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Characteristics and effectiveness of university spin-off support programmes

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Abstract

Purpose – The purpose of this paper is to identify different program models supporting the creation of spin-offs at universities, analyzes the characteristics that differentiate them, and identifies the factors that determine their effectiveness.

Design/methodology/approach – The analysis was performed using data collected through a survey targeting the heads of spin-off support programs at universities in the UK and Spain. The authors then applied factorial and cluster analysis techniques and a logistic regression analysis to the data to confirm the results.

Findings – The analysis identified three types of spin-off support programs in these universities. Among these, the authors found one that appears to be the most effective model. The authors also found a certain "country effect" on the characteristics of the most effective model. Finally, the authors noted the importance the literature places on university R&D activity and the existence of a favorable environment for the performance of spin-off programs.

Research limitations/implications – This research is limited by the use of number of spin-offs and survival rate as performance indicators for support programs. Future research should consider the effective contributions to economic growth and the extent to which such effects are related to university-level policies.

Practical implications – The typology of the spin-off support programs identified here provides insight for recommendations to improve less-effective models.

Originality/value – This study contributes to the understanding of the role of university policy measures in spin-off support program effectiveness, and of how the environment influences these policies.

Keywords Technology transfer offices, Knowledge transfer, Academic spin-offs, University entrepreneurship, University spin-off support programmes

Paper type Research paper

Resumen

Propósito – Este estudio identifica diferentes modelos de programas de apoyo a la creación de spin-offs en las universidades, analiza sus características diferenciadoras e identifica los factores que determinan su eficacia.

Diseño/metodología/enfoque – El análisis se ha realizado a partir de los datos recabados a través de una encuesta, dirigida a responsables de programas de apoyo a la creación de spin-offs en universidades del Reino Unido y España. A continuación se ha aplicado un análisis cluster y un análisis de regresión logística para confirmar sus resultados.

Resultados – El análisis ha identificado tres tipos de programas de apoyo a la creación de spin-offs en estas universidades. Entre éstos se ha encontrado uno que parece ser el modelo más eficaz. También se ha encontrado un cierto "efecto país" en las características del modelo más eficaz. Finalmente se ha podido confirmar la importancia dada por la literatura a la actividad de I + D de la universidad y a la existencia de un entorno favorable para el éxito de estos programas.

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Limitaciones/implicaciones de la investigación – Esta investigación está limitada por el uso del número de spin-offs y la tasa de supervivencia como indicadores de rendimiento de estos programas de apoyo. La futura investigación debe considerar su contribución efectiva al crecimiento económico y el grado en el que estos efectos se relacionan con las políticas a nivel universitario.

Implicaciones prácticas – La tipología de programas de apoyo a la creación de spin-offs identificada permite realizar algunas recomendaciones para la mejora de los modelos menos eficaces.

Originalidad/valor – Este studio contribuye a la comprensión del papel de las medidas de política universitaria en la eficacia de los programas de apoyo a la creación de spin-offs y de la influencia del entorno sobre estas políticas.

Palabras clave Emprendimiento universitario, transferencia de conocimiento, spin-offs académicas, oficinas de transferencia tecnológica, programas de apoyo a la creación de spin-offs universitarias

Introduction

The creation of knowledge-based firms has become particularly important in recent decades (European Commission, 2002; Festel, 2013; Shane, 2004; Swamidass, 2013), and has been accompanied by a proliferation of university support programs for spin-offs (Algieri *et al.*, 2013; Berbegal-Mirabent *et al.*, 2012; Calvo *et al.*, 2012; Davenport *et al.*, 2002; Helm and Mauroner, 2007; Lundqvist, 2014; Markman *et al.*, 2005b; Shane, 2004; Sternberg, 2014). Considerable differences exist in the various programs' structures and operations in terms of their aims, strategies, functions, activities, organizational structures, and the services they offer (Clarysse *et al.*, 2002, 2005; Davenport *et al.*, 2002; Degroof, 2002; European Commission, 2002; Markman *et al.*, 2005a; Mustar and Wright, 2010; Roberts and Malone, 1996; Wright *et al.*, 2007). In addition, many of these programs are newly founded and consequently have neither a solid organizational structure nor clearly defined activities (Clarysse *et al.*, 2005; Davenport *et al.*, 2002; Heirman and Clarysse, 2004). For this reason, different models of academic spin-off support programs have been proposed (Clarysse *et al.*, 2002, 2005; Degroof, 2002; Roberts and Malone, 1996).

Existing works in this area are based on university programs in the USA and some European countries, including France, Belgium, the UK, the Netherlands, Germany, Italy, and Ireland. Therefore, it may be instructive to analyze the situation in other countries and validate the models identified.

The main aim of this work is therefore to identify the different models of spin-off support programs found in British and Spanish universities, and to analyze the characteristics that differentiate them, distinguishing those that seem to be more effective. We selected these countries because they have different structural characteristics. The UK is composed of more advanced, innovative, and entrepreneurial regions (Ács *et al.*, 2014; Hollanders, 2007; Mate-Sanchez-Val and Harris, 2014), whereas Spain belongs to the "follower" group of countries in Europe and is characterized by regions with lower economic and technological development.

We believe that this study is particularly useful because it examines universities from two European countries with different degrees of experience in developing spin-off support programs. This provides a varied sample that may identify how different program types support the creation of spin-offs, with more general results than those from a single-country analysis. Moreover, most studies to date on this issue have analyzed spin-off creation in a single university or in a small number of benchmark universities (e.g. Clarysse *et al.*, 2002; Degroof, 2002; Roberts and Malone, 1996; Serasols *et al.*, 2009). This study, which includes a wider set of universities, therefore provides a more realistic view of the position of the spin-off support programs in universities and offers various recommendations for improving these programs.

For this purpose, we used data collected through a survey targeting the people in charge of university programs that support the creation of spin-offs, and performed a statistical analysis applying univariate and multivariate techniques. First, we applied the factorial analysis technique to identify the most significant variables explaining the characteristics of these programs. Second, using the cluster analysis technique, we classified the universities. Using a one-factor analysis of variance (ANOVA) and a logistic regression analysis, we described the differentiated characteristics of each of the clusters found, analyzing the extent to which the results support the hypotheses and identifying the characteristics of the most effective programs.

This analysis enabled us to identify three types of spin-off support programs. Among them, one appears to be the most effective model. We also found a certain "country effect" on the characteristics of the most effective model. Finally, we noted the importance the literature places on university R&D activity and on the existence of a favorable environment for the performance of spin-off programs.

Thus, this study contributes to the understanding of the role that university policy measures play in spin-off support program effectiveness, and of how the environment influences these policies.

Theoretical framework

This paper is particularly concerned with the support programs set up by universities to promote the creation of university spin-offs among members of their scientific communities. Therefore, it forms part of the so-called "university level" of analysis, to use the classification established by Pirnay (2001). Because it adopts the perspective of the academic authorities, this research deals with organizational considerations relating to the universities' support policies.

In this specific field, two main groups of work can be distinguished in the literature: some studies analyze the organizational and institutional factors that determine the creation of spin-offs, while others examine the process of creating the spin-offs.

Within the first group, studies examining organizational aspects have highlighted the role of the technology transfer units found in some universities as a support mechanism for setting up spin-offs (Hague and Oakley, 2000; McDonald *et al.*, 2004). This line of research has focussed on determining the characteristics of the most successful technology transfer units. In this area, important contributions have been made by Algieri *et al.* (2013), Berbegal-Mirabent *et al.* (2012), Bercovitz *et al.* (2001), Di Gregorio and Shane (2003), European Commission (2004), Lockett *et al.* (2003), Lockett and Wright (2005), Markman *et al.* (2005b), O'Shea *et al.* (2005), and Rodeiro *et al.* (2008).

Meanwhile, studies analyzing institutional aspects have concluded that a university's spin-off activity reflects its institutional behavior. Universities with a culture of supporting activities to market their research results will obtain better technology transfer and spin-off creation results. Important contributions have been made in this area by Calvo *et al.* (2012), Polt *et al.* (2001), Roberts (1991), Siegel *et al.* (2003), and Solé (2005).

The second group of studies has analyzed the process of creating spin-offs. Specifically, these studies have identified the different stages in the process, the principal barriers, the resources required at each stage, and the measures that need to be adopted for the process to be efficiently implemented (Clarysse *et al.*, 2005;

Degroof, 2002; Hindle and Yencken, 2004; Pirnay, 2001; Vohora *et al.*, 2004). Some authors have also concluded that the characteristics of policies to support the creation of spin-offs in universities depend on factors such as the environment, the objectives pursued, the type of spin-offs, and the resources available (Clarysse *et al.*, 2002, 2005; Roberts and Malone, 1996; Sternberg, 2014; Wright *et al.*, 2007).

