

## Article

# Rethinking the Resources and Responsibilities of University Spin-Offs: Critical Factors in Times of Global Crisis

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**Abstract:** In recent years, the promotion of university spin-offs has become a measure adopted by many European universities to facilitate the commercialization of new technologies and knowledge that can lead to more sustainable economies and societies. However, the effectiveness of university-based companies has also been questioned, as many of them are resource-constrained, remain small in size and struggle to consolidate once they leave the university context. This paper addresses two main research questions: what are the critical factors inhibiting the consolidation, performance, and sustainable development of university spin-offs at a mid-range European university, and which critical factors need to be addressed the most thoroughly by the university's support programs in order to improve their efficiency? To answer these questions, we collected relevant information from a panel of experts and interviewed academic entrepreneurs from a public university in the South of Spain. The analytic hierarchy process was applied to identify and prioritize the critical factors and sub-factors encountered by the university-based companies. The results show that poor management is the biggest critical factor in the consolidation of the spin-offs. One implication, the findings of our study reveal, is the need for university administrators to improve support for university spin-offs in terms of managing the new business as opposed to prioritizing the difficulties associated with the launch. Another is the need to raise awareness among faculties of the importance of finding an appropriate balance between technical and managerial skills in order to improve the chances of entrepreneurial success.

**Keywords:** university spin-offs; academic entrepreneurship; technology transfer; entrepreneurial universities; analytic hierarchy process (AHP)



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## 1. Introduction

In the last few years, European societies have had to face major societal and environmental challenges [1–4]. The COVID-19 pandemic and the war between Russia and Ukraine have worsened existing problems, such as ageing populations, energy shortages, and climate change [1,5,6]. In this context, universities have been recognized as essential agents in Europe's post-pandemic recovery for shaping resilient societies and sustainable economies [7]. Universities are acknowledged as key actors in conducting research to find solutions in cooperation with industry and society [1], and particularly in laying the paths for environmental sustainability through the commercialization of their scientific discoveries and technological innovations via spin-offs [7–12].

Indeed, the creation of university spin-offs or university-based companies—new companies established for the exploitation of the results of scientific knowledge, core technology, or technology-based ideas generated within a university [13,14]—is currently one of the most celebrated tools of knowledge and technology transfer by universities and local policymakers [12,15]. University-based companies have been widely acclaimed by local

and regional governments for their contribution to the transformation of low-tech sectors into high-tech industries, especially through stimulating sustainable process design [16,17], increasing regional productivity [18], and creating new employment opportunities in sustainable sectors [12]. At the same time, university spin-off creation has become one of the main strategies for turning higher education institutions into entrepreneurial universities [19,20], thus materializing their third mission—the transfer of new technology and knowledge to the productive sector and to society in general—alongside the traditional university functions of research and education [21].

Notwithstanding the increasing interest in the creation of university spin-offs [20,22,23], it remains the most complex way of commercializing technology and academic research [24,25]. The process can take a long time—even years—to come to fruition [25], and compared with other technology transfer strategies, such as research collaborations with businesses, it consumes more university resources and requires greater involvement from other socio-economic agents [26]. In fact, in the European context, where there is not a strong tradition of collaborations between universities and industries, such as might be found in the well-known examples of Silicon Valley and the Boston area [27], the need for links with industry and other public and social agents turns out to be a significant barrier for the creation of university-based companies [28,29].

In this respect, the support measures adopted by universities through their technology transfer offices become fundamental [30]. The role that they may play in the effectiveness of university-based companies has been widely studied by scholars [30,31]. Nonetheless, in the wake of the unexpected events of the COVID-19 pandemic and the unprecedented disruptions to scientific research that took place as a consequence, concerns have recently been raised [32,33]. In mid-range universities [29], the uncertainty surrounding R&D processes, along with a lack of resources, are considered critical factors in the success and consolidation of university-based companies [32]. In fact, it is generally recognized that, in this context, university spin-offs do not attain the same social and economic results as their non-academic counterparts [15,28]. Although previous studies have explored the reasons for these differences, e.g., [14,28], their findings are open to interpretation, and the focus has often been put on large, consolidated universities [14]. Moreover, since the start of the present global crisis triggered by the COVID-19 pandemic, research into these issues remains scarce, particularly in reference to smaller universities. In this paper, we aim to address this gap in the literature by identifying the main difficulties faced by university spin-offs in the present global crisis in order to gain a better understanding of factors hindering their success and to suggest actions and tools for tackling such challenges. More specifically, we address this gap by providing evidence from academic entrepreneurs who set up university spin-offs at a mid-range university in the South of Spain.

