rothaermel et al. (2007) found that "*Research Policy published the most articles (47 or 27%) followed by the Journal of Technology Transfer (32 articles or 18%), Technovation (18 articles or 10%), the Journal of Business Venturing (16 articles or 9%) in fourth place, and Management Science (13 articles or 8%) coming in fifth"*. Yusof and Jain (2010) found that 26% of the papers included in their sample are published in Research Policy, followed by the Journal of Technology Transfer (17%), the Journal of Business Venturing (11%) and Management Science (10%).

Moreover, similarly to Rothaermel et al. (2007) and Yusof and Jain (2010) we have also found that "*All the top-publishing journals, with the exception of management Science, can be considered specialty or niche journals to some extent.*" (Rothaermel et al. (2007:697). In this sense, we agree with Rothaermel et al. (2007) that "*the majority of articles on university entrepreneurship have been published in specialty or niche journals can be expected given the nascent nature of university entrepreneurship*", and also that "*the general absence of university entrepreneurship research from the most prestigious journals may be explained by its embryonic stage in the life cycle of academics fields*" (Rothaermel et al. (2007:698-699).

Table 10: Top 10 journals or reviews by number of total cites received

JOURNAL'S NAME	PAPERS	CITES	CITES / YEAR	CITES / YEAR/PAPER
Research policy	29	3850	567	20
Journal of Business Venturing	12	1847	197	16
The Journal of Technology Transfer	26	1371	238	9
Technovation	19	1139	140	7
Management science	5	863	97	19
Small Business Economics	4	582	60	15
R&D Management	11	569	60	5
Industrial and Corporate Change	4	414	86	22
Science and Public Policy	6	376	32	5
Entrepreneurship Theory and Practice	6	256	56	9

The last column of **Table 10** shows the average number of citations per year received by each UBC paper per journal. Thus this variable represents the *efficiency* of an academic journal to generate impact in the UBC field of research. In order to develop a journals' ranking based on this criterion we believe is better to include only those journals with at least five UBC papers published.[21] Following this criteria, we have found that with an average of 20 cites/year/paper, Research Policy is the most efficient

[21] Thus, we reduce the effect of a high impact paper that may create distortion on the average number of CITES/YEAR/PAPER of a journal. This is the case of the journal Industrial and Corporate Change with a paper published in 2007 and written by Rothaermel, Agung and Jiang: "University entrepreneurship: a taxonomy of the literature". This paper receives an average of 66 citations per year, being the second paper with the highest impact after DiGregorio and Shane (2003) published in Research Policy.

journal publishing UE-related papers. It is very closely followed by Management Science with 19 cites/year/paper. The following most efficient journals publishing UE papers are the Journal of Business Venturing (16 cites/year/paper), the Journal of Technology Transfer (9 cites/year/paper) and Entrepreneurship Theory and Practice (9 cites/year/paper).

These results have important implications for researchers willing to publish an academic article in the UE field of study. In this sense, researchers looking forward to publish outstanding very high impact UE papers should concentrate on those journals publishing a high number of UE papers and also providing the highest possible rate of cites/year/paper (i.e. Research Policy, Management Science or Journal of Business Venturing). Moreover, researchers willing to publish good quality research (but not outstanding) should focus on journals publishing a high number of UE papers and providing an average rate of cites/year/paper (i.e. Journal of technology Transfer, Technovation, R&D Management or Science and Public Policy).

Furthermore, researchers willing to publish a moderate impact type of research (with limited contributions and originality) should concentrate on journals publishing a significant number of UE papers but with a low average of cites/year/paper (i.e. International Entrepreneurship and Management Journal, Economics of Innovation and New Technology, Industry and Higher Education or the Journal of Small Business and Enterprise Development).[22]

It is interesting to compare these results with the JCR of ISI Web of Knowledge. In particular, the top-cited journals in our review are also highly ranked in the JCR of ISI Web of Knowledge. Indeed, Research Policy, Management Science and the Journal of Business Venturing present a JCR index for the last five years higher than 3,5. In the same line, the second stage of journals publishing UE papers presents a five years JCR lower than 3. Finally, the third stage of journals publishing UE papers are not indexed in the JCR of ISI Web of Knowledge. This consistency between our results and the ranking developed by JCR of ISI Web of Knowledge suggests that our sample of UE papers is representative of the total impact journals have over the academic arena.

Until this point of section three we have shown the results from the bibliometric study including 328 academic documents (not only papers) dealing with the general topic of University Entrepreneurship. In the following parts of this section we shall present the results of the content analysis from the review of 72 empirical articles specifically dealing with the UBC phenomenon.

[22] We believe so because most cited journals are the ones that usually are the most demanding in terms of papers' contribution and originality.

3.4. State of the art and gaps in UBC research

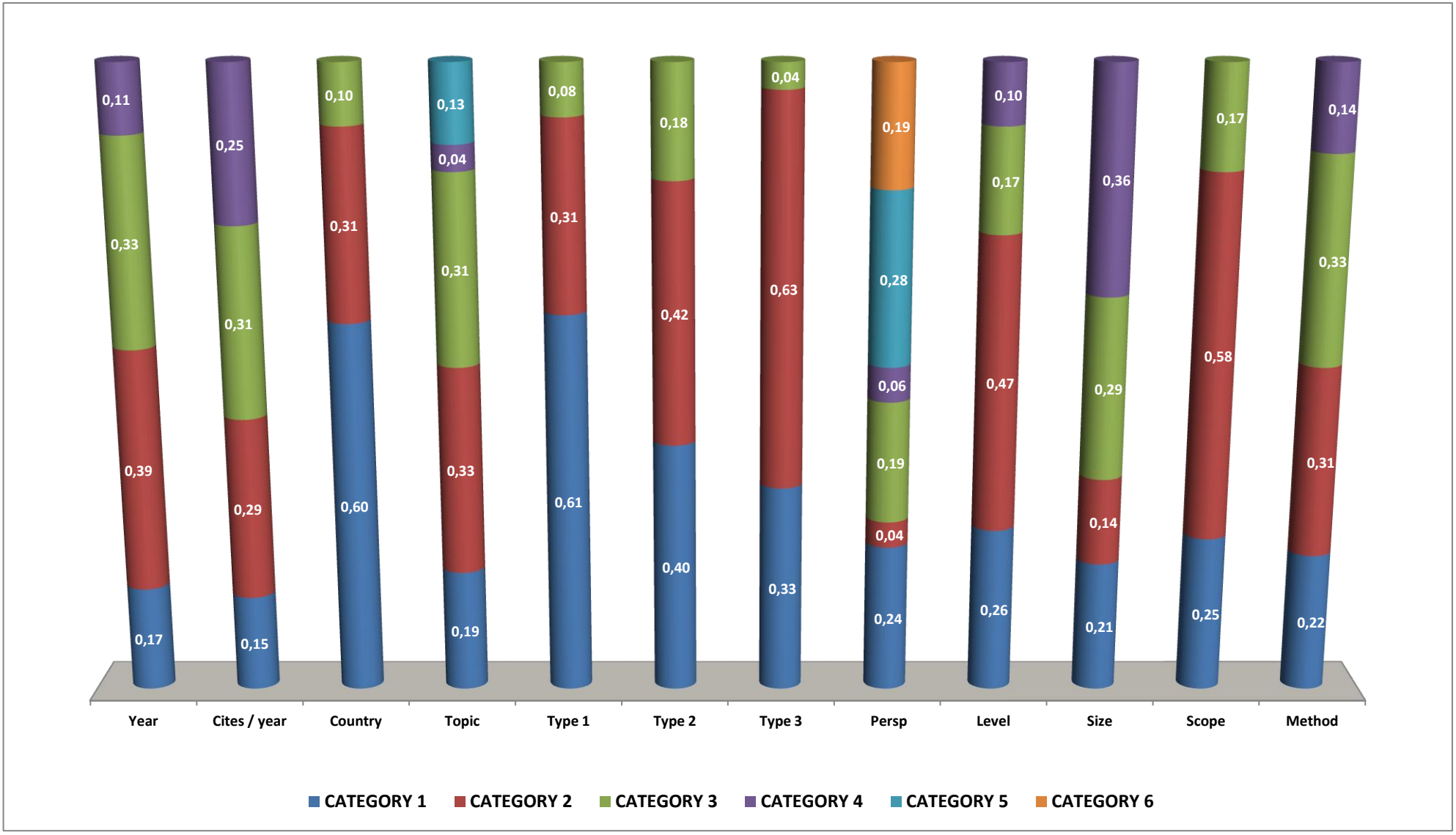
In **Figure 3** we have a graphic representation of the distribution of the categories for each of the variables used in the UBC literature content analysis. Each color in **Figure 3** represents one category of the variables included in the analysis. From **Figure 3** we may see that the big majority of the papers (83%) included in the sample were published after the year 2000. Thus, our results suggest that the UBC field of research attracted the attention of scholars and journals recently.

Figure 3 shows that most of these studies (91%) focus on countries located in North America and/or Europe. In this sense, there is a lack of academic studies treating the UBC phenomenon in countries located in South America, Asia or Africa. Furthermore, almost two thirds of the papers (64%) in the sample concentrate on the UBC creation (33%) or UBC development (31%) subtopics. Thus, we have found that there is a lack of studies aiming at disentangling the impact or effects of UBC over university entrepreneurs, parent universities (PU) or the local hosting environment (only 4%).

From **Figure 3** we may also see that almost two thirds of the papers in the sample are quantitative in nature but that there is still almost one third of the studies that are qualitative. In this line, we have found that there are more exploratory papers (42%) in the sample than explanatory studies (40%). This result supports Rothaermel et al. (2007) argument that the University Entrepreneurship field of study is still in its infancy and therefore there is still a lot of qualitative and exploratory research to be done in order to further develop and consolidate the field of study. On the other hand, we miss UBC studies using qualitative/exploratory and quantitative/explanatory methodologies simultaneously.

Figure 3 shows that the majority of the papers (63%) in the sample uses cross sectional datasets while one third of them are longitudinal studies. We have found very few UBC studies using both cross sectional and longitudinal datasets in their analysis. Moreover, the managerial and the economic conceptual perspectives are the two most commonly adopted theoretical frameworks by the papers in the sample. In addition, a significant proportion of the papers in the sample (28%) adopt multiple perspectives to study the UBC phenomenon. On the other side, there are still almost one fifth of the UBC studies with no clear theoretical framework adopted. Once more, this is a signal that the University Entrepreneurship paradigm is not yet consolidated among business scholars.

Figure 3: Distribution of all the variables included in the content analysis (n=72)



Furthermore, we see in **Figure 3** that almost half of the papers in the sample study the UBC phenomenon from the point of view of the firm (meso level of analysis). On the other side, we have found a lack of studies adopting a multi-level approach to UBC research. We believe that a mono-level research approach is limiting our understanding of the UBC phenomenon. Thus future UBC research should consider studying this phenomenon from various points of view simultaneously.

Finally, **Figure 3** shows that the big majority of the papers (83%) in the sample based their analysis in one or more PU but always located in the same country. Thus, there are few UBC studies basing their analysis in several PU from different countries. This result suggests that there is a lack of studies comparing the UBC phenomenon among different countries. We encourage future research to exploit this gap in the UBC literature.

Moreover, in order to specify even further the gaps in the UBC literature, we draw on O'Shea et al. (2008) and Djokovic and Souitaris (2008) to a priori classify the UBC literature following two variables or dimensions: TOPIC and LEVEL (see **Table 11**). We also differentiate between the number of quantitative and qualitative studies published.

In **Table 11** we can see that there are a total of 78 papers (50 quantitative and 28 qualitative) while there are only 72 papers included in the review. This is because there are six papers using quantitative and qualitative methodologies simultaneously (Pérez and Martínez, 2003; Brennan and McGowan, 2005; Markman et al., 2005; Del Palacio Aguirre et al., 2006; Libaers et al., 2006; van Geenhuizen and Soetanto, 2009).

From **Table 11** we can see that papers describing UBC phenomenon are basically meso-level studies trying to define, classify and characterize university-based companies (i.e. McQueen and Wallmark, 1982; Smilor et al., 1990; Carayannis et al., 1998; Steffensen et al., 2000; Druilhe and Garnsey, 2004). Only three studies concentrate in characterizing the university entrepreneur's profile (Chrisman et al., 1995; Ensley and Hmieleski, 2005; Hsu et al., 2008).

It is interesting to see that in the sample the description of the individual university entrepreneur has been done only in quantitative terms. Thus, there is no UBC paper in the sample describing the individual university entrepreneur using case study methodology. This gap in the UBC literature may be exploited by future researchers willing to better characterize university entrepreneurs.

Moreover, **Table 11** shows that most UBC creation papers are quantitative studies trying to explain the micro and/or macro determinant factors of university start-up activity. There is only one quantitative and explanatory research studying the meso-level determinant factors of UBC creation (Müller, 2010). Papers treating the UBC creation process are mostly qualitative and exploratory studies (Samson and Gurdon, 1993; Nlemvo et al., 2002; Meyer, 2003; Rasmussen, 2011).

Table 11: Classification matrix of the UBC literature reviewed. Finding the gaps.

		SUBTOPIC (article's focus)											
		Description		Creation		Development		Impact		Creation & development		Total	
		Quanti	Quali	Quanti	Quali	Quanti	Quali	Quanti	Quali	Quanti	Quali	Quanti	Quali
LEVEL OF ANALYSIS	MULTI	1	0	1	2	2	1	1	1	1	0	**6**	**4**
	MACRO	0	0	8	2	0	1	0	0	0	2	**8**	**5**
	MESO	6	4	1	3	15	2	0	0	0	4	**22**	**13**
	MICRO	3	0	9	1	1	2	1	1	0	2	**14**	**6**
Total		**10**	**4**	**19**	**8**	**18**	**6**	**2**	**2**	**1**	**8**	**50**	**28**

Furthermore, **Table 11** shows that most of the papers concentrating in the development and performance of UBC, are quantitative meso-level studies. On the other hand, there are no quantitative papers in the sample studying the macro-level determinant factors in UBC development and only one paper studying the individual level determinant factors of UBC performance (Grandi and Grimaldi, 2003). Finally, we have found only seven papers adopting a multi-level approach to study the UBC phenomenon (Chiesa and Piccaluga, 2000; Del Palacio Aguirre et al., 2006; Libaers et al., 2006; Toole and Czarnitzki, 2007; Toole and Czarnitzki, 2009; van Geenhuizen and Soetanto, 2009, Rasmussen and Borch, 2010).

3.5. Main streams in UBC research

In order to objectively classify the UBC literature reviewed, we have undertaken a multiple correspondence analysis (MCA) including all variables described in **Table 2**. The MCA simultaneously relates all different categories of every variable included pointing out homogenous groups in the UBC literature. **Figure 4** shows the output of the Multiple Correspondence Analysis (MCA) undertaken.

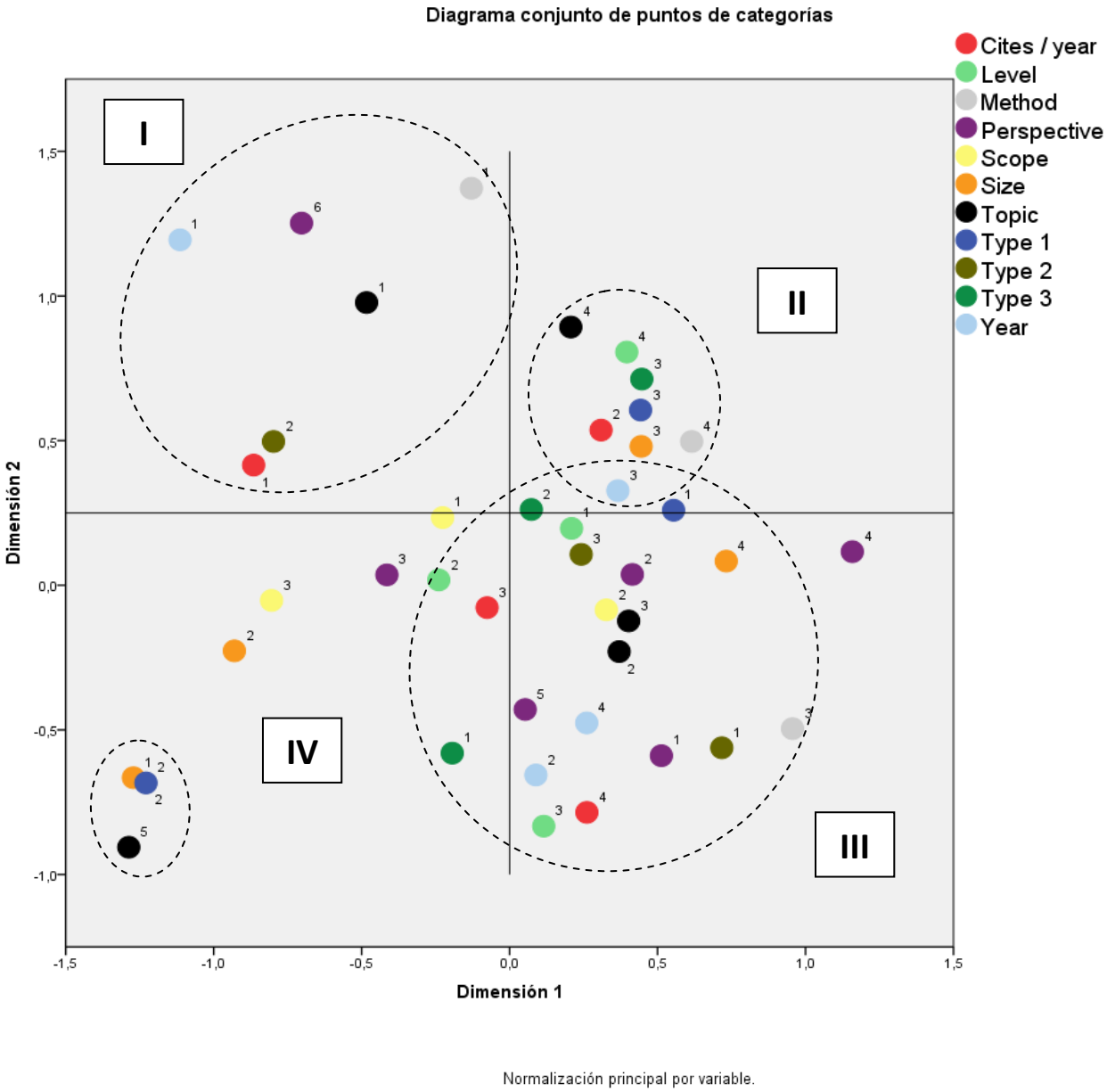
We can divide **Figure 4** in four quadrants or sectors. In the first quadrant of **Figure 4** we have a group of papers dealing with the description of UBC (variable TOPIC, category 1), with no theoretical framework (variable PERSPECTIVE, category 6), being mainly exploratory studies (variable TYPE 2, category 2) and using descriptive statistics as their method of analysis (variable METHOD, category 1). These papers were mainly published before the year 2000 (variable YEAR, category 1) and have received less than five citations per year (variable CITES/YEAR, category 1). Finally, many of these studies are based on data collected from one Parent University alone (variable SCOPE, category 1).

In quadrant two of **Figure 4** we find papers dealing with the impact that UBC have in their founders, in their Parent Universities (PU) and in their hosting regions. This group of papers usually adopts a multi-level approach, are mixed type of studies (quantitative and qualitative, explanatory and exploratory, longitudinal and cross sectional), use a medium sample size and a combination of different methods of analysis. These papers are mostly published after the year 2006 and receive in average between ten and twenty citations per year.

In quadrant three of **Figure 4** we have a group of papers dealing with UBC creation and papers dealing with UBC development. These papers are based on data collected from several PU from the same country, adopt a variety of conceptual perspectives and a micro or macro level of analysis, are mainly quantitative explanatory studies with a large sample size and use regressions as their main method of analysis. Most of these papers are published after the year 2000 and receive more than 20 cites/year.

Finally, in quadrant four of **Figure 4** we have a group of papers treating UBC creation and UBC development simultaneously. This group of papers is mainly composed by qualitative studies with less than 30 observations/cases coming from several universities from different countries. Most of these UBC creation/development studies are published after the year 2006.

Figure 4: Multiple Correspondence Analysis (MCA) output. Relating the categories of the variables included in the literature review



4. Conclusion

In the University Entrepreneurship literature it is widely proven that university-based companies (UBC) have emerged as an effective alternative commercialization channel for knowledge developed at parent universities (PU). In this sense, UBC are proven to be a more effective and profitable commercialization channel for tacit non-patentable knowledge than more traditional ways of commercializing university technology (i.e. patents and licenses or research contracts).

On the other side, the literature about the UBC phenomenon has remained elusive and diluted among other subtopics of the University Entrepreneurship paradigm (i.e. the entrepreneurial university or technology transfer). In particular, there is a lack of conceptual studies reviewing the academic literature specifically concentrating in the UBC phenomenon and providing a classification framework based on quantitative methodologies.

Thus, in this study we review, critically synthesize and provide a framework to classify the extant literature dealing with UBC. In the first stage of this review, we undertake a comprehensive bibliometric study of the full field of University Entrepreneurship to identify and rank the most influential UBC-related documents, authors and journals. In the second stage we use multiple correspondence analyses (MCA) and other quantitative techniques to classify the literature focusing specifically on the UBC phenomenon.

Our results show that the University Entrepreneurship field of research started to raise the attention from scholars at the beginnings of the seventies. But we have to wait until the beginning of this century to see a rampant increase in the number of publications, authors and journals treating the UBC phenomenon. Moreover, the number of citations received by these UBC-related publications has also radically increased since the year 2000. In this sense, we believe that University Entrepreneurship is a prominent field of study providing interesting publication opportunities to academics and researchers.

Furthermore, our results show that the UBC-related academic study with the highest impact in the University Entrepreneurship field of research is the book written by Dr. Scott Shane entitled *Academic Entrepreneurship. University Spinoffs and Wealth Creation*. Other highly influential studies in the field are DiGregorio and Shane (2003), Rothaermel et al. (2007), Shane and Stuart (2002), Vohora et al. (2004), Stuart and Ding (2006), O'Shea et al. (2005), Bercovitz and Feldman (2008), Wright et al. (2007) or Lockett and Wright (2005).

Following our results, the most influential author publishing UBC-related documents is Dr. Scott Shane (in terms of number of citations received). Moreover, Dr. Mike Wright is found to be the second most influential author and the first most active author publishing UBC-related documents (in terms of the number of

documents published). Other highly influential authors in the field are Lockett, Clarysse, Mustar, Rothaermel, Stuart, Rogers, Vohora, Pirnay or O'Shea. Other scholars that recently started to strongly contribute to the field are Colombo, Piva, Renault, Rasmussen or Moray.

Research Policy is the journal publishing the highest number of UBC-related articles and also the most influential in terms of citations received. Other very active journals in the University Entrepreneurship field of research are the Journal of Technology Transfer, Technovation, the Journal of Business Venturing or R&D Management. Moreover, Research Policy, Management Science and the Journal of Business Venturing are the three most efficient journals in terms of the average number of citations per year received for each UBC-related paper published. Thus, we believe that researchers willing to publish high impact UBC studies should concentrate in one of these three journals.

Following the results of this review, we believe that the state of the art in UBC research includes quantitative and longitudinal studies trying to explain the creation and development of UBC from a multi-level point of view and adopting multiple conceptual perspectives in a large sample of parent universities located in different countries. Again, researchers willing to publish high impact UBC papers should concentrate in developing this type of studies.

Moreover we have found several gaps in the UBC literature. For example, there is a lack of studies dealing with the impact or effect that UBC have over university entrepreneurs, parent universities or the local environment. Moreover, we miss studies dealing with the UBC phenomenon outside the US, Canada, UK or other developed European country. In the same line, there is a lack of mixed type of studies using qualitative/exploratory and quantitative/explanatory methodologies simultaneously. Finally, we have found very few UBC studies adopting a multi-level point of view (micro, meso and macro) to analyze the UBC phenomenon. In this sense, we believe that future lines in UBC research will concentrate in filling these literature gaps.

From the results of the multiple correspondence analyses undertaken we can conclude that the UBC literature may be classified in three main different streams: (i) seminal UBC studies, (ii) mainstream UBC literature and (iii) new avenues in UBC research. The first stream of the literature includes studies exploring and describing the UBC phenomenon with no specific theoretical framework and using a small sample usually coming from just one Parent University. Studies in this first stream of the UBC literature are mainly published before the year 2000.

The second stream of the literature includes articles trying to explain the creation or the development of UBC. These are usually quantitative studies published between the year 2000 and the year 2006, using large samples from several parent universities but located in the same country. Finally, the third stream of the literature

includes studies about the impact of UBC that usually adopts a multi-level perspective, are mixed type of studies, use medium sized samples and a combination of different methods of analysis. These papers are mostly published after the year 2006.

This study is not free of limitations. In this sense, we have to acknowledge that our search of UBC-related documents is limited by the number of keywords used. Even though we have included a large number of validated keywords to look for at the titles of documents, we have missed some relevant UBC publications not including in their titles any of the selected keywords.[23] To reduce this limitation, future UBC research may want to combine a keywords' search with a saturation method.

The time spam of this study may be also considered a research limitation. In this sense, the literature review undertaken in this study includes academic articles until the year 2011 inclusive (see **Table 3**). Actually, the final bibliometric search includes articles until May 2012, but we have very few articles from 2012. On the other hand, in the rest of this doctoral dissertation we have been able to include more recent studies relevant for the study of the UBC phenomenon.[24] This is due to the fact that the bibliometric study and the literature review were done at the very first stage of this doctoral research. Moreover, while it was possible to add new references in the other chapters of this doctoral dissertation as time passed, it was not possible to add them to this chapter without changing the results of the analysis.

Moreover, the use of Google Scholar database as the source of UBC-related documents and citations' metrics may not be appropriate for some academic spheres. In this sense, we believe that it would be interesting that future UBC research undertakes a similar bibliometric study but using the Journal Citation Report (JCR) of ISI Web of Knowledge as the data source and comparing the results with the results of this study. Lastly, there are some timing limitations in this study. In this sense, it takes months for a published document to be indexed in Google Scholar and it may take several years before the document is read and cited in posterior publications. Thus, we believe that the number of UBC publications and in particular the number of citations received might be highly underestimated for the last two years of the bibliometric study (2011 and 2012).

[23] For example: Florida and Kenney (1988), Roberts (1991), Radosevich (1995), Roberts and Malone (1996), Zucker et al., (1998), Rappert et al. (1999), Bozeman, 2000; Agrawal (2001), Shane (2001), Shane (2002), Siegel et al. (2003), Markman et al. (2004), Siegel et al. (2004), Clarysse et al. (2005), Debackere and Veugelers (2005), Markman et al. (2005), Stuart and Ding (2006), Wright et al. (2008), Thursby and Thursby (2011) or York and Ahn (2012).

[24] For example: Abramo et al. (2012), D'Este et al. (2012), Guerrero and Urbano (2012), Karlsson and Wigren (2012), Marion et al. (2012), Algieri et al. (2013); Astebro et al. (2013); Berbegal et al. (2013), Karnani (2013), Resende et al. (2013), Swamidass (2013), Treibich et al. (2013), Epure et al. (2014), Guerrero et al. (2014), Lehoux et al. (2014), Lundqvist (2014), Nelson (2014), Ortin and Vendrell (2014), Rasmussen et al. (2014), Sanchez-Barrioluengo (2014), Shah and Pahnke (2014), Sternberg (2014), Wright (2014), Goel et al. (2015), Huyghe and Knockaert (2015), Kalar and Antoncic (2015), O'Kane et al. (2015).

CHAPTER TWO

DEFINING, CLASSIFYING AND CHARACTERIZING UNIVERSITY-BASED COMPANIES

1. Introduction

> "*… USOs are extraordinarily heterogeneous and their borders can vary significantly according to the perception of the practitioners and scholars. ... As a consequence, a general framework specifying the type of phenomenon under consideration is necessary to accumulate useful knowledge in this key field of research. The lack of such a framework not only leads to crude generalization of research results…, but also contributes to poor empirical results due to the non-comparability of both samples and situations studied*."
>
> (Pirnay et al., 2003: 356).

University-based companies (UBC) are proven to be beneficial agents for the commercialization of the knowledge and technology developed at research universities (Roberts and Malone, 1996; DiGregorio and Shane, 2003; Shane, 2004; Lockett and Wright, 2005; O'Shea et al., 2005; Ortin et al., 2008; O'Shea et al., 2008; Wright et al., 2008; Rodeiro et al., 2010; Yusof and Jain, 2010; Vendrell and Ortin, 2010; Beraza and Rodriguez, 2011; Iglesias et al., 2012; Algieri et al., 2013; Karnani, 2013; Swamidass, 2013; Criaco et al., 2014; Shah and Pahnke, 2014).

In this sense, the study of the University Entrepreneurship phenomenon and in particular of the companies generated at parent universities (PU) has received increased attention from scholars, practitioners and policy makers (Rothaermel et al., 2007; Djockovic and Souitaris, 2008; Yusof and Jain, 2010; Abramo et al., 2012; Epure et al., 2014; Guerrero et al., 2014; Lehoux et al., 2014; Lundqvist, 2014; Mendez, 2014; Nelson, 2014; Ortin and Vendrell, 2014; Rasmussen et al., 2014; Rolf, 2014; Sanchez-Barrioluengo, 2014; Shah and Pahnke, 2014; Wright, 2014; Goel et al., 2015; Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015; O'Kane, 2015).

Although the phenomenon of new ventures created at universities has been studied for more than forty years, academics have reached no agreement about what is a university-based company (Pirnay et al., 2003; Nicolau and Birley, 2003; Clarysse and Moray, 2004; Bathelt et al., 2010; Müller, 2010; Bonardo et al., 2011; Iglesias et al., 2012; Swamidass, 2013; Treibich et al., 2013; Ortin and Vendrell, 2014; Shah and Pahnke, 2014). This fact may be pervasive for university entrepreneurship research because as stated by Pirnay et al. (2003) an ambiguous definition of the phenomenon under study may undermine researchers' empirical results because they would be difficult to generalize and compare with other studies.

Moreover, the heterogeneity of this type of firms, while sometimes acknowledge in conceptual research (Pirnay et al., 2003; Nicolau and Birley, 2003; Mustar et al., 2006; Iglesias et al., 2012; Shah and Pahnke, 2014), is very rarely considered in empirical studies (Wright et al., 2004; Zhang, 2009a; Bathelt et al., 2010; Müller, 2010; Bonardo et al., 2011; Karnani, 2013; Treibich et al., 2013; Epure et al., 2014). In this line,

Harrison and Leitch (2010) argue that: "*it is also evident that university spin-off companies are not homogenous with comparable needs and prospects.*"

Indeed, UBC is not a homogeneous phenomenon. For example, through a cluster analysis Iglesias et al. (2012) identify three homogenous groups of UBC based on their life-cycle: (i) initiating or starting companies, (ii) companies that are in the growth stage and (iii) consolidated companies. In the same line, Epure et al. (2014) include three different types of UBC in their sample: (i) companies with formal technology transfer agreements with their parent universities, (ii) companies with no formal technology transfer agreements but with at least one member of the parent university in their founding teams and (iii) companies with no formal agreements and with no member of the parent university in their founding teams.

In this sense, Shah and Pahnke (2014: 780) argue that: "*To date, most research has focused on academic entrepreneurship — new ventures that spin out of academic laboratories. However, universities also give rise to startups that do not directly exploit knowledge generated within academic laboratories.* In the same line, Shah and Pahnke (2014: 781) also argue that: "*There are many start-ups that owe their origins to knowledge gained within university environments, but that do not coalesce around technologies developed within academic laboratories. The cultivation, prevalence, and pathways traversed by these startups has been less well understood and studied*."

The objective of this study is twofold. The first objective is to identify commonalities among the different UBC definitions and typologies found in the literature and propose a coherent framework to define and classify university-based companies. The second objective of this study is to characterize and compare the different types of UBC identified in the first stage. Therefore the research questions in this study include: (i) what is a university-based company (UBC)? (ii) What are the different types of UBC? (iii) How can researchers and practitioners classify UBC? (iv) What are the main characteristics and differences among UBC types? (v) What is the growth and risk potential of each type of UBC?

We believe to contribute to business science by developing a conceptual framework to define and classify UBC with relevant implications for researchers and practitioners. Thus, in this study we contribute by providing a coherent, comprehensive and parsimonious definition and classification of the UBC phenomenon. Moreover, this study also contributes to the University Entrepreneurship field of research by providing a detailed profile of each type of UBC previously identified.

Based on previous literature, in the next section we develop a definition and taxonomy of UBC. In section three, we describe the methodology and the results of the empirical analysis undertaken to characterize each type of UBC. In section four we discuss the results obtained and in section five we conclude by highlighting some implications and limitations of this study.

2. Defining and classifying university-based companies

We have reviewed a total of 130 research articles directly considering the UBC phenomenon.[25] We used a list of validated keywords to look for UBC articles published at Google Scholar(R) database and selected those with more than two citations per year or more than ten citations received during their whole "life" (from publication date).

From the initial list of papers, we have selected 26 articles that specifically focus in the issue of UBC definition, typology and/or characterization. In **Table 1** we present a summary of these papers. Papers are sorted following their year of publication. **Table 1** quotes the authors' views about how to define and classify university-based companies. We have look for commonalities and differences among the definitions and typologies or classifications provided. In the rest of this section we develop our analysis of the literature towards a coherent and comprehensive definition and classification of UBC.

At the beginning of the field of research, academics used to define university-based companies (UBC) in a narrowly manner. In this sense, McQueen and Wallmark (1982) and Doutriaux (1987) required the new firm created by a Parent University (PU) to meet two conditions in order to be called UBC. First the founders of the new company have to be active members of the PU (academics, students or staff). Thus, new companies founded by graduate students or emeriti academics with the support of a PU are not considered university-based companies by these seminal authors.

The second condition is that the new company has to be based on a technological innovation produced at the PU and commercially exploited by the UBC. In this sense, we may say that the first academic studies specifically dealing with the definition of a UBC used a narrow approach only including as UBC new technology-based firms (NTBF) founded by active members of a Parent University (PU).

In the nineties researchers started to broaden-up the UBC definition in order to include new firms founded by external or surrogate entrepreneurs (Smilor et al., 1990; Roberts and Malone, 1996; Carayannis et al., 1998; Klofsten and Jones Evans, 2000; Steffensen et al., 2000).[26] Although these studies accept the possibility of an external entrepreneur in the definition of UBC, they still considered that in order to be called UBC, the Parent University have to transfer a core technology to the new venture; which in turn has to be

[25] 72 were empirical studies, 16 were conceptual investigations and 7 were literature reviews. All articles are available from the authors under request.

[26] External founders include anyone that is not a member of the Parent University (PU). An external or surrogate entrepreneur is neither an academic, student or staff (active PU's members) nor a graduate student or an emeriti academic (non-active PU's members). The use, advantages and disadvantages of a surrogate entrepreneur instead of an academic as the UBC founder is extensively discussed in Franklin et al. (2001).

Table 1: Some UBC definitions and typologies recognized in the literature

REFERENCE	UBC DEFINITION	UBC TYPOLOGY
1. Mc.Queen & Wallmark (1982)	"In order to be classified as a **spin-off company** from Chalmers three criteria had to be met. First the **company founder** or founders had to come from Chalmers (**faculty, staff or student**). Second the **activity of the company** had to be **based in technical ideas** generated in the Chalmers environment. Third, the **transfer** from Chalmers to the company **had to be direct** rather than via an intermediate employment somewhere else." (pp. 307).	**N/A**
2. Doutriaux (1987)	"**Academic start-up** is a new business **venture created by university professors, technicians, or students to exploit commercially an invention** made in its (the university's) own laboratories." (pp. 285).	"several groups, each representing one type of activity and the current contractual links of the owner-entrepreneur with a university: (i) **Firms** offering **technical services** to the community or doing R&D activities, having their **owner still on university payroll** (**TSU**) or **completely independent (TSI)**; (ii) **Firms** involved in some type of **manufacturing** activities, with the **entrepreneur still on university payroll (MU) or not (MI)**." (pp. 288)
3. Smilor et al. (1990)	"A **spin-out company** is defined in **two ways**: (1) **the founder was a faculty member, staff member, or student** who left the university to start a company or who started the company while still affiliated with the university; **and/or** (2) **a technology** or technology-based idea **developed within the university was used to start the company**." (pp. 64).	"Research focuses on technology-based spin-out companies from the University of Texas at Austin. Spin-out firms that provide consulting services or other types of products were not included in the study." (pp. 64). Two types: (i) **technology-based spin-offs** and (ii) **service and consultancy spin-offs**.
4. Roberts & Malone (1996)	"A **spin-off company** is a **separate business entity** that is formed using investment funding. The **parent organization provides the technological base**, supplemented on occasion by some risk capital, in return for equity." (pp. 3).	(i) Model 1: **technology push** with independent principal groups; (ii) Model 2: **technology push/business pull** with an **entrepreneurial technology originator**; (iii) Model 3: **technology push/business pull** with an **entrepreneurial technology originator** and an **internal venture capital fund**; (iv) Model 4: **business pull** with **internal capital funds** and (v) Model 5: **business pull** with an **entrepreneur/venture capital fund alliance**.
5. Carayannis et al. (1998)	**A priori definition**: "spin-off as a **new company** that is **formed** (1) **by** individuals who were **former employees** of a parent organization, **and** (2) **around a core technology** that **originated at a parent organization** and that was then transferred to the new company. This definition is based on that of Smilor et al. (1990)" (pp.1). **Definition after empirical evidence**: "thus definning a **spin-off** more boradly as a **new company** that is **established by transferring its core technology, founders, or other resources from a parent organization**." (pp. 10)	Several types according to the resources transferred from the parent organization to the new venture: "(i) **technology spin-off**, (ii) **founder spin-off**, (iii) **venture capital spin-off**, etc." (pp. 10)
6. Klofsten & Jones-Evans (2000)	"commonly known as the academic or technology-based spin-offs." (pp. 300) ... "**Spin-off** firms **are new firms** or organizations **formed to exploit the results of the university research**." (Table 1, pp. 300).	**N/A**

7. Steffensen et al. (2000)	"A **spin-off** is a **new company** that is **formed** (1) **by** individuals who were **former employees** of a parent organization, **and** (2) **a core technology that is transferred from the parent organization**. This definition is based on that of Smilor, Gibson, and Dietrich (1990)." (pp. 97).	"A **planned spin-off** is a new venture resulting from an organized effort by the parent organization. A **spontaneously-occurring spin-off** is a new company instigated by an entrepreneur who identifies a market opportunity and establishes the spin-off with relatively little encouragement (and perhaps with discouragement) from the parent organization." (pp. 107).
8. Nicolau & Birley (2003)	"… we propose the following definition of **university spinouts**. Spinouts involve: (1) the **transfer of a core technology from an academic institution into a new company and** (2) the **founding member(s) may include the inventor academic**(s) who may or may not be currently affiliated with the academic institution." (pp. 333-334).	"we propose the following trichotomous categorisation of university spinouts. (i) An **orthodox spinout** involves both the academic inventor(s) and the technology spinning out from the institution. (ii) A **hybrid spinout** involves the technology spinning out and the academic(s) retaining his or her university position, but holding a directorship, membership of the scientific advisory board or other part time position within the company. (iii) A **technology spinout** involves the technology spinning out but the academic maintaining no connection with the newly established firm." (pp. 340).
9. Pirnay et al. (2003)	"… we specify our own definition of **university spin-offs** as: **new firms created to exploit commercially some knowledge, technology or research results developed within a university**" (pp. 356).	"The proposed typology is based on two key discriminatory factors, namely (1) the status of individuals involved in the new business venturing process (researcher or student) and (2) the nature of the knowledge transferred from university to the new venture (codified or tacit), inducing the nature of the USO activities (product or service-oriented). (pp. 355).
10. Clarysse & Moray (2004)	"a **spin-off** can be seen as a **technology transfer mechanism for the commercialization of a technology developed at** an R&D institution or **university**."… "we posit a **transfer of technology** from a research organization as a **conditio sine qua non** for defining a company as a **research-based spin-off.** (pp.59).	"Depending on the intensity of the management of the potential spin-off's trajectory, three different modes seem to emerge: a **protected mode**, a **free market mode**, and a **Keynesian mode**." (pp. 59)
11. Druilhe & Garnsey (2004)	"we restricted our analysis to **direct spin-outs**, that is **companies drawing on university-based technological** and scientific **knowledge and involving academics or students** who were still members or had just quit the University." (pp. 274)	"On the basis of types of productive opportunity/activity and required resource bases, we distinguish between five categories of university spin-outs … which differentiates business activities linearly according to their nature and degree of difficulty for academic entrepreneurs." (pp. 273). (i) technical consultancy and R&D **services firms**; (ii) **R&D companies**; (iii) **software companies**; (iv) **product companies** and (v) **infrastructure companies**. (Figure 1, pp. 273).
12. Vohora et al. (2004)	"a **venture founded by employees of the university around a core technological innovation** which had initially been developed at the university. The USO is created solely to overcome technical and market uncertainties. **This definition deliberately excludes** those USOs traditionally regarded as **life-style companies** that are not established with the objective of creating a high return for their shareholders." (pp. 149).	**N/A**
13. Wright et al. (2004)	"**USO** is a **new company founded by employees of the university around a core technological innovation** which had initially been developed at the university." (pp. 288).	(i) **Joint Venture spin-off** (JVSO) and (ii) **independent spin-off**.

14. Lockett & Wright (2005)	"We narrowly define **university spin-outs** as **new ventures** that are **dependent upon** licensing or **assignment of the institution's intellectual property for initiation** ... Hence, **we exclude all companies** not based on technology assigned/licensed from the university, such as companies that may be established by graduates or university researchers **that are not directly related to intellectual assets** created from research funded by government or industry." (pp. 1044-1045).	"We also distinguish between external equity backed university spin-outs and those that do not receive such financial support." (pp. 1045). Two types: (i) **equity backed university spin-outs** and (ii) **university spin-outs with no external equity financial support.**
15. Mustar et al. (2006)	"**RBSOs** (Research-based Spin-offs) involve the creation of **ventures based on** the **formal and informal transfer of technology or knowledge** generated by public research organisations." (pp. 289).	"The **dimensions that differentiate between firms are the type of resources, the business model and the institutional link**." (pp. 289). **A three dimensional typology** based on the conceptual perspectives assumed in the articles reviewed: the type of institutional link with the parent university, the business model and the resources of the new venture.
16. Mustar et al. (2008)	**University spin-off** (**USO**)"… **new ventures** that involve the **spin-off of technology and knowledge** generated by PROs (Parent Research Organizations)." (pp. 67).	"Our detailed analysis at the firm level suggests that three very different types of spin-off exist, which we have labelled, respectively, the **VC-backed** type, the **prospector** type and the **lifestyle** type." (pp. 70)
17. Ortin et al. (2008)	"For the majority of the TTOs the criterion that is followed to consider a firm as a **spin-off of the university** is that the **firm actively involves a professor from the university**."	**N/A**
18. Fini et al. (2009)	"We include in our analysis **all new ventures based on the transfer of knowledge** generated within the five Emilia Romagna universities. Our definition of an **academic spin-off** includes companies **which have either the university or at least one academic** (full, associate, assistant professors, PhD students, research fellows or technicians) **among the founders**." (pp. 388). "In our definition **we do not include those firms based on a university technology licensing established by surrogate academic entrepreneurs**." (pp. 389).	"Such a definition encompasses situations where: (a) there is **formal commitment from the university** (the spin-off has passed through the university spin-off regulation approval, and/or the university is involved as one of the founders); (b) there is **no formal commitment** from the academic organization (except for individuals who decide to share equity)." (pp. 388-389).
19. Bathelt et al. (2010)	"We define **university spin-off/start-up** as a firm which **draws upon knowledge that is produced or circulated at the university**, **in which the founders have met or become associated** in the context of a university, **and where the business opportunities are the outcome of the university's existing areas of competence in research and teaching**." (pp. 522). "we assume that there is a direct transfer from the university to the new firms and/or a direct link between the university and the founder(s) that create the opportunity to start-up a new venture in a specific technology field." (pp. 522).	According to how close their start-up process is to the university core research competencies." Two types: (i) **sponsored** vs (ii) **unsponsored** firms (pp. 522). In terms of university involvement, we differentiate between three types of ventures: (i) **spin-offs from university research**, (ii) **spin-offs** that result **from university-industry joint ventures**, (iii) **start-ups** resulting **from decentralized individual or collective ideas** ... unrelated to the university's research projects." (pp. 523). Differentiate according to the ... pattern of co-location of the founders: (i) **co-localized** and (ii) **non co-localized**. Finally according to "the character of university knowledge that is used for the spin-off/start-up process, ... (i) **generic,** broader, less specific **knowledge** ... and (ii) **specific knowledge** ... closely tied to university research." (pp. 524)

20. Müller (2010)	"I follow Pirnay et al. (2003) and define **spin-offs** as **new firms created to exploit commercially some knowledge, technology, or research results developed within a university**. … the common two-dimensional approach does not solely include formally transferred technologies, but also scientific as well as technical skills acquired during a person's academic activity." (pp. 190).	"I will **distinguish between three types of knowledge** which is **transferred** from the public research institution: research results, newly developed scientific methods and specific skills acquired at the public research institution." Three types of spin-offs: (i) **research-transfer spin-offs**; (ii) **method-transfer spin-offs** and (iii) **competence spin-offs**.
21. Bonardo et al. (2011)	"... **university-based firms** are defined as **companies that were either developed by faculty members** based on their own research **or created specifically to capitalize on academic research**." (pp. 6)	"we distinguish between university-based firms whose TMTs still contain academics and those with no formal involvement … " (pp. 6). Two types: (i) **academic** and (ii) **non-academic university-based companies**.
22. Iglesias et al. (2012)	"Spin-off is defined as a company **born inside** research centres or **universities** and **promoted by the researchers** with the objective of transforming the results and knowledge from research into high value-added products and technologies." (pp. 241)	**Start-up Spin-Off**: firms in start-up phase of development initiating their R&D activities. **Growing Spin-Off**: firms already undertaking valuable R&D activities but with limited commercial applications. **Consolidated Spin-Off**: firms undertaking valuable R&D activities and also commercializing R&D results at the markets. (pp. 252)
23. Karnani (2013)	"**The central criterion for classifying a company as a spin-off of a university** or research institution **is the *transfer effect***, which means the spin-off company's exploitation of the knowledge created at the university." Spin-offs are: "**knowledge-based start-up companies from universities** and research institutes." (pp. 236)	"**Tacit start-up knowledge**: The spin-off was based on knowledge that was only present at the university in a tacit form." "**Codified start-up knowledge**: The start-up was based on knowledge that was recorded at the university in an explicit or codified form." (pp. 241-242)
24. Treibich et al. (2013)	"Academic spin-offs, that is, **firms founded by staff or graduates** of academic institutions **that exploit research outcomes**." (pp. 450)	**Manifest segregative UBC**: interactions' intensity with the parent university (PU) is always low. **Delayed segregative UBC**: interactions' intensity with PU start to decrease after 4/5 years the firm is created. **Manifest interactive UBC**: interactions' intensity with the parent university (PU) is always high. **Delayed interactive UBC**: interactions' intensity with PU start to increase after 4/5 years the firm is created. (pp. 457/8)
25. Epure et al. (2014)	The authors extend the UBC definition stated in Pirnay et al. (2003) to **include firms that do not commercially exploit any knowledge developed within universities**. (pp. 6-7)	**STTU**: firms with formal technology transfer agreements with the parent university. **SPU**: firms with no formal technology transfer agreements with the parent university (PU) but with at least one member from the PU in the founding team. **OSU**: firms with no formal technology transfer agreements and no member of the PU in the founding team. (pp. 7)
26. Shah and Pahnke (2014)	The authors present the general concept of UBC as "**entrepreneurial ventures cultivated within** their – **universities'** – walls". (pp.780)	**Spinouts Type 1**: "new firms that commercialize technologies developed by faculty, staff or students as part of academic research programs." **Spinouts Type 2**: "form when technological knowledge comes from the university, but entrepreneurial know-how does not. These firms may or may not be founded by individuals associated with the university." **Offshoots**: "academic research is not the source of innovative knowledge, but where the university does provide critical entrepreneurial knowledge." **Seeds**: "firms which neither commercialized ideas generated by academic research nor benefited from formal entrepreneurship education provided by a university." (pp. 784-786)

commercialized at the markets for products: In this sense, Smilor et al. (1990: 64) argue that: "*Research focuses on technology-based spin-out companies … Spin-out firms that provide consulting services or other types of products were not included in the study.*"

Some years later, Carayannis et al. (1998) started their paper with a UBC definition based on Smilor et al. (1990). After an empirical examination of the phenomenon the authors proposed to redefine UBC based on the type of resources transferred from the parent university to the new firm. In this sense, the authors include as UBC any firm that has received some type of strategic resource from the PU to start-up the business (i.e. technology, people, money, facilities, incubation space, etc.). Thus, Carayannis et al. (1998) conclude that UBC has to be defined in a very broad manner or that researchers have to be more specific about the type of UBC under analysis in their studies (based on the type of strategic resource transferred from the PU to the firm).

Following **Table 1** we can see that Nicolau and Birley (2003) present a UBC definition and typology based on networks perspective and contingency approach. The authors proposed a definition of university spinouts based on previous definitions found in the UBC literature (Smilor et al., 1990; Radosevich, 1995; Roberts and Malone, 1996; Carayannis et al., 1998) which is intended to be *encompassing and parsimonious*. In this sense, the authors proposed a UBC definition that necessarily includes: "*The transfer of a core technology from an academic institution into a new company.*" But that in the other hand: "*The founding member(s) may include the inventor academic(s) who may or may not be currently affiliated with the academic institution.*" (Nicolau and Birley, 2003: 340). Thus we can say that Nicolau and Birley (2003) propose an intermediate definition of a UBC including the possibility of an external or surrogate entrepreneur starting the new venture but with a new technology being transferred from the PU to the firm.

Later in the same year, Pirnay et al. (2003) went one step further in broadening-up the UBC definition. In this sense the authors not only include the possibility that the UBC was founded by an external entrepreneur, but also contemplate the transfer of tacit non-protected knowledge from the PU to the new venture. This is an important step because it changes the general view that UBC are all new technology-based firms (NTBF) aiming to commercialize a technological innovation developed at a PU. Pirnay et al. (2003) proposed a new definition and typology of UBC including, in addition to NTBF, new ventures based on "*some knowledge*" transferred from the PU to the firm. UBC that commercialize tacit knowledge generated at the parent university are usually service-oriented companies, as consultancies or technical service companies. In this definition "some knowledge" is interpreted by the authors as: "… *not only technological innovation and patents ... but also scientific and technical know-how accumulated by an individual during his/her academic activities.*" Pirnay et al. (2003: 357).

In the following year, Clarysse & Moray (2004) referring to Nicolau and Birley (2003), posit the transfer of an innovative technology from a parent organization as a condition sine qua non for defining a spin-off company. Thus the authors acknowledge for the

possibility of a surrogate entrepreneur starting-up the new venture, but only included in their definition new firms based on a technology transferred from a parent university.

In the same year three more studies about the UBC phenomenon decided to narrow-down the UBC definition and only included new companies meeting both conditions: (i) founded by active members of the parent university (PU) and (ii) based on a core technology transferred from the PU to the firm (Druilhe and Garnsey, 2004; Vohora et al., 2004; Wright et al., 2004). In this sense, the authors exclude from their definitions companies founded by *graduates long after they have left the university* (Druilhe and Garnsey, 2004: 274) or firms *traditionally regarded as life-style companies that are not established with the objective of creating high returns to their shareholders* (Vohora et al., 2004: 149). The following year Lockett and Wright (2005) shared this restrictive approach and "*narrowly define university spin-outs as new ventures that are dependent upon licensing or assignment of the institution's intellectual property for initiation.*" In this sense, Lockett and Wright (2005) define UBC as new firms that have *formally* received some piece of protected intellectual property from the PU in the form of patents or licenses.

In 2006 a group of researchers investigating the UBC phenomenon among different European countries published a review of the literature about new technology-based firms (NTBF) with the aim of developing a conceptual taxonomy of research-based spin-offs (RBSO) (Mustar et al., 2006).[27] The authors of this review present a UBC definition that includes new companies founded by external entrepreneurs and based on some knowledge generated at a public research organization (Mustar et al., 2006: 289). In this sense, the authors propose a broad definition of UBC including knowledge-based companies with external founders. This broad UBC definition is reaffirmed in a conceptual paper published two years later by Mustar, Wright and Lockett willing to cover ten years of the UBC experience and lessons in different European countries (Mustar et al., 2008).

In the same year and willing to characterize Spanish UBC, Ortin et al. (2008) found that: "*The results of this second research reveal that for the majority of TTOs the criterion that is followed to consider a firm as a spin-off of the university is that the firm actively involves a professor from the university.*" In this sense, Ortin et al. (2008) introduced a new practical dimension to define UBC: the criteria followed by the TTOs. Thus, Ortin et al. (2008) include in their sample any firm that is considered as UBC by any university in Spain. Therefore, the authors do not limit the UBC concept to the researchers' deductions or thoughts.

The following year, Fini et al. (2009) published an empirical study aiming to better understand the factors that fosters academics to start-up a new venture. Following this objective, the authors specifically exclude new companies with no members from the

[27] The authors of the review are: Mustar and Renault (France), Colombo and Piva (Italy), Fontes (Portugal), Lockett and Wright (UK) and Clarysse and Moray (Belgium).

PU in their founding teams. In this sense, Fini et al. (2009) propose a rather broad definition of a UBC including new companies founded by at least one active member of the PU and based on some knowledge (not necessary a technological innovation) generated at the PU.

Bathelt et al. (2010) introduced two new concepts to the definition of a UBC. First the authors acknowledged that a UBC *"draws upon knowledge that is produced or circulated at the university"*. This means that the UBC may not commercialize some PU's technology, but just use some knowledge that has been circulating at the university to do business (as a consultancy firm). Moreover, Bathelt et al. (2010) also emphasized the importance that the business opportunity of a UBC has to be the outcome of the PU's *areas of competence in research and teaching* and that the founders of the UBC *have met or become associated* at the PU. In this sense the authors believe that the business origination process of a UBC (opportunity recognition and founders' association) has to be the outcome of a personal interaction in *the context of a university.* Thus, Bathelt et al. (2010) proposed a broad definition of a UBC including new firms founded by external entrepreneurs which draw upon some knowledge (tacit or explicit) generated at a parent university.

In the same year Müller (2010) also proposed a broad definition of a UBC in terms of a surrogate entrepreneur founding the company and different types of knowledge transferred from the PU to the new venture. The following year, Bonardo et al. (2011) proposed an intermediate UBC definition including new firms founded by external entrepreneurs but *created specifically to capitalize on academic research*.

Moreover, Iglesias et al. (2012) proposed a rather restrictive definition of UBC. The authors define UBC as companies born inside universities and promoted by the researchers with the aim of transforming the research results into high value-added products. In this sense, Iglesias et al. (2012) limit the concept of UBC only including companies founded by university researchers willing to commercialize their research results at the markets for goods and services. In the same line, Treibich et al. (2013: 450) also narrow the definition of UBC to include only "*firms founded by staff or graduates of academic institutions that exploit research outcomes.*"

On the other side, Karnani (2013: 236) argue that: "*The central criterion for classifying a company as a spin-off of a university or research institution is the transfer effect, which means the spin-off company's exploitation of the knowledge created at the university*." Thus, Karnani (2013) includes as UBC any company commercially exploiting some piece of knowledge (codified or tacit) previously transferred from a university. The author also argues that UBC may be defined as: "*knowledge-based start-up companies from universities*". In this sense, Karnani (2013) does not consider the transfer of people from the PU to the firm as a condition to be called UBC.

One year later, in an empirical study willing to assess the efficiency of a sample of firms created at Catalonian universities, Epure et al. (2014: 7) extend the definition provided

by Pirnay et al. (2003) in order to include firms that do *not have a clear relationship with the parent university; ...* and firms that are *not exploiting technology developed within the university.* On the other side, Ortin and Vendrell (2014: 101) define university spin-off companies as *new technology-based firms created with the support of a university by some of its members...*" Thus, Ortin and Vendrell (2014) include as UBC firms created by any of the PU's members but do not include firms that are not considered as technology-based companies.

Finally, in a conceptual study willing to better understand the diversity of UBC and university support programs, Shah and Pahnke (2014: 780) open-up the definition of UBC to include any *entrepreneurial ventures cultivated within their* – parent universities' – *walls*". In this sense, Shah and Pahnke (2014) include in their UBC definition any company that was generated inside a university. Thus, following Shah and Pahnke (2014) UBC may be founded by anyone (PU's members or not) and may be firms of any type (technology-based firms or not). The only condition for Shah and Pahnke (2014) in order to be called UBC is that the firm was created inside a university.

Drawing on the literature reviewed in this section we propose the following definition of the phenomenon under study: ***University-based companies (UBC)***[28] ***are firms created inside the spatial and institutional context of a university (the Parent University, PU) which draw upon knowledge generated or circulated at the PU and with at least one member of the PU in their founding teams.*** This definition includes companies founded by academics, students, graduates or staff from the PU and based on some knowledge that was originally developed or identified in the PU's context.

This definition is particularly eclectic because it includes companies: (i) founded by any of the members of the PU (academics, students, graduates or staff personnel); (ii) based on some knowledge (codified or tacit, generic or specific); (iii) that was originally developed (or identified) inside the PU's context and (iv) transferred (in a formal or informal manner) from the parent organization to the new venture.

On the other hand and in line with Fini et al. (2009), this UBC definition does not include firms founded exclusively by external or surrogate entrepreneur/s with no members of the PU in their founding teams (Shah and Pahnke, 2014). Moreover, we exclude *spontaneous-occurring* companies founded by PU's members but with neither the support nor the acknowledgement of their parent organizations (Steffensen et al., 2000; Fini et al., 2009; Bathelt et al., 2010).

[28] The terminology used by researchers to describe this group of firms is very wide: university spin-off (USO) (Pirnay et al., 2003; Mustar et al., 2008; Bathelt et al., 2010), university spin-out (USO) (Nicolau and Birley, 2003; Druilhe and Garnsey, 2004; Lockett and Wright, 2005), university start-up (USU) (Bathelt et al., 2010), academic spin-off (ASO) (Klofsten and Jones-Evans, 2000; Fini et al., 2009), academic start-up (ASU) (Doutriaux, 1987), research-based spin-off (RBSO) (Clarysse and Moray, 2004; Mustar et al., 2006). We specifically use the term university-based companies (UBC) in order to include different types of firms that fall into the category under analysis (USO, USU, ASO, ASU, RBSO, academic NTBF, campus companies, etc). The term UBC is also used in Bonardo et al. (2011).

Most of the UBC definitional papers reviewed in this study also developed UBC taxonomies in order to identify different existing types of UBC. Thus researchers proposed an array of different dimensions to classify UBC. For example some authors differentiate UBC by the type of business model that the company follows or its stage of development (Doutriaux, 1987; Smilor et al., 1990; Druilhe and Garnsey, 2004; Iglesias et al., 2012). Other studies propose to differentiate among UBC following the existing institutional link between the firm and the parent university (Steffensen et al., 2000; Nicolau and Birley, 2003; Clarysse and Moray, 2004; Fini et al., 2009; Treibich et al., 2013).

Moreover, some other studies differentiate among UBC by the type of resources transferred from the parent university to the firm (Carayannis et al., 1998; Pirnay et al., 2003; Müller, 2010; Bonardo et al., 2011). Finally, we found that there is also a group of studies using a financial perspective to differentiate among UBC and UBC founders (Vohora et al., 2004; Wright et al., 2004; Lockett and Wright, 2005; Mustar et al., 2008).

In particular, Pirnay et al. (2003) is one of the most relevant (with highest academic impact) studies willing to provide a homogenous and comprehensive UBC taxonomy and therefore, differentiate among UBC types. In their conceptual study the authors develop a UBC taxonomy based on the status of individuals involved in the new business venturing process (academic or student) and on the nature of the knowledge transferred from university to the new venture (codified or tacit). Moreover, in an attempt to summarize and better understand the heterogeneity and types of UBC; Mustar et al. (2006) proposed a three dimensional UBC typology drawing on research-based spin-off (RBSO) literature: "*The dimensions that differentiate between firms are the type of resources, the business model and the institutional link*." Mustar et al. (2006: 289).

Four years later Bathelt et al. (2010) added new concepts to classify UBC and proposed a four dimensional UBC typology. In this sense the authors distinguish between: (i) *sponsored* vs. *unsponsored* firms, (ii) *spin-off* vs. *start-up* firms, (iii) *co-localized* vs. *non co-localized* firms and (iv) *generic* vs. *specific knowledge-based firms*. Sponsored UBC are firms included in some type of business start-up program of a parent university and have received the support of the PU in their creation and development process. Unsponsored UBC are firms created without the support of the PU and there are not recognized by the PU as official UBC. This type of firms was already acknowledged by Steffensen et al. (2000) as "spontaneous" spin-offs. Fini et al. (2009) also recognized this type of companies as firms with *no formal commitment from the academic organization*.

Moreover, Bathelt et al. (2010) differentiate between spin-off firms that draw on some technological innovation or research results developed at the PU and start-up firms *unrelated to the university's research projects*. The authors also distinguished UBC *according to the pattern of co-location of the founders.* Finally Bathelt et al. (2010)

classify UBC according to *the character of university knowledge that is used for the spin-off/start-up process.* The following year and similar to Pirnay et al. (2003), Bonardo et al. (2011) differentiate between two types of UBC depending on the status of individuals in the UBC founding teams: *academic and non-academic university-based companies*.

Willing to characterize UBC Iglesias et al. (2012) differentiate between three groups of firms following the stage of development in their R&D and commercial activities. The authors distinguish between firms that are initiating their R&D activities and with no commercial activity (called "*start-up spin-offs*"), firms with ongoing R&D activities but with no commercial impact yet (called "*growing spin-offs*") and firms with consolidated R&D activities and already selling their R&D results at the markets (called "*consolidated spin-offs*").

One year later, Karnani (2013: 239) hypothesize that: "*Spin-offs can be categorised in two general groups according to the knowledge they employ: One group primarily uses codified knowledge while the other group predominantly uses the tacit knowledge of the parent institute.*" After an empirical analysis the author concluded that UBC can effectively be divided into two types: (i) firms based on tacit knowledge from the PU (*tacit start-up knowledge*) and (ii) firms based on explicit knowledge from the PU (*codified start-up knowledge*).

The same year, Treibich et al. (2013) based on a longitudinal analysis of 25 case studies from France and Switzerland, examine the development of interactions between UBC and their PU. In their study, the authors develop a typology of the dynamic patterns ruling the interactions between UBC and their PU. In particular, Treibich et al. (2013) conclude that there are four possible modes of interactions between UBC and PU: *Manifest segregative UBC*: interactions' intensity with the parent university (PU) is always low. *Delayed segregative UBC*: interactions' intensity with PU start to decrease after 4/5 years the firm is created. *Manifest interactive UBC*: interactions' intensity with the parent university (PU) is always high. *Delayed interactive UBC*: interactions' intensity with PU start to increase after 4/5 years the firm is created

The following year and willing to better understand the relative efficiency among different types of UBC, Epure et al. (2014) separate their sample of 94 Catalonian UBC into three homogenous and mutually exclusive groups: (i) *STTU*: firms with formal technology transfer agreements with the parent university. *SPU*: firms with no formal technology transfer agreements with the parent university (PU) but with at least one member from the PU in the founding team. *OSU*: firms with no formal technology transfer agreements with the PU and no member of the PU in the founding team. In this sense, Epure et al. (2014) use two dimensions to classify UBC: (i) the way the knowledge is transferred from PU to firms (formal or informal) and (ii) the transfer of people from PU to firms (with or without a PU's member in the founding teams).

