

Academic spin-off creation: barriers and how to overcome them

Maria Neves¹ and Mário Franco²

¹University of Beira Interior, Estrada do Sineiro, 6200-209 Covilhã, Portugal. mfn@ubi.pt

²Management and Economics Department, CEGAGE-UBI Research Center, University of Beira Interior, Estrada do Sineiro, 6200-209 Covilhã, Portugal. mfranco@ubi.pt

The aim of this study is to analyze the process of academic spin-off creation, identifying the barriers to suggest how to overcome them. For this purpose, a case study method was adopted, and as data-collecting instruments, several in-depth interviews and documentary analysis were used from three academic spin-offs. The empirical evidence captures the different views of the founding researchers of the academic spin-offs, the researching lecturers in the department creating the spin-offs and the manager of the technology transfer office at the Portuguese university studied here. The results show that the different perceptions of barriers are seen to be solved through an internal strategy within the university. The findings also show that applied research should be valued in assessing lecturers, as it contributes, not only to the link with industry, and therefore to regional development, but also to universities' sustainability, overcoming the lack of financial support as a result of constant budget cuts. The contact networks resulting from universities' links with the different stakeholders will benefit the spin-offs themselves, facilitating their survival in the first years of their life.

1. Introduction

Knowledge is one of the most important strategic resources of organizations in general, and of Higher Education Institutions (HEIs) in particular, as their mission is to create it intensively (Fuller, 2004; Grant and Baden-Fuller, 2004; Greiner et al., 2007; Etzkowitz, 2013b; Fromhold-Eisebith and Werker, 2013; Jiang et al., 2013; Kronberga, 2013). However, what happens is that most of the knowledge created in HEIs by their researchers does not come to light, remaining in publications, tidied away, when it often contains the solution to «real life» problems (Kessels

and Kwakman, 2006). Both creators and users are known to have their «reasons» for being in this deadlock (Becheikh, 2010).

Academia's connection with the outside world is developed through different knowledge transfer mechanisms (Bercovitz and Feldmann, 2006). However, some authors consider the creation of spin-offs as the principal transaction mechanism (Bercovitz and Feldmann, 2006; Figlioli and Porto, 2006; Karnani, 2012).

In this context, academic spin-offs are created within HEI Faculties to make a profit from the results of research carried out in HEIs and are considered

important for economic growth because of their positive impact on the process of technological change and economic development (Kingma, 2011; Ramaciotti et al., 2011). The creation of academic spin-offs allows the exploitation of intellectual property generated through research developed in public universities. As stated by Kingma (2011, p. ix), «Faculty, as entrepreneurial thinkers, seek new ways to engage with the community to create value, and this value creation within a local community establishes the university as an anchor institution». Although the transfer process involves a true sharing of knowledge and know-how between HEIs and Economic Agents (EAs), respectively, in this study, an academic spin-off is defined as a new venture based on the formal transfer from the academic university to the new venture of protected knowledge (Shane, 2004; Djokovic and Souitaris, 2006). Indeed, the criteria for classifying an HEI spin-off is the “transfer effect” that corresponds to exploitation of the knowledge created in universities by the spin-off (Karnani, 2012).

Despite the existence of some studies on knowledge transfer and, more precisely, on researching the factors related to universities’ propensity to generate spin-offs (Gregorio and Shane, 2003; Lockett et al., 2003; Gómez Gras et al., 2007), few identify the process of academic spin-off creation, and the main barriers to the effective application of knowledge, proposing solutions so that the knowledge initially created in HEIs is applied in a way that may create value for society. In this connection, this study intends to contribute to comprehension of academic spin-off creation, and how to overcome barriers so that knowledge comes out of the cupboard and is used where it is necessary, in the business world or in public organizations, and in this way creates value for society, through the necessary dynamics, first of all by the proximity to HEIs’ surrounding areas (Zack, 1999; Bercovitz and Feldmann, 2006; Becheikh, 2010; Etzkowitz, 2013a, 2013b; Fromhold-Eisebith and Werker, 2013). In doing so, the study will try to answer the following research questions: *What are the determining factors that motivate the creation of an academic spin-off? What barriers affect the success of academic spin-offs? And how can these barriers be overcome?*

The remainder of the paper is structured as follows: Section 2 begins with a literature review focusing on the academic spin-off as an instrument of knowledge transfer. Then, the barriers to academic spin-offs from HEIs to Society/Community will be identified. This is followed by the empirical study, which will analyze knowledge transfer in three different projects developed in three different areas of knowledge (Faculties) in an HEI. The paper ends with the conclusions arising from the results concerning barriers and solutions in

academic spin-off creation. Some implications for theory and practice are also presented in the last section.

2. Theoretical framework

2.1. Academic spin-off as an instrument of knowledge transfer

Since the 80 seconds, and with the beginning of globalization, the competitive strategy of American key firms came to be based on Research and Development (R&D) (Etzkowitz, 1998; Vallas and Kleinman, 2007). Far from being a mere coincidence, since that decade a new mission has been added to HEIs, that of «knowledge transfer» (Fernandes and Ferreira, 2013; Kronberga, 2013).