According to several authors (European Commission, 2002; Hague and Oakley, 2000; Shane, 2004; Wright *et al.*, 2007), an environment of innovation appears to have a positive effect on the characteristics and results of university spin-off support programs. For example, Algieri *et al.* (2013), analyzing the determinants of spin-off creation in Italy, revealed significant differences in the probability of success for universities operating in northern, central, and southern Italy. This suggests that the economic context in which each spin-off support program operates is important. Sternberg (2014) highlighted that similar support programs have different effects on similar university spin-offs, and that the explanation at least partially lies in differing regional framework conditions. A more favorable economic and technological environment has a more positive influence on the chances of success for university spin-offs supported by an appropriate program.

Roberts and Malone (1996) maintained that in favorable environments, the spin-off process can follow a business pull strategy, that is, the university can adopt a passive approach since it benefits from the entrepreneurial culture in its environment, which allows it to select the best projects and bring in any resources it might need. Having a developed venture capital industry near at hand allows the university to take a neutral stance when it comes to funding, leaving the market to select and finance the most promising projects. In this kind of environment, partnerships are sometimes formed between experienced entrepreneurs and venture capital organizations with a view to discovering and exploiting business opportunities based on technologies generated in R&D organizations. These partnerships are based on the venture capital organization's faith in the entrepreneur's capacity to successfully exploit an initially unidentified business opportunity. The entrepreneur, in turn, expects the venture capital firm to provide funding if a promising business opportunity is discovered.

Therefore, spin-offs are more common in places where high technology start-ups are more common, because the components necessary to create spin-off companies (experienced managers, customers and suppliers, and so on) tend to be present in those areas. Hence:

H1. An environment of innovation increases the effectiveness of university spin-off programs.

For Roberts and Malone (1996), the two main dimensions of a policy of knowledge commercialization through spin-off creation are selectivity and support. Selectivity is the extent to which the university is rigorous in selecting the research results that could be commercialized via a spin-off; support is the extent to which the university provides the necessary resources and skills throughout the different phases of the spin-off creation process. They distinguish between high and low levels for both selectivity and support, and they argue that there are only two viable models of support policy: low selectivity/low support and high selectivity/high support.

For them and for Brunitz *et al.* (2008), a high-selectivity/high-support policy is more likely in environments in which spin-offs are more unusual and venture capital is scarce, because in this context a university has no choice but to take the place of the financial market, playing the role of a financial investor and encouraging a culture of entrepreneurship. In less favorable environments, therefore, the spin-off process can follow a technology push strategy, in which the university must get involved in the process of selecting and supporting the spin-offs through all stages of the process. Moreover, Fini *et al.* (2011) found that universities should limit their support in contexts in which ad-hoc regional support mechanisms offer a significant contribution. Hence:

> *H2*. A policy of high support/high selectivity is more likely in unfavorable environments.

Meanwhile, Degroof (2002) analyzed how an environment unfavorable to entrepreneurship affects the type of spin-offs created in academic institutions. Based on a study of spin-off creation in five organizations of this type, he identified two models for creating spin-offs in this type of environment: one favored by specialist research institutes and the other more typical of universities.

The process used by specialist research institutes has a long incubation period, lasting several years. The new company is only incorporated when it can avail of protected technology, a business plan with strong market potential, a convincing business model to draw on, and lastly an entrepreneurial team capable of leading the project with the help of venture capital organizations, company directors from the industry, and other advisers.

In contrast, the process pursued by universities does not normally include incubation or assistance in developing the business plan. The spin-offs are founded at a very early stage, when the project is still undefined. As a result, in most cases the business is developed after the spin-off's incorporation, when it is already up and running as a firm.

Degroof goes on to relate the results of the study to Roberts and Malone's selection and support dimensions in the spin-off process, and concludes that the process adopted by specialist research institutes involves pursuing a high selectivity/high support policy, whereas the process identified in the universities involves a low selectivity/low support policy, thus contradicting Roberts and Malone's conclusions. However, the author notes this process is not static, but becoming increasingly more sophisticated as institutions learn from their experience.

This approach sheds lights on one important practical aspect: the difficulty of establishing, from the outset, a high selectivity/high support policy in an environment that is unfavorable to entrepreneurship. Implementing such a policy requires considerable resources and skills, which may not exist in the universities; moreover, implementing them involves, among other factors, bringing about a considerable cultural and structural change.

Even in unfavorable environments, therefore, a university can start out in a position of low selectivity/low support and gradually move toward a position of greater selectivity and support, although it remains to be seen whether all universities are capable of following this path and at what speed.

Likewise, Davenport *et al.* (2002) charted the development over time of the spin-off strategy of research and technology institutes that are not universities, from an unintentional consequence of restructuring and changing funding priorities, toward a purposive strategy requiring different management structures and processes. These authors proposed a three-stage model (spin-offs by exception, spin-offs by occasion, and spin-offs as strategy) to describe the evolution of spin-off strategy. In proposing this model, they did not intend to imply that there is any imperative or necessity to progress through the different stages. They concluded that the few studies providing evidence of research technology institutes having moved to stage 3 have been conducted in research environments where receptor capacity is particularly weak. Hence:

H3. Universities in unfavorable environments are forced to start with low selectivity/low support programs for the creation of spin-offs.

Before knowledge can be successfully commercialized, it needs to be generated. Therefore, the commercialization of research results through spin-offs is partly influenced by the quantity and quality of the research at the university. According to Gómez *et al.* (2008), Hewitt-Dundas (2012), Lockett *et al.* (2003), Lockett and Wright (2005), O'Shea *et al.* (2005), Powers and McDougall (2005), Rodeiro *et al.* (2008), Van Looy *et al.* (2011), Vinig and van Rijsbergen (2009), and the university's stock of technology is one of the most widely used inputs with a positive influence on the university spin-off process. However, Berbegal-Mirabent *et al.* (2012) did not find significant associations between the amount of R&D funding received and the number of new spin-offs.

Another factor is academic quality (Shane, 2004; Zucker *et al.*, 1998). Spin-offs are more likely to be founded to exploit the technology of more prestigious universities than to exploit the technology of less prestigious ones. Nevertheless, Rodeiro *et al.* (2008) did not find significant associations between academic quality and spin-off activity. Hence:

H4. Previous technology stock promotes the effectiveness of university spin-off programs.

Other studies analyzing institutional aspects have found that a university's spin-off activity reflects its institutional behavior. Universities with a culture of supporting activities to market their research results will obtain better technology transfer and spin-off creation results (Calvo *et al.*, 2012; Fini *et al.*, 2009; Rasmussen and Borch, 2010; Searle, 2006; Uyarra, 2010).

Roberts (1991) maintained that the university's social rules and expectations are decisive factors in its technology transfer activity. Likewise, Polt *et al.* (2001) highlighted that many factors critical to the success of knowledge transfer (suitable institutional environment, organizational culture, institutional leadership, appropriate incentive system, level and orientation of the research, legal context) cannot be resolved by intermediation structures on their own. As a result, universities often fail to promote knowledge transfer if these factors have not been overcome beforehand. Meanwhile, Siegel *et al.* (2003) found that critical organizational factors affecting technology transfer activity are related to faculty reward systems, staffing/compensation practices, and the cultural barriers between universities and firms. Similarly, Solé (2005) argued that a university whose objectives include a commitment to development will create more companies than one in which technology transfer has a lower priority. According to Calvo *et al.* (2012), university spin-offs have an advantage over other spin-offs because of the support provided by universities in terms of financial investments, infrastructure such as technological and scientific parks, and the involvement of academic experts. At the same time, they can consider commercial alliances with similar firms, taking advantage of their spatial proximity and academic relationship. Hence:

H5. The university's commitment to promoting an entrepreneurial culture improves the effectiveness of university spin-off programs.

The relationship between the resources possessed by a technology transfer office (TTO) and technology transfer performance has been studied thoroughly. Rogers *et al.* (2000) found that access to human resources is essential in achieving effective technology transfer. Likewise, Thursby and Kemp (2002) found a positive link between the number of TTO staff and licensing activity. Moreover, Algieri *et al.* (2013), Berbegal-Mirabent *et al.* (2012), Caldera and Debande (2010), Gómez *et al.* (2008), O'Shea *et al.* (2005), Van Looy *et al.* (2011), Vinig and van Rijsbergen (2009) and found that the number of TTO staff has a positive influence on the number of spin-off companies formed. Nevertheless, Lockett and Wright (2005), Rodeiro *et al.* (2008) did not find a significant link between the number of TTO staff and the spin-off activity. Hence:

H6. The human resources available in the program improve the effectiveness of university spin-off support programs.

In addition to the quantity of staff, the quality and experience of the personnel are predictors of the effectiveness of university spin-off programs. According to Gómez *et al.* (2008), Lockett and Wright (2005), O'Shea *et al.* (2005), Powers and McDougall (2005), Rodeiro *et al.* (2008), Vinig and van Rijsbergen (2009), the more experience a TTO has in handling technology transfer activities, the more its staff will have developed the skills and abilities necessary to handle the spin-off process. However, Algieri *et al.* (2013) and Berbegal-Mirabent *et al.* (2012) did not find significant associations between the age of the TTO and the spin-off activity. Hence:

H7. The experience of the program contributes to the effectiveness of university spin-off support programs.