Finally, Shah and Pahnke (2014) identify four types of UBC: *Spinouts Type 1*: new firms that commercialize technologies developed by faculty, staff or students as part of academic research programs. *Spinouts Type 2*: technological knowledge comes from the university, but entrepreneurial know-how does not. These firms may or may not be founded by individuals associated with the university. *Offshoots*: academic research is not the source of innovative knowledge, but the university does provide critical entrepreneurial knowledge. *Seeds*: firms which neither commercialized ideas generated by academic research nor benefited from formal entrepreneurship education provided by a university.

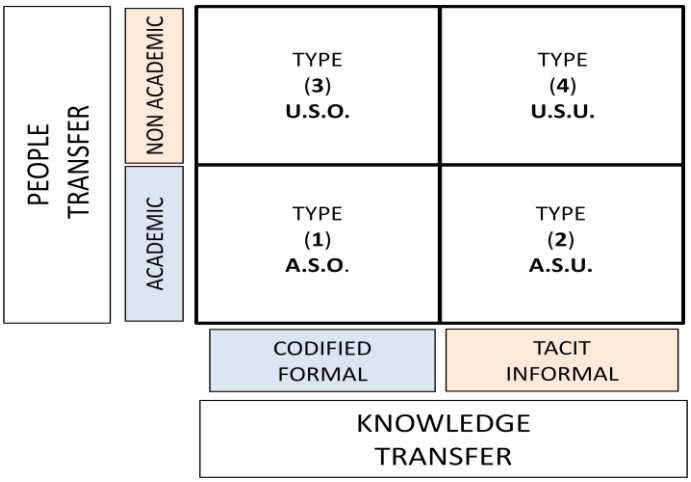
From the literature reviewed and specifically drawing on the work done in Pirnay et al. (2003), Bathelt et al. (2010), Bonardo et al. (2011), Karnani (2013) and Epure et al. (2014); we have identified two dimensions to differentiate among UBC: (i) the transfer of people and (ii) the transfer of knowledge from the PU to the new venture. The first dimension differentiates between *academic companies* (UBC founded by academics from the PU) and *university companies* (UBC founded by students, graduates or staff from the PU). The second dimension distinguishes UBC by the type of knowledge transferred from the PU to the firm. In this sense, we differentiate between *spin-offs* (technology-based firms drawing on codified knowledge formally transferred from the PU) and *start-ups* (firms based on some type of tacit knowledge acquired or recognized at the PU and informally transferred to the firm).

Thus we propose a two-dimensional UBC typology with four homogenous and mutually exclusive categories: (i) academic spin-offs (***ASO***), (ii) academic start-ups (***ASU***), (iii) university spin-offs (***USO***) and (iv) university start-ups (***USU***). In **Figure 1** we can see the two-dimensional matrix for UBC classification and the four corresponding types of UBC. ***Academic Spin-offs*** (ASO) have at least one academic (faculty, researcher or doctoral fellow student) from the parent university (PU) in their founding teams and have formally received a codified type of knowledge from the PU.

Academic Start-ups (ASU) also have at least one academic in their founding teams but have acquired some type of tacit knowledge during the founders' work at the PU. ***University spin-offs*** (USO) are companies with no academics in their founding teams, which draw on codified knowledge produced at the PU and formally transferred to the new venture. Finally ***University start-ups*** (USU) are firms with no academics in their founding teams, drawing on some type of tacit knowledge acquired or identified at the PU and informally transferred to the new venture.[29]

[29] A formal knowledge transfer process include the licensing of a technology, selling a patent, some know-how or industrial secret, providing copyrights or rights of use over some piece of intellectual property developed at the parent university and legally protected.

Figure 1: A two-dimensional typology of university-based companies



3. Characterizing university-based companies

3.1. Methodology

Our unit of analysis is the university-based company as described in the previous section of this study. We have then contacted the responsible of the Technology Trampolines Network (XTT) at CIDEM for a list of companies created and developed with the support of Catalonian universities (UBC).[30] We received a preliminary list of 348 university-based companies (UBC) with the names of the founders, the year of creation, emails, telephone numbers and their Parent Universities.

Taking a closer look at the list of firms and by calling most of them, we realized that 13 of them had received the support from more than one Parent University. In addition we 33 of these companies had closed down the business at the time of the research and 32 more were inaccessible by the contact information we had. Finally we have also found that 8 of these companies did not consider themselves as university-based firms and specifically asked to be removed from our study. We ended with a final list of 262

[30] The XTT (Xarxa de Trampolins Tecnològics) is founded by CIDEM in late 2000 (Centre d'Innovació i Desenvolupament Empresarial) a business development institution from the Generalitat de Catalunya. Technological Trampolines (TTs) are business formation support institutions for promoting technology-based and knowledge-based companies spin-off from the academia. Their main mission is to detect, select, evaluate and give advice to new spin-off projects. Generally, a Technological Trampoline is a public independent entity integrated in a Technology Transfer Office (TTO) from a public university. Although the TT is linked to the TTO in terms of office spaces and other physical resources, its functioning and budget are independent from both the University and the TTO. The CIDEM is exclusively funding the TT, however, spaces and other physical resources are usually provided by the university for free.

university-based companies born at Catalonian universities (see **Table 3**). In **Appendix 1** we have the list of 262 Catalonian UBC identified grouped by Parent University.[31]

Table 3: Population of Catalonian university-based firms

Parent University	Initial Number of firms	Closed firms	Not accessible	Not linked to PU	Net firms
Universitat Politècnica de Catalunya (UPC)	186	18	26	3	**139**
La Salle	66	5	0	2	**59**
Universitat de Barcelona (UB)	31	6	3	2	**20**
Universitat Autònoma de Barcelona (UAB)	25	3	3	1	**18**
Universitat de Girona (UdG)	9	1	0	0	**8**
ESADE	6	0	0	0	**6**
Universitat Rovira i Virgili (URV)	6	0	0	0	**6**
Universitat Pompeu Fabra (UPF)	4	0	0	0	**4**
IESE	1	0	0	0	**1**
Universitat de Lleida (UdL)	1	0	0	0	**1**
TOTAL	**335**	**33**	**32**	**8**	**262**

The next stage in our research procedure is to design the questionnaire necessary to collect the data for the analysis. In this sense, we have previously made a review of the empirical and theoretical literature about university-based companies. From this review we have identified the key variables to best characterize university-based companies and their founding teams. These selected variables were the base to write down the questions of our survey.

Before sending the questionnaire to the firms, we wanted to make sure that every question was understandable in the same way that we did. In order to check the questions of our survey, we personally interviewed the founders of 15 university-based companies from UAB and UdG. At this stage of the research we have also interviewed the responsible of the Technology Park of UdG, the responsible of business creation at CIDEM and the responsible of the XTT. Once we have incorporated the comments from these interviews we proceed to develop our final questionnaire with 53 questions. In **Appendix 2** we have the final questionnaire developed in this part of the research.

The third stage in our characterization study is to select the sample of companies from the population that we wanted to include in our analysis. In this case, given that the total number of Catalonian university-based companies was manageable, we decided to send our questionnaire to the whole population of firms (262).

We used Snap Survey 9 to create and published the questionnaire on Internet. [32] This software platform allows you to create a survey and post it on a website. This facilitates

[31] This figure is consistent with Epure et al. (2014).

the work of respondents because they can fill the survey whenever they want with only an Internet access.[33] In addition, all answers are automatically incorporated to the Snap analysis tool.

During the data collection process we called the participants in order to motivate them to fill in the survey. In this process, the TT responsible in each University helped us. We have sent several emails to remember participants the importance of the study and asking them to fill the survey as soon as they could. We have also undertaken two more personal interviews and seven telephone interviews in order to collect the data.

The data collection process took us three months from April to June 2008. At the end of this process we had a total of 94 complete answers from founders of Catalonian university-based companies. **Table 4** shows a summary of the results of the data collection process. The answer rate was almost 36%.[34]

We use descriptive statistics to characterize the profile of firms created at Catalonian universities and their founding teams. We used Microsoft Excel 2007 to analyze the data. In some cases we had to complete some of the questionnaires that were incomplete. We used SABI[35] database to include missing data of the survey participants. Our final database has a total of 249 variables and 94 observations. In **Table 5** we present the summary of the sampling and data collection processes for the study about the characterization of Catalonian university-based firms.

3.2. Results

- **General characteristics**

In **Figure 2** we can see the distribution of each of the four types of university-based firms described before over the total number of companies. From **Figure 2** we can see that academic start-up companies (ASU) are the type of university-based companies (UBC) more common in our sample. All four types of UBC have a significant representation in the sample.

Moreover, in **Figure 2** we can see that 46% of UBC in our sample are spin-off companies (with formal transfer of a codified piece of knowledge from the parent university to the firm) and 54% are start-up companies (with no formal transfer of knowledge from the parent university to the firm). Furthermore, in our sample of 94 UBC, 55% have at least one academic from a parent university (PU) in their founding teams (academic UBC) and 45% do not have any academic from the PU in their founding teams (non-academic UBC).

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[32] Available at http://www.snapsurveys.com/.
[33] The questionnaire was available at http://selene.uab.es/cserarols/snap/spinoff_uab.htm.
[34] This database is similar to the one used in Epure et al. (2014).
[35] SABI (Sistemas de Balances Ibéricos) is a database that provides the suscriptor with economic and financial information about every registered company with more than 10 employees in Spain or Portugal.

These results are consistent with the sample of 81 Catalonian UBC included in Epure et al. (2014). In their study the authors found that 45,6% of the companies in the sample are UBC with formal technology transfer agreements with their PU (spin-off companies) and 54,4% are companies with no formal technology transfer agreements with their PU (start-up companies). In the same line, Karnani (2013) found that for a sample of 25 UBC from French and Swiss universities, 55% were *tacit start-up knowledge* and 45% were *codified start-up knowledge*.

In **Figure 3** we see that La Salle and UPC are the two universities with the highest number of companies in our dataset. Both, La Salle and UPC are technical schools. This is consistent with the results found by Di Gregorio and Shane (2003) and from O'Shea (2007) about the positive effect of the technical bias in the research orientation of the Parent University over the number of university-based companies created. This result is also consistent with Ortin et al. (2008) where the authors found that the technical universities of Catalonia and Valence include more than half the total UBC in Spain.

In **Figure 4** we can see the distribution of the university-based firms in our dataset by type of company for each of the Parent Universities. From **Figure 4** we can see that 80% of firms created at the UdG are academic spin-off companies and the other 20% are academic start-up companies. Following our sample of university-based firms we have that: UdG produces only academic type of companies, UB and UAB do not produce any non-academic start-up company and (3) La Salle and UPC produce all four types of university-based companies with a focus on start-up firms.

Moreover, **Figure 5** shows the distribution of our set of university-based firms by the Municipality where they were located at time of constitution of the company. We can see that, at time of constitution, most of the university-based companies in our dataset were located in the city of Barcelona (61%). This result complies with the accepted empirical evidence showing that university-based companies usually set up their businesses close to the facilities of the Parent University (Shane, 2004).

From the general findings of this study we would like to highlight that almost the totality (97%) of UBC in our dataset is limited liability companies (SRL). Only two firms are public companies (present in the stock exchange market) and only one company is a Labour Cooperative. This is highly consistent with Ortin et al. (2008) where the authors found that the firms in their sample are constituted as limited liability companies.

All firms in our sample had an average age of 5,1 years old at the end of the year 2007. This figure is consistent with the results obtained in Ortin et al. (2008). In their characterization study of Spanish UBC, the authors found that 75% of firms in their sample had less than five years. In the same line, Treibich et al. (2013: 456) found in a multiple case study from France and Switzerland that: "*At the time of the interviews ... The average age of the spin-offs in the sample lies around 6,5 years old.*" Considering that Treibich et al. (2013) run the interviews between the years 2008 and 2009, we can say that our results are similar to theirs.

Table 4: Summary of the characterization study

Parent University	Total population	Received answers	Personal Interviews	Telephone Interviews	Internet surveys	Answer rate
(UPC)	139	**28**	0	1	27	**20,1%**
La Salle	59	**33**	1	2	30	**55,9%**
(UB)	20	**8**	1	1	6	**40,0%**
(UAB)	18	**13**	10	2	1	**72,2%**
(UdG)	8	**5**	5	0	0	**62,5%**
ESADE	6	**2**	0	1	1	**33,3%**
(URV)	6	**2**	0	0	2	**33,3%**
(UPF)	4	**2**	0	0	2	**50,0%**
IESE	1	**1**	0	1	0	**100,0%**
(UdL)	1	**0**	0	0	0	**0,0%**
TOTAL	**262**	**94**	**17**	**7**	**70**	**35,9 %**

Table 5: Summary of the characterization study

Units of Analysis	University-based companies and their founding teams
Geographical Scope	Catalonia
Total Population	262 university-based companies
Sample Size	94 university-based companies
Confidence Level	Z=95% ; K=1,96 ; p=q=0,50
Sample Error	+/- 8,10%
Data Collection Process	Telephone and personal 20 min. interviews + Internet survey using Snap Surveys 9 software
Time to Collect Data	From April to June 2008

Figure 2: Distribution of university-based firms by type

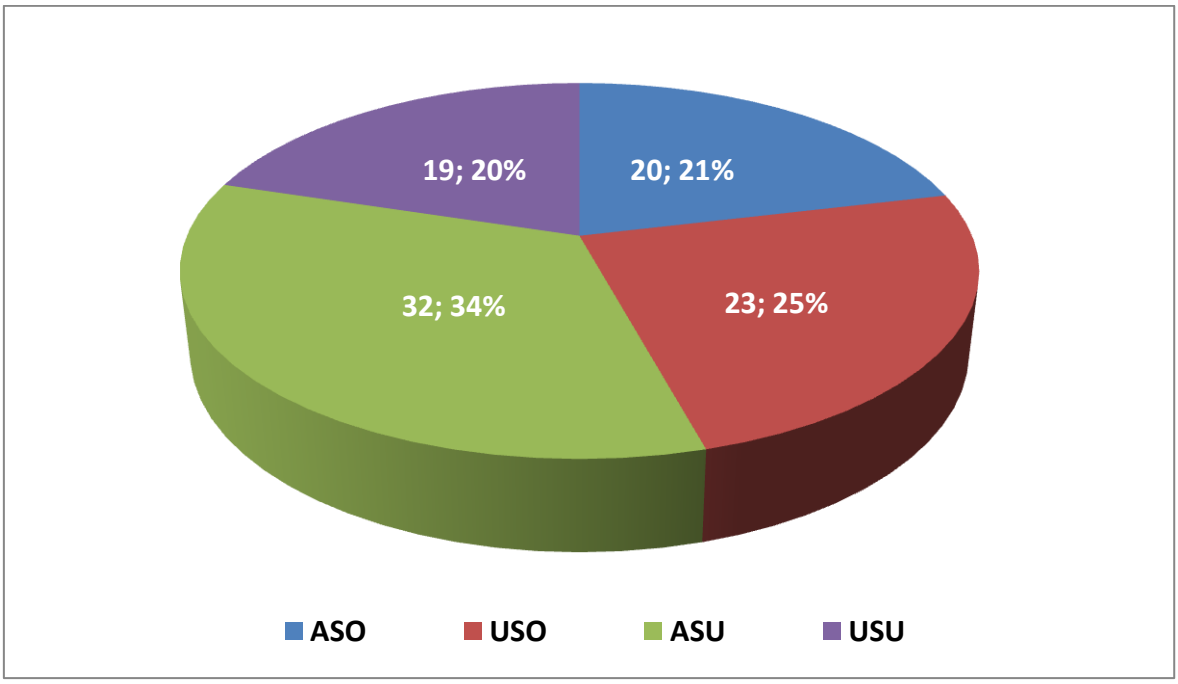


Figure 3: Distribution of university-based firms by Parent University

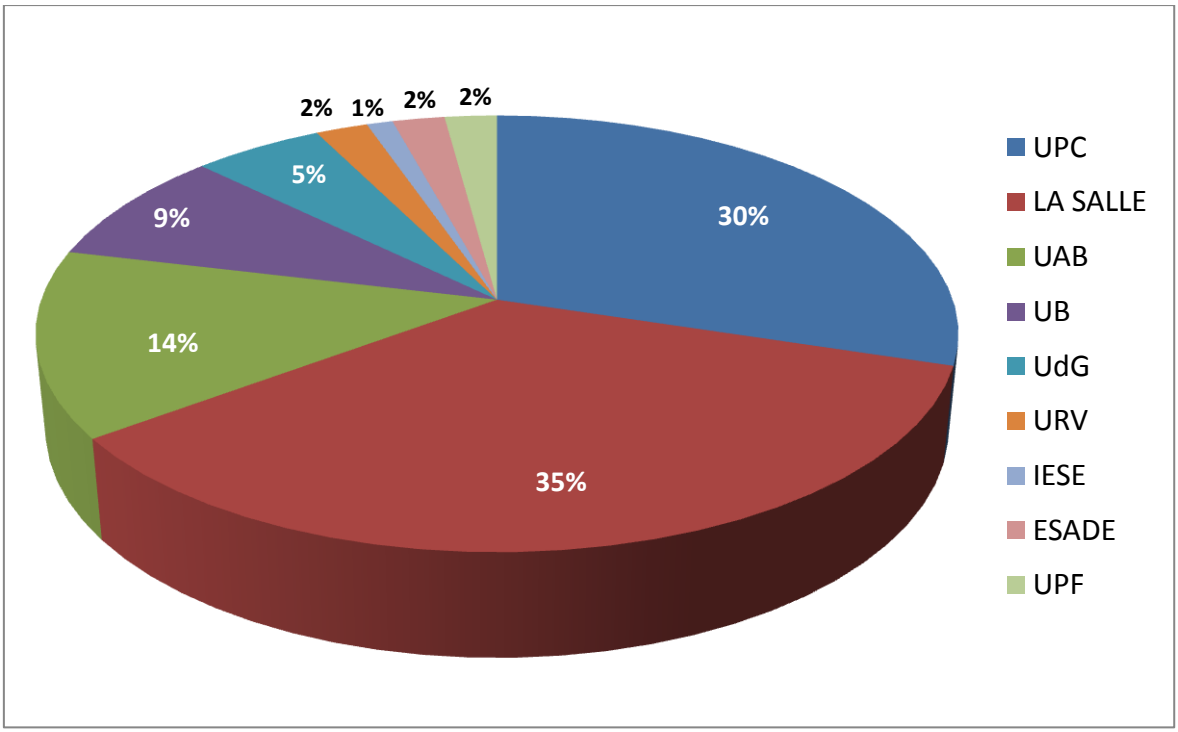


Figure 4: Distribution of university-based firms by type of company for each of the parent Universities

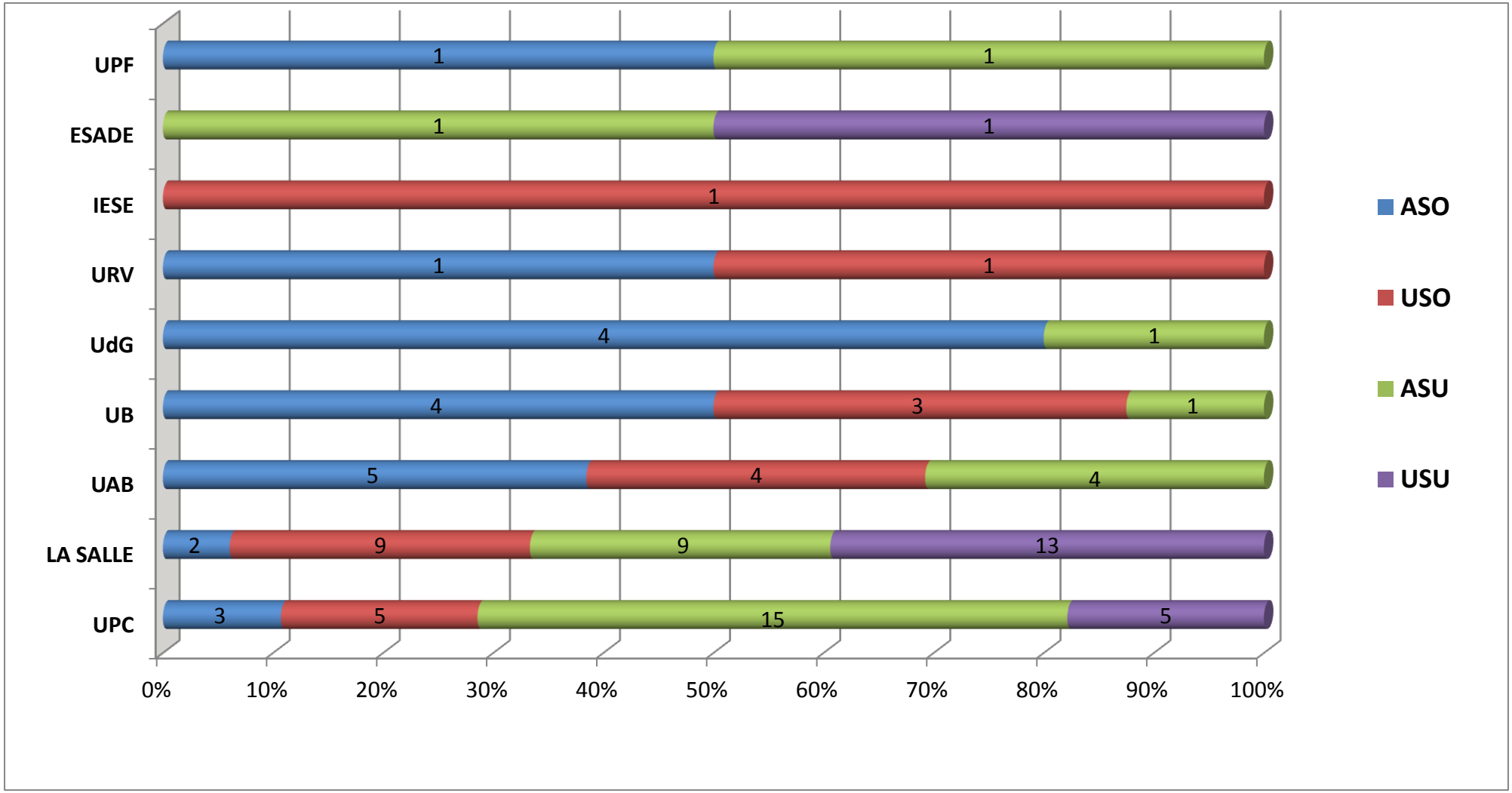
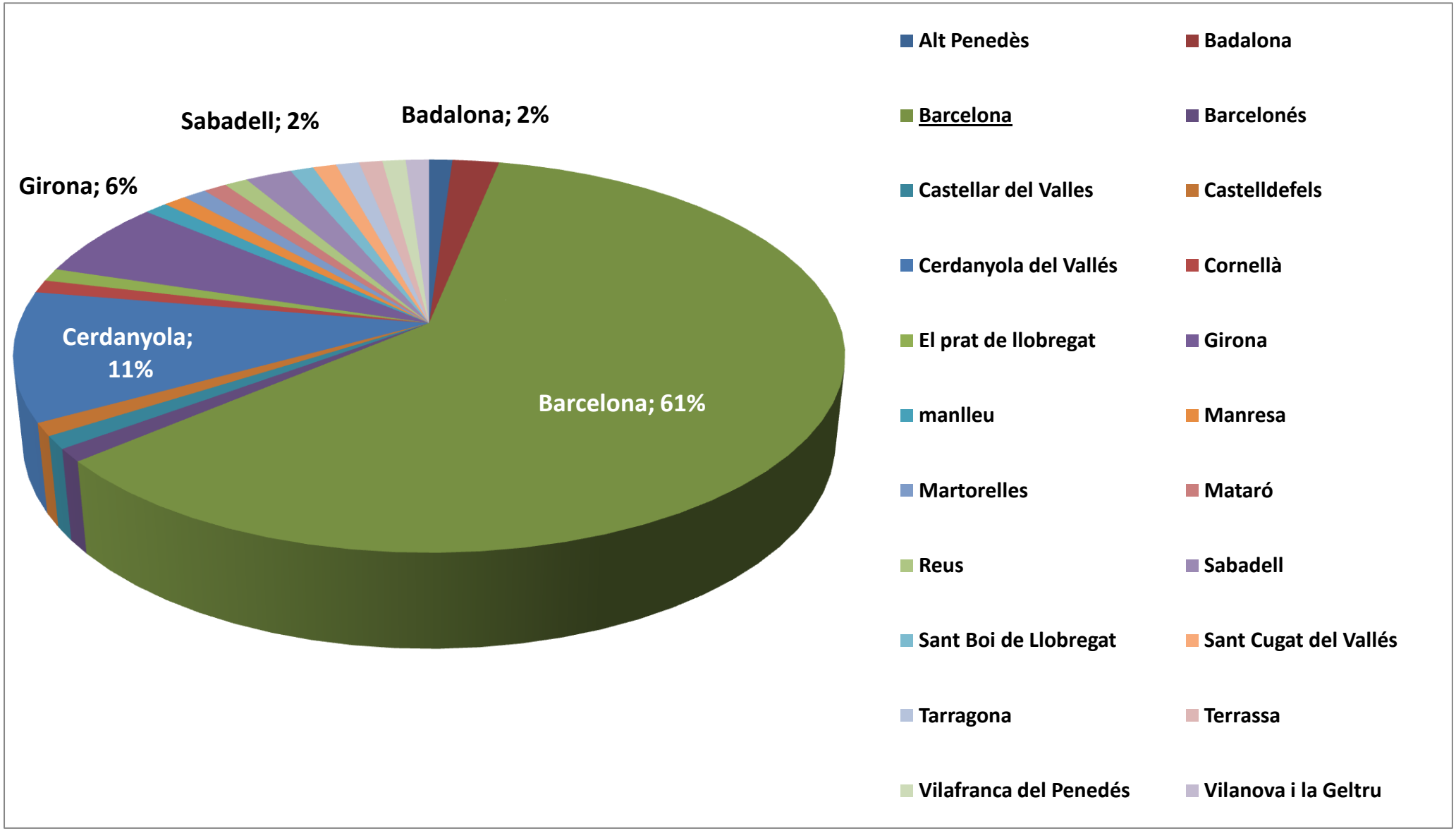
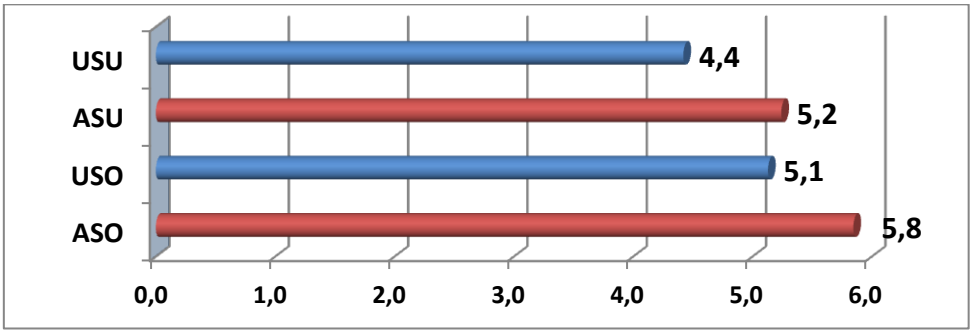


Figure 5: Distribution of university-based firms by Municipalities



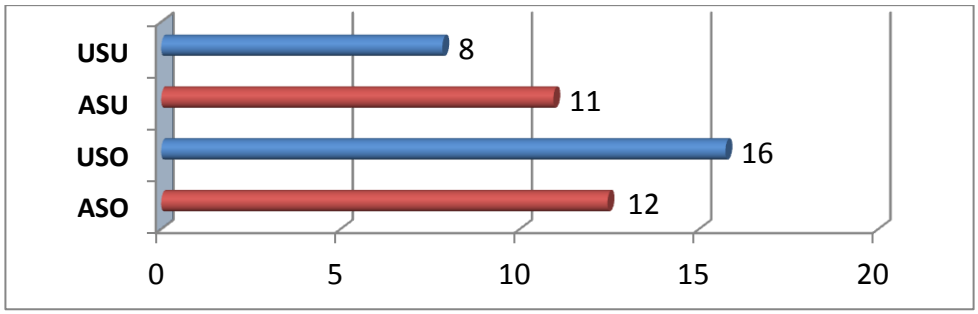
In **Figure 6** we can see the average age of our sample of university-based companies (UBC) for each type of firm at the year 2007. Academic spin-off companies (ASO) are in average the oldest firms in our dataset (5,8 years old). In the other side, our results show that non-academic start-up (USU) companies are in average the youngest firms in our sample (4,4 years old). These differences in age could affect the growth measures among UBC types presented afterwards.

Figure 6: Average age in years of university-based companies at year 2007



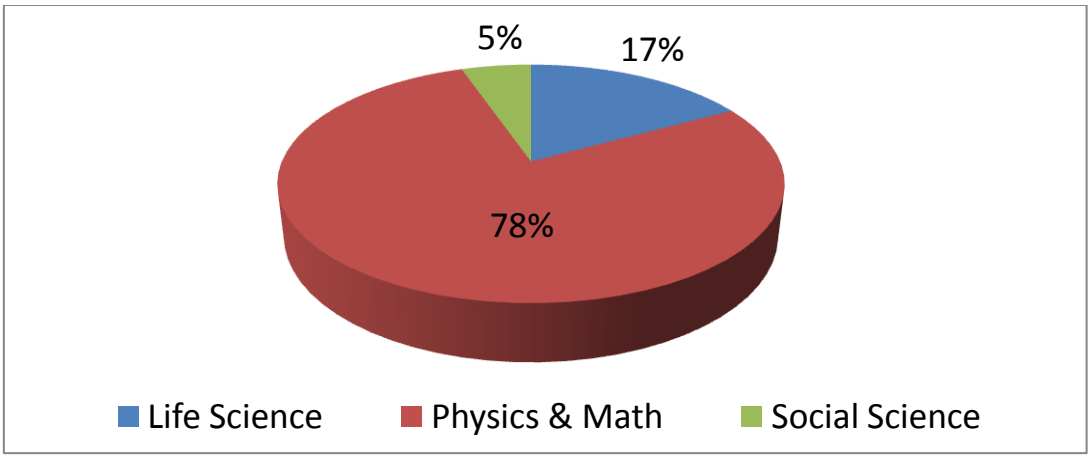
In **Figure 7** we can see the average time in months that each type of UBC has taken from the business idea to the firm's constitution. From **Figure 7** we can see that non-academic spin-offs (USO) have taken in average 16 months from the conception of the business idea until the legal constitution of the firm. In the other hand, our results show that non-academic start-ups (USU) have taken in average half that time (only 8 months).

Figure 7: Average time in months between business idea and firm constitution



In **Figure 8** we can see the distribution of university-based firms by the branch of science where they belong. We can see that most of our sample companies are in physics or mathematics (including engineering and computer science). 17% of our sample belongs to the life sciences (medicine, biology and chemistry) and only 5% of the companies are in social sciences (economics, sociology, psychology, etc.). These results are similar to the findings in Ortin et al. (2008) and the findings in Karnani (2013) where the authors found that engineering and computer sciences grouped most of the UBC in their samples.

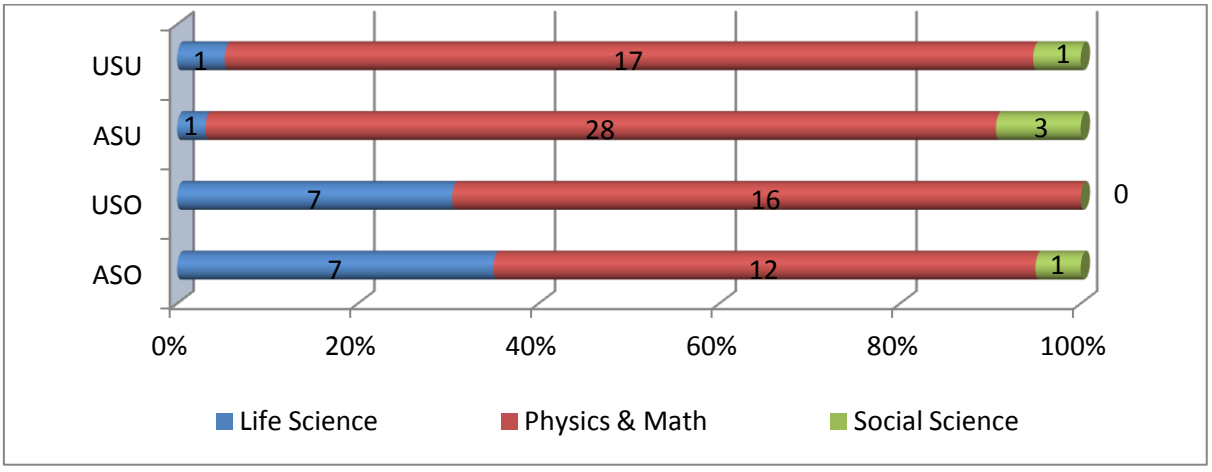
Figure 8: Distribution of university-based firms by science branch



Moreover, **Figure 9** shows the distribution of university-based firms by the branch of science where for each type of company. We can see that none of the USO in our sample belongs to the social science branch. 80% of the UBC operating in social sciences are start-up companies (USU and ASU) with no formal technology transfer agreements with a parent university. On the other side, 87,5% of the UBC in the sample operating in the life sciences are spin-off companies (USO and ASO) having formal technology transfer agreements with a parent university.

Karnani (2013) found similar results. The author found that 67% of the UBC in the sample operating in social sciences are *tacit start-up knowledge* companies with no formal technology transfer agreements with a parent university. The author also found that 80% of the UBC in the sample operating in health sciences are *codified start-up knowledge* companies with some kind of formal technology transfer agreement with a parent university.

Figure 9: Distribution of university-based firms by science branch for each type of company



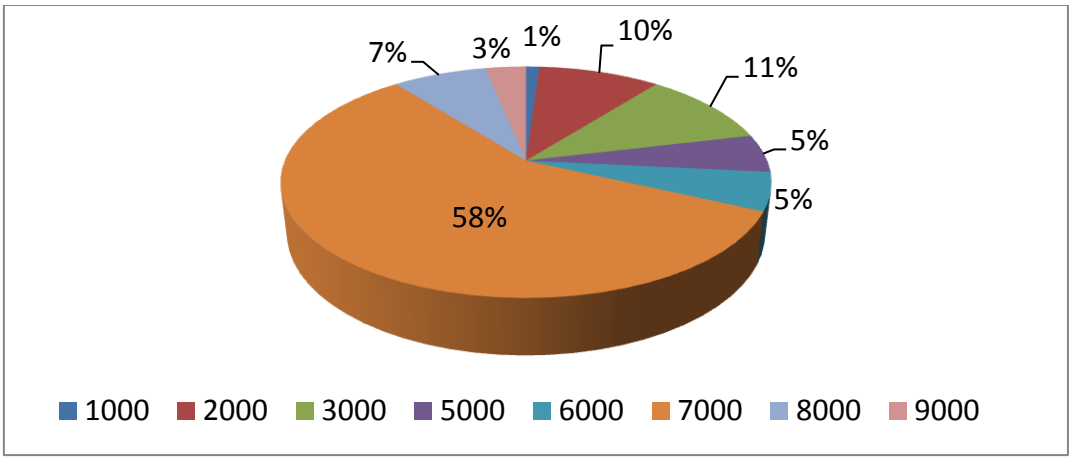
In order to identify the sector of activity of UBC, **Table 6** shows the classification of our set of companies following CNAE's criteria.[36] In this table we also show the sub-sector of activity where the companies belong to. The CNAE family code gives you the general sector of activity of the company. The second column of the table specifies the sub-sector of activity of firms. We can see from **Table 6** that 57% of companies in the sample are in the *Business Services* sector of activity.

Table 6: Classification of university-based firms by CNAE's sectors of activity

CNAE code	Sub-sector of activity	Nº of firms
1000	Extraction of minerals	1
2000	Chemical & Pharmaceutical	9
3000	Manufacturing	10
5000	Commerce & Trading	5
6000	Telecommunications	5
7000	Business Services	54
8000	Social & Health Services	7
9000	Other Professional Services	3
Total		**94**

Moreover, in **Figure 10** we show the distribution of our dataset of companies using CNAE's classification. In this figure we can see that the majority of the firms in our sample are in the service sector (78%) and that only 22% of the firms are in the industrial and primary sectors.[37]

Figure 10: Distribution of university-based firms by sector of activity



[36] Clasificación Nacional de Actividades Económicas (National Classification of Economic Activities).
[37] Industrial and primary sectors = 1000 + 2000 + 3000. Service sector = 5000 + 6000 + 7000 + 8000 + 9000.

In this line, **Figure 11** shows the distribution of university-based firms by the sector of activity for each type of company in our dataset. This figure shows that the share of industrial companies over service companies is mainly constant among types of firms. In particular we have that for every type of company in our sample, around 20% are industrial companies and the other 80% are service companies.

Figure 11: Distribution of university-based firms by sector of activity for each type of company

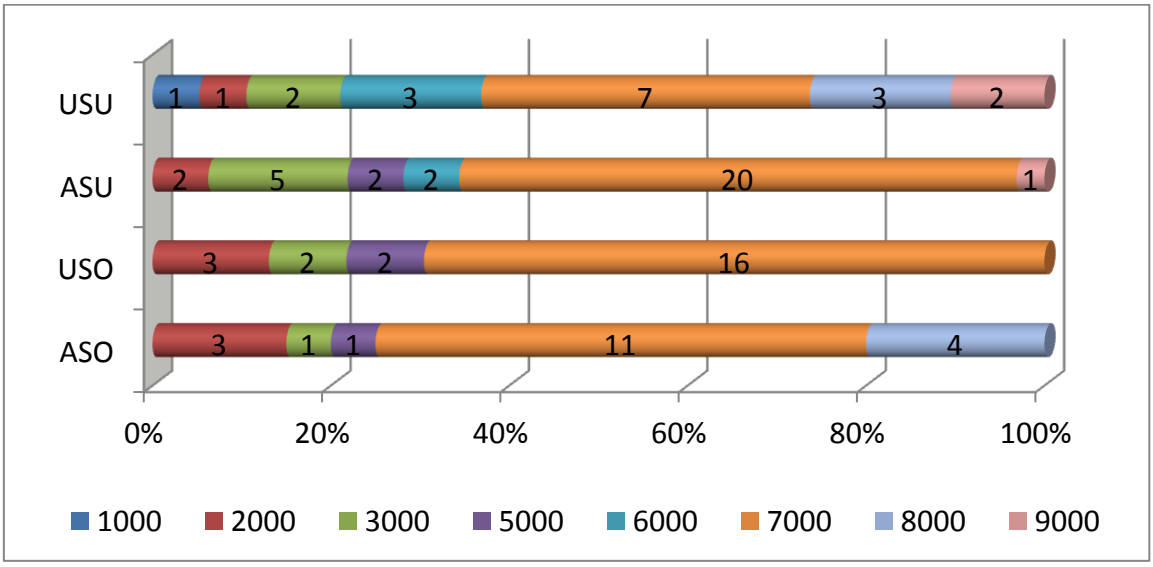
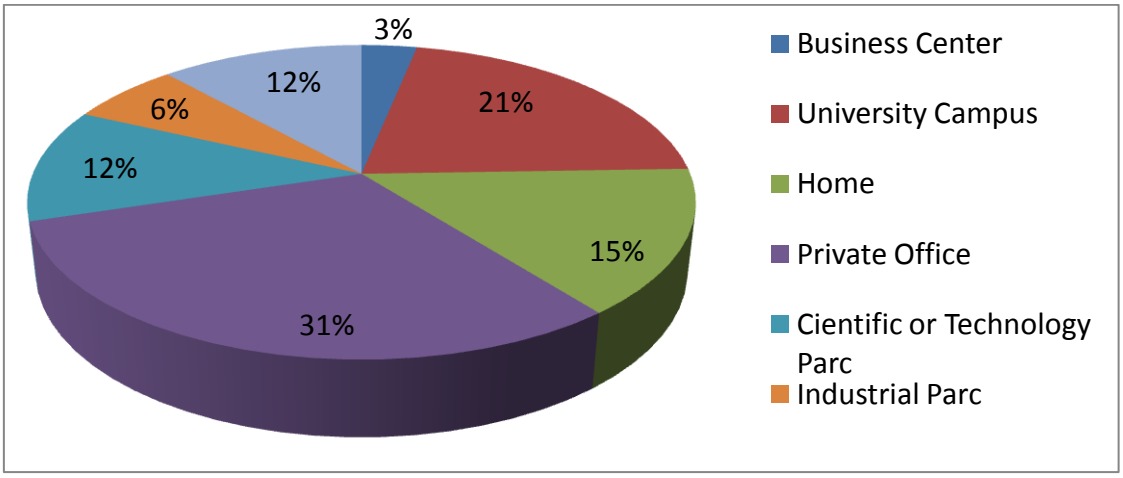


Figure 12 shows the distribution of our dataset of university-based firms by the type of facility where the business was started. Our results show that almost one third of the companies in our dataset started business from a private office. It is interesting to see that 15% of the firms in the sample started business from their home. It is also worthy to remark that more than one fifth of the firms in the sample have started business at the university campus.

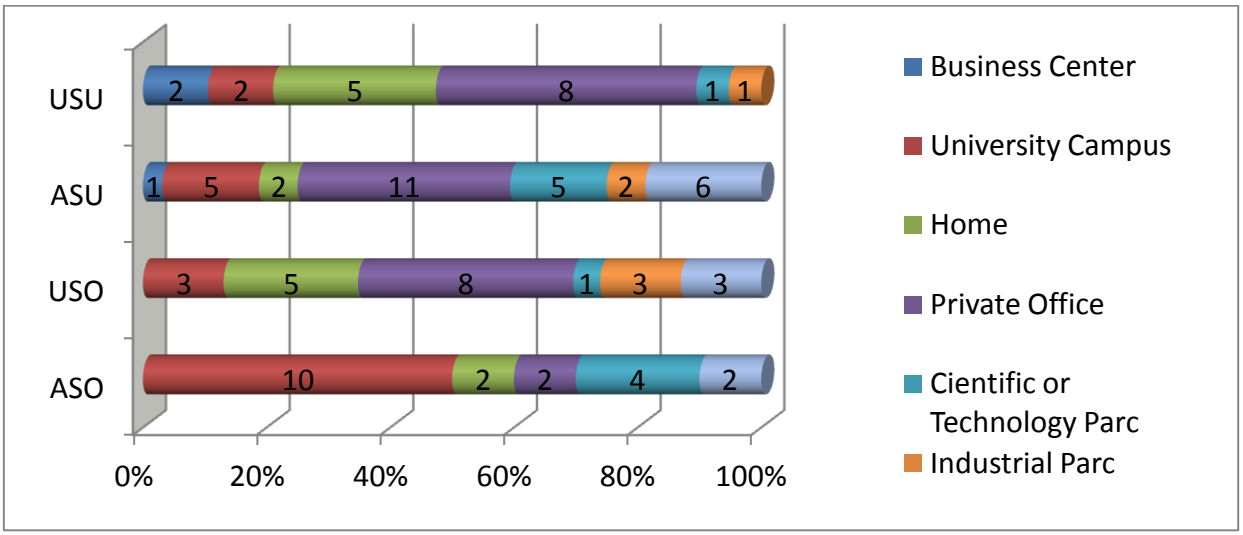
Figure 12: Distribution of university-based firms by starting facility



In this line, **Figure 13** shows the distribution of university-based firms by the type of starting facility for each of the groups of firms previously defined. The results show that half of the academic spin-off companies (ASO) of our sample are located at the Parent University campus. This share is much higher for this type of companies than for the other types. This fact may have an effect over the probability that UBC would access strategic resources from PU. Therefore, it seems that ASO may have a better access to start-up resources from the PU compare to other types of UBC.

It is also worth noting that only 10% of ASO in our dataset are located in a private office. This share is much lower for this type of UBC than for the other types. Another interesting result is that only 7% of academic UBC in the sample have started business from home; compare to almost one quarter of non-academic UBC. Thus, we deduce that UBC with at least one academic from the PU in their founding teams (academic UBC) have better access to initial location resources compare to non-academic UBC. This fact may benefit the performance and reduce the failure risk of academic UBC compare to non-academic UBC.

Figure 13: Distribution of university-based firms by starting facility for each type of company



- **Link with the Parent University (PU)**

In **Table 7** we can see the number of academic and university spin-off companies commercially exploiting a patent or having a license from their Parent University. We have found that 60% of the academic spin-off companies (ASO) in our dataset have a patent or license from the Parent University (PU). In contrast, only 48% of non-academic spin-off companies (USO) have a patent from the PU. This result suggests that having an academic from the PU in the founding team increases the probability of commercially exploiting a technological patent licensed from a university and therefore may increase UBC performance and reduce the failure risk.

In **Table 8** we can see the number of spin-off companies in our dataset with the Parent University as a business partner. From **Table 8** we can see that almost half of the academic spin-offs (ASO) in our sample have the Parent University as a business partner. In contrast, only 17% of non-academic spin-offs (USO) have the Parent University as business partner. This result suggests that having an academic from the PU in the founding team increases the probability of having the PU as a business partner; and in this way reducing failure risk of companies.

Furthermore, in **Table 9** we can see the number and amount of R&D contracts between spin-off companies and the Parent University when the business started. From this table we can see that academic and non-academic spin-offs in our sample have in average a very similar number and amount of R&D contracts with the Parent University.

Table 7: Spin-off companies with a patent or licence from the Parent University

TYPE	Firms with patent or licence from PU	% over total nº of firms
ASO	12	60%
USO	11	48%
TOTAL	**23**	**53%**

Table 8: Spin-off companies with the Parent University as a business partner

TYPE	Firms with the PU as partner	% over total nº of firms
ASO	9	45%
USO	4	17%
TOTAL	**13**	**30%**

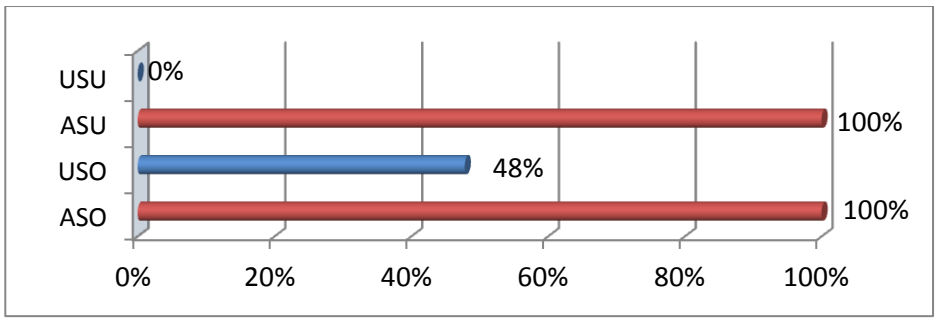
Table 9: R&D contracts between spin-off companies and the Parent University

TYPE	Nº of R&D contracts with PU	Amount of R&D contracts with PU	AVG nº of R&D contracts with PU	AVG amount of R&D contracts with PU
ASO	12	275.040 €	0,60	13.752 €
USO	14	333.000 €	0,61	14.478 €
TOTAL	**26**	**608.040 €**	**0,60**	**14.140 €**

By definition, non-academic university-based companies do not have a member of the Parent University in their founding teams; while academic companies have. But on the other hand, either type of companies (academic or non-academic) may have employees (not founders) coming from the Parent University. The results show that two thirds of the UBC in our sample had at least one employee coming from the Parent University.

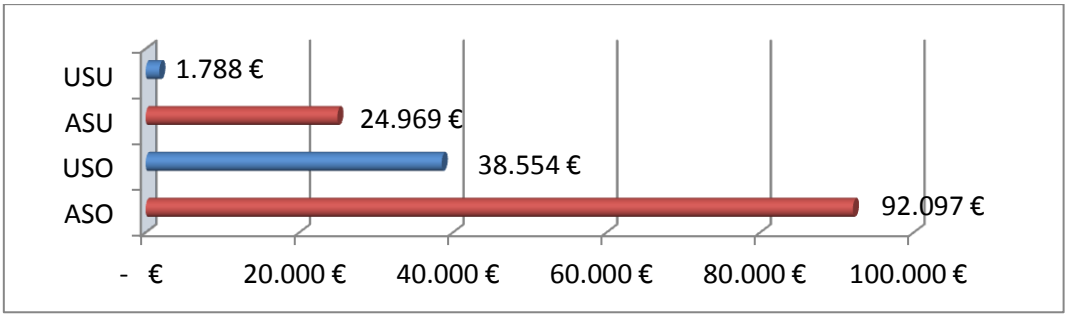
In this line, **Figure 14** shows the percentage of firms with at least one employee coming from the Parent University when the business was started for each type of UBC. We can see from this figure that while 100% of academic spin-offs (ASO) and academic start-ups (ASU) have at least one employee coming from the Parent University at time of creation, none of the non-academic start-ups (USU) have and almost half of the non-academic spin-offs (USO) have.[38] In this line, Epure et al. (2014) found that having employees from the PU increases the efficiency level of UBC. Thus, we believe that academic UBC (ASU and ASO) would be better positioned to outperform non-academic UBC and more in particular USU companies.

Figure 14: Percentage of firms with at least one employee from the Parent University by type of company



In **Figure 15** we present the average amount of subsidies obtained through the Technology Trampoline of the Parent University by each type of university-based companies during the first year of activity. ASO are by far the type of UBC receiving the highest amount of subsidies through the TT. On the other side, USU hardly receive any subsidy through the TT of the PU. In this sense, we believe that academic spin-off companies (ASO) have better access to strategic start-up resources compare to other UBC types. Thus, we believe that ASO may confront a reduced risk of failure comparing with other UBC types.

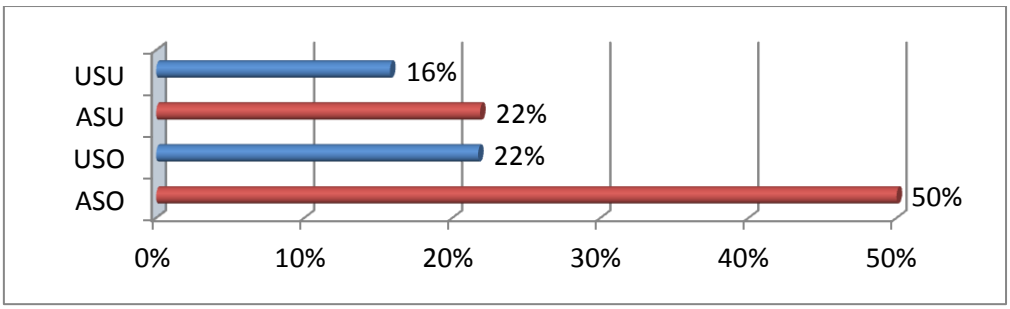
Figure 15: Average amount of subsidies obtained through the Technology Trampoline of the Parent University during the first year of activity



[38] Note that academic firms (ASO and ASU) may or may not have any employee from the Parent University at time of creation.

To end this part of the section, in **Figure 16** we can see the percentage of founders that would not have created the university-based company without the support of the Technology Trampoline of the Parent University. Once more, the results show that academic spin-off companies (ASO) present the highest degree of link dependence towards the Parent University. Half of the ASO in our dataset answered that they would not have started the business without the institutional (formal) support from the Parent University. This result suggests that although ASO have better access to strategic start-up resources (compare to other UBC types), they are also more dependent on the support given by PU.

Figure 16: Percentage of founders that would not have created the university-based company without the support of the Technology Trampoline

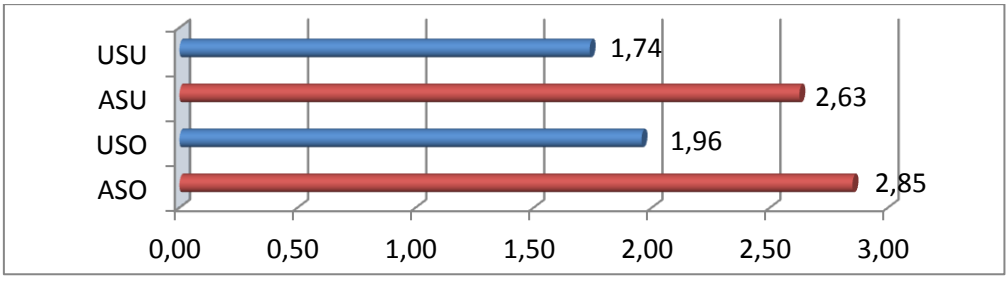


- **Initial size and finance**

In **Figure 17** we present the average number of employees for each type of company when the business was started. The results show that academic spin-off companies (ASO) are the ones starting with a highest number of employees. ASU start also with a relatively high number of full-time employees (FTE). On the other side, non-academic UBC (USU and USO) start operations with a relatively low number of FTE.

Thus, we may conclude that academic UBC start operations relative bigger (in terms of FTE) than non-academic UBC. This result is supported by the fact that at the time of founding academic UBC always include at least one academic from the PU; and thus generally increasing the average number of employees at the beginning of the business.[39]

Figure 17: Average number of employees by type of company at start-up



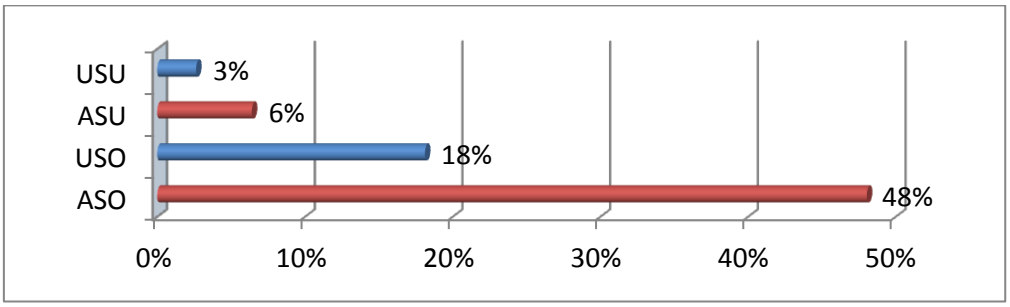
[39] This is true because in some cases the academic founder of the UBC is also an employee of it.

For the total sample of 94 UBC, firms had at the beginning of their operations an average of 2,35 full-time employees (FTE). This result is highly consistent with the findings in Karnani (2013) who found that the average number of employees in the start-up year for their sample of 136 UBC is 2,20.

Furthermore, in **Figure 18** we show the percentage of employees with a PhD degree for each type of company when the business started. In average only 17% of employees of all UBC in the sample have a PhD. The results also show that almost half of the employees from ASO in our sample had a PhD degree at the time of business creation. On the other side, only 3% of the employees from non-academic start-up companies (USU) had a PhD degree when starting the business.

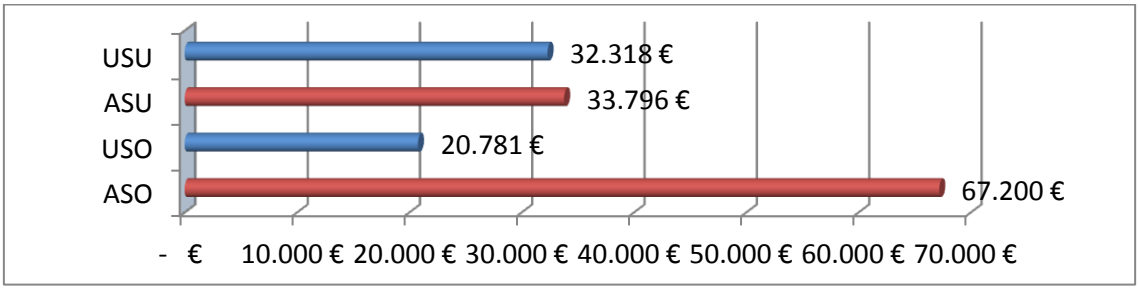
Moreover, while one third of the employees of spin-off companies (ASO and USO) have a PhD only 10% of employees from start-up companies UBC (ASU and USU) have a PhD. Once more, these results suggest that UBC with formal technology transfer agreements, and more in particular academic spin-off companies (ASO), have better access to strategic start-up resources compare to other UBC types. This may influence UBC performance and the failure risk of different UBC types.

Figure 18: Percentage of employees with PhD degree by type of company



In **Figure 19** we present the average salary expense for each type of company for the first complete year of activity. The results show that academic spin-off companies (ASO) are the ones starting with a highest amount of salary expenses. This result is consistent with the two previous ones about the average number of starting employees and the level of education of them (both higher for ASO than for the other types of university-based companies).

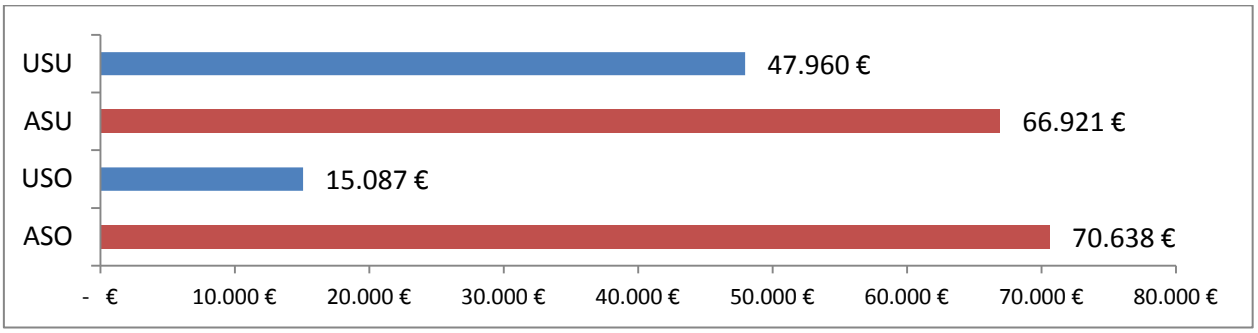
Figure 19: Average salary expense in the first year of activity



In **Figure 20** we present the average amount of sales generated by each type of company at the end of the first year of activity. We can see that academic spin-off companies (ASO) present in average the higher amount of sales in their first year of business activity. Academic start-up companies (ASU) also show a high amount of average sales during the first year.

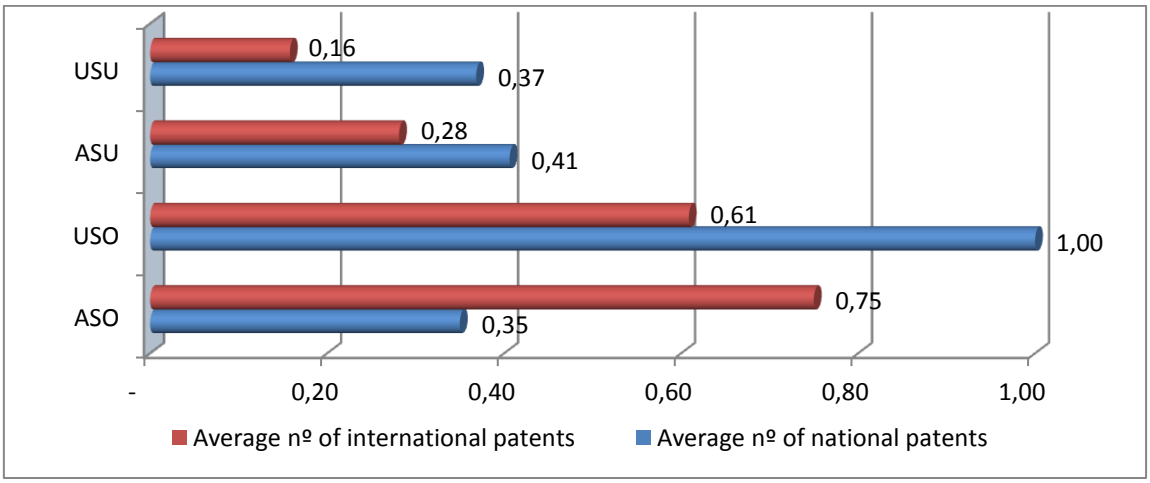
On the other side, non-academic spin-off companies (USO) present a surprisingly low level of sales in the first year of activity.[40] From **Figure 20** we can conclude that UBC having at least one academic from the PU in their founding teams (academic UBC) start relatively bigger (in terms of sales) than non-academic UBC.

Figure 20: Sales at the end of the first year of activity



In **Figure 21** we present the average number of national and international patents for each type of company for the first complete year of activity. In terms of international patents, the results follows a logical path from a minimum of 0,16 patents per non-academic start-up companies (USU) to a maximum of 0,75 international patents per academic spin-off company (ASO). On the other hand, ASO present the lowest average number of national patents (only 0,35 patents per firm). In contrast, non-academic spin-off companies (USO) in our sample present in average one national patent per firm.

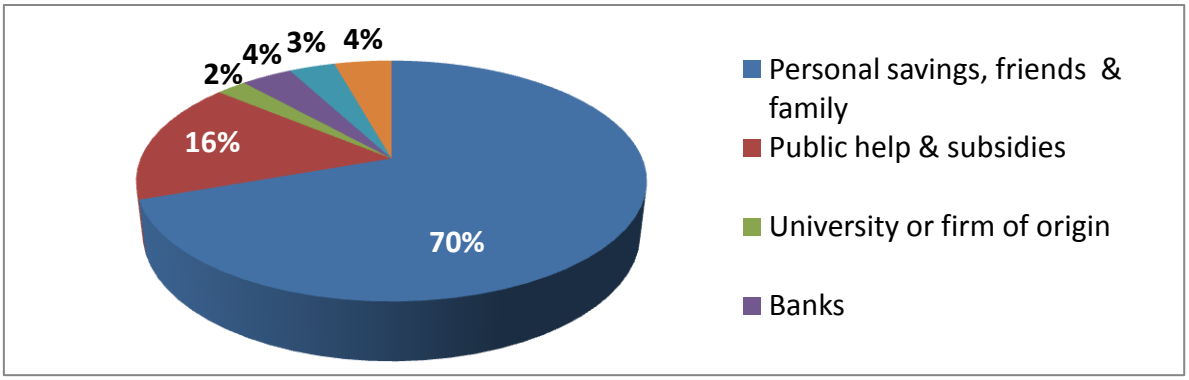
Figure 21: Average number of national and international patents by type of company



[40] We actually suspect that this surprisingly low figure may be due to an error in our dataset.