At the moment we are witnessing a change of paradigm in international organizations’ entrepreneurial strategy, whereby they prefer to let go of formal control and internalization of certain competences, and tend to apply all their resources to their core business (Wright and Dana, 2003). In this way, due to the financial investment and costs involved in companies’ R&D, HEIs tend to satisfy the lack of R&D infrastructure in their local areas (Cowan and Zinovyeva, 2013). The intensity of interaction and cooperation processes between creators, users and suppliers of knowledge greatly influences a region’s competitive and technological development (Debackere et al., 2005; Guerrero et al., 2012). The panorama of collaboration consists of a wide variety of domains where there is real expertise and strength, often of a highly specialist kind, including supporting spin-off companies from research teams, to help government agencies to attract major employers to invest in the region/country (Wilson, 2012; Lockett et al., 2015). In addition, HEIs have the opportunity to learn from EAs’ experience in dealing with real life problems (Kingma, 2011).

HEIs have also adopted a more entrepreneurial role, through their departments and faculties (Wright et al., 2004) with collaborative experiences between academic scientists and firms (Lam, 2011). Researchers are encouraged to produce applicable knowledge and codify the result of their research through publications and patents (Zack, 1999; Becheikh, 2010). Karnani (2012) states that EAs, in general, and spin-offs, in particular, undertake the outsourcing of economically relevant knowledge created in HEIs. This knowledge is outsourced by the founders and exploited economically in the form of a start-up.

Prior to the 1990s, government policy had already changed the research exploitation system from one in which universities published their research findings

and industry managed the subsequent intellectual property and innovation, to one in which universities were encouraged to enhance their “technology push,” developing their own intellectual property methods through patenting, licensing and spin-offs (Wilson, 2012; Lockett et al., 2015).

Both academics and business users are unanimous in concluding that knowledge transfer has to be encouraged, to create value not only for society (Davenport and Prusak, 1998; Becheikh, 2010; Etzkowitz, 2013b; Fromhold-Eisebith and Werker, 2013), but also for the sustainability of HEIs (Zack, 1999; Laukkanen, 2003). Without financial resources, HEIs cannot continue their knowledge-generating activities, and therefore public policies have also tried to stimulate the creation of knowledge with a commercial value, as an alternative to public finance. This fact has changed the working behavior of researchers in recent years: to seek for research funding; to look for collaboration with industry given the lack of positions in HEIs and also due to the inherent prestige (Franco et al., 2014). Different university policies, such as the attitude toward surrogate entrepreneurs, preferred methods of technology transfer, equity investments, intellectual property protection, and the development model (e.g., proactive, planned, or spontaneous; Chiesa et al., 2000; Lockett et al., 2003), all of them play a role in contributing to or inhibiting academic spin-off activities (Rothaermel et al., 2007).

There is a type of symbiosis based on a win-win vision: on one side, HEIs seek contact with industry to apply and commercialize the results of research, taking advantage of learning processes resulting from different forms of interpreting information (Laukkanen, 2003; Metcalfe, 2006). On the other hand, firms recognize the University as a source of knowledge (Cohen et al., 2002; Figlioli and Porto, 2006; Etzkowitz, 2013b). A study made by Greiner et al. (2007) concluded that the most successful knowledge management projects were those that resulted from market needs and whose main goals were to create value for firms, in both cases to sustain the main activity of creating knowledge, because, as Zack (1999, p. 137) states, «exploiting knowledge to no gain, is not economically sustainable». In addition, it is through investigation carried out in HEIs that the creation, discovery or improvement of goods, services and processes is sought (Metcalfe, 2006; O'Shea et al., 2007). These can later be exploited commercially, sometimes setting out from an academic spin-off (Gunasekara, 2006; Fromhold-Eisebith and Werker, 2013).

According to Roberts and Malone (1996), in contexts where levels of industry-university collaboration are high, the number of university spin-off firms is higher than in other contexts. Similarly, Gregorio

and Shane (2003) argue that the greater the commercial orientation of the university, the greater its propensity to generate academic spin-offs, but provide only limited empirical support for their claim.

2.2. *Barriers to academic spin-offs and how to overcome them*

There is a wide gap between the knowledge produced by researchers and what is used in practice (Siegel et al., 2003). Indeed, a great amount of knowledge created in HEIs does not come to be applied and consequently to create value (Bank, 2002; Nations, 2005; Sedlacek, 2013), becoming an obstacle to economic development, and so it is necessary to encourage the link between HEIs and EAs, stimulating the reciprocal share of knowledge and know-how.

The current literature identifies some factors that may influence the generation of academic spin-off firms, such as the research income from industry (Lockett and Wright, 2005; O'Shea et al., 2005; Powers and McDougall, 2005); the presence and expertise of a technology transfer office (TTO) (Lockett and Wright, 2005; Powers and McDougall, 2005; O'Shea et al., 2007); experience and frequency of technology transfer activity (Lockett and Wright, 2005; Powers and McDougall, 2005); university quality usually measured by scientific publications and citations (Powers and McDougall, 2005; O'Shea et al., 2007); and contextual characteristics, mostly measured by the degree of innovation (Lockett and Wright, 2005; Powers and McDougall, 2005).

Recent studies focusing on the variables that influence academic spin-offs reveal that gender, age and Faculty influence academic staff's tendency to cooperate with the business sector, concluding in general that the area of Engineering is most likely to carry out applied research. The factors which influence the creation and performance of university spin-offs can be identified (Rothaermel et al., 2007) as incentive systems, university statutes, location, culture, intermediary agents, experience and university goals.

In their meta-analysis, Rothaermel et al. (2007), establishing the HEI as neutral ground favorable to sharing between HEIs and EAs, identified several success factors from the HEI point of view for new firm creation. However, the objective reason for founding academic spin-offs is economic exploitation of the results of knowledge created (Kingma, 2011; Ramaciotti et al., 2011). Furthermore, with good management, university spin-offs may grow into major firms.