At the same time, some authors believe that level of proactivity is an important characteristic of university spin-off support policies (Degroof, 2002; Pirnay, 2001; Wright *et al.*, 2007). When it comes to recognizing commercial opportunities for exploiting research results, the university can take a reactive or proactive stance. A reactive stance involves waiting for researchers to propose a way of commercializing the results of their research. A proactive stance involves detecting and identifying projects in the research units with commercialization potential. A reactive stance can suffer from the possible disinterest of researchers in potential commercial applications of their research results, and the difficulty in identifying these results, thus reducing the number of ideas with the potential for economic commercialization. A proactive stance poses certain problems related to the independence associated with the academic culture and the great diversity of research activities being conducted in universities. It is difficult for academic authorities to oblige researchers to communicate the contents of their research results to an administrative institution without coming into conflict with the university culture of academic independence. Moreover, the diversity of the research being conducted in the research units and their high level of sophistication raise the issue of the degree of expertise required by the personnel tasked with identification. Finally, it is difficult a priori to estimate the potential for commercial application of research still underway, which raises the problem of defining the criteria for identifying ideas for commercialization (Pirnay, 2001).

Degroof (2002) stated that in an unfavorable context for entrepreneurship, universities are obliged to consider ways to increase the number of ideas that can be spun off. This requires a proactive search for technological opportunities with commercial potential. Along the same lines, Moray and Clarysse (2005) suggested the creation of an "idea board" with a technological orientation to enable proactive identification of technological ideas or opportunities. Davenport *et al.* (2002) concluded that the significant difference in reaching stage 3, as already discussed, is that the research and technology institute is perceived to be active in identifying candidates for spin-offs and has appropriate operational human resources and financial strategies in place to support this strategy. Hence:

H8. Proactivity in searching for and detecting ideas contributes to the effectiveness of university spin-off support programs.

University researchers normally have limited financial resources that are insufficient to meet the financial needs of the initial phases of a spin-off. The university's participation in financing these early phases is therefore critically important (Heirman and Clarysse, 2004; Mustar, 1997; Shane, 2004). Moreover, this participation reflects the university's commitment to exploiting research commercially, and to stimulating innovation (McCooe, 2004).

At the same time, in return for the spin-off's use of the university's intellectual property, the university generally receives an initial amount of money and/or royalties; in recent years, however, it is becoming increasingly common for it to take a share in the capital of the spin-off, which either complements or acts as a substitute for this initial payment (Bray and Lee, 2000; Matkin, 2001). These authors – Bray and Lee (2000) and Matkin (2001) – argued that this practice aligns the interests of the two parties, thus improving relations between the university and the spin-off, and provides greater prestige and legitimacy to the spin-off. The results of a European Commission study suggest that spin-off support programs that have funds to invest tend to be more productive in terms of the number of spin-offs created per project supported (European Commission, 2002).

Moreover, researchers/entrepreneurs sometimes have a commercial instinct and can adopt the role of manager/entrepreneurs, although this does not happen in most cases. On many occasions, therefore, the spin-off cannot be set up and developed without participation from external individuals with complementary skills and networks of relationships that the spin-off can call upon when it needs to make various decisions. In general, however, an excessive dependency on the university may be counterproductive. It is important for the new company to have its own identity and to be located outside the university. The company must be run by the people who work in it and not by university staff (Belani, 2004). Hence:

H9. The university's involvement in spin-offs contributes to the effectiveness of university spin-off support programs.

As we have already discussed, selectivity is one of the dimensions of a policy of economic exploitation through the creation of spin-offs (Clarysse *et al.*, 2002, 2005; Degroof, 2002; Roberts and Malone, 1996; Sternberg, 2014; Wright *et al.*, 2007). A university must decide how rigorous it is going to be in selecting research results that might be exploited through a spin-off. It is important to bear the university's motives in mind.

Degroof (2002) noted that the sort of spin-off process pursued will have implications for the type of firm created. His study shows that, in reality, different types of research institutions pursuing different processes create different types of companies. Specialist research institutes create venture capital backed firms[1] after a long process of incubation, whereas the companies created in universities at an initial stage are mainly lifestyle spin-offs[2], although as the programs gain greater experience, more growth-oriented spin-offs may emerge, particularly prospector spin-offs[3], if the environments are unfavorable to enterprise. Therefore, if the aim is to back technological projects with strong growth potential, research institutions should implement a rigorous selection process, accepting only the most promising projects. In this way, it will be in a position to offer them all the attention and resources they need to realize their potential. If, on the contrary, the aim of the model is to create as many spin-offs as possible, these spin-offs need not be exclusively technological, but can also be based on skills developed in the university.

Finally, Clarysse *et al.* (2002, 2005) and Wright *et al.* (2007) initially distinguished between two models of support for creating spin-offs in universities: the low selective or self-selective model, and the supportive model.

In the low selective model, there is an attempt to stimulate entrepreneurial initiative, with less attention paid to economic or financial potential. This means that the main activity of the universities is raising awareness and searching for opportunities. The aim of this model is to create as many spin-offs as possible that are not exclusively based on technology, but also on skills developed in the university.

In the supportive model, it is essential to manage intellectual property and prepare a business plan. Public and private funding is also needed to allow the projects to develop in the initial stages. In this model, the spin-offs are an alternative option for obtaining value from technological development. Therefore, purely knowledge-based consultancy firms do not tend to be supported. The aim of this model is to create spin-offs with an ambition for growth (although this ambition may not be put to the test at the moment of start-up).

In subsequent studies, Clarysse *et al.* (2005) and Wright *et al.* (2007) identified two additional categories, which they distinguished from the two previous models: the resource-deficient group of organizations, and the skills-deficient group.

The resource-deficient group is characterized primarily by the fact that it does not have sufficient financial resources to invest in the spin-offs, and also by the fact that the staff have neither the expertise nor the necessary contact networks to perform the required activities. Finally, this group also suffers a lack of support from the research institution's management team. Because of these deficiencies, such programs are considered to be weakly supported.

The skills-deficient group includes spin-off support programs that have the necessary resources but lack the necessary skills; that is, they lack the knowledge to integrate resources in such a manner that the required skills can be generated.

Summing up, there is no single model for spin-off support policy. Hence:

H10. Universities pursue different spin-off support policies, generate firms with different characteristics, and have different levels of effectiveness.

Figure 1 shows these hypotheses graphically. Together they provide a representative model of the conditions for university spin-off support program effectiveness.

Below, we present the research methodology used, including the model of the spin-off process used as a starting point for the empirical study, the process for gathering and processing the information, and the questions asked in the questionnaire that this study is based on.

Methodology

Population of European universities, selection of the sample and information-gathering technique

The study population comprises European universities in general, and Spanish and British universities in particular, that perform some type of activity involving spin-off creation[4].

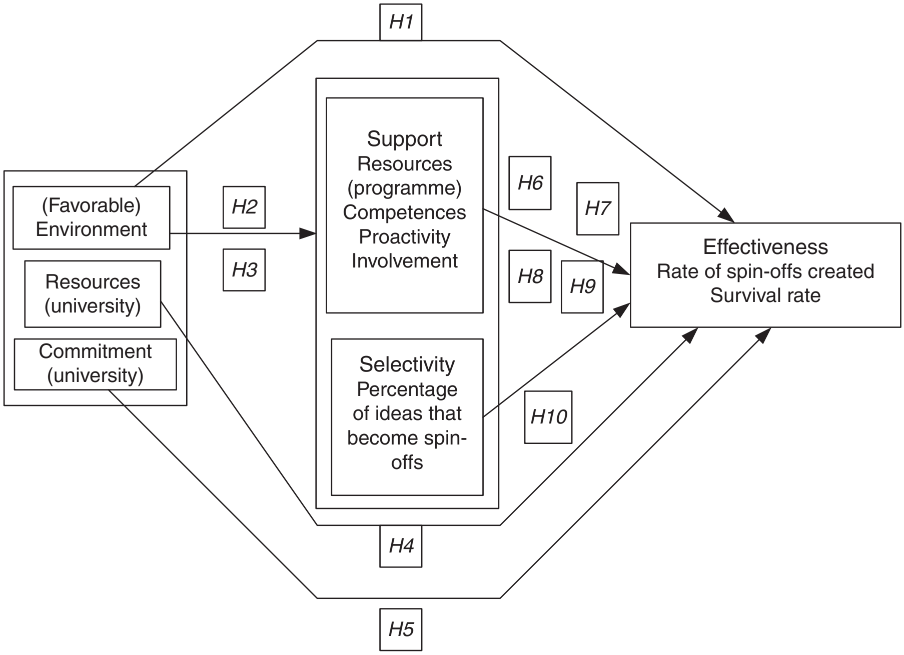


Figure 1.
Representative model of the conditions for the effectiveness of a university spin-off support program

The system used to identify the study population and select the sample was as follows: first, we searched in Google for a list of European universities, classified by country; second, we visited the web site of each of these universities; third, we tried to identify a body specifically devoted to supporting the creation of spin-offs and if none could be found we looked for the body responsible for technology transfer activities or, failing that, the body responsible for research/innovation/corporate relations; and finally we identified the people in charge of these bodies and recorded their details including name, position, telephone number and e-mail address.