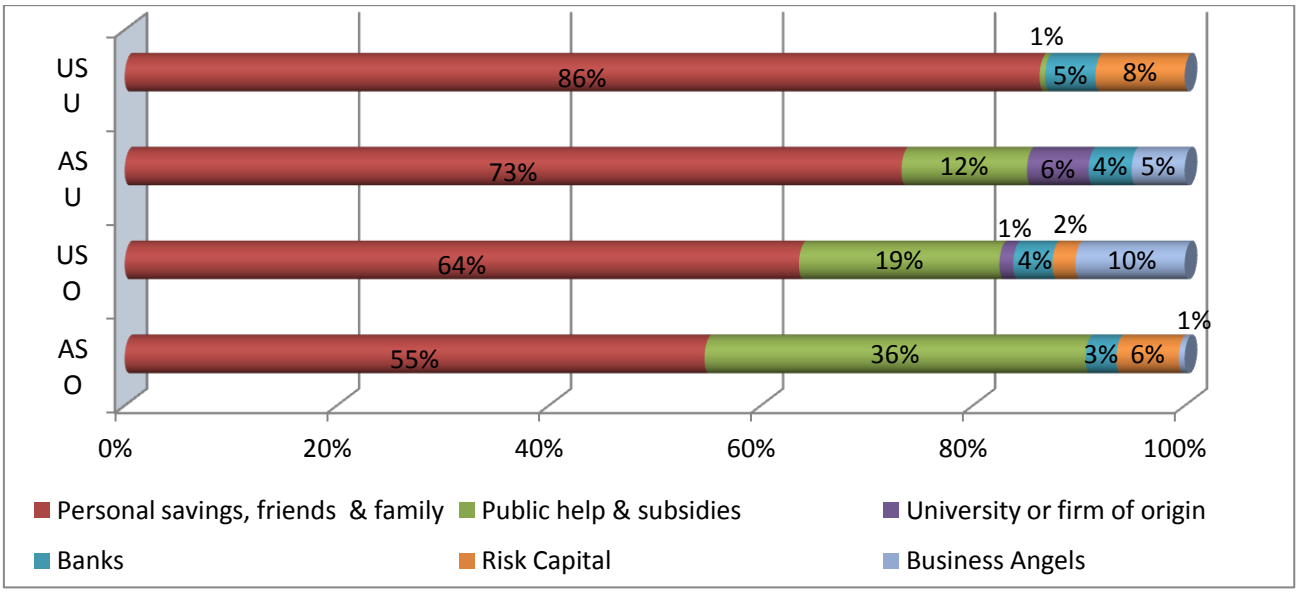
In **Figure 22** we can see the distribution of our set of university-based companies grouped by source of initial financing of the business. Our results show that the majority (70%) of the initial financing of our set of university-based companies comes from personal savings, friends or family of the founders. This result is in line with Ortin

Figure 22: Distribution of university-based companies by sources of initial financing



In **Figure 23** we can see the distribution of university-based firms by the source of initial financing for each of the groups of firms previously defined. It is interesting to see that while non-academic start-up companies' (USU) founders have financed 86% of the business with personal savings, academic spin-off companies' (ASO) founders financed only 55% of the business beginnings. In addition, while USU have financed only 1% of the business start with public subsidies, ASO have financed 36% of the business initiation with this same source. This result is consistent with the findings in Ortin et al. (2008) who found that almost 40% of academic spin-off companies had received public support to finance their business starts.

Figure 23: Distribution of university-based firms by source of initial financing

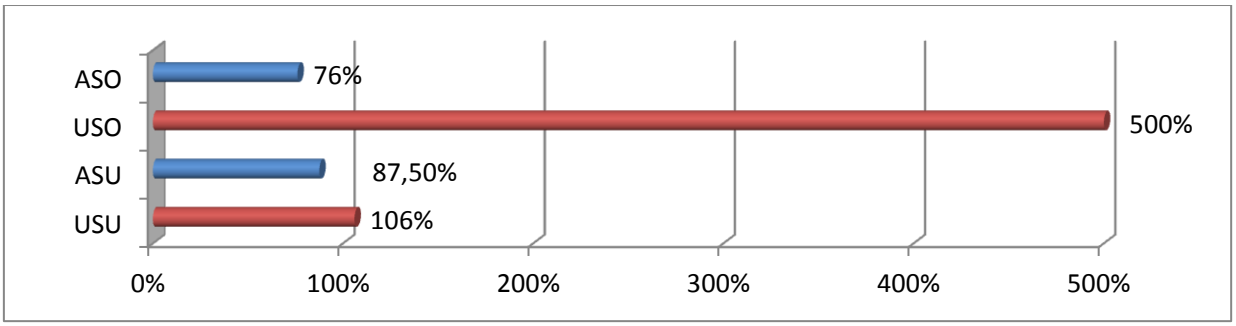


- **Growth**

In **Figure 24** we show the annual percentage sales increase between the first year and 2007. We can see in **Figure 24** that USO has increased the amount of sales by 500% in each year. This figure is partially explained by the low level of initial sales that USO present (see **Figure 20**). We acknowledge that this figure may be a limitation in our dataset. Moreover, USU present an average annual sales increase over 100%. On the other side, academic spin-offs (ASO) present the lowest average annual sales increase.

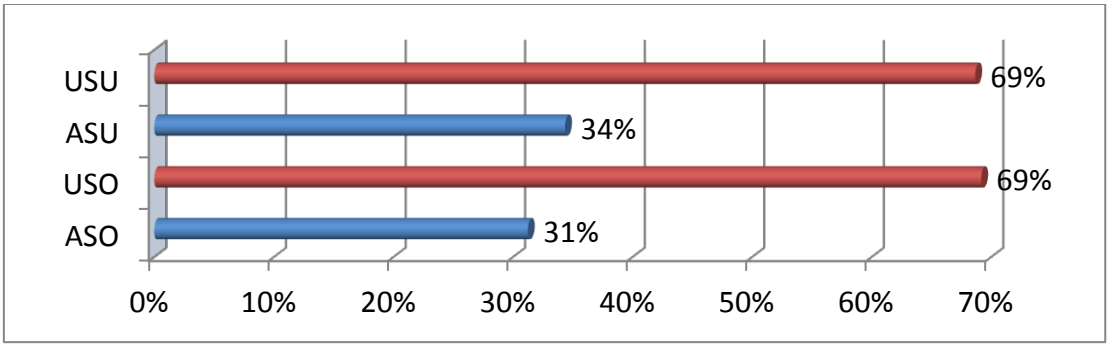
Moreover, we can see in **Figure 24** that academic UBC (ASO and ASU) present in average a relatively lower annual sales increase compare to non-academic UBC (USO and USU). This result differs from the findings in Epure et al. (2014) who argue that: "*employing university workers is associated with higher efficiency.*"

Figure 24: Percentage annual sales increase between the first year and year 2007



In the same line, **Figure 25** shows the percentage annual growth in the number of employees between the first year of activity and the year 2007. USU and USO (non-academic UBC) show the same average annual growth in the number of employees (almost 70% per year). On the other side, ASU and ASO (academic UBC) have grown in average just above 30% per year. Thus, our results show that non-academic UBC have grown (in terms of employees) twice as big compare to academic UBC. This result differs from Vendrell and Ortin (2010) who found that Spanish UBC have grown in average 24,5% annually (in terms of FTE).

Figure 25: Percentage annual growth in the number of employees between the first year of activity and the year 2007



4. Discussion

In the first part of this study, we have drawn on previous University Entrepreneurship literature to propose a rather broad definition of UBC. In this sense, we have limited our UBC definition to two basic resources (or dimensions) transferred from the PU to the firm: (i) knowledge-based resources and (ii) human resources. Other resources that may be transferred from the PU to the UBC are considered to be a consequence rather than a cause of the type of company the UBC is. Therefore other resources transferred from the PU are not consider as definitional conditions of the UBC concept (Pirnay et al., 2003; Fini et al., 2009; Bathelt et al., 2010; Karnani, 2013; Epure et al., 2014).

In Carayannis et al. (1998) the authors end the paper by proposing two possible alternatives to the issue of UBC definition. "*We should either (1) expand our definition of spinoffs to include these other resource-transfers (thus defining a spin-off more broadly as a new company that is established by transferring its core technology, founders, or other resources from a parent organization), or (2) limit the concept of spin-off to specific resource-transfers, such as in the case of a technology spin-off, a founder spin-off, a venture capital spin-off, etc.*"

We believe that concentrating or limiting the UBC definition to just one resource-transfer (i.e. people or knowledge) would mislead the concept of UBC because it would include any company founded by university members and any company based on some knowledge produced at a PU. For example, a company founded by a PU's graduate student with no other link to the PU would be considered as UBC of that PU. This would lead researchers to a definition of UBC which would be too broad, unnecessary heterogeneous and basically inconclusive for the study of the UBC phenomenon.

We have also followed the approach proposed in Nicolau and Birley (2003) in order to consider the possibility of having an external or surrogate entrepreneur in the UBC (Franklin et al. 2001). On the other hand, in line with Fini et al. (2009), we do not include in our definition of UBC firms founded exclusively by an external or surrogate entrepreneur with no members of the PU in their founding teams. Thus, in order to be considered UBC we believe that there should be the transfer of some *members* (people) from the PU to the firm (Ortin and Vendrell, 2014).

Moreover, differently from Druilhe and Garnsey (2004) and Fini et al. (2009) and in line with more recent studies (Karnani 2013; Treibich et al., 2013; Epure et al., 2014; Shah and Pahnke, 2014) we have also included in our UBC definition companies founded by ancient graduate students, emeriti professors or former employees who have left the PU many years before founding the company. This inclusion may radically change the average profile of the UBC in our sample compare to samples of UBC in other University Entrepreneurship studies including companies founded only by active members of the PU (Ortin et al., 2008; Iglesias et al., 2012; Ortin and Vendrell, 2014).

For example, in a characterization study of Spanish UBC, Ortin et al. (2008) find that for the majority of Spanish technology transfer offices (TTO) the criterion to be considered as a *spin-off from the university* is that at least one *professor* (not just a member) of the parent university is involved in the creation and development of the new venture. This finding is important because it limits the practical applicability of the UBC definition provided in this study.

In this study we also draw on the literature reviewed to develop a typology based on the same two dimensions or *resource-transfers* used to define a UBC: the knowledge and the people transferred from the PU to the new venture (Pirnay et al., 2003; Bathelt et al., 2010; Bonardo et al., 2011; Karnani, 2013; Epure et al., 2014). In this sense, our typology differentiates among four types of homogenous and mutually exclusive categories of UBC: (i) academic spin-offs (ASO), (ii) non-academic spin-offs (USO), (iii) academic start-ups (ASU) and (iv) non-academic start-ups (USU).

ASO are firms that have at least one member of the parent university (PU) in their founding teams and at the same time have formally received an explicit type of knowledge from the PU. USO are firms that have also formally received an explicit type of knowledge from the PU but do not have any members of the PU in their founding teams. ASU are firms with one member of the PU in their founding teams but having informally received a tacit type of knowledge from the PU. Finally, USU are firms that do not have a member of the PU in their founding teams and that have informally received a tacit type of knowledge from the PU.

The UBC taxonomy proposed is very similar to the one used in Epure et al. (2014). In fact, the only different between both typologies is that Epure et al. (2014) include in the first UBC group (they call this group as *STTU*) every company with formal technology transfer from the PU (with or without a member of the PU in their founding team). On the other hand, our typology distinguish between UBC with formal technology transfer and a member of the PU in their founding team (we call them *ASO*) from UBC also having formal technology transfer but with no member of the PU in their founding team (we call them *USO*).

Our typology helps researchers, university entrepreneurs and university managers to differentiate between UBC that are new technology-based firms (NTBF) commercially exploiting a technological innovation with usually high-growth potential and innovative product-oriented companies with high needs of seed capital to develop, from knowledge-based firms; usually les innovative service-oriented companies with lower growth expectations but a lower need of PU's support and external financing to start-up the business.

Our typology also distinguishes between UBC founded by academics, faculty or researchers of the PU, from non-academic UBC founded by other PU's members (i.e. students, graduates, staff). This distinction is also useful for researchers and practitioners because academic UBC usually have a stronger link with the PU than non-

academic UBC; allowing them to have an easier access to PU's resources and networks. In this sense and in line with the results found in Criaco et al. (2014) and in Epure et al. (2014), we believe that UBC with at least one academic from the PU in their founding teams (academic UBC) should present a better level of performance and a lower risk of failure compare to non-academic UBC.

On the other hand, academic UBC usually lack the managerial skills and the entrepreneurial capabilities compare to UBC founded by other PU's members, as students or graduates, or an external entrepreneur. Thus academic and non-academic UBC follow different business strategies according to their needs and may thus reach different levels of business performance. These differences among each type of UBC imply that university managers and policy makers should take into consideration this UBC typology to properly adapt their programs and support measures to each UBC type.

In the second part of this study we draw on an empirical analysis of 94 UBC created with the support of Catalonian universities to develop a characterization for each of the UBC types identified in part one. From this analysis, we have been able to compare the profile of different types of UBC and relate these UBC types to the growth and risk potential of firms.

In this sense, every firm in our sample of 94 Catalonian UBC was properly classified into the four homogenous and mutually exclusive groups of companies previously identified. Thus, every company in the sample fit one of the categories of our UBC taxonomy. Moreover, each of the four UBC types are represented by a significant number of companies from the sample. In particular, we have found that 20 (21%) of the UBC in the sample are ASO, 23 (25%) are USO, 32 (34%) are ASU and 19 (20%) are USU.

This result is highly consistent with the findings in Epure et al. (2014: Table 2). Indeed, in their sample of 81 companies created with the support of Catalonian universities, the authors found that 40% were ASU (they call them *SPU*) and 15% were USU (they call them *OSU*). Moreover, similar to our results, Epure et al. (2014) found that 45% of the UBC in their sample have formal technology transfer agreements with the PU (spin-off companies). In the same line, Karnani (2013) found that 45% of the UBC in the sample of study are *codified start-up knowledge* having formal technology transfer agreements with their PU.

We have also found that 65% of UBC in our sample come from technical universities. This result is consistent with Ortin et al. (2008) who found that most than half the UBC in Spain are generated by the two biggest Spanish technical universities (UPC and UPV). On the other side, Karnani (2013: Table 2) found that 61% of the UBC in the sample come from non-technical universities. Moreover, our results show that the average age of the UBC in the sample is around 5 years. This result is in line with the findings in previous studies analysing the UBC phenomenon in Spain (Ortin et al.,

2008; Rodeiro et al., 2010; Vendrell and Ortin, 2010; Iglesias et al., 2012; Epure et al., 2014; Ortin and Vendrell, 2014).

We have also found that most of the UBC in our sample (almost 80%) operate in the fields of engineering and computer science. This is also in line with previous studies in Spanish university entrepreneurship (Ortin et al., 2008; Rodeiro et al., 2010; Vendrell and Ortin, 2010; Iglesias et al., 2012; Epure et al., 2014; Ortin and Vendrell, 2014). Furthermore, we found that UBC in our sample had in average 2,35 full-time employees (FTE) during their first year of operations. This result is very similar to the findings in Karnani (2013) who found that UBC started operations with an average of 2,20 FTE. In the same line, Vendrell and Ortin (2010) found that Spanish UBC start activity with an average of 2,7 FTE.

From the characterization analysis undertaken by type of UBC, our results show that non-academic start-ups (USU) took in average half the time to start the business compared to non-academic spin-offs (USO). This result suggests that although USU may be high growth UBC, they are also high risk companies compared to other UBC types. In this sense, we believe that the time taken to set up a business (the start-up speed) may be an indicator of the dynamism and therefore of the growth potential of firms. On the other side, we believe that companies that set-up in a short time may be more "fragile" to changes and contingencies compared to companies that undertook a long start-up process

Moreover, following the business model perspective, the sector of activity where the UBC operates may influence the growth potential and risk level of the company. In this sense, we have found that while a significant proportion of academic start-ups (ASU) in our sample operate in the social science service sector (mainly professional consulting businesses), most of non-academic spin-offs (USO) are computer science-based companies providing new technologies, new products and technical services to their clients.

The growth potential and risk level of firms may be also influenced by the level of access to specific start-up and business development resources. In particular, we believe that restricted access to physical, financial, technological, social and/or human resources may limit the growth potential of UBC and increase their risk of failure.

In this sense, our results show that while most of the USU in the sample (70%) started operations from their homes or private offices, only one fifth of the ASO used founders' homes and private offices as their starting location facility. In the same line, we have found that none of the USU in the sample started operations at the PU's business incubator. These results suggest that USU have a lower access to physical start-up resources compared to other type of UBC, and therefore we believe USU may show a higher level of failure risk than other UBC types (particularly ASO).

Moreover, we have found that academic spin-off companies (ASO) start bigger than other UBC types in terms of the number of full-time employees (FTE). In addition,

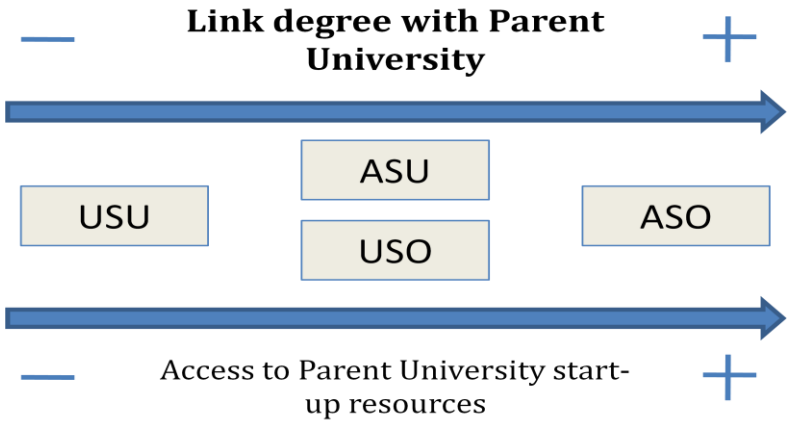
almost half of ASO's employees have a PhD, a much higher proportion than in the rest of UBC types. Thus, from our results we can infer that UBC with at least one academic from the PU and with formal technology transfer agreements with the PU have better access to human resources at the start-up phase. In this sense, we believe that USO would show a lower risk of failure compare to other UBC types.

In the same line, our findings reveal that in average spin-off UBC with formal technology transfer agreements with the PU (ASO and USO), have received significantly more public subsidies and financial help than start-up UBC (ASU and USU). In particular, while ASO have financed 36% of their start-up process using public help, USU have only financed 1% of their start-up process using public help. Furthermore, ASO present a higher level of sales during the first year compare to other UBC types. Thus, from our findings we may conclude that ASO may have better access to financial start-up resources than other UBC types.

Moreover, we have found that start-up UBC (USU and ASU) have a significant lower number of national and international patents (technological resources) compared to spin-off UBC (USO and ASO). Moreover, we have found that start-up UBC receive four times less subsidies through the PU's Technology Transfer Office (financial resources) than spin-off UBC. These results suggest that start-up UBC (no formal transfer of technology from the PU to the firm) may show a lower growth potential and a higher risk of failure compared to spin-off UBC (formal technology transfer from PU to the firm).

Furthermore, we have showed that university-based companies having an academic from the Parent University in the founding team increases the link between the company and the university. In the same line, companies that present a formal knowledge transfer from the Parent University also present a high degree of link dependence towards the university. In **Figure 26** we have a graphical representation of the link dependence degree towards the Parent University by type of UBC.

Figure 26: Degree of link dependence towards the Parent University



It is important to acknowledge that UBC with a stronger link with the PU will usually have a better access to strategic start-up resources. Thus, in **Figure 26** we can see that as the link degree with the PU increases, the access to PU's start-up resources also increases. From the previous figure and considering the elements previously presented, we can say that non-academic start-ups (USU) present the lowest degree of link dependence towards the Parent University. In the other end, academic spin-offs (ASO) present the highest link with the PU. In the middle, we find academic start-ups (ASU) and non-academic spin-offs (USO). Thus, once more our results suggest that USU are moderate growth companies with limited access to strategic resources and a high risk of failure compared to other UBC types.

Finally, our results show that the number of full-time employees (FTE) has increased more than twice in non-academic UBC (USO and USU) compared to academic UBC (ASO and ASU). Moreover, we have also found that non-academic spin-offs (USO) are the type of UBC that have most increased sales from the beginning of their operations until the year 2007. On the other side, we have found that academic UBC are the types of UBC that have less increased the amount of sales.

Different from our findings, Epure et al. (2014) found that higher UBC efficiency is positively associated with the formal transfer of technology from the PU to the firm and it is also positively associated with the transfer of people from PU to the firm. In this sense, Epure et al. (2014: 14/5) argue that "*the best-practice frontier is mostly shaped by spin-offs with formal technology transfer agreements*." Moreover, the authors argue that "*employing university workers is associated with higher efficiency*."

On the other hand and relating UBC inefficiency levels with firms' level of failure risk; we can say that the findings in Epure et al. (2014) are in line with our results. In this sense, Epure et al. (2014) found that academic spin-offs (formal technology transfer agreement and transfer of academic/s from PU to the firm) are the most efficient type of UBC and non-academic start-ups (no formal technology transfer agreement and no transfer of academic/s from PU to the firm) are the less efficient type of UBC. At the middle (in terms of efficiency), Epure et al. (2014) found academic start-ups and non-academic spin-offs. Thus, we have found similar results compare to Epure et al. (2014) in terms of the firms' risk of failure.

In the same line, Criaco et al. (2014) found that the probability of closing a UBC is negatively associated with the presence of members from the parent university (PU) in the founding team. Thus, we agree with Criaco et al. (2014) in that UBC with at least one member of the PU in the founding would show a lower risk of failure compare to UBC with no members of the PU in their founding teams.

5. Conclusion

Previous research on University Entrepreneurship has shown that university-based companies (UBC) are usually highly-performance firms generating positive returns to their Parent Universities (PU) and to the local environment (Rodeiro et al., 2010; Yusof and Jain, 2010; Iglesias et al., 2012; Algieri et al., 2013; Treibich et al., 2013; Mendez, 2014; Shah and Pahnke, 2014; Goel et al., 2015). On the other side, while UBC is a complex and heterogeneous phenomenon, academic studies in the University Entrepreneurship field of research have hardly recognized UBC heterogeneity and the particularities/characteristics of each type of UBC (Pirnay et al., 2003; Wright et al., 2004; Mustar et al., 2006; Wright et al., 2008; Iglesias et al., 2012; Treibich et al., 2013; Epure et al., 2014).

In addition, scholars in this field of study have not reach an agreement about what should be included under the UBC concept (Pirnay et al., 2003; Nicolau and Birley, 2003; Clarysse and Moray, 2004; Bathelt et al., 2010; Müller, 2010; Bonardo et al., 2011; Iglesias et al., 2012; Swamidass, 2013; Treibich et al., 2013; Ortin and Vendrell, 2014; Shah and Pahnke, 2014). Thus, in this study we draw on previous literature to develop a comprehensive UBC definition and taxonomy. Moreover, we also provide a detailed characterization of each type of UBC previously identified based on an empirical analysis of 94 firms created with the support of Catalonian universities.

University managers and regional agents of socio-economic development may find the results of this study useful to properly define what type of companies are UBC and thus which are the companies that may be included in UBC business development programs and support measures. Business development policies are only effective if they are specifically targeted and adapted to the target group. Thus, policy makers and university managers need to properly identify UBC in order to develop effective business support measures.

Researchers may be interested in the results of this study to be able to clearly define the scope and boundaries of the UBC phenomenon. In this sense an ambiguous UBC definition may lead researchers to inconclusive results difficult to compare or generalize (Pirnay et al, 2003). Therefore, the results of the first part of this study allow researchers to be more specific about the object of analysis and facilitate the comparison of their empirical evidence with the results of other UBC studies. Finally, researchers may find our typology useful as a framework to properly include UBC heterogeneity in their studies and disentangle the effects of university resources and policies over each type of UBC.

Moreover, in the second part of this study, we have found that USU are high risk ventures usually founded by current or graduate students with moderate growth potential and limited access to strategic resources from the Parent University (PU). ASU are *life-style* companies, mainly business consultancy firms founded by academics with limited growth potential but a rather low risk of failure. Moreover, USO are high

growth new technology-based firms (NTBF), mainly in computer science and engineering with limited access to PU's resources (and therefore presenting some risk of failure). Finally, ASO are research-based companies founded by academics from the PU with good growth potential and a low failure risk but highly dependent on PU's support.

The results of the second part of this study have relevant practical implications. For example, university managers and policy maker willing to foster the creation of high-growth UBC should focus their attention and efforts towards developing the necessary technological resources (patents) to support spin-off companies (formal technology transfer). In the same line, venture investors may find in USO an interesting line of equity investment with a high probability of making a "good" capital gain when exiting.

On the other side, venture investors looking for a low risk investment should focus their attention in academic UBC. In particular, academic spin-off companies (ASO) seem to be the most attractive type of UBC for venture investors. Finally, university entrepreneurs willing to create USU have to consider (before setting-up the company) that they will have limited access to PU's resources/support and that most of the finance of the business is going to come from their own pockets.

We believe that this study has its limitations. For example, although we have draw on previous literature to develop a definition and taxonomy of UBC, we did not confirm our theoretical findings using principal component analysis (PCA), cluster analysis or other quantitative grouping technique (Iglesias et al., 2012). In this sense, future research may want to collect data from companies created with the support of universities in order to quantitatively validate or invalidate the UBC definition and classification provided in this study.

The empirical analysis of this study is also not free of limitations. In particular, we believe that they are certain specific conditions of our sample that may be causing bias in our results and conclusions. In this sense, we believe that the age of the companies in the sample at the time of the survey (year 2007) may influence their growth rate. ASO and ASU are found to be the oldest UBC in the sample. Thus, we believe that part of the lack of growth (in terms of new employees) of academic UBC in our sample could be explained by the fact that these companies were older at the time of the research compare to non-academic companies (USO and USU). In the same line, at the starting phase academic UBC are larger firms compare to non-academic UBC (in terms of sales amount and number of employees). The greater start-up size of academic UBC could partially explain the lack of growth shown by these companies**.**

Finally, we have characterized each UBC type (ASO, ASU, USO and USU) using descriptive statistics. Thus, we have measured relative differences among UBC types. On the other hand, we have not assessed the significance level of these relative differences among UBC types. In this sense, future UBC research may be interested in deploying the necessary quantitative tools and techniques to properly assess the significance level of UBC types' differences.

Appendices

Appendix 1: List of 262 Catalonian university-based companies

URV

1	Aplicacions de la Catàlisi, S.L.
2	BEYOND FOOD, SL
3	EDIS, S.L
4	Eidola SL
5	M-BOT Solutions SL
6	SIMPPLE, S.L

UPF

1	BMAT (Barcelona Music & Audio Technologies)
2	Chemotargets SL
3	SecondNews
4	Sociedad General de Software Educativo S.L

UB

1	Advancell
2	Agrasys
3	ABBCN (Antibody BCN)
4	Arsus papel
5	Biocontrol Technologies
6	Diverdrugs
7	Enantia
8	Era-Biotech
9	Infinitec Activos
10	Intelligent Pharma
11	Meteosim
12	Neurosciences Technologies
13	Neurotec Pharma
14	OED (Oleoyl-Estrone Developments)
15	Omnia Molecular
16	Palobiofarma
17	Reidesen
18	TotemGuard
19	UBAN
20	XOP Conserves del Ponent

UAB

1	AB-BIOTICS, S.L
2	ACTIVERY BIOTECH, S.L
3	AQUALAB, Assessoria i Anàlisis d'aigües, S.L
4	BIOACCEZ Controls, S.L.
5	D+T MICROELECTRÒNICA, A.I.E.
6	DAVANTIS TECHNOLOGIES, S.L.
7	ECOMUNICAT ELECTRONICS, S.L.
8	ENDOR Nanotechnologies, S.L.
9	FIT FUNDACIO
10	HEXASCREEN CULTURE TECHNOLOGIES, S.L.
11	ICAR VISION SYSTEMS, S.L.
12	INSPECTA, S.L.
13	MUF, Laboratori d'Imatge, Art i Animació, S.L.
14	OBELISK VoIP High Tech, S.L.
15	PATATA BRAVA, S.L.
16	SPORA SINERGIES, S.L.
17	UNIVET, S.L
18	X-RAY IMATEK, S.L.

IESE

1	Kubi Wireless SL

ESADE

1	Agua Nafree
2	B2i Design
3	Dantex consulting
4	FUTURLINK
5	GEOTICS
6	iMente Global S.L.

UdG

1	Aqsense
2	DSET Technology
3	Edicions a petició EAT
4	Mellitus
5	Microbial

6	SISLtech
7	Tecnoartés
8	TR Composites

La Salle Bonanova

1	Active Career
2	ADECQ
3	ADICIONA Servicios Informáticos, SL
4	Aifos Solutions
5	Aira Networks
6	AirWatter UFBAF
7	Apartamentum
8	Ariadna
9	BanckUP
10	BRYTE
11	Calor Natural (Ecogetic Soluciones Energéticas Alternativas)
12	CHANNER
13	Contact Center Institute
14	CRTC (Xperience Consulting)
15	CUATIC
16	DAEM
17	Deliverty Wireless
18	DiggerTools
19	Digital Legends
20	DPLUS3 (Desarrollos dentales Plus Tres)
21	e-Controls
22	EduExcellence
23	EMOVILIA (Soluciones Digitales de Movilidad)
24	Etnia
25	FincaSMS
26	Fleet MRS (SITEP, Sistemas de Información Territorial y de Posicionamiento)
27	Flubetech
28	Frog2Frog
29	GENAKER
30	Global Ser
31	Hidroflot
32	Ictineu Submarins
33	Imagsa
34	Indiseg
35	ISIGMA
36	Leyenda Films
37	Linkara

38 Linquia
39 Media Game, S.L
40 Mobile 4 Media, S.L
41 Mortimer
42 Nadir
43 Novarama
44 ON-Laser
45 OPENMET
46 Polinomi Media
47 Polymita
48 ProductiveMail
49 Signaletics
50 SkiTrack
51 Ta with you
52 TaxiChannel
53 VidaSoftware
54 Vidimicrocar
55 Voxel
56 VozTelecom
57 WATTPIC
58 WUTUTU
59 Z2Secure

UPC - Innova

1 3D Produccions
2 3Scale Networks, S.L
3 3Sphera Integración, SL
4 ACTIO
5 Adam Documental (tb-security)
6 ADAPTA, S.L.
7 ADMIRA TV. INTERACTIVE, S.L.
8 AD-Teramics (Advanced Technicals Ceramics)
9 Advancare, SL
10 Advanced Communications & Technologies, SL
11 AEC Center Net
12 Age Business, SL
13 AidaCentre, SL
14 AiguaSol (Tecnología Solar Concentradora)
15 AIRA (Asesoramiento Industrial en Robotica y Automatización)
16 Aleasoft (Alea Business Software)
17 Aleria Devices, S.L
18 ALUVIAL
19 Anunzia Solucions Tecnològiques, SL

20 APC SYSTEMS BCN, S.L
21 Arlas Invest (Capricornio)
22 Autana Technologies, SL
23 AZ Engin, SL
24 Baolab Microsystems, SL
25 BCN Events Comunicación
26 Biicsoftware, s.l.
27 Biocom21, SL (Innovació en Energies Renovables)
28 Bioglutamic
29 Bioingenium, S.L.
30 Bionanomics, S.L
31 Call Contact Instirute, S.L
32 Catalana Innovacions per a la construcció, SL
33 Centuno Sviluppi, SL
34 Cerfilter, SL
35 Codiumnetworks, SL
36 Communi.tv S.L.
37 COMPASS Ingeniería y Sistemas
38 COMPEGPS, SL
39 Compostadores
40 Cotton High Tech
41 Crystax Pharmaceuticals
42 CSC (Conservación de sustratos celulósicos)
43 Delclos Consultors (Coneix Project Management)
44 DENEB Latinoamericana
45 DEXMA SENSORS, S.L.
46 DiaSolar (sistemes d'energia solar)
47 DLM
48 DOC on time
49 EiMode
50 Elephant Memo, SL
51 e-Mascaró Consulting
52 Encuestas-Internet SL
53 EnginDat, SL
54 Enginyeria Mapex
55 Enix IT, S.L
56 ENTEC Enginyeria i seveis, SL
57 ESCOM Gabinete de Ingeniería
58 Espacio Solar Ingenieros
59 Foreco Technologies, S.L.
60 Forest Jou, SL
61 Fractus
62 Free Power, SL
63 Global SIO, SL
64 Goa Internet Services, S.L.

65 GREENCLASS
66 Hogar Digital (Blaunet Web Factory)
67 HYDS
68 IBQ Investigaciones Bioquímicas, SL
69 IHG, Information Highway Group
70 Imago, S.L.
71 INETSECUR
72 Ingenia Biosystems
73 Ingenia- CAT
74 Ingeniactiva, S.L.
75 INGENT Group Systems, SL
76 INGESOFT
77 Inoitulos
78 Inventar i Construir s.l.
79 Justinmind (Internet per la difusió d'innovacions)
80 Luz de nueva generación, s.l.
81 Mania Internet Studios - Mania Studios -
82 Marcià Codinachs
83 Maths for more
84 Medical Soft
85 Melcart Projects
86 Micropup, S.L
87 MobiFriends Solutions
88 Movetech,S.L.
89 MP-BATA Consultoría Medioambiental
90 Neovee Solutions, S.L.
91 NPG-Emergetech, SL
92 On Site Asistencia - Accesis-
93 Open Alliance Software Libre, SL
94 Open Studio Networks
95 OPENTRENDS, SL
96 Openwired, SL
97 PACI Enginyers
98 Perception technologies
99 Polmarsa S.L.
100 Porec Irrigation, S.L
101 Praesentis
102 PRAKTON SL
103 Projecte ALGWEB.net - Matemarius -
104 Qualitat de Serveis Empresarials
105 QualityChoice, S.L.
106 Quantech ATZ
107 Radiantis, SL
108 Rankdom Systems
109 Rational Time, S.L

110 RBS (Road Beacon System)
111 Reconeixement de Veu
112 Rededia
113 Rig Barcelona S.C.P.
114 RILAIC (red Ibero-Latino Americana de Investigación en Carreteras)
115 Sabirmedical, s.l.
116 Safiratec SL
117 SCYTL Online World Security
118 Sensofar-Tech
119 Serveis de Participació Interactiva
120 Serveis d'Internet Javajan
121 SIOP Simulacions Òptiques, SL
122 Sit consulting
123 Smart Information Systems - SmartIS -
124 Social capital
125 Solomenu.com, SL
126 South-Wing
127 Special Pi (A+Especial Solutions), SL
128 Step2U
129 Tanaki Visión
130 TARPUNA Iniciatives Sostenibles
131 Teccon Evolution, SL
132 Tecnologia i Innovació Empresarial
133 Terceros de Confianza
134 Tinytronic
135 TRANS (Transferencia de recursos avanzados)
136 TSS-Transport Simulation Systems
137 Vasic Innovació, SL
138 Visiometrics
139 ZENTIC, S.L.

Appendix 2: Questionnaire for the characterization study of Catalonian university-based companies

A.- INFORMACIÓ GENERAL DE L'EMPRESA

1) Indiqui la data de constitució legal de l'empresa:

Mes *(de l'1 al 12)* ___

Any *(aaaa)* _____

2) Indiqui la forma jurídica de l'empresa.

- ❑ Societat de Responsabilitat Limitada
- ❑ Societat Anònima
- ❑ Altres

(Especificar Altres, quan s'hagi marcat) _____
_____
_____
_____

3) Indiqui el mes i l'any de l'inici de les activitats: ***(en el cas que encara no hagi començat les activitats, indiqui la data aproximada de començament)***

Mes *(de l'1 al 12)* ___

Any *(aaaa)* _____

4) Quin és el producte/servei que comercialitza la seva empresa?

5) A quin sector d'activitat econòmica pertany la seva empresa?

❑ Ciències de la vida (biologia, farmàcia, química, etc.)

❑ Ciències físiques (enginyeria, informàtica, etc.)

❑ Ciències socials (la resta)

6) **Indiqui el CNAE de la seva empresa** _____

7) **Indiqui la universitat de procedència** ***(la universitat de procedència és aquella que el trampolí tecnològic de la qual ha donat suport a la spin-off. En el cas que hagi utilitzat diversos trampolins, indiqui el que considera que és el principal)***

❑ Universitat Politècnica de Catalunya (UPC, Innova)

❑ La Salle Bona nova

❑ Universitat Autònoma de Barcelona (UAB)

❑ Universitat de Barcelona (UB)

❑ Universitat de Girona (UdG)

❑ Universitat Rovira i Virgili

❑ IESE

❑ ESADE

❑ Universitat de Lleida

8) **En quin municipi està ubicada l'empresa?**

A l'inici _____

A l'actualitat _____

9) **On està ubicada l'empresa?** ***(campus universitat, parc tecnològic, polígon industrial, oficina privada, casa particular, etc.)***

A l'inici	_____
	_
A l'actualitat	_____
	_

10) Disposa d'algun contracte de cessió de tecnologia, patent o algun altre tipus de Know-how amb la universitat de procedència?

- ❑ Sí
- ❑ No

11) La universitat de procedència té o ha tingut participació accionarial en l'empresa?

- ❑ Sí
- ❑ No

12) Participació accionarial de la universitat en %

Any de creació	_____
2007	_____

13) La universitat de procedència té o ha tingut opcions de compra sobre l'empresa?

- ❑ Sí
- ❑ No

14) Participació en l'opció de compra per part de la universitat en %:

Any de creació	_____
2007	_____

15) Quina és la despesa TOTAL en SOUS (€) de la seva empresa?

Any de creació	_____
2007	_____

16) Quants treballadors provenen de la universitat de procedència de la spin-off?

Any de creació	_____
2007	_____

17) Indiqui el nombre de patents que ha generat l'empresa:

Patents nacionals	___
Patents internacionals	___

18) Indiqui el <u>nombre de treballadors</u> en plantilla a JORNADA COMPLETA en la primera fila.

Indiqui també el <u>% de treballadors</u> en plantilla a JORNADA COMPLETA segons la seva formació en les files restants *(ha de sumar 100%)*:

Any de creació	_____
% de Doctors	_____
% de Llicenciats/enginyers superiors	_____
% de Diplomats/enginyers tècnics	_____
% de FP/Batxillerat	_____
% de Altres (sense estudis, primaris, etc.)	_____
% de Doctors	_____
2007	
% de Llicenciats/enginyers superiors	_____
% de Diplomats/enginyers tècnics	_____
% de FP/Batxillerat	_____
% de Altres (sense estudis, primaris, etc.)	_____

19) Indiqui el <u>nombre de treballadors</u> en plantilla a MITJA JORNADA en la primera fila.

Indiqui també el <u>% de treballadors</u> en plantilla a MITJA JORNADA segons la seva formació en les files restants *(ha de sumar 100%)*:

Any de creació (primer any d'operació complert)	_____
% de Doctors/màsters	_____

% de Llicenciats/enginyers superiors	_____
% de Diplomats/enginyers tècnics	_____
% de FP/Batxillerat	_____
% de Altres (sense estudis, primaris, etc.)	_____
2007	
% de Doctors/màsters	_____
% de Llicenciats/enginyers superiors	_____
% de Diplomats/enginyers tècnics	_____
% de FP/Batxillerat	_____
% de Altres (sense estudis, primaris, etc.)	_____

20) Indiqui les VENDES de la seva empresa en € en la primera fila.

Indiqui també la distribució de vendes en % a les files restants *(ha de sumar 100%)*:

Any de creació (primer any d'operació complert)	_____
% de vendes a Catalunya	_____
% de vendes a la resta d'Espanya	_____
% de vendes internacionals	_____
2007	
% de vendes a Catalunya	_____
% de vendes a la resta d'Espanya	_____
% de vendes internacionals	_____

21) Indiqui les DESPESES (sense incloure sous) de la seva empresa en € en la primera fila.

Indiqui també la distribució de la despesa (sense incloure sous) en % a les files restants *(ha de sumar 100%)*:

Any de creació (primer any d'operació complert)	_____
% de despesa a Catalunya	_____
% de despesa a la resta d'Espanya	_____
% de despesa internacional	_____
2007	
% de despesa a Catalunya	_____
% de despesa a la resta d'Espanya	_____
% de despesa internacional	_____

B.- VALORACIÓ DEL SUPORT REBUT PER PART DEL TRAMPOLÍ

22) **Coneix el Trampolí Tecnològic?**

- ❑ Sí
- ❑ No

23) **Com va conèixer el Trampolí Tecnològic?**

- ❑ Membres del departament
- ❑ Altres professors/res de la universitat
- ❑ Jornada de difusió d'activitats OITT
- ❑ Web de la universitat/trampolí
- ❑ Altres persones/organismes
- ❑ Altres (premsa, fulletons, etc)

24) **Valori la importància dels serveis oferts pel Trampolí Tecnològic que figuren a continuació** ***(1 significa "mínima importància" i 7 "màxima importància")*****:**

	1 (mínima)	2	3	4	5	6	7 (màxima)
Formació per a emprenedors (gestió empresarial, creació d'empreses, etc.)	❑	❑	❑	❑	❑	❑	❑
Espais, equips i serveis compartits (oficines, sales de reunions, fax, etc.)	❑	❑	❑	❑	❑	❑	❑
Ajuda en l'anàlisi de la viabilitat de l'oportunitat empresarial	❑	❑	❑	❑	❑	❑	❑
Suport en l'elaboració del pla d'empresa	❑	❑	❑	❑	❑	❑	❑
Assessorament en propietat intel·lectual i industrial	❑	❑	❑	❑	❑	❑	❑
Informació i tramitació d'ajuts públics	❑	❑	❑	❑	❑	❑	❑

Cerca de finançament i/o socis industrials	❑	❑	❑	❑	❑	❑	❑
Suport en el procés de comercialització dels vostres productes o serveis	❑	❑	❑	❑	❑	❑	❑
Selecció de personal per completar l'equip emprenedor	❑	❑	❑	❑	❑	❑	❑
Assessorament legal, administratiu i fiscal	❑	❑	❑	❑	❑	❑	❑

25) **Ha utilitzat algun dels serveis que ofereix el Trampolí Tecnològic?**

❑ Sí

❑ No

26) **Marqui els serveis oferts pel Trampolí Tecnològic que hagi utilitzat:**

❑ Formació per a emprenedors (gestió empresarial, creació d'empreses, etc.)

❑ Espais, equips i serveis compartits (oficines, sales de reunions, fax, etc.)

❑ Ajuda en l'anàlisi de la viabilitat de l'oportunitat empresarial

❑ Suport en l'elaboració del pla d'empresa

❑ Assessorament en propietat intel·lectual i industrial

❑ Informació i tramitació d'ajuts públics

❑ Cerca de finançament i/o socis industrials

❑ Suport en el procés de comercialització dels vostres productes o serveis

❑ Selecció de personal per completar l'equip emprenedor

❑ Assessorament legal, administratiu i fiscal

27) **Puntui els serveis que ha utilitzat per part del Trampolí Tecnològic**
***(1 significa "gens satisfet" i 7 "molt satisfet")*:**

	1 (mínima)	2	3	4	5	6	7 (màxima)
Formació per a emprenedors (gestió empresarial, creació d'empreses, etc.)	❑	❑	❑	❑	❑	❑	❑

Espais, equips i serveis compartits (oficines, sales de reunions, fax, etc.)	❑	❑	❑	❑	❑	❑	❑
Ajuda en l'anàlisi de la viabilitat de l'oportunitat empresarial	❑	❑	❑	❑	❑	❑	❑
Suport en l'elaboració del pla d'empresa	❑	❑	❑	❑	❑	❑	❑
Assessorament en propietat intel·lectual i industrial	❑	❑	❑	❑	❑	❑	❑
Informació i tramitació d'ajuts públics	❑	❑	❑	❑	❑	❑	❑
Cerca de finançament i/o socis industrials	❑	❑	❑	❑	❑	❑	❑
Suport en el procés de comercialització dels vostres productes o serveis	❑	❑	❑	❑	❑	❑	❑
Selecció de personal per completar l'equip emprenedor	❑	❑	❑	❑	❑	❑	❑
Assessorament legal, administratiu i fiscal	❑	❑	❑	❑	❑	❑	❑

28) **Valori, en general, el suport rebut per part del Trampolí Tecnològic:** ***(1= molt deficient i 10= excel·lent)***

1	2	3	4	5	6	7	8	9	10
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

29) **Valori, en general, el suport rebut per part del CIDEM:** ***(1= molt deficient i 10= excel·lent)***

1	2	3	4	5	6	7	8	9	10
❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

30) **Hauria creat l'empresa o una altra organització similar sense el suport rebut per part del Trampolí Tecnològic?**

❑ Sí

❑ No

31) **Quins aspectes considera més positius del suport rebut per part del Trampolí Tecnològic?**

32) **Quins aspectes considera més negatius del suport rebut per part del Trampolí Tecnològic?**

33) **Quins serveis troba a faltar en el Trampolí Tecnològic?**

34) **Ha rebut ajut (assessorament, reunions, etc.) per part del Trampolí Tecnològic després de la constitució de l'empresa?**

- ❑ Sí
- ❑ No

C.- IMPACTE EN INNOVACIÓ I DESENVOLUPAMENT

35) **Indiqui les següents dades sobre R+D de la seva empresa:**

(Any de creació, primer any d'operació complert)

Nombre de contractes/serveis R+D amb la universitat de procedència	_____
Import dels contractes/serveis R+D amb la universitat de procedència (€)	_____
Nombre de contractes/serveis R+D amb altres universitats i/o centres de recerca	_____
Import dels contractes/serveis R+D amb altres universitats i/o centres de recerca (€)	_____
Volum **d'ajudes públiques concedides** que han estat **gestionades pel Trampolí** (€)	_____

% d'ajudes locals/provincials (Universitat, Cambra de comerç, Ajuntament, parc tecnològic, etc.)	_____
% d'ajudes regionals (Generalitat, CIDEM, COPCA, etc.)	_____
% d'ajudes nacionals (CDTI, Ministeri, etc.)	_____
% d'ajudes internacionals (Unió Europea, etc.)	_____

Indiqui les següents dades sobre R+D de la seva empresa:

(2007)

Nombre de contractes/serveis R+D amb la universitat de procedència	_____

Import dels contractes/serveis R+D amb la universitat de procedència (€) _____

Nombre de contractes/serveis R+D amb altres universitats i/o centres de recerca _____

Import dels contractes R+D amb altres universitats i/o centres de recerca (€) _____

Volum **d'ajudes públiques concedides** que han estat **gestionades pel Trampolí (€)** _____

% d'ajudes locals/provincials (Universitat, Cambra de comerç, Ajuntament, parc tecnològic, etc.) _____

% d'ajudes regionals (Generalitat, CIDEM, COPCA, etc.) _____

% d'ajudes nacionals (CDTI, Ministeri, etc.) _____

% d'ajudes internacionals (Unió Europea, etc.) _____

37) Quines fonts de finançament disposa la seva spin-off?

(Any de creació, han de sumar 100%)

% Estalvis personals i/o familiars _____

% Amics i/o veïns _____

% d'ajudes regionals (Generalitat, CIDEM, COPCA, etc.) _____

% Companys de feina _____

% Empresa i/o Universitat on treballa _____

% Bancs i/o caixes _____

% Capital risc _____

% Inversors privats (Business Angels) _____

% Ajudes públiques _____

% Altres _____

Quines fonts de finançament disposa la seva spin-off?

(2007, han de sumar 100%)

% Estalvis personals i/o familiars _____

% Amics i/o veïns _____

% d'ajudes regionals (Generalitat, CIDEM, COPCA, etc.) _____

% Companys de feina _____

% Empresa i/o Universitat on treballa _____

% Bancs i/o caixes _____

% Capital risc _____

% Inversors privats (Business Angels) _____

% Ajudes públiques _____

% Altres _____

D.- PERFIL DE L'EQUIP FUNDADOR

39) **Quants fundadors té l'empresa?** ***(a l'inici)***

- ❑ 1
- ❑ 2
- ❑ 3
- ❑ 4
- ❑ Més de 4

40) **Quants fundadors principals té l'empresa?** ***(els que han tirat el negoci endavant, a l'inici)***

- ❑ 1
- ❑ 2
- ❑ 3
- ❑ 4
- ❑ Més de 4

41) **Indiqui l'ocupació del fundador/s en el moment de crear l'spin-off**

	Empleat en una empresa d'alta tecnologia	Empleat en una empresa no relacionada amb l'activitat actual	Professor o investigador funcionari	Professor o investigador contractat	Becari predoctoral o postdoctoral	Estudiant	Altres
Fundador 1	❑	❑	❑	❑	❑	❑	❑
Fundador 2	❑	❑	❑	❑	❑	❑	❑

Fundador 3	❑	❑	❑	❑	❑	❑	❑
Fundador 4	❑	❑	❑	❑	❑	❑	❑

42) **Com es varen conèixer els socis fundadors?** ***(ADMET VÀRIES RESPOSTES)***

- ❑ En el treball, eren companys de feina o col·laboraven d'alguna manera
- ❑ En els estudis, eren companys de classe i/o es varen conèixer a l'escola, institut o universitat
- ❑ Amics d'infància i/o veïns
- ❑ Es van conèixer creant l'empresa
- ❑ Altres (especificar)

43) **Quin és el sexe dels socis fundadors?**

	Home	Dona
Fundador 1	❑	❑
Fundador 2	❑	❑
Fundador 3	❑	❑
Fundador 4	❑	❑

44) **Quina edat tenien els socis fundadors en el moment de crear l'empresa?**

Fundador 1	_____
Fundador 2	_____
Fundador 3	_____
Fundador 4	_____

45) **Hi ha hagut algun altre empresari a la seva família?**

	Sí	No
Fundador 1	❑	❑
Fundador 2	❑	❑
Fundador 3	❑	❑
Fundador 4	❑	❑

46) **Quin parentiu té amb vosté l'empresari de la seva família?**

	Pare/mare	Avi/à	Germà/na	Fill/a	Altres
Fundador 1	❑	❑	❑	❑	❑
Fundador 2	❑	❑	❑	❑	❑
Fundador 3	❑	❑	❑	❑	❑
Fundador 4	❑	❑	❑	❑	❑

47) **Ha creat alguna empresa amb anterioritat a l'actual?**

	Sí	No
Fundador 1	❑	❑
Fundador 2	❑	❑
Fundador 3	❑	❑
Fundador 4	❑	❑

48) **Tenia formació en administració, direcció i/o creació d'empreses en el moment de crear l'empresa?**

	Sí	No
Fundador 1	❑	❑
Fundador 2	❑	❑
Fundador 3	❑	❑

Fundador 4	❑	❑

49) **Quin és el nivell d'estudis dels fundadors en el moment de crear l'empresa?**
(Posar el nivell més alt)

	Doctorat/màster	Llicenciat/enginyer superior	Diplomat/enginyer tècnic	FP/Batxillerat	Altres
Fundador 1	❑	❑	❑	❑	❑
Fundador 2	❑	❑	❑	❑	❑
Fundador 3	❑	❑	❑	❑	❑
Fundador 4	❑	❑	❑	❑	❑

50) **Tenia experiència empresarial en administració/direcció d'empreses en el moment de crear l'empresa**
(Una persona té experiència en gestió/direcció si ha treballat com a directiu (gerent, director tècnic, director financer, director de màrqueting, etc.) un mínim de 3 anys durant la seva carrera)

	Sí	No
Fundador 1	❑	❑
Fundador 2	❑	❑
Fundador 3	❑	❑
Fundador 4	❑	❑

51) **En el moment de creació de la spin-off col·laborava en algun projecte/servei de R+D amb la universitat de procedència?**

	Sí	No
Fundador 1	❑	❑
Fundador 2	❑	❑

Fundador 3	❑	❑
Fundador 4	❑	❑

52) **Tornaria a crear una altra empresa?**

	Sí	No
Fundador 1	❑	❑
Fundador 2	❑	❑
Fundador 3	❑	❑
Fundador 4	❑	❑

53) **Dels factors que s'exposen a continuació, indiqui quins són els més rellevants en la creació de la spin-off. Valori la seva importància utilitzant una escala de 1 a 7, on 1 significa "mínima importància" i 7 "màxima importància":**

	1 (mínima)	2	3	4	5	6	7 (màxima)
He identificat una oportunitat de mercat	❑	❑	❑	❑	❑	❑	❑
Possibilitat de posar en pràctica la meva recerca i/o coneixements tècnics previs	❑	❑	❑	❑	❑	❑	❑
Afany de guanyar més diners que treballant per compte de tercers	❑	❑	❑	❑	❑	❑	❑
Prestigi o estatus d'empresari	❑	❑	❑	❑	❑	❑	❑
Insatisfacció en l'ocupació anterior i/o impossibilitat de trobar feina adequada o d'aconseguir els meus objectius en altres camps	❑	❑	❑	❑	❑	❑	❑
Afany d'independència personal i avantatges de treballar pel teu compte	❑	❑	❑	❑	❑	❑	❑
Altres	❑	❑	❑	❑	❑	❑	❑

54) **Quins han estat els tres principals problemes que ha hagut d'afrontar en el procés de creació de la seva spin-off?**

55) **Quan de temps varen tardar (en mesos) des de la concepció de la idea fins a la creació formal de l'empresa?**

Nombre de mesos ___

56) **Vol afegir alguna cosa més?**

CHAPTER THREE

PARENT ORGANIZATIONAL DETERMINANTS OF UNIVERSITY START-UP ACTIVITY

A LONGITUDINAL STUDY FROM SPAIN

1. Introduction

At these times of macro-economic stagnation and high unemployment rates, where knowledge has emerged as the alternative to the traditional sources of wealth (labour, land and capital), research universities have become relevant poles for technological innovation and regional economic growth (Guerrero and Urbano, 2012; Iglesias et al., 2012; Algieri et al., 2013; Berbegal et al., 2013; Criaco et al., 2014; Epure et al., 2014; Guerrero et al., 2014; Mendez et al., 2014; Ortin and Vendrell; 2014; Sanchez-Barrioluengo, 2014; Shah and Pahnke, 2014; Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015). In this sense, Sanchez-Barrioluengo (2014: 1769) argue that: "*Modern universities contribute by generating research and consultancy income, embedding knowledge in students and employees, upgrading regional business environments, and potentially improving the process of regional value capture.*"

In particular, through the creation of new ventures, universities may commercialize their knowledge, increase their income, attract better academics and students, allow their members to develop profitable businesses, motivate knowledge and technology transfer mechanisms with the industry, accelerate technological development and improve local, regional and national economic performance (DiGregorio and Shane, 2003; Shane, 2004; Etzkowitz et al., 2000; O'Shea et al., 2005; O'Shea et al., 2008; Wright et al., 2008; Rodeiro et al., 2010; Yusof and Jain, 2010; Iglesias et al., 2012; Algieri et al., 2013; Treibich et al., 2013; Mendez, 2014; Shah and Pahnke, 2014; Goel et al., 2015).

In this line, Mendez et al. (2014: 380) argue that: "*Research Centers and Universities are leaving their traditional role of being mere fosters of knowledge, to become important agents of technology transfer to society through promotion and creation of Technology-based companies.*" In the same line, Shah and Pahnke (2014: 780) state that: "*Universities are widely recognized as a critical source of technological innovation and are heralded for the entrepreneurial ventures cultivated within their walls. ... Such firms - and the societal and economic benefits they create - are an important contribution of modern universities.*"

Based on the Triple Helix model developed by Etzkowitz and Leydesdorff (2000) and Etzkowitz (2002),[41] policy makers and regional agencies of economic development realized that they could contribute to industrial change through the transfer of tacit and codified knowledge from public research organizations to the private sector. Therefore, since the beginning of the eighties, with the approval of the Bayh-Dole Act,[42] universities in the Unites States have radically increased their role as engines of economic and technological development (Rogers, 1986; Siegel et al., 2003; Markman et al., 2004; Link and Scott, 2005; O'Shea et al., 2005; Powers and McDougall, 2005;

[41] The Triple Helix model promotes the cooperation among universities, the markets and the government to develop a system of regional endogenous socio-economic and technological development.

[42] The Bayh-Dole permits a university, small business, or non-profit institution to elect to pursue ownership of an invention financed with federal funds, in preference to the government.

Wright et al., 2007). Moreover, during the nineties some prestigious European universities with a world-class research base started to implement policies to foster the commercialization of their research (Degroof and Roberts, 2004; Moray and Clarysse, 2005; Wright et al., 2007; Beraza and Rodriguez, 2011; Guerrero and Urbano, 2012; Shah and Pahnke, 2014; Kalar and Antoncic, 2015).

In this sense, the University Entrepreneurship paradigm based on Etzkowitz' Triple Helix model has become a mandatory statement for most research university in the United States and Occidental Europe (Etzkowitz, 1998; Etzkowitz and Leydesdorff, 2000; Etzkowitz et al., 2000; Etzkowitz, 2002; Moray and Clarysse, 2005; Huyghe and Knockaert, 2015). Moreover, being an Entrepreneurial University (Etzkowitz, 1983, 1998 and 2008; Clark, 1998; Guerrero and Urbano, 2012; Guerrero et al., 2014) in a highly competitive academic context is considered as an important factor to attract more and better members (students, faculty, researchers and staff) to their institutions (Etzkowitz, 2003; Shane 2004; Migliorini et al., 2010).

Following this expanding line of research, we have seen a rampant increase in the number of authors and academic publications studying University Entrepreneurship and the UBC phenomenon (Rothaermel et al., 2007; Djokovic and Souitaris, 2008; O'Shea et al., 2008; Yusof and Jain, 2010; Berbegal et al., 2013; Criaco et al., 2014; Epure et al., 2014; Ortin and Vendrell; 2014). On the other hand, in the University Entrepreneurship literature we may find few studies dealing with the creation of UBC outside *top-range* environments (Degroof and Roberts, 2004; del Palacio et al., 2006; Wright et al., 2008; Fini et al., 2009; Nosella and Grimaldi, 2009; Migliorini et al., 2010; Rasmussen and Borch, 2010; Rodeiro et al., 2010).

Moreover, in the literature we have also found few quantitative and explanatory studies presenting longitudinal evidence about the UBC creation phenomenon. In particular we have found few studies concentrating in explaining the parent organizational determinant factors of UBC creation using a quantitative and longitudinal methodology (DiGregorio and Shane, 2003; O'Shea et al., 2005; Clarysse et al., 2011; Fini et al., 2011). Moreover, most of these studies focus on parent universities located in highly-developed technological environments with abundant entrepreneurial resources (Wright et al., 2008; Rasmussen and Borch, 2010). Thus, the general aim of this study is to contribute to the University Entrepreneurship literature by presenting a quantitative and longitudinal study explaining UBC creation outside *top-range* environments.

Therefore, in this research we draw on the Resource-Based View (RBV), the Dynamic Capabilities Perspective and the Institutional Economic Theory to empirically assess university-level determinant factors of start-up activity outside *top-range* environments. In this sense, our research questions include: (i) which are the university-level determinant factors that significantly influence the rate of UBC creation by parent universities (PU) located outside *top-range* environments? (ii) What can be done by research universities' managers and regional policy makers to increase start-up activity?

On the other hand, universities may show an entrepreneurial behaviour through other activities apart from firm creation (Klofsten and Jones-Evans, 2000; Landry et al., 2006; Abreu and Grivenich, 2013; Huyghe and Knockaert, 2015). In this sense, Klofsten and Jones-Evans (2000) consider as university entrepreneurship *any activity undertaken by an academic that is outside the normally accepted duties of academics, which are recognized ... as teaching and research*. Klofsten and Jones-Evans (2000) identified eight types of university entrepreneurship activities. This research concentrates on the entrepreneurshial activity number five recognized in Klofsten and Jones-Evans (2000: Table 1): "*the formation of new firm or organization to exploit the results of the university research*".

In the same line, Rothaermel et al. (2007) have extensively reviewed the University Entrepreneurship literature and concluded that there are four main literature streams: (i) the entrepreneurial research university, (ii) the productivity of technology transfer offices, (iii) new firm creation and (iv) the environmental context of innovation. This research would be included in the "*New firm creation"* stream of literature described in Rothaermel et al. (2007:749). Finally, this study fits particularly well the second and third streams of the University Entrepreneurship literature described in O'Shea et al. (2008): "Organizational determinants of university spin-off activity" (O'Shea et al., 2008: 656) and "Institutional determinants of spin-off activity" (O'Shea et al., 2008: 658).

We contribute to the field of study including in our empirical analysis data from universities located outside *top-range* environments with scarce entrepreneurial and technological resources. This is important because weak economic and technological environments have different needs and respond differently to policies compare to world-class technology clusters (DiGregorio and Shane, 2003; Degroof and Roberts 2004; Clarysse et al., 2005; Wright et al., 2008). Thus, the results of the UBC creation research from *top*-range or *eminent* universities located near global technological clusters may not be applicable to universities located outside *top-range* environments (DiGregorio and Shane, 2003; Degroof and Roberts 2004; Wright et al., 2008; Nosella and Grimaldi, 2009; Rasmussen and Borch, 2010; Fini et al., 2011).

In this sense, DiGregorio and Shane (2003: 224) found that "*For more eminent schools, we find that our results are even stronger than for the entire sample. In contrast, our model holds less well for less eminent universities.*" Moreover, the authors suggested that "*start-up rates at less eminent universities are driven by more idiosyncratic factors than start-up rates at more eminent institutions.*" In the same line, Fini et al. (2011:1113) concluded that "*regional settings' idiosyncrasies should be considered for universities to develop effective spin-off support policies*"

We also believe to make a methodological contribution to the field of research. Indeed, the unique dataset of Spanish research universities and their UBC is also a contribution of this study. In our knowledge this is the first quantitative and longitudinal study

covering a wide range of Spanish universities generating UBC. Finally, we contribute to the University Entrepreneurship field of study by including in the analysis a comprehensive set of university-level explanatory variables of start-up activity (resources, capabilities and institutions), enabling the authors and readers to have a more comprehensive view and understanding of the UBC phenomenon.

In section two we review previous studies treating the UBC creation phenomenon from the PU's points of view. Section three presents the theoretical framework of this study and develops the research hypotheses. Section four explains the research methodology adopted and in section five we present and discuss the results in the light of previous studies. Finally we conclude by giving answer to our research questions and emphasizing some implications and limitations of the study.

2. Review of previous studies

We have reviewed a total of 142 articles empirically dealing with the UBC phenomenon.[43] Articles were selected using a list of validated keywords and looking for them through the titles of the articles.[44] Only articles with more than 10 citations received during their life-time or at least 2 citations per year were included in the review. In this way we have only included those UBC articles with the highest impact in the University Entrepreneurship field of study.

From the review, we have been able to classify the UBC literature into four distinct subtopics: (i) UBC definition, types and characterization, (ii) UBC creation process and determinant factors, (iii) UBC development process and performance factors and (iv) UBC impact over individuals, universities, industries and the environment. In this sense, out of the initial review of 142 articles, we have selected 48 specifically concentrating in identifying the determinant factors of UBC creation.

Moreover, as we want to elucidate which are the organizational determinant factors that significantly influence university start-up activity, we decided to concentrate on those empirical articles using the Parent University (PU) as their unit of analysis. Following this procedure, we ended with a list of 23 articles empirically studying university-level determinant factors of start-up activity. In **Table 1** we have the summary of the reviewed articles.

[43] The list of 102 papers are available from the authors (pablo.migliorini@uab.es).
[44] Validation of keywords was done using a three-step Delphi process of consultation of academic researchers specialized in the field of University Entrepreneurship.