The core of this study should therefore be viewed as an analysis of the barriers to knowledge transfer which prevent the creation of academic spin-offs and how to overcome them (see Table 1).

Table 1. Theoretical framework

#	Barriers	Author(s)	Solution
1	– Patents; interoperability (when the equipment does not fit together or combine with those of other organizations) and specific knowledge; informational gaps	Becheikh (2010), Chiesa et al. (2000), Etzkowitz and Leydesdorff (2000), Franklin et al. (2001), Kinsella and McBrierty (1997), Steffensen et al. (1997), and Zack (1999)	– Culture of sharing and disseminating information – Motivating user involvement, early in the research
2	–The specialized and unattractive way that researchers present the results of their investigation	Becheikh (2010), Jacobson et al. (2005), Kodama (2008), Lundvall and Borrás (1997), and Silva (2003)	– Knowledge should be easily understood by the receiver, with the use of appropriate, clear, precise and simple language, supported by examples, conceptual models and concrete experiences
3	– The lack of organizational support for transfer tasks and encouragement for researchers engaging in adaptation of new knowledge and in the transfer process; lack of competency in founding teams – Insufficient resources for technology transfer; the costs associated with innovation; resource scarcity; lack of «seed capital» – Lack of awards for research; status and prizes are awarded only to holders of knowledge – Stability and lifelong employment at universities	Alves (2010), Becheikh (2010), Chiesa et al. (2000), Davenport and Prusak (1998), Debackere et al. (2005), Franklin et al. (2001), Kinsella and McBrierty (1997), Lundvall and Borrás (1997), Mudambi and Swift (2009), Siegel et al. (2003), and Steffensen et al. (1997)	– Increase financial, physical, and human resources in organizations for the transfer of knowledge and encourage users to acquire, adapt and use new knowledge – Regular interaction between researchers/liaison officers and users, adopting simple and common language with synthetic, attractive and understandable information – HEIs should apply additional resources to knowledge transfer – Evaluate performance and provide incentives to whoever shares knowledge; promotion of transfer awards
4	– Bureaucratic procedures, lack of support and negative pressure from colleagues; – Innovative technologies' "time-to-market"	Alves (2010), Becheikh (2010), and Mudambi and Swift (2009)	– Low degree of formalization and centralization (bureaucracy) of some organizations
5	– The lack of applicability of some knowledge; unrealistic expectations – Negative attitude towards research, by some users – Believing that knowledge is only intended for certain groups	Becheikh (2010), Chiesa et al. (2000), Debackere et al. (2005), Franklin et al. (2001), Kinsella and McBrierty (1997), Mudambi and Swift (2009), Steffensen et al. (1997), Wright et al. (2004), and Zack (1999)	– Demonstration of the importance, credibility and timeliness of research – Encourage a nonhierarchical approach to knowledge – Improve users' perception of the benefits of using the results of investigation in the context and practice – The information must be accessible to users through "interactive learning"
6	– Different vocabulary and reference models – Differences of knowledge and opinions between funder and academic; different organizational cultures between industry and the HEI (e.g., objectives, levels of formality, lack of concern about time, risk)	Alves (2010), Chiesa et al. (2000), Collier et al. (2011), Davenport and Prusak (1998), Franklin et al. (2001), Kinsella and McBrierty (1997), Lam (2011), Lambert (2003), and Steffensen et al. (1997)	– The competence of the liaison officers and users (specific training needs) – Create a solid foundation through education, discussion, teamwork, and job rotation
7	– Universities' lack of knowledge about scientific standards and	Alves (2010), Chiesa et al. (2000), Davenport and Prusak (1998), Laukkanen (2003), Siegel et al.	– HEIs should eradicate cultural barriers that impede knowledge transfer

Table 1. (Continued)

#	Barriers	Author(s)	Solution
	regulations; Regulations regarding technology – Lack of marketing skills, negotiation techniques and business experience	(2003), and Vallas and Kleinman (2007)	
8	– Lack of trust	Davenport and Prusak (1998)	– Build relationships and gain confidence through face-to-face meetings
9	Entrepreneurs/researchers' individualism – Different expectations between HEIs and companies – Different contexts in which the HEI/companies live	Davenport and Prusak (1998), Etzkowitz (2013b), Franco and Belo (2013), and Silva (2003)	– Networks–Network; collaboration protocols; consortia; Business-Angels, building links between academics and entrepreneurs for the creation of new technologies, new products and new businesses

To be able to overcome barriers, it is critical to establish networks or operate through the so-called «intermediary connection agents» who, according to Becheikh (2010), are individuals in contact with both researchers and users and who can build bridges allowing greater interaction between these two types of actors (Smith and Bagchi-Sen, 2012), TTOs, or through Science and Technology Parks. Monck et al. (1988), in their study of the interaction between firms situated in Science and Technology Parks and HEIs, concluded that the most frequently mentioned form of relationship was «informal contact» followed by «access to equipment» and finally «formal relationships» with HEI professionals. Figlioli and Porto (2006) identify the actions necessary for knowledge to be transferred from HEIs to firms located in Science and Technology Parks: identification of the area of knowledge created by the university and seeking out projects and EAs that can use them; creation of an information network to stimulate the creation of university spin-offs; the rotation of staff between academia and firms; and seeking research sponsorships or partnerships, among others. Therefore, one of the main tools used to foster technology transfer activities generally, and academic-spin-off activity in particular, is the presence of a TTO (Siegel et al., 2003). It has been argued that TTOs are important for enhancing universities' technology transfer activities, especially if managed by competent staff and based on accumulated experience in such activity (Siegel et al., 2003; Powers and McDougall, 2005; Muscio, 2009).