In this context, we are particularly concerned with the following research questions: what are the critical factors inhibiting the consolidation, performance, and sustainable development of such spin-offs within their field; and which critical factors need to be addressed the most thoroughly by the university's support programs in order to improve their efficiency? The answers to these questions required identifying and prioritizing the critical factors and sub-factors encountered by the university-based companies. To do so, we collected relevant information over the years 2020, 2021, and 2022 and used the analytic hierarchy process (AHP) to determine the importance of one particular factor in relation to another. AHP is a multi-criteria decision analysis technique, which, because of its recognition of biases and inconsistencies in subjective judgments [34,35], is used across a wide range of fields involving group decision-making. It enables the inconsistencies to be tested and improved, resulting in a more consistent final ranking [36]. The results of our application of AHP to the challenges facing university spin-offs shed light on the chief obstacles to their creation and consolidation at mid-range universities. Furthermore, the AHP approach provides practical applications for academic entrepreneurs, university policymakers, and other stakeholders who seek a framework to guide the comprehensive

qualitative and quantitative assessment of dimensions, factors, and attributes that influence the activity of university spin-offs in challenging times.

In the remainder of the paper, we first review the literature about the main constraints that hamper the consolidation and sustainability of university spin-offs. This is followed by a description of the research methodology, after which the main results are presented. Finally, we highlight the main conclusions and future lines of research.

## 2. Literature Review

The effectiveness and success of university spin-offs are affected by two basic premises. The first is their scientific and technological basis, as a consequence of which they encounter the same difficulties as any other new technology, in addition to all the traditional problems start-ups face [37,38]. The second is that, because they are companies created within a university context, their outcomes are expected to have a social and environmental value, at least within the local and regional sphere, in addition to operating within the ethical guidelines binding higher education institutions [10]. As a consequence, university spin-offs are uniquely configured and constrained in terms of resources and responsibilities in comparison with other new enterprises [13,14,39]. We analyze these aspects in more detail in the following subsections.

### 2.1. University Spin-Offs: Critical Resources

As noted above, university-based companies carry out entrepreneurial activities that involve the development of scientific knowledge or the application of new technology [13]. From a resource-based perspective, in which companies are described as a bundle of resources [40], it is in scientific knowledge or new technology that university spin-offs find their *raison d'être*. These resources play a key role not only in differentiating them from other companies [41], but also with regard to their expected impact in terms of their performance and contribution to the transition to more sustainable economies [7,42]. Despite these high expectations, empirical studies have demonstrated that university-based companies are resource-constrained firms [28,43]; they tend to remain relatively small—not larger than ten employees—and fail to grow [15,25,28,44].

Previous studies have stressed four kinds of resources that are especially problematic for university spin-offs: human, commercial, financial, and institutional [25,41]. Specifically, the composition of the founding team and their entrepreneurial capabilities are considered a key part of the human capital, affecting the consolidation and long-term performance of university spin-offs [15,45,46]. Moreover, although academic entrepreneurs are frequently outstanding in terms of their technical and research capabilities, they typically lack market-based experience, with the result that many of them fail to seize market opportunities [47]. Indeed, throughout their life-span, many university-based companies face various kinds of market-related difficulties [14,48]. In this regard, it has been recognized that establishing strong ties and collaborations with different stakeholders (e.g., industrial customers, financial companies) is an extremely important means by which academic entrepreneurs can access managerial resources and capabilities [13,47]. Industrial partnerships, for instance, are acknowledged as particularly critical assets for the development of university spin-offs [49]; yet the difficulties in establishing such ties seem to be higher in southwest European countries, such as Italy and Spain [50].