Table 1: Empirical articles studying university-level determinant factors of start-up activity

REFERENCE	Journal	Type of study	Conceptual Perspective	Period of Analysis	Unit of Analysis	Sample Size - nº of cases	Sample Scope	Methodology
Roberts and Malone (1996)	R&D Management	Quali, Explora & Cross	Institutional Theory	N/A	University	8	US & EU universities	Case Study
Franklin et al. (2001)	Journal of Technology Transfer	Quanti, Explora & Cross	Institutional Theory	1994 - 1998	University	57	UK universities	Mean comparison and Non-parametric tests
Di Gregorio and Shane (2003)	Research Policy	Quanti, Explana & Longi	Resource-Based View + Institutional Theory	1994 - 1998	University	457	US universities	Panel PA GEE Negative Binomial Regression
Lockett et al. (2003)	Small Business Economics	Quanti, Explora & Cross	Strategic Management	1994 - 1998	University	57	UK universities	Mean comparison and Non-parametric tests
Markman et al. (2004)	Journal of Technology Transfer	Quali + Quanti, Explora + Explana & Cross	Agency theory	1999	University	128	US universities	Case Study + Hierarchical regressions
Clarysse et al. (2005)	Journal of Business Venturing	Quali + Quanti, Explora & Cross	Resource-Based View + Institutional Theory	N/A	University	7 cases & 43 observations	EU universities	Case Study + Descriptive Statistics
Link and Scott (2005)	Research Policy	Quanti, Explana & Cross	Resource-Based View	2002	University	51	US universities	Tobit regression
Lockett and Wright (2005)	Research Policy	Quanti, Explana & Cross	Resource-Based View + Dynamic Capabilities	2001 - 2002	University	48	UK universities	Poisson + Negative Binomial Regression
Markman et al. (2005)	Journal of Business Venturing	Quali + Quanti, Explora & Cross	Agency theory + Strategic Management	1998 - 2001	University	128	US universities	Case Study + Descriptive Statistics
O'Shea et al. (2005)	Research Policy	Quanti, Explana & Longi	Resource-Based View + Dynamic Capabilities	1995 - 2001	University	987	US universities	Panel RE Negative Binomial Regression
Powers and McDougall (2005)	Journal of Business Venturing	Quanti, Explana & Cross	Resource-Based View	1996 - 2000	University	120	US universities	Negative Binomial Regression
del Palacio et al. (2006)	Inter. Entrepreneurship & Management Journal	Quali, Explora + & Cross	Process Approach	2001 - 2005	Firm + University	20 firms & 37 universities	Spanish universities	Case Study

O'Shea et al. (2007)	R&D Management	Quali, Explora + Explana & Cross	System Perspective + Resource-Based View + Institutional Theory	2001 - 2002	University	1 (MIT)	US university	Case Study
Wright et al. (2008)	Research Policy	Quali, Explora & Cross	Resource-Based View + Institutional Theory	2004 - 2005	University	6	EU universities	Case Study
Nosella and Grimaldi (2009)	Technology Analysis & Strategic Management	Quanti, Explana & Cross	Resource-Based View	2003 - 2005	University	37	Italian universities	Poisson + Negative Binomial Regression
Rasmussen and Borch (2010)	Research Policy	Quali, Explora & Longi	Dynamic Capabilities + Process Approach	N/A	Firm + University	4 firms & 2 universities	Norwegian universities	Case Study
Rodeiro et al. (2010)	Rev. Europea de Dirección y Economía de la Empresa	Quanti, Explana & Cross	Resource-Based View + Institutional Theory	2004	University	47	Spanish universities	Poisson + Negative Binomial Regression
Van Looy et al. (2011)	Research Policy	Quanti, Explana & Cross	Resource-Based View + Institutional Theory	2003	University	105	EU universities	OLS regression + Negative Binomial regression
Algieri et al. (2013)	Journal of Technology Transfer	Quanti, Explana & Cross	Resource-Based View + Dynamic Capabilities	2009	University	58	Italian universities	Logistic regression
Berbegal et al. (2013)	Journal of Business Research	Quanti, Explora & Cross	Resource-Based View	2009	University	44	Spanish universities	Data Envelopment Analysis (DEA) + Cluster and Discriminant Analysis
Swamidass (2013)	Journal of Technology Transfer	Quali, Explora & Cross	Investment risk perspective	2009	University	3	US university	Case Study
Huyghe and Knockaert (2015)	Journal of Technology Transfer	Quanti, Explana & Cross	Institutional Theory + Entrepreneurial Intentions	2012	Academic + University	437 academics & 6 universities	German & Swedish universities	OLS regression
Kalar and Antoncic (2015)	Technovation	Quanti, Explora and Explana & Cross	Institutional Theory + Entrepreneurial Intentions	2013	Academic + University	1266 academics & 4 universities	EU universities	Descriptive statistics, t-tests and exploratory factor analysis

Note: Quanti = quantitative study. Quali = qualitative stud. Explana = explanatory study. Explora = exploratory study. Longi = longitudinal study. Cross = crossectional study.

In **Table 1** we may see that the Resource-Based View (RBV) and the Institutional Economic Theory are the two most common conceptual perspectives adopted by studies in the sample. From **Table 1** we can also see that there are only two studies in the sample that are quantitative and longitudinal (DiGregorio and Shane, 2003; O'Shea et al., 2005). Moreover, most of the studies in the sample focus on parent universities located in the United States (US) or the United Kingdom (UK) as their unit of analysis. Finally, there is a variety of methodologies used in the sample, being the case study (for qualitative research) and the Poisson or Negative Binomial regression (for quantitative studies) the two most commonly used methods of analysis.

Aiming at identifying the organizational predictors of university start-up activity, we focused on those articles of **Table 1** willing to empirically explain the university-level determinant factors of UBC creation. Following this criterion, we have selected 13 articles from **Table 1**. In **Table 2** we can see the list of explanatory and empirical articles treating the UBC creation phenomenon from the PU's point of view.[45]

From **Table 2** we can see that all of these studies use differences among PU to explain differences in their rate of UBC creation. In particular, studies in **Table 2** postulate that differences among the stock of PU's resources (DiGregorio and Shane, 2003; Lockett and Wright, 2005; O'Shea et al., 2005; Powers and McDougall, 2005; Rodeiro et al., 2010), the level of PU's capabilities (Lockett and Wright, 2005; Nosella and Grimaldi, 2009; Rasmussen and Borch, 2010; Clarysse et al., 2011) and/or the availability of PU's formal or informal start-up institutions (Roberts and Malone, 1996; Franklin et al., 2001; Locket et al., 2003; Clarysse et al., 2005, O'Shea et al., 2007, Fini et al., 2009) explain inter-university differences in UBC creation.

3. Theoretical framework and hypotheses

We draw on three theoretical pillars commonly used in management science to develop our hypotheses: (i) the Resource-Based View of the firm (Penrose, 1959; Wernefelt, 1984 and 1995; Barney, 1986 and 1991; Peteraf, 1993; Barney et al., 2001), (ii) the Dynamic Capabilities Perspective (Teece and Pisano, 1994; Teece et al., 1997; Eisenhardt and Martin, 2000; Teece, 2007; Zahra et al., 2007) and (iii) the Institutional Economic Theory (North, 1990; North, 1994; Bruton et al., 2010; Powell and DiMaggio, 2012). All three conceptual perspectives have been proven to be appropriate to frame academic research in the field of Entrepreneurship and New Venture Creation (Alvarez and Busenitz, 2001).

45 We have not included in **Table 2** exploratory articles because it is not possible to clearly identify the variables under study in them.

Table 2: Explanatory and empirical articles studying university-level determinant factors of start-up activity

REFERENCE	Explained Variable/s (output/s)	Explanatory Variables (inputs)	Control Variables	Main results
Di Gregorio and Shane (2003)	Number of UBC created per year	1) VC availability in the region, 2) University commercially-oriented research, 3) Intellectual eminence of academics, 4) Royalty distribution policy for the inventor, 5) Presence of a business incubator, 6) UBC equity investment policy, 7) existence of a start-up investment fund or other sources of UBC financing.	1) number of patents assigned to the university, 2) number of invention disclosures made by academics to the TTO, 3) number of licenses agreements made by the TTO, 4) number of FTE in the TTO, 5) amount of sponsored research expenditure, 6) year dummies.	Significant UBC creation factors are: 1) intellectual eminence of faculty and academics, 2) the university policy of making equity investments in UBC and 3) the university policy of keeping a low share of royalties for the inventor. The availability of VC in the region, the commercial orientation of the research, the presence of a business incubator and the availability of sources of financing do not significantly influence the rate of UBC creation by a parent university.
Markman et al. (2004)	1) number of equity licenses to new ventures, 2) number of business incubators associated and 3) number of UBC created	1) average percentage licensing revenue given to the academic inventor, 2) average percentage licensing revenue given to the academic's department and 3) average annual salary of TTO staff.	1) age of the TTO, 2) presence of medical school, 3) amount of research grants.	Monetary incentives to academic entrepreneurs and to their departments are negatively related to start-up activity. In contrast, the salary of the TTO staff is positively related to start-up activity.
Link and Scott (2005)	Percentage of park organizations that are UBC	1) binary: 1 if university is a top 100 in terms of R&D spending and 2) Age of the park in years since its foundation.	1) Distance between the park and its university, 2) public vs private, 3) 1 if park is operated by the university, 4) 1 if IT is the dominant technology at the park, 5) 1 if bioscience is the dominant technology at the park and 6) 1 if the park is in the south of the country.	UBC are a greater proportion of the companies in older parks, in parks related to a richer technological environment, in parks that are closer to its parent university and in parks with a biotechnology focus.
Lockett and Wright (2005)	1) total number of UBC created and 2) count number of equity investments made in existing UBC.	1) total research expenditure, 2) expenditure in external IP protection services, 3) number of FTE of the TTO, 4) age in years of the TTO, 5) level of business development capabilities of the TTO, 6) the incentive and rewards policy for university entrepreneurs and 7) the royalty distribution policy for the academic inventor.	1) presence of medical school, 2) presence of a science park and 3) R&D intensity in the region.	University start-up activity is significantly influenced by: 1) the expenditure in IP protection services, 2) the level of the business development capabilities of the TTO and 3) the royalty distribution policy of university-based inventions.
O'Shea et al. (2005)	Number of UBC created per year	1) pre-sample start-up activity, 2) number of researchers, 3) science & engineering rating, 4) percentage of the science & engineering funding coming from industry, 5) number of FTE of TTO and 6) availability of business incubator.	1) presence of medical school, 2) public vs private, 3) dummy for land grant, 4) industrial development of the hosting region, 5) number of patents issued and 6) total university endowments.	Factors that positively influence university start-up activity: 1) previous start-up experience, 2) science & engineering academic quality, 3) science & engineering funding from the industry, 4) size of the TTO and 5) number of patents issued by the university. The number of researchers at the university and the availability of a business incubator are not significantly related to start-up activity.

Powers and McDougall (2005)	1) total number of UBC created during the period of analysis and 2) the count number of newly public companies to which a university had previously licensed a technology.	1) average annual industry R&D revenues over a 3-year period, 2) total number of citations received over a 3-year period, 3) index of the degree of patent basicness, 4) age in years of the TTO, 5) total amount of VC investment in the hosting metropolitan area between 1995 and 1999.	1) total university endowments secured in 1995 and 2) total number of full-time academics employed in 1995.	Factors that positively influence university start-up activity: 1) level of industry R&D funding, 2) the quality of the faculty and researchers, 3) the age of the TTO and 4) the level of VC investment in the region. The degree of patent basicness is not a significant predictor of start-up activity.
O'Shea et al. (2007)	Start-up activity in terms of the number of new ventures created by the university.	1) industry R&D funds, 2) quality of academics, 3) presence of TTO, 4) presence of entrepreneurship development programs, 5) presence of interdisciplinary research centres, 6) the mission, 7) the culture, 8) the history and 9) the environment.	0	Factors that significantly explain MIT's success in terms of new venture creation are: 1) excellence in research in practical fields, 2) large and mature networks with the government, the industry and the academia, 3) experienced organizational structures dedicated to start-up activities, 4) clear policies that encourage UBC creation, 5) highly-trained technical staff in the TTO, 6) its tradition in successfully commercializing radical technologies, 7) academics' positive attitude towards commercializing research, 8) high degree of industrial and military funding and 9) its location in one of the leading technological clusters in the world.
Nosella and Grimaldi (2009)	Number of UBC created during the period of analysis.	1) the size of TTO's networks, 2) the strength of TTO's networks, 3) number of FTE of TTO, 4) the number of start-up support services provided to university entrepreneurs: opportunity recognition, business plan development, IP protection and secure financing, 5) availability of business incubator, 6) presence of clear UBC regulations, 7) presence of a business plan competition	1) number of patents issued, 2) the region, 3) presence of a TTO.	Factors that positively influence university start-up activity: 1) the size of the TTO, 2) the intensity of the TTO's networks and 3) the availability of supportive start-up activities and mechanisms offered by the university to its members.
Rodeiro et al. (2010)	Number of UBC created in 2004.	1) total research expenditure, 2) funding for applied research, 3) number of FTE of the TTO, 4) number of academic publications per researcher, 5) percentage of doctoral dissertation in the experimental science fields, 6) age in years of the TTO and 7) presence of a business incubator and a science park.	1) percentage of GDP assigned to R&D activities in the region and 2) the number of patents issued.	The financial (R&D expenditure), human (FTE of TTO) and technological (patents) university start-up resources have a positive influence over the number of UBC created by a parent university. The start-up experience of the TTO has also a positive effect over new venture creation. On the other hand, the number of publications per researcher has a negative effect over university start-up activity. The presence of start-up support facilities (incubator and park) is not significantly related to new venture creation.

Van Looy et al. (2011)	1) amount of patent activity, 2) amount of contract research activity and 3) number of spin-offs created. (pp. 556)	The PU's scientific productivity (number of scientific publications divided by academic staff)	1) Total number of academic staff, 2) range of scientific disciplines at PU, 3) presence of a TTO, 4) number of FTE of TTO and 5) regional R&D intensity.	The size of the PU's TTO (in terms of FTE), the scientific productivity (in terms of scientific publications) and the R&D intensity of the region positively influence the number of spin-off created by PU.
Algieri et al. (2013)	"*the total variation in the number of spin-offs between 2008 and 2009*" (pp. 388/9)	1) annual budget of the TTO, 2) the age of the TTO, 3) number of FTE of the TTO, 4) number of total enrolled students, 5) ratio between number of researchers and number of professors, 6) hosting region of the TTO, 7) number of workers employed in R&D per 1000 residents, 8) percentage of public expenditure in R&D and 9) social cohesion measured by a legality and security index.	0	"*both the budget and the number of employees are statistically significant at the 10 and 1% level, respectively, with the expected positive sign." "The age of the office, on the contrary, does not influence the capacity for creating additional spin-offs." "Public expenditure in R&D is significant at the 5% level." "The number of workers employed in R&D activities is significant at the 10% level*." (pp. 391-393)
Huyghe and Knockaert (2015)	University academics intentions in terms of (i) creating a spin-off, (ii) patenting or licensing a technology (IPR intentions) and (iii) interacting with the industry (research contracts or consulting services or ISR intentions)	1) the entrepreneurial component of the university mission, 2) the presence at the PU of successful role models in university entrepreneurship, 3) the extent to which the reward system of the PU values entrepreneurial activities among PU's academics.	1) entrepreneurial self-efficacy, 2) gender, 3) academic position, 4) technical degree, 5) academic experience, 6) scientific discipline and 7) country of origin.	*"Entrepreneurial mission only shows a significant positive relationship with spin-off intentions and IPR intentions, but not with ISR intentions. The presence of spin-off role models is positively related to spin-off intentions, IPR role models to IPR intentions and ISR role models to ISR intentions. Entrepreneurial rewards has a significant positive influence on spin-off intentions just as IPR intentions, but not on ISR intentions*." (pp. 152)
Kalar and Antoncic (2015)	"All academic activities, traditional as well as entrepreneurial, were measured by *the frequency of engagement in a particular activity or the time devoted to a particular activity*." (pp. 5)	1) the entrepreneurial orientation (EO) of universities' departments measured by the ENTRE-U scale developed by Todorovic et al. (2011) and 2) the scientific discipline of the university academic (social science versus natural science).	0	"*The results indicate that perceiving the university department as highly or lowly EO may have a significant effect on whether academics engage in some activities that are more entrepreneurial in nature, but conversely has a negligible influence on academics' engagement in activities that are more traditional."* (pp. 8).

The Resources, Capabilities and Institutional frameworks have been extensively used for the study of University Entrepreneurship and the UBC phenomenon (Roberts and Malone, 1996; Shane and Stuart, 2002; DiGregorio and Shane, 2003; Siegel et al., 2003; Degroof and Roberts, 2004; Markman et al., 2004; Clarysse et al., 2005; Lockett and Wright, 2005; O'Shea et al., 2005; Powers and McDougall, 2005; O'Shea et al., 2007; Ortin et al., 2008; Fini et al., 2009; Nosella and Grimaldi, 2009; Rasmussen and Borch, 2010; Rodeiro et al., 2010; Clarysse et al., 2011; Van Looy et al., 2011; Guerrero and Urbano, 2012; Algieri et al., 2013; Berbegal et al., 2013; Resende et al., 2013; Epure et al., 2014; Guerrero et al., 2014; Rasmussen et al., 2014; Wright, 2014; Huyghe and Knockaert; 2015; Kalar and Antoncic, 2015).

For example, in an attempt to determine the characteristics and outcomes of three different models of UBC creation that PU can adopt (Low Selective, Supportive and Incubator model), Clarysse et al. (2005) identified six types of PU's resources required for UBC creation: organizational, human, technological, physical, financial and social resources. Moreover, Clarysse et al. (2005) also identified six different types of activities undertaken or support services offered by the PU aiming at facilitating new venture creation by their members: business opportunity recognition support service, the selection criteria and firm legal constitution service, intellectual property protection service, incubation and business plan development services, support in the funding process and after start-up control service.

Furthermore, O'Shea et al. (2007) found that the success of the Massachusetts Institute of technology (MIT) as a new venture creator is explained by certain formal and informal university-based institutions that facilitate the UBC creation process. In the same line, Huyghe and Knockaert (2015) found that the parent organizational culture and climate significantly influence entrepreneurial intentions among university research scientists. In this line, Kalar and Antoncic (2015: 8) concluded that: "*perceiving the university department as highly or lowly EO* -entrepreneurially oriented- *may have a significant effect on whether academics engage in some activities that are more entrepreneurial in nature.*"

In this sense, we argue that there are certain university *start-up* resources, *start-up* capabilities and *start-up* institutions that significantly influence the rate of new venture creation by PU. Indeed, in the University Entrepreneurship literature we find abundant evidence positively relating PU's stock of *start-up* resources, level of *start-up* capabilities and presence of *start-up* institutions to the rate of UBC creation.

3.1. University start-up resources and new venture creation

The Resource-Based View of the firm (RBV) was first developed by Penrose in 1959. In her book, the author describes the firm as a heterogeneous bundle of organization-specific resources that have to be managed to achieve business objectives. Thus, following this view, every organization is unique because each one is based in a different bundle of resources (Penrose, 1959; Nelson, 1991). The RBV was further developed by Wernefelt (1984 and 1995), Barney (1991 and 2001) and Barnet et al. (2001). These authors argue that firms based their competitive advantages on resources' differences. Thus in the RBV, resources provide firms with the competitive edge necessary to successfully implement business strategies and reach organizational objectives.

The RBV has been intensively used to frame multitude of business and management academic studies. In particular, the RBV has been found useful to explain differences in firm performance and organizational development success. Moreover, the RBV has also been used as the theoretical framework in several studies in the field of entrepreneurship and new venture creation. In the entrepreneurship context, the RBV postulates that there are certain resources that facilitate and foster the creation of new companies. In this sense, previous studies in entrepreneurship and management have already proven that the RBV is a valid framework to analyze business creation and development issues (Alvarez and Busenitz, 2001).

We extend this view to the university context and hypothesize that certain resources provide Parent Universities (PU) with a competitive advantage to create and develop UBC. Although the RBV was originally developed to assess differences in firms' performances in a competitive environment and in the for-profit private sector, we argue that the current reality of budgetary and grants restrictions allows us to extend this view to the university entrepreneurship context. Indeed, state-owned universities have to compete for research funds, teaching budgets and resources, star researchers and faculty, land and infrastructure grants, top-quality students and staff. In this sense, we argue that state-owned PU currently behave as private companies competing for resources (inputs) and willing to increase the number of UBC created (output).

In the University Entrepreneurship literature several authors stress the relevance of the RBV to explain inter-university differences in UBC creation rates (Shane and Stuart, 2002; DiGregorio and Shane, 2003; O'Shea et al., 2005; Powers and McDougall, 2005; Ortin et al., 2008; Rodeiro et al., 2008; Nosella and Grimaldi, 2009; Rodeiro et al., 2010; Van Looy et al., 2011; Guerrero and Urbano, 2012; Algieri et al., 2013; Berbegal et al., 2013; Guerrero et al., 2014; Wright, 2014; Shah and Pahnke, 2014). For example O'Shea et al. (2005: 1006) concluded that "*A central finding of our research confirms the notion that each university, as a function of its history and past success, has different resource stocks available and these resource combinations are shown to be a relevant factor in explaining inter-university variation in spin-off activity*."

Moreover, Powers and McDougall (2005: 296) argued that "*Given the tenets of the resource-based view as applied to contemporary research universities, certain resources may provide a university with technology transfer performance advantages.*" Therefore, in this study we argue that the stock of resources that PU advocate to start-up activities are significant predictors of UBC creation rates. In particular, we hypothesize that PU with a higher stock of resources available for start-up activities will generate a higher number of UBC per year than PU with a lower number of start-up resources available to their members.

Extending the RBV to the University Entrepreneurship context, we have called *university start-up resources* (USUR) the stock of resources used by a Parent University to create and develop UBC. Therefore, USUR are those resources advocated by a Parent University to facilitate and foster the creation and development of university-based companies (UBC). Thus, applying the RBV to the University Entrepreneurship context we propose that differences in the stock of PU's start-up resources explain differences in their rates of UBC creation. Therefore, our first main research hypothesis states that,

Hypothesis 1: There is a positive influence between a Parent University's stock of ***start-up resources (USUR)*** and its rate of new venture creation.

Moreover, the RBV is particularly helpful in shedding light on the specific resources improving university start-up activity and outcomes. Thus, the RBV brings valuable evidence in terms of the resources required by PU to create UBC (DiGregorio and Shane, 2003; Clarysse et al., 2005; Lockett and Wright, 2005; O'Shea et al., 2005; Powers and McDougall, 2005; Nosella and Grimaldi, 2009; Rodeiro et al., 2010; Guerrero and Urbano, 2012; Guerrero et al., 2014; Wright, 2014).

We have reviewed the main academic literature relating the RBV with UBC creation. In the literature we have identified four families of resources used by PU to facilitate the creation of UBC: (i) *physical start-up resources* (Mian, 1996; DiGregorio and Shane, 2003; Clarysse et al., 2005; Grimaldi and Grandi, 2005; O'Shea et al., 2005; O'Shea et al., 2007; Vendrell and Ortin, 2008; Fini et al., 2009; Nosella and Grimaldi, 2009; Rodeiro et al., 2010; Van Looy et al., 2011; Guerrero and Urbano, 2012; Algieri et al., 2013; O'Kane et al., 2015), (ii) *human start-up resources* (Franklin et al., 2001; DiGregorio and Shane, 2003; Siegel et a., 2003; Clarysse et al., 2005; Lockett and Wright, 2005; O'Shea et al., 2005; Powers and McDougall, 2005; Renault, 2006; Van Looy et al., 2011; Guerrero and Urbano, 2012; Algieri et al., 2013; Berbegal et al., 2013; Lundqvist, 2014), (iii) *technological start-up resources* (DiGregorio and Shane, 2003; Shane, 2004; Clarysse et al., 2005; O'Shea et al., 2005; Powers and McDougall, 2005; Van Looy et al., 2011; Guerrero and Urbano, 2012; Algieri et al., 2013; Berbegal et al., 2013;) and (iv) *social start-up resources* (Nicolau and Birley, 2003; Clarysse et al., 2005; O'Shea et al., 2007; Nosella and Grimaldi, 2009).

Physical start-up resources include facilities, equipment, machinery, infrastructure, buildings and office space available to university members for the creation and development of UBC. Physical start-up resources include the technology transfer office (TTO), the business incubator and the science/technology park associated to the PU (Mian, 1996; DiGregorio and Shane, 2003; Ferguson and Olofsson, 2004; Grimaldi and Grandi, 2005; Link and Scott, 2005; O'Shea et al., 2005; Landry et al., 2006; O'Shea et al., 2007; Vendrell and Ortin, 2008; Fini et al., 2009; Van Looy et al., 2011; Guerrero and Urbano, 2012; Algieri et al., 2013; O'Kane et al., 2015).

Based on previous University Entrepreneurship literature, we argue that as UBC founders do not generally count with the space and equipment to develop their entrepreneurial activities, the presence and availability of a business incubator or a science/technology park associated to the PU will increase the number of UBC created per year (Mian 1996, DiGregorio and Shane, 2003; Link and Scott, 2005).

Indeed, the availability of a PU's business incubator may provide UBC with a competitive advantage in terms of administrative cost reduction and other business development benefits (Mian, 1996; DiGregorio and Shane, 2003; Nosella and Grimaldi, 2009). In addition, the presence of a science park associated to the PU facilitates the access to key tacit knowledge, equipment and network of contacts useful for UBC development (Link and Scott, 2005; Wright et al., 2008).

Moreover, as UBC founders generally have scarce managerial and business development capabilities, the TTO plays an important role in the creation of new ventures (O'Shea et al., 2005; Powers and McDougall, 2005; O'Shea et al., 2007; Ortin et al., 2008; Vendrell and Ortin, 2008; Algieri et al., 2013; Ortin and Vendrell, 2014; O'Kane et al., 2015). In particular, it is recognized in the University Entrepreneurship literature that the TTO provides substantial assistance to university entrepreneurs during their first stages of their development process (O'Shea et al., 2005; O'Shea et al., 2007; Nosella and Grimaldi, 2009; Migliorini et al., 2010; Algieri et al., 2013; Swamidass, 2013). In this line, Powers and McDougall (2005: 299) argued that "*Given that faculty know relatively little about the business of technology commercialization ... TTO professionals are key players in the commercialization of a technology.*"

In this sense, willing to identify the characteristics of an Entrepreneurial University, O'Shea et al. (2007: 6) argued that for the Massachusetts Institute of Technology (MIT) case the TTO "*plays a very proactive role in technology transfer activities*." In the same line, Powers and McDougall (2005: 299) affirmed that "*TTOs represent an important resource to university faculty*". Moreover, O'Shea et al. (2005: 998) argued that the "*technology transfer office plays a key role with respect to engendering academic entrepreneurship.*" Finally, Algieri et al. (2013: 382) argue that "*TTOs have been created to stimulate and encourage the dissemination of the research outcomes, translate them into practice, and facilitate their interrelations with the other two agents of the innovation systems: industries and government.*" Thus, we state that

Hypothesis 1(a): There is a positive influence between a Parent University's stock of ***physical start-up resources*** and its rate of new venture creation.

In the same line, several studies in the University Entrepreneurship literature stress the importance of the human resources at the TTO for the creation and development of UBC (DiGregorio and Shane, 2003; Siegel et al., 2003; Clarysse et al., 2005; Lockett and Wright, 2005; O'Shea et al., 2005; Nosella and Grimaldi, 2009; Rodeiro et al., 2010; Van Looy et al., 2011; Guerrero and Urbano, 2012; Algieri et al., 2013; Berbegal et al., 2013; Lundqvist, 2014). For example, O'Shea et al. (2005: 998) emphasized that "*the number of full-time equivalents (FTE's) engaged in encouraging technology transfer within universities is an important determinant to successful technology transfer.*"

Moreover, Lockett and Wright (2005: 1047) argued that the "*role of the technology transfer office staff may be particularly important given the traditional non-commercial nature of university environment*." In particular, the authors affirmed that "*As academic inventors may not necessarily be the best individual to recognize an opportunity, technology transfer office staff may be more alert to such opportunities*". In the same line, Nosella and Grimaldi (2009:683) said that "*technology transfer officers can play a key role in the recognition of commercial opportunities for the inventions developed by academic scientists.*"

Furthermore, Nosella and Grimaldi (2009:683) affirmed that "*technology transfer staff has an important role in the creation of an entrepreneurial culture within the university, taking time and effort to break down the barriers that in many cases exist between university scientists and the industrial world.*" Indeed, the TTO staff of a PU is usually in charge of setting-up different types of events aiming at stimulating an entrepreneurial culture among PU's members (i.e., management courses, seminars in entrepreneurship, conferences, forums or business plan competitions). Moreover, these events also increase PU members' awareness about the university start-up support services, resources and benefits available to UBC founders (O'Shea et al., 2007; Nosella and Grimaldi, 2009; Algieri et al., 2013; Swamidass, 2013).

Thus, following previous studies in University Entrepreneurship, we argue that human resources of the TTO may provide valuable help to university entrepreneurs during different stages of the UBC creation and development process (Lockett et al., 2003; Lockett and Wright, 2005; O'Shea et al., 2005; Powers and McDougall, 2005; O'Shea et al., 2007; Nosella and Grimaldi, 2009; Algieri et al., 2013; Swamidass, 2013). Moreover, we argue that the TTO's human resources play an important role in encouraging university researchers to disclose technological innovations and commercialize them with the support of the PU (O'Shea et al., 2007; Algieri et al., 2013; Swamidass, 2013; O'Kane et al., 2015). Furthermore, the employees of the PU's TTO also help university entrepreneurs to write their business plans and secure external

financing (Nosella and Grimaldi, 2009; Algieri et al., 2013; Swamidass, 2013; O'Kane et al., 2015). Therefore, we hypothesize that:

Hypothesis 1(b): There is a positive influence between a Parent University's stock of ***human start-up resources*** and its rate of new venture creation.

It is also widely recognized in the University Entrepreneurship literature that the stock of technological resources available to PU's members fosters the creation and development of UBC (Siegel et al., 2003; Clarysse et al., 2005; Lockett and Wright, 2005; Powers and McDougall, 2005; Fini et al., 2009; Van Looy et al., 2011; Guerrero and Urbano, 2012; Algieri et al., 2013; Berbegal et al., 2013). In particular, previous studies in University Entrepreneurship identified the number of patents issued/required by the TTO or the number of technological innovations disclosed to the TTO by PU's researchers as a significant factor determining university start-up activity (Siegel et al., 2003; Nosella and Grimaldi, 2009; Rodeiro et al., 2010).

In this sense, Lockett and Wright (2005:1046) argue that: "*The stock of technology in a university provides a key resource input into the spin-out process. The higher the stock of technology, the greater the scope for the transfer of that technology.*" Moreover, DiGregorio and Shane (2003:217) claimed that: "*Because we expect that the number of TLO start-ups would be related to the number of inventions produced by the university, we control for the production of technology in three ways.*" Thus, considering that UBC are companies created with the aim of commercializing knowledge/technology developed at the PU, we argue that the stock of technological resources available to PU's members increases the number of UBC created by the PU. Therefore, we hypothesize that:

Hypothesis 1(c): There is a positive influence between a Parent University's stock of ***technological start-up resources*** and its rate of new venture creation.

Finally, the use of social networks has been also widely recognized as a key element for the creation and development of companies (Low and MacMillan, 1988; Johannisson et al., 1994). In particular, social networks are recognized in the University Entrepreneurship literature as an important factor of university start-up activity (Lockett et al., 2003; Perez and Martinez, 2003; Clarysse et al., 2005; Grandi and Grimaldi, 2005; Johansson et al., 2005; Nosella and Grimaldi, 2009).

In this sense, Lockett et al. (2003:187) argue that "*In order to develop and implement a strategy to transfer technology through spin-out companies, universities may need access to key expertise and networks.*" Moreover, the authors affirm that the "*networks of universities' working relationships with both external organizations and individuals may also be crucial to the successful implementation of spin-out strategies.*"

In the same line, Nosella and Grimaldi (2009) argue that there are four main advantages in using networks to foster university start-up activity: (i) facilitate the business opportunity recognition by members of the PU, (ii) improve access to key start-up resources, (iii) save time and (iv) they are used a source of status or to provide referrals to third parties. Thus, Nosella and Grimaldi (2009) propose that "*the higher the level of social resources that UTTUs have, the greater will be the number of academic spin-offs generated.*" Therefore, we make the following hypothesis:

Hypothesis 1(d): There is a positive influence between a Parent University's stock of ***social start-up resources*** and its rate of new venture creation.

3.2. The effective use of resources: university start-up capabilities

The effective application of university start-up resources (USUR) in the UBC creation process depends on the abilities and knowledge of the users of those USUR. In this sense, Wu (2007: 549) "*proposes that an intermediate variable, dynamic capability, existed between start-up performance and resources. Moreover, in actual operations, this study demonstrated that dynamic capabilities were significant, transforming entrepreneurial resources into performance, and that dynamic capabilities were the mediating variable between entrepreneurial resources and performance. Without dynamic capabilities to convert resources into advantage, entrepreneurial resources do not translate into performance*." Thus, in this study we argue that there are certain university start-up capabilities (USUC) that condition the effective use of USUR and therefore also determine university start-up performance.

The RBV is complemented years later by the dynamic capabilities perspective (Teece and Pisano, 1994; Teece et al., 1997). In this framework capabilities are resources that are not fixed or static; they are flow measures in contrast with stock of resources (Lockett and Wright, 2005). Thus, capabilities can be learned, improved, flawed or abandoned with time. In this sense, capabilities may be seen as dynamic or flow resources that evolve and develop with their use and application (Lockett and Wright, 2005).

Trying to explain the nature of Dynamic Capabilities in a more practical and empirically useful manner, Eisenhardt and Martin (2000: 1107) defined them as: "*the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve and die*." The authors further explain this definition in terms of "*Dynamic capabilities are the antecedent organizational and strategic routines by which managers alter their resource base ... to generate new value-creating strategies.*" The authors also affirmed that dynamic capabilities "*are neither vague nor tautological*" but they are "*a set of specific and identifiable processes such as product development, strategic decision making and alliancing.*" (Eisenhardt and Martin, 2000: 1105).

Moreover, Alvarez and Busenitz (2001) have conceptually related the Dynamic Capabilities perspective with the Entrepreneurship Theory. In this article the authors claim that is possible to identify specific abilities that facilitate the entrepreneurial activity. In this sense, Alvarez and Busenitz (2001) identified three types of entrepreneurial capabilities: (i) *entrepreneurial alertness* (the opportunity recognition capability), (ii) *entrepreneurial knowledge* (or start-up experience) and (iii) the *ability of coordinating resources* (managerial capabilities).

Furthermore, Lockett and Wright (2005) reaffirmed Penrose's seminal view that differentiated between firms' resources and the "*productive services*" that can be created by deploying a firm's stock of resources (Penrose, 1959). In particular, the authors identified some "*capabilities and routines possessed and developed by universities that may be expected to enable them to generate spin-outs*." (Lockett and Wright, 2005: 1046). Moreover, the authors argued that these "*routines/capabilities are likely to be unequally distributes across universities and involve processes for assessing intellectual property rights, processes for spinning-out companies, and skills embodied in university staff in terms of both managing the commercialization process and specific technical and marketing skills.*"

Following this line of reasoning, in this study we argue that PU's differences in the level of entrepreneurial routines/capabilities explain differences in their level of start-up activity. Therefore, we hypothesize that:

Hypothesis 2: There is a positive influence between a Parent University's level of ***start-up capabilities (USUC)*** and its rate of new venture creation.

We have reviewed the University Entrepreneurship literature to identify the most relevant categories of university start-up capabilities (USUC). We have found in the literature that parent universities may foster the creation of new firms by their members using or applying two types of start-up capabilities: (i) university ***business development capabilities*** (Roberts and Malone, 1996, Locket et al., 2003; Siegel et al., 2003; Clarysse et al., 2005; Locket and Wright, 2005; del Palacio, 2006; Ortin et al., 2008; Fini et al., 2009; Nosella and Grimaldi, 2009; Rasmussen and Borch, 2010; Clarysse et al., 2011; Guerrero and Urbano, 2012; Resende et al., 2013; Swamidass, 2013; Guerrero et al., 2014; Wright, 2014) and (ii) ***university start-up experience*** (Meyer, 2003; Siegel et al., 2003; Markman et al., 2004; Link and Scott, 2005; Locket and Wright, 2005; Powers and McDougall, 2005; Rasmussen and Borch, 2010; Clarysse et al., 2011; Guerrero and Urbano, 2012; Algieri et al., 2013; Berbegal et al., 2013; Swamidass, 2013; Guerrero et al., 2014).

University business development capabilities refer to a variety of university start-up support services, activities and practices aiming at facilitating university members to create and develop companies based on the knowledge developed at the PU (Roberts and Malone, 1996; Steffensen et al., 2000; Siegel et al., 2003; Clarysse et al., 2005;

Lockett and Wright, 2005; Ortin et al., 2008; Nosella and Grimaldi, 2009; Guerrero and Urbano, 2012; Berbegal et al., 2013; Resende et al., 2013; Swamidass, 2013; Wright, 2014).

For example, PU may offer to its members technical support to recognize and evaluate potential business opportunities (Clarysse et al., 2005; Lockett and Wright, 2005; del Palacio et al., 2006; Nosella and Grimaldi, 2009; Resende et al., 2013; Swamidass, 2013), to write a business plan (Clarysse et al., 2005; Lockett and Wright, 2005; del Palacio et al., 2006; Nosella and Grimaldi, 2009), to find sources of start-up financing (Clarysse et al., 2005; Lockett and Wright, 2005; del Palacio et al., 2006; Vendrell and Ortin, 2008; Nosella and Grimaldi, 2009) or to protect and commercialize intellectual property developed at the PU (Clarysse et al., 2005; Siegel et al., 2003; Lockett and Wright, 2005; Nosella and Grimaldi, 2009; Algieri et al., 2013).

In this line, Nosella and Grimaldi (2009:684) affirmed that: "*Another important factor that helps to explain cross-university variation in the generation of academic start-ups is represented by the organisational services that universities offer to support the creation of new ventures.*" Moreover, Lockett and Wright (2005:1048) argued that: "*Universities with greater development capabilities may be able to focus attention on those spin-outs, which they perceive are going to make the greatest return.*" Following these arguments we hypothesize that:

Hypothesis 2(a): There is a positive influence between a Parent University's level of ***business development capabilities*** and its rate of new venture creation.

Furthermore, the effective application of university start-up capabilities (USUC) highly depends on the level of knowledge and experience accumulated by parent universities in their task of spinning-out new ventures (Markman et al., 2004; Link and Scott, 2005; Lockett and Wright, 2005; Rasmussen and Borch, 2010; Clarysse et al., 2011; Algieri et al., 2013; Berbegal et al., 2013). In this sense, Lockett and Wright (2005: 1048) emphasized that "*the development of these routines/capabilities* (university start-up capabilities) *relies heavily upon the experience and expertise of technology transfer personnel.*" In the same line, Rasmussen and Borch (2010) found that "*these capabilities* – university start-up capabilities - *are dependent on prior spin-off experience*".

In particular, the literature stresses the positive relation between the number of years that a PU is involved in technology transfer and start-up activities and its rate of UBC creation (Siegel et al., 2003; Markman et al., 2004; Link and Scott, 2005; Lockett and Wright, 2005; Rodeiro et al., 2010; Algieri et al., 2013). In this line, Markman et al. (2004: 358) emphasized that "*older university TTOs are assumed to be more experienced and have access to a broader industry network.*" Similarly, Lockett and Wright (2005:1047) affirmed that "*Experience may be positive associated with the length of time a university has been actively involved in technology transfer activities.*"

Furthermore, the experience in start-up activities accumulated by a PU increases the efficiency of the technology transfer officers of the PU and therefore improve the quality of start-up support services offered by the PU to their members (Siegel et al., 2003; Lockett and Wright, 2005; Rodeiro et al., 2010). In this line, Lockett and Wright (2005: 1047) affirmed that the "*Experience of spinning-out companies is an important resource that may increase the efficiency of a university in spinning-out companies. Through being actively involved in technology transfer activities, universities may become better able to create university spin-outs.*" Thus, we argue that PU with longer experience in start-up activities will generate more UBC than PU with shorter start-up experience. Hence, we hypothesize that:

Hypothesis 2(b): There is a positive influence between a Parent University's level of ***start-up experience*** and its rate of new venture creation.

3.3. Contextualizing resources and capabilities: university start-up institutions

Resources and capabilities used or applied by PU are highly context dependent (Roberts and Malone 1996; Degroof and Roberts, 2004; Clarysse et al., 2005; Wright et al., 2008; Rasmussen and Borch, 2010). In this sense, formal and informal context-related factors will significantly influence the amount and variety of resources and capabilities available to PU (Mustar et al., 2006; Guerrero and Urbano, 2012; Guerrero et al., 2014; Wright, 2014; Huyghe and Knockaert; 2015; Kalar and Antoncic, 2015). The Institutional Economic Theory first developed by North (1990) named these context-related or environmental factors *institutions*.

Institutions include any form of constraint that human beings create to shape human interaction (North, 1990). Institutions can be either formal (i.e. laws, policies, political and economic rules or contracts) or informal (i.e. codes of conduct, attitudes, perceptions, values, norms of behaviour or cultural conventions). Recent work on the heterogeneity of research-based spin-offs describes the institutional perspective as the relationship with and the embeddedness within firms' parent organisations, which have their own cultures, incentive systems, rules and procedures (Mustar et al., 2006).

Thus, in this study we claim that there are certain university *start-up* institutions (USUI) that limit the access to USUR and condition the use of USUC; therefore, also determining university start-up activity. We draw on the Institutional Economic Theory and on previous UBC creation studies to develop our third main research hypothesis that states that:

Hypothesis 3: There is a positive influence between a Parent University's presence of ***start-up institutions (USUI)*** and its rate of new venture creation.

We have reviewed the main studies relating the institutional perspective with UBC creation phenomenon. From our review we have identified studies that focus on ***formal institutional factors*** (Franklin et al., 2001; DiGregorio and Shane, 2003; Markman et al., 2004; Clarysse et al., 2005; Debackere and Veugelers, 2005; Lockett and Wright, 2005; Renault, 2006; O'Shea et al., 2008; Fini et al., 2009; Guerrero and Urbano, 2012; Berbegal et al., 2013; Guerrero et al., 2014; Wright, 2014; Huyghe and Knockaert; 2015) and ***informal institutional factors*** (Siegel et al., 2003; Ferguson and Olofsson, 2004; del Palacio et al., 2006; Renault, 2006; O'Shea et al., 2007; Fini et al., 2009; Guerrero and Urbano, 2012; Berbegal et al., 2013; Guerrero et al., 2014; Wright, 2014; Huyghe and Knockaert; 2015; Kalar and Antoncic, 2015).

University start-up formal institutions refer to official written norms and policies that are accepted by every member of the PU. In this sense, we have identified in the literature three categories of formal policies directly influencing the rate of UBC creation by PU: (i) the incentive and reward system of the PU (Lockett et al., 2003; Markman et al., 2004; Lockett and Wright, 2005; Renault, 2006; Fini et al., 2009; Guerrero and Urbano, 2012; Berbegal et al., 2013; Huyghe and Knockaert; 2015), (ii) the new venture projects' selection criteria (Roberts and Malone, 1996; Degroof and Roberts, 2004; Clarysse et al., 2005) and (iii) the mission and objectives of the PU's technology transfer office (Clarysse et al., 2005; Markman et al., 2005; Mustar et al., 2006; Wright et al., 2008; Guerrero and Urbano, 2012; Berbegal et al., 2013; Guerrero et al., 2014; Huyghe and Knockaert; 2015).

The incentive system refers to policies and norms of a PU that stipulate the monetary and labour benefits awarded to UBC founders (Markman et al., 2004; Renault, 2006; Fini et al., 2009; Huyghe and Knockaert; 2015). In this sense, we argue that an appropriate incentive system *signals to the academics that the university is seeking to encourage technology transfer* (Lockett and Wright, 2005: 1048). Thus, we agree with Lockett and Wright (2005) about the *positive relationship between an incentive and reward system that promotes commercialization and the creation of university spin-outs*. In the same line, Berbegal et al. (2013: 2057) concluded that *universities should design more attractive incentives for faculty members*.

Moreover, selection criteria refers to the PU's requirements in order for a start-up project to be able to access the PU's start-up program/s, resources and services (Roberts and Malone, 1996; Degroof and Roberts, 2004; Clarysse et al., 2005). In this sense, we agree argue that PU with less restrictive selection criteria (in terms of new projects acceptance) will generate a greater number of UBC than PU with a low rate of acceptance of new venture projects. Furthermore, start-up formal institution refers to the university mission and objectives in terms of knowledge transfer activities (O'Shea et al., 2007; Guerrero and Urbano, 2012; Berbegal et al., 2013; Guerrero et al., 2014; Huyghe and Knockaert; 2015). The mission and objectives of the TTO plays a key role in determining the effort that PU's members will put in the UBC creation process (Huyghe and Knockaert; 2015).

Following the different university start-up strategies identified in Clarysse et al. (2005), we argue that PU with a reward system valuing knowledge transfer activities, with an open UBC selection criteria and fully integrating knowledge transfer activities in their mission statement, will generate significantly more firms than PU with a reward system and mission statement prioritizing traditional academic activities (teaching and research) and following a restrictive criteria to accept UBC.

Thus, we draw on previous studies in UBC creation to argue that there are certain formal university *start-up* institutions (formal USUI) that significantly influence the rate of UBC creation by PU. Thus, we hypothesize that:

Hypothesis 3(a): There is a positive influence between a Parent University's presence of ***start-up formal institutions*** and its rate of new venture creation.

Finally, university start-up informal institutions refer to role models, unwritten rules, common understandings and ways of behaviour shared (but not necessary accepted) by the PU's community (Huyghe and Knockaert; 2015; Kalar and Antoncic, 2015). These factors may be summarized in what is usually called the *culture* of the PU (Huyghe and Knockaert; 2015). In this sense, O'Shea et al. (2007) claimed that one of the most important factors explaining MIT's entrepreneurial success is the university favourable culture towards knowledge commercialization and faculty involvement in business development. Thus, in this study we argue that there are a set of informal university start-up institutions (informal USUI) that will foster or hinder university start-up activity.

We have grouped university start-up informal institutions found in the UBC literature around four main categories: (i) perceptions about the priority given to knowledge transfer and UBC creation activities by the PU (Renault, 2006; O'Shea et al., 2007; Huyghe and Knockaert; 2015; Kalar and Antoncic, 2015), (ii) perceptions about the "effective" availability of UBC support services provided by the PU to its members (Fini et al., 2009), (iii) perceptions about the entrepreneurial attitude of the PU and their members (O'Shea et al., 2007; Fini et al., 2009; Huyghe and Knockaert; 2015; Kalar and Antoncic, 2015) and (iv) perceptions about the level of involvement of the PU during the start-up process (Renault, 2006; O'Shea et al., 2007).

Therefore, we argue that the PU members' perceptions about how entrepreneurial is the culture present at the PU will affect their decisions of founding UBC (O'Shea et al., 2007; Renault, 2006; Fini et al., 2009; Huyghe and Knockaert; 2015; Kalar and Antoncic, 2015). In this sense, Renault (2006:230) proposed that "*the norms and informal rules of the institution provide a context for the individual to make choices. The most important norm is the professor's beliefs about academic capitalism and the proper role of the university in the commercialization of inventions that emerge from university research. These beliefs constrain the entire decision-making process that a*

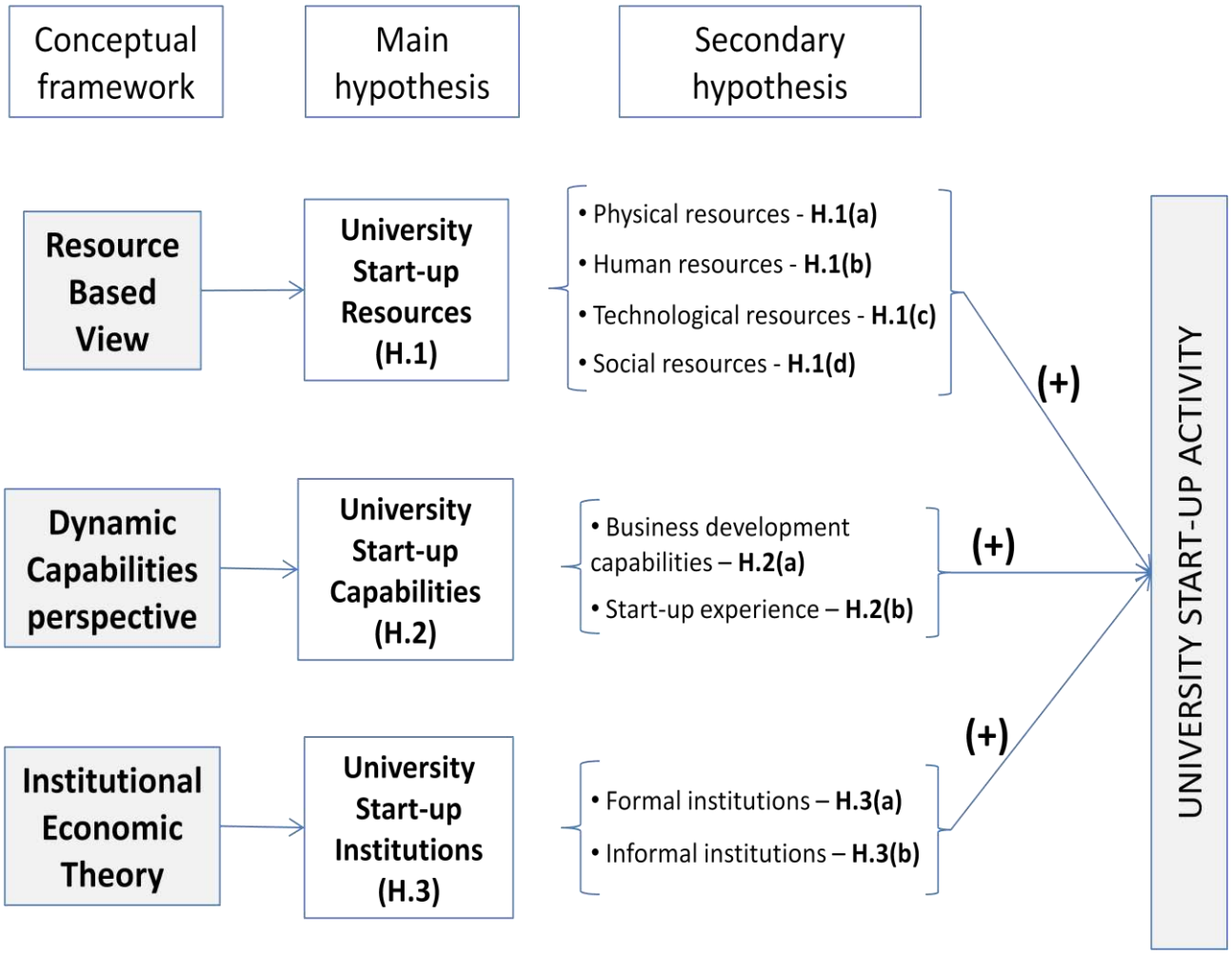
professor uses when evaluating research topics, assessing different funding sources and deciding how to publicize his/her results."

Thus, in this study we draw on previous contributions in the University Entrepreneurship field of research to argue that there are certain informal university start-up institutions (informal USUI) that significantly influence UBC creation rates. Therefore, we hypothesize that:

Hypothesis 3(b): There is a positive influence between a Parent University's presence of ***start-up informal institutions*** and its rate of new venture creation.

To end this section of the study, we present in **Figure 1** a graphic representation of our theoretical framework and the research hypotheses we shall empirically test in the following section.

Figure 1: Theoretical framework and research hypotheses



4. Data and methodology

4.1. Population and unit of analysis

In the Spanish university system, start-ups are mainly created by state-owned universities (Ortin et al., 2008; Rodeiro et al., 2008; Vendrell and Ortin, 2008; Beraza and Rodriguez, 2009; Rodeiro et al., 2010; Vendrell and Ortin, 2010; Beraza and Rodriguez, 2011; Guerrero and Urbano, 2012; Iglesias et al., 2012; Guerrero et al., 2014; Ortin and Vendrell, 2014; Sanchez-Barrioluengo, 2014). Usually, private universities have little or no start-up activity. This is due to the fact that private Spanish universities usually present a scarce research base frequently insufficient for spinning-off new ventures. [46]

On the other hand, public Spanish universities count with a pre-assigned research budget and a significant stock of research resources (i.e. land grant campus, research centres and specialized facilities, science and technology parks, innovation networks). Thus, some public Spanish universities developed a set of research capabilities that allowed them to undertake profitable technology transfer processes (del Palacio et al., 2006; Beraza and Rodriguez, 2011; Guerrero and Urbano, 2012; Iglesias et al., 2012; Guerrero et al., 2014; Sanchez-Barrioluengo, 2014).

In this sense, Sanchez-Barrioluengo (2014: 1764) emphasizes that: "... *public universities, which represent a quarter of total R&D expenditure and almost half of all research in Spain.*" Moreover, we agree with Sanchez-Barrioluengo (2014: 1765) who argue that: "*The importance of these public institutions in the Spanish research system puts them at the core of this analysis. Excluding the National Distance Education University, our study population is composed of 47 Spanish public HEIs*" In the same line, we consider Spanish in-person state-owned universities as our unit of analysis.

From our field work we have identified a total of 48 state-owned Spanish universities offering in-person (face to face) degrees. At-distance (eyewitness) universities as the UNED (the National Distance Education University*)*, present similar limitations compare to private universities in terms of a scarce research base and limited technological resources contributing to start-up formation. Thus we have not included at-distance universities in our population of analysis.

This result is in line with the findings in previous studies of the University Entrepreneurship phenomenon in Spain (Beraza and Rodriguez, 2009; Rodeiro et al., 2010; Beraza and Rodriguez, 2011; Iglesias et al., 2012; Berbegal et al., 2013; Sanchez-Barrioluengo, 2014). Therefore, we consider these 48 Spanish public in-person universities as our population of analysis.

[46] There are few exceptions to this fact. For example the Ramon Llull University also show significant start-up activity especially in the fields of engineering and computer science.

Due to the lack of updated information in the Spanish UBC field of research it is difficult to give an accurate figure of the total number of new ventures created by Spanish universities (Ortin et al., 2008; Rodeiro et al., 2010; Iglesias et al., 2012; Sanchez-Barrioluengo, 2014). As we consider this information to be key for our research, we decided to undertake a census of the Spanish UBC population. Thus, at the beginning of the year 2012 we ask all 48 Spanish public in-person universities to count and give us the total number of start-ups created during their life-time.

In **Table 3** we have the list of the 48 state-owned in-person Spanish universities and the number of UBC created by them. **Table 3** shows that there are two universities in the Spanish population that, at the moment of the survey, have not created any company at all (University La Laguna and University of Vic). Moreover, **Table 3** also shows that there are three universities answering that they were not involved in start-up activities and therefore did not want to participate in the survey (University of Jaen, University of Leon and University of Salamanca).

From **Table 3** we may also see that the Polytechnic University of Valence (UPV) is by far the most active parent institution in terms of new venture creation. With more than 500 UBC created and a long trajectory of technology transfer activities, we may consider the UPV as an outsider case. Indeed, UPV has an active start-up and new venture creation program supported by a formal Technology Transfer Office (TTO) since the year 1992. Moreover, UPV has an active Intellectual Property Protection Office (IPPO) giving service to university members since the year 1980. Thus, for our analysis we consider the Polytechnic University of Valence as an outsider case in terms of UBC creation and start-up activity in Spain.

On the other hand, due to the "open" selection criteria applied by the university, the total number of firms created with the support of the UPV may be over-estimated. For example, Iglesias et al. (2012: Table 2) using a very restrictive criteria to define UBC, found that UPV only had one company meeting the conditions to be considered by the authors as a proper UBC.[47] In this sense, UPV considers any company created with some support from the TTO as UBC. This support may be limited to just one or two interviews with a technology transfer officer or a business creation officer.

Thus, for some of the companies that UPV considers as UBC, their founders deny such status arguing that they just consulted the UPV's TTO once or twice but did not receive any significant support from it (i.e. opportunity recognition services, search for public finance and subsidies, business plan development, incubation services, proof of concept, intellectual property protection services or help to find first clients/sales). Moreover, many of the companies created with the UPV's support are not active anymore. In this sense, Ortin et al. (2008) found that only 166 of the companies created with the UPV's support were still in activity in the year 2007.

[47] Iglesias et al. (2012) consider as UBC any technology-based company directly linked to a parent university (PU) research department and founded by academics from the PU.

Table 3: Population of Spanish state-owned parent universities and UBC by the year 2011

NAME OF UNIVERSITY	Autonomous Community	Total UBC created
Universidad Autònoma de Barcelona	Catalonia	45
Universidad Autónoma de Madrid	Madrid	19
Universidad Carlos III de Madrid	Madrid	24
Universidad Complutense de Madrid	Madrid	16
Universidad de Alcalá	Madrid	6
Universidad de Alicante	Valence	5
Universidad de Almería	Andalucia	22
Universidad de Barcelona	Catalonia	60
Universidad de Burgos	Castile Leon	1
Universidad de Cádiz	Andalucia	30
Universidad de Cantabria	Cantabria	22
Universidad de Castilla La Mancha	Castile La Mancha	8
Universidad de Córdoba	Andalucia	20
Universidad de Extremadura	Extremadura	11
Universidad de Girona	Catalonia	9
Universidad de Granada	Andalucia	64
Universidad de Huelva	Andalucia	8
Universidad de Jaén	Andalucia	N/A
Universidad de La Coruña	Galicia	21
Universidad de La Laguna	Canary Islands	0
Universidad de La Rioja	La Rioja	2
Universidad de las Islas Baleares	Baleares Islands	8
Universidad de Las Palmas de Gran Canaria	Canary Islands	47
Universidad de León	Castile Leon	N/A
Universidad de Lérida	Catalonia	4
Universidad de Málaga	Andalucia	61
Universidad de Murcia	Murcia	10
Universidad de Oviedo	Asturias	12
Universidad de Santiago de Compostela	Galicia	28
Universidad de Salamanca	Castile Leon	N/A
Universidad de Sevilla	Andalucia	39
Universidad de Valencia	Valence	10
Universidad de Valladolid	Castile Leon	21
Universidad de Vic	Catalonia	0
Universidad de Vigo	Galicia	15
Universidad de Zaragoza	Aragon	22
Universidad del País Vasco	Basque Country	34
Universidad Jaume I	Valence	5
Universidad Miguel Hernández de Elche	Valence	6
Universidad Pablo de Olavide	Andalucia	4
Universidad Politécnica de Cartagena	Murcia	6
Universidad Politécnica de Cataluña	Catalonia	69
Universidad Politécnica de Madrid	Madrid	46
Universidad Politécnica de Valencia	Valence	501
Universidad Pompeu Fabra	Catalonia	3
Universidad Pública de Navarra	Navarra	28
Universidad Rey Juan Carlos	Madrid	6
Universidad Rovira i Virgili	Catalonia	10

Source: own survey

From **Table 3** we can also see that the Polytechnic University of Catalonia and the Polytechnic University of Madrid are also very active in terms of new venture creation.[48] In fact, with the exception of the recently founded, small-sized and rather isolated Polytechnic University of Cartagena, all polytechnic universities in Spain seem to be important poles of start-up creation (Ortin et al., 2008; Beraza and Rodriguez, 2011; Guerrero and Urbano, 2012; Guerrero et al., 2014; Ortin and Vendrell, 2014; Sanchez-Barrioluengo, 2014).

4.2. Data collection and sample description

As emphasize in Rodeiro et al. (2010) one of the main problems of doing research in the Spanish UBC field is the scarcity and incompleteness of usually incoherent information available in secondary sources. Therefore, in order to obtain faithful information from Spanish parent universities and their start-up activity, we developed a three-stage data collection process.

In the first stage we sent to all 48 public universities rectors' offices a postal letter introducing the research and asking for the contact data of their technology transfer offices (TTO). 100% of the surveyed population answered the letter. Three out of 48 universities (6%) mentioned idiosyncratic limitations and answered that they did not want to participate in this research. Two additional universities (4%) were reluctant to participate in this research because they did not count with any specific start-up creation program or resources. This let us a first stage response rate of 90% and a total of 43 universities going to the next stage in the data collection process.

In stage two we sent an email to the 43 directors of the Spanish TTO still in the process. In this email we introduced once again the research in process and also asked them to send back by email a list with the names and year of foundation of every company created with the parent university support. By doing so, we collected all necessary information related to our dependent variable (the number of start-ups created by year and by Parent University). We received back a total of 34 complete lists with names and founding years of the companies generated by each parent university (80% response rate).

In the third stage and in order to collect the necessary information about our explanatory variables, we developed a questionnaire survey including 67 variables related to university start-up resources, capabilities and institutions for a seven-year period (2004-2010 included). **Appendix 1** shows the complete questionnaire that we sent. Before sending the survey to universities we have interviewed seven TTO directors in order to

[48] In chapter two of this doctoral dissertation we have found that by the end of the year 2007, the Polytechnic University of Catalonia (UPC) has 139 active UBC. As in the case of the Polytechnic University of Valence (UPV), this figure is also overstated because of the fact that the UPC considers as UBC a broad range of companies not always linked to the parent university.

refine and clarify the questionnaire. In May 2012 we sent the questionnaire to the 34 TTO that have properly answered in stage two. After several email reminders and telephone calls, we have been able to collect 16 complete questionnaires with all 67 variables for every year of the period under analysis (47% response rate). Thus, this set of 16 state-owned in-person universities constitutes our sample of analysis.

In **Table 4a** we have the technical summary of the study. From this table we can see that with 95% of confidence the maximum error of the sample is 20% (assuming maximum dispersion among observations). This means that a new study using the whole population of Spanish PU instead of a sample, would find results that differ from our results in a maximum of 20%. In other words, we can consider that 80% of the results in this study would be very similar to the results found in a study using the total population of Spanish PU instead of a sample.

Table 4a: Technical summary of the study

Time period of field work	From September 2011 to July 2012.
Time frame of data	From the year 2004 to the year 2010 (included).
Population of study	48 state-owned in-person universities.
Geographical scope	Spain.
Sampling and data collection procedure	Survey sent by email to the heads of universities' TTO (several follow-ups by email and telephone).
Sample size	16 universities and 7 years => 112 year observations.
Response rate	33%
Confidence interval	95%
Sample proportion	50% (maximum dispersion)
Sample error	20%

16 complete questionnaires represent only one third of the total universe of state-owned in-person Spanish universities. Thus, we have run a mean difference test between the 16 universities that answered the survey and the other 32 universities that did not answered in a complete manner or did not answer at all. We have found no significant differences between the mean numbers of UBC created by the two groups ($p<0,05$). Therefore, we believe that sample bias should not hinder the results of our analysis.

From **Table 4b** we can see that the parent universities compounding our sample have created 349 UBC until the year 2011. Considering the Polytechnic University of Valence as an outsider in terms of start-up activity, the population of Spanish state-owned in-person universities has generated a total of 887 UBC until 2011. In this sense, we include in our sample parent universities generating almost 40% of the total number of UBC created in Spain. Moreover, our sample of parent universities is evenly distributed among different Spanish autonomous communities. In this sense, our sample includes universities from all major Spanish regions in terms of start-up activity (Catalonia, Valence, Madrid, Andalucia and Galicia).

Furthermore, Sanchez-Barrioluengo (2014: 1766) found that "*In 2007 and 2008 Spanish universities created 220 new spin-offs.*" Following this finding, the population of Spanish universities create in average 2,34 UBC per year. In **Table 4b** we can see that this figure is very similar to the average number of UBC created per year by our sample of Spanish PU (2,30 UBC per PU per year). In this line, Rodeiro et al. (2008) found that in the year 2004 the population of Spanish Universities have created an average of 2,85 UBC per year.

In addition, Sanchez-Barrioluengo (2014: Table 2) found that the population of Spanish public universities applied in average to 19,5 patents in the years 2007 and 2008 (thus, 9,75 patents applications per PU per year). Once more this figure is very similar to the findings in our sample of Spanish PU (11,7 patents applications per PU per year). All these argumentations favour the representativeness of our sample of study and limit the effects of sample bias.