A total of 74 universities were identified in the UK. We sent these universities a letter of presentation by e-mail, inviting them to fill out the online questionnaire. The information-gathering process ran from the beginning of November 2005 to the end of February 2006. Replies were received from 25 universities in the UK, representing a response rate of 34 percent[5]. In the case of Spanish universities, the letter of presentation was sent to practically all universities with a TTO, the great majority of which were public universities. In all, 35 replies were received, representing a response rate of 58 percent. Altogether, a total of 134 letters were sent, and 60 replies were received, representing a response rate of 45 percent. Not all universities that replied to the questionnaire answered all the questions. Specifically, 17 universities replied to few items and 24 furnished no information on spin-off creation. Thus only 43 universities replied to all or practically all questions.

We then proceeded to discard universities with a certain number of incomplete replies or those that might be considered atypical, finally obtaining a database comprising a total of 41 universities, of which 18 were in the UK and 23 in Spain. The rate of complete replies was therefore 31 percent for the sample as a whole, 24 percent for British universities, and 38 percent for Spanish universities.

Questions

In designing the empirical study and selecting the questions used in the research, we used a model of the linear process of valorization via spin-off, which sets out the various stages a university needs to consider in supporting the creation of spin-offs, with particular emphasis on stages and activities in which the university's direct intervention can be decisive (Clarysse *et al.*, 2005; Degroof, 2002; Hindle and Yencken, 2004; Roberts and Malone, 1996; Shane, 2004; Vohora *et al.*, 2004). These can be grouped analytically into four basic stages: promotion of entrepreneurial culture, search for and detection of ideas, evaluation and valorization of ideas, and creation of spin-offs. To these four stages we added a further section corresponding to general information.

The questions included in each of the five sections are described below.

General information. The university itself is the most important element in the support programs, as a source of marketable research results (Polt *et al.*, 2001). For this reason, as well as the identifying data, three additional questions were included in the survey: the type of body performing the spin-off set-up support activities; the number of people in that body; and the activities related to spin-offs that are carried out at the university.

Promotion of entrepreneurial culture. In conditions that are unfavorable for entrepreneurship, a prerequisite for creating spin-offs is the promotion of an entrepreneurial culture among university personnel (Henry *et al.*, 2005; Jack and Anderson, 1999; Klofsten, 2000; Pirnay, 2001; Trim, 2003). Four questions were therefore included in the survey to gauge this: the university's level of commitment to promoting entrepreneurial culture; the actions being taken to promote this culture; the number of people that will benefit from these activities; and the degree of effectiveness obtained.

Search for and detection of ideas. Commercially exploitable ideas derived from university research do not normally arise spontaneously (Long and McMullan, 1984; McDonald *et al.*, 2004; Panagopoulos and Carayannis, 2013; Shane, 2004; Siegel *et al.*, 2003). Four questions were included in the survey for this reason: the university's level of proactivity in searching for and detecting ideas; the actions carried out to search for and detect ideas; the source of the entrepreneurial ideas; and the degree of effectiveness obtained.

Evaluation and valorization of ideas. The ideas initially detected need to be assessed to determine whether they meet a series of prerequisites for viable commercial exploitability (Wright *et al.*, 2004). Likewise, the university as an institution, and the people who have the idea, must support the project in order for it to finally become a spin-off (Visintin and Pittino, 2014; Vohora *et al.*, 2004). Nine questions were included in the survey for this reason: the use of a specific methodology for evaluating and exploiting ideas; the use of external personnel in technological assessment; the use of external personnel in market assessment of the idea; the profile of these personnel; who assumes the leadership in promoting the spin-off; the role generally taken in the spin-off by the research group from which the idea originated; the number of exploitable ideas detected over a one-year period; the percentage of these ideas that are positively evaluated; and the percentage of positively evaluated ideas that lead to the creation of a spin-off.

Creation of spin-offs. The ideas detected and supported lead to the creation of spin-offs, which can be of varying types and have varying degrees of success (Bathelt *et al.*, 2010; Clarysse *et al.*, 2005; Lundqvist, 2014). The university can also have different links with these spin-offs (Lockett *et al.*, 2003; Lundqvist, 2014; Treibich *et al.*, 2013).

Nine questions were included in the survey for this reason: number of spin-offs created over the last 5 years; type of spin-offs created; average length of time from detection of the marketable idea to creation of the spin-off; most common source of financial resources; university's stake in the spin-off's capital; university's involvement in its management; survival rate of this type of company; percentage of firms that fail in their first three years; and the year in which the university began activities to support spin-off creation.

The variables and scales of measurement used for each of the five sections of the survey are presented in Table I.

Multivariate analysis

Factorial analysis: obtaining representative substitute variables

We performed a factorial analysis on the database containing the information obtained from the questionnaires to determine the most significant variables explaining the characteristics of university spin-off support programs[6]. Using this technique we first proceeded to identify factors. To do this, we used the principal components analysis data reduction method. To determine the number of factors to be extracted, we used the latent root criterion technique[7]. We then calculated the contributions of each variable to the different factors and selected the variables that contributed most to each one, in order to identify the variables that most appropriately described the university spin-off support programs, and used them in the subsequent cluster analysis.

We originally used 47 variables in this study – all the quantitative variables in the survey. The value of the determinant of the correlation matrix is practically zero; likewise, Bartlett's sphericity test rejected the null hypothesis that the matrix of correlations is an identity matrix with a significance level of 1 percent. Factorial analysis is therefore a relevant technique for analyzing these variables, and by applying the latent root criterion, the final solution chosen was that formed by 16 factors. In order to improve the solution, a varimax rotation was used. This solution preserved 78.652 percent of total variability. We then selected the variables with the greatest load for each factor, as representative of each of the factors. In this way, we managed to group the original quantitative variables, which are intended to represent different aspects corresponding to the different stages of support in the creation of spin-offs, into 16 variables. Table I shows these variables classified according to the different phases of the process of exploitation by spin-off.

Cluster analysis: typology of spin-off support programs in universities in the UK and Spain

After identifying the most significant variables, we classified the British and Spanish universities using the cluster analysis technique based on the 16 most significant variables identified in the previous sub-section. The Euclidean distance squared was used following standardization of the variables by transforming them into Z scores with mean of 0 and standard deviation of 1. The clusters were formed using hierarchical clustering and Ward's method.

There is no standard procedure for determining the final number of clusters, and in this case the clustering coefficient criterion does not give clear results, since it does not experience relevant changes when the number of clusters varies. We therefore opted to obtain various cluster arrangements, from two to four, and, by using the one-factor ANOVA, checked whether there were significant differences between these clusters.

Table I.
Variables in each of the sections

No.	Variables	Scale	Results
General information			
1	Type of body performing support	Internal/external	Mostly internal
2	Number of people who are part of the body[b]	Intervals	Mostly between 1 and 5
3.1	Relative importance of the promotion of entrepreneurial culture[b]	0-100%	27.46
3.2	Relative importance of search for and detection of ideas[b]	0-100%	22.33
3.3	Relative importance of evaluation and valorisation of ideas[a]	0-100%	22.76
3.4	Relative importance of the creation of spin-offs[a]	0-100%	27.43
Promotion of entrepreneurial culture			
4	University's commitment to the promotion of entrepreneurial culture[a]	1-5	3.66
5.1	Importance of business design/project competitions[a]	1-5	3.35
5.2	Importance of courses and seminars on entrepreneurship[a]	1-5	3.46
5.3	Importance of the encouragement to prepare the business plan in final year assignments[a]	1-5	2.23
5.4	Importance of the information service[a]	1-5	3.72
5.5	Importance of internal marketing[a]	1-5	2.98
5.6	Importance of conducting meetings between employers/students/investors/researchers[a]	1-5	2.94
5.7	Importance of promoting the experiences of the spin-offs created[a]	1-5	3.45
6	Number of persons benefitting from these activities[a]	Intervals	Mostly <75
7	Success in the promotion of entrepreneurial culture[b]	1-5	3,20
Search for and detection of ideas			
8	Proactivity in searching for and detecting ideas[a]	1-5	3.26
9.1	Importance of monitoring of the projects undertaken by research groups[b]	1-5	2.91
9.2	Importance of monitoring theses and final-year assignments[a]	1-5	2.02
9.3	Importance of monitoring of business design/Project competitions[b]	1-5	3.31
9.4	Importance of monitoring students on entrepreneurship courses[a]	1-5	2.57
9.5	Importance of hiring of personnel specialising in idea detection[a]	1-5	2.52

(*continued*)