The literature also notes the significance of financial resources for the consolidation of university-based companies [14,15]. Achieving financial support is one of the biggest challenges that university-based companies face in counterbalancing the limitations imposed by small size and novelty that typically accompany university spin-offs [44]. Further, the high costs of developing technological innovation [7,42] have been exacerbated by the problems that the COVID-19 pandemic and the recent energy crisis have brought to the business world [28,33].

Finally, institutional factors associated with the parent university and the local context are, at times, important barriers to the consolidation and success of university spin-

offs [22,45]. For instance, the internal set-up, such as the approaches used by the technology transfer office to promote and support the creation and consolidation of university spin-offs, can have a significant effect on their activities and outcomes [28,51]. More specifically, weak infrastructures, scarce support mechanisms from the parent university, and insufficient resources for technology transfer are clear obstacles that impede the performance of university-based companies [14,52]. A particular challenge for academic entrepreneurs at mid-range universities with little entrepreneurial tradition is that the academic system itself, with a high level of bureaucracy and an aversion to risk, tends to display a low appreciation of the commercialization of science and technology [14,28]. All these difficulties might lead to conflicts between the parent university and the university spin-off, which need formal interventions to be resolved [53,54]. In the same vein, the negative perception of some academic departments and colleagues towards university spin-offs can also be a critical factor hampering the activities of university-based companies [55,56].

## *2.2. University Spin-Offs and the Limits of Academic Entrepreneurs' Critical Responsibilities*

While academic entrepreneurs are often well perceived as teachers and researchers—teaching at a university is recognized as a prestigious profession [57]—the creation of university spin-offs adds new responsibilities to their professional practices. As entrepreneurs, the academics become engaged not only with the norms and values established by the higher education institution but also with the ethical regulations and practices that operate in the industry and the business world [58]. For example, over the last two decades, there has been a notable increase in the commitment of universities to sustainable development [12]. Recently, they have begun to place such a commitment at the heart of their third mission, with norms and regulations that serve to align their structures and activities with new sustainable development responsibilities, such as those promoted by the United Nations' 2030 Agenda for Sustainable Development [59]. The creation of a university spin-off thus implies that the process of establishing the business has already been evaluated in terms of what is allowed and what is forbidden in the university context. In addition to regulatory considerations, this responsibility also includes a personal commitment on the part of the development team to adhere to the university regulations concerning the creation of spin-offs.

However, academic entrepreneurs' commitment to science and university life might, at times, conflict with their entrepreneurial activities, especially when research and business interests diverge [15]. In this respect, serving the public interest—a typical goal of academic activity—might conflict with the commercialization of knowledge and technology by university spin-offs [60], so that academic entrepreneurs may find themselves facing ethical dilemmas without a clear indication of how they should respond. We might think of cases, for example, in which academics accustomed to unhurried deliberation find their habitual practices to be in total contrast to those associated with business management, e.g., Western traditions of rapid decision-making [61]. Recent literature has also drawn attention to the pressure that some academic entrepreneurs might come under in their search to align useful scientific knowledge with knowledge that may be useful from a commercial point of view [60]. Indeed, there is an ongoing debate about whether and how knowledge and technology generated within universities should be commercialized, and there are increasing concerns that the very notion of serving the public interest is in danger of becoming enveloped by market logic [60,62]. The challenge is to balance academic entrepreneurs' scientific interests with their entrepreneurial orientation; the former is essential for the process of discovery and early technological development, while the latter is equally necessary to ensure the successful incorporation of their discoveries into the marketplace [15].

### 3. Methodology

#### 3.1. Research Context

The research context of our study is located in a public university in the South of Spain. It is a mid-range university [29] created in 1993 in a small province of around 500,000 inhabitants. The staff comprises approximately one thousand lecturers distributed across 23 departments, plus more than four hundred administrative and support staff. There are close to 12,000 full-time students, including about 2000 postgraduates [63].

Since its creation, the attitude of policymakers at the university towards knowledge and technology transfer has been positive and proactive, despite limited resources. They have implemented policies aimed at promoting good relations with the local community and have carried out activities oriented towards improving the economic, environmental, and cultural development of the local context [63]. One of the main economic agents in the area is a chemical park, the largest of its kind in Spain, which provides employment for over 10,000 people [64]. In addition to the chemical industry, the agricultural and fishing sectors, along with the tourism industry, are also important economic agents in the area with which the university has important links.