We have followed a similar work done by O'Shea et al. (2005) to define the number of years under analysis. Moreover, we have selected this specific time frame (2004-2010) looking for variability in our dependent and independent variables.[49] In this sense, we have gathered data from 16 Spanish state-owned universities for the time period going from year 2004 to the year 2010 included (112 year observations). **Table 4b** presents some general results to describe the sample of analysis.

Spanish PU in our sample have created in average almost 22 UBC per university since they started to spin-off companies until the year 2011. This result is consistent with the evidence shown in other studies focusing on universities in US or Europe but located outside *top-range* environments. For example Degroof and Roberts (2004) found that their sample of eight universities located in *mid-range* environments in Belgium generated an average of 12,5 UBC since they started to spin-off companies until the year 2001 (ten years before our sample). In the same line, Wright et al. (2008) found that a sample of four universities located outside *top-range* environments in the UK, Belgium and Holland have generated an average of 16,5 UBC until the year 2004 (seven years before our sample).

On the other hand, O'Shea et al. (2005) presented evidence that the top twenty PU (in terms of start-up activity) have created a total of 1376 UBC until the year 2001 (O'Shea et al., 2005: Table 1). Generalizing this results to the whole population of top-range US universities we can conclude that top-range US universities have created in average 68,8 UBC until the year 2001. This is a figure more than three times bigger than in our sample. Thus, considering that our sample includes UBC creation observations until the year 2011, we may conclude that our sample of Spanish PU is effectively composed by universities located outside *top-range* environments.

[49] Indeed, from the year 2004 onwards we can witness a change among Spanish universities relative to start-up activity and resources devoted to it. While some universities in the sample started to generate UBC between these years, others started to offer incubation space for new ventures during this period.

Moreover, we can see in **Table 4b** that every Parent University (PU) in the sample has created at least one UBC during its lifetime. Indeed, until the year 2011 the University of Burgos has generated only one start-up company. On the other end of the sample we find two universities from Andalucía: the University of Malaga with 70 UBC created and the University of Granada with 64 UBC created. This high variability in start-up activity among parent universities is also evident in previous studies (DiGregorio and Shane, 2003; Lockett and Wright, 2005; O'Shea et al., 2005; Ortin et al., 2008; Rodeiro et al., 2010; Iglesias et al., 2012; Berbegal et al., 2013; Epure et al., 2014; Sanchez-Barrioluengo, 2014). The variability in the number of UBC created by parent universities increases our motivation to understand the organizational determinant factors of university start-up activity.

During the period of analysis (2004-2010), our sample of parent universities has generated 258 UBC. Again we see a high variability in the number of new ventures created by sampled parent universities during the period of analysis. While University of Granada or University of Malaga have generated in average more than 7 UBC per year, the University of Burgos or the University Pompeu Fabra have created in average less than half a UBC per year between the period 2004 and 2010.

We would like to emphasize that with the exception of Santiago de Compostela University, [50] most of the companies generated by sampled parent universities were created during the period of analysis (2004-2010). This may be due to the fact that before the year 2004 start-up activity was much reduced among Spanish state-owned universities (Ortin et al., 2008; Rodeiro et al., 2008; Rodeiro et al., 2010; Epure et al., 2014; Ortin and Vendrell, 2014).

Moreover, we can see in **Table 4b** that with five exceptions (Malaga, Granada, Seville, Santiago de Compostela and Cantabria), all other parent universities have generated cero UBC in at least one year of the period under analysis. In the same line, 75% of PU in the sample have created a maximum of five UBC in one year. Thus, we may deduct that we shall deal with a skewed distribution of our dependent variable (UBC created per year) around cero and very low values.

Furthermore, while in the sample there are some parent universities with a relatively long start-up experience (i.e. Granada, Huelva, Malaga or Santiago de Compostela), others have recently started to create UBC (i.e. Burgos, Lerida or Pompeu Fabra). In the same line, we find that while some PU in the sample have long counted with a technology-transfer office (TTO) (i.e. La Coruña, Huelva or Islas Baleares), others have recently started to offer this service to university members (i.e. Burgos, Lerida or Pompeu Fabra). It is important to remark that every university in the sample counted with a TTO before the end of the year 2010.

[50] Santiago de Compostela University has a long tradition in new venture creation and therefore was already an active start-up generator before the year 2004.

Table 4b: Sample description

UNIVERSITY NAME	Total UBC created (until 2011)	UBC created (2004 - 2010)				Patents apps. (Avg / year)	Age in years (until 2011) of							Avg UBC / year (until 2011)*	Nº of full-time employees (Avg / year)			
		Total	Avg / year	Min / year	Max / year		1st UBC	PROG	TTO	IPPO	INCUB	PARK	FUND		TTO	IPPO	INCUB	Total
Alcalá	**8**	6	0,9	0	2	12,6	7	7	7	23	4	10	0	1,14	0,6	2,6	0,4	3,6
Burgos	**1**	1	0,1	0	1	3,4	3	3	3	17	4	6	6	0,33	0,3	2,1	0	2,4
Cantabria	**23**	18	2,6	1	5	1,7	12	13	13	3	13	13	0	1,92	1,6	0,4	2	4
Extremadura	**11**	11	1,6	0	4	5,7	8	8	8	23	7	3	0	1,38	0,3	0,3	0	0,6
Granada	**64**	54	7,7	2	11	29,2	21	12	12	10	0	0	0	3,05	1	1,7	0	2,7
Huelva	**10**	8	1,1	0	3	3,1	15	16	17	19	0	0	0	0,67	0,9	1	0	1,9
Islas Baleares	**15**	7	1,0	0	2	5,3	12	4	16	16	0	0	0	1,25	0,4	5	0	5,4
La Coruña	**25**	18	2,6	0	5	7,4	11	8	21	21	8	7	2	2,27	0,3	3	0,3	3,6
Lérida	**6**	4	0,6	0	2	2,4	5	6	6	6	5	7	0	1,20	1,4	1,4	0	2,8
Málaga	**70**	51	7,3	2	14	22,6	14	15	8	23	15	0	0	5,00	1	1,1	0	2,1
Pompeu Fabra	**4**	3	0,4	0	1	4,6	6	20	6	6	1	5	0	0,67	0,4	1,1	0	1,5
Rey Juan Carlos	**6**	6	0,9	0	2	5,1	8	6	8	7	4	0	0	0,75	1	1	0,4	2,4
Santiago de Compostela	**28**	11	1,6	1	3	27,3	13	8	14	23	14	0	0	2,15	9,1	1,9	4,9	15,9
Sevilla	**44**	34	4,9	1	12	38,1	11	14	8	23	7	19	0	4,00	0,9	1,3	0,9	3,1
Valencia	**11**	10	1,4	0	5	8,9	6	8	7	23	4	5	0	1,83	0,7	3,1	0,9	4,7
Valladolid	**23**	16	2,3	0	8	9,4	10	7	5	23	5	5	0	2,30	1,6	0,9	0	2,5
Total / Average	**349**	**258**	**2,30**	**0,4**	**5,0**	**11,7**	**10,1**	**9,7**	**9,9**	**16,6**	**5,7**	**5,0**	**0,5**	**1,87**	**1,3**	**1,7**	**0,6**	**3,7**

* Since the creation of the first UBC.

Source: own survey

From **Table 4b** we can see that every university in the sample also counts with an intellectual property protection office (IPPO) with the aim of managing the commercialization rights of university discoveries and technological innovations. The IPPO is generally older than the TTO in our sample of Spanish parent universities. Indeed, there are several universities in the sample counting with an IPPO for more than 20 years (i.e. Malaga, Sevilla or Santiago de Compostela). On the other hand, most of the universities in the sample have recently started to offer incubation space (INCUB) for their UBC (i.e. Pompeu Fabra, Burgos or Rey Juan Carlos) or did not count with a business incubator by the end of year 2010 (i.e. Huelva, Islas Baleares or Granada).

Following **Table 4b** we can also see that several universities in the sample did not count with a science and technology park by the end of year 2010 (i.e. Malaga, Granada, Huelva or Rey Juan Carlos). On the other hand, universities as Seville, Cantabria or Alcala have a science park for ten years or more. Finally, only the University of La Coruña and the University of Burgos had a start-up investment fund by the end of year 2010. All other parent university in the sample did not count with an investment fund to finance start-up projects during the period of analysis.[51]

4.3. Variables and model of analysis

4.3.1. Variables

Similar to previous longitudinal studies about organizational determinant factors of university start-up activity, our dependent variable is the count number of university-based companies (UBC) created by a Parent University (PU) at a given year (DiGregorio and Shane, 2003; O'Shea et al., 2005). This variable is characterized by a discrete non-negative function with an over-dispersion around cero and very low values.

Because most UBC outside *top-range* environments tend to be life-style companies with moderate growth rates and small regional impact (Degroof and Roberts, 2004; Nosella and Grimaldi, 2009; Beraza and Rodriguez, 2011), some researchers may argue that the count number of new ventures created by PU does not fully represent the scope of technology transfer activities at research universities (Harrison and Leitch, 2010; Epure et al., 2014; Ortin and Vendrell, 2014). Indeed, from a regional perspective, a variable measuring the quality, the performance and/or the impact of all UBC created by each PU would possibly be more relevant to study. The measurement and use of such a variable exceeds the scope of the present study.

On the other hand, several authors have recognized the appropriateness and relevance of new venture creation as a measure of university performance in terms of technology transfer activities (Anderson et al., 2007; Kim, 2011; Berbegal et al., 2013). In this sense, in an efficiency input/output analysis of Spanish universities Berbegal et al.

[51] This lack of variability is the reason why we could not include the availability of PU's start-up investment funds as an explanatory variable in our econometric model.

(2013: 2054) argue that: "*the number of new academic ventures in 2009 is found to be the most appropriate output linked to knowledge transfer activities.*"

Moreover, from the empirical data and based on the conceptual framework described before, we have been able to collect information about resources, capabilities and institutions used by Spanish parent universities to create and develop UBC. Due to the large amount of closely related explanatory variables included in our survey, we suspect that we may have multi-collinearity restrains if all explanatory variables were directly included in the analysis.

Thus, we decided to undertake two techniques to reduce the number of explanatory variables we want to test and to ensure orthogonality among the factors included in the analysis. In this sense we have undertaken a principal component analysis (PCA) including all quantitative scale variables and a multiple correspondence analysis (MCA) including all qualitative categorical variables from the survey.

We have first run a PCA for all seven years as a pooled-data sample. In **Appendix 2** we can see the results of the PCA including all explanatory quantitative variables as a pool sample. We can see in **Appendix 2** that the KMO and Barlett test indicate that undertaking a PCA with this set of variables is an adequate technique to reduce dimensions without losing much of the explaining power of the model. Keeping components with eigenvalues over the unity, the PCA reduces 33 quantitative explanatory variables to nine factors or components with a total variance explained equal to 83% of the original sample (see **Appendix 2**).

In order to confirm the stability of these factors among the seven years in the sample, we have also run a PCA for each of the seven years included in the sample independently (year by year). In **Appendix 3** we can see the results of all seven PCA (one per year of analysis). We have found five components remaining stable along all years in the sample. These five components explain 58% of the total variance explained by the 33 initial quantitative variables from the survey.

Moreover, not all the variables of a component remained the same for different years (the composition of the factors changes depending on the year of the sample). Thus, with the objective of naming the components, we have only kept (inside each component) the variables being part of the factors in every year of the sample. **Appendix 4** shows the variables included in the five stable factors obtained from the PCA. Finally, the number of the component that should be considered may change for each year of the sample. **Appendix 5** shows the name and the number of the component for each of the years in the sample that is included in the regression analysis.

In **Appendix 4** we can see that the yearly-stable variables included in component one are: (i) *intellectual property protection services* (Siegel et al., 2003; Locket and Wright, 2005; Nosella and Grimaldi, 2009), (ii) *support for business plan* realization and

presentation (Locket and Wright, 2005; del Palacio et al., 2006; Nosella and Grimaldi, 2009), (iii) *opportunity recognition and evaluation support* (Locket and Wright, 2005; del Palacio et al., 2006; Nosella and Grimaldi, 2009) and (iv) *support to find public start-up finance* (del Palacio et al., 2006; Nosella and Grimaldi, 2009).

We have followed Locket and Wright (2005) and measure the variables included in component one of the PCA using a Lickert Scale. Respondents were asked to rate the level or quality of start-up support service offered by the PU from one (poor) to seven (excellent). We have called this first component "***Business development capabilities***" and is related to our second research hypothesis about the influence of university start-up capabilities over the rate of new venture creation.

In the second component of the PCA we have found four variables that remained stable for every year: (i) *perceptions about the involvement of the PU during the start-up process* (Renault, 2006; O'Shea et al., 2007), (ii) *perceptions about the priority given by the Parent University to knowledge transfer and start-up activities* (Renault, 2006; O'Shea et al., 2007), (iii) *perceptions about the availability of start-up services offered by the PU* (Renault, 2006; Fini et al., 2009) and (iv) *perceptions about the entrepreneurial attitude of the PU* (O'Shea et al., 2007; Fini et al., 2009).

Similar to Renault (2006), the values of the variables of the second component were obtained using a one to seven Lickert Scale. Respondents were asked to give their subjective perceptions about the PU's involvement during the start-up process, about the "effective" availability of the start-up support services provided by the PU, about the priority given by the PU to knowledge transfer and start-up activities and about the entrepreneurial attitude of the PU (Renault, 2006). We have called this second component "***Start-up informal institutions***" and is related to our third research hypotheses about the influence of university start-up institutions over the rate of new venture creation.

The third component of the PCA includes two variables that remain stable for every year: (i) the *number of full time employees (FTE) in the PU's business incubator* and (ii) the *number of FTE in the PU's technology transfer office* (TTO). In the University Entrepreneurship literature the TTO's and the business incubator's personnel are directly linked to the creation of new ventures by PU (DiGregorio and Shane, 2003; Siegel et al., 2003; Lockett and Wright, 2005; O'Shea et al., 2005; Nosella and Grimaldi, 2009; Rodeiro et al., 2010). We have called this third component "***Start-up human resources***" and is related to our first research hypotheses about the influence of university start-up resources over the rate of new venture creation.

Component four of the PCA includes two variables that remain stable for every year: (i) the *number of national patents applications* and (ii) the *number of international patents applications* by the parent university in each year. The number of patent applications is

a good proxy of the number of patents issued by PU.[52] In this sense, the number of patent applications is a fair measure of the knowledge and technology stock available for university entrepreneurs to start-up new ventures (DiGregorio and Shane, 2003; O'Shea et al., 2005; Nosella and Grimaldi, 2009; Rodeiro et al., 2010).[53] Thus, we have called this third component "***Start-up technological resources***" and is related to our research hypotheses one about the influence of university start-up resources over the rate of new firm creation.

Finally we can see in **Appendix 4** that component five includes three stable variables: (i) the *age in years of the TTO*[54], (ii) the *age in years of the first UBC created* with the support of the PU and (iii) the *age in years of the start-up program* offered by the PU. The numbers of years that a PU has been undertaking start-up activities is a measure of the experience that the PU has in creating new ventures (Markman et al., 2004; Lockett and Wright, 2005; Powers and McDougall, 2005; O'Shea et al., 2007). We have called this last component "***Start-up experience***" and is related to our second research hypotheses about the influence of university start-up capabilities over the rate of new venture creation.

Moreover, we have also run a multiple correspondence analysis (MCA) to reduce the number of categorical variables included in the analysis. In **Appendix 6** we can see the results of the MCA undertaken. As shown in **Appendix 6.1**, we have been able to reduce five binary variables (the presence or not of a *business incubator*, existence of *other incubation space*, existence of a *TTO*, existence of an *IPPO* or existence of a *Science Park*) into one dimension called "***Start-up physical resources***" (DiGregorio and Shane, 2003; Lockett and Wright, 2005; Markman et al., 2005; O'Shea et al., 2005; Nosella and Grimaldi, 2009; Rodeiro et al., 2010).

Furthermore, in **Appendix 6.2** we can see that we have reduced two binary variables (presence or not of a *network of investors* and presence or not of an *R&D network*) into one dimension called "***Start-up social resources***" (Siegel et al., 2003; O'Shea et al., 2007; Nosella and Grimaldi, 2009).

In **Appendix 6.3**, we can see that the same categories of the variables related to parent universities' start-up policies are grouped together, indicating that the binary variables *leave of absence policy*, *labour incompatibility policy* and *day reduction policy* may be grouped together under one dimension that we have called "***Start-up formal institutions***" (Franklin et al., 2001; Lockett et al., 2003; Siegel et al., 2003; Markman et al., 2004; Clarysse et al., 2005). In **Appendix 7** we can see a description of the qualitative variables included in the three dimensions obtained from the MCA.

[52] Because universities effectively issue only a portion of the patents they apply for, the number of patent applications should be always greater than the number of patents effectively issued.
[53] We could have also used the number of patents actually approved (instead of required) with similar results in our findings.
[54] It is operationalize as the number of years since the TTO has at least 0,5 FTE.

Summarizing this part of the methodology section, in **Table 5** we describe the five components from the PCA and the three dimensions obtained in the MCA including the corresponding items and literature references for each of the factors found. Finally, to close the variables subsection of this study, we show in **Table 6** the description of all variables included in the analysis and we also show the main descriptive statistics for each of them.

Table 5: Description and bibliographic references of the PCA and MCA factors included

FACTOR DOMAIN	FACTOR NAME	FACTOR ITEMS AND DESCRIPTION	FACTOR REFERENCES
USUR	**Physical Resources**	Presence of: a technology transfer office (TTO), a business incubator, an intellectual property protection office (IPPO) and a science park.	Mian (1996, 1996a), DiGregorio and Shane (2003), Clarysse et al. (2005), Link and Scott (2005), Lockett and Wright (2005), O'Shea et al. (2005), O'Shea et al. (2007), Fini et al. (2009), Nosella and Grimaldi (2009), Rodeiro et al. (2010).
USUR	**Human Resources**	Number of full-time employees (FTE) working at the TTO and number of FTE working at the business incubator.	DiGregorio and Shane (2003), Siegel et al. (2003), Clarysse et al. (2005), Lockett and Wright (2005), O'Shea et al. (2005), Nosella and Grimaldi (2009), Rodeiro et al. (2010).
USUR	**Technological Resources**	Number of national and international patent applications (or invention disclosures) done by the PU.	Siegel et al. (2003), Clarysse et al. (2005), Lockett and Wright (2005), Powers and McDougall (2005), Fini et al. (2009), Nosella and Grimaldi (2009), Rodeiro et al. (2010).
USUR	**Social Resources**	Availability of a start-up equity investment network and availability of a network of R&D external agents.	Lockett et al. (2003), Perez and Martinez (2003), Clarysse et al. (2005), Grandi and Grimaldi (2005), Johansson et al. (2005), Nosella and Grimaldi (2009).
USUC	**Business Development Capabilities**	Quality of university start-up support services in opportunity recognition, IP protection, business plan development and start-up finance.	Siegel et al. (2003), Clarysse et al. (2005), Lockett and Wright (2005), O'Shea et al. (2007), Fini et al. (2009), Nosella and Grimaldi (2009), Rasmussen and Borch (2010), Clarysse et al. (2011).
USUC	**Start-up Experience**	Age of the TTO, age of the first UBC created and age of the university start-up program of PU.	Siegel et al. (2003), Markman et al. (2004), Link and Scott (2005), Lockett and Wright (2005), O'Shea et al. (2005), Powers and McDougall (2005), O'Shea et al. (2007), Rodeiro et al. (2010).
USUI	**Formal Institutions**	Availability of favourable start-up policies and incentive systems for UBC founders: leave of absence policy, day reduction policy and labour incompatibility policy.	Roberts and Malone (1996), DiGregorio and Shane (2003), Siegel et al. (2003), Markman et al. (2004), Clarysse et al. (2005), Lockett and Wright (2005), Fini et al. (2009).
USUI	**Informal Institutions**	Perceptions about PU's involvement during the start-up process, the priority given by PU to start-up activities, the availability of PU's start-up support services and the entrepreneurial attitude of the PU.	Siegel et al. (2003), Markman et al. (2004), Lockett and Wright (2005), O'Shea et al. (2007), Fini et al. (2009).

Table 6: Description and descriptive statistics of the variables included in the analysis

VARIABLE	Definition	TYPE	N	Mean	S.D.	Min.	Max.	Hypo.
Yit	Number of UBC created by university *i* in year *t*	non-negative integers	112	2,30	3	0	14	Dep. Var.
TTOit	Presence of a Technology Transfer Office at university *i* in year *t*	Binary (yes = 1; no = -1)	112	0,73	0,7	-1	1	H1.a
IPPOit	Presence of an Intellectual Property Protection Office at university *i* in year *t*	Binary (yes = 1; no = -1)	112	0,82	0,6	-1	1	H1.a
INCUBit	Presence of a Business Incubator affiliated to university *i* in year *t*	Binary (yes = 1; no = -1)	112	0,07	1	-1	1	H1.a
OINCUBit	Presence of other start-up incubation space in university *i* in year *t*	Binary (yes = 1; no = -1)	112	-0,07	1	-1	1	H1.a
PARKit	Presence of Science Park affiliated to university *i* in year *t*	Binary (yes = 1; no = -1)	112	0,27	1	-1	1	H1.a
TTO_FTEit	Number of full-time employees of the TTO of university i in year t	Non-negative continuous	112	1,32	2,3	0	14	H1.b
INCUB_FTEit	Number of full-time employees of the Incubator of university i in year t	Non-negative continuous	112	0,61	1	0	5	H1.b
NAT_PATit	Number of national patents' applications of university *i* in year *t*	Non-negative integers	112	8,32	7,9	0	32	H1.c
INTER_PATit	Number of international patents' applications of university *i* in year *t*	Non-negative integers	112	3,35	5,2	0	25	H1.c
INVEST_NETit	Presence of a start-up investment network affiliated to university *i* in year *t*	Binary (yes = 1; no = -1)	112	-0,57	0,8	-1	1	H1.d
R&D_NETit	Presence of a R&D network affiliated to university *i* in year *t*	Binary (yes = 1; no = -1)	112	0,07	1	-1	1	H1.d
BUSOPP_SUPPit	Level of opportunity recognition support services of university *i* in year *t*	Lickert scale (min=1; max=7)	112	5,31	2,2	1	7	H2.a
IPP_SUPPit	Level of intellectual property protection services of university *i* in year *t*	Lickert scale (min=1; max=7)	112	5,13	2,3	1	7	H2.a
BUSPLAN_SUPPit	Level of business plan support services for members university *i* in year *t*	Lickert scale (min=1; max=7)	112	5,44	2,2	1	7	H2.a
PUBLIC_FINANit	Level of public start-up financing support services of university *i* in year *t*	Lickert scale (min=1; max=7)	112	4,91	2,3	1	7	H2.a
UBC_XPit	Age in years of the first UBC created by university i in year t	Non-negative integers	112	10,1	4,8	3	21	H2.b
TTO_XPit	Age in years of the Technology Transfer Office of university i in year t	Non-negative integers	112	9,9	5,1	3	21	H2.b
PROG_XPit	Age in years of the UBC creation program of university i in year t	Non-negative integers	112	9,69	5,1	3	20	H2.b
LEAVE_ABSCit	Leave of absence incentive policy for UBC founders in university *i* in year *t*	Binary (yes = 1; no = -1)	112	0,23	1	-1	1	H3.a
DAY_REDUCit	Day reduction incentive policy for UBC founders in university *i* in year *t*	Binary (yes = 1; no = -1)	112	0,16	1	-1	1	H3.a
INCOMPAit	Labour incompatibility policy for UBC founders in university *i* in year *t*.	Binary (yes = 1; no = -1)	112	-0,21	0,5	-1	1	H3.a
PRIOR_KTRANSFERit	How important are knowledge transfer activities for university *i* in year *t*?	Lickert scale (min=1; max=7)	112	3,51	2,5	1	7	H3.b
UBC_SERVICESit	How available are the start-up support services offered by university *i* in year *t?*	Lickert scale (min=1; max=7)	112	3,98	2,1	1	7	H3.b
PU_INVOLVEit	How much involved is university *i* in year *t* in the start-up creation process*?*	Lickert scale (min=1; max=7)	112	3,37	2,1	1	7	H3.b
PU_ATTITUDEit	How entrepreneurial is the attitude of university *i* in year *t?*	Lickert scale (min=1; max=7)	112	4,17	2,1	1	7	H3.b

4.3.2. Model specification

In this study we want to empirically test the following relationship:

$$\mathbf{UBC_t} = \boldsymbol{f}\,(\,\mathbf{USUR_t};\ \mathbf{USUC_t};\ \mathbf{USUI_t}\,)$$

Thus, to test our hypothesis about the influence of university start-up resources (***USUR***), university start-up capabilities (***USUC***) and university start-up institutions (***USUI***) over the rate of new venture creation by PU, the following model is estimated:

$$\boldsymbol{Y_{it}} = \boldsymbol{f}\,(\beta_0 + \beta_1\,\boldsymbol{USUR_{it}} + \beta_2\,\boldsymbol{USUC_{it}} + \beta_3\,\boldsymbol{USUI_{it}} + \eta_i + v_t) \qquad \textbf{(1)}$$

where $\boldsymbol{Y_{it}}$ is the count number of companies started by university *i* in year *t*; $\boldsymbol{USUR_{it}}$ are university *i* start-up resources in year *t;* $\boldsymbol{USUC_{it}}$ are university *i* start-up capabilities in year *t* and $\boldsymbol{USUI_{it}}$ are university *i* start-up institutions in year *t*. Moreover, the terms η_i and v_t represent university and year specific unobservable differences with explanatory power.

As our dependent variable takes the form of count data, using Ordinary Least Squares (OLS) estimation models to test our hypothesis would be inappropriate (Greene, 2000). Indeed, following the literature there are two main ways to deal with discrete count data dependent variables: (i) Poisson regression models and (ii) negative binomial regression models (Haussman et al., 1984; Cameron and Trivedi, 1986; Cameron and Trivedi, 2013).

Although Poisson is the most commonly used regression model to treat count data, it still has its limitations. In particular a Poisson distribution assumes that the conditional mean of the dependent variable is equal to its variance (Cameron and Trivedi, 1986). This condition is violated when there is over or under dispersion in the data (Cameron and Trivedi, 1986; Cameron and Trivedi, 2013).

We have run a goodness-of-fit test to evaluate if the Poisson distribution assumption of equal-dispersion holds in our case. The null hypothesis in the test is that the conditional mean of the dependent variable equals its variance (equal-dispersion), while the alternative hypothesis is that the conditional mean of the dependent variable is not equal to its variance (over-dispersion). The test indicated a highly skewed distribution around zero and very low values. Thus we have rejected Poisson because of over-dispersion in our dependent count variable.

The negative binomial regression models basically provide a solution to the over-dispersion issue by assuming a gamma distribution of the conditional mean of the dependent variable (Rodeiro et al., 2010). Thus, negative binomial models allow the conditional mean and the variance of the dependent count variable to differ (Cameron and Trivedi, 2013).

So in this study, and following the methodology used in previous similar studies, we apply negative binomial regression models to evaluate the organizational determinants of university start-up activity (DiGregorio and Shane, 2003; Lockett and Wright, 2005; O'Shea et al., 2005; Powers & McDougall, 2005; Nosella and Grimaldi, 2009; Rodeiro et al., 2010).

Thus, based on **equation (1)** we analyze a 7-year panel data sample using negative binomial random effects estimation models to evaluate the influence of parent universities' start-up resources, capabilities and institutions over the rate of new venture creation. Previous research has suggested that a 7-year time frame is appropriate to study the creation of UBC (O'Shea et al., 2005).

As our dependent variable is highly skewed around cero and low values, we have to rule-out fixed-effects regression models and therefore we rely on a random-effects' estimation technique (Hausman et al., 1984; Cameron and Trivedi, 1986; O'Shea et al., 2005). In this sense, O'Shea et al. (2005: 1001) argue that: "*Assuming unobserved heterogeneity is randomly distributed across universities ... we rely on a random effect model. The reason that guides our choice is that our data exhibits highly skewed distributions and as such many universities generate no spinoffs in a given year or over consecutive periods of time. This rules out a fixed effects model*."

Thus, similar to O'Shea et al. (2005), this study has the methodological limitation of assuming that unobserved differences among PU (in terms of start-up activity) do not respond to a common pattern (i.e. the entrepreneurial attitude and intentions of PU's members). Finally, we apply maximum likelihood estimation to obtain the value of the regressors.

5. Empirical evidence and discussion

5.1. General results

Table 6 describes all the variables included in the analysis and show the main descriptive statistics of them. Following **Table 6**, during the period of analysis (2004-2010), Spanish parent universities have created in average 2,3 UBC per year. This finding is consistent with the results obtained in Rodeiro et al. (2010) where the authors found that the population of 47 Spanish in-person and state-owned universities have created in average 2,85 UBC in the year 2004 (Rodeiro et al., 2010: Table 2).

This result is also consistent with the empirical evidence found in other UBC creation studies dealing with *mid-range* parent universities (PU). For example Fini et al. (2009) found that their sample of five PU located in *mid-range* environments in Italy created an average of 2 UBC per year between the year 1999 and the year 2005 (Fini et al., 2009:

Table 2). In the same line, Nosella and Grimaldi (2009) found that that their sample of 37 Italian universities created in average 2,54 UBC during the year 2004 (Nosella and Grimaldi, 2009: Table 6).

Moreover, Degroof and Roberts (2004) found that for a group of eight universities located in weak entrepreneurial environments in Belgium have created an average of 1,5 UBC in the year 2000 (Degroof and Roberts, 2004: Figure 4). Even though this figure may seem low, we should consider the time period of the study. Indeed, in the year 2000 most Spanish universities did not create any company at all. In the same line, Wright et al. (2008) found that a group of four universities (University of Nottingham, Ghent University, University of Brussels and University of Antwerp) located in *mid-range* environments in UK, Belgium and Holland have created until the year 2004 an average of 1,62 UBC per year. Similarly, we have found that our sample of *mid-range* Spanish universities have created until the year 2011 an average of 1,87 UBC per year (see **Table 4**).

On the other hand, O'Shea et al. (2005) found that the top twenty universities (in terms of start-up activity) have created 949 UBC in a seven-year period. Thus, O'Shea et al. (2005) presented evidence that top-range universities in the US created an average of 6,76 UBC per year between the year 1995 and the year 2001. This number is almost triple that the average number of UBC created per year by our sample of Spanish universities between the year 2004 and the year 2010. Once more, this fact provides evidence that university start-up activity is a smaller phenomenon in Spain compare to top-range universities located in the US.

It is also interesting to compare our results with the findings in Roberts and Malone (1996) complemented with the results in Clarysse et al. (2005). On the one hand, Roberts and Malone (1996) concluded that for PU located in highly developed environments (in terms of availability of venture capital firms and entrepreneurs), a low-selective and low-support model of UBC creation is the most appropriate. On the other hand, Clarysse et al. (2005) found that while PU using a low-selective and low-support UBC creation model generated an average of 5,8 UBC in the year 2002, PU using an incubator model (high-selective and high-support model) generated an average of 2,6 UBC in the same year (Clarysse et al. (2005: Table 6).

Continuing with the description of our general results, in 87% of the year observations in our sample we were able to identify a specific organizational structure (inside or outside the PU) to foster the creation and development of UBC (see **Table 6**). This organizational structure, usually called TTO, showed for our sample of PU an average age of ten years old (until the year 2011) and an average number of 1,32 FTE (full-time employees). This result differs from that obtained in Rodeiro et al. (2010). In this study the authors found that the average age of Spanish university TTO is 12,2 years old (until year 2004). The authors also found that in average Spanish TTO counted in 2004 with 13,85 FTE dedicated to technology transfer and start-up activities.

Thus Rodeiro et al (2010) found that in average Spanish TTO are nine years older and have ten times more FTE than our sample of 112 university-year observations. The difference in the number of FTE may be explained by the fact that we only considered technical (not administrative) TTO's personnel specifically advocated to UBC creation and start-up activities. Thus, we did not include in our sample neither FTE working at the intellectual property protection office (IPPO) or at the science park nor FTE working at the TTO but in administrative positions. In terms of the age of the TTO the issue may be the small number of PU in our sample. Moreover, we have excluded the Polytechnic University of Valence as being considered an outsider in terms of start-up activity.

On the other hand, our results are consistent with other studies treating the UBC creation phenomenon in universities located in *mid-range* environments. For example, Fini et al. (2009) found that the in average Italian PU has opened their TTO and started to offer an UBC creation program in mid 2002. Thus, the authors found that in average Italian TTO have, until the year 2011, 8,5 years old. Moreover, the authors found that in average Italian TTO have 1,7 FTE in charge of start-up activities. In this line, Nosella and Grimaldi (2009) found that in the year 2004 the average number of FTE working at Italian TTO was 2,6 (Nosella and Grimaldi, 2009: Table 6).

Finally, Wright et al. (2008) in a qualitative study of *mid-range* universities found that in the year 2004 the University of Nottingham (UK) had two FTE dedicated two start-up activities. The authors also found that in the same year the University of Brussels (Belgium) had three FTE dedicated to the same purpose (Wright et al., 2008: Table 4).

Our results are also consistent with studies focusing on universities located in more developed environments. For example, in a study of 101 US universities (including 89 of the top 100 universities in US and accounting for 85% of the total number of patents issued to US universities), DiGregorio and Shane (2003) found that during the period 1994-1998 the average number of FTE in top-range US universities' TTO was 6,77 (DiGregorio and Shane, 2003: Table 1).

Similarly, in a study of 48 top-range universities in UK, Lockett and Wright (2005) found that the average number of FTE working at UK university TTO was 5,56 employees in the year 2002 (Lockett and Wright, 2005: Table 2). Moreover, using a sample of 103 UK universities[55], the authors found that UK university TTO have an average of 7,13 years old (until the year 2002). Thus, Lockett and Wright (2005) found that in average UK university TTO were settled down in the year 1995 (Lockett and Wright, 2005: Table 1).

Our results show that during the period of analysis (2004-2010), 53,5% of the Spanish PU in the sample have a business incubator affiliated to them. Moreover, we have found

[55] 48 universities responding to their whole questionnaire and 55 universities not answering to the full survey (see Table 1 in Lockett and Wright, 2005). Thus, making a total of total of 103 observations.

that 63,5% of the universities in the sample count with the presence of a science park also affiliated to them. These results are consistent with Rodeiro et al. (2010) who found that in the year 2004, 38% of Spanish PU had an affiliated business incubator and that 55% of them had a science and technology park associated to them. Thus, we may see a logical progression in the availability of physical start-up resources in the Spanish university system. On the other side, in a study of 128 US university TTO, Markman et al. (2005) found that in the year 2001, 62% of US universities counted with a business incubator for start-up activities (Markman et al., 2005: Table 5).

In terms of the availability of technological resources, we have found that in average our sample of Spanish universities have made 11,7 patents' applications per year.[56] This value is in line with the findings obtained in Rodeiro et al. (2010) where the authors found that in the year 2004 Spanish PU issued an average of 7,9 patents (Rodeiro et al., 2010: Table 2). Our result is also consistent with other studies of top-range universities. For example, DiGregorio and Shane (2003) found that during the period 1994-1998, 101 US universities have issued in average 21,3 patents and have disclosed an average of 79,4 technological inventions.

From **Table 6** it is remarkable to see that during the period of analysis, only 53,5% of Spanish PU in our sample count with a network of R&D external institutions to support UBC creation. Moreover, we have found that in average only 22% of the Spanish PU in our sample has a network of external equity investment agents to finance start-up activity.[57] This result differ from Nosella and Grimaldi (2009) who found that in 2004 their sample of 37 Italian PU has in average 5,5 ties with R&D, financial and other external organizations that may facilitate the start-up process (Nosella and Grimaldi, 2009: Table 6).

From **Table 6** we can see that the business development capabilities of the universities in our sample have been highly graded by respondents. In this sense, the average grade for the four business development capabilities surveyed was 5,2/7 (almost 75%). This result is similar to the findings in Lockett and Wright (2005). In this study, including 48 top-range UK universities, the authors found that respondents rated the business development capabilities construct with an average grade of 3,11/5 (62%).

On the other side, the average grade given by respondents to university start-up informal institutions is equal to 3,7/7 (53%). In particular respondents said that Spanish PU show a limited level of involvement during the start-up process. We did not find any quantitative study enabling us to compare this result with other *mid-range* environments or with top-range universities' studies.

[56] Including national and international patents' applications.

[57] Including business angels, private investors, venture capital firms, investment funds, bancs or other type of financial institution.

5.2. Organizational determinants of university start-up activity

In **Table 7** we can see the results of the negative binomial regression for the seven-year panel data under analysis. We have included in the regression analysis the five stable quantitative components obtained in the PCA and the three categorical dimensions obtained in the MCA. Furthermore, we may see in **Table 8** the confirmation of our research hypothesis including all eight components of the econometric model and the three corresponding research hypotheses previously described.

Considering university start-up resources (USUR), we have found that while social and technological start-up resources are significant predictors of university start-up activity ($p < 0{,}001$), physical and human resources do not seem to significantly influence the rate of new venture creation by PU. Therefore, following the empirical evidence found in this study we are able to confirm hypotheses **H1.c** and **H1.d**. On the other hand, hypotheses **H1.a** and **H1.b** are not supported by the results of this study (see **Table 8**).

In particular, we have found that PU offering university entrepreneurs access to equity investment networks and networks of R&D institutions, create significantly more companies than PU with no networking connexions with external financing or R&D agents ($p < 0{,}001$). Thus, we fully confirm our hypothesis **H1.d** about the positive influence that the stock of social USUR has over the rate of UBC creation by PU.

This result is consistent with the findings in Nosella and Grimaldi (2009). In this study of 37 PU located outside *top-range* environments in Italy, the authors found that the intensity (frequency) of the ties that the PU has with external organizations has a positive influence over the number of UBC created by the PU. On the other hand, Nosella and Grimaldi (2009) could not found any evidence supporting their hypothesis that the size (number) of university start-up networks has a positive influence over UBC creation.

Comparing our results with other studies focusing on universities located in *top-range* environments, we have also found some evidence (but not empirically proven) that university networks are significant determinants of university start-up activity (Lockett et al., 2003; Siegel et al., 2003). In this sense, Siegel et al. (2003:42) conclude that "*the formation of social networks could be important in university-industry technology transfer.*" In the same line, Lockett et al., (2003:187) affirmed that "*the networks of universities' working relationships with both external organizations and individuals may also be crucial to the successful implementation of spin-out strategies.*"

Our empirical evidence also shows that Spanish PU with a higher stock of technological USUR will generate more UBC than PU with scarce and rather limited technological USUR ($p < 0{,}001$). In this sense, PU applying for a high number of national and/or international patents generate significantly more UBC than PU applying for a smaller number of patents each year. Thus, we can fully confirm our hypothesis **H1.c.**

We may compare this result with other studies of PU located outside *top*-range environments using the number of patents issued as a control variable in their analysis. For example, Rodeiro et al (2010) found that the number of patents issued by Spanish PU is positively and highly related to the number of UBC created by them. In contrast, Nosella and Grimaldi (2009) have found that the number of patents issued by PU has no impact over university start-up activity outside *top*-range environments.

Moreover, other studies of universities located in more advanced or developed entrepreneurial environments presented similar results to ours. For example, Siegel et al. (2003) found that the number of university invention disclosures was a significant factor that positively influences the number of licensing agreements of top-range US universities.[58] In this line, DiGregorio and Shane (2003) found that the number of invention disclosed (used as control variable) by top-range PU positively influences their rate of UBC creation.

On the other hand, our regression analysis results show that the stock of physical USUR is not significantly related to university start-up activity. Indeed, the presence/existence of a technology transfer office (TTO), a business incubator or a science and technology park does not seem to affect the rate of UBC creation by PU. In the same line, we have found that the stock of human USUR (in terms of the number of full-time employees working at the TTO or at the business incubator) is not a significant predictor of university start-up activity. I this sense, we cannot confirm neither **H1.a** nor **H1.b and therefore** our first main hypothesis **H1** about the positive influence of university start-up resources (USUR) over university start-up activity is only partially confirmed (see **Table 8**).

Other studies trying to determine UBC creation predictors outside *top*-range environments have also used the presence of different physical university start-up resources as explanatory or control variables. For example, Nosella and Grimaldi (2009) found that while the presence of a TTO is not significantly related to university start-up activity, the availability of a business incubator increases the number of UBC created by Italian PU.

Similarly, in a qualitative study of five Italian universities, Fini et al. (2009:399) concluded that "*the existence of formal or informal unit in charge of technology transfer activities ... turn out to be irrelevant in our respondents experiences.*" Moreover, Rodeiro et al. (2010) found that the presence of a science and technology park does not affect the number of UBC created by Spanish PU. Thus, we find in other studies evidence that physical USUR does not significantly influence university start-up activity outside *top*-range environments.

[58] The sample of universities used in this study includes 80 out of 89 US "Research 1" institution following Carnegie Foundation qualification standards (Siegel et al., 2003:33).

Table 7: Negative binomial regression model estimation

Number of observations: 112 ; Number of groups: 7 ; Wald c_2 = 116.47

Log likelihood = -184.54821 ; Prob > c2 = 0.0000

Likelihood-ratio test vs. pooled: chibar^2 (01) = 2.31 ; Prob >= chibar2 = 0.064

Explanatory Variable	**Obs**	**Coeficient**	**Estándar error**	**z - value**	**P>|z|**	**[95% confidence interval]**	
Business Development Capabilities	112	.2988284	.1118419	2.67	0.008**	.0796223	.5180346
Informal Start-up Institutions	112	.350083	.0970425	3.61	0.000***	.1598832	.5402828
Human Start-up Resources	112	-.0118739	.0896066	-0.13	0.895	-.1874997	.1637518
Technological Start-up Resources	112	.6129425	.0639497	9.58	0.000***	.4876035	.7382816
Start-up Experience	112	.2917401	.0856014	3.41	0.001**	.1239645	.4595158
Physical Start-up Resources	112	-.2931315	.2252624	-1.30	0.193	-.7346378	.1483747
Social Start-up Resources	112	.8803691	.2286966	3.85	0.000***	.432132	1.328.606
Formal Start-up Institutions	112	.7864202	.2054778	3.83	0.000***	.3836912	1.189.149
_cons	112	.6025058	.5829851	1.03	0.301	-.5401241	1.745.136
/ln_r		4.357.297	1.043.709			2.311.666	6.402.929
/ln_s		3.317.799	1.058.471			1.243.234	5.392.364
r		7.804.592	8.145.721			1.009.122	6.036.104
s		2.759.954	2.921.331			3.466.808	2.197.221

Significance level: * p < 0.05; ** p < 0.01; *** p < 0.001

Table 8: Research hypothesis confirmation table

VARIABLE	SECONDARY HYPOTHESIS	MAIN HYPOTHESIS	Confirmed?
Intellectual Property (IP) protection services	**H2(a). Start-up Support Services**	**H2. UNIVERSITY START-UP CAPABILITIES**	**YES**
Business plan realization support			
Opportunity recognition support			
Search for public financing support			
Perceptions on the PU's opportunity recognition involvement	**H3(b). Start-up Informal Institutions**	**H3. UNIVERSITY START-UP INSTITUTIONS**	**YES**
Perceptions on the PU's knowledge transfer priority			
Perceptions on the PU's quality of UBC support services			
Perceptions on the entrepreneurial attitude of the PU			
Number of FTE at the business incubator	**H1(b). Start-up Human Resources**	**H1. UNIVERSITY START-UP RESOURCES**	**NO**
Number of FTE at the Technology transfer office (TTO)			
Number of national patents solicited	**H1(c). Start-up Technological Resources**	**H1. UNIVERSITY START-UP RESOURCES**	**YES**
Number of international patents solicited			
Age of the Technology transfer office (TTO)	**H2(b). Start-up Experience**	**H2. UNIVERSITY START-UP CAPABILITIES**	**YES**
Age of first UBC created			
Age of UBC support program			
Presence of a business incubator	**H1(a). Start-up Physical Resources**	**H1. UNIVERSITY START-UP RESOURCES**	**NO**
Presence of a Technology transfer office (TTO)			
Presence of an intellectual property protection office (IPPO)			
Existence of other incubation space			
Presence of a science and technology park			
Presence of an investment network	**H1(d). Start-up Social Resources**	**H1. UNIVERSITY START-UP RESOURCES**	**YES**
Presence of a R&D network			
Leave of absence policy for academic entrepreneurs	**H3(a). Start-up Formal Institutions**	**H3. UNIVERSITY START-UP INSTITUTIONS**	**YES**
Absence of a Labour Incompatibility policy			
Day reduction incentive policy for academic entrepreneurs			

In the literature we have also found evidence that the presence of physical USUR is not a significant predictor of the number of UBC created by PU located at *top*-range environments. In this sense, Lockett and Wright (2005) found no significant relation between the presence of a science park and top-range university start-up activity.[59] In addition, DiGregorio and Shane (2003) have also presented evidence that the presence of a university-affiliated incubator does not affect top-range university start-up activity. In this line, O'Shea et al. (2005:1003) found that "*the presence of a university-affiliated incubator was not significant in our study.*"

Moreover, in their study, Rodeiro et al. (2010) have found that the number of full-time employees (FTE) working at the university TTO will positively influence start-up activity. This result is in line with Nosella and Grimaldi (2009) findings stating that the number of FTE related to PU's technology transfer and start-up activities is also positively associated with the number of UBC created by PU located outside *top*-range environments. Thus, we find in the literature evidence contradicting our results in terms of the significance of the TTO's size (number of FTE) over university start-up activity outside *top*-range environments.

We also find evidence in the literature that the number of FTE associated to technology transfer and start-up activities positively influence the number of UBC created by PU located in *top-range* environments (DiGregorio and Shane, 2003; O'Shea et al., 2005). In this sense, O'Shea et al. (2005:1006) concluded that "*the greater the size of the TTO offices, the greater the likelihood of the university to produce spinoffs.*" Moreover, Siegel et al. (2003) in their study of 113 US universities found that the number of FTE working at the TTO will positively influence the number of licensing agreements done by PU.

This apparent contradiction in the results may be explained by the fact that we have also included the FTE working at the business incubator in the component used as explanatory variable in the regression analysis. On the other side, we have only included in this explanatory variable technical FTE working at the TTO (neither including TTO's administrative staff nor personnel from the intellectual property protection office). Therefore, we believe that another measure of this explanatory variable may have leaded to different results. Supporting this argument, Lockett and Wright (2005), who also found that there is no relation between FTE of the university TTO and UBC creation, have also excluded from their explanatory variable any university personnel associated with technology transfer and start-up activities but not working at the TTO.

Furthermore, we have found that both measures of university start-up capabilities significantly influence the rate of new venture creation by Spanish PU ($p < 0.01$). Indeed, we have empirically proven the existence of a positive effect that PU's business

[59] Lockett and Wright (2005) include in their sample 48 UK universities that "*are likely to create more spin-outs, generate more equity investment in spin-outs, have a greater total research income, have a greater experience of involvement in technology transfer activities, be more likely to have a medical school and a science park.*" (Lockett and Wright, 2005:1049).

development capabilities and PU's accumulated entrepreneurial experience have over university start-up activity. In this sense, we can confirm our hypothesis **H2.a** and **H2.b** and therefore we can fully confirm our second main research hypothesis **H2** about the positive influence of university start-up capabilities (USUC) over the rate of UBC creation by PU (see **Table 8**).

Consisting with our results, Nosella and Grimaldi (2009) found that the number of support services offered by the TTO to PU's members will significantly increase the number of UBC created by PU.[60] Moreover, Fini et al. (2009) have also found a set of "*University support services*" that foster Italian academics to start new ventures. Similarly, Rasmussen and Borch (2010), in a longitudinal study of two universities located at *mid-range* environments have found "*three university capabilities that facilitate the venture-formation process*". This result is also similar to the results found in UBC creation studies from PU located at *top-range* environments. For example, Lockett and Wright (2005) have found that their Business Development Capabilities construct is positively related to university start-up activity.

Our evidence also shows that older TTO generate a higher rate of UBC per year than younger TTO (see **Table 7**). In this sense, we have found that the age (in years) of the TTO is positively related to university start-up activity. This result is in line with Rodeiro et al. (2010) who found that Spanish universities' TTO experience is significantly and positively associated with UBC creation. In the same line, Rasmussen and Borch (2010) have found that start-up capabilities of PU located outside *top-range* environments *are dependent on prior spin-off experience*.

On the other side, the literature focusing on *top-range* universities has shown mixed evidence about the influence of TTO's age on university start-up activity. For example, Lockett and Wright (2005:1047) emphasized that "*Through being actively involved in technology transfer activities, universities may become better able to create university spin-outs.*" Moreover, the authors also affirmed that "*the more experience the university has in spinning-out companies, the more effective the managers will become.*" On the other hand, in their study the authors concluded that "*the stock of experience in terms of the number of years involvement with technology transfer does not appear to be important per se, but rather the skills accruing to technology transfer officers and the presence of technology transfer routines.*" (Lockett and Wright, 2005:1054-1055).

Moreover, while Siegel et al (2003) found that the TTO's age (as control variable) has no significant effect on UBC creation, Powers and McDougall (2005) found that the age of TTO is highly and positively related to university start-up activity. In this sense, Powers and McDougall (2005) said that "*older, more established TTOs appear to have better developed the needed competences to more effectively facilitate technology*

[60] In this study the authors considered the same TTO's support services as in our study: opportunity recognition support, business plan support, IP protection support and support in finding sources of funding.

transfer." Similarly, O'Shea et al. (2005) have found that prior start-up experience is a key determinant factor of UBC creation by US universities.

We have also found that the existence of formal and informal start-up institutions significantly influence the rate of new venture creation by Spanish PU ($p < 0.001$). Our results show that perceptions about the attitude and behaviour of the Parent University will affect the number of UBC created by PU in Spain. In the same line, we have shown that a labour incentive policy that facilitates UBC creation will foster the rate of new venture creation by Spanish PU. In this sense, we have confirmed hypothesis **H3.a** and **H3.b**. Therefore, we have confirmed our third main research hypothesis **H3** about the positive influence of university start-up institutions (USUI) over the rate of UBC creation by PU (see **Table 8**).

In other studies, formal USUI are also found to be significant predictors of university start-up activity outside *top-range* environments. For example, Nosella and Grimaldi (2009) found that the existence of a clear spin-off regulation policy increases the number of UBC created by Italian PU. In this line, DiGregorio and Shane (2003) found that the PU's policy of making equity investments in start-ups was the only determinant factor significantly influencing the rate of UBC creation by *less eminent* universities. Moreover, in other exploratory studies, we also find evidence that formal USUI are important for university start-up activity outside *top-range* environments (Roberts and Malone, 1996; Degroof and Roberts, 2004; Clarysse et al., 2005).

In the literature we have also found evidence that formal USUI has a significant effect on the number of UBC created by *top-range* PU. For example, DiGregorio and Shane (2003) found that the PU's royalty policy (maximum royalties paid to the technology developer) and the equity investment policy (the PU is allowed to buy equity of UBC) significantly affect the number of UBC generated by *more eminent* universities. Moreover, Lockett and Wright (2005) has also shown evidence that the royalty policy of 48 top-range UK universities significantly influence start-up activity. O'Shea et al. (2007) emphasize the significance of the formal mission of Massachusetts Institute of Technology (MIT) over MIT's entrepreneurial success.

Finally, in the University Entrepreneurship we have found evidence supporting our results that informal PU's institutions may have significant effects over the number of UBC created by PU (O'Shea et al., 2007; Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015). In this sense, Kalar and Antoncic (2015) found that perceiving university departments as more entrepreneurially oriented increases the probability of university academics being involved in entrepreneurial activities. In the same line, Huyghe and Knockaert (2015) found that the PU's organizational culture and entrepreneurial climate significantly affects the entrepreneurial intentions of PU's academics. Also, in a case study of the MIT, O'Shea et al. (2007) concluded that MIT's entrepreneurial culture was (and still is) a significant factor explaining MIT's success as firms' creator.

In this study we have empirically proven that there are certain *start-up* resources, capabilities and institutions that significantly influence the rate of new venture creation by PU located outside *top-range* environments. Thus, our results suggest that PU located outside *top-range* environments may foster UBC creation by increasing the stock of *start-up* resources, the level of *start-up* capabilities and the presence of *start-up* institutions.

Our results are in line with the results from a study aiming to assess Spanish PU's efficiency in terms of knowledge transfer activities (Berbegal et al., 2013). Berbegal et al. (2013: 2057) concluded that: "*the results indicate that accumulated knowledge, previous experience, and knowledge transfer resources lead to the creation of knowledge spillovers that are expected to boost knowledge transfer activities and, more specifically, enhance the creation of new spin-offs within universities.*" Moreover, the authors concluded that: "*universities should promote entrepreneurial mindsets inside their organizational structures to consolidate their objective function ….First, universities should design more attractive incentives for faculty members, …Second, universities should reformulate organizational processes and structural choices, recognizing that knowledge transfer activities must not only be placed alongside but fully integrated with mainstream teaching and research activities.*"

To close this section of the study we want to emphasize that we have not found significant differences between the determinant factors of UBC creation by PU located inside or outside *top-range* environments. Indeed, we have found similar results in terms of the resources, capabilities and institutions that significantly influence *mid* and *top-range* university start-up activity. In this sense, it appears that the premise made at the introduction (the effect of university start-up support mechanisms will depend on the environment where the PU is located) may not completely hold. This question merits further research that exceeds the scope of the present study.

6. Concluding remarks

As a particular way of knowledge transfer, university-based companies (UBC) are new ventures founded by members of Parent Universities (PU) willing to commercialize some knowledge originally developed inside the PU's context. Using the count number of UBC created by PU at a given year as our dependent variable; in this study we have assessed different types of university-level determinant factors that significantly affect start-up activity in Spain. In this sense, we have collected data of start-up resources (USUR), start-up capabilities (USUC) and start-up policies or institutions (USUI) from16 Spanish state-owned universities between the years 2004 and 2010 (included).

Drawing on the Resource-Based View, the Dynamic Capabilities Perspective and the Institutional Economic Theory; we have identified different sets of organizational determinant factors that significantly influence the rate of UBC creation by Spanish PU.

In particular, we can conclude that while the university stock of human and physical start-up resources do not significantly influence university start-up activity, the stock of technological and social university start-up resources do.

Furthermore, we can also conclude that university start-up capabilities have a positive and significant effect over the rate of UBC creation by Spanish PU. In this sense, Spanish PU with a higher level of business development capabilities and providing more and better start-up support services to their members will increase their rate of UBC creation. In the same line, following our analysis we can conclude that PU having accumulated more entrepreneurial experience will show a higher rate of UBC creation than PU with shorter start-up experience.

From the analysis done in this study we can finally conclude that Spanish PU having a specific set of policies, systems and measures to facilitate and motivate the creation of UBC by their members, will have a higher rate of UBC creation than PU with a lack of formal start-up institutions. In the same line, university start-up informal institutions (measured by the perceptions of university members about the attitude and priority given by the PU to knowledge transfer activities) will also affect university start-up activity in Spain.

The results of this study have important implications for managers of universities located outside *top-range* environments. Moreover, this study is also relevant for regional policy makers willing to increase university start-up activity in contexts with limited entrepreneurial and technological resources. In particular, our finding that the number of patents' applications positively influence university start-up activity suggests that universities located outside *top-range* environments should encourage and facilitate their researchers to disclose the maximum number of technological inventions to the technology transfer office TTO. This can be done by giving specific incentives to researchers to disclose inventions and/or by pro-actively seeking at research units technological inventions that may be patentable.

Another important implication of this study is that universities located outside *top-range* environments willing to increase the rate of UBC creation should develop networks of contacts especially with other R&D organizations and external financial institutions. PU may develop this kind of networks using regional and local agents of economic development as networking intermediaries.

Moreover, our findings suggest that PU located outside *top-range* environments and aiming at increasing start-up activity should rather invest in experienced technology transfer officers with the specific knowledge and networks of R&D and financial contacts, rather than hiring a large number of un-experienced TTO personnel. In the same line, PU aiming at increasing start-up activity should rather invest in developing/improving business development capabilities and start-up support services

rather than investing in enlarging the availability of physical start-up resources (i.e. a new or bigger TTO, a science park or an incubator).

Thus, a general implication of our results is that investments aiming at improving the quality of the start-up support services and the quality of the TTO's personnel are more effective for increasing university start-up activity than investments aiming at increasing the quantity of physical and human start-up resources. Therefore, any investment done by a PU in creating or enlarging the TTO or the business incubator will not have a short-run effect over its rate of UBC creation.

This study does not lack of its limitations. In particular, we believe that the small number of universities included in the sample may limit the generalization of the results. We acknowledge that this limitation has to be overcome in order to be able to publish this study at top-ranked JCR academic journals.

On the other hand, we have shown in the methodology section that even though our dataset includes 16 parent universities (PU), this figure represents one third of the population of Spanish research universities. Moreover, the sample includes PU from the most relevant Spanish regions in terms of technology transfer and start-up activities (i.e. Catalonia, Madrid, Andalucia or Valence) and also includes almost 40% of the total number of UBC created by all Spanish PU.

In addition, we have run a t-test between our sample of PU and the rest of Spanish PU that did not answer to our survey properly. We have found no significant differences in the number of UBC created by the two groups of PU. Thus, we believe that sample bias effects should not hinder the results of our analysis.

Moreover, in this study, we concentrate in determining university level determinant factors of UBC creation only for the Spanish context. Thus, future researchers willing to better understand the University Entrepreneurship phenomenon should try to include in their analysis a greater number of parent universities from different countries and also include multi-level determinant factors of UBC creation (micro, meso and macro-level factors).

Furthermore, some researchers argue that more important than measuring the number of UBC created by each PU (our dependent variable), is to measure the quality or performance and therefore the impact or benefits of these UBC for the local and/or regional context (Vendrell and Ortin, 2008; Harrison and Leitch, 2010; Epure et al. 2014; Ortin and Vendrell, 2014; Sanchez-Barrioluengo; 2014). In this sense, Harrison and Leitch (2010: 1242) argue that: "*there are growing concerns that the focus of universities and of policy-makers has been on the number, rather than on the quality and commercial viability, of these start-up ventures, with correspondingly less attention given to their wider and longer-term impact.*"

This limitation is particularly important outside *top-range* environments where the real or net contributions of UBC over the local context are much reduced (Degroof and Roberts, 2004; Wright et al., 2008; Nosella and Grimaldi, 2009; Harrison and Leitch, 2010, Beraza and Rodriguez, 2011). In this sense, Harrison and Leitch (2010: 1243) argue that: "*The economic impact of university spinoff activity outside the unique environment of technology intensive core regions is likely to be very much less than advocates believe*." Thus, future research may want to measure the regional impact of the UBC created by each PU (i.e. the total number of jobs generated by all UBC of a PU) and use this measurement as the dependent variable of the econometric model.

We also have to acknowledge limitations when measuring some of the explanatory variables used in the econometric model. In this sense, we believe that a different measure of human USUR[61] (including all FTE involved in technology transfer and start-up activities) may have leaded us to a different conclusion in this matter. Moreover, we believe that our measure of business development capabilities (as start-up support services offered by the TTO) may not be representative of the individual abilities of technology transfer officers. Thus, future research may want to develop an individual-level survey to assess the significance of TTO's business development capabilities over university start-up activity.

Moreover, we have not been able to include in our study some variables that previous university entrepreneurship research has identified as significant factors of university start-up activity. In particular, we did not include any explanatory variable measuring the stock of financial USUR. To assess the significance of this factor, in the survey we included a question about the availability of a university-owned start-up equity investment fund, but almost 90% of the respondents answered that they did not count with any form of equity investment fund to finance newly created companies. Thus, we did not have any empirical variability in this factor and therefore could not be used as explanatory variable in the model. Future research should try to include a different measure of financial USUR in their studies.

Another limitation of this study is the fact that we did not include any variable measuring the quality of the faculty and researchers. This variable could be included in future research using the academic scores published in public reports. In the same line, we missed to include any explanatory variable related to the orientation of the research at the PU. Future studies may try to include in their analysis a dummy variable indicating the presence of a medical school at the PU and also a variable measuring the percentage of the PU's total budget that goes into science and engineering departments.

Furthermore, we could not include in our analysis the tendency of the PU to use the figure of an external surrogate entrepreneur to run UBC. We have initially included a question aiming at collecting this data but we received ambiguous answers that made us believe the question was not well understood. In addition, we did not control neither by

[61] University start-up resources (USUR).

the size nor by the age of PU. Moreover, we did not include in the regression model any lag of explanatory variables. Thus, we may have some endogeneity limitations in the results.

Finally, we have made no distinction among the different types of UBC that PU generate. Thus, future research should try to identify the specific parent organizational determinant factors in the creation of each type of UBC (academic spin-off, non-academic spin-off, academic start-up and non-academic start-up). By relating different UBC types with performance differences among companies (see the conclusion section of chapter two in this doctoral dissertation), future research may try to identify the significant PU's determinant factors enhancing the regional impact of UBC and thus provide great contribution to the University Entrepreneurship field of study.

Appendices

Appendix 1: Questionnaire used to collect data for explanatory variables

Encuesta a las Universidades Públicas Españolas

Recursos, políticas y actividades relativas a la creación de empresas universitarias

Universitat Autònoma de Barcelona

Antes que nada, queremos agradecerle sinceramente por su colaboración con esta encuesta y asegurarle que todos estos datos serán tratados con la mayor confidencialidad y que serán utilizados únicamente como cuerpo central de esta investigación doctoral. Una vez más, muchas gracias por su ayuda. Lo saluda atentamente,

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Consideraciones Iniciales

Por favor complete las preguntas que se responden por SI (afirmativo) o por NO (negativo) de la siguiente manera:

Afirmativo = 1
Negativo = 0
No sabe = X
No aplica la pregunta = NA

También puede utilizar los *botones* al final de las filas de **SI**, **NO** o **NO SABE** para **TODOS LOS AÑOS** rellenando el fondo de la celda que quiere marcar de color rojo. Al final del cuestionario tiene un espacio libre para poner cualquier comentario que le parezca oportuno respecto a esta encuesta. Este cuestionario está debidamente

estructurado para ser impreso en 6 páginas y es libre de imprimirlo.

En este estudio llamaremos **EMPRESA UNIVERSITARIA (EU)** a toda organización con fines de lucro creada con el apoyo institucional de una universidad madre. De esta forma consideramos EU a cualquier empresa que ha nacido y se ha desarrollado inicialmente dentro de un programa de creación de empresas de una universidad.

En este estudio entendemos por PROGRAMA DE CREACIÓN DE EMPRESAS a un conjunto de recursos, actividades y servicios que la universidad ofrece a sus miembros para motivar y facilitar la identificación, evaluación y explotación de una oportunidad de negocio. Por ejemplo ofrecer a sus miembros espacios para la incubación de las empresas creadas, ayuda técnica en la realización del plan de empresa, ayuda para la búsqueda de financiación externa, asesoría legal y técnica para la protección de la propiedad intelectual, etc.