Powers and McDougall (2005) show that receiving R&D funding from industry leads to a greater number of spin-offs from US universities. The authors argue that collaborating with industry contributes to building the networking relationships and capabilities needed to

motivate scientists to create academic spin-offs (Colyvas et al., 2002; Wright et al., 2004; O'Shea et al., 2007). Krabel and Mueller (2009), in an individual-level study, also argue that scientists who collaborate with industry are more likely to found a spin-off. The lack of business experience may be perceived as a barrier to success (Samsom and Gurdon, 1993), so contact networks for access to resources and role models when forming entrepreneurial teams are of great importance.

Several studies point out that undertaking any type of technology transfer activity or experience of collaboration with industry, should have a positive effect and motivate individual researchers and universities to engage in spin-off activity (Lockett et al., 2003; Lockett and Wright, 2005; Powers and McDougall, 2005), and that, on the other hand, considered as barriers are: Stability and lifelong employment at universities; difficulty to obtain funding; the entrepreneur's limited management skill (Chiesa et al., 2000). Other informational gaps mentioned are, unrealistic expectations, lack of skill in forming teams, resource scarcity, and cultural problems (Kinsella and McBrierty, 1997; Steffensen et al., 1997; Chiesa et al., 2000; Franklin, 2001).

Blumenthal et al. (1996) also suggest that faculty members who collaborate with industry and other stakeholders tend to show greater involvement in commercially oriented activities compared to those researchers whose work is publicly funded.

To sum up, barriers linked to academic spin-offs may take several forms, from mental barriers and patterns of perceptions among investors and potential entrepreneurs to access to different resources and services. In addition, conflicts between different stakeholders regarding the development of new business can represent important barriers to be overcome.

3. Methodology

3.1. Type of study and case selection

The type of study adopted here was exploratory. This type of study allows the researcher to collect data resulting in patterns which, through formulating questions and refining matters, will allow a more systematic study (Patton, 1990).

Within the qualitative approach, the case study method was adopted. The aim of the case study is to bring together rich, comprehensive and systemized information about the case of interest, so as to find out more about the subject and agents studied, using qualitative data (Barañano, 2008). Three case studies were carried out at the University of Beira Interior in Portugal during 2014 and 2016, with the unit of analysis used in the research being the academic spin-off (S-O) creation. The cases (S-O1, S-O2, and S-O3) were chosen based on the criterion of geographical proximity and merely subjective interest due to the fact of being the creation of three different spin-offs, from three scientific areas (Engineering, Science and Health) of the five faculties with applied research in the HEI studied here, and provided rich material related to the basic obstacles. The intention was also to determine whether these obstacles vary according to the area of knowledge.

3.2. Data collection and treatment

As data-gathering technique, it was decided to hold interviews based on a semi-structured script applied to the various agents studied: the founders of the three spin-offs (FSO1, FSO2, and FSO3), the researching lecturer from the department originating the spin-off (DSO1, DSO2, and DSO3) and the person responsible for the knowledge-transfer service (RSO). According to Patton (1990), «key informants» are knowledgeable people, whose vision can be particularly useful in helping the observer to understand the phenomenon under analysis. So this method provided direct contact with the various agents involved in the spin-off created. Before and during the visit, information and other important data from the web pages of each spin-off were collected, namely about its purpose, mission and values. According to Patton (1990), during the interview process, i.e., during the data-collection phase, the goal is to record the interviewee's particular perspective as precisely as possible, and the interviews were recorded. The post-interview period was critical for reflection, elaboration and to ensure the data obtained were useful, reliable and valid. After complete transcription to a *word file*, they were returned to each interviewee to confirm their content.

Then the data were treated through content analysis, which consists of «the process of identification, codification and categorization of the main patterns in the data obtained» (Patton, 1990, p. 381).

The interviews had an average duration of 50 minutes (see Table 2) aiming to capture interviewees' perception of the transfer process through the creation of the spin-off itself and of the barriers, and how the university can overcome them to improve that process. It was therefore a question of obtaining data from a primary source, which makes an added contribution to originality, increasing the interest to the scientific community and the usefulness for the universe being studied.

4. Results and discussion

Bearing in mind the aim of this study and to answer the research questions, the content of the interviews was organized and treated, with elaboration according to Table 3 (barriers to academic spin-offs). This table contains the excerpts from the interviews with the corresponding number of the barriers identified in Table 1, resulting from the literature review. This method, presented by Miles and Huberman (1994), intended to simplify the information to facilitate analysis and comparison of the data.

4.1. Barriers to academic spin-off creation

Analysis of the data obtained from the interviews reinforces many of the inferences arising from the literature review carried out.