Despite these links to a varied range of industries, the creation of university-based companies remains an exceptional activity among academics. At the beginning of 2020, there were twelve established university spin-offs, of which eight still retained a strong link with the parent university and which served as the sample for the empirical study presented in this paper. Among the main characteristics of this sample of academic entrepreneurs, half are women and half are men, with an average age of 52 years. Most had been working at the university for more than 15 years (88%) and had a permanent position (75%). Seven out of the eight spin-offs had been running for more than three years and none employed more than three workers. Half were created to commercialize scientific knowledge, while the other half were the result of technological innovation. Most targeted global markets (63%) worked in collaboration with other firms (100%) and generated revenues of less than EUR 20,000 per year (62%) (see Table 1).

**Table 1.** Profile of the academic entrepreneurs and university spin-offs.

Characteristics	Frequency	Percent (%)
Academic entrepreneurs		
Gender		
Female	4	50
Male	4	50
Age		
40–50	4	50
51–60	2	25
>60	2	25
Current Situation		
Faculty member without permanent position	2	25
Faculty member with permanent position	6	75
N <sup>o</sup> years working at the University		
Between 5 and 10 years	1	12.5
Between 15 and 20 years	4	50
More than 20 years	3	37.5
University spin-offs		
Activity sector		
Traditional or “low tech” sectors	3	37.5
High-tech sectors	5	62.5
Number of employees (even only some periods)		
Only one	2	25
Between 2 and 4	6	75

**Table 1.** *Cont.*

Characteristics	Frequency	Percent (%)
Collaboration with other firms		
Yes	8	100
No	0	0
The creation of the spin-off/start-up was the result of		
A technological innovation or technological progress	4	50
A commercialization-driven innovation process	4	50
General revenues per year		
Less than 20,000 €	5	62.5
Between 20,000 and 50,000 €	3	37.5
Main market		
Local	1	12.5
National	2	25
Global	5	62.5

### 3.2. Research Design

As noted above, the main goal of this study was to identify and understand the relative importance of the most critical factors facing spin-offs at a mid-range university in the South of Spain, in order to consolidate their market position and contribute to sustainable development, especially during the time of global crisis that began with the COVID-19 pandemic. To this end, during the year 2020 (from April to June), 12 online interviews were conducted with each academic entrepreneur responsible for the spin-offs at the university. The interviews lasted between 60 and 90 min. No specific protocol was followed; instead, an open question format was used with the sole aim of learning about the main challenges of developing the spin-offs as the entrepreneurs saw them. There were three interviewers taking part, who took notes throughout.

These initial interviews were then followed up in 2021 in order to update the academic entrepreneurs' perceptions of the everyday challenges of running their business. However, only eight of the academic entrepreneurs took part in this second round of interviews, as one spin-off had since folded, and three of the others could no longer continue with the study. In a similar fashion, the interviews were conducted by just two of the original interviewers. In parallel with these interviews, we consulted a panel of experts (six people in total), consisting of teaching staff and specialists in the technology transfer offices of several southern universities (in Spain and Portugal). The panel was constituted by convenience sampling. We specifically adopted a snowball sampling approach [65] so as to obtain the names of researchers whose views could be of interest in clarifying our concerns in this paper. Among potential participants (ten in total), our final choice was based on accessibility to an available pool of respondents and their technical and professional knowledge, which would provide interesting insights into the topic (see details in Table 2). This panel, operating over a series of online meetings, provided information about the typical demands of spin-offs on their parent universities and exchanged different perspectives on the challenges they face.

**Table 2.** Expert panel's details.

Expert	Gender	Age	Country	Professional Profile
E1	Male	47	Spain	Staff from the TTO
E2	Male	54	Spain	University professor, TTO's adviser and entrepreneur
E3	Male	51	Portugal	Director from the TTO
E4	Female	51	Spain	University professor and academic entrepreneur
E5	Female	54	Spain	University professor and researcher
E6	Female	50	Spain	University professor and researcher

All the information collected during 2020 and 2021 was contrasted with the literature, and applied to the design of a questionnaire for analysis following the standard paths of the AHP method [66,67] (see Appendix A). This questionnaire was then used in a series of final interviews with the eight academic entrepreneurs, which took place in 2022 (from March to June). The AHP method and the steps we took are explained in the following subsection, followed by the results of the questionnaire.