No.	Variables	Scale	Results
10.1	Relative importance of teachers and research groups in the origin of ideas[a]	0-100%	46.97
10.2	Relative importance of postgraduate-PhD students in the origin of ideas[a]	0-100%	29.66
10.3	Relative importance of companies in the origin of ideas[a]	0-100%	15.60
10.4	Relative importance of "Others" in the origin of ideas[b]	0-100%	7.77
11	Success of activities for seeking and detecting ideas[a]	1 a 5	3.20
Evaluation and valorisation of ideas			
12	Use of a specific methodology for idea evaluation and valorisation	Yes/no	Mostly yes
13	Use external personnel for technological assessment	Yes/no	Mostly yes
14	Use external personnel for market assessment	Yes/no	Mostly yes
15	Profile of external personnel for market assessment (multi-response)	Employers/advisors/VC/others	Mostly consultants
16.1	Relative frequency of research groups as leaders in fostering the spin-off[a]	0-100%	44.11
16.2	Relative frequency of postgraduate-PhD students as leaders in promoting spin-offs[b]	0-100%	30.90
16.3	Relative frequency of external personnel hired as leaders in promoting spin-offs[b]	0-100%	14.49
16.4	Relative frequency of "Others" as leaders in promoting spin-offs[a]	0-100%	10.18
17.1	Appropriate for research groups to take shareholdings in the spin-offs[a]	1-5	3.48
17.2	Appropriate for research groups to transfer technology to spin-off in exchange for royalties[a]	1-5	3.00
17.3	Appropriate for research groups to provide technological consultancy to the spin-offs[b]	1-5	3.06
17.4	Appropriate for research groups to support the spin-off with new developments (R&D + *i*)[a]	1-5	3.66
18	Number of ideas detected over a year[a]	Intervals	Mostly <20
19	Percentage of ideas detected over a one-year period that are positively evaluated[b]	Intervals	Mostly between 20 and 40%
20	Percentage of positively evaluated ideas that lead to the creation of a spin-off[b]	Intervals	Mostly between 20 and 40%
Creation of spin-offs			
21	Average number of spin-offs created between 2000 and 2004[a]	Numerical	4.56
22.1	Percentage of technological spin-offs[a]	0-100%	61.07

(*continued*)

Table I.

Table I.

No.	Variables	Scale	Results
22.2	Percentage of knowledge-based spin-offs[b]	0-100%	34.21
22.3	Percentage of "Other" spin-offs[b]	0-100%	4.72
23	Average time from the detection of idea to creation of the spin-off[a]	Intervals	Mostly between 1 and 2 years
24	Common source of financial resources of the spin-offs	Business Angels/VC/ companies/university/ public administ./other	Very widely distributed
25	University's stake in the spin-offs capital[a]	Never/sometimes/ usually/always	Mostly never
26	University's involvement in the spin-off's management [b]	Never/minimally/ actively	Mostly never
27	Spin-off survival rate[a]	1-5	4.09
28	Percentage of spin-offs who dies before 3 years[b]	0-100%	1438
29	Year in which the university began activities to support spin-off[a]	Intervals	Mostly after 2000

Notes: [a]Variables factorial analysis; [b]most significant variables classified according to the stages of the process of exploitation by spin-off

The results show that a number of variables with significant differences are practically the same for the three- and four-cluster arrangements and that differences are smallest for the two-cluster arrangement. We therefore opted for the three-cluster arrangement, since it allows greater differentiation between the programs, without proving excessive. In this cluster arrangement, eight variables have significant differences. Table II shows these variables.

Characterization of spin-off support models and discussion of results
We then identified the characteristics distinguishing spin-off support models by means of an ANOVA analysis and a confirmatory multivariate statistical analysis (logistic regression analysis)[8], and examined the results obtained.

Characterization of spin-off support models
Having identified the clusters and the variables with significantly different means, we then examined the characterization of the clusters identified as representatives of different models or types of spin-off creation support in more detail, comparing and contrasting them to highlight possible similarities and differences.

For the purposes of this characterization, we first used all the quantitative variables included in the survey that showed significant differences between clusters, as well as one new variable not included: the number of patents. The reason for including this variable is that given the somewhat subjective nature of cluster analysis, and in order to ensure the validity and practical relevance of the solution obtained, it is recommendable to incorporate variables that have not been used to form the clusters, but that are known to vary in value from one another, as is the case with the variable chosen; moreover, this variable is relevant in this study, as explained below.

Patent applications by universities are an indicator of university R&D results and commercial orientation. While not all academic spin-offs are based on patented knowledge, a relationship can also be expected between the number of patents and the business creation process in universities. In some cases, however, the number of patent applications by universities varies greatly from one year to another. For this reason, the variable used in the analysis is the average number of patent applications during the period 2002-2005 in the case of British universities, and 2000-2005 in the case of Spanish universities.

Table II shows the means of all the quantitative variables with significant differences obtained in the survey for the clusters of spin-off support programs.

Taking these variables as our reference, we can describe the profiles of each of the three types of program identified[9].

Cluster 1 contains 20 universities, comprising seven in the UK and 13 in Spain, that have a relatively low level of patent activity, have started spin-off programs recently, and have a small number of people devoted to spin-off support. They place relatively little importance on the evaluation and valorization of ideas and, conversely, relatively greater importance on the promotion of entrepreneurial culture. Their commitment to promoting an entrepreneurial culture and the importance placed on business design/project competitions, entrepreneurship courses, and promoting the spin-offs created is limited, with the result that their activities benefit a small number of people and they have little success promoting an entrepreneurial culture. They are not very proactive in searching for and detecting ideas, and they place little importance on monitoring projects undertaken by research groups or business design/project competitions, with the result that they have little success searching for and detecting ideas, and, therefore,

Table II. Means of all variables with significant differences in clusters[a]

	Ward method 1	2	3	Total
Number of people who are part of the body[b]	(−)1.05	(+)2.36	1.20	1.44
Relative importance of evaluation and valorisation of ideas	(−)21.75	24.00	(+)29.00	25.00
University's commitment to the promotion of entrepreneurial culture	3.30	(+)4.36	(−)3.00	3.51
Importance of business design/project competitions	2.90	(+)4.00	(−)2.80	3.17
Importance of entrepreneurship courses	3.15	4.09	(−)2.90	3.34
Importance of promoting the spin-offs created	(−)3.05	(+)4.09	3.10	3.34
Number of people benefiting from these activities	(−)1.40	(+)2.91	2.00	1.95
Success in the promotion of entrepreneurial culture[b]	2.85	(+)3.82	(−)2.60	3.05
Proactivity in searching for and detecting ideas	(−)3.00	3.27	(+)3.80	3.27
Importance of monitoring of the projects undertaken by research groups[b]	(−)2.45	(+)3.55	3.50	3.00
Importance of monitoring of business design/project competitions[b]	(−)2.60	(+)4.09	3.70	3.27
Success in searching for and detecting ideas	(−)2.75	(+)3.73	3.10	3.10
Number of ideas detected over a year	(−)1.50	(+)2.82	1.70	1.90
Percentage of ideas detected over a one-year period that are positively evaluated[b]	(−)1.75	2.18	(+)3.60	2.32
Percentage of positively evaluated ideas that lead to the creation of a spin-off[b]	(−)2.00	2.18	(+)2.90	2.27
University's involvement in the spin-off's management[b]	(−)1.40	(−)2.00	1.70	1.63
Percentage of spin-offs who dies before 3 years[b]	(−)7.10	(+)26.82	7.50	12.49
Year in which the university began activities to support spin-off	(+)2,000.40	(−)1,996.27	1,999.90	1,999.17
Average number of spin-offs created between 2000 and 2004	(−)1.72	(+)5.35	2.93	2.9895
Average of patents	(−)7.73	(+)23.05	10.8	12.56

Notes: [a]The cluster marked with a (+) or (−) has the highest or lowest mean for the corresponding variable; [b]representative variables showing significant differences between the three clusters the number of ideas detected is very limited. They give a positive rating to, and spin-off, a small percentage of the ideas detected; they generate few ventures, but with a high survival rate, and do not intervene in the running of spin-offs.

Cluster 2 is in turn made up of 11 universities, seven in the UK and four in Spain, that have a relatively high level of patent activity, experience in spin-off support, and a large number of people devoted to spin-offs. They place relatively greater importance on the evaluation and valorization of ideas and on spin-off support. Their commitment to promoting an entrepreneurial culture and the importance placed on business design/project competitions, entrepreneurship courses, and promoting the spin-offs created is high, with the result that their activities benefit a large number of people and they have quite a lot of success promoting an entrepreneurial culture. They are quite proactive in searching for and detecting ideas, but to a lesser extent than universities in cluster 3. Moreover, they place great importance on monitoring the projects undertaken by research groups and on monitoring business design/project competitions, with the result that they have quite a lot of success searching for and detecting ideas, and, therefore, the number of ideas detected is relatively high. They give a positive rating to, and spin-off, a small percentage of the ideas detected, but more than the universities in cluster 1. They generate a large number of spin-offs, though their rate of mortality is also high, and they tend to intervene in their running, but not actively.