4.1.1. Lack of resources

It can be observed that barrier (3) is mentioned by all the DSO, FSO and the RSO who speaks of the lack of financial support to apply as «seed capital» as an incentive to the creation of spin-offs and in the requirement for lecturers to publish for their assessment, which leaves them little time to transfer knowledge, with the warning that it is essential to align research with market needs, since here lies an important source of finance for both research units and HEIs. As for FSO1, he mentions the same barrier. From his perspective, he sometimes feels these difficulties in using resources (laboratories, equipment, contacts belonging to UBI), because as he says «each penny counts». As for DSO1 and DSO2, mentioning this barrier has to do with the limited pro-activeness of the transfer service. Much remains to be done for this service to get to know the business sector. These results are reported by a great amount of the literature

Table 2. Key informants and interviews

Spin-offs	Function performed	Gender Age Faculty	Position held	Date and duration of interviews
	RSO	Male 57 Engineering	Vice-Rector responsible for creating and supporting spin-offs at UBI, who coordinates the university's transfer service named GA-API (Research Project Support Office)	11th April 2014 45 minutes
S-O1	FSO1	Male 29 Engineering	Founder of the spin-off (IS2You). In the end-of-course project in Computer Engineering he elaborated the academic project of Wi-Go, which is an autonomous, self-guided shopping trolley for people with reduced mobility.	10th April 2014 75 minutes
	DSO1	Male 51 Engineering	Lecturer and Researcher in the Department of Computer Engineering. He coordinates various interdisciplinary and incubation projects in the Department (hereafter referred to as DSO1), from which the spin-off studied emerged.	16th April 2014 50 minutes
S-O2	FSO2	Female 37 Engineering	Founder of the spin-off (Blossom Essence) which is dedicated to the extraction of essential oils from aromatic plants, medicinal and culinary plants produced biologically	5th April 2016 30 minutes
	DSO2	Female 58 Sciences	Lecturer and Researcher in the Department of Chemistry. She coordinates various interdisciplinary projects in the Department (hereafter referred to as DSO2), from which the spin-off studied emerged.	7th March 2016 40 minutes
S-O3	FSO3	Female 38 Health Sciences	Founder of the spin-off (Labfit). Labfit specializes in pharmaceutical technology, microbiology, physical-chemical characterization, toxicology, and integrated systems of quality assurance and quality control services and characterization of cosmetic and personal hygiene products as well as health products, in accordance with the legislation and standards in force	17th March 2016 60 minutes
	DSO3	Female 35 Health Sciences	Lecturer and Researcher in the Department of medical sciences. She coordinates various interdisciplinary projects in the Department (hereafter referred to as DSO3), from which the spin-off studied emerged.	30th March 2016 40 minutes

as a lack of resources for knowledge and technology transfer, covering both organizational support for transfer tasks and incentives for researchers to devote themselves to adapting new knowledge, awards for research, as well as financial, physical, material and human resources to acquire, adapt and use new knowledge (Davenport and Prusak, 1998; Siegel et al., 2003; Debackere et al., 2005; Mudambi and Swift, 2009; Alves, 2010; Becheikh, 2010). These studies demonstrate that both HEIs and firms are restricted by financial difficulties.

4.1.2. Individualism of business-people/researchers

This is also mentioned by the interviewees as a barrier (9), The RSO states that the university insists on

researchers integrating international networks, facilitating the contact network, since these include the fundamental players of interest in terms of research. FSO 3 considers participation in international networks as proof of quality, despite not yet having benefited from the contacts in terms of new projects. In turn, FSO1 says that in Portuguese regions (Vale do Ave, Minho and Porto) there is an external context providing contacts and growth opportunities for spin-offs, as it is these business-people already established who order work from the spin-offs, allowing them to get through the first years, considered the «valley of death» and survive in the difficult early stages. He recalls that when he was in *Parkurbis*, the Science and Technology Park associated with UBI in the community he did not meet the other business-people located there.