### 3.3. Analytic Process

The AHP is a method used in multi-criteria decision-making problems. It assigns different weights to the evaluation items based on the weights of the decision criteria. The main functions of the method are structuring complexity, measuring on a ratio scale, and synthesizing a decision [68,69]. The method was introduced by Thomas Saaty [68,70], and over the years, he and his collaborators [71] have provided detailed information about the AHP axioms that should be considered in any study using this method.

The AHP has recently been used in the spheres of entrepreneurship and technology transfer [72,73]. In this paper, we apply the AHP to prioritize the critical factors or obstacles that affect the consolidation of spin-offs at a mid-range university in the South of Spain. This approach aims to convert qualitative factors into a quantitative analysis via fuzzy mathematical theory [74], which can adequately deal with the inherent uncertainty and imprecision of the human decision-making process [75].

We followed the sequence of stages in the standardized application of the AHP method, which consists of determining the structure of the hierarchical model, formulating a paired comparison matrix of the elements, and establishing priorities [70].

#### 1. Determination of the structure of the hierarchical model

The initial step in the process is to formulate the decision problem into a hierarchical structure by identifying the most significant components. First, the overall objective is established, and then the criteria for achieving this are identified, along with the alternatives [67,76]. Items on the same level have the same order of magnitude and are related to items on the next level.

In our study, the criteria and subcriteria refer to the difficulties and challenges that university spin-offs have faced in their everyday business activities since the COVID-19 pandemic. The items used as criteria (factors) and subcriteria (sub-factors) were derived from the literature review (see Sections 2.1 and 2.2) and from our conversations with the expert panel, respectively. Figure 1 presents these criteria and subcriteria, while Table 3 provides a brief conceptual clarification for each one.

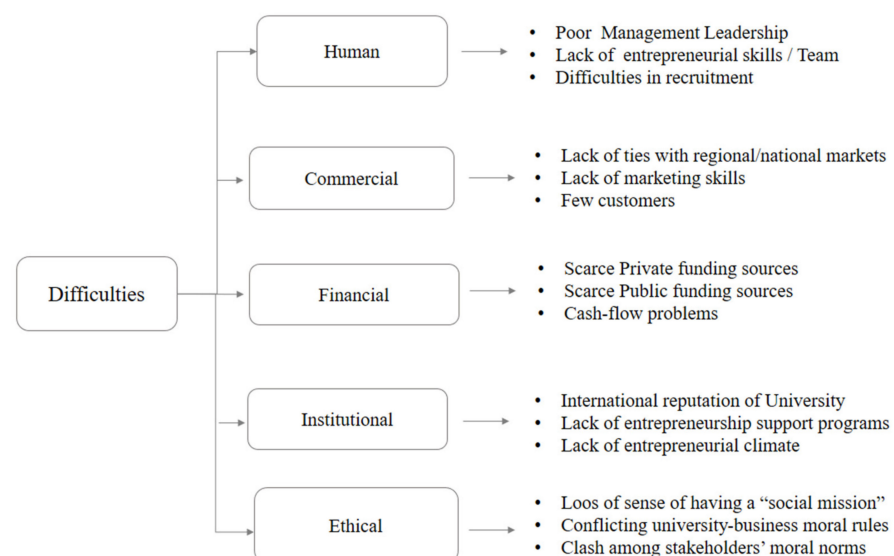


Figure 1. Hierarchy of application model.