Datos de contacto del encuestado

Nombre y apellidos:
Puesto o posición de trabajo:
Teléfono de contacto:
Email:
Universidad de procedencia:

Preguntas Iniciales

1	¿En qué año su universidad ha comenzado a ofrecer un programa específico para incentivar y apoyar a sus miembros (docentes, investigadores, estudiantes, graduados y personal administrativo) a crear empresas?	
2	¿En qué año se fundó la primera empresa con el apoyo de su universidad? (año de fundación de la primera EU)	
3	¿Cuál es el número total de empresas creadas con el apoyo de su universidad? (total de EUs)	

A. Recursos

	OFICINA CREACIÓN DE EMPRESAS										
4	¿En qué año se creó una estructura administrativa específica para apoyar la creación de empresas por parte de los miembros de su universidad? (OTRI, Oficina de Creación de Empresas, Trampolín Tecnológico, etc.)										
		2010	2009	2008	2007	2006	2005	2004			
5	¿Existe una estructura administrativa específica para apoyar la creación de empresas por parte de los miembros de su universidad? (OTRI, Oficina de Creación de Empresas, Trampolín Tecnológico, etc.)								SI	NO	NO SABE
6	¿Esta estructura administrativa se encuentra dentro del organigrama (la plantilla) de la propia universidad o es parte de una estructura organizativa independiente de la universidad, como una fundación o un consorcio privado?								SI	NO	NO SABE
7	¿Cuántos empleados a tiempo completo (ETC) trabajan en esta estructura administrativa de apoyo a la creación de empresas por miembros de su universidad?								NO SABE		
8	¿Cuántos ETC técnicos trabajan en esta estructura administrativa de apoyo a la creación de empresas por miembros de su universidad?								NO SABE		
9	¿Cuántos ETC técnicos trabajan para dar apoyo a la creación de empresas por miembros de su universidad pero que no se encuentren dentro de la estructura administrativa anteriormente descrita?								NO SABE		

	OFICINA DE PATENTES										
10	¿En qué año se creó una estructura administrativa específica para apoyar la protección y comercialización de la propiedad intelectual desarrollada por miembros de su universidad? (Oficina de Patentes)										
		2010	2009	2008	2007	2006	2005	2004			
11	¿Existe una estructura administrativa específica para apoyar la protección y comercialización de la propiedad intelectual desarrollada por miembros de su universidad? (Oficina de Patentes)								SI	NO	NO SABE
12	¿Esta estructura administrativa se encuentra dentro del organigrama (la plantilla) de la propia universidad o es parte de una estructura organizativa independiente de la universidad, como una fundación o un consorcio privado?								SI	NO	NO SABE
13	¿Cuántos empleados a tiempo completo (ETC) trabajan en esta estructura administrativa de apoyo a la protección y comercialización de la propiedad intelectual desarrollada por miembros de su universidad?								NO SABE		

14	¿Cuántos ETC técnicos trabajan a tiempo completo en esta estructura administrativa de apoyo a la protección y comercialización de la propiedad intelectual desarrollada por miembros de su universidad?								**NO SABE**		
15	¿Cuántos ETC técnicos trabajan para dar apoyo a la protección y comercialización de la propiedad intelectual desarrollada por miembros de su universidad pero que no se encuentren dentro de la estructura administrativa anteriormente descrita?								**NO SABE**		
16	¿Cuál es el número de patentes nacionales solicitadas por su universidad?								**NO SABE**		
17	¿Cuál es el número de patentes internacionales solicitadas por su universidad?								**NO SABE**		

	INCUBADORA DE EMPRESAS										
18	¿En qué año su universidad ha comenzado a ofrecer a sus miembros un espacio dedicado exclusivamente a la incubación de empresas? (año de fundación de la incubadora de empresas en su universidad)										
		2010	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**			
19	¿Su universidad ofrece a sus miembros un espacio dedicado exclusivamente a la incubación de empresas? (incubadora de empresas)								**SI**	**NO**	**NO SABE**
20	¿La incubadora de empresas es gestionada por la propia universidad? (si la universidad participa de la gestión de la incubadora, poner 1; si es gestionada exclusivamente por una organización independiente de la universidad, como una fundación o un consorcio privado, poner 0)								**SI**	**NO**	**NO SABE**
21	¿La incubadora de empresas de su universidad está ubicada en alguno de los edificios del campus universitario (poner 1 si en campus) o por el contrario se encuentra ubicada en un centro empresarial o polígono industrial externo (poner 0 si fuera del campus)?								**SI**	**NO**	**NO SABE**
22	¿La incubadora de empresas de su universidad está acondicionada para acoger empresas que realicen actividades técnicas que necesiten del uso de laboratorios, talleres o maquinaria industrial?								**SI**	**NO**	**NO SABE**
23	¿Cuál es el espacio total aproximado (en metros cuadrados) de la incubadora de empresas de su universidad? (cuántos metros cuadrados tiene la incubadora de empresas)								**NO SABE**		
24	¿Hay o había (para cada año) espacio disponible en la incubadora para acoger a nuevas empresas creadas por miembros de su universidad?								**SI**	**NO**	**NO SABE**

25	¿Cuántos empleados a tiempo completo (ETC) trabajan en la incubadora de empresas de su universidad?								**NO SABE**		
26	¿La universidad ofrece otros espacios de incubación (fuera de la incubadora) a las empresas creadas por sus miembros? (oficinas de alquiler, salas y espacios en parques empresariales o tecnológicos, etc.)								**SI**	**NO**	**NO SABE**

	PARQUE CIENTÍFICO-TECNOLÓGICO											
27	¿En qué año su universidad ha fundado un parque científico y tecnológico asociado para facilitar la investigación de sus miembros y el desarrollo de nuevas tecnologías? (año de fundación del parque científico-tecnológico de su universidad)											
		2010	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**			
28	¿El parque científico-tecnológico es gestionado por la propia universidad? (si la universidad participa de la gestión del parque poner 1; si es gestionado exclusivamente por una organización independiente de la universidad, como una fundación o un consorcio privado, poner 0)								**SI**	**NO**	**NO SABE**
29	¿El parque científico-tecnológico de su universidad está ubicado en el propio campus universitario (poner 1) o por el contrario se encuentra ubicado fuera del campus de su universidad (poner 0)?								**SI**	**NO**	**NO SABE**

	RECURSOS FINANCIEROS Y SOCIALES											
30	¿En qué año su universidad ha creado un fondo de inversión propio para financiar la creación y el desarrollo de las empresas fundadas por miembros de su universidad? (fondo de inversión para empresas creadas por sus miembros)											
		2010	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**			
31	¿Cuál es el presupuesto total que su universidad dedica al programa de apoyo a la creación de empresas?								**NO SABE**		
32	¿Su universidad posee y ofrece un fondo de inversión específico para financiar la creación y el desarrollo de empresas por miembros de su universidad?								**SI**	**NO**	**NO SABE**
33	¿Su universidad forma parte de alguna red de inversores (pública o privada) disponible para financiar la creación y desarrollo de empresas? (red de Business Angels, inversores privados o red de instituciones financieras)								**SI**	**NO**	**NO SABE**
34	¿Su universidad forma parte de alguna red de I+D+i (pública o privada) disponible para el intercambio de conocimientos y la transferencia de tecnología con las empresas creadas? (red de centros o institutos de I+D+i)								**SI**	**NO**	**NO SABE**

B. Políticas

	NORMATIVA PARA EL PERSONAL Y CREACIÓN DE EMPRESAS	2010	2009	2008	2007	2006	2005	2004			
35	¿Su universidad posee un reglamento propio que especifica las normas y procedimientos para la creación de empresas basadas en el conocimiento generado por parte de sus miembros?								**SI**	**NO**	**NO SABE**
36	¿El personal de su universidad puede tomar un permiso de excedencia en su puesto de trabajo de varios años para crear una empresa asociada manteniendo su posición en la plantilla de la universidad? (permiso de excedencia laboral, LOU)								**SI**	**NO**	**NO SABE**
37	¿El personal de su universidad puede asumir un puesto de gestión en la EU creada manteniendo en simultáneo su actividad laboral en la universidad? (normativa sobre la incompatibilidad laboral)								**SI**	**NO**	**NO SABE**
38	¿Se incentiva al personal de su universidad a asumir el puesto de gerente de la EU creada? (o por el contrario se incentiva la contratación de un administrador externo)								**SI**	**NO**	**NO SABE**
39	¿El personal de su universidad que decide crear una empresa basada en el conocimiento generado en la investigación, recibe algún tipo de bono o complemento salarial?								**SI**	**NO**	**NO SABE**
40	¿El personal de su universidad que decide crear una empresa basada en el conocimiento generado en la investigación, tiene la posibilidad de pedir una reducción de su jornada laboral?								**SI**	**NO**	**NO SABE**
41	¿Cuál es la participación (% de propiedad) máxima que puede tener el personal de su universidad sobre una EU creada?								**NO SABE**		
42	¿Cuál es el % de royalties máximo que puede recibir un investigador/inventor de su universidad si se comercializa una patente o propiedad intelectual desarrollada por el propio investigador?								**NO SABE**		
43	¿Cuál es la participación (% de propiedad) máxima que puede tener su universidad sobre una empresa creada? (% de participación máxima de la universidad en una EU creada)								**NO SABE**		

	CRITERIOS DE SELECCIÓN DE PROYECTOS DE EMPRESAS Para que un proyecto sea aceptado dentro del programa de creación de empresas de su universidad:	2010	2009	2008	2007	2006	2005	2004			
44	¿Es necesario que haya al menos un miembro de su universidad en el equipo fundador de la empresa que se propone crear? (personal docente-investigador (PDI), estudiante, graduado o personal administrativo)								**SI**	**NO**	**NO SABE**
45	¿Es necesario que haya al menos un miembro del personal docente e investigador (PDI) de su universidad en el								**SI**	**NO**	**NO SABE**

	equipo fundador de la empresa que se propone crear?										
46	¿Es necesario que el proyecto de empresa presente una innovación tecnológica comercializable? (que sea una empresa de base tecnológica)								**SI**	**NO**	**NO SABE**
47	¿Es necesario que haya transferencia formal de conocimiento entre la empresa creada y su universidad? (licencias de patentes o contratos de investigación entre la empresa y la universidad madre)								**SI**	**NO**	**NO SABE**
48	¿Es necesario que la empresa creada sea participada por la universidad madre? (que la universidad forme parte del accionariado de las EU creadas)								**SI**	**NO**	**NO SABE**
49	**Por favor, indique cualquier otro criterio o filtro para la selección de proyectos empresariales a dar soporte**										

	MISIÓN Y OBJETIVOS **Responda con un número del 1 al 7. Poner 1 si está completamente en desacuerdo con la afirmación y poner 7 si está completamente de acuerdo con la afirmación realizada**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	
50	La transferencia de conocimiento y tecnología a la sociedad a través de la creación de empresas es parte prioritaria de la misión general de su universidad								**NO SABE**
51	Su universidad prioriza una política de creación de empresas como forma de transferencia de tecnología por encima de una política de licenciar la propiedad intelectual (licencias de patentes) desarrollada por sus investigadores/inventores								**NO SABE**
52	Su universidad ofrece programas y servicios suficientes y adecuados para apoyar la creación de empresas por sus miembros								**NO SABE**
53	Su universidad se involucra proactivamente en la búsqueda de nuevas oportunidades empresariales nacidas de la investigación y el conocimiento generado por sus miembros								**NO SABE**
54	Su universidad es una institución con vocación innovadora que busca fomentar el espíritu emprendedor entre sus miembros								**NO SABE**

55	Los miembros de su universidad (en especial el PDI) tienen una actitud emprendedora? (actitud positiva respecto a la creación de empresas asociadas (EU)?								**NO SABE**
	Los siguientes objetivos son prioritarios para la Oficina de Creación de Empresas de su universidad	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	
56	Maximizar el número total de empresas constituidas en cada año (empresas de todo tipo)								**NO SABE**
57	Maximizar el número de empresas constituidas en cada año con al menos un profesor/investigador en el equipo fundador								**NO SABE**
58	Maximizar el número de empresas constituidas en cada año con transferencia formal de conocimiento y/o de base tecnológica								**NO SABE**
59	Maximizar el número de empresas constituidas en cada año con participación societaria de la universidad (EU participadas)								**NO SABE**
60	**Por favor, indique cualquier otro objetivo o misión de la Oficina de Creación de Empresas de su universidad**								

C. Actividades

	Programas y servicios de apoyo a los potenciales empresarios	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**			
61	¿Se ofrecen cursos de formación especializada a los potenciales empresarios (cursos de gestión, contabilidad, fiscalidad, protección de la propiedad intelectual, etc.)?								**SI**	**NO**	**NO SABE**
62	¿Se ofrece ayuda y soporte a los potenciales empresarios para la identificación y evaluación de una oportunidad de negocio (estudio de mercado y estudio de viabilidad del negocio)?								**SI**	**NO**	**NO SABE**
63	¿Se ofrece ayuda y soporte a los potenciales empresarios para evaluar y proteger la propiedad intelectual que comercializará la empresa creada (estudio de la propiedad intelectual y gestión de la solicitud de patentes)?								**SI**	**NO**	**NO SABE**
64	¿Se ofrece ayuda y soporte a los potenciales empresarios para la realización del plan de empresa?								**SI**	**NO**	**NO SABE**

65	¿Se ofrece ayuda y soporte a los potenciales empresarios para conseguir financiación pública para la creación de empresas (préstamos participativos, subsidios, ayudas públicas, préstamos de ICO y otros préstamos subsidiados)?								**SI**	**NO**	**NO SABE**
66	¿Se ofrece ayuda y soporte a los potenciales empresarios para conseguir financiación privada para la creación de empresas (préstamos bancarios y líneas de crédito, red de inversores privados y business angels o empresas de capital riesgo)?								**SI**	**NO**	**NO SABE**
67	¿Se llevan a cabo eventos para dar a conocer los servicios de apoyo a la creación de empresas y promover el espíritu emprendedor entre los miembros de su universidad (jornadas de emprendeduría, concursos planes de negocio, encuentros de emprendedores, etc)?								**SI**	**NO**	**NO SABE**

68	**A continuación puede agregar cualquier comentario que desee respecto a las preguntas de la encuesta. Por favor, ponga el número de la pregunta que quiera comentar y a continuación el comentario que crea oportuno.**
Nº	**COMENTARIO**

69	**A continuación puede agregar cualquier comentario que desee**

Appendix 2: Principal component analysis results

KMO and Bartlett Test

Medida de adecuación muestral de Kaiser-Meyer-Olkin.		,693
Prueba de esfericidad de Bartlett	Chi-cuadrado aproximado	4583,757
	gl	528
	Sig.	,000

Total variance explained

Componente	Autovalores iniciales			Sumas de las saturaciones al cuadrado de la extracción			Suma de las saturaciones al cuadrado de la rotación		
	Total	% de la varianza	% acumulado	Total	% de la varianza	% acumulado	Total	% de la varianza	% acumulado
1	10,190	30,879	30,879	10,190	30,879	30,879	5,674	17,195	17,195
2	3,205	9,712	40,591	3,205	9,712	40,591	5,257	15,931	33,126
3	3,101	9,398	49,989	3,101	9,398	49,989	3,378	10,237	43,363
4	2,438	7,387	57,376	2,438	7,387	57,376	2,486	7,533	50,896
5	2,316	7,017	64,393	2,316	7,017	64,393	2,383	7,222	58,118
6	1,925	5,832	70,225	1,925	5,832	70,225	2,303	6,979	65,097
7	1,558	4,720	74,946	1,558	4,720	74,946	2,238	6,783	71,880
8	1,459	4,420	79,366	1,459	4,420	79,366	2,001	6,065	77,946
9	1,201	3,638	83,004	1,201	3,638	83,004	1,669	5,058	83,004
10	,998	3,024	86,029						
11	,875	2,650	88,679						
12	,762	2,309	90,988						
13	,563	1,707	92,695						
14	,428	1,296	93,991						
15	,312	,944	94,936						
16	,276	,837	95,773						
17	,221	,668	96,441						
18	,175	,531	96,972						
19	,165	,499	97,471						
20	,149	,451	97,922						
21	,141	,427	98,348						
22	,125	,380	98,728						
23	,088	,265	98,993						

24	,079	,238	99,232						
25	,064	,194	99,426						
26	,054	,163	99,589						
27	,031	,094	99,683						
28	,029	,088	99,770						
29	,024	,074	99,844						
30	,018	,056	99,900						
31	,013	,040	99,941						
32	,011	,032	99,973						
33	,009	,027	100,000						

Rotated components matrix (33 vars)	1	2	3	4	5	6	7	8	9
IP protection services	,921								
Business plan support	,894								
Opportunity recognition services	,865								
Public financing support	,861								
Private financing support	,736		,331						
UBC awareness events	,696		,380	,315					
UBC courses	,584		,384	,324		,389			
Opportunity recognition involvement		,836	,324						
K-transfer priority		,785							
UBC services	,348	,777							
Entrepreneurial uni		,707	,341	,304					
Max participated UBC		,689				-,457			
Max total UBC	,377	,658							,311
UBC priority		,592					,469		
Max techno-based UBC		,585						,542	
Max academic UBC	,373	,513				-,463			
Incubator's age			,775	,357					
Incubator's HHRR			,728						
Incubator's space			,710						
TTO HHRR			,666						
International patents				,829					

National Patents				,724					
TTO age					,917				
Age first UBC				,429	,720				
Program age	,334		,459	,305	,532			-,413	
IPPO age						-,799			
Entrepreneurial memebers		,388				,685			
Park age							,879		
Uni max participation					,449		-,649		
Inventors' max royalties							-,528	-,447	
IPPO HHRR								,833	
Invest fund age									,846
Founders' max participation		-,353					,302		,535

Covariance matrix of the resulted components

Componente	1	2	3	4	5	6	7	8	9
1	1,000	,000	,000	,000	,000	,000	,000	,000	,000
2	,000	1,000	,000	,000	,000	,000	,000	,000	,000
3	,000	,000	1,000	,000	,000	,000	,000	,000	,000
4	,000	,000	,000	1,000	,000	,000	,000	,000	,000
5	,000	,000	,000	,000	1,000	,000	,000	,000	,000
6	,000	,000	,000	,000	,000	1,000	,000	,000	,000
7	,000	,000	,000	,000	,000	,000	1,000	,000	,000
8	,000	,000	,000	,000	,000	,000	,000	1,000	,000
9	,000	,000	,000	,000	,000	,000	,000	,000	1,000

Appendix 3: Results of the principal components analysis by year of the sample

Appendix 3.1: Results of the principal components analysis for the year 2004

Matriz de componentes rotados[a]

	Componente							
	1	2	3	4	5	6	7	8
Public financing support	,825	,379						
National Patents					,512		,807	
UBC awareness events	,798		,404					
UBC courses	,793		,426					
IP protection services	,744	,573						
International patents					,484		,744	
Business plan support	,740	,537						
Opportunity recognition services	,596	,487		,449				
Max participated UBC		,904						
Max academic UBC		,783		,434				
Max total UBC	,387	,750			,311			
UBC services	,453	,746	,346					
Max techno-based UBC		,743						,398
K-transfer priority	,350	,732	,363			,326		
Opportunity recognition involvement	,370	,716	,449					
Entrepreneurial university	,513	,652	,447					
Private financing support	,554	,587	,401					
Incubator's HHRR			,852					
Incubator's age	,327				,824			
Incubator's space					,812	,350		
TTO HHRR	,591		,695					
Founders' max participation								,861
TTO age				,811				
Age first UBC				,633				
Program age			,474	,597				
Park age	,327							
UBC priority	,370	,479			,590			
Uni max participation		,318		,366			,413	
IPPO age						-,916		
Entrepreneurial memebers	,390	,383				,666		,415
Inventors' max royalties								,888
IPPO HHRR								,912

Método de extracción: Análisis de componentes principales.

Método de rotación: Normalización Varimax con Kaiser.

a. La rotación ha convergido en 33 iteraciones.

Appendix 3.2: Results of the principal components analysis for the year 2005

Matriz de componentes rotados[a]

	Componente								
	1	2	3	4	5	6	7	8	9
IP protection services	,885								
Business plan support	,884								
Public financing support	,856								
UBC courses	,841								
Private financing support	,833	,328							
UBC awareness events	,830		,307						
Opportunity recognition services	,807							-,341	
Max techno-based UBC	,546	,441			-,342		,329	,385	
Max academic UBC	,543	,508				-,422		-,339	
Max participated UBC		,920							
Max total UBC	,389	,757							
UBC services	,473	,714							
K-transfer priority	,457	,710	,344						
Opportunity recognition involvement	,474	,649	,404			,314			
Entrepreneurial university	,526	,577	,398						
Incubator's space							,839		,315
Incubator's HHRR			,811						
Incubator's age					,387		,724		
TTO HHRR	,479		,603		,506				
Park age								,952	
International patents				,878					
UBC priority	,716	,549							
Uni max participation		,306		-,351	,454	,400			
National Patents	,407			,514	,457				-,356
Age first UBC					,813		,340		
Program age			,411		,741				
IPPO age						-,862			
Entrepreneurial memebers	,375					,743			
TTO age					,870				
IPPO HHRR							,833		-,312
Founders' max participation								-,809	
Inventors' max royalties									,852

Método de extracción: Análisis de componentes principales.

Método de rotación: Normalización Varimax con Kaiser.

a. La rotación ha convergido en 10 iteraciones.

Appendix 3.3: Results of the principal components analysis for the year 2006

Matriz de componentes rotados[a]

	Componente								
	1	2	3	4	5	6	7	8	9
IP protection services	,957								
Business plan support	,949								
Opportunity recognition services	,944								
Public financing support	,914								
UBC awareness events	,799			,402					
Private financing support	,775		,328						
TTO HHRR			,546	,333					
Max total UBC		,868							
Max participated UBC		,860							
Opportunity recognition involvement		,691	,409					,337	
UBC services	,403	,685					,316		
Invest fund age	-,372	,663					-,460		
Max academic UBC	,450	,632						-,413	
K-transfer priority	,317	,563	,510		,362		,312		
Entrepreneurial university		,521	,432	,337	,344		,343		
Incubator's space									,545
Incubator's HHRR			,811						
Incubator's age				,831					
International patents					,790	,470			
UBC courses	,548			,553	,424				
Program age			,392	,490			,373		,835
Max techno-based UBC									,378
Founders' max participation	,363				-,392				
National Patents	,372				,559		-,354	-,465	
Park age						,940			
UBC priority		,391				,725	,307		
Uni max participation					-,329	-,608	,306	,392	
Inventors' max royalties							,802		
IPPO HHRR		-,318	-,355				-,607		,480
IPPO age								-,813	
Entrepreneurial memebers						,322		,752	
TTO age									,909
Age first UBC				,336					,714

Método de extracción: Análisis de componentes principales.

Método de rotación: Normalización Varimax con Kaiser.

a. La rotación ha convergido en 14 iteraciones.

Appendix 3.4: Results of the principal components analysis for the year 2007

Matriz de componentes rotados[a]

	Componente								
	1	2	3	4	5	6	7	8	9
Opportunity recognition services	,959								
Business plan support	,958								
IP protection services	,921								
Public financing support	,919								
Private financing support	,677					-,347			
UBC awareness events	,643		,456	,387					
IPPO HHRR		-,396	,584				,400	-,421	
UBC courses	,545		,473	,501					
Max total UBC	,490	,482					-,387		-,385
Opportunity recognition involvement		,898							
UBC services		,894							
K-transfer priority		,856							
Entrepreneurial university		,799	,327						
Max participated UBC		,642		-,483					
Max techno-based UBC	-,428	,540			-,428				,357
Incubator's age				,820					
Incubator's HHRR		,352		,806					
TTO HHRR	,523		,748						
Incubator's space		,324	,586						
International patents			,556			,449	,648		
IPPO age				-,884					
Entrepreneurial memebers		,435		,691		,356			
Max academic UBC		,529		-,542					
TTO age					,902				
Age first UBC					,659		,434		
Uni max participation	,328				,622	-,539			
Park age						,939			
UBC priority		,550				,568			
National Patents			,317				,831		
Inventors' max royalties								,867	
Program age	,484		,455		,597			,528	
Invest fund age	-,388								-,766
Founders' max participation		-,398							-,750

Método de extracción: Análisis de componentes principales.

Método de rotación: Normalización Varimax con Kaiser.

a. La rotación ha convergido en 11 iteraciones.

Appendix 3.5: Results of the principal components analysis for the year 2008

Matriz de componentes rotados[a]

	Componente									
	1	2	3	4	5	6	7	8	9	10
Opportunity recognition services	,917									
Business plan support	,915									
IP protection services	,899									
K-transfer priority		,892								
Max techno-based UBC		,760		,314	-,326					
UBC priority		,758		-,350						
Entrepreneurial university		,642		,336	,397					
Opportunity recognition involvement		,563	,418	,364	,323	-,355		,331		
TTO age			,847							
Uni max participation			,443							
Founders' max participation										-,676
UBC awareness events			-,607	,462						
Age first UBC			,670			,403	,490			
Incubator's HHRR		,322		,858						
TTO HHRR				,787						
Incubator's age				,666	,422					
IPPO HHRR					-,903					
Max total UBC					,660	-,329				
UBC services		,502			,552		,357			
Program age			,513	,341	,535	,473	,355			
Invest fund age						-,889				
Public financing support	,457					,747				
Max participated UBC		,443			,330	-,633		-,420		
National Patents							,874			
International patents							,787	,392		
Entrepreneurial memebers								,879		
UBC courses				,439				,544	-,357	
Private financing support									-,841	
Max academic UBC	,450	,361							,630	
IPPO age					-,362			-,457	,607	
Inventors' max royalties										-,892
Park age		,308						,476		,643
Incubator's space				,490	,389					,560

Método de extracción: Análisis de componentes principales. Método de rotación: Normalización Varimax con Kaiser.

Appendix 3.6: Results of the principal components analysis for the year 2009

Matriz de componentes rotados[a]

	Componente									
	1	2	3	4	5	6	7	8	9	10
K-transfer priority	,843									
UBC priority	,835									
UBC services	,777						,328			
Entrepreneurial university	,730									,352
Opportunity recognition involvement	,660		,370		,307	,372				,303
Business plan support		,904								
Opportunity recognition services		,892								
IP protection services		,770	-,347							
Max total UBC	,355	,582					,437		-,401	
Uni max participation							,314			
Founders' max participation							-,795			
TTO age			,792						,384	
UBC awareness events			-,480	,434				,376	-,355	
International patents				,896						
National Patents				,882						
Age first UBC			,566	,579						
Invest fund age					,923					
Public financing support		,762		,348						
Max participated UBC	,577				,586					-,378
Private financing support					-,560			,354	-,484	
Incubator's HHRR						,853				
TTO HHRR						,834				
Incubator's age			,372			,524	,398			
Max techno-based UBC	,431						-,762			
Program age			,747	,367						
IPPO HHRR					,547		-,596			
Inventors' max royalties		-,312						-,863		
Park age	,377							,748		,341
Incubator's space						,467		,649		
IPPO age									,764	
Max academic UBC	,439	,359				,323			,539	
UBC courses				,476		,301		,320	-,511	
Entrepreneurial memebers										,914

Método de extracción: Análisis de componentes principales.

Método de rotación: Normalización Varimax con Kaiser.

Appendix 3.7: Results of the principal components analysis for the year 2010

Matriz de componentes rotados[a]

	Componente									
	1	2	3	4	5	6	7	8	9	10
UBC services	,904									
K-transfer priority	,830									
Entrepreneurial university	,799	-,369						,330		
National Patents							,790	-,339		
UBC priority	,746						-,354			
Opportunity recognition involvement	,655			,388				,410		
Max total UBC	,450	,433		,380	-,337					
Business plan support		,940								
Max academic UBC					,892					
Opportunity recognition services		,878								
IP protection services		,654		-,336		-,530				
Max participated UBC		,505	-,389	,383	-,341			-,341		
IPPO age		,457		-,339	-,329			-,390		
Max techno-based UBC			-,930							
Program age										,828
Uni max participation				,891						
Founders' max participation				-,739					-,305	
Invest fund age					-,932					
Public financing support		,836								
Private financing support		,615	-,491				,353			
IPPO HHRR		,331	-,396		-,573					,330
Incubator's space						,801				
Park age				-,435		,764				
Inventors' max royalties		-,411	,346			-,602	-,466			
Incubator's age			,348	,435		,470			,415	
UBC awareness events		-,312		-,353				,795		
UBC courses								,788		
International patents	,492						,618			,421
Entrepreneurial memebers								,927		
Incubator's HHRR						,351			,811	
TTO HHRR							,392		,672	
TTO age				,434						,779
Age first UBC	,342		,440							,695

Método de extracción: Análisis de componentes principales.

Método de rotación: Normalización Varimax con Kaiser.

Appendix 4: Description of the components obtained in the Principal Components Analysis (PCA)

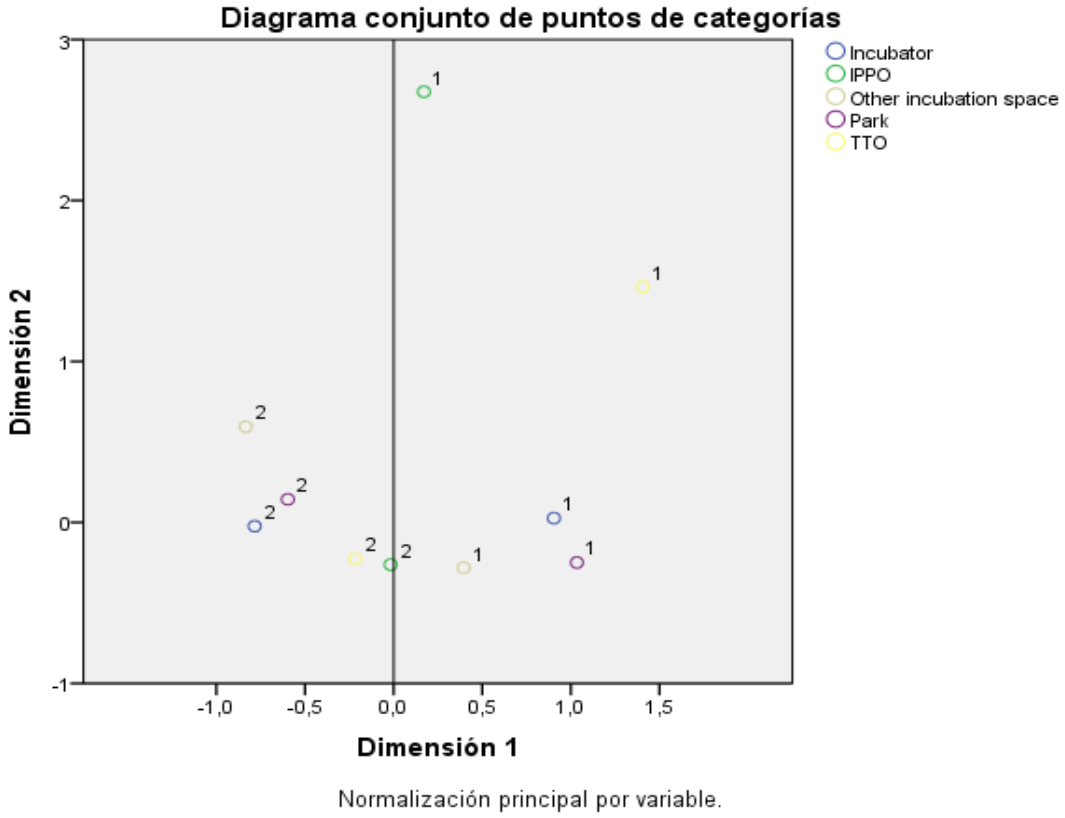
Component / variables	Main hypothesis / variables' description	Secondary hypothesis
C.1- BUSINESS DEVELOPMENT CAPABILITIES	**H.2- UNIVERSITY START-UP CAPABILITIES**	
IP protection services	Quality of intellectual property protection service at the PU	H.2(a)
Business plan support	Quality of support services for business plan realization and presentation	H.2(a)
Opportunity recognition support	Quality of support services for recognizing and evaluating a business opportunity	H.2(a)
Public financing support	Quality of support services to find public financing for UBC	H.2(a)
C.2- INFORMAL INSTITUTIONS	**H.3- UNIVERSITY START-UP INSTITUTIONS**	
PU involvement	Perceptions about PU's involvement during the start-up process	H.3(b)
Knowledge transfer priority	Perceptions about the priority given by PU to knowledge transfer activities	H.3(b)
Start-up support services	Perceptions about the availability of the UBC support services provided by PU	H.3(b)
Entrepreneurial university	Perceptions about the entrepreneurial attitude of the PU and its members	H.3(b)
C.3- HUMAN RESOURCES	**H.1- UNIVERSITY START-UP RESOURCES**	
Incubator's human resources	Number of full-time employees working at the business incubator of PU	H.1(b)
TTO human resources	Number of full-time employees working at the technology transfer office of PU	H.1(b)
C.4- TECHNOLOGICAL RESOURCES	**H.1- UNIVERSITY START-UP RESOURCES**	
National patents	Number of national patents required by PU	H.1(c)
International patents	Number of international patents required by PU	H.1(c)
C.5- START-UP EXPERIENCE	**H.2- UNIVERSITY START-UP CAPABILITIES**	
Age of TTO	Number of years since the technology transfer office started its activities	H.2(b)
Age of first UBC	Number of years since the first UBC created started its activities	H.2(b)
Age of UBC program	Number of years since the PU started to offer a formal UBC program	H.2(b)

Appendix 5: Number of component to be considered for each year of the sample

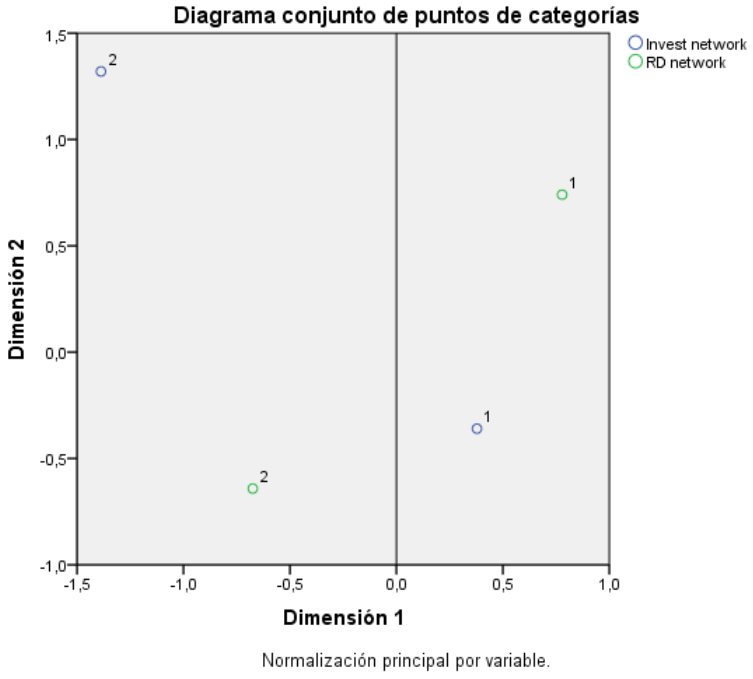
Component / Year	2004-2010	2004	2005	2006	2007	2008	2009	2010
UBC start-up services	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**
Start-up informal institutions	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**1**
Human resources	**3**	**3**	**3**	**3**	**3**	**4**	**6**	**9**
Technological resources	**4**	**7**	**4**	**5**	**7**	**7**	**4**	**7**
Start-up experience	**5**	**4**	**5**	**9**	**5**	**3**	**3**	**10**

Appendix 6: Multiple correspondence analysis results

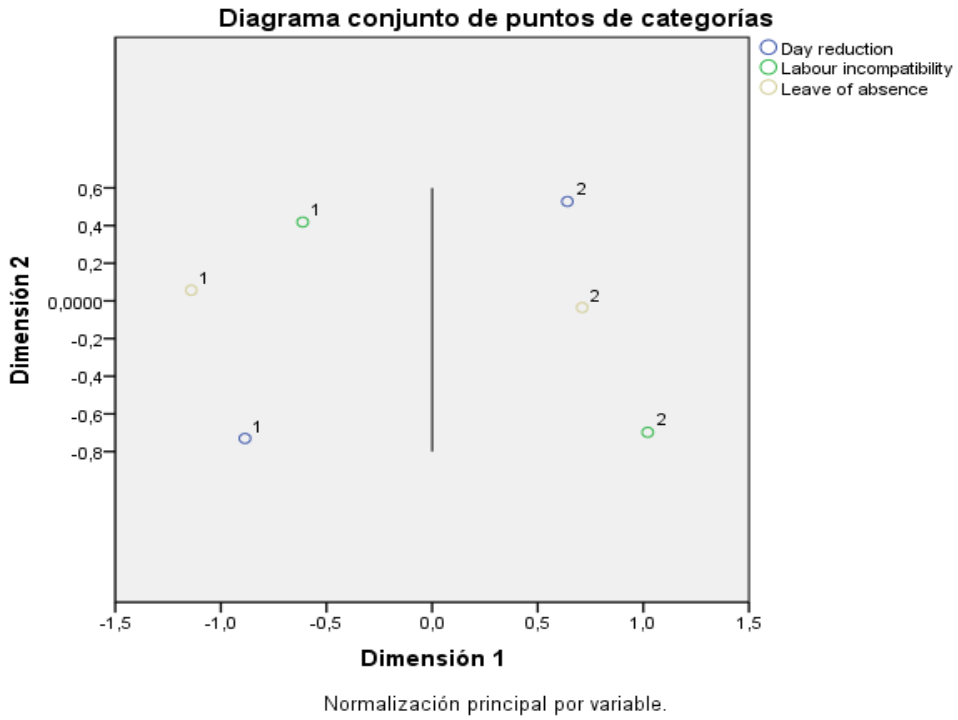
Appendix 6.1: Physical start-up resources



Appendix 6.2: Social start-up resources



Appendix 6.3: <u>Formal start-up institutions</u>



Appendix 7: Description of the dimensions obtained in the Multiple Correspondence Analysis (MCA)

DIMENSION / HYPOTHESIS	VARIABLE NAME	DESCRIPTION of VARIABLES
START-UP PHYSICAL RESOURCES (H1.a)	**TTO**	Presence of a technology transfer office
	IPPO	Presence of an intellectual property protection office
	INCUBATOR	Presence of a business incubator
	Other incubation space	Presence of other incubation space
	PARK	Presence of a science park
START-UP SOCIAL RESOURCES (H1.d)	**Invest network**	Availability of a network of start-up and equity investors.
	R&D network	Availability of a network of R&D institutions and agents.
START-UP FORMAL INSTITUTIONS (H3.a)	**Day reduction**	Existence of a labour day reduction incentive policy for UBC founders.
	Labour incompatibility	Absence of a labour incompatibility policy for UBC founders.
	Leave of absence	Existence of a leave of absence incentive policy for UBC founders.

CHAPTER FOUR

OVERCOMING CRITICAL JUNCTURES IN UNIVERSITY-BASED COMPANIES

Evidence from Catalonia

1. Introduction

With the approval of the Bayh-Dole Act in the year 1980 research universities in the United States (US) increased their support and attention towards the commercialization of their research in the markets for goods and services (Markman et al., 2004; Link and Scott, 2005; O'Shea et al., 2005; Powers and McDougall, 2005; Guerrero and Urbano, 2012; Berbegal et al., 2013; Guerrero et al., 2014; Kalar and Antoncic, 2015). In this sense, most US universities with the necessary R&D resources and capabilities started to commercialize their research results following the *Triple Helix* model of regional development originally outlined by Henry Etzkowitz (Etzkowitz, 1998; Etzkowitz and Leydesdorff, 2000; Etzkowitz et al., 2000; Etzkowitz, 2002).

During the 90's Etzkowitz's Triple Helix model started to spread among research universities in Europe (Wright et al., 2007; Guerrero et al., 2014; Ortin and Vendrell, 2014). Indeed, by the end of the twentieth century European research universities started to adopt the *Third Mission*; stating that in addition to the traditional responsibilities of teaching and doing research, universities have to create and sustain commercial value from the knowledge and technology generated by their members (Guerrero et al., 2014; Sanchez-Barrioluengo, 2014; Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015). With this objective in mind, at the beginning of this century some European research universities (especially the ones located near high-technology clusters of companies) increased their support and involvement in knowledge transfer activities with the industry and markets (Wright et al., 2007; Guerrero et al., 2014; Ortin and Vendrell, 2014; Kalar and Antoncic, 2015).

Originally, the most common way to transfer knowledge and technology from research universities to the private business sector was by partnering with the industry in R&D projects through R&D contracts or by licensing the technology to third parties (Bozeman, 2000). On the other hand, in the last two decades the creation of university-based companies (UBC) by parent universities (PU) has gained terrain as a way to transfer knowledge and create commercial value from the research undertaken at PU (Djokovic and Souitaris, 2008, Harrison and Leitch, 2010; Iglesias et al., 2012; Criaco et al., 2014; Epure et al., 2014; Ortin and Vendrell, 2014).

Thus, the phenomenon of spinning-off new ventures from parent universities (PU) has increasingly received the attention of scholars and policy makers willing to better understand the causes and consequences of University Entrepreneurship (Rothaermel et al., 2007; Djokovic and Souitaris, 2008; O'Shea et al., 2008; Ortin and Vendrell, 2014). In this sense, during the last two decades we have seen a rampant increased in the number of academic publications dealing with the UBC phenomenon (Rothaermel et al., 2007; Djokovic and Souitaris, 2008; Wright, 2014).

On the other hand, a significant group of the University Entrepreneurship literature focuses on defining and characterizing UBC, their founders and/or their parent organizations (McQueen and Wallmark, 1982; Smilor et al. 1990; Carayannis et al., 1998; Steffensen et al., 2000; Pirnay et al., 2003; Mustar et al., 2006; Beraza and Rodriguez, 2011; Guerrero and Urbano, 2012; Iglesias, et al., 2012; Karnani, 2013; Treibich et al., 2013; Epure et al., 2014; Guerrero et al., 2014; Ortin and Vendrell, 2014; Shah and Pahnke, 2014).

Another important group of studies in the University Entrepreneurship literature concentrates in identifying determinant factors facilitating UBC creation (DiGregorio and Shane, 2003; Meyer, 2003; Lockett and Wright, 2005; O'Shea et al., 2005; Ortin et al., 2008; Fini et al., 2009; Nosella and Grimaldi, 2009; Rasmussen and Borch, 2010; Clarysse et al., 2011; Karlsson et al., 2012; Marion et al., 2012; Algieri et al., 2013; Swamidass, 2013; Mendez et al., 2014; Nelson, 2014; Rolf, 2014; Goel et al., 2015; Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015; O'Kane, 2015).

These groups of studies mainly present cross-sectional evidence with no emphasis in the UBC development process. In this sense, we have found fewer empirical longitudinal studies in the University Entrepreneurship literature dealing with the process of UBC development (Clarysse and Moray, 2004; Clarysse et al., 2005; Moray and Clarysse, 2005; Rasmussen and Borch, 2010; Rasmussen, 2011).

Moreover, most studies in the University Entrepreneurship literature focus on PU located in *top-range* environments in the US or UK with abundant technological and entrepreneurial resources and a long tradition in knowledge transfer activities (Vendrell and Ortin, 2008; Vendrell and Ortin, 2010; Beraza and Rodriguez, 2011; Ortin and Vendrell, 2014). In this sense, we have found few empirical studies willing to disentangle the UBC creation and development process outside the most commonly studied *top-range* environments of US or UK. In particular, we have found very few studies investigating the UBC creation and development process in Spain (del Palacio et al., 2006; Perez et al., 2013). The present study aims at covering this gap in the University Entrepreneurship literature.

The UBC creation and development process is itself complex, interactive and requiring some trial and error (Ndonzuau et al., 2002; Vohora et al., 2004; Vendrell and Ortin, 2008; Vendrell and Ortin, 2010). In this sense, Ndonzuau et al. (2002: 282/3) argue that: "*The process is neither straightforward nor spontaneous. Instead, it is strewn with numerous obstacles, difficulties, impediments, hindrances, and other sources of resistance.*" In this study we do not aim at developing a new UBC creation and development model (Bowe and O'Shea, 2012). Instead, we draw on the on work done in Vohora et al. (2004) to identify the resources, capabilities and institutional factors used by UBC (located outside top-range environments) in order to progress from one stage of development to the next one.

On the other hand, a direct quantitative contrast of the UBC development model described in Vohora et al. (2004) will be very costly in terms of the required data (Vendrell and Ortin, 2010). Instead, in this study we take an intermediate position and draw on Vohora et al. (2004) to develop our research propositions about how UBC overcome critical obstacles in their development process (Vendrell and Ortin, 2010). We then contrast the research propositions with the empirical evidence revealed by a multiple case study analysis and discuss our findings in the light of previous studies.

Therefore, framing our research in the Resource Based View, the Dynamic Capabilities Perspective and the Institutional Economic Theory and drawing on the UBC development process detailed in Vohora et al. (2004), in this study we analyse the creation and development of eleven UBC from two different parent universities located in Catalonia, Spain. Thus, the aim of this study is to shed some light on the process of UBC creation and development outside the most commonly studied *top-range* environments. In this sense, the research questions of this study include: (i) what are the stages of development of UBC located outside *top-range* environments? (ii) which are the obstacles/difficulties that these UBC have to face in order to progress from one stage of development to the next one? How do these UBC overcome obstacles/difficulties in their development process?

In the next section of this study we review the literature related to the UBC development process and develop the research propositions. In section 3 we explain the methodology adopted and in section 4 we reveal and discuss the empirical evidence obtained. Finally we conclude by highlighting some implications and limitations of this study.

2. Review of previous studies and theoretical framework

2.1. The Process Approach and Stage-Based Models of UBC development

To guide our research we draw on the literature adopting a *Process Approach* to better understand new venture development in the university academic context. More in particular, this study draws on previous studies relating *Stage-Based Models* of venture development with the UBC development process (Roberts and Malone, 1996; Ndonzuau et al., 2002; Clarysse and Moray, 2004; Degroof and Roberts, 2004; Vohora et al., 2004; Clarysse et al., 2005; Gübeli and Doloreux, 2005; Moray and Clarysse, 2005; Kirwan et al., 2006; Vanaelst et al., 2006; Vendrell and Ortin, 2008; Rasmussen and Borch, 2010; Vendrell and Ortin, 2010; Beraza and Rodriguez, 2011; Rasmussen, 2011; Bowe and O'Shea, 2012; Perez et al., 2013).

A long tradition in studying the process of new firm development and in particular the UBC development process, generally stems on the assumption of a rather linear unitary

process, composed by a set of activities or critical events beginning with the recognition of a business opportunity and culminating with the consolidation of the firm at the markets (Kazanjian & Drazin, 1990; Ndonzuau et al., 2002; Vohora et al., 2004). We call these models *Stage-Based Models* of new venture development.

Yet there is little empirical evidence that either validates or fails to validate *Stage-Based Models*, they have been widely used to obtain insights about the process of UBC formation and development (Roberts and Malone, 1996; Ndonzuau et al., 2002; Degroof and Roberts, 2004; Vohora et al., 2004; Clarysse et al., 2005; Gübeli and Doloreux, 2005; Kirwan et al., 2006; Vanaelst et al., 2006; Vendrell and Ortin, 2008; Rasmussen and Borch, 2010; Vendrell and Ortin, 2010; Beraza and Rodriguez, 2011; Rasmussen, 2011; Bowe and O'Shea, 2012; Perez et al., 2013).

The *Stage-Based Models* literature focuses on how firms develop over time usually assuming that the venture development process may be decomposed in interrelated stages or phases of development. This assumption simplifies the conceptualization of firms' development processes and therefore facilitates insights from empirical research. One of the objectives of adopting this conceptual perspective is to identify which are the stages or phases that best describe the development process of companies. These stages or phases of development may be successive or not. Moreover, the development process may follow a linear path or on the contrary stages of development may be interconnected following other relational patterns.

The *Stage-Based Models* also aims at identifying the required organizational changes if a venture is to continue from one stage of development to the next one. In this sense, most studies willing to disentangle the development process of UBC using *Stage-Based Models* also adopt the *Resource-Based View* of the firm (RBV), the *Dynamic Capabilities Perspective* and the *Institutional Economic Theory* as their conceptual frameworks (Roberts and Malone, 1996; Degroof and Roberts, 2004; Vohora et al., 2004; Clarysse et al., 2005; Vanaelst et al., 2006; Rasmussen and Borch, 2010; Beraza and Rodriguez, 2011; Bowe and O'Shea, 2012).

In the University Entrepreneurship field of research, *Stage-Based Models* identify several phases of UBC creation/development and the organisational characteristics, resources, capabilities, policies, behaviours and practices exhibited within each stage (Roberts and Malone, 1996; Degroof and Roberts, 2004; Vohora et al., 2004; Clarysse et al., 2005; Vanaelst et al., 2006; Rasmussen and Borch, 2010; Beraza and Rodriguez, 2011; Bowe and O'Shea, 2012; Perez et al., 2013).

Although there is no generally accepted stage-based model of UBC development, all emphasise that the nature of a business changes as it grows (Vohora et al., 2004; Clarysse, et. al., 2005; Rasmussen, 2011). On the other hand, different authors emphasize different stages of development and different paths followed by UBC. Moreover, researchers do not always agree on the key factors facilitating or hindering UBC transition from one stage of development to the next one. The evidence provided

in our literature review emphasize the existence and importance of feedback among development stages and the potential for a non-linear UBC development process (Vohora et al., 2004; Clarysse, et. al., 2005; Rasmussen and Borch, 2010).

We have reviewed the reference literature using *Stage-Based Models* to analyse the creation and development process of university-based companies.[62] From **Table 1** we can see the main results about the UBC creation and development process of the studies reviewed. Thus, **Table 1** outlines the stages of UBC development identified in each study and possible challenges or obstacles that UBC have to overcome in order to pass from one stage of development to the next one.

Our review reveals that Roberts and Malone (1996) were among the first researchers explicitly stating that *Stage-Based Models* were appropriate to gain insight about the UBC creation and development process. In this sense, Roberts and Malone (1996: 5) argue that: "*A stages model can be used to describe the evolution of new ventures, emphasizing the sequential nature of venture development.*" Roberts and Malone (1996) also emphasize the complexity of the spin-off process from research organizations identifying a total of eleven sequential stages of UBC development (see **Table 1**).

Moreover, Roberts and Malone (1996) also identify four main groups of stakeholders involved in the UBC creation process with different and sometimes contradictory objectives that add further complexity to the spin-off process: (i) the academic inventor or technology originator that develops the knowledge/technology that the UBC will commercialize in the markets, (ii) the entrepreneur or the entrepreneurial team that "champions" the new venture, (iv) the parent university (PU) or the R&D parent organization that gave support to the new venture and (v) the new venture investors as venture capital firms, seed capital funds, business angels or private and public investors.

Finally, Roberts and Malone (1996) developed five different models to describe the spin-off process from parent R&D organizations based on different spin-off strategies and alternatives. For each of the five models the stages of UBC development may vary substantially. On the other hand, the authors recognized that *all models address the basic objectives of the interactions that occur between the parties*. These interactions include at least five main phases that the authors recognize in the UBC development process (see **Table 1**).

In this line, some years later Degroof and Roberts (2004) found that they are four main "*archetypes*" that a parent R&D organization can follow to spin-out companies and commercialize research results: (i) absence of proactive spin-off policies, (ii) minimal support and selectivity, (iii) intermediate support and selectivity and (iv) comprehensive support and selectivity. The authors also outline three consecutive stages in the UBC development process and the necessary resources and capabilities required in each of the stages (see **Table 1**).

[62] Articles are available from the author.

Table 1: *Stage-Based Models* and UBC creation/development process: review of previous studies

Reference	Type	Theoretical Perspective	Process of UBC Creation and Development
Roberts & Malone (1996)	Conceptual	Stage-Based Models + Institutional Theory	· UBC are created and develop following a linear model of eleven consecutive stages: (i) resources, (ii) research & development, (iii) invention, (iv) disclosure, (v) evaluation, (vi) protection, (vii) new venture creation, (viii) product development, (ix) incubation, (x) business development and (xi) initial public offering (IPO). (pp. 7, Figure 1). · These stages may be grouped in five main phases of UBC development: (i) origination and transfer of the core technology, (ii) identification of a business opportunity, (iii) development of the business proposal and acquisition of necessary managerial resources, (iv) funding process and (v) the venture spin-out process from the parent R&D organization. (pp. 6/8).
Ndonzuau et al. (2002)	Empirical Exploratory Longitudinal	Stage-Based Models	· The process of UBC development is composed by five consecutive stages interacting in a sequential manner: (i) results of research, (ii) business idea, (iii) new venture project, (iv) spin-off firms and (v) creation of economic value. (pp. 283, Figure 2). · In order to pass from one stage to the next one UBC have to be able to: (i) generate a suitable business idea, (ii) finalise the new venture project, (iii) launch the spin-off firm and (iv) strengthen its economic value. (pp. 283, Figure 2).
Clarysse & Moray (2004)	Empirical Explanatory Longitudinal	Life Cycle Perspective + Human Capital Theory	· UBC develop through four distinct phases: (i) idea phase, (ii) pre start-up phase, (iii) start-up phase and (iv) post start-up phase. (pp. 64).
Degroof & Roberts (2004)	Empirical Exploratory Crossectional	Stage-Based Models + Resource-Based View + Dynamic Capabilities + Institutional Theory	· UBC develop following three main stages: (i) origination phase, (ii) concept testing phase and (iii) start-up support phase. (pp. 333).
Vohora et al. (2004)	Empirical Exploratory Crossectional	Stage-Based Models + Resource-Based View + Dynamic Capabilities	· UBC move through five successive phases in their development in an iterative non-linear way: (i) research phase (ii) opportunity framing phase, (iii) pre-organization phase, (iv) re-orientation stage and (v) sustainable returns phase. (pp. 151). · In order to pass from one phase of development to the next one UBC must overcome four *critical junctures*: (i) opportunity recognition, (ii) entrepreneurial commitment, (iii) threshold of credibility and (iv) threshold of sustainability. (pp. 159).
Clarysse et al. (2005)	Empirical Exploratory Longitudinal	Stage-Based Models + Resource-Based View + Dynamic Capabilities + Institutional Theory	· Three different stages can be distinguished in the UBC development process: (i) the research or *invention* phase, (ii) the business validation or *transition* phase and (iii) the growth validation or *innovation* phase. (pp. 186/7). · In their development process UBC have to face and overcome six main challenges (undertake six activities): (i) opportunity search and identification, (ii) strategic choice of how to commercialize R&D, (iii) IP protection, (iv) incubation and business plan development, (v) the funding process and (vi) after spin-out organization control and management. (pp. 187).
Gübeli & Doloreux (2005)	Empirical Exploratory Crossectional	Stage-Based Models + Networks Theory	· UBC follow three main stages in their development process: (i) pre-founding stage, (ii) founding stage and (iii) post-founding stage. (pp. 271/2).

Moray & Clarysse (2005)	Empirical Exploratory Longitudinal	Life Cycle Perspective + Resource-Based View + Institutional Theory	· The process through which UBC evolve before it is actually spun off from the PU includes five phases of development: (i) opportunity recognition, (ii) from first market analysis to incubation, (iii) incubation and business plan development, (iv) transfer of intellectual property and (v) the funding process. (pp. 1015/17).
Kirwan et al. (2006)	Empirical Explanatory Crossectional	Stage-Based Models + Social System Theory + Networks Theory	· UBC follow a three stages non-linear development process (i) opportunity recognition, (ii) opportunity exploration and (iii) opportunity exploitation. (pp. 175).
Vanaelst et al. (2006)	Empirical Exploratory Longitudinal	Stage-Based Models	· UBC follow four main phases of development: (i) research commercialization and opportunity screening, (ii) organization in gestation phase, (iii) proof of viability of the newly established venture and (iv) the maturity phase. (pp. 254).
Vendrell and Ortin (2008)	Conceptual	Stage-Based Models + Resource-Based View + Institutional Theory	· The authors draw on the development process described in Vohora et al. (2004).
Rasmussen & Borch (2010)	Empirical Explanatory Longitudinal	Process approach + Stage-Based Models + Dynamic Capabilities	· UBC have to overcome four main challenges or obstacles in order to pass from one stage of development to the next one: (i) opportunity exploration, (ii) resource acquisition, (iii) decoupling from academic setting and (iv) integrating into commercial setting. (pp. 607, Table 5). · These findings imply that UBC develop following a linear path with five consecutive stages of development.
Vendrell and Ortin (2010)	Empirical Exploratory Crossectional	Stage-Based Models + Resource-Based View + Dynamic Capabilities	· The authors draw on the UBC development process described in Vohora et al. (2004).
Beraza & Rodriguez (2011)	Empirical Exploratory Crossectional	Stage-Based Models + Resource-Based View + Dynamic Capabilities + Institutional Theory	· The UBC linear creation process distinguish among six successive stages of PU's intervention: (i) to foster an entrepreneurial culture among university members, (ii) to search and identify business opportunities, (iii) to evaluate business ideas, (iv) to develop business projects, (v) to initiate operations and (vi) to consolidate the value-creation of the UBC. (pp. 95). · These stages of UBC creation may be grouped in three: (i) fostering an entrepreneurial culture and start-up awareness among PU's members, (ii) the search and identification of a business opportunity and (iii) the evaluation and valorisation of a business idea. (pp. 96).
Rasmussen (2011)	Empirical Exploratory Longitudinal	Process approach + Stage-Based Models	· UBC develop following a four phases non-linear and not uniform process: (i) research phase, (ii) opportunity framing or pre start-up phase, (iii) proof of viability phase and (iv) maturity or post start-up phase. (pp. 455/7).
Bowe & O'Shea (2012)	Empirical Exploratory Crossectional	Stage-Based Models + Resource-Based View + Dynamic Capabilities	· The authors draw on the UBC development process described in Vohora et al. (2004).
Perez et al. (2013)	Empirical Exploratory Longitudinal	Stage-Based Models	· "*Our analysis shows four distinct phases of development … 1) A first phase is related to the idea phase; 2) The pre-start-up phase is introduced by the actual decision to spin-off from the university; 3) and 4) The start-up and post-start-up phases are characterized by gaining strategic focus and professionalizing the organization of the team.*" (pp. 154).

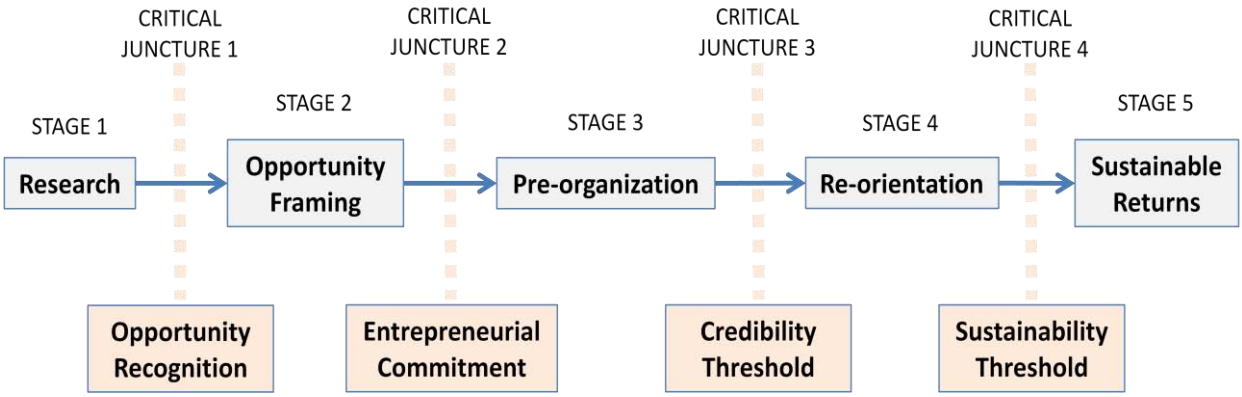
Drawing on the work done in Roberts and Malone (1996) and Degroof and Roberts (2004), Clarysse et al. (2005) found that parent research institutions (PRI) may follow three different types or models to support UBC development: (i) low selective model, (ii) supportive model and (iii) incubator model. For each of these incubation strategies the authors identify three consecutive stages in UBC development and a set of six sequential support activities undertaken by the PRI to facilitate the spin-out process (see **Table 1**). These activities may be seen as the obstacles or challenges that UBC have to face and overcome in order to continue their development process. In the same line, Gübeli and Doloreux (2005) and also Kirwan et al. (2006) identify three stages in the UBC development process (see **Table 1**).

On the other hand, some other studies propose that UBC develop following four distinctive stages (Clarysse and Moray, 2004; Vanaelst et al., 2006; Rasmussen, 2011; Perez et al., 2013). For example, in a study willing to better understand the formation and development process of the entrepreneurial teams from companies spun-off by research organizations, Clarysse and Moray (2004) found that research-based spin-offs develop along their organizational life cycle following a linear path of four consecutive stages (see **Table 1**). The authors also identify internal and external factors influencing each of the four stages in the UBC development process.

Finally, there is a group of studies that in line with the seminal work of Roberts and Malone (1996) argue that the UBC creation and development process is better described by a five stages model of new venture development (Ndonzuau et al., 2002; Vohora et al., 2004; Vendrell and Ortin, 2008; Rasmussen and Borch, 2010; Vendrell and Ortin, 2010; Bowe and O'Shea, 2012). In some of these studies the authors also identify key obstacles, challenges or critical events that UBC must face and overcome in order to pass from one stage of development to the next one (Vohora et al., 2004; Vendrell and Ortin, 2008; Vendrell and Ortin, 2010; Bowe and O'Shea, 2012). These obstacles are located at the interstices between two successive stages of development. Vohora et al. (2004) have called these key challenges in the UBC creation and development process "*critical junctures*".

Employing a multiple case study inductive approach and based on the empirical evidence from nine UBC created at seven different *top-range* or *elite* research universities from UK, Vohora et al. (2004: 151) found that "*USOs move through a number of successive phases in their development in an iterative non-linear way.*" Moreover, the authors found that "*USOs develop ... over five distinct phases.*" Furthermore, the findings in Vohora et al. (2004: 150) revealed that "*USOs encounter critical junctures that must be overcome in order to make the transition from one phase of development to the next.*" In **Figure 1** we may see a diagrammatic representation of the UBC creation and development model outlined in Vohora et al. (2004).

Figure 1: The UBC creation and development process



Source: Vohora et al. (2004).

From **Figure 1** we can see that, following Vohora et al. (2004), the first stage in the UBC creation and development process is the *research phase*. At this stage of development, the UBC is not properly defined as a business project and future founders have not identified a business opportunity yet. Indeed, at the research phase of UBC development, academic founders are usually not aware of possible commercial applications of their research results.

At this stage of development, future UBC academic founders are in charge of developing the basis of the technology that the firm will eventually commercialize at the markets for goods and services. In this sense, Roberts and Malone (1996: 6) argue that at this stage of UBC development: "*The technology that is provided establishes the initial core competencies of the new company.*"

The second phase of UBC development recognized in Vohora et al. (2004) is the *opportunity framing phase*. At this stage, "*the academic and the TTO worked towards examining whether the recognized opportunity had sufficient underlying value to warrant further effort in pursuing commercialization. This "screening" process first involves evaluating the technology and to ensuring there is sufficient evidence that it actually works and shows sufficient promise for applications outside the laboratory.*" (Vohora et al., 2004: 151). Moreover, Vohora et al. (2004: 151) argue that at this stage of the UBC development process, "*academic entrepreneurs and TTOs tried to identify alternative "markets", what applications of the technology to develop for those markets and how best to access customers to target with the innovation.*"

In the same line, Ndonzuau et al. (2002: 284) consider that: "*At this stage* – framing the business opportunity - *there is merely a feeling or a rough presumption that research results display promising economic potential. That presumption must be validated in a business project.*" The validation of the business project described in Ndonzuau et al. (2002) is an activity that UBC undertake in the next phase of development: the *pre-organization phase*.

Explaining the third stage of UBC development (*pre-organization phase*), Vohora et al. (2004: 156) argue that: "*Having framed the opportunity during the previous phase and committed to commercially exploiting it, the management of the USO venture can develop and start to implement strategic plans during the pre-organization phase. For all cases, this involved taking decisions over what existing resources and capabilities to develop, what resources and knowledge to acquire now and in the future, as well as when and where to access these resources and knowledge*."