Table 3. Empirical evidence

RSO	FSO	DSO
<ul style="list-style-type: none"> – # (5) – <i>It is a difficult problem, in universities, to make the correspondence between market needs and research (applied research)</i> – # (2, 5) <i>often (the barrier) will be to find the ideal partner outside the university who is willing to take on the project. On other occasions, it will be researchers who focus on a given area and firms are not interested, as it has no practical application;</i> – # (3) <i>TTO has operated with limited resources for a lot of people and this has to be strengthened to be able to give another type of support to researchers and firms (3)</i> – # (3) <i>TTO has neither knowledge nor resources for that (being a «facilitator»)</i> – # (2) <i>Researchers have very little perception, mastery and knowledge of the market, of how to reach firms</i> – # (3) <i>The problem of lecturers is the demand for publication and not being open to another type of activity/research</i> – # (9) <i>The university insists on researchers linking to international networks facilitating the contact network, as there are firms in those networks that will identify who are the fundamental players that interest them in terms of research</i> – # (3) <i>Lack of finance, as at the beginning spin-offs should have the so-called «seed capital» which is a type of «non-repayable» financing that lets them start up without fearing the risk</i> – # (7) <i>Another will be the level of entrepreneurship of the researcher, who may actually have a good idea, but through a lack of entrepreneurial capacity does not see its potential and does not know how to transmit it to business-people who could invest in development and commercialization</i> – # (7) (...) <i>not having a curricular unit in the study cycles that provides the basis for people with a more entrepreneurial spirit to become successful</i> – # (4) <i>HEIs are complex organizations in which the control chain is very scattered, as there is the Rector, the Scientific Councils, the Faculty Heads, the Department Heads (and also the FCT,</i> 	<ul style="list-style-type: none"> – # (5) <i>I cannot call it a barrier, but rather a “difficulty”: in reaching people or connecting some people. For example, for my project I needed a designer, an Electro-technical student and a Computer Engineer, and to conciliate these people with three lecturers in the same project, for the same purpose, it is very difficult (FSO1)</i> – # (5) <i>The HEI can pro-actively look for R&D solutions for itself which include collaboration with firms, as there is no false morality: in co-promoted projects everyone gains economically (FSO3)</i> – # (7) <i>The main support I had, was in registering patents, in defining the business plan, as I came from Computer Engineering and as such, had no grounding in those areas of market studies(FSO1)</i> – # (3) <i>I understand up to a certain point, but when we want to transfer technology, “every penny counts” as there is a lack of funding, and if we can use resources from other laboratories, we will economize, we will optimize our solution (FSO1)</i> – # (3) <i>Nobody depends more on a project than the founders who are launching it and a decision must be taken, which is: deciding if the desire is to benefit economically from the spin-off.(FSO3)</i> <i>There were initial contacts with TTO, but as the demands of the process increased and business matters emerged, we had to seek specialized help outside the HEI (FSO3)</i> <i>TTO needs to know how to carry out legal lobbying with financing bodies to show what has been achieved with financing of previous projects, so that they feel comfortable in future undertakings. (FSO3).</i> – # (9) <i>In Vale do Ave, Minho, Porto, and Famalicão, where there is industry and a business sector that is linked to the universities, there is industry and when a new firm emerges, they turn to the new firms, placing orders, giving work, which helps them keep going at the beginning and come through this first stage of life (FSO1)</i> – # (1, 6, 8) (...) <i>the University can help a lot with its contacts and with the agreements it forms, for example: PT and the consortiums</i> 	<ul style="list-style-type: none"> – # (5, 6, 8) (During a communication) <i>«I took the chance to say to the approximately 30 business-people who were there: You have a problem that you don't know how to solve, contact the University and we'll get students to investigate and devote themselves to solving, scientifically, your problem. (...) They were surprised, they were unaware, they didn't know it was possible, they had no knowledge of it (DSO1)</i> – # (7) <i>It's that students leave here with good tools, but without management, financial and human experience (DSO1)</i> – # (7) <i>Researchers are comfortable with the scientific and development aspects, but the lack of knowledge of terms of management, given they have neither experience nor knowledge of the market, is limiting (they don't know how much their technology is worth or the appropriate business model or how to ensure independence to continue research and development without conflicts of interest arising)(DSO3)</i> – # (3) <i>The HEI needs to optimize application processes for projects as neither researchers nor business-people perceive the actions with the best chances of finance, the investigations with financing potential, or the right terminology for project design (DSO2)</i> – # (5) <i>We often develop technology and go looking for someone who wants that technology, who has a problem and is willing to invest in the solution (DSO1)</i> – # (9) <i>If the organization does not feel, endogenously, the need to change or solve the problem, try to «push» the solution, it will not result, as the firm may even acquire the equipment, but may not use it, and so it will always be a strange body in the midst of the organization; (DSO1)</i> – # (9) <i>The individualism of researchers and firms may have to do with the lack of experience in formal contacts, and so it is up to the HEI to facilitate this through workshops in which economic agents and researchers participate. (DSO2)</i> – # (4) <i>Researchers who decide to create a spin-off, to reach the</i>

Table 3. (Continued)

RSO	FSO	DSO
<i>intervening in the Ph.D.s), it is difficult to get everyone to «row in the same direction», it's not like in a firm, where top management gives an order and everyone carries it out.</i>	<i>that can be formed. But UBI does not yet make these connections, as happens in Porto or in Lisbon, with the «Start-up Lisboa» (FSO1)</i> – # (9) <i>When we were in Parkurbis for a year I noticed that the people there didn't even know each other. Which is very different from what happens in other places, for example, I go to Start-up Lisboa or an INP and the bar is always full of directors, business-people chatting, exchanging projects (FSO1)</i> – # (9) <i>Another problem which demonstrates the situation of the lack of communication and bridges promoted by UBI is that I don't know the UBI spin-offs! And that's bad, because if I apply and know what they do, I can even involve them and vice-versa. (FSO1)</i>	<i>market they will have to be aware that 100% research activity has to be abandoned. (DSO3)</i> – # (5) <i>The great barrier to technology transfer is the knowledge and creation of the University technology not being aligned with market needs (DSO1)</i> – # (3) <i>(About GAAPI) It doesn't seem to me that they have «gone after» the project, I think it «fell from above», they only had to check internally who they could turn to (DSO1)</i>

However, when he goes to Lisbon, for example, the Lisbon start-up, the meeting point is the cafeteria which is always full of business-people and researchers making informal contacts and exchanging projects. He says that UBI has a lot to do, because as a spin-off he does not know the other spin-offs of UBI (!); he mentions the lack of a business sector in the region to sustain/grow spin-offs in the first years of their life and mainly the lack of contact networks between the HEI and the business world which would help to obtain more projects and work. FSO3 mentions that her spin-off, due to the services it provides, depends more on itself and adhering to high standards of quality to stand out as a national reference, rather than on other firms. Nevertheless, she recognizes that through the informal contact network she managed to obtain projects that help to pay for general costs.

In the same connection, DSO1 mentions that the international network he belongs to has provided various contacts and satisfied precise needs, and he is trying to set up a laboratory that can serve as an anchor for the Horizonte 2020 projects, looking for funding, associating University Laboratories with firms' researchers to form consortiums to compete for R&D projects. He points out that many of the business-people he contacts are former UBI students and that it is often the networks that «call for» needs, as referred to by the RSO when mentioning the strategy of intelligent R&D RIS 3 (Innovation, Research and Entrepreneurship), that is, working on the demand side, in areas where the University knows beforehand that there will be funding. On the other hand, DSO 2 says that her network was formed through personal

informal contacts, and that in her Department lecturers spend their own time and resources to maintain their informal networks, being unaware of institutional support from the HEI.