Finally, cluster 3 comprises ten universities, four in the UK and six in Spain, which have a relatively low level of patent activity, have started spin-off programs recently, and have a small number of people devoted to spin-off support. They place relatively high importance on the evaluation and valorization of ideas and, conversely, relatively low importance on the promotion of entrepreneurial culture. Their commitment to promoting an entrepreneurial culture and the importance placed on business design/project competitions, entrepreneurship courses, and promoting the spin-offs created is limited, with the result that their activities benefit a small number of people and they have little success promoting an entrepreneurial culture. They are quite proactive in searching for and detecting ideas; they place importance on monitoring the projects undertaken by research groups and the business design/project competitions, but they have little success searching for and detecting ideas, and, therefore, the number of ideas detected is very limited. They give a positive rating to, and spin-off, a high percentage of the ideas detected. They generate an intermediate number of spin-offs, with a reduced mortality rate, and do not normally intervene in their running.

Second, starting with a smaller number of variables with significant differences between the clusters identified, we characterized the profiles of these clusters and examined the degree of support obtained for the hypotheses proposed in the second section. Specifically, the seven variables used in this characterization are as follows:

- *Age* of the spin-off support activities as an indicator of experience and, consequently, of availability of the necessary skills to carry out the activities required.
- *Number of people* in the body, as an indicator of the resources available to the spin-off support program.
- University *commitment* to promoting an entrepreneurial culture, as an indicator of integration of entrepreneurial vision into the university's strategy and, consequently, the day-to-day activities of the organization.
- *Proactivity* in searching for and detecting ideas, as an indicator of capacity to detect possibilities for commercialization of the knowledge generated in the university from an early stage.

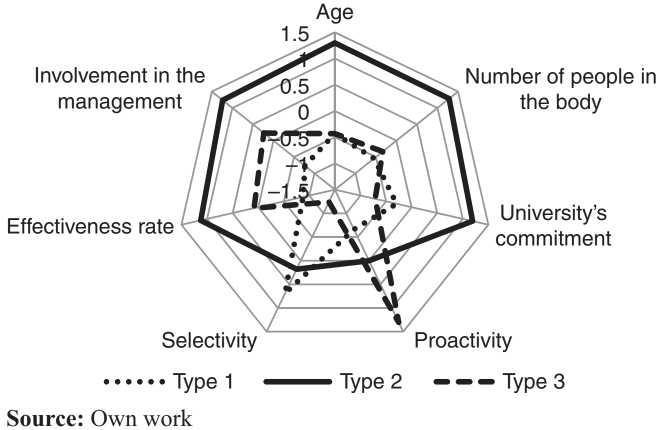
- *Selectivity*, as an indicator of the university's rigor in selecting the results of research capable of being commercialized via a spin-off. (This variable was not included in the survey but was obtained indirectly from the "percentage of ideas detected over a 1-year period that are positively evaluated" and ";percentage of positively evaluated ideas that led to the creation of a spin-off" variables.)
- *Effectiveness rate*, as an indicator of the results of the support programs. (This variable was not included in the survey but was obtained indirectly from the "average number of spin-offs created between 2000 and 2004" and "percentage of spin-offs that survive for 3 years" variables.)
- *Involvement in spin-off management*, as an indicator of the university's involvement in the spin-offs.

Figure 2 shows the profiles of the three types of programs identified according to these variables with significant differences indicated above. Type 1 programs have little experience in spin-off support, have few resources for this task, and do not enjoy much commitment from the university. They are not very proactive in searching for and detecting ideas and follow a high-selectivity policy; as a result, they are not very effective in the creation of spin-offs and do not intervene in their running.

Type 2 programs have great experience in spin-off support, have plenty of resources for this task, and enjoy great commitment from their universities. They are not very proactive in searching for and detecting ideas and follow a policy of intermediate selectivity; as a result, they have great effectiveness in the creation of spin-offs and intervene in their running.

Finally, Type 3 programs have little experience in spin-off support, enjoy few resources for this task and less commitment from their universities, and are very proactive in the search for and detection of ideas, but follow a low selectivity policy; as a result, they have intermediate effectiveness in the creation of spin-offs and intervene in their running, but not actively.

Therefore, Type 2 programs seem to be the most effective.



Source: Own work

Figure 2.
Profiles of the three types of program

Most significant features differentiating spin-off support models

Having identified the characteristics distinguishing spin-off support models, we proceeded to determine whether there are any statistically significant differences between Type 2 programs and the others, and which variables best quantify the differences between the groups of universities by means of binary logistic regression analysis[10].

Table III presents the main results and statistics of the logistic regression analysis. The sample includes 41 university spin-off support programs with complete data. The dependent variable is dichotomous, Type 2 (11 observations) with Code 1, and Types 1 and 3 (30 observations) with Code 0. The independent variables are the seven variables included in the above characterization, except effectiveness rate. The variables included in the final logistic regression model are: "number of people who are part of the body" (number of people), "university's commitment to the promotion of entrepreneurial culture" (commitment), and "year in which the university began activities to support spin-offs" (year). The value of the likelihood ratio (−2 log of the likelihood) falls, which demonstrates that the overall fit of the model improves with each step. Cox and Snell's R^2 and Nagelkerke's R^2 statistics also show that the overall fit of the model improves with each step, since the value increases. Similarly, the Hosmer-Lemeshow χ^2 statistic makes it possible to accept the null hypothesis that there are no differences between the observed probabilities and those forecast by the model, which allows us to confirm the goodness-of-fit of the final model. Finally, Press's Q statistic makes it possible to conclude, with a significance level of 1 percent, that the success prediction is better than that obtained randomly.

With the logistic regression model and the precision of the classification determined to be statistically significant, the results were interpreted by examining the model to determine the relative importance of each independent variable in the differentiation of the groups. For this purpose, we first analyzed the coefficients of the model and their significance. The significance of each coefficient was assessed using the Wald statistic. In addition, in order to interpret the logistic regression model obtained, we studied the sign of the coefficient assigned to each independent variable. A positive coefficient indicates that an increase in the corresponding variable raises the probability that a university is allocated to the group with Code 1. A negative coefficient indicates that an increase in the corresponding variable reduces the probability that a university is assigned to the group with Code 1 or, conversely, increases the probability that a university is allocated to the group with Code 0.

The logistic regression model reveals that the variables *number of people* and *commitment* can be seen to be positively associated with the dependent variable, implying that these variables occur to a greater extent in Type 2.

Conversely, the variable *year* is negatively associated with the dependent variable, which means that this variable occurs to a greater extent in Types 1 and 3.

These results confirm those obtained in the ANOVA analysis, with the exception of those corresponding to the variable "number of people who are part of the body," which is not significant in the logistic regression analysis.

However, because regression coefficients are in log-odds units, they are often difficult to interpret. In case of OLS regression, the regression coefficient represents the change in dependent variable with one unit change in independent variable. This concept is not valid in the case of logistic regression. Moreover, interpreting regression coefficients in terms of marginal effects in nonlinear models, such as our logistic regression model, can be difficult because the marginal effects are nonlinear functions

Table III. Statistically significant differences between Type 2 university spin-off support programs and Types 1 and 3

Variables in the model	
Constant	405.854*
	(3.418)
	[$1.82e^{176}$]
Number of people[a]	2.231
	(2.258)
	[9.305]
Commitment	1.872**
	(4.489)
	[6.501]
Year	−0.209*
	(3.558)
	[0.812]
Variables not in the model	Score
Proactivity	0.045
% ideas detected	1.590
% of positively evaluated ideas	0.044
Involvement in spin-off management	0.021
Statistics	
Number of observations	41
−2 log of the likelihood[b]	22.073
−2 log of the likelihood test[c]	χ^2 (3, 41) = 22.073, $p < 0.001$
Pseudo R^2: Cox and Snell[d]	0.465
Pseudo R^2: Nagelkerke	0.676
Model fit: Hosmer and Lemeshow[e]	4.368
	(0.823)
Prediction: Press's Q statistic[f]	20.51***
	(0.01)