**Table 3.** Items summary.

Criteria	Subcriteria	Description	References
Human	Poor management	Limitations in the capability to efficiently manage human problems among the members of the team and/or in the capacity of knowledge management to enhance the spin-off's innovation	[45,46]
	Lack of entrepreneurial skills/Team	Lack of entrepreneurial skills and/or unbalanced skills in team	
	Difficulties in recruitment	Limitations in the capability to recruit and retain high-skilled employees (with a strong educational background in science, engineering, and management)	
Commercial	Lack of ties with regional/national markets	Lack of opportunities to meet with local/regional/national or foreign businesses that might collaborate with the spin-off	[14,48]
	Lack of marketing skills	Limitations in marketing skills and the use of social media as marketing instruments to attract potential customers	
Financial	Few customers	Lack of a critical mass of customers for the product/service	[14,15]
	Scarce private funding sources	Difficulties in attracting external venture capital support	
	Scarce public funding sources	Difficulties in applying for state (public) subsidies	
Institutional	Cash-flow problems	Difficulties in maintaining regular activities that provide the necessary cash flow to face current expenses	[28,51]
	International reputation of university	Lack of research orientation, tangible resources, prestige, and reputation at the university/institution	
	Lack of entrepreneurship support programs	Lack of incubators, accelerators, technology parks, or support measures to support entrepreneurship	
Ethical	Lack of entrepreneurial climate	Lack of an entrepreneurial culture and climate within universities and departments	[60,62]
	Loss of sense of having a "social mission"	Lack of sense of achievement; loss of the sense of "having a social mission to be of greater help to society"; failure to achieve the expected standards of excellence	
	Conflicting university-business ethical norms	Conflicting norms and directives between entrepreneurial and academic life	
	Clash with stakeholders' ethical behaviours	Conflicts between academic entrepreneurs' personal ethical values and stakeholders' (e.g., specific customers, partners, competitors, public institutions) ethical demands in unexpected situations	



## 2. Pairwise comparisons of the elements through fuzzy logic

In this phase, a matrix of pairwise comparisons of the criteria and subcriteria was created according to the evaluations given by the expert panel and using the Saaty [70] measurement scale (see Appendix A). Hence, a total of six pairwise comparison matrices (five  $3 \times 3$  for the sub-criteria and one  $6 \times 6$  for the criteria) were obtained. A sample received from the expert panel is shown in Table 4.

**Table 4.** Pairwise comparison matrix of the “human” sub-criteria.

Subcriteria *	C 1.1	C 1.2	C 1.3
C 1.1	1	6	7
C 1.2	1/6	1	6
C 1.3	1/7	1/6	1

\* C 1.1: Poor management; C 1.2: Lack of entrepreneurial skills/Team; C 1.3: Difficulties in recruitment.

The resultant matrix of judgments was then transformed into fuzzy numbers by converting the Saaty scale into a scale of fuzzy triangular numbers following the alternative proposed by Kabir and Hasin [77]. These were represented as triplets (l, m, n) where m was the mean value, n the upper limit, and n the lower limit (triangular membership function). In addition, linguistic variables were established for the importance weights of each criterion. Table 5 shows the fuzzy matrix obtained for Table 4.

**Table 5.** Fuzzy pairwise comparison matrix of “human” sub-criteria.

Subcriteria *	C 1.1	C 1.2	C 1.3
C 1.1	(1, 1, 1)	(5,6,7)	(6,7,8)
C 1.2	(0.14, 0.174, 0.2)	(1, 1, 1)	(5,6,7)
C 1.3	(0.12, 0.14, 0.16)	(0.14, 0.174, 0.2)	(1, 1, 1)

\* C 1.1: Poor management; C 1.2: Lack of entrepreneurial skills/Team; C 1.3: Difficulties in recruitment.

## 3. Establishment of priorities

This step aimed to determine the geometric mean for each diffuse criterion. Following Rostamy et al. [78], we used the geometric technique to calculate the geometric mean of the fuzzy comparison values of criterion  $i$  with respect to each of the other criteria:

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \dots \otimes \tilde{a}_{in})^{\frac{1}{n}} \quad (1)$$

where  $an$  is the fuzzy value of the pairwise comparison of criterion  $i$  with respect to criterion  $n$ . Then, the fuzzy weights of each of the criteria were calculated via:

$$\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \dots \oplus \tilde{r}_n)^{-1} \quad (2)$$

Afterwards, the fuzzy weight of criterion  $i$  was transformed into a positive equivalent number and then normalized:

$$M_i = \frac{l \times w_i + m \times w_i + n \times w_i}{3} \quad (3)$$

$$N_i = \frac{M_i}{\sum_{i=1}^n M_i} \quad (4)$$

The weight of each alternative was multiplied by each of the corresponding criteria, and the score for each alternative was obtained as a result. In this phase, the consistency index was calculated to reduce the subjectivity of the judgment and to guarantee the rationality of the weightings. When the consistency index was less than 0.1, the consistency of the judgment matrix was considered reasonable.