All the interviewees, therefore, similarly to what is found by various authors, emphasize the need to overcome the individualism of researchers and business-people through necessary cooperation via international networks and contacts that facilitate the transfer of knowledge and wealth by building links between academics and businesses to create new technologies, new products and new firms (Hutt et al., 2000; Kodama, 2008; Etzkowitz, 2013b; Franco and Belo, 2013).

4.1.3. Lack of applicability of knowledge

Barrier (5) was mentioned by the RSO and DSO1, DSO2 and DSO3, all of them concerned about the lack of applicability of the knowledge created in the HEI, i.e., market needs corresponding to the research carried out in the HEI, sometimes making it difficult to find the ideal partner outside the HEI, and at other times because researchers are focused on areas that do not interest firms. This is confirmed by DSO1 when he says that, occasionally, in his Department, technology is developed and later the person is looked for who has «that» problem to acquire the «solution» created. He recognizes that in those cases the technology will always be seen as a strange body in the firm, as it did not set out from an endogenous need. DSO3 says she transformed the basic research developed in the HEI in services according to the needs felt in the

market. DSO1 and DSO2 also point out the business sector's unawareness of the work carried out within the HEI, and the HEI should act «upstream», making firms aware so that they can seek innovation through HEIs, mentioning the need for training in the area of entrepreneurship, too. This barrier (the lack of applicability of the knowledge created in HEIs) is widely confirmed in the literature by several authors (Zack, 1999; Wright et al., 2004; Debackere et al., 2005; Mudambi and Swift, 2009; Becheikh, 2010).

4.1.4. Lack of training in entrepreneurship

Mentioned by the RSO and both the FSOs and DSOs is barrier (7) regarding the lack of grounding in entrepreneurship, felt by new graduates in the area of market studies, to go ahead with company creation, which should be remedied by the HEI. This barrier is also mentioned in a great amount of literature (Davenport and Prusak, 1998; Laukkanen, 2003; Siegel et al., 2003; Vallas and Kleinman, 2007; Alves, 2010).

On the other hand, the information gathered from the webpages of each spin-off, namely about the purpose, mission and values, emphasizes the link with the HEI as a factor of credibility and quality assurance.

4.2. Overcoming barriers in academic spin-offs

Agarwal et al. (2004) consider that spin-offs have a survival edge in the market over other entrants as the result of a combination of entrepreneurial flexibility and inherited knowledge, and regarding the barriers observed, the interviewees also identified solutions to minimize and/or avoid them. The interviewees (FSO1, FSO2 and FSO3; RSO; DSO1, DSO2, and DSO3) are unanimous in considering the need for alignment between the research carried out in the HEI and market needs, agreeing with Greiner et al. (2007), who concluded that the most successful knowledge management projects are those resulting from market needs and whose goals were to create value for companies. FSO1 and FSO2 recall that the value of the *win ubi* award promoted by the HIE was the fundamental «launch pad» for the idea of forming the spin-off. In the same way, all the interviewees emphasize the symbiosis between the HEI and the business world, the former looking for contact with industry to apply and commercialize the results of research, taking advantage of learning processes resulting from different forms of interpreting information (Laukkanen, 2003; Metcalfe, 2006) and also (RSO) as an alternative due to the lack of public finance (Franco et al., 2014) and the business world as a source of

knowledge, namely through highly qualified human resources (FSO1, FSO2, and FSO3 and DSO1, DSO2, and DSO3), contributing to the dynamics of economic innovation and growth (Gunasekara, 2006; Fromhold-Eisebith and Werker, 2013).

The business culture in the HEI's local region greatly limits the HEI's power as a catalyst. As mentioned by both FSOs and RSO, the lack of firms and institutions with capacities, together with budget cuts, prevents the existence of the so-called «seed capital», able to stimulate the creation of new firms and growing them through orders from other established firms, allowing them to survive in the first (difficult) years of their life. It is therefore seen that the relevance of the HEI's role in its region lies in its greater or lesser ability to transfer the knowledge it generates internally through its researchers' activity (Etzkowitz, 2013b; Cowan and Zinovyeva, 2013).

In these circumstances, there must be reflection on the lack of success in transferring knowledge to the regions, according to Klein Woolthuis et al. (2005) and Metcalfe (2006). As the RSO clarifies, stressing the importance of the business sector, «*It's clear that firms are the «basic cell» of economic activity and it is they who give value to knowledge, through innovation. That's the importance of firms, because it's difficult to take knowledge to society if there are no firms to do so*». In addition, we can conclude that the TTO (GA-API) seems not to perform the role of facilitator in transfer and dissemination to users through identifying the knowledge created by the university and seeking projects that can use and create an information network that may stimulate the creation of university spin-offs (Hansson et al., 2005; Figlioli and Porto, 2006; Smith and Bagchi-Sen, 2012).