Notes: This table presents stepwise binary logistic regression analysis where dependent variable equals one for Type 2 programs and zero for Types 1 and 3. The data are drawn from an online questionnaire and include a total of 41 university spin-off support programs, of which eleven were Type 2 and 30 Types 1 and 3. Below the coefficients are the *t*-statistics in parentheses. The value of −*2* log of the likelihood is used to compare different models having different number of dependent variables. The odds ratios (the exponentiated coefficients) are given in square brackets. The reported R^2 are Cox and Snell and Nagelkerke pseudo-R^2. The Hosmer-Lemeshow χ^2 statistic is used to confirm the goodness-of-fit of the model. The Press's $Q\chi^2$ statistic is used to confirm the goodness-of-prediction of the model. [a]Although the coefficient of this variable is not significant according to the Wald statistic, the variable has been maintained in the model. [b]The value of −2 log of the likelihood is a deviance statistic between the observed and predicated values of the dependent variable. If this deviance statistic is insignificant, it indicates that the model is good and there is no difference between observed and predicted values of dependent variable. This number in absolute term is not very informative. However, it can be used to compare different models having different number of dependent variables. In fact, the value of −2 log of the likelihood should keep on decreasing if you go on adding the significant independent variables in the model. [c]With this test we can test the significance of the difference between initial model and final model. Our initial model had a −2 log of the likelihood statistic of 47.687 and the final model of 22.073. This difference is a χ^2 statistic on 3df. [d]Unlike OLS regression equation, there is no concept of R^2 in logistic regression. However, several authors have suggested pseudo R^2 that are not equivalent to the R^2 that is calculated in OLS regression. Two such pseudo R^2 have been suggested by Cox and Snell and Nagelkerke. [e]In order to find whether the deviance statistic −2 log of the likelihood is insignificant or not, Hosmer and Lemeshow suggested a R^2 statistic. In order that the model is efficient, this χ^2 statistic should be no significant. [f]Press's Q statistic is used to compare the number of correct classifications with the total sample size and the number of groups. The calculated value is compared with a critical value which is determined using the χ^2 distribution. *,**,***Statistical significance at the 10, 5 and 1 percent levels, respectively of the coefficients and the levels of the independent variables; this makes it especially difficult to interpret interaction terms because the marginal effects differ for each observation. A logistic regression model, however, is linear in the log-odds metric. Therefore, the log-odds and thus the odds ratios (the exponentiated coefficients), represent the constant effect of a given variable on the likelihood of a university spin-off support program belonging to Type 2, in our case. These odds ratios are shown in square brackets behind the regression coefficients of the logistic model in Table III.

To assess the significance of our results, we noted that 27 percent of university spin-off support programs are Type 2.

The odds ratio of 9.305 for the number of people indicates that the probability of belong to Type 2 programs is 9.305 times higher when the value of number of people is increased by one unit and other variables are kept constant. If the odds ratio for commitment is 6.501, this indicates that the probability of belonging to Type 2 programs is 6.501 times higher when the value of commitment is increased by one unit. On the other hand, if the odds ratio for the year is 0.812, it indicates that there is a negative relationship between year and Type 2 programs. In other words, the longer a program has been running, the higher the probability of it belonging to Type 2 (1.2315 times higher when years of operation is increased by one unit).

Consequently, in relation to Types 1 and 3 spin-off support programs, Type 2 programs are characterized as having more resources available, greater integration of entrepreneurial vision into university strategy, and greater experience in, and consequently availability of, the necessary skills to support spin-offs.

Discussion of results

Type 2 programs were found to be the most effective. This type of program has the resources, experience, and university commitment to support spin-offs. These programs seem to opt for a policy of intermediate proactivity in searching for and detecting ideas and selecting the identified ideas that ultimately lead to the creation of spin-offs. Moreover, they appear more supportive of spin-offs, since this cluster has the greatest mean time between detection of the idea and spinning it off, and is the cluster most involved in spin-off management. This results in the creation of a relatively large number of companies, but not a very high survival rate. Thus, Type 2 programs appear to implement a policy that approaches the supportive model proposed by Clarysse *et al.* (2002, 2005) and Wright *et al.* (2007).

In contrast, Type 1 programs show that it is difficult to establish, from the outset, a policy of high proactivity/high selectivity/high support, since following this policy requires considerable resources and skills that are not always available. Although universities of this type have opted from the beginning for a high-selectivity policy, their low proactivity and reduced involvement in spin-off management limits their effectiveness in the creation of spin-offs.

Finally, Type 3 programs appear to show that some spin-off programs are resource or competence deficient. Among other factors, the lack of resources is reflected in the fact that university administration support is lacking, and the lack of competence is reflected in the absence of the skills needed to carry out the activities required. Although universities of Type 3 appear to be very proactive and pursue a policy of very low selectivity, they have intermediate effectiveness in the creation of spin-offs.

While this analysis is exploratory, the results obtained allow us to examine the degree of support obtained for the hypotheses proposed in the second section.

First, it seems clear that universities pursue different spin-off policies, generate firms with different characteristics, and have different levels of effectiveness, as various authors have indicated (Clarysse *et al.*, 2002, 2005; Sternberg, 2014; Wright *et al.*, 2007), therefore supporting *H10*.

Moreover, it should be noted that, with only three exceptions, Type 2 universities – that is, the "successful model" – are found in regions with above-average innovation behavior for their respective countries (Hollanders, 2007). An innovating environment, therefore, appears to have a positive effect on the characteristics and results of university spin-off support programs, thus supporting *H1*. This result backs up the literature's insistence on the importance of a favorable environment for effective spin-off programs (Algieri *et al.*, 2013; European Commission, 2002; Hague and Oakley, 2000; Sternberg, 2014; Wright *et al.*, 2007), but it also calls into question Roberts and Malone's (1996) assertion that a policy of high support/high selectivity is more likely in unfavorable environments; therefore *H2* is not supported. Nonetheless, this last statement needs to be qualified, since when Roberts and Malone (1996) referred to a favorable setting, they were referring to the USA, and more specifically to universities such as MIT and Stanford, which continue to be an international reference point for spin-off support programs. However, these two cases are atypical, even in the USA.

Furthermore, although Types 1 and 3 appear to show that some spin-off support programs lack resources or competence, they follow different policies: Type 3 programs follow a low-selectivity policy, while Type 1 programs follow a high-selectivity policy. Taking into account that in both cases these programs are relatively recent, it appears our findings do not confirm the conclusion of Degroof (2002), expressed in *H3*, that universities will initially be forced to start with a low-selectivity/low-support policy, moving gradually toward a position of greater selectivity and support. Moreover, it remains to be confirmed whether universities applying a policy of low selectivity/low support will gradually move toward a position of high selectivity/high support. According to Davenport *et al.* (2002), there is no imperative or necessity to progress in this direction.

For *H4*, it is found that Type 2 programs have the greatest number of patents. This result is in consonance with the literature, which sees R&D activity as a factor related to the business creation process in universities (Gómez *et al.*, 2008; Hewitt-Dundas, 2012; Lockett *et al.*, 2003; Lockett and Wright, 2005; O'Shea *et al.*, 2005; Powers and McDougall, 2005; Rodeiro *et al.*, 2008; Van Looy *et al.*, 2011; Vinig and van Rijsbergen, 2009), at the same time, it also shows that patent applications by universities are an indicator of the results of university R&D and its commercial orientation. Accordingly, *H4* is supported. This suggests that policy support for infrastructure and staffing to support the creation of spin-offs needs to consider the institutional and organizational resources of universities as reflected in their research performance.

Finally, Type 2 programs have much experience in spin-off support and plenty of human resources for this task, enjoy great commitment from their universities, and intervene in the running of spin-offs. These results give support to *H7*, *H6*, *H5*, and *H9*, and emphasize the fact that, in addition to experience and resources, institutional factors are critical to the success of university spin-off support programs. Policies of support for the creation of university spin-offs must be aligned with the organization's goals and objectives. In other words, even when resources are available to support the creation of spin-offs, they will not yield good results if they are not accompanied by the integration of entrepreneurial vision into the university's strategy.

However, Type 2 programs are not very proactive in searching for and detecting ideas, which does not support *H8*. This result is not very surprising, as according to Degroof (2002), a proactive search for technological opportunities with commercial potential makes sense in an unfavorable context for entrepreneurship and, as indicated, most Type 2 universities are found in regions with above-average innovation behavior for their respective countries. Moreover, a very proactive attitude can pose problems in terms of efficiency: Institutionalizing the systematic identification of promising research projects may require mobilizing a volume of resources not justified by the aims pursued (Pirnay, 2001).

Conclusions

Great importance has been placed on the creation of knowledge-based ventures over the last decade. In keeping with the idea of the university's "third mission," this has led to a proliferation in spin-off support programs. Although much research has examined the relationship between universities and the creation of spin-offs, the heterogeneity in the different models of programs for supporting the creation of spin-offs has rarely been taken into account. This is important because significant differences exist in the behavior of universities.

In this paper, we set out to identify the different models of support program in universities in Spain and in the UK, and to identify successful models and their characteristics. In doing so, we applied multivariate statistical analyses – particularly the cluster analysis technique – to the results of a survey of the people in charge of these types of programs. Having identified the support program models, we performed a statistical analysis to characterize them clearly. This enabled us to reach a series of conclusions, summarized below.

We identified three clusters of spin-off support programs in Spanish and British universities, differing in terms of experience, resources, university commitment, proactivity, selectivity, number of spin-offs created, and rate of survival. All these variables have been identified by the literature as determining spin-offs' characteristics and outcomes. The results confirm that universities pursue different spin-off support policies, utilize different spin-off creation processes, and generate different numbers of companies with different characteristics.