First, the eigenvector  $\lambda_{max}$  was calculated as:

$$\lambda_{max} = T \times W \quad (5)$$

where  $W$  was the triangular number representing the sum of the columns of the comparison matrix and  $T$  was the normalized eigenvector. Table 6 shows the results of applying the previous steps to the “human” sub-criteria.

**Table 6.** Geometric means ( $\tilde{r}_i$ ) & fuzzy weight ( $\tilde{w}_i$ ) and averaged weight ( $M_i$ ) and normalized weight ( $N_i$ ) of “human” sub-criteria.

C 1 *	$\tilde{r}_i$	$\tilde{w}_i$	$M_i$	$N_i$
C 1.1	(3.10, 3.47, 3.82)	(0.85, 1.12, 1.42)	1.130	0.728
C 1.2	(0.89, 1.00, 1.12)	(0.24, 0.32, 0.41)	0.327	0.211
C 1.3	(0.26, 0.28, 0.32)	(0.07, 0.09, 0.12)	0.095	0.061

\* C<sub>1.1</sub>: Poor management; C<sub>1.2</sub>: Lack of entrepreneurial skills/Team; C<sub>1.3</sub>: Difficulties in recruitment.

Subsequently, the consistency index (CI) was calculated as:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (6)$$

Given that  $\lambda_{max}$  was also represented by a triangular number, it could be transformed using, for example, the central value of the triangular number representing the position of the centroid of the triangle corresponding to the maximum triangular number.

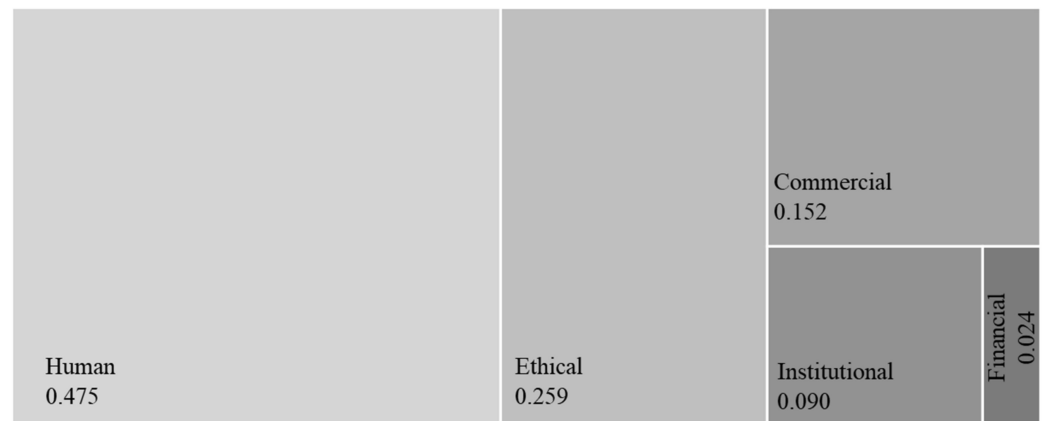
Finally, the consistency ratio (CR) was calculated as:

$$CR = \frac{CI}{RI} \quad (7)$$

$RI$ , random index, is a constant value for an  $n \times n$  matrix, obtained by simulating matrices of equal size, taking into account the same comparison scale and ensuring that  $a_{ij} = 1/a_{ji}$ . In order to calculate it, Saaty [79] approximated the accumulated index of cases (IA) for various sample sizes  $n$  based on different tests. If  $CR$  is less than 0.1, this indicates that the total consistency of the evaluations or comparisons is expressed in the comparison matrix.

#### 4. Research Findings and Discussion