The fourth stage of UBC development recognized in Vohora et al. (2004), the *re-orientation phase*, implies that the new venture has to face important organizational changes to be able to reconfigure the resource and knowledge base of the firm and gain competitiveness at the markets. In this sense, Vohora et al. (2004: 156) argue that: "*during the re-orientation phase, the entrepreneurial teams faced the challenges of continuously identifying, acquiring and integrating resources and then subsequently re-configuring them.*"

Finally, as argue in Vohora et al. (2004: 159): "*The final phase is characterized by the USO attaining sustainable returns. The fundamental objective of the entrepreneurial teams is to access and re-configure resources to assemble the capabilities which enable the venture to reach such a phase.*" Moreover, Vohora et al. (2004: 168) argue that: "*At the sustainability phase, there is a need for further iteration of activities to achieve the critical mass to serve the market in order to obtain further rounds of funding resources*."

Summarizing the results obtained in Vohora et al. (2004) the authors concluded that: "*First, the case study analysis indicates that USOs go through a number of different distinct phases of activity in their development. Each venture must pass through the previous phase in order to progress to the next one but each phase involves an iterative, non-linear process of development in which there may be a need to revisit some of the earlier decisions and activities. Second, at the interstices between the different phases of development we found that ventures face "critical junctures" in terms of the resources and capabilities they need to acquire to progress to the next phase of development.*" Thus, we draw on the results found in Vohora et al. (2004) to propose that:

Proposition 1: UBC develop following an iterative non-linear path with five consecutive stages and four critical junctures that UBC have to overcome in order to progress from one stage of development to the next one.

Moreover, it seems that during their development process, UBC have to acquire, develop and reconfigure their resource base and start-up capabilities (Roberts and Malone, 1996; Degroof and Roberts, 2004; Vohora et al., 2004; Clarysse et al., 2005; Rasmussen and Borch, 2010; Vendrell and Ortin, 2010; Beraza and Rodriguez, 2011; Rasmussen, 2011; Ortin and Vendrell, 2014; Wright, 2014). In this sense, Vohora et al. (2004: 150) argue that: "*by examining the USO ventures both before and after each*

transition, we found them to be qualitative different in terms of their resources, capabilities and social capital."

In the same line, Clarysse et al. (2005: 187) argue that: "*Spin-outs need to develop their resources over time to progress through different phases of development and create significant wealth.*" Moreover and in line with the results found in Brush et al. (2001), the authors recognize six types of resources that are key in the UBC spin-out process: (i) human resources, (ii) social resources, (iii) financial resources, (iv) physical resources, (v) technological resources and (vi) organizational resources.

Furthermore, other studies in the University entrepreneurship literature have emphasized how relevant are certain *entrepreneurial* capabilities in the UBC creation and development process (Roberts and Malone, 1996, Locket et al., 2003; Siegel et al., 2003; Clarysse et al., 2005; Locket and Wright, 2005; del Palacio, 2006; Ortin et al., 2008; Fini et al., 2009; Nosella and Grimaldi, 2009; Rasmussen and Borch, 2010; Vendrell and Ortin, 2010; D'Este et al., 2012; Ortin and Vendrell, 2014; Rasmussen et al., 2014). For example, D'Este et al. (2012) found that there are *a set of skills and expertise of scientists* that significantly influence the capacity of academic researchers *to contribute to technical advance ... engaging in the exploitation of entrepreneurial opportunities*.

In this line, the empirical evidence from the multiple case study analysis in Rasmussen and Borch (2010: 607) revealed that: "*From our analysis, we identified three university capabilities that facilitated the USO formation process at different phases of development. First, the initiation of the venturing processes was facilitated by capabilities that opened new paths of action.... Second, the launch of the venture was facilitated by capabilities that balanced academic and commercial interests.... Third, the initial resource endowment of the nascent venture was facilitated by capabilities that integrated new resources*". Thus, drawing on previous studies relating the *Resource-Based View* of the firm (RBV) and the *Dynamic Capabilities Perspective* with the UBC development process, we propose that:

Proposition 2: UBC make use of their own and their parent universities' resources and capabilities to progress from one stage of development to the next one.

Moreover, most of the University Entrepreneurship literature also emphasizes the importance of parent universities' (PU) formal support (usually provided through the technology transfer office and/or specialized start-up programmes) in the UBC creation and development process (DiGregorio and Shane, 2003; Shane, 2004; Degroof and Roberts, 2004; Gübeli and Doloreux, 2005; del Palacio et al., 2006; Guerrero and Urbano, 2012; Algieri et al., 2013; Berbegal et al., 2013; Nelson, 2014; Rasmussen et al., 2014; Sanchez-Barrioluengo, 2014; Wright, 2014; Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015; O'Kane et al., 2015).

In this sense, Clarysse et al. (2005) found that: "*To enable spin-out companies to move through the different stages in the spin-out process, there may be a need for support from the parent RIs, that is, for the parent to perform an incubation role.*" In the same line, Gübeli and Doloreux (2005: 271) argue that: "*The significance of the university in technology transfer during the founding of the spin-off has already been demonstrated.*"

On the other hand, some of these studies assessing the determinant factors in the UBC development process, recognized that the support given by PU to UBC is of special importance during the early stages of the new venture development but losses relevance as the UBC progress to more advanced stages of development (Ndonzuau et al., 2002; Degroof and Roberts, 2004; Clarysse and Moray, 2005; Vohora et al., 2004; Clarysse et al., 2005; Gübeli and Doloreux, 2005; Beraza and Rodriguez, 2011; Sternberg, 2014).

In this line, Gübeli and Doloreux (2005: 279) concluded that: "*it is clear that the parental organisation, or the host university, plays a pivotal role in the spin-off process, especially in its early development. … However, as the spin-off evolves, this pre-incubation service complements yet more support services of municipality and region, which stand to be more important in the technological and business development of the spin-off.*"

Giving support to this argument, Beraza and Rodriguez (2011: 95) argue that *the implication of parent universities is indispensable during the first stages of UBC development process but that it gradually loss importance because there are other agents in the community (i.e. financial institutions, science and technology parks, business centres or business incubators) that may facilitate the UBC development in a more effective and efficient manner*.[63] Thus, we draw on previous studies assessing PU's support during the UBC creation and development process to propose that:

Proposition 3: While the support given by PU is especially important during the first stages of UBC development, it looses relevance during more advanced stages of UBC development.

2.2. Critical junctures in UBC development

In order to get a rich understanding of how UBC develop from a research stage into a fully consolidated company commercializing technology at the markets, we believe it is important to identify not only the path and stages of growth but also the obstacles that UBC have to overcome during their development process. Following Vohora et al. (2004) we call these obstacles, challenges or key events in the UBC development process *critical junctures*.

Critical junctures are defined as the difficulties that the UBC has to overcome in order to pass from one phase of development to the following one (Vohora et al., 2004;

[63] This is a direct translation from Beraza and Rodriguez (2011). We apologize for any mistake or misleading translation that we may have done.

Vendrell and Ortin, 2008; Vendrell and Ortin, 2010). In this sense, Vohora et al. (2004: 159) *define critical junctures as a complex problem that occurs at a point along a new high-tech venture's expansion path preventing it from achieving the transition from one development phase to the next. The venture reaches a performance threshold from where its continued development is constrained.*"

Critical junctures arise because the venture requires new configurations of resources, capabilities, network ties and support from institutions (Vendrell and Ortin, 2008; Rasmussen and Borch, 2010; Vendrell and Ortin, 2010). In order to be able to progress from one stage of development to the next one, UBC management teams and the PU's TTO have to properly identify these critical junctures and find ways to overcome them.

In this sense, Vohora et al. (2004: 150) argue that: "*Identifying these critical junctures is important because they characterize inherent conflicts that exist within the USO venture preventing development."* Moreover, if critical junctures are not overcome in a timely manner, UBC risk failing. In this sense, Vohora et al. (2004: 150) argue that: "*If the critical junctures remain unresolved for a prolonged period of time, the venture will eventually fail.*"

In their study, Vohora et al. (2004) found that the there are four main challenges or critical junctures that UBC have to overcome to successfully progress from one development stage to the next one: (i) *opportunity recognition*, (ii) *entrepreneurial commitment*, (iii) *credibility threshold* and (iv) *sustainability threshold*. Each of these critical junctures is located at the interstice of two consecutive phases in the UBC development process. In this sense, "*The critical juncture of opportunity recognition lies at the interface of the research phase and opportunity framing phase* (Vohora et al., 2004: 160).

Following Vohora et al. (2004: 160) "*Opportunity recognition is the match between an unfulfilled market need and a solution that satisfies the need that most others have overlooked. Thus, opportunity recognition involves capturing break through ideas that trigger an evaluation, as a precursor to the formation of commercialization effort*." The opportunity recognition critical juncture arises because universities and academics usually have significant technological knowledge but insufficient knowledge of how to serve markets (Vohora et al., 2004: 160). Moreover, academic founders and parent universities may have *unrealistic expectations of the profits that could be derived from the technologies they* have *discovered* (Vohora et al., 2004: 160).

Furthermore, *entrepreneurial commitment can be defined as acts which bind the venture champion to a certain course of events* (Vohora et al., 2004: 160). In addition, Vohora et al. (2004: 163) argue that: "*the critical juncture of entrepreneurial commitment arises due to the conflict between the need for a committed venture champion to develop the USO venture and the inability to find an individual with the necessary entrepreneurial capabilities.*" Thus, in the *entrepreneurial commitment* critical juncture the UBC has to

find a venture champion with the necessary entrepreneurial and managerial capabilities and who can solidly commit to develop and consolidate the company in the markets.

Once the necessary entrepreneurial resources are committed to the new venture development, the following critical juncture UBC have to face is to gain credibility at the markets. In the words of Vohora et al. (2004: 164): "*At this stage in the development of a USO, the academic or surrogate entrepreneur has conceived an opportunity, and committed him/herself and a team to developing it into a USO.*" Thus, in order to overcome the third critical juncture UBC have to convince markets' agents (i.e. customers, distributors, suppliers, partners, competitors or investors) that the firm is able to provide competitive products/services and will be able to continue competitively commercializing its products/services in the future.

Gaining credibility at the markets is one of the major problems that UBC have to face. UBC generally lack brand awareness, commercial experience and other business-related capabilities that severely constrains the firms' ability to access and acquire key resources in their development process (Vohora et al., 2004; Vendrell and Ortin, 2010; Ortin and Vendrell, 2014). This constrain in new ventures' development was first conceptualized in the management literature as firms' *Liability of the Newness* (Freeman et al., 1983; Singh et al., 1986). In this sense, Vohora et al. (2004: 165) argue that: "*We suggest that without this initial credibility, new high-tech ventures will not be able to overcome skeptical customer perceptions, gain access to markets and successfully achieve the transition from a "concept" to a "legitimate business" engaged in transactions in the market*."

Once UBC have secured the necessary entrepreneurial resources and gained credibility at the markets, they have to face a final critical juncture in their development process: the *sustainability threshold*. At this point UBC have to stabilize operations and sales securing a steady flow of cash inputs and benefits. UBC may reach sustainable returns in various ways. In this sense, Vohora et al. (2004: 166) suggest that: "*Sustainable returns may take the form of revenues from customers for services or products sold, milestone payments from collaborative agreements or investment from existing or new investors. This is a sign that the entrepreneurial team has the ability to create value from having developed the appropriate resources, capabilities and social capital.*"

In the rest of this section, we shall uncover the key factors found in the University Entrepreneurship literature that may enhance or restrain the overcoming of critical junctures during the UBC development process. In this sense, we have reviewed the reference academic literature aiming at identifying critical resources, capabilities or institutional factors influencing the process of overcoming critical junctures by UBC. In **Table 2** we may see the results from our review.

From **Table** 2 we can see that several authors emphasize the importance of parent universities' (PU's) support and PU's start-up capabilities to overcome the first critical juncture (*opportunity recognition*) in the UBC development process (Roberts and

Malone, 1996; Degroof and Roberts, 2004; Gübeli and Doloreux, 2005; Vanaelst et al., 2006; Rasmussen and Borch, 2010; Vendrell and Ortin, 2010; Beraza and Rodriguez, 2011; Bowe and O'Shea, 2012; Perez et al., 2013). Moreover, we have found in the literature reviewed that PU's entrepreneurial orientation and culture also influence the recognition of a business opportunity by PU's members (Ndonzuau et al., 2002; Clarysse and Moray, 2004; Guerrero and Urbano, 2012; Guerrero et al., 2014, Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015).

In the same line, we have found that social resources (networks of contacts) of parent universities (PU) will enhance the probability that UBC overcome the first critical juncture in their development process (Degroof and Roberts, 2004; Gübeli and Doloreux, 2005; Rasmussen and Borch, 2010; Bowe and O'Shea, 2012; Perez et al., 2013). From the literature, it seems that the UBC founders' networks are also a key factor influencing the recognition of business opportunities by members of the PU (Vohora et al., 2004; Kirwan et al., 2006). UBC founders' capabilities, previous experience and personal characteristics will also influence the process of *opportunity recognition* (Venkataraman, 1997; Vohora et al., 2004; Clarysse et al., 2005; Vendrell and Ortin, 2008; Marion et al., 2012).

Finally, the University Entrepreneurship literature also recognizes that it is easier to identify a business opportunity from applied research (that is closer to the markets) than from basic or fundamental research (far away from markets). Thus, it is argued in the University Entrepreneurship literature that the degree of commercial application of the research also influences the probability that UBC overcome the *opportunity recognition* critical juncture (Clarysse and Moray, 2004; Vohora et al., 2004; Moray and Clarysse, 2005; Vanaelst et al., 2006; Rasmussen and Borch, 2010; Bowe and O'Shea, 2012; Perez et al., 2013).

Thus, drawing on the literature trying to identify the key factors influencing the overcoming of the *opportunity recognition* critical juncture by UBC we propose that:

Proposition 4: The key factors influencing the probability that UBC overcome the *opportunity recognition* critical juncture are: (i) PU's support; (ii) UBC founders' social resources, industry knowledge and entrepreneurial capabilities and (iii) the commercial applicability of the research/technology developed by academic founders.

Most of the studies in the University Entrepreneurship literature aiming at better understanding *entrepreneurial commitment* in UBC emphasize the relevant role that PU play in facilitating overcoming this critical juncture (Roberts and Malone, 1996; Degroof and Roberts, 2004; Clarysse and Moray, 2004; Clarysse et al., 2005; Rasmussen and Borch, 2010). In this sense, PU's support and capabilities to find and help to recruit capable and committed personnel enhance the probability that UBC overcome the *entrepreneurial commitment* critical juncture (Roberts and Malone, 1996; Degroof and Roberts, 2004; Bowe and O'Shea, 2012).

Table 2: Determinant factors necessary to overcome critical junctures in the UBC development process

CRITICAL JUNCTURE	RESOURCES, CAPABILITIES AND INSTITUTIONAL FACTORS INFLUENCING THE PROBABILITY TO OVERCOME THE CRITICAL JUNCTURE	FACTOR TYPE
Opportunity Recognition (identify a commercial application of the knowledge generated at the PU which is unfulfilled or is not well served by current market alternatives)	· **PU's support for searching and evaluating business opportunities.** (Roberts and Malone, 1996; Ndonzuau et al., 2002; Degroof and Roberts, 2004; Clarysse et al., 2005; Gübeli and Doloreux, 2005; Vanaelst et al., 2006; Rasmussen and Borch, 2010; Vendrell and Ortin, 2010; Beraza and Rodriguez, 2011; Bowe and O'Shea, 2012).	CAPABILITIES
	· **PU's entrepreneurial orientation and culture.** (Ndonzuau et al., 2002; Clarysse and Moray, 2004; Gübeli and Doloreux, 2005; Moray and Clarysse, 2005; Beraza and Rodriguez, 2011; Guerrero and Urbano, 2012; Guerrero et al., 2014; Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015).	INFORMAL INSTITUTIONS
	· **PU's monitoring and assessment of research projects, research results, doctoral dissertations and research groups. Technology audits undertaken by PU's TTO**. (Beraza and Rodriguez, 2011; Bowe and O'Shea, 2012).	CAPABILITIES
	· **UBC founders' idiosyncratic information**. (Roberts and Malone, 1996; Degroof and Roberts, 2004; Vohora et al., 2004).	HUMAN RESOURCES
	· **PU's and UBC founders' social capital (networks**). (Degroof and Roberts, 2004; Vohora et al., 2004; Gübeli and Doloreux, 2005; Kirwan et al., 2006; Rasmussen and Borch, 2010; Bowe and O'Shea, 2012; Perez et al., 2013).	SOCIAL RESOURCES
	· **UBC founders' creativity, motivation and business vision**. (Venkataraman, 1997; Vohora et al., 2004; Clarysse et al., 2005; Gübeli and Doloreux, 2005; Rasmussen and Borch, 2010; Bowe and O'Shea, 2012; Perez et al., 2013).	HUMAN RESOURCES
	· **UBC founders' ability to combine and synthesize scientific knowledge from different research fields adapting to markets' needs**. (Vohora et al., 2004; Gübeli and Doloreux, 2005; Vendrell and Ortin, 2008; Rasmussen and Borch, 2010).	CAPABILITIES
	· **UBC founders' previous industry experience**. (Degroof and Roberts, 2004; Vendrell and Ortin, 2008; Marion et al., 2012; Bowe and O'Shea, 2012; Perez et al., 2013).	HUMAN RESOURCES
	· **Degree of commercial application of the research. Basic versus applied research**. (Clarysse and Moray, 2004; Vohora et al., 2004; Moray and Clarysse, 2005; Vanaelst et al., 2006; Rasmussen and Borch, 2010; Perez et al., 2013).	TECHNOLOGICAL RESOURCES

Entrepreneurial Commitment (secure the necessary managerial resources; in particular the general manager or CEO of the company)	· **UBC founders' and PU's capabilities to find a suitable *venture champion* or *surrogate entrepreneur* and commit him/her to manage the firm development process**. (Roberts and Malone, 1996; Degroof and Roberts, 2004; Clarysse and Moray, 2004; Vohora et al., 2004; Clarysse et al., 2005; Vanaelst et al., 2006; Vendrell and Ortin, 2008; Vendrell and Ortin, 2010; Bowe and O'Shea, 2012; Perez et al., 2013; Lundqvist, 2014).	CAPABILITIES
	· **UBC founders' and PU's social capital**. (Vohora et al., 2004; Kirwan et al., 2006; Vendrell and Ortin, 2008; Vendrell and Ortin, 2010; Bowe and O'Shea, 2012; Perez et al., 2013).	SOCIAL RESOURCES
	· **PU's rewards system**. (Vohora et al., 2004; Vendrell and Ortin, 2008; Vendrell and Ortin, 2010; Huyghe and Knockaert, 2015).	FORMAL INSTITUTIONS
	· **PU's policies on UBC creation and labour policies**. (Rasmussen and Borch, 2010; Perez et al., 2013).	FORMAL INSTITUTIONS
	· **PU's support to recruit**. (Clarysse and Moray, 2004; Clarysse et al., 2005; Rasmussen and Borch, 2010).	CAPABILITIES
	· **PU's entrepreneurial orientation and culture**. (Beraza and Rodriguez, 2011; Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015).	INFORMAL INSTITUTIONS
	· **PU's resources and facilities for UBC creation and development**. (Rasmussen and Borch, 2010; Perez et al., 2013).	PHYSICAL RESOURCES
	· **PU's successful entrepreneurial role models**. (Clarysse and Moray, 2004; Vohora et al., 2004; Bowe and O'Shea, 2012).	INFORMAL INSTITUTIONS
	· **UBC founders' ability to delegate firm control**. (Vohora et al., 2004; Bowe and O'Shea, 2012).	HUMAN RESOURCES
	· **UBC founders' prior entrepreneurial and managerial experience**. (Vohora et al., 2004; Gübeli and Doloreux, 2005; Bowe and O'Shea, 2012; Marion et al., 2012; Perez et al., 2013).	HUMAN RESOURCES
	· **UBC founders' personality and personal limitations**. (Vohora et al., 2004; Bowe and O'Shea, 2012).	HUMAN RESOURCES
	· **The sales growth and profit potential of the new venture project**. (Gübeli and Doloreux, 2005; Vendrell and Ortin, 2010; Bowe and O'Shea, 2012).	FINANCIAL RESOURCES
	· **Potential value of UBC's intellectual property. Is UBC's legally protected from competitors?** (Ndonzuau et al., 2002; Clarysse et al., 2005; Vanaelst et al., 2006; Beraza and Rodriguez, 2011).	TECHNOLOGICAL RESOURCES
	· **The creation of a UBC has to be perceived as a better alternative for university entrepreneurs compare to other labour alternatives (i.e. staying at the PU)**. (Vendrell and Ortin, 2008; Vendrell and Ortin, 2010).	INFORMAL INSTITUTIONS

Credibility Threshold (gain market legitimacy overcoming liabilities of newness)	· **UBC founders' and management teams' characteristics, resources and capabilities.** (Ndonzuau et al., 2002; Degroof and Roberts, 2004; Vohora et al., 2004; Gübeli and Doloreux, 2005; Vanaelst et al., 2006; Rasmussen and Borch, 2010; Beraza and Rodriguez, 2011; Bowe and O'Shea, 2012; Perez et al., 2013).	HUMAN RESOURCES
	· **UBC founders' and management teams' social resources.** (Degroof and Roberts, 2004; Gübeli and Doloreux, 2005; Kirwan et al., 2006; Bowe and O'Shea, 2012; Perez et al., 2013).	SOCIAL RESOURCES
	· **UBC founders' academic eminence and their legitimacy in the scientific community**. (Vohora et al., 2004).	INFORMAL INSTITUTIONS
	· **UBC founders' share of the UBC capital**. (Vendrell and Ortin, 2008).	FINANCIAL RESOURCES
	· **UBC's leverage** (Vendrell and Ortin, 2010).	FINANCIAL RESOURCES
	· **Secure external seed finance** (Roberts and Malone, 1996; Ndonzuau et al., 2002; Vohora et al., 2004; Gübeli and Doloreux, 2005; Moray and Clarysse, 2005; Vanaelst et al., 2006; Vendrell and Ortin, 2010; Beraza and Rodriguez, 2011).	FINANCIAL RESOURCES
	· **Reach key initial customers**. (Vohora et al., 2004; Bowe and O'Shea, 2012; Perez et al., 2013).	ORGANIZATIONAL RESOURCES
	· I**ndustry partners and joint ventures**. (Rasmussen and Borch, 2010).	ORGANIZATIONAL RESOURCES
	· V**enture capital firms, banks and other financial institutions**. (Roberts and Malone, 1996; Degroof and Roberts, 2004; Clarysse et al., 2005).	FINANCIAL RESOURCES
Sustainability Threshold (achieve sustainable returns from operations)	· **UBC founders' and management teams' capabilities**. (Clarysse and Moray, 2004; Degroof and Roberts, 2004; Vohora et al., 2004; Gübeli and Doloreux, 2005; Vendrell and Ortin, 2008; Rasmussen and Borch, 2010; Bowe and O'Shea, 2012; Perez et al., 2013).	CAPABILITIES
	· **UBC founders' and management teams' social capital.** (Gübeli and Doloreux, 2005; Kirwan et al., 2006; Perez et al., 2013).	SOCIAL RESOURCES
	· **UBC founders' and management teams' capacity to cope with change and constantly adapt the business**. (Ndonzuau et al., 2002; Vohora et al., 2004; Bowe and O'Shea, 2012).	CAPABILITIES
	· **Access to new rounds of financing**. (Clarysse et al., 2005; Gübeli and Doloreux, 2005; Moray and Clarysse, 2005; Vanaelst et al., 2006; Perez et al., 2013).	FINA NCIAL RESOURCES
	· **UBC founders' ability to decouple from the academic setting and integrate with the business setting** (Ndonzuau et al., 2002; Moray and Clarysse, 2005; Rasmussen and Borch, 2010; Bowe and O'Shea, 2012; Perez et al., 2013).	CAPABILITIES
	· **UBC founders' and management teams' innovation capabilities**. (Clarysse and Moray, 2004; Vendrell and Ortin, 2010).	CAPABILITIES
	· **Strength of the UBC intellectual property**. (Beraza and Rodriguez, 2011).	TECHNOLOGICAL RESOURCES

In the same line, in the University Entrepreneurship literature we have found evidence supporting that these same capabilities are also important for UBC founders willing to overcome the *entrepreneurial commitment* critical juncture (Vohora et al., 2004; Vendrell and Ortin, 2008; Vendrell and Ortin, 2010; Lundqvist, 2014). Thus, from the literature reviewed the absence of these entrepreneurial or start-up capabilities among PU or among UBC founders may hinder firms' possibility to properly overcome the *entrepreneurial commitment* critical juncture.

Indeed, from our literature review we may conclude that it seems that one of the most relevant factors for UBC to overcome the *entrepreneurial commitment* critical juncture is the PU's and UBC founders' capabilities to find a suitable person to *champion* the new venture into sustainable returns. In this sense, Vohora et al. (2004: 163) found that: "*The critical juncture of entrepreneurial commitment arises due to the conflict between the need for a committed venture champion to develop the USO venture and the inability to find an individual with the necessary entrepreneurial capabilities*".

We have found in the University Entrepreneurship literature several reasons why PU and UBC founders may not be able find and hire a suitable venture champion. For example, both PU and UBC founders, may lack the necessary social resources (networks) to find a capable person interested in devoting his/her time exclusively to the new venture project (Vohora et al., 2004; Kirwan et al., 2006; Vendrell and Ortin, 2008; Vendrell and Ortin, 2010).

Another important reason why UBC may not properly overcome this critical juncture is that the new venture project may lack the growth and profits potential in order to be perceived as an attractive labour alternative for suitable managers (Ndonzuau et al., 2002; Clarysse et al., 2005; Gübeli and Doloreux, 2005; Vanaelst et al., 2006; Vendrell and Ortin, 2008; Vendrell and Ortin, 2010; Beraza and Rodriguez, 2011).

Moreover, PU with a reward system favouring technology transfer and entrepreneurial activities facilitate the overcoming of this critical juncture by UBC (Vohora et al., 2004; Vendrell and Ortin, 2008; Vendrell and Ortin, 2010; Huyghe and Knockaert, 2015). On the other hand, restrictive labour and UBC creation PU's policies will hinder the possibility for UBC to overcome the *entrepreneurial commitment* critical juncture (Rasmussen and Borch, 2010).

The culture, climate and entrepreneurial orientation of PU and their members are also found to be relevant factors for UBC to overcome this second critical juncture in their development process (Beraza and Rodriguez, 2011; Guerrero and Urbano, 2012; Huyghe and Knockaert, 2015; Kalar and Antoncic, 2015). In the same line, it seems that having access to successful entrepreneurial role models increases the probability that UBC successfully overcome the *entrepreneurial commitment* critical juncture (Clarysse and Moray, 2004; Vohora et al., 2004).

In addition, some authors emphasize that PU provision of certain strategic physical resources and facilities (i.e. laboratories and testing facilities, incubators, science and technology parks, production facilities, storage or office space) will influence the possibility that UBC properly overcome the *entrepreneurial commitment* critical juncture (Rasmussen and Borch, 2010).

Finally, in the University Entrepreneurship literature we have found some authors outlining personal characteristics of UBC founders (i.e. ability to delegate control, prior entrepreneurial and managerial experience or some personal limitations) as key factors for UBC to properly overcome the *entrepreneurial commitment* critical juncture (Vohora et al., 2004; Gübeli and Doloreux, 2005; Marion et al., 2012).

Drawing on the literature trying to identify the key factors influencing the overcoming of the *entrepreneurial commitment* critical juncture by UBC we propose that:

Proposition 5: The key factors influencing the probability that UBC overcome the *entrepreneurial commitment* critical juncture are: (i) PU's support, PU's reward system and PU's policies; (ii) UBC founders' social resources and (iii) the business project potential to grow, succeed and generate sustainable returns.

Our review of the University Entrepreneurship literature also revealed that PU's support looses relevance during the latter stages of UBC development (Ndonzuau et al., 2002; Degroof and Roberts, 2004; Clarysse and Moray, 2005; Vohora et al., 2004; Clarysse et al., 2005; Gübeli and Doloreux, 2005; Beraza and Rodriguez, 2011; Sternberg, 2014).

In this sense, in **Table 2** we may see that while PU's support, capabilities and resources were key factors influencing the process of overcoming the first two critical junctures in UBC development (*opportunity recognition* and *entrepreneurial commitment*), the literature signals that there is little or no presence of PU during UBC overcoming process of the third and fourth critical junctures (*credibility threshold* and *sustainability threshold*).

Another important difference we have found in the University Entrepreneurship literature dealing with the process of UBC development is that while PU loose presence after UBC pass the second critical juncture, a new actor or agent comes into place: the manager or management team. This figure was not present during the first two critical junctures in UBC development and becomes of great relevance after UBC overcome the *entrepreneurial commitment* critical juncture, thus securing a venture champion to lead the UBC until sustainable returns. Before the *entrepreneurial commitment* critical juncture is passed, the manager position is generally covered by the academic founder/s or is not covered at all.

In this sense, we may see in **Table 2** that one of the key factors influencing UBC overcoming the *credibility threshold* is UBC founders' and managers' resources and capabilities. In particular, from **Table 2** we can see that the University Entrepreneurship

literature emphasizes the importance of UBC founding and management teams' characteristics (human resources) and business development capabilities (Ndonzuau et al., 2002; Degroof and Roberts, 2004; Vohora et al., 2004; Gübeli and Doloreux, 2005; Vanaelst et al., 2006; Rasmussen and Borch, 2010; Beraza and Rodriguez, 2011).

In the same line, some of the authors dealing with the UBC development process also outline how relevant UBC founders' and managers' social resources are in order for UBC to overcome the *credibility threshold* gaining legitimacy at the markets (Degroof and Roberts, 2004; Gübeli and Doloreux, 2005; Kirwan et al., 2006).

Moreover, our review of the University Entrepreneurship literature also reveals that the financial resources secured by the firm are key elements for UBC to gain credibility at the markets and therefore overcome the third critical juncture in their development process (Vohora et al., 2004; Moray and Clarysse, 2005; Vendrell and Ortin, 2008; Vendrell and Ortin, 2010; Beraza and Rodriguez, 2011).

For example, Vendrell and Ortin (2010) argue that the share of external finance over total financial resources (firm's leverage) is a sign of credibility in front of markets. In this line, Vendrell and Ortin (2008) found that the share of the UBC capital in hands of academic founders is assimilated as a signal of credibility by the potential investors.

Finally, from **Table 2** we can see that there are some organizational resources (i.e. key clients, industry partners or joint ventures agreements) that may enhance UBC probability of overcoming the *credibility threshold* critical juncture (Vohora et al., 2004; Rasmussen and Borch, 2010).

Thus, we draw on the literature trying to identify the key factors influencing the overcoming of the *credibility threshold* critical juncture by UBC to propose that:

Proposition 6: The key factors influencing the probability that UBC overcome the *credibility threshold* critical juncture are: (i) UBC managers' social resources and commercial capabilities and (ii) UBC's financial and organizational resources.

During the transition through the fourth and final critical juncture (*sustainability threshold*), UBC have to consolidate operations at the markets generating cash inflows in a regular manner. This implies that UBC willing to overcome this last critical juncture should have the capabilities to reconfigure their resource bases and adapt their business models to new internal or external situations (Clarysse and Moray, 2004; Degroof and Roberts, 2004; Vohora et al., 2004; Rasmussen and Borch, 2010).

In the same line, the University Entrepreneurship literature also recognizes the importance of UBC founders' and managers' business development (managerial) capabilities in order to overcome the *sustainability threshold* in their development process (Degroof and Roberts, 2004; Vohora et al., 2004; Gübeli and Doloreux, 2005; Vendrell and Ortin, 2008; Rasmussen and Borch, 2010). In this line, some studies argue that more innovative UBC and UBC with the ability to rapidly cope with change will

have better chance to overcome this last critical juncture than UBC showing scarce innovation capabilities (Ndonzuau, 2002; Clarysse and Moray, 2004; Vendrell and Ortin, 2010).

Moreover, some studies emphasize the relevance that UBC founders' and managers' social resources have over this last junctures in UBC development (Gübeli and Doloreux, 2005; Kirwan et al., 2006). Furthermore, from the literature reviewed it seems that UBC's technological resources (intellectual property) also play an important role in the transition of this last critical juncture (Beraza and Rodriguez, 2011).

Finally, in the University Entrepreneurship literature we find evidence supporting that UBC's financial resources are once more important to overcome the *sustainability threshold* critical juncture (Clarysse et al., 2005; Gübeli and Doloreux, 2005; Moray and Clarysse, 2005; Vanaelst et al., 2006).

Therefore, drawing on the literature trying to identify the key factors influencing the overcoming of the *sustainability threshold* critical juncture by UBC we propose that:

Proposition 7: The key factors influencing the probability that UBC overcome the *sustainability threshold* critical juncture are: (i) UBC managers' social resources and business adaptation capabilities and (ii) UBC's financial and technological resources.

3. Research methodology

An exploratory, qualitative research methodology was adopted to obtain greater knowledge on the process by which university entrepreneurs create and develop their ventures. Via a multiple case study analysis we provide an in-depth exploration of each spin-off and give rich insights about the entrepreneurial process followed by UBC. This inductive approach allows for the correspondence between theory and data enriching the existing theoretical frameworks proposed in previous research (Bowe and O'Shea, 2012). In performing this study we followed procedures commonly recommended for conducting case study research (Eisenhardt, 1989; Yin, 1989).

Thus, in this research we draw on multiple case study technique to disentangle the process of overcoming critical junctures by UBC located outside *top-range* environments. The multiple case study methodology allows a replication logic treating the analysis of cases as a series of independent observations (Eisenhardt and Graebner, 2007). This method facilitates to empirically contrast research propositions. In this sense, we believe that the results of this study while not representative of every UBC development process could be cautiously generalized to most UBC located outside *top-range* environments.

3.1. Data selection

As we want to contrast our research propositions with companies created at universities located outside the most commonly studied *top-range* environments, the selection of the cases of this study was not random. Following Bowe and O'Shea (2012) we have used *theoretical sampling* to select suitable cases for this study. In this sense, companies were selected from two parent universities (PU) located outside *top-range* environments and described as inefficient or underdeveloped universities in terms of technology transfer and new venture creation activities (Beraza and Rodriguez, 2011; Berbegal et al., 2013; Sanchez-Barrioluengo, 2014).

Moreover, the UBC included in this study were selected looking for variety among the stages of development and critical junctures already overcome by each of them. On the other hand, we did not want to include in this study UBC at the very first stages of development because we wanted to collect data from all four critical junctures. Finally, we selected cases following the criterion of population representativeness in terms sector of activity and UBC type.

We define as our unit of analysis companies that have signed (agreed) for the support of a parent university (PU) in Catalonia, Spain. Therefore, we consider all firms created with the support of Catalonian universities as the population under study. In chapter two of this doctoral dissertation we have characterized a sample of Catalonian UBC from a recognized population of 262 active firms. These firms have emerged from ten different parent universities located in Catalonia before may 2008. In **Table 3** we may see the population of Catalonian UBC grouped by parent university (PU) and ordered by the number of UBC created by PU.[64]

As we can see in **Table 3**, in the Autonomous Community of Catalonia there are ten academic institutions generating UBC by the year 2008. In this study we wanted to include PU with significant technology transfer and new venture creation activity but we were not looking for top-performer PU. In this sense, from our population of ten Catalonian PU we excluded both extremes in terms of the number of UBC created.

On the one side, we excluded technical universities (UPC and La Salle) as they may be considered as central poles of new technology-based firms (NTBF) creation (Ortin et al., 2008; Beraza and Rodriguez, 2011; Guerrero and Urbano, 2012; Guerrero et al., 2014; Ortin and Vendrell, 2014; Sanchez-Barrioluengo, 2014). On the other hand, we also excluded PU with just one active UBC by May 2008 (UdL and IESE).

Moreover, looking to improve the representativeness of our sample of UBC, in this study we decided to include companies that emerged from research universities offering a broad curriculum of degrees and educational programs. Thus, we decided not to include PU with an educational focus (UPF) or business schools (ESADE).

64 In Appendix 1of chapter two of this doctoral dissertation we have a list with all 262 Catalonian UBC identified grouped by PU.

Thus, from a population of ten Catalonian PU we identified four that suit the purpose of this study (UB, UAB, UdG and URV). These four academic institutions are state-owned research universities offering a broad range of subjects and counting with a technology transfer office (TTO) to facilitate new venture creation activities.

Moreover, willing to assess the efficiency among Catalonian UBC, Epure et al. (2014) found that firms that emerged from UAB and UdG show the highest levels of inefficiency compared to other Catalonian UBC. Furthermore, Berbegal et al. (2013) confirm that UAB is among the most inefficient Spanish universities in terms of technology transfer and new venture creation activities. Therefore, we finally decided to approach the TTO of UAB and UdG in order to get in contact with the UBC created by them.

Table 3: UBC population in Catalonia

PARENT UNIVERSITY	Founding year	Type - Focus	TTO	Active UBC
Polytechnic University of Catalonia (UPC)	1971	Technical	Yes	139
University Ramon Llull (La Salle)	1903	Technical	Yes	59
University of Barcelona (UB)	1430	Universal	Yes	20
Autonomous University of Barcelona (UAB)	1968	Universal	Yes	18
University of Girona (UdG)	1992	Universal	Yes	8
University Ramon Llull (ESADE)	1958	Business School	No	6
University Rovira i Virgili (URV)	1992	Universal	Yes	6
University Pompeu Fabra (UPF)	1990	Economics	No	4
University of Navarra (IESE)	1958	Business School	No	1
University of Lerida (UdL)	1992	Universal	Yes	1
TOTAL CATALONIA (10 parent universities)				**262**

Source: Own survey to Catalonian universities undertaken in May 2008.

3.2. Parent universities

Vohora et al. (2004) considered the research income as a measurement of research elite universities in the UK. While this classification is mainly income-oriented, others are more publication-oriented. For example, the most well-known ranking for universities worldwide is the one elaborated by the University of Jiao Tong from Shangai (China).

This Ranking, also known as the Academic Ranking of World Universities (ARWU), classifies the best 500 universities around the world based on Nobel laureates, fields'

medals, highly-cited researchers and papers published in nature and science indexes among others. In addition, they scanned major universities of every country with significant amount of articles indexed in recognised citation indexes (Liu and Cheng, 2005).

The majority of manuscripts describing the spin-off phenomenon and the entrepreneurial transformation of a public research institution have focused on universities labelled as productive, effective, excellent, elite or top-ranked. These universities are always included in the Top 500 ARWU. Most of the cases studied belonged to universities ranked in the first quartile of those indexes. However, the universities chosen for the purpose of this study belong to last quartile or they do not even appear in the ranking. According to the ARWU, the UAB is classified in the position 300-400 and the UdG does not even appear in this ranking.

In **Table 4**, we have standardized research figures for UAB, UdG and MIT considering the size of the university under analysis. We observe remarkable differences between UAB, UdG and MIT in terms of spin-offs created, number of research institutes and total research expenditure divided by the total number of academics. With 1,704 academics working at MIT in 2007, it produces 12 times more spin-offs than UAB and almost 8 times more than the UdG. MIT's research expenditure by academic is around 20 times bigger than the UAB or the UdG.

According to figures in **Table 4**, while we can consider MIT as a *top-range* university in terms of technology transfer and start-up activities, UAB and UdG have to be considered as rather *mid-range* universities.

Table 4: Comparing UAB, UdG and MIT (year 2007)

	UAB	**UdG**	**MIT**
Nº of research institutes*	0.65	0.82	3.40
Nº of spin-offs*	0.65	1.03	7.86
Annual research expenditure**	15,237 €	11,113 €	U$S 351,115

* Per hundred academics.

** Per total number of academics.

Source: Research reports of UAB and UdG, and MIT web page.

In **Table 5** we have the main figures describing the two parent universities under study. While UAB is a big university with approximately 40,000 students and attracts academics and students from all over the world, the UdG is a medium-small university with regional scope and approximately 14,000 students. Both are considered research universities active in technology transfer and new venture creation. They both have technology and science parks and also offer incubation space for their UBC.

Table 5: General information of the UAB and UdG

	UAB	UdG
Faculties	15	18
Departments	54	20
Research groups	154	100
Research institutes	25	8
Scientific and Technological park	Yes	Yes
Business incubator	Yes	Yes
Electronic bulletin on research	Yes (monthly)	Yes (monthly)
Academics	3,813	970
Bachelor degrees	78	21
Bachelor degrees with entrepreneurship subjects	2	1
Master degrees	169	25
Master degrees with entrepreneurship subjects	4	2
PhD programmes	85	17
Postgraduate and PhD students	11,044	2,417
Number of R&D contracts	481	164
Incomes generated R&D contracts	€ 17,700,000	€ 3,020,000
External research funds	€ 51,140,000	€ 9,570,000
Internal research funds	€ 6,960,000	€ 1,210,000

Source: Research reports of UAB and UdG 2007.

3.3. Firms under study

In order to obtain a better insight from our analysis, we have included firms at different stages of development. In this sense, we may see in **Table 6** that most of the university spin-off companies are at the business re-orientation phase. Two of them (X-Ray Imatek and Aqsense) are still at the pre-organization phase of development. On the other hand, Patatabrava and Univet have gone through all critical junctures and have reached the phase of sustainable returns.

Moreover, all firms included in the study were funded between the year 2001 (Univet) and the year 2006 (Patatabrava and X-Ray Imatek). Differently from Vohora et al. (2004) this study includes *life-style* companies (see **Type of Firm** in **Table 6**). Life-style companies *are not established with the objective of creating a high return for their shareholders*" (Vohora et al., 2004: 149). In this sense, we expect to obtain somehow different results compare to Vohora et al. (2004), thus contributing to the University Entrepreneurship field of research.

Table 6: Descriptions of the cases under analysis

Spin-off company	Parent University	Year	Industry	Type of Firm	Type of UBC	Main Activity	Phase of Development
AB-BIOTICS	UAB	2004	Biotech	Rent-seeking	ASO	Development and production of micro-organisms for the food industry.	Re-orientation
DAVANTIS	UAB	2005	IT	Rent-seeking	USO	Design and manufacture intelligent security and video surveillance software.	Re-orientation
ECOMUNICAT	UAB	2005	Consumer Electronics	Life-style	USU	Design and manufacture electrical products in the field of artificial vision and wireless communication.	Re-orientation
HEXASCREEN	UAB	2005	Biotech	Rent-seeking	ASO	Develop, manufacture and commercialize equipment for the biotechnological and biomedical markets.	Re-orientation
PATATABRAVA	UAB	2006	Web Content	Life-style	USU	They have developed and now operate one of the biggest university online portals in Spain. Online content developer and manager.	Sustainable Returns
UNIVET	UAB	2001	Biotech	Life-style	ASO	Development and commercialization of treatments against pets' allergies and skin problems.	Sustainable Returns
X-RAY IMATEK	UAB	2006	Electronic Equipment	Rent-seeking	ASO	Design and manufacture of digital pixel detectors for medical imaging.	Pre-organization
AQSENSE	UdG	2004	IT	Rent-seeking	ASO	Develops and commercializes 3D image acquisition and processing technologies that allow high speed in-line production inspections.	Pre-organization
EAP	UdG	2003	Content	Life-style	ASU	Content developer and print-on-demand services. Editing and publishing services.	Re-orientation
MICROBIAL	UdG	2005	Biotech	Rent-seeking	ASO	Design, production and commercialization of detection tools for pathologic cells in water and food.	Re-orientation
SISLTECH	UdG	2003	IT	Rent-seeking	ASO	Develops and implements artificial intelligence systems for the control of complex environmental processes.	Re-orientation

Following the UBC taxonomy developed in chapter two of this doctoral dissertation, in this study we classify UBC in four main groups or types: (i) academic spin-offs (ASO), (ii) academic start-ups (ASU), (iii) non-academic or university spin-offs (USO) and (iv) non-academic or university start-ups (USU). In **Table 6** we can see that the majority of the firms included in this study are *academic* UBC (firms founded by one or more academics from PU). In the same line, most of companies included in this study are *spin-offs* (formal technology transfer from PU).

In addition, as we may see from **Table 6** four out of the eleven UBC under study are in the biotechnology sector (AB-Biotics, Hexascreen and Univet from the UAB and Microbial from UdG). This abundance of firms in biotech may be explained by the fact that UAB is one of the leading Spanish universities in health sciences and veterinary. Moreover, three of the UBC under study are technology developers in the IT industry (Davantis, AQSense and SisLtech).

Furthermore, two of the UBC under study work on the electronics industry (Ecomunicat and X-Ray Imatek) and the last two are content developers and providers, one through a web-portal (Patatabrava) and the other one through more traditional on-paper means (EAP). In this sense, the cases selected for this study cover the range of activities described in previous studies of the UBC phenomenon in Spain (Ortin and Vendrell, 2014).

3.4. Data collection

Over a year period, from February 2008 to February 2009 a series of semi-structured interviews were held among UBC founders. These interviews were held on site at business and we conducted follow-up interviews and phone calls to clarify issues. For each interview we tape-recorded the conversation and then worked from the tape transcriptions. Thus, primary data was recorded using in-depth, semi-structured interviews and ensuring cross-case comparability (Bryman and Bell, 2007).

Interviews were divided in three main blocks. During the first part of the interviews, respondents were asked to freely describe the process of firm creation and development that they have followed. Moreover, we have asked interviewees during this first part to outline the main factors facilitating or hindering their development process of their companies.

The purpose of this part of the interview was to contrast our first research proposition, stating that UBC develop following the five stages model described in Vohora et al. (2004), and to contrast our second research proposition, stating that UBC make use of an array of resources, capabilities and institutions in order to overcome the obstacles found in their development process.

In order to contrast our third research proposition, during the second part of the interview we ask respondents to explain what was the role taken by the PU in their

development process. Finally, the last and longer part of the interview concentrated in understanding how UBC have done to overcome each of the critical junctures recognized in Vohora et al. (2004) during their development process (with special emphasis in the resources, capabilities and institutions used by UBC).

In a qualitative case study research, corroboration of interviews through the use of archival records is important to validate information (Yin, 1989). Therefore, the interview data was supported with information from other sources. We had access to copies of company documentation such as plans, accounts and commercial brochures. Moreover, we have also collected information about companies through their corporate internet sites.

For reliability purposes a case study protocol was established to ensure that the data collection was focused on how they overcome each critical juncture identified in the literature, verified that the same information was being collected for all the cases, and aided in the data analysis. Validity was established by using multiple sources of evidence (triangulation), by transcribing and checking the interviews with the interviewees and having key informants review drafts of the final report (Yin, 1989).

To avoid confirmatory biases, one of the authors was kept at a distance from the field observations and focused on conceptualisation and analysis of the interpretations developed by other researchers (Vohora, et al., 2004). Finally, a database with the detailed case studies was prepared for each company with specific table shells to record the data (Miles & Huberman, 1984). Recursive trends and patterns were extracted using cross-case analysis techniques (Eisenhardt, 1989).

4. Results and discussion

4.1. General results

During the first part of the interviews we asked respondents (usually the founder of the company) to freely describe how he/she has perceived the development process of the UBC they have created. At this part of interviews we did not mention any type of new venture development model or anything that could induce the answer of respondents in a certain way. In fact, we have just asked them to describe in their own terms their experience creating and developing UBC and then we have just listened to their answers without adding anything else. Thus, we believe that the information collected from the first part of interviews is largely free from researchers' bias.

Surprisingly every UBC's founder interviewed adopted a process approach to describe their experiences as university entrepreneurs. In this sense, all eleven UBC's founders interviewed described the development of their companies as a more or less linear succession of stages or phases of development. For example, the founder of Univet said:

"*It was a really complicated process with many interrelated parts and a lot of different actors involved in each part.*"

Moreover, some of these UBC founders also emphasize the existence of certain difficulties in the transition from one stage of development to the next one. In this sense, the founder of Ecomunicat said: "*It is always difficult to pass from one stage to the next. There are many contingencies that you have to face and that are difficult to anticipate. You have to deal with them at that transition moment; not before and not after.*"

These difficulties are found to be highly interrelated and sometimes are resolve in an iterative manner. For example in the case of Aqsense, hiring an experienced manager (second critical juncture recognized in Vohora et al., 2004) helped them to review the business opportunity they had previously identified (the first critical juncture recognized in Vohora et al., 2004).

On the other hand, we received different answers concerning the number and the sequence of the stages of development of their companies. For example, while founders of *academic spin-offs* (ASO), UBC with formal technology transfer and at least one academic in their founding teams, said that the conceptualization or gestation of the business idea was made during their research at the PU; founders of *non-academic* UBC did not mention the existence of a staring *research phase* in their development process.

For example, one of the founders of Ecomunicat said that: "*Everything started when we* – himself and his business partner - *finished our careers as electronic engineers at UAB. We did not want to start working at a big company for third parties and we got together to think about what we can do with the knowledge acquired at the university.*" It is clear that for the case of Ecomunicat there was not a starting research phase in their development process.

Moreover, the founder of Ecomunicat said that they finally did not recognize any specific business opportunity, but that they just had faith in their personal and professional capabilities. Thus, differently from Vohora et al. (2004), in the case of Ecomunicat the development process of the company started directly with the *entrepreneurial commitment* critical juncture and the *pre-organization phase* (avoiding passing through the *research* phase and the *opportunity recognition* critical juncture).

On the other hand, the founder of Univet described a development process that is very similar to the one in Vohora et al. (2004). Indeed, Univet's founder mentioned that the company had to pass four previous phases of development before the firm was finally consolidated at the markets. In the same line as Vohora et al. (2004), Univet's founder also emphasised that the company had to overcome a series of obstacles during its development. Differently from Vohora et al. (2004), Univet's founder located these obstacles at the same stages of development and not at the interstice between two consecutive stages.

Thus, our empirical evidence shows that most UBC interviewed agree with the proposition that UBC develop following a non-linear path of successive stages. Moreover, they all seem to agree that there are certain difficulties that UBC have to overcome in their development process. On the other hand, the UBC interviewed in this study, do not seem to agree in relation to the number and the sequence (the order) of stages of UBC development. In particular, *non-academic start-ups*, UBC with no academic/s in their founding teams and informal tacit knowledge transferred from PU, do not recognize the first stage of UBC development identified in Vohora et al. (2004): the *research phase*.

Therefore, following the results of this first part of the study we can give only partial support to our first research proposition stating that UBC develop following the five stages model described in Vohora et al. (2004). Indeed, while it seems that UBC develop in consecutive stages by overcoming critical obstacles in their development process, the number and location of these stages and obstacles of development may vary from case to case. Thus, our research **Proposition 1** is only partially supported by the empirical evidence obtained in the first part of this study (see **Table 9** at the end of the chapter).

During this part of the interview with UBC founders and managers we were particularly interested in collecting their personal views about how they think their companies had done to go from one stage of development to the next one. As during this part of the interviews we did not make any particular questions, just letting them describe their university start-up experiences, we received a variety of answers about how their companies managed to go through the development process. For example, Univet mentioned that having access to PU's facilities and resources was a key factor in their development process.

Moreover, Davantis mentioned that the computer-vision technology they have developed and the know-how about security systems they have acquired during the first years of the company were two key factors in their development process. Furthermore, one of the academic founders of AB-Biotics said that their development as a technology-based company was restrained by the lack of managerial capabilities and entrepreneurial experience among leading founders. In addition, SisLtech said that the PU's support and more in particular, the fact that the PU's TTO secured an industry sponsor for them, was a critical factor facilitating their initial steps as UBC.

Even though the variety of answers from UBC's founders and managers about how their companies managed to develop over time was significant, the big majority of the factors mentioned can be classified under four groups: (i) PU's support services and policies, PU's start-up resources and entrepreneurial capabilities and PU's entrepreneurial orientation and attitude (ii) founders/managers' personal characteristics, resources, skills

and experience and (iii) context-related factors.[65] In this sense, UBC founders and managers interviewed outlined the importance of resources, capabilities and institutional factors in the development process of their companies. Thus, **Proposition 2** of this research is fully supported by the data collected during the first part of interviews (see **Table 9** at the end of the chapter).

During the second part of interviews UBC founders/managers explained what has been the role of PU in their development process. In this sense, most of founders/managers interviewed answered that the presence and support of the PU was a key factor during the first stages of their development process. In particular, you may see in **Table 7** that six out of the eleven UBC said that the TTO helped them to overcome the first critical juncture in their development process (AB-Biotics, Patatabrava, X-Ray Imatek, AQsense, Microbial and SisLtech).

On the other hand, UBC founders/managers were reluctant to include PU's support as a key factor influencing their process of overcoming the second critical juncture of *entrepreneurial commitment*. This may be due to the fact that with the exception of AQsense, none of the companies in this study hired an external surrogate entrepreneur to champion the new venture into sustainable returns.

In the case of AQsense, one of their founders said that thanks to the support of the PU's TTO they were able to hire an experienced manager (although with neither knowledge nor contacts in the specific industry where AQsense operated). Instead, other UBC with no external manager hired, mentioned that the flexible labour and spin-off policies of PU (formal institutions) facilitated the decision of academic founders to commit to the CEO position of the new venture.

During this second part of the interviews, some respondents mentioned that being a spin-off company from locally prestigious academic institutions may have helped them to gain credibility at the markets. In this sense, the founders of AB-Biotics, Davantis and Ecomunicat mentioned that during their daily work at clients (basically business presentations), using the PU's name (UAB) and showing data that they were UAB's spin-offs helped them to reach first sales.

Moreover, EAP said that they could reach their first customers and sales drawing on the support and industry networks of the PU's department where the academic founders worked at. Thus, it seems that PU's support, social resources and institutions (informal institutions in this case) may enhance the probability that UBC overcome the third critical juncture in their development process (*credibility threshold*).

With the available data from our eleven cases of study, it is difficult to assess the use of PU's support, resources and institutions by UBC to overcome the last critical juncture because only two of our cases of analysis have passed this juncture and reach

[65] The study of context-related environmental and macro-economic factors exceeds the scope of this research.

sustainable returns (Patatabrava and Univet). In addition, X-Ray Imatek and AQsense had not even passed the third critical juncture by the time of interviews. From the other seven cases of study it was really difficult to obtain information about why they were struggling to overcome the last critical juncture because they just did not know why. As one of the founders of AB-Biotics put it: "*If I knew, I would do it. Don't you think so?*"

Therefore, following the empirical evidence from our cases of analysis it seems that in UBC located outside *top-range* environments the support of the PU is particularly important for overcoming the first critical juncture in UBC development process (*opportunity recognition*). This result is consistent with the findings of UBC studies from PU located in *top-range* environments in terms of technology transfer activities (Vohora et al., 2004).

Moreover, our evidence suggests that PU's support and policies (formal institutions) may be an important factor to overcome the second critical juncture in UBC development (*entrepreneurial commitment*). Even though none of the UBC mentioned that PU's support was key to overcome the third and fourth critical junctures (*credibility threshold* and *sustainability threshold*), some of them said that it was important for them to be a spin-off from UAB in order to gain market credibility and make the first sales.

In line with previous studies, our evidence shows that PU's support, resources and institutions are key factors for UBC to overcome the first critical juncture in their development process. Following our results PU's support seems to lose some relevance during the second critical juncture. Moreover, it seems that PU's support is not relevant for UBC to overcome the third critical juncture. But, on the other hand, every academic founder that committed to the CEO position at the UBC, mentioned that the labour and start-up policies of the PU motivated them to took that commitment.

In the same line, some of our cases under study mentioned that it was important to be a spin-off from prestigious academic institutions in order to gain market credibility. Thus, following the results of this second part of the study we can give only partial support to our research **Proposition 3** (see **Table 9** at the end of the chapter).

4.2. Overcoming critical junctures in UBC development

During the third part of interviews, UBC founders/managers were first introduced to the UBC development model proposed in Vohora et al. (2004) and then were asked to describe their perceptions about how their companies did to overcome the four critical junctures identified in Vohora et al. (2004). A summary of the UBC's answers to how they overcome critical junctures in their development process can be found in **Table 7**. In the rest of this section we highlight the key resources, capabilities and institutional factors affecting this process which have been outlined by the UBC founders/managers interviewed.

Table 7: How UBC overcome critical junctures in their development process

NAME OF THE COMPANY	OPPORTUNITY RECOGNITION	ENTREPRENEURIAL COMMITMENT	CREDIBILITY THRESHOLD	SUSTAINABILTY THRESHOLD
AB-BIOTICS	Market study, done by a major consultancy firm and financed with a public subsidy secured through the university TTO + Applied research.	The academic founders committed full time to the UBC and left their academic positions. They had no market-industry knowledge, neither firm management experience.	Academic founders acquired business management knowledge (did an MBA) + daily work with potential clients (products presentations) + used the UAB name to reach first clients.	NOT REACHED YET
DAVANTIS	Founders developed an advanced computer vision technology + award received in business plan competition (INSEAD, France) + Applied research.	The founder team took the management of the UBC. The 3 of them had an MBA degree. They had no specific market knowledge or network of contacts with the industry.	They won the Caixa Manresa Award for best technological company in 2005 + used the UAB spin-off name to gain technical credibility and reach first customers.	NOT REACHED YET
ECOMUNICAT	Founders (both UAB engineers) did not recognize any particular business opportunity but they were confident about their technical skills + Applied research.	One of the founders assumed as full time CEO without any market knowledge neither management experience.	Daily work with potential clients (products presentations) + used the UAB name as spin-off + business model and product adaptation to client needs + low cost & low price strategy.	NOT REACHED YET
HEXASCREEN	The founders recognized the business opportunity assisting to an academic congress in their field of research + Industry knowledge + Applied research.	One of the academic founders assumed as full time CEO, leaving academic position + a scientific council was created that committed part time to the UBC.	The scientific council used its network of contacts in the industry => product tests at the client site.	NOT REACHED YET
PATATABRAVA	Founders were involved in the spin-off venture before having recognized any particular business opportunity. The TTO guided them towards possible commercial applications.	Both founders assumed as full time managers of the UBC without any business experience or any market knowledge.	Patatabrava web portal became the leading university social network online platform in Spain with 150,000 registered users.	Organization of social events in order to keep high traffic in their web portal + product adaptation to clients' needs + new product development.

UNIVET	The founder team had a clear knowledge of the markets => developed a network of contacts in the industry => secured research financing from an industry sponsor + Applied research.	One of the academic founders assumed as full time CEO, leaving academic position. No market-industry knowledge, neither firm management experience.	The industry sponsor became their major client.	Large technology portfolio to commercialize. Adapt their products and services to the needs of new clients + develop new and better products from existing technology + PU's support.
X-RAY IMATECH	The technology developed was among the best possible option available at the markets + TTO support + Industry knowledge + Applied research.	Academic founder assumed as full time CEO, leaving academic position. No market-industry knowledge, neither firm management experience.	NOT REACHED YET	NOT REACHED YET
AQSENSE	The university TTO motivated the founder team to identify and commercialize their technology + Industry knowledge.	With the TTO support, they hired an experienced managers but without any market knowledge.	NOT REACHED YET	NOT REACHED YET
EAP	One of the founders recognized the opportunity inspired in a successful role model he saw in a German university.	Two of the founders took the management of the UBC without having any market knowledge neither business experience.	The parent university became their major client. The UBC also took advantage of the support and industry contacts of the university department.	NOT REACHED YET
MICROBIAL	The university TTO realized a market study to commercialize the technology developed by the research group + Applied research.	One of the academic founders assumed as full time CEO, but kept her academic position. No market-industry knowledge, neither firm management experience.	Product presentation at client sites + approval of international technological patents.	NOT REACHED YET
SISLTECH	With the university TTO support the research group secured an industry sponsor that better defined the business opportunity + Industry knowledge	Academic founder assumed as part time CEO and kept his academic position. No market-industry knowledge or managerial experience.	The UBC had to change its commercial strategy and business model in order to adapt to market requirements.	NOT REACHED YET

4.2.1 Opportunity recognition

The inherent conflict at this juncture is that universities and academics possess significant technological know-how yet had insufficient knowledge of how to serve markets and unrealistic expectations of the profits that could be derived from the technologies they had discovered (Vohora et al, 2004:160). From our data, we observe that the founding teams of Hexascreen, Univet, X-ray Imatek, Aqsense and Sisltech recognised their business opportunities because they had some knowledge of the target market and, therefore, were involved in applied research with the industry, very close to markets' needs.

In the cases of Univet and Sisltech, their research was sponsored by an industrial partner willing to develop a product, who played a key role in the opportunity recognition process by guiding the research group (the founder team) towards a technically and commercially feasible product/service suited to fulfil a concrete market need.

In Ab-biotics, X-ray Imatek, Aqsense, Microbial and Sisltech, the support of the technology transfer office (TTO) was essential to recognise the business opportunity. The TTO helped the founders to overcome this critical juncture at least in three ways: 1) guiding and motivating academics to commercialize their research (X-ray Imatek and Aqsense); 2) financing or directly evaluating the commercial feasibility of their research results (Ab-biotics and Microbial) and; 3) finding out industrial sponsors (Sisltech). In the case of Microbial, the TTO evaluation of the research group technology to fulfil a market need was the key driver initiating the venture creation process.

The founder and CEO of Microbial explained: "*It was the university TTO that evaluated the commercial applicability of the research I was involved in. The TTO made a market study and concluded that the technology we were developing had a great commercial potential. For me it is clear that without the support and motivation given by the TTO's staff, I would not have identified the business opportunity myself.*"

The firms that were not involved in research projects at university (Patatabrava and Ecomunicat), the firms that were not based in any breakthrough technology (EAP) and the firms founded by non-academics (Davantis) did not receive the same level of attention by the TTO's staff. Only Patatabrava's CEO mentioned that the TTO helped them to focus on online advertising instead of other business models.

In this line, the founders of Hexascreen and X-ray Imatek identified their business opportunities by benchmarking their research results in congresses, conferences and workshops. Furthermore, one of the founders of Davantis said: '*we knew we've got something good on hands when we ended up in third position at the 2003 annual entrepreneurship contest in INSEAD*[66]*.'* One of the founders of EAP recognised the opportunity when during a research stay in a German, a group of students had created a similar company with great success.

[66] One of the most prestigious Business Schools in France.

Finally the founders of Ecomunicat and Patatabrava did not recognise a concrete business opportunity but they were confident about their ideas and personal skills. Ecomunicat's founder said: '*we were committed to the business without having recognised any particular opportunity. We were just confident of our technical capacity and we knew this business would work some way or another.'* In this sense, starting the venture project without having recognized a clear business opportunity, will affect the overcoming of future critical junctures (specially the entrepreneurial commitment and credibility). This result differs from Vohora's et al. (2004) findings where every UBC recognize a business opportunity before starting the project.

Our data also show that the UBC under study do not possess the same level of intellectual capital as research-based spin-off companies emerged from eminent universities (Vohora et al., 2004). Only Microbial and X-ray Imatek had patents protecting their technology. This patented technology was an important factor for Microbial and X-ray Imatek to draw the attention of the TTO and investors. Therefore, UBC included in this study would have higher difficulties to recognize a business opportunity compared to UBC located in *top-range* environments because they have lower levels of research excellence or IP protection.

We have also observed that even though academic founders of the UBC included in this study have little market knowledge; they are still close enough to potential clients and industry contacts. This would ease the application of their research or technology to fulfil a concrete market need. Thus, we may conclude that UBC can benefit from their market knowledge and industry experience in order to recognize a business opportunity from their research.