Summarizing, the results show that the different perceptions of barriers contribute to a three-dimensional analysis of the question/subject. While top management (RSO) perceives the lack of finance, the need for a more active attitude by researching lecturers in seeking finance for their own projects through integrating European research networks with the help of HEI infrastructure and contacts, as well as training in entrepreneurial skills, the DSO perceives the importance of lecturers belonging to European research networks, and the need to align the research done with market needs, also considering that business-people «upstream» should be made more aware of what is done in HEIs. However, these interviewees consider lecturer assessment should reflect the value of the knowledge transfer aspect, so that applied research, which is important for the HEI's sustainability, has a corresponding value in assessing their performance. As stated by DSO2, lecturers are all different, some with a greater vocation for

teaching, others for research and yet others for knowledge transfer. However, HEIs are assessed only in terms of research (ISI publications) and so knowledge transfer, despite giving visibility to the HEI and promoting the economy, is not valued in terms of lecturers' appraisal. The FSO's perception is that HEI support is effective in the area of physical infrastructure, laboratories and in most technical support, as well as in transmitting information about projects and competitions. Because of the «incipient» nature of the region's business sector and the importance of an informal, easily accessed contact network, the HEI had to take on that facilitating role. It is the TTO's duty to promote the HEI's openness to the community, establishing interdisciplinary links between the existing supply in the HEI's various Departments and Faculties and EAs looking for projects. However, barriers were detected in teamwork, in conciliating interdisciplinary projects within the HEI. This difficulty, from what was mentioned by the RSO, can arise from the fact of HEIs *«being complex organizations in which the control chain is very scattered, as there is the Rector, the Scientific Councils, Faculty Heads, Department Heads (and also the FCT, intervening in Ph.D.s), it is difficult to get everyone to «row in the same direction», it's not like a firm, where top management gives an order and everyone carries it out»*.

5. Conclusions and implications

The aim of this study was to analyze the process of academic spin-off creation, identifying the barriers and suggesting how to overcome them. The empirical evidence let us conclude that some universities in less developed regions of European countries are experiencing serious financial problems and cannot allocate their resources to things other than their operation, and so the only chance will be Community funding and getting researchers themselves to look for investment for their research. That is the role of the TTO, which has to be more pro-active, possibly organizing themed obligatory departmental initiatives/workshops to show what is done internally and encourage the presentation of new projects, with lecturer/researcher involvement, having consequences in their assessment. To do so, the TTO must have specialized and qualified technical staff who knows how to gather the right researchers around the existing project or create projects joining EAs and researchers. Indeed, besides publications, it must be conveyed to researchers that the commercial value of their research is very important, not only for themselves, but also for the university and its region. In addition, it is imperative to act «upstream», informing the business sector regularly

and openly about the work done inside HEIs, showing flexibility in handling and developing mechanisms or instruments of regular interaction that allow sharing. This finding applies equally to all the spin-offs studied, whatever their area of knowledge. The Lecturer Assessment Regulation (LAR) of the university studied here could contribute to that strategy, valuing collaboration with firms through agreements formed, stimulating researchers to leave their offices and look for partners to collaborate with, showing how they can contribute to firms' competitive advantage.

So despite the different nuances, it is seen that the various barriers could be overcome through the HEI's internal strategy, giving value to applied research in assessing lecturers, as this contributes not only to links with the business sector and consequently to its development, but also to the HEI's very sustainability, overcoming the lack of finance due to budget cuts.

With HEIs being connected to the business sector, academic spin-offs will benefit from the contact networks formed, which will help their survival in the first years. It is also confirmed that HEIs and the business sector cooperate with a strategic-economic objective: HEIs to obtain income (to compensate for the lack of finance) and the business sector turns to the knowledge produced in HEIs to obtain a competitive advantage (technological, human resources, infrastructure and other resources). Spin-off founders really need to learn from established firms, because collaboration is dominated by research-related motivations, including learning from industry and fundraising (while patenting and spin-off founding are motivated by commercialization). Only experience of collaboration can break down the tendency towards individualism in HEIs and EAs.

Spin-offs should be positively discriminated by HEI policies, and the HEI should be financed by its transfer activities to economic operators so as raise “seed capital” to support the start-up of spin-offs, the incubation phase.

This study is not without limitations. One of these could lie in the fact there is no previous data allowing us to make a comparison regarding the existence of barriers to academic spin-off creation and how to overcome them. In addition, being specific case studies and due to the potential “social and culture effect” arising from the geographically circumscribed research context, the generalization of our findings should therefore be made with due care.

For future lines of research, this work could be a starting point for carrying out other studies revealing other evolving solutions to barriers in HEIs. It would also be interesting to analyze empirically the change in the transfer of knowledge created in HEIs, if greater value was given to the knowledge transfer aspect in

assessing lecturer performance. In addition, consequent assessment of whether the research carried out in HEIs will be affected mostly by the interest of financing EAs and how that fact will determine the type of spin-off created. To encourage the creation of new academic spin-offs, it would be interesting to study a mechanism/channel of communication between economic agents and academic researchers that allowed more open contact between the needs of the former and the latter's ability to propose solutions.

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Maria Neves received her Master degree in Management from Beira Interior University (Portugal) and now she is a PhD candidate at the same University. Her research interests include: Public Management, Public Administration, Networks, knowledge Transfer, and Strategic Management.

Mário Franco is an Assistant Professor of Entrepreneurship and SME Administration at the Department of Management and Economics, Beira Interior University, Portugal. He received his PhD in Management from Beira Interior University in 2002. In 1997, he was a doctoral candidate and participated in the European Doctoral Programme in Entrepreneurship and Small Business Management in Spain and Sweden. His research focuses on strategic alliances, business networks, innovation and business creation. He is also a member of a Research Center (CEFAGE-UBI) and currently involved in several research projects on SMEs.

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