Type 2 programs appear to offer a successful model, implementing a policy that approaches the supportive model proposed by Clarysse *et al.* (2002, 2005) and Wright *et al.* (2007), the aim of which is to create companies with economic potential and growth ambition.

It should also be noted that Type 2 programs have the greatest number of patents, which is in consonance with the literature that sees R&D activity as a factor related positively to the success of universities' spin-off processes. Furthermore, Type 2 universities are generally located in regions with above-average innovation behavior for their respective countries, confirming the assertion of the literature that an innovating environment improves the effectiveness of spin-off programs. These results demonstrate the complexity of using spin-offs as a mechanism of knowledge transfer. The creation of spin-offs requires universities to have a certain degree of research capacity, appropriate support mechanisms and bodies, and an environment that facilitates commercialization of research results through spin-offs.

Types 1 and 3 programs, on the other hand, lack resources and competence, but follow different policies: high selectivity in type 1, and low selectivity in type 3. Taking into account that both types are relatively recent, it appears they do not confirm the assertion of Degroof (2002) that universities are forced to start with a low-selectivity/low-support policy, moving gradually toward a position of greater selectivity and support.

We believe it would be useful and straightforward for a university to recognize in which type it predominantly sits. This recognition should enable a university to develop appropriate processes suited to that type. Moreover, the typology of spin-off support programs identified in this work enables us to make some recommendations for improving the less-effective models.

Type 1 programs must devote more resources to spin-offs and strengthen their related skills. Universities that adopt such programs appear to be clear on the support policies they wish to pursue, but lack the resources and skills needed to put them into practice. If they want to improve their results, they need to devote more resources to their programs, strengthen their competence by training and hiring specialist personnel, and establish collaboration networks with external agents specializing in each of the activities in the process. However, developing a supportive model does incur significant costs. Therefore, one alternative for universities lacking sufficient scale is to group together to create joint spin-off programs or consider establishing joint spin-off support programs in specific territorial areas. Given that many universities do not have the critical mass to sustain a support program for spin-offs, they may consider it advisable to establish a joint unit in collaboration with other universities and research centers in the area, or even geographically distant ones with similar technologies. It may even be advisable for public authorities to promote or establish spin-off support programs in universities, research centers, technology centers, and companies in specific territorial areas, as has been done in other countries.

Type 3 programs must prioritize the establishment of the support policies they wish to pursue. Although universities that adopt such programs might seem to be pursuing policies with high proactivity in searching for and detecting ideas and low selectivity of the detected ideas that are finally spun off, a lack of necessary resources and competence actually appears to be what leads them to pursue this policy. They must first establish the support policies they wish to apply, making it essential to have prior commitment from university management.

In any case, according to Sternberg (2014), the environment has to be considered when university spin-off support programs are created or when there is a desire to move from one type to another. The same kind of program does not automatically get the same results in different environments.

The results obtained in this paper enable us to offer an additional observation. According to the results of cluster analysis, cluster 2 can be broken down into two subtypes that show the existence of a “country effect” on the characteristics of effective university programs. Thus, subtype 1, made up of Spanish universities (with one exception) has substantial experience in spin-off support and plenty of resources for this task, and enjoys great commitment from the university; it is quite proactive in searching for and detecting ideas and pursues an intermediate selectivity policy. Consequently, it generates a comparatively high number of technology- and knowledge-based spin-offs, but with a high mortality rate, and it does not intervene in their running. Subtype 2, meanwhile, is made up only of British universities, and is similar to subtype 1 with regard to experience, resources, commitment, and selectivity, but is not very proactive in searching for and detecting ideas. Consequently, it generates a smaller number of spin-offs, mostly technology based, but with a reduced mortality rate, and it intervenes actively in their running.

These differences are not surprising. According to Mustar and Wright (2010), in the UK, the rationale for spin-off policy is mainly to develop a third stream of financing. Spin-offs are part of a policy to commercialize the technology and knowledge universities create. British universities have to find a balance between licensing and spin-off creation, and they can take equity in these new firms. The UK has placed the universities at the heart of policies aimed at the creation of spin-offs. An issue remains as to whether the different numbers of spin-offs and distributions in their types are due to the fact that spin-offs seem to present a certain ambiguity that hinders analysis.

Moreover, using the number of spin-offs and the survival rate as performance indicators of support programs is not enough. We still know little about the development of spin-offs, and it is necessary to attain a better knowledge of university spin-off performance. According to Fini *et al.* (2011), future research should consider spin-offs' effective contributions to economic growth and the extent to which such effects could be related to university-level policies.

The analyses in this paper face some limitations. First, the methodology used is inadequate for reflecting the complexity of support for the creation of university spin-offs. This study is cross-sectional in nature, and therefore has no dynamic perspective. Since the process of creating spin-offs is by its very nature longitudinal, more studies of this type are needed. Second, the technique used for collecting information – a survey of the heads of spin-off support programs in universities – does not allow complete apprehension of the issues associated with support for the creation of spin-offs, because a university that wishes to support spin-off creation successfully needs to be part of networks that offer relationships with a wide variety of agents from the domains of research and business in the different stages of the process (business angels, corporate ventures, venture capital, business incubators, science and technology parks, entrepreneurship centers, government). The need to limit the contents of the survey in order to obtain a sufficient number of answers and the difficulty of obtaining sensitive information, such as the financial resources used by the program or their origins, are also challenges. Finally, although the Spanish sub-sample includes most of the support programs in the country's universities, the sub-sample from the UK cannot be considered sufficiently representative for two reasons: its limited size and the absence of certain prestigious universities.

Notwithstanding all of the above, we believe that this study, by empirically testing some arguments already available in the literature (Clarysse *et al.*, 2002, 2005; Degroof, 2002; Roberts and Malone, 1996; Wright *et al.*, 2007), contributes to the understanding of the role that university policy measures play in spin-off support program effectiveness, and how the environment influences these policies.

Notes

1. Venture capital backed firms start out with external capital from venture capitalists or venture capital firms. They normally have a patented innovating technology that can be used for different applications (a technological platform), and when set up they are still a long way from having a commercially viable product. They tend to have a large entrepreneurial team with little experience in management and industry; however, they usually bring experienced managers on board during the venture's first few years. These companies target significantly sized international or global markets.

2. Lifestyle spin-offs look for a market large enough to provide the founder and his/her family with a comfortable lifestyle, and support job creation or retain employment in the new company's local area. They are characterized by low capitalization, capital owned by people

connected to the founder, low management capacity, and little or no growth orientation. They are ultimately survival oriented.

3. Prospector spin-offs are growth oriented, but in a university environment that is unfavorable to entrepreneurship they get no support. As a result, they are spun off at an early stage with no solid business model; their main base is the founders' scientific knowledge. They have moderate growth orientation, an intermediate level of capitalization, and capital owned by people closely connected to the founder, as well as some external investors who are not venture capitalists. As time passes, they gain management experience and skills, enabling them to determine their specific business models and grow faster.
4. This study is part of a broader literature that has evaluated the degree of implementation of university spin-off support programs in Europe, the type of measures adopted, the main problems faced and the results obtained. Moreover, we proceed to identify distinguishing features of Spanish universities compared to the UK and the rest of Europe. For this reason, the starting sample used in the factorial analysis consists of European universities, although the cluster analysis applies only to Spanish and British universities.
5. Likewise, 255 universities were identified in the rest of Europe and replies were received from 42, representing a response rate of 17 percent. However, only 24 universities replied to all or practically all items. Thus, the complete response rate was 9 percent in the rest of Europe.
6. From this exploratory perspective, factorial analysis has no restriction a priori on the estimation of the components or number of components to be extracted.
7. This criterion is based on the rationale that any individual factor must justify the variance of, on average, at least one unique variable. Each variable contributes a value of 1 to the total eigenvalue. For this reason, only factors that have latent roots or eigenvalues >1 are taken into account.
8. We used logistic regression analysis because other types of analysis, such as discriminant analysis, rely on fulfillment of the assumptions of multivariate normality, homoscedasticity and the equality of covariance matrices among the groups, conditions that have not been proven to exist in our case. In contrast, logistic regression does not rely on such strict assumptions and is much more robust when the assumptions are not met, thereby making it eminently suitable for these situations.
9. According to Snedecor's *F*-test, the three conglomerates do not show significant differences in size, measured in terms of the number of students. Thus, Conglomerate 1 has 24,988 students on average, Conglomerate 2 has 25,337, and Conglomerate 3 has 23,846. Size does not, therefore, appear to be a differentiating characteristic for the conglomerates.
10. Binary logistic regression with SPSS allows defining the method of entering the independent variables for developing the model. One can choose any of the options including Enter, Forward:LR, Forward:Wald, Backward:LR, or Backward:Wald. Enter method is usually selected when a specific model needs to be tested or the contribution of independent variables toward the target variable is known in advance. On the other hand, if the study is exploratory in nature, any of the forward or backward methods are used. The Forward:Wald method was used in this study because it is exploratory in nature.

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