4.2.2 Entrepreneurial commitment

This critical juncture arises due to the conflict between the need for a committed venture champion to develop the UBC venture and the inability to find an individual with the necessary entrepreneurial capabilities (Vohora et al, 2004: 163). From the data, only Aqsense had the ability to hire an external venture champion with managerial experience. Aqsense hired a surrogate entrepreneur with the help of the TTO's network of contacts. In the rest of the cases, one of the founders or the whole founding team took such a responsibility with no previous managerial experience and very few (or none) industry contacts (Ab-biotics, Ecomunicat, X-ray Imatek and Microbial).

Additionally, Ab-biotics' and X-ray Imatek's academic founders committed as full-time CEO of the new venture and had to leave his/her academic position at the parent university. The academic founder of Microbial combined her full-time CEO position with teaching part-time at academia. In Sisltech, the academic founder joined the company as part-time CEO while keeping his academic position at the university.

We have identified three reasons that prevented UBC to hire an experienced manager from the industry. First, the lack of economic resources to attract the right venture

champion by offering a salary and incentive package according to his/her merits (Abbiotics, Davantis, Patatabrava and Microbial). Second, the scarce social resources of the founding teams (most of them with only academic background), which limited them identifying suitable managers from their network of contacts (Aqsense and X-ray Imatek). Third, the UBC' general perspectives of low sales volume for the following years demoralize potential surrogate entrepreneurs to join the UBC as CEOs (Sisltech).

Surprisingly we have identified a key player for UBC to overcome this critical juncture: the doctoral fellow student[67]. The full time venture champion position was taken by a doctoral fellow student in Hexascreen, Univet and EAP. In these cases, the academic founders proposed the fellow students as CEO of the firms because their scholarships were reaching an end. This 'cheap' way of overcoming entrepreneurial commitment by UBC may have negative effects on future critical junctures. For example, an inexperienced manager without industry contacts will have great difficulties gaining credibility in the markets.

Thus, we may conclude that outside *top-range* environments, UBC do not generally hire external manager or surrogate entrepreneurs to run the business (Franklin et al., 2001; Rothaermel and Thursby, 2005; Lundqvist, 2014). These findings considerable differ from Vohora et al. (2004) findings where most UBC secure a suitable external manager to champion the company into sustainable returns. Consequently, our results suggest that the CEO position and the role of venture champion in UBC located outside *top-range* environments is generally assumed by one of the academic founders, who usually has little industry experience and no managerial education. This will increase the difficulty of properly overcoming future critical junctures (in particular to gain markets and investors credibility).

It is also noteworthy that most of the initial funding of the UBC comes from personal and family savings. Another important source of initial funding is public soft loans and subsidies to the UBC. Only Sisltech S.L. received initial private funding from a venture capital firm. These findings also differ from Vohora et al. (2004) where most of the UBC secure external finance during this transition stage in their development process.

In addition we observe that some of the UBC academic founders in this study were more willing to assume the CEO position and thus leave their academic position in comparison to Vohora's et al. (2004) results. As Ecomunicat's founder said: *I liked the idea of becoming a business manager. This was totally new for me and I was motivated to do it properly*. It seems that founders of UBC located outside *top-range* environments are more likely to tolerate risk and face uncertainty than academic founders from eminent universities located near techno-clusters of companies. Probably, the opportunity cost due to the prestige and labour alternatives of such academics is higher in *top-range* universities than in *mid-range* universities.

[67] Any tenant of a research scholarship at university.

4.2.3 Credibility threshold

This critical juncture arises due to the entrepreneur's ability to gain access to and acquire an initial stock of resources, which are required for the business to begin to function (Vohora et al., 2004: 164). From our data, X-ray Imatek and Aqsense are still trying to overcome this juncture. X-ray Imatek is unable to gain market credibility because they don't have an industrial partner willing to develop and manufacture a digital mammography machine based on their sensor. As X-ray Imatek CEO said:

We have already developed a high performing sensor for digital mammography; which is much better than what you can find in the market. But our potential clients [mainly hospitals] *are just interested in buying a completely finished digital mammography machine, key at hand! As you can imagine, we do not have the resources neither the knowledge to build digital mammography by ourselves.*

In the case of Aqsense, the surrogate entrepreneur lacked the industry-market knowledge and the social resources necessary to reach customers and make the first sales. As Aqsense's founder said: *'The image monitoring industry, especially applied to control manufacturing processes, is an economic sector with huge economic players trying to monopolize the market. At present, we certainly lack the necessary industry contacts in order to reach this market.'*

The rest of the UBC had overcome this juncture mainly by adapting their technology, products or services to the specific needs of their clients. For example, Sisltech had to change its business model and became a service-oriented company that worked only under client orders. Ecomunicat had to completely expand and adapt its product portfolio to their clients' needs. Ecomunicat also benefited from a low-cost strategy to gain market credibility and reach first sales.

Moreover, Ab-biotics, Hexascreen and Microbial emphasized the importance of working close with their potential clients. For example, Ab-biotics was constantly performing demonstrations of their products and services at their clients' sites. In the same line, Microbial frequently organized courses and seminars to show their technology to potential clients. Moreover, Hexascreen and Univet offered free product trials to clients as a way of gaining credibility in the markets.

In our *mid-range* university context most of the spin-offs do not have any particular IP protection mechanism, only X-ray Imatek and Microbial had patented technologies. Patents are intellectual valuable assets for the UBC, therefore, the lack of them could explain the difficulty to get external funding. This was the case of Sisltech: '*We have developed a good technology but we couldn't patent it because it wasn't innovative enough. We write down a notary act describing our technology and know-how but it didn't have the same effect on potential investors compare to a patent*.'

On the contrary Microbial's CEO got seed capital thanks to their international patents. The CEO pointed out: '*With the approval of our international patents, especially the one for EEUU, investors started to take a closer look at our company'.* In this case, the approval of international patents was the key driver to gain credibility with potential investors but had a limited effect on sales.

The support of the TTO is usually weak at this transition stage. In general, the TTO does not have the industry contacts necessary to penetrate the markets (Patatabrava and Sisltech). But, Ab-biotics, Davantis and Ecomunicat made good use of the university's prestige/brand to gain technological credibility in the industry.

As one of the founders of Davantis said: "*Being a university spin-off under the institutional umbrella of the UAB*, *is usually seen as positive when you are discussing the technical advantages of the technology developed. But it does not help you to gain credibility with clients or with potential investors. It is even the other way round!*"

In the case of EAP the institutional link with the parent university was crucial to gain market credibility. EAP's parent university became its first and most important client of the firm. Thanks to this, the UBC was able to attract new clients and gain market credibility.

In order to gain investors credibility UBC located outside *top-range* environments often have to deal with the absence of patents or other kind of IP protection. Venture capitalists and private investors are willing to invest in UBC in return of some kind of value; therefore, having an IP protection is an asset well-valued. As stated in Vohora et al. (2004: 165): '*The business angels and particularly the venture capitalists, consistently asked the same question to the entrepreneur. What is I'm buying here? What am I getting for my money?'*

Thus, our results suggest that UBC located outside *top-range* environments have greater difficulties to gain investors credibility due to the absence of IP protection and patents, which is mainly caused by their lack of technological resources.

Finally, our results show that the academic prestige of the university helps to gain credibility among technology partners and developers. However, in terms of financial markets and customers' credibility this issue is not important. On the contrary, it can be seen as a liability due to the lack of commercial orientation of universities. In terms of Vohora et al. (2004: 166): '*External financiers and customers may be suspicious of the extent to which universities' non-commercial cultures may have an influence over the UBC'*.

4.2.4 Sustainability threshold

At the sustainable returns juncture the ability to continuously re-configure existing resources, capabilities and social capital with new information, knowledge and resources is required (Vohora et al., 2004: 166). Only Patatabrava and Univet overcame this critical juncture and reached the phase of sustainable returns.

For example, Patatabrava could sign long term online advertising contracts with major clients of the industry due to their traffic in its web portal. They could keep high traffic because they were constantly involved in the organization of social and leisure events promoted through their web portal. As one of Patatabrava's founders said: *We have already gained the attention of the big fishes of the industry* [online advertising] *but we must keep on doing anything to retain them as loyal clients. The key to do so is securing a high amount of traffic in our web. Of course, our web technology must also work perfectly 365 days a year and 24 hours a day.*

The strategy taken by Univet to reach sustainable returns was mainly to constantly renew its products/services catalogue based on new lines of research. Univet was able to develop new technologies and find new commercial applications of existing technologies with the support of the parent university. Univet is located at the Faculty of Medicine, where they have access to university laboratories and other facilities and with continuous contact with doctors.

All these factors allowed Univet to establish long term agreements with international pharmaceutical companies for the development and commercialization of veterinary treatments for skin illnesses. As the academic founder of Univet explained: *'We were able to keep on growing thanks to our tenacity on improving our products and developing new ones.'*

The rest of university spin-off companies are still struggling to reach the phase of sustainable returns. Before that to happen, they have to gain the ability to adapt their technology to the market needs (Davantis and Ab-biotics) and to gain the capacity of reconfiguring their resources or acquire new ones in order to develop new product lines and reach new clients (EAP, Hexascreen and Microbial).

In Sisltech, the main factor preventing the UBC from reaching sustainability is the small size of the target market. They are thinking to change the business model once again and totally abandon product development and focus on consultancy services for the industry. Finally, Ecomunicat is in its way to sustainability by adapting its technology to clients needs and increasing the list of products and services provided. They have also moved to a technological park very close to their clients and to major industry players.

4.2.5 Summary of results and contrast of research propositions

Willing to summarize the results from our multiple case study analysis, in **Table 8**, we present our key findings about the resources, capabilities and institutional factors influencing the overcoming of critical junctures in UBC development.

Table 8: Resources, capabilities and institutional factors influencing critical junctures overcoming by UBC located outside *top-range* environments

Opportunity Recognition	**Entrepreneurial Commitment**	**Credibility Threshold**	**Sustainability Threshold**
PU's support	PU's support	PU's support and name (prestige)	PU's support
UBC founders' entrepreneurial capabilities	PU's labour policies and PU's policies concerning spin-off created by their members	UBC managers' industry experience and social resources	UBC managers' capabilities to adapt the business model to the needs of the markets.
UBC founders' social resources and industry experience	PU's attitude towards technology transfer and entrepreneurial activities	UBC managers' business capabilities	UBC technological resources (large and wide portfolio of technologies to offer)
Access to successful role models in university entrepreneurship	UBC founders' social resources	UBC technological resources	
Technological resources of the new venture (degree of innovation and commercial application)	The sales and profits prospects of the new venture	UBC organizational resources	
University support and entrepreneurial mentality			

From **Table 8** we observe that UBC will have a higher probability to recognize a business opportunity from their research results if their founding teams have a good knowledge of the target market and contacts with potential partners, distributors and other key players of the industry (*social resources* and *industry experience*). Moreover, our empirical evidence suggests that the entrepreneurial capabilities of founders may influence the recognition of a business opportunity (*entrepreneurial capabilities*).

It is also easier for the founders to recognize an opportunity when the UBC presents a patented breakthrough technological innovation (*technological resources*). In the same line, university entrepreneurs have a better chance to recognize a business opportunity if the research they are involve in its market-oriented or applied research instead of basic or fundamental research (*technological resources*).

In **Table 8** we may see that the support and motivation given by the parent university may also be an important factor to overcome this critical juncture. In this sense, some universities have specialized staff dedicated to evaluate research projects and their commercial feasibility (*PU's support*). Thus, we may conclude that research **Proposition 4** is fully supported by the results of this study (see **Table 9**).

Moreover, in **Table 8** we can see that in order to attract a capable and experienced venture champion, the UBC needs to have a substantial volume of sales perspectives and has to offer an attractive compensation package or IP to the surrogate entrepreneur (*sales and profits prospects*).

The personal contacts and networks of the founding team could also help to identify and hire an experienced surrogate entrepreneur (*social resources*). The PU's support to find and hire and external manager and PU's labour policies and policies about spin-off creation will also conditioned the overcoming of the *entrepreneurial commitment* critical juncture (*PU's support* and *policies*). Thus, research **Proposition 5** is fully supported by the empirical evidence presented in this study (see **Table 9**).

Furthermore, our results suggest that the market knowledge and industry contacts of the UBC managers are essential for the UBC to gain market credibility (*social resources* and *industry experience)*. To gain credibility from external investors it is better for the UBC to have patents or other type of IP protection mechanism (*technological resources*). Having a good management team with complementary capabilities is also a valuable resource for the UBC to gain investors' credibility (*business capabilities*). The support of the parent university and its prestige in the UBC's field of research is also an important factor if the UBC wants to penetrate the markets and reach first sales (*PU's support* and *name*).

On the other hand, we have not found evidence supporting the proposition that the financial resources of the UBC influence the overcoming of the third critical juncture in their development process. Moreover, differently from our research propositions, we have found evidence outlining the PU's support for UBC to overcome the last critical juncture (*PU's support*). Thus, research **Proposition 6** is only partially supported by the empirical evidence presented in this study (see **Table 9**).

Finally, our results suggest that overcoming the *sustainability threshold* largely depends on the size and flexibility of the technological portfolio the UBC has (*technological resources*). A flexible structure and business model will also facilitate the process of overcoming this critical juncture.

Table 9: Contrast of research propositions

Nº	PROPOSITION DESCRIPTION	SUPPORT
1	UBC develop following an iterative non-linear path with five consecutive stages and four critical junctures that UBC have to overcome in order to pass from one stage of development to the next one.	PARTIALLY SUPPORTED
2	UBC make use of their own and their parent universities' resources and capabilities to progress from one stage of development to the next one.	FULLY SUPPORTED
3	While the support given by PU is especially important during the first stages of the UBC development process, it gradually looses relevance during more advanced stages of UBC development.	PARTIALLY SUPPORTED
4	The key factors influencing the probability that UBC overcome the ***opportunity recognition*** critical juncture are: (i) PU's support; (ii) UBC founders' social resources, industry knowledge and entrepreneurial capabilities and (iii) the commercial applicability of the research/technology developed by academic founders.	FULLY SUPPORTED
5	The key factors influencing the probability that UBC overcome the ***entrepreneurial commitment*** critical juncture are: (i) PU's support, PU's reward system and PU's policies; (ii) UBC founders' social resources and (iii) the business project potential to grow, succeed and generate sustainable returns.	FULLY SUPPORTED
6	The key factors influencing the probability that UBC overcome the ***credibility threshold*** critical juncture are: (i) UBC managers' social resources, industry knowledge and commercial capabilities and (ii) UBC's financial and organizational resources.	PARTIALLY SUPPORTED
7	The key factors influencing the probability that UBC overcome the ***sustainability threshold*** critical juncture are: (i) UBC managers' social resources and business adaptation capabilities and (ii) UBC's financial and technological resources.	PARTIALLY SUPPORTED

In this line, we have found that UBC managers' capabilities to adapt the business model and develop new products following market needs (*capabilities*) is a key factor enhancing the probability that UBC overcome the last critical juncture in their development process. Thus, similarly to Vohora et al. (2004) our data show that the UBC' capacity to quickly reconfigure its resources, routines and organizational structure in order to adapt to new clients' requirements, is the critical factor to overcome this last business development juncture and achieve sustainable returns.

On the other hand, we have found no support for our research proposition stating that UBC managers' social resources and UBC financial resources influence the probability that UBC overcome the *sustainability threshold* critical juncture. Moreover, our findings suggest that the PU's support is still an important factor for UBC located outside *top-range* environments to overcome the last critical juncture in their development process. Thus, we have found only partial support to our research **Proposition 7** (see **Table 9**).

5. Conclusion

The aim of this study is to increasing our understanding of the university-based companies (UBC) development process outside the most commonly studied *top-range* environments (TRE). In this sense, we draw on previous studies (in particular we draw in the work of Vohora et al., 2004) to develop seven research propositions about UBC development process and key factors influencing the transition between one stage of development to the next one.

Research propositions were contrasted with the empirical evidence provided in a multiple case study of eleven UBC from two different parent universities (PU) located outside TRE in Spain. The multiple case study approach enables us to use a replication logic treating each case under analysis as independent events. Moreover, cases under study were selected looking for substantial variety and representativeness of the whole population of UBC located outside TRE. Thus, we believe that the findings of this study should not be generalized to the entire UBC phenomenon without considering possible differences in the sample (cases) of analysis.

The empirical evidence found in this study reveals several insights about the UBC development process outside TRE. First, we have found that UBC outside TRE develop following four or five consecutive stages and overcoming three or four *critical junctures* located at the interstice between one stage of development and the next one. In this sense, our results are similar to the findings in Vohora et al. (2004) but with one important difference. As many of the UBC created outside TRE are not based on previous academic research, the first phase of UBC development identified in Vohora et al. (2004) (*research phase*) is not always present in the development process of UBC outside TRE.

In the same line, some of the UBC interviewed declared not to have passed the first critical juncture identified in Vohora et al. (2004) (*opportunity recognition*). Instead, these companies said that they actually did not recognized any particular business opportunity and that they had started their venture project directly at the second development phase identified in Vohora et al. (2004) (*opportunity framing*).

Moreover, our results suggest that the support from parent universities (PU) looses relevance as the UBC progress through the stages of development. In particular, we have found that PU's support is especially important during the first critical juncture in UBC development. PU's support is still relevant for UBC looking to hire an external suitable manager, thus to overcome the second critical juncture (*entrepreneurial commitment*). Finally, it seems that PU's support is not that important during the third and last critical juncture (*credibility* and *sustainability thresholds*).

In this sense, our results are similar to the findings in other studies dealing with the UBC development process in Spain (Beraza and Rodriguez, 2011). On the other hand, studies dealing with the UBC development process at TRE outline that PU's support is

almost inexistent during the third and fourth critical juncture (Vohora et al., 2004). This difference suggests that while UBC located outside TRE need the support from PU all along their development process, UBC located at TRE use PU's support only during the very first stages of development. This finding has important implications for university managers and policy makers willing to facilitate the UBC development process outside TRE.

Furthermore, we have found that the majority of the UBC interviewed did not properly overcome the second critical juncture (*entrepreneurial commitment*) in their development process. In fact, with one exception, in all cases under study one or more of the founders committed to the CEO position at the new venture. These founders/managers usually lack the industry experience and managerial capabilities necessary for leading UBC into sustainable returns.

Thus, the inability to find and hire a suitable surrogate entrepreneur seems to be a great obstacle in the development process of UBC located outside TRE. This result differs from Vohora et al. (2004) who found that UBC at TRE usually find and hire an external manager to champion the company into sustainable returns. Once more, this finding has important implications for university managers and policy makers willing to facilitate the UBC development process outside TRE.

Finally, we have found that the resources and capabilities of firms' founders and managers are important factors influencing the UBC development process outside TRE. In this sense, we have found that UBC founders' industry experience and entrepreneurial capabilities may enhance firms' probability of identifying an attractive business opportunity and hiring a suitable surrogate entrepreneur. Moreover, we have found that UBC managers' capabilities to adapt the business model to markets' needs is a key factor influencing the second part of the UBC development process. These findings are similar to the results in Vohora et al. (2004).

This study is not free of limitations. In particular, we believe that the results of this study should not be generalized to the whole UBC population. Even though we took care to select companies representing most UBC located outside TRE, the scarce number of UBC included in this study (eleven) impedes the use of quantitative methodologies to fully contrast the UBC development model proposed in Vohora et al. (2004). In this sense, future research may wish to collect the necessary data to undertake a quantitative analysis and contrast Vohora et al. (2004) UBC development model.

CHAPTER FIVE

FOUNDERS' HUMAN CAPITAL AND THE SURVIVAL OF UNIVERSITY-BASED COMPANIES

1. Introduction

University-based companies (UBC) are firms founded by university members (i.e. academics, students and graduate students or staff), created with the support of a parent university (PU) and with the objective of commercializing knowledge (tacit or codified) initially developed at the PU and transferred to the firm (Pirnay et al., 2003; Vohora et al., 2004; O'Shea et al., 2008; Epure et al., 2014).

Due to their significant contribution to economic and technological development, the study of UBC has become a relevant topic for small business management and entrepreneurship scholars (Rothaermel et al., 2007; Djokovic and Souitaris, 2008; O'Shea et al., 2008; Ortin and Vendrell, 2014; Wright, 2014). On the other hand, in the University Entrepreneurship literature we may find fewer studies trying to explain UBC performance or their success factors (Shane and Stuart, 2002; Grandi and Grimaldi, 2005; Niosi, 2006; Walter et al., 2006; Zhang, 2009; Epure et al., 2014; Ortin and Vendrell, 2014).

In this line, we have found few studies focusing on UBC survival and most of these studies are either descriptive (Lowe, 2002) or try to understand whether the use of firm resources, such as social capital and patents, increases the probability of UBC survival (Shane and Stuart, 2002; Nerkar and Shane, 2003). None of these studies examine the relationship between founders' human capital characteristics and the survival of UBC. Our research aims to fill this gap.

Among the different dimensions of performance, survival becomes particularly interesting in a UBC context because it allows long-term innovation, knowledge transfer and regional development. In this sense, Epure et al. (2014: 2) argue that: "*In the short run, the main firm objective is ... to increase the probability to survive by maximizing returns.*"

In addition, in some cases university academics create UBC as a mean of continuing a line of research or as a *life-style* company not targeted at maximizing the returns for its shareholders (Vohora et al., 2004; Migliorini et al., 2010). Thus, commonly used firm success dimensions as profitability or growth may not be adequate measures of UBC performance.

Moreover, UBC are generally small companies with scarce initial resources (Ortin et al., 2008; Harrison and Leitch, 2010; Vendrell and Ortin, 2010; Ortin and Vendrell, 2014). In this sense, most UBC start business with the human capital of their founders as their main competitive asset (Shane and Stuart, 2002; Colombo and Piva, 2012). Therefore, the survival of this type of firms is heavily dependent on the human capital characteristics of their founders (Ortin et al., 2008; Vendrell and Ortin, 2010). Thus, in this study we argue that founders' human capital is a key element to understand and explain why some UBC survive while others do not.

We draw on Becker (1975) *Human Capital Theory* and on Gimeno et al. (1997) *Threshold Model of Entrepreneurial Exit* (TMEE) to evaluate the contribution of founding teams' human capital characteristics on UBC survival. Thus, our research question is which are the founders' human capital characteristics that significantly influence the probability of UBC survival?

Using a unique sample of 80 Catalonian UBC, this study confirms that different types of specific human capital have different effects on firm survival. In particular, our results show that while industry specific human capital has a negative effect on UBC survival, university specific human capital positively affects UBC survival. Furthermore, our results show that entrepreneurship human capital only partially enhances UBC survival.

In the following section we develop the theoretical framework and research hypothesis of this study. The research methodology is explained in section three and the results are presented and discussed in section four. Finally, section five concludes highlighting some implications and limitations of this study.

2. Theoretical framework and hypothesis development

2.1 The Threshold Model of Entrepreneurial Exit (TMEE)

We draw on Gimeno's et al. (1997) Threshold Model of Entrepreneurial Exit (TMEE) to study the influence of founders' human capital on the likelihood of UBC survival. Gimeno et al. (1997) argue that the drivers of firm survival are not only related to the absolute level of firm performance, but rather on the correct equilibrium between firm economic performance and performance threshold requested by the entrepreneurs.

Moreover, the application of the TMEE is highly relevant for this research since it helps to take into account the effect of founders' human capital characteristics both on organization economic performance and organization threshold of performance, and thus finally on organization survival. In this line, the TMEE model has proved its effectiveness along two decades and has been widely applied in research in both entrepreneurship and management literature (DeTienne and Cardon, 2012). In the next paragraph we shortly describe the TMEE.

The economic performance realized by the new venture is the first element determining firm survival and it consists of the monetary returns obtained by owners from their business activity. On the other hand, the model suggests that entrepreneurs also have organizational performance thresholds, below which they will close the firm. Organization's threshold of performance is thus the minimum level of economic performance required by shareholders to maintain their business in activity and it is determined by three dimensions or elements of the owners: 1) the opportunity costs of

remaining in the business, 2) the psychic income deriving from entrepreneurship and 3) the costs of switching to an alternative occupation.

In Gimeno's et al. (1997) TMEE, founders' *opportunity costs* are the expected monetary returns available in an alternative occupation. *Psychic income* from entrepreneurship is determined by the non-monetary returns (personal satisfaction) obtained from being an entrepreneur. Finally, *switching costs* include all difficulties, obstacles and monetary costs entrepreneurs should account if they want to change occupation from their current entrepreneurial activities to other type of employment activity.

Moreover, since high levels of threshold of performance encourage entrepreneurs to move away from entrepreneurship, the higher the organizational threshold of performance, the smaller the probability that firms survive. In this sense, an organization will remain active if the returns from the business are higher than the organizational threshold of performance.

Furthermore, following Gimeno's et al. (1997) TMEE , economic performance of organizations and their threshold of performance are influenced by their founders' human capital characteristics. In particular, Gimeno et al. (1997) claim that organization *economic performance* is positively related to both general and specific founders' human capital.

In this sense, *general human capital* refers to entrepreneurs' general knowledge obtained through formal education and professional experience, which may be applicable in a wide range of occupational alternatives (Gimeno et al., 1997; Colombo and Grilli, 2005). On the contrary, *specific human capital* characteristics refer to the skills and capabilities gained by entrepreneurs through education, job training and work experience, which have a limited scope of applicability (Gimeno et al. 1997).

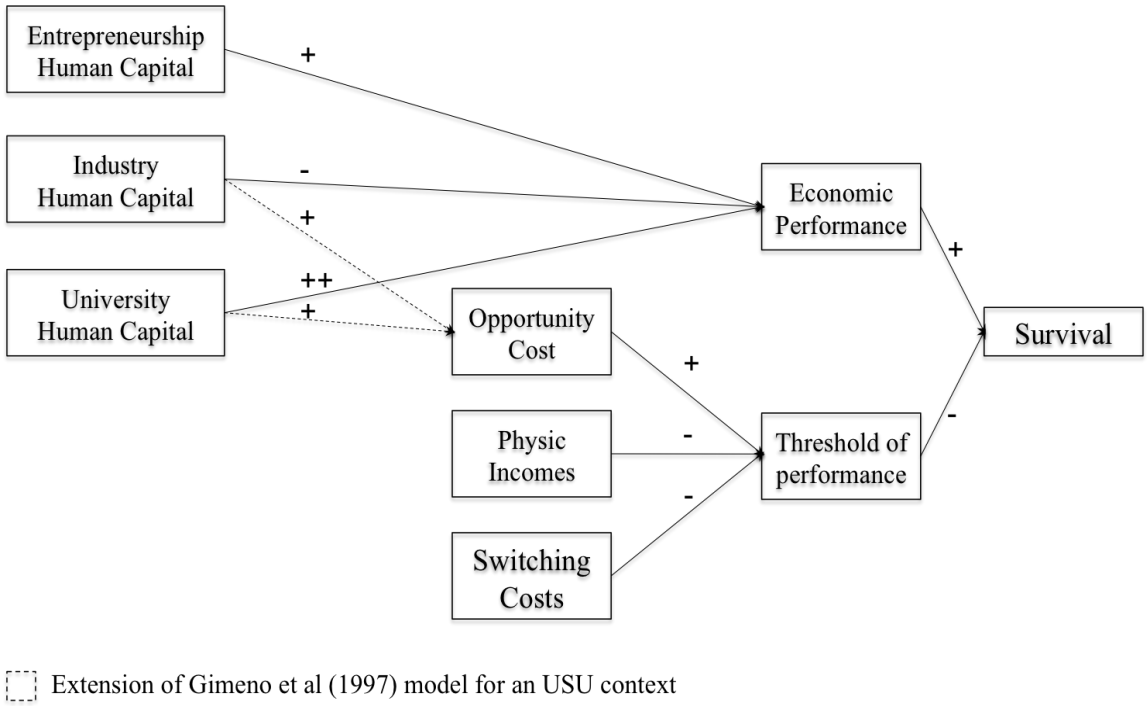
Moreover, Gimeno et al. (1997) claim that general human capital has an indeterminate effect on organization survival because it has a positive influence on both, organizational economic performance and the threshold of performance of the organization. On the other hand, Gimeno et al. (1997) claim that specific human capital has a positive influence on organization survival since it only positively affects organizational economic performance. The reason why specific human capital only affects economic performance and not the threshold of performance lays on Gimeno's et al. (1997) assumption that founders' future occupation is unknown *a priori* and so their specific human capital is a priori unusable for it.

Thus, we draw on Gimeno et al. (1997) TMEE to predict the effect of founders' specific human capital over the probability of UBC survival. We do not to include USU founders' general human capital in our model for several reasons. First, as shown by Gimeno et al. (1997), general human capital influences on firm survival is not significant as it affects positively both economic performance and threshold level of performance. Second, general human capital is not considered to be a distinctive

characteristic among academic entrepreneurs. In this sense, most of university entrepreneurs have a similar and high level of general education and experience, leading the variance of such variable to be low. Finally, we find evidences in the entrepreneurship literature stating that founders' general human capital do not significantly affect the performance of new firms (Colombo et al., 2004).

Furthermore, we draw on Gimmon and Levie (2010) to divide UBC founders' specific human capital into three components or validated constructs: (i) Entrepreneurial Human Capital (EHC), (ii) Industry Human Capital (IHC) and (iii) University Human Capital (UHC). EHC refers to the knowledge derived from founders' education in entrepreneurship and personal experience in starting-up new ventures. IHC refers to the knowledge derived from founders' previous jobs, which can be applied in the current UBC. Finally, UHC refers to the experience derived from founders' previous job at the parent university. In **Figure 1** we show the conceptual framework adopted to study the influence of founders' specific human capital on the probability of UBC survival.

Figure 1: The theoretical model



2.2 Hypothesis development

In this part of the section we shall develop the hypotheses that will guide our research. It is important to emphasize that we want to test hypothesis relating UBC founders' specific human capital characteristics and firm survival. Thus, we shall neither test nor

hypothesize about the effect of UBC founders' human capital characteristics over firm performance nor over its threshold of performance.[68]

In the NTBF and entrepreneurship literature we find studies positively relating founders' Entrepreneurial Human Capital (EHC) with organizational performance. In this sense, the literature emphasize that firms founded by teams endowed with entrepreneurial education and start-up experience will perform better than firms having no EHC among their founders (Bates, 1990; Gimeno et al., 1997).

On the other hand, founders' EHC has no affect over the threshold of performance of these companies because founders with higher EHC are not necessarily endowed with the competences needed in an alternative occupation. Thus we expect EHC to positively affect UBC performance, to have no effect over the UBC threshold of performance and therefore to increase the probability of UBC survival. This result is also confirmed by Shepherd et al. (2000) that found empirical evidence positively relating NTBF founders' start-up experience with firm survival.

In this sense, Gimeno et al. (1997:759) affirmed that "*entrepreneurs with previous venture start-up or ownership experience may be endowed with human capital that is valuable in new venture situations because they have experience in the start-up process and in running their own business. This experience may not be as valuable in alternative occupations that include work in established firms*". Thus, EHC does not increase the opportunity cost of UBC founders and therefore does not affect their threshold of performance. Therefore, our first hypothesis states that:

Hypothesis 1: Entrepreneurial human capital (EHC) of UBC founders is positively related to firm survival.

Furthermore, the effect of founders' Industry Human Capital (IHC) over firm performance has remained ambiguous in the literature. In this sense, while Shane and Stuart (2002) find industry experience to be weakly but positively related to UBC performance, Shrader and Siegel (2007) find industry experience to be strongly and negatively related to NTBF's profitability and sales growth.[69] As the relationship between human capital and performance is stronger when measurements capture more specific dimensions of human capital, we adopt Shrader and Siegel (2007) perspective, and maintain that founders' IHC negatively affects organizational performance.

On the other hand, networking resources should also increase the availability of a higher salary in an alternative occupation and thus is useful when considering exiting the

[68] In our study, like DeTienne and Cardon (2012), firm performance and threshold of performance are indeed unobserved variables used to conceptualize the effect of founders' human capital characteristics over firm survival.

[69] Nevertheless, we believe that Shrader and Siegel (2007) findings are more comprehensive than Shane and Stuart (2002). While the former study includes six dimensions on experience (industry, technical, marketing, finance, international, and start-up experience), the latter only includes industry and start-up experience.

current venture and switch to a wage-employment or join another start-up project. In particular, UBC founders endowed with IHC usually have a valuable knowledge about the technology commercialization process. In this sense, we consider that founders' industry experience positively affects the opportunity cost and thus the firm's threshold of performance. Finally, Grilli (2011) found that there exists a positive relationship between specific working experience (in the same sector as the one of the actual venture) and firm exit. Following the previous reasoning about the effect of founders' IHC over venture performance and threshold of performance, our research hypothesis two states that:

Hypothesis 2: Industry human capital (IHC) of UBC founders is negatively related to firm survival.

University Human Capital (UHC) endows UBC founders with a strong legitimacy in both the academic and the business context. Indeed, UBC founders endowed with UHC will provide the firm with a higher numbers of strong informal ties with the Parent University (PU) (Johansson et al., 2005). In this sense, the link that UBC have with their PU facilitates them to overcome obstacles in their development process (Vohora et al. 2004) and also helps granting firm survival (Westhead and Storey 1995).

Moreover, the University Entrepreneurship literature emphasize that UBC whose founders are endowed with UHC establish technological alliances with public research organizations more frequently and are more likely to participate in international collaborative R&D projects than UBC not endowed with founders' UHC (Colombo and Piva, 2012). Therefore, we argue that founders' UHC will enhance UBC performance.

On the other hand, UHC has a positive but weaker influence on the threshold of performance since the income available from an alternative occupation in the industry would not be very high for UBC founders with university experience. Indeed, university employment tends to be less volatile than the one experienced in the private sector (Ensley and Hmieleski, 2005). Thus, UBC founders with university working background would hardly obtain a higher salary that the one obtained before (when working at the parent university) because their alternative occupation most likely consists to go back to their university position.

In this sense, we believe that the UHC of founders will have a positive but moderate effect on the UBC threshold of performance. Thus, we predict that while UBC founders' UHC will be strongly and positively related to firm performance, founders' UHC is positively but weakly related to the UBC threshold of performance. Therefore, our third research hypothesis states that:

Hypothesis 3: University human capital (UHC) of UBC founders is positively related to firm survival.

3. Methodology

3.1. Sample selection and data collection

We base our analysis on Catalonia, a Spanish region located at the north-east of the Iberian Peninsula along the Mediterranean Sea with the Pyrenees and France as it northern border. In economic, industrial and technological terms Catalonia is one of the most developed regions of Spain. Moreover in Catalonia there are ten state-owned universities that create and develop spin-off companies with the support of the XTT program.[70]

Catalonian universities started to commercialize their technological knowledge through start-up companies during the 90's and nowadays there are more than 250 active companies spun-off by Catalonian universities (Ortin et al., 2008; Migliorini et al. 2010). Due to the business and technological development of the region, its academic proficiency, the university spin-off tradition and the XTT program support, we believe that Catalonia is a remarkable territory to study the university spin-off phenomenon.

The database used for this study combines an exploratory study conducted between January 2008 and June 2008 with an integrative follow-up contribution released in May 2011. The first study aimed to census all those companies supported by Catalan Technological Trampolines along with understanding the main characteristics of the firm and its founders.

On April 2008, Catalan Technological Trampolines provided us with an updated list made of 348 university-based companies. By analyzing such list, we find that some companies had received support from two or more Trampolines (13 firms), thus reducing the number of companies down to 335. Moreover, others were closed or inactive[71] (33 companies), others that could not be contacted because the data was wrong or did not exist (32 companies) and others, despite being in the database indicated that they had no relationship to the trampoline when contacted (8 companies), leaving a total of 262 firms active and accessible.

Based on a preliminary list of university-based companies supported by Catalan Technological Trampolines, a sample of 15 university-based companies was selected to conduct a pilot test with the funding partners in order to test the suitability of the questionnaire. Additionally, the director of the Technology Park of the University of

[70] The XTT (Xarxa de Trampolìs Technològics or Technological Trampolines Network) is a support program developed and funded by the Catalonian Government aiming at helping academics and other university members to create and develop university spin-off companies.

[71] As usual in studies that use survey-based data, the analysis presented in this paper suffers from a survivorship bias (Colombo and Piva 2012) that might have significant consequences for our study. Indeed, if we divide the number of inactive firms (32) by the total (and corrected) number of UBC (294), we would found a mortality rate of 11 percent. If we would find a similar result in our study, we could easily claim not to suffer from a survivorship bias.

Girona, the director of Acció and the manager of XTT were also interviewed to incorporate their comments to the questionnaire.

A final questionnaire was sent to all 262 Catalonian UBC on May 2008. The data collecting process followed different steps. First, a collaboration request was sent to companies via email. This request explained the objectives of the study and it also reported that a member of staff would contact via phone to solicit their cooperation in the following days. Phone calls were made and the respondents were offered the possibility of completing the questionnaire online, by phone or through a personal interview. This phase has received the support of the Technological Trampolines who made e-mail reminders to companies that had not yet responded to the questionnaire.

Primary sources obtained from the questionnaires were then reviewed in order to detect errors or inconsistencies. Those entrepreneurs whose answers could lead to confusion were thus contacted again. Financial data was contrasted with secondary data using both SABI (Bureau Van Dijk's database, which includes balance sheets, income statements and other indicators) and Acció Concept Capital database. Finally, in June 2008 we were able to collect 94 (35,9%) properly completed surveys.

A follow-up study was conducted 3 years afterwards (May-June 2011) with the aim of monitoring the development of the phenomenon. In such way, we could assess the mortality rate of the companies studied in the first phase. SABI database was used in order the see the actual legal status of the company.

Moreover, two companies were detected as liquidated. Furthermore, those UBC whom operating revenues were not updated until 31-12-2010 were contacted telephonically and asked what their actual status was. Additional information was browse in local press and the Internet with the intent to collect additional news for those companies that did not answer to our calls and for inoperative landline numbers. **Table 1** presents the data sheet for the study.

Considering the heterogeneity of the UBC phenomenon in Catalonia we include in our sample every company created with the institutional support of a parent university, presenting any type of business model and having received at least one type of resource transferred from the parent university to the firm. By adapting such filters, our sample decreased from 94 to 80 UBC. These companies were created between the year 1999 and the year 2007. Thus we avoid possible bias in the information collected due to the financial and economic crisis that started in Spain during the last quarter of 2007. Finally, all of these companies have received some kind of support from the XTT program described before.

Table 1: Datasheet of the study

	Survey (June 2008)						Follow-Up (June 2011)
Parent University	**Population**	**Responses Obtained**	**Personal Interview**	**Telephone Interview**	**Web**	**Response Rate (%)**	**Response Rate (%)**
Universitat Politècnica de Catalunya (UPC)	139	27	0	1	26	19.4	100
La Salle (URL)	59	33	1	2	30	55.9	100
Universitat de Barcelona (UB)	20	8	1	1	6	40.0	100
Universitat Autònoma de Barcelona (UAB)	18	13	10	2	1	72.2	100
Universitat de Girona (UdG)	8	5	5	0	0	62.5	100
ESADE (URL)	6	2	0	1	1	33.3	100
Universitat Rovira i Virgili (URV)	6	2	0	0	2	33.3	100
Universitat Pompeu Fabra (UPF)	4	2	0	0	2	50.0	100
IESE	1	1	0	1	0	100.0	100
Universitat de Lleida (UdL)	1	0	0	0	0	0,0	100
TOTAL	**262**	**93**	**17**	**7**	**69**	**35.9**	**100**

3.2. Variables and model of analysis

In **Table 2** we have a description of all variables included in the analysis.

3.2.1 Dependent variable

In this study the dependent variable is the active or inactive status of UBC in June 2011. More precisely, UBC that are found to be in activity (operating) by June 2011 receive the value 1 while UBC that are found to be inactive (closed) by June 2011 receive the value 0.

3.2.2. Explanatory variables

Entrepreneurial Human Capital (EHC) is measured with two variables: (i) *Entrepreneurial Education*, which is coded 1 if at least one member of the founding team has formal education in entrepreneurship and/or business management by the time he/she started the business, and (ii) *Start-up Experience*, which is coded 1 if at least one member of the founding team has previously launched a new company.

Table 2: Variables description and measurements

Dimension	Variable	Measurement
Survival	*UBC Survival*	Value 1 if UBC is still operating by June 2011 and value 0 if UBC is closed by June 2011.
Entrepreneurship Human Capital	*Entrepreneurial Education*	Taking value 1 if there is at least one member in the founding team with entrepreneurial education, 0 if not.
	Start-up Experience	Taking value 1 if there is at least one member in founding team who has created a company prior to the current UBC, 0 if not.
Industry Human Capital	*Industry Experience*	Taking value 1 if there is at least one member in founding team whose previous job was at a high tech company or if he/she has established a R&D collaboration contract with the parent university, 0 if not.
University Human Capital	*University Experience*	Taking value 1 if there is at least one member in founding team whose previous job was that of either academic or doctoral/post-doctoral student at the parent university, 0 if not.
Psychic Income (control)	*Entrepreneurial Family*	Taking value 1 if there is at least one member whose relatives owned or owns a business, 0 if not.
Switching Costs (control)	*Team Age*	Average age of founding team.
Other Control Variables	*Bio Tech*	Taking value 1 if UBC operates in the Biotechnology sector, 0 if not.
	ICT	Taking value 1 if UBC operates in the ICT sector, 0 if not.
	UBC Age	Number of years since firm's foundation until June 2011.

Following Shane and Stuart (2002), we measure Industry Human Capital (IHC) through *Industry Experience*, which is coded 1 if at least one member of the founding team has previous experience in the same industry of the current UBC or has established an R&D collaboration contract with the parent university.

Finally, UHC relies on the different skills and knowledge a founder could achieve through past experience in the university. Such specific human capital is measured with *University Experience*, which is coded 1 if at least one member of the founding team has been employed at the university, either as a professor or as a researcher (Colombo and Grilli, 2010).

3.2.3. Control variables

We shall first include as control variables the other two dimensions influencing the threshold of performance of organizations in Gimeno's et al. (1997) TMEE. In this sense, we measure *Psychic Income* from entrepreneurship using the *Entrepreneurial Family* variable. Such variable has been assessed as the presence on the founding team of at least one member whose close relatives (parents, grandfather, brothers or sisters) were entrepreneurs at the time of the survey or have been self-employed in the past. Moreover, following Gimeno et al. (1997), we measure switching costs as the average *Team Age* of founders.

We also include as secondary control variables firm level characteristics as the UBC age or its sector of activity. In this sense, we measure *UBC Age* as the number of years since founding until June 2011. Our sample is also controlled by the sector where UBC operate. We use two dichotomous variables, *BioTech* and *ICT*, in order to measure sector affiliation. Both variables are often controlled in previous survival studies (Gimeno et al., 1997; Delmar and Shane, 2006).

3.2.4. Relation among variables and model of analysis

Table 3 presents means, standard deviations, simple pair-wise correlations and Variance Inflation Factor (VIF) for all variables included in the analysis (except for secondary control variables).

Since there is some correlation among the explanatory variables, a multicollinearity test is undertaken in order to see if such correlations will blur the model. As a consequence, we assess the Variance Inflation Factor (*VIF*), which simply is the reciprocal of the tolerance. The *VIF* shows us how much the variance of the coefficient estimate is being inflated by multicollinearity. A *VIF* of ten or higher (or equivalently, tolerances of .10 or less) may be reason for concern. As shown in **Table 3** none of the variable in our model has a *VIF* higher than ten. Therefore, we may affirm that no multicollinearity limitations are hindering our results (Hair et al., 2006).

Finally, a binary logistic regression serves as our econometric model to test the impact of the explanatory variables on the dependent one. The use of such technique is adequate since the dependent variable is dichotomist and such practice allows estimating the probability of independent variables to assume either one or the other value of the dependent variable (Lyles et al., 2004).

Table 3 Mean, standard deviation, correlation table and multicollinearity test.

	Mean	S.D.	1	2	3	4	5	6	7	VIF
1. UBC Survival [a]	.825	.38236	-							
2. Entrepreneurial Education [a]	.525	.50253	.060	-						1.34
3. Start-up Experience [a]	.4375	.49921	-.022	.168**	-					1.32
4. Industry Experience [a]	.725	.44933	-.049	.090	.092	-				1.33
5. University Experience	.4375	.49921	.080	-.060	-.109	.142*	-			1.58
6. Entrepreneurial Family [a]	.75	.43575	.063	.114*	.019	.013	-.032	-		1.11
7. Team Age [b]	35.065	7.3278	.165	.204	.199	.267*	.300**	-.050	-	1.34

[a]: Correlation has been assessed by using Kendall tau rank correlation coefficient

[b]: Correlation has been assessed by using spearman correlation coefficient

*: Significance level <0.05. **: Significance level <0.01.

4. Results

Concerning our dependent variable, 82 percent of the university-based companies sampled were still operating while the rest 17.5 percent were either liquidated or failed by May 2011. Such result is quite similar with previous descriptive studies investigating UBC survival (Shane and Stuart, 2002). **Table 4** shows the results obtained from the logistic regression analysis.

Table 4 shows that while founders' entrepreneurial education is positively relate to UBC survival, founders' start-up experience is not. Moreover, in **Table 4** we can see that founders' University Human Capital positively and significantly influences the probability of UBC survival. On the other hand, our empirical evidence shows that Industry Human Capital of UBC founders negatively affect the probability of firm survival. In this sense, we can fully confirmed hypotheses two and three but we can only partially confirmed hypothesis one. **Table 5** shows the confirmation/rejection of the research hypotheses of this study.

Table 4 The effect of human capital on UBC survival - Logistic regression results

	MODEL	
	Coef.	**Std. Err.**
Constant	-3.145683	3.130361
UBC Age	.176137	.1902218
Bio Tech	-2.65108*	1.443611
ICT	-1.685222	1.058505
Entrepreneurial Education	2.038699**	.9984917
Start-up Experience	.2458897	.9022341
Industry Experience	-3.71977**	1.588694
University Experience	2.965751**	1.21282
Entrepreneurial Family	1.846831**	.9263136
Team Age	.1402598	.0874869
$\chi 2$	23.33***	
Prob $>\chi^2$	0.0055	
−2 log likelihood	50.865744	
Hosmer–Lemeshow goodness of fit	3.11[b]	
Pseudo R^2	0.3144	
N	80	

*: Significance level <0.1. **: Significance level <0.05. ***: Significance level <0.01.

[a]: Hosmer-Lameshow's Pearson χ^2

[b]: Since the number of covariates is equal to the number of observations, the Hosmer-Lameshow test was calculated subdividing observations in 10 groups.
(http://www.ats.ucla.edu/stat/stata/output/old/lognoframe.htm)

Table 5 Corroboration of hypotheses

H1: Entrepreneurship human capital (EHC) of the UBC founding team increases the probability of firm survival.	Partially Supported
H2: Industry human capital (IHC) of the UBC founding team increases the probability of firm survival.	Supported
H3: University human capital (UHC) of the UBC founding team increases the probability of firm survival.	Supported

The literature on NTBF survival generally hypothesizes Industry Human Capital (IHC) of founders as being one of the strongest determinants of firm survival (Gimmon and Levie, 2010). Our theoretical model and results speak in another direction. Indeed, in a UBC context, we find founders with higher industry experience are more likely to exit firms.

The explanation of such apparently surprising result stands on the importance of the organizational threshold of performance. In this sense, the higher the UBC founders' industry experience the higher the opportunity cost of staying at the new venture and thus the higher the threshold of performance. Thus, the threshold of performance plays a prevailing impact, significantly lowering the UBC likelihood of survival. On the other hand, university Human Capital (UHC) shows a positive impact on UBC survival. Results confirm our theoretical reasoning, as founding teams with UHC contribute to a better performance. Moreover, their threshold of performance is not as high as for team with IHC, since the former possess few options about alternative occupations.

Concerning Entrepreneurial Human Capital (EHC), we only find entrepreneurial education to be positively influencing UBC survival (star-up experience had no effect on the dependent variable). Many UBC entrepreneurs are researchers and scientist deeply focused in their field of research and inventions (Franklin et al. 2001). Therefore, they may lack fundamental understandings and training in subjects such as business administration and entrepreneurship. Such shortage can eventually lead to inaccurate evaluations of activities and strategies. Therefore, a deeper understanding in entrepreneurship subjects becomes a critic advantage for the survival of the UBC.

For the *start-up experience* variable Nerkar and Shane (2003) discovered a similar finding in a UBC context. Nevertheless authors refrain to offer a comprehensive explanation of it. The reason why such variable is not significantly related to firm survival may be because it is often measured in general terms. Indeed, most empirical studies either assess if the founder has previously started another firm (*i.e.* dichotomous variable) or the number of firms previous started (Chandler and Jansen, 1992; Shane and Stuart, 2002).

Nevertheless, recent studies highlight the importance of positive start-up experience in sub-sequent entrepreneurship (Mungai and Velamuri, 2011).Thus, the presence of experienced but not successful entrepreneurs may alter the results. Therefore, we believe that a deeper research needs to be conducted about the influence of successful *vs.* unsuccessful start-up experience on UBC survival.

Finally, Gimeno's et al. (1997) TMME suggests that specific human capital positively impacts firm survival. However, we highlight that, the closer the future occupation to the current, the more valuable the specific human capital is (since it can be successfully and efficiently transferred from the present to the future occupation). That is presumably because most of his knowledge will be valorized in an industry that is similar, if not coincident, with the one he is actually working in.

5. Conclusion

The positive effect of entrepreneurs' human capital on firm survival is often taken for granted (Bates 1990). In this study we empirically examine the role of specific components of firms founders' human capital over firm survival, in a relevant and unique UBC setting, through the lenses of Becker's (1975) Human Capital Theory and drawing on Gimeno's et al. (1997) Threshold Model of Entrepreneurial Exit (TMEE). Our research validates and extends Gimeno's TMEE, confirming its explanatory power and robustness for different types of entrepreneurial settings.

In this sense, this study sheds some light over the determinants of university-based companies (UBC) survival. In particular this article aims at understanding which are the founders' human capital characteristics that significantly increase the probability of survival of UBC. In this sense, we believe this to be a pioneer attempt trying to assess the effect of human capital resources over the likelihood of survival of UBC. By adopting and extending Gimeno et al. (1997) TMEE, we develop and test hypotheses on the relationship between founders' human capital and firm survival on a unique sample of 80 UBC from ten Catalonian Parent Universities (PU).

Our results show insightful findings about the effect of specific human capital on firm survival. More precisely, we find a negative relationship between Industry Human Capital (IHC) of founders and UBC likelihood of survival. Such relationship takes place because of the higher-level threshold of performance of UBC founders with industry experience. Indeed, specific IHC is more valued in the job market and thus those individuals that possess it are more exposed to change occupation, and thus to close down the UBC, if they perceive better financial returns in alternative occupations.

On the other hand, we have found that founders' University Human Capital (UHC) enhances UBC survival. Indeed, such specific type of capital is a driver for firm performance while it is not considered as a core asset particularly desirable in alternative occupations. Finally, this study highlights the positive effect of entrepreneurial education, as part of founders' Entrepreneurial Human Capital (EHC), on UBC survival.

Our research adds to literature in several ways. First, it addresses a lack of research and theoretical advancement in UBC survival studies. Given their well-known contribution to regional development, high survival rate of UBC are to be understood, pursued and fostered, as a measure of effectiveness of research funding (Clayman and Holbrook, 2004). In this sense, whereas the importance and relevance of survival for this type of firm is acknowledged, it has not sufficiently attracted effort from scholars.

Our research also contributes to the understanding of entrepreneurial dynamics by disentangling the effect of different type of human capital over UBC survival, answering to Unger et al.'s (2011) call for more studies that investigate survival appropriately by linking it to founders' human capital. Moreover, this research add to

Gimeno et al. (1997) by opening the *black box* concerning the indeterminate effect of specific human capital over the organizational threshold of performance and thus on firm survival, in a specific UBC context.

Our study addresses specific insights to Technology Transfer Offices (TTO), to Parent Universities' managers, to policy makers and to university entrepreneurs. As UHC has been shown to positively affect UBC survival, Technology Transfer Office and university managers should be careful in fostering entrepreneurship in high-reputation and socially embedded academics, so to legitimate the technology transfer process from the university to the firms. Moreover, they should provide aspiring entrepreneurs with entrepreneurial education as this also increases the likelihood of UBC survival.

Policy makers, on their side, are provided with an evaluation framework that can help them to spot individual levels antecedent of UBC survival. They are thus enabled to effectively allocate resources towards those entrepreneurs whose specific human capital improve firm survival. On the other side, they have to allow flexibility in market labour in order to favour entry and exit strategy. Thus, this study provides UBC founders with useful insights that could help them evaluating their current situations, persistence in entrepreneurship and future occupational alternatives.

Data availability in this study negatively impacted the size of the sample and measurement of the constructs. Although our sample is representative of the UBC phenomenon in Catalonia, a larger and more heterogeneous sample would allow investigating survival factors more in depth. Moreover, a larger sample would also allow us to distinguish among different exit strategies (i.e. mergers and acquisitions, employee takeover, etc.).

In the same line, in this study we lack a comparative sample of other types of spin-offs (i.e. corporate spin-offs) or other new technology-based firms (NTBF) that would allow us to better assess the effect of human capital differences over firm performance and survival (Ortin and Vendrell, 2014). A comparative study exceeds the scope of this research.

Finally, more accurate measurements of human capital would help to better quantify the weight or relevance of such human capital over UBC performance and survival. We also believe that the unobservability of both economic performance and threshold of performance is also a limitation of this study. While economic performance is easy to measure, the threshold level of performance is extremely difficult to assess since it requires accurate information about the valuation of entrepreneurs' human capital by external stakeholders. Such difficulties are often overcome by assessing the direct effect of founders' human capital on firm survival.

DOCTORAL DISSERTATION CONCLUSION

In this doctoral research I have first review the UBC literature (chapter one). I have then define and characterize UBC (chapter two). In chapter three, I have identified the Parent University (PU) determinant factors of UBC creation and in chapter four I have disentangled the UBC development process. Finally, in chapter five I have identified the founders' human capital characteristics that significantly influence UBC survival.

During this doctoral research process I have been able to acquire different layers of knowledge related to the UBC phenomenon. In this sense, I have improved my understanding about this recent but prominent phenomenon from different conceptual perspectives and levels of analysis. I sincerely hope that this piece of research serves as a platform for the development of future studies about university-based companies.

1. UBC as a prominent field of scholar research

In chapter one, we have undertaken a comprehensive bibliometric study including 328 UBC-related documents published and accessible at Google Scholar database. The results from this study show that the University Entrepreneurship field of research began to attract the attention of scholars in the early seventies. In addition, the results show that from the beginning of this century there has been a rampant increase in the number of published documents, authors and journals treating the UBC phenomenon.

Moreover, from the results of the bibliometric study undertaken in chapter one, we have been able to rank UBC documents, UBC authors and journals publishing UBC articles according to the number of citations received. In this sense, we have found that the five UBC-related documents with the highest impact on the University Entrepreneurship field of study are in this order: (i) Shane (2004), (ii) DiGregorio and Shane (2003), (iii) Rothaermel et al. (2007), (iv) Shane and Stuart (2002) and (v) Vohora et al. (2004). Moreover, the five authors with the highest impact in the field are in this order: (i) Shane, (ii) Wright, (iii) Stuart, (iv) Lockett and (v) Clarysse. Finally, the five most influential academic journals in the University Entrepreneurship field of study are in this order: (i) Research Policy, (ii) Journal of technology Transfer, (iii) Journal of Business Venturing, (iv) Technovation and (v) Management Science.

Furthermore, the results from the review of 72 academic articles empirically treating the UBC phenomenon, allowed us to classify the existing UBC literature in three main streams or categories: (i) *seminal UBC studies*, (ii) *mainstream UBC literature* and (iii) *new avenues in UBC research*. The first stream of the UBC literature includes explorative and descriptive studies willing to define or characterize UBC and following in general no particular theoretical framework. Stream two includes quantitative studies willing to explain UBC creation and development determinant factors, drawing on a

variety of different theoretical frameworks and generally using regressions as their method of analysis. Finally, stream three includes mainly qualitative studies exploring the creation and development of UBC simultaneously or the impact of UBC over individuals, universities and hosting regions.

The results from chapter one indicate that incoming researchers willing to publish high impact UBC studies should focus their attention in analysing the impact of UBC, using a longitudinal approach and a multi-level of analysis: UBC impact over university entrepreneurs (micro), UBC impact over parent universities (meso) and UBC impact over the hosting region (macro). Moreover, incoming researchers willing to publish high impact papers should draw on the most influential UBC-related documents and authors mentioned before. Finally, high impact UBC researchers should concentrate their publications in the most cited journals found in this chapter.

2. Defining and classifying UBC

In chapter two, first we draw on the literature reviewed in chapter one to develop a comprehensive and coherent definition and typology of UBC. In the second part of this chapter, we draw on an empirical analysis of 94 UBC created with the support of ten Catalonian universities to characterize the profile of the different UBC types identified in the first part of the chapter.

Drawing on the results of this chapter we propose the following UBC definition: *University-based companies (UBC) are firms created inside the spatial and institutional context of a university (the Parent University, PU) which draw upon knowledge generated or circulated at the PU and with at least one member of the PU in their founding teams.*

This definition is particularly eclectic because it includes companies founded by academics, students, graduate students or administrative staff from the PU and based on some knowledge (explicit or tacit) that was originally developed (or identified) in the PU's context. Thus, this UBC definition has important implications for delineating the boundaries of the phenomenon under study. In particular, this definition contradicts the extended believe that UBC are all new technology-based firms (NTBF) founded by university researchers willing to commercialize a technological innovation originally developed at the Parent university.

Moreover, following the literature reviewed in this chapter we identify four mutually exclusive types of UBC: (i) *academic spin-offs* (*ASO*), (ii) non-academic or *university spin-offs* (*USO*), (iii) *academic start-ups* (*ASU*) and (iv) non-academic or *university start-ups* (*USU*). ASO are firms founded by one or more academics from the PU which draw on some piece of technology initially developed at the PU and formally transferred from the PU to the firm. USO are firms with no academics from the PU in their founding teams but that still draw on a formally transferred university technology. ASU

are firms founded by PU's academics but drawing on some type tacit (non-patentable) knowledge originally developed or identified at the PU. Finally, USU are firms with no academics in their founding teams and drawing on tacit (non-patentable) knowledge identified or learned at the PU.

The empirical findings from the analysis of 94 Catalonian UBC show that USO is the type of UBC with the highest growth potential. In this sense, USO are new technology-based firms (NTBF) with a growth-oriented strategy. On the other hand, ASU seem to be the UBC type with the lowest potential for growth. In this sense, ASU are generally life-style companies (Vohora et al., 2004) where academic founders found a way to finance the continuity of their investigations and have access to PU's strategic resources.

The results from the empirical analysis also show that the most risky type of UBC are USU. Indeed, university start-ups do not count with any technological innovation allowing them to create and maintain competitive advantages. Moreover, as USU do not have any academic from the PU in their founding teams, they usually have a limited access to PU's strategic resource, thus increasing business uncertainty. On the other side, ASO are the less risky UBC type because they not only count with a technological innovation to compete in the markets, but also count with academics from the PU in their founding teams (thus facilitating access to strategic resources).

3. UBC creation determinants from Parent Universities

In chapter three we undertake a longitudinal study to evaluate Parent University (PU) determinant factors of UBC creation. Our results show that PU's start-up resources, start-up capabilities and start-up institutions are significant predictors of UBC creation rates. In particular, we have found that while physical and human university start-up resources do not affect the rate of UBC creation by PU, technological and social university start-up resources are positively associated with the rate of UBC creation by PU.

Moreover, the results from chapter three show that the amount and quality of start-up support services offered by PU is positively related with UBC creation rates. In this sense, PU offering a wider range of high quality start-up support services (i.e. opportunity recognition, business plan development, securing finance or intellectual property protection services) will generate more UBC per year than PU offering a narrow and rather weak portfolio of start-up support services.

In the same line, we have found that the entrepreneurial experience accumulated by PU is also a significant predictor of the rate of UBC creation. Thus, it seems that PU having started to launch UBC early in time are now benefited from the knowledge and experience they have earned. This result also suggests that there is a learning process going on at PU's Technology Transfer Offices (TTO).

Finally, the results from chapter three indicate that the institutional context of PU is a key factor explaining the rate of UBC creation. Indeed, we have found that formal university start-up institutions (i.e. the PU's mission and objectives, the incentive system for university entrepreneurs or the procedures and requirements of the PU's start-up programme) and informal university start-up institutions (i.e. the perceived level of access to PU's start-up support services and resources or the entrepreneurial attitude of the PU's members) have a significant influence over the rate of UBC creation by PU.

4. Understanding the UBC development process

In chapter four we have done a multiple case study of eleven UBC created with the support of the Universitat Autònoma de Barcelona (UAB) and Universitat de Girona (UdG) to understand how UBC overcome obstacles (critical junctures) in their development process. We draw on Vohora et al. (2004) who identified four critical junctures in the development of UBC: (i) opportunity recognition, (ii) entrepreneurial commitment, (iii) threshold of credibility and (iv) sustainability threshold.

Our results show that UBC use a variety of resources, capabilities and institutions in order to overcome different critical junctures. In particular, we have found that university entrepreneurs with significant industry knowledge are better positioned to recognize a business opportunity than individuals with scarce industry experience. Moreover, we have found that the technology transfer office (TTO) plays a key role in helping university entrepreneurs to recognize business opportunities.

Our results also show that UBC overcome the entrepreneurial commitment critical juncture using the figure of the doctoral fellow student as the manager of the new venture. Indeed, we have found that UBC hardly have the financial resources to attract external surrogate entrepreneurs to their ventures (Franklin et al., 2001). Therefore in many cases UBC hire the doctoral fellow student who is helping in the research as the manager of the company.

Furthermore, we have found that in most cases UBC draw on their network of contacts to overcome the credibility threshold. In this sense, UBC draw on the social resources of their founders to secure their first customers and sales. Finally, our results show that UBC willing to overcome the sustainability threshold and stabilize their long-term returns mainly draw on their capabilities to constantly adapt their technologies and services to the needs of the customers and markets.

5. Founders' Human Capital and the survival of UBC

In the final chapter of this doctoral dissertation we draw on the same database used in chapter two complemented with a follow-up contribution about the UBC status (active or inactive) to assess the influence of founders' human capital characteristics over firm survival. Moreover, this study is framed under the Human Capital Theory (Becker, 1975) and it extends the Threshold Model of Entrepreneurial Exit developed by Gimeno et al. (1997) to the UBC context.

The results from this chapter show that while UBC founders' entrepreneurial human capital (EHC) and university human capital (UHC) enhance the probability of firm survival, industry human capital (IHC) of founders is negatively related to UBC survival. In particular we have found that UBC whose founders are endowed with entrepreneurship and managerial education have a greater probability of survival than UBC with no EHC among their founders.

In the same line, we have found that UBC having an academic from the PU in their founding teams have a higher probability of survival than UBC with no academics among their founding teams. This result is in line with the findings in chapter two where we found that academic UBC are less risky than non-academic UBC.

Finally, in this chapter we have found that UBC whose founders have significant industry experience and contacts will show a lower probability of survival compare to UBC whose founders present scarce industry knowledge. This result is explained by the fact that UBC founders with significant IHC have a higher opportunity cost to remain working at the UBC instead of working in an alternative occupation. Moreover, UBC founders endowed with IHC lower the switching costs of changing to an alternative occupation and thus are more predisposed to leave the UBC.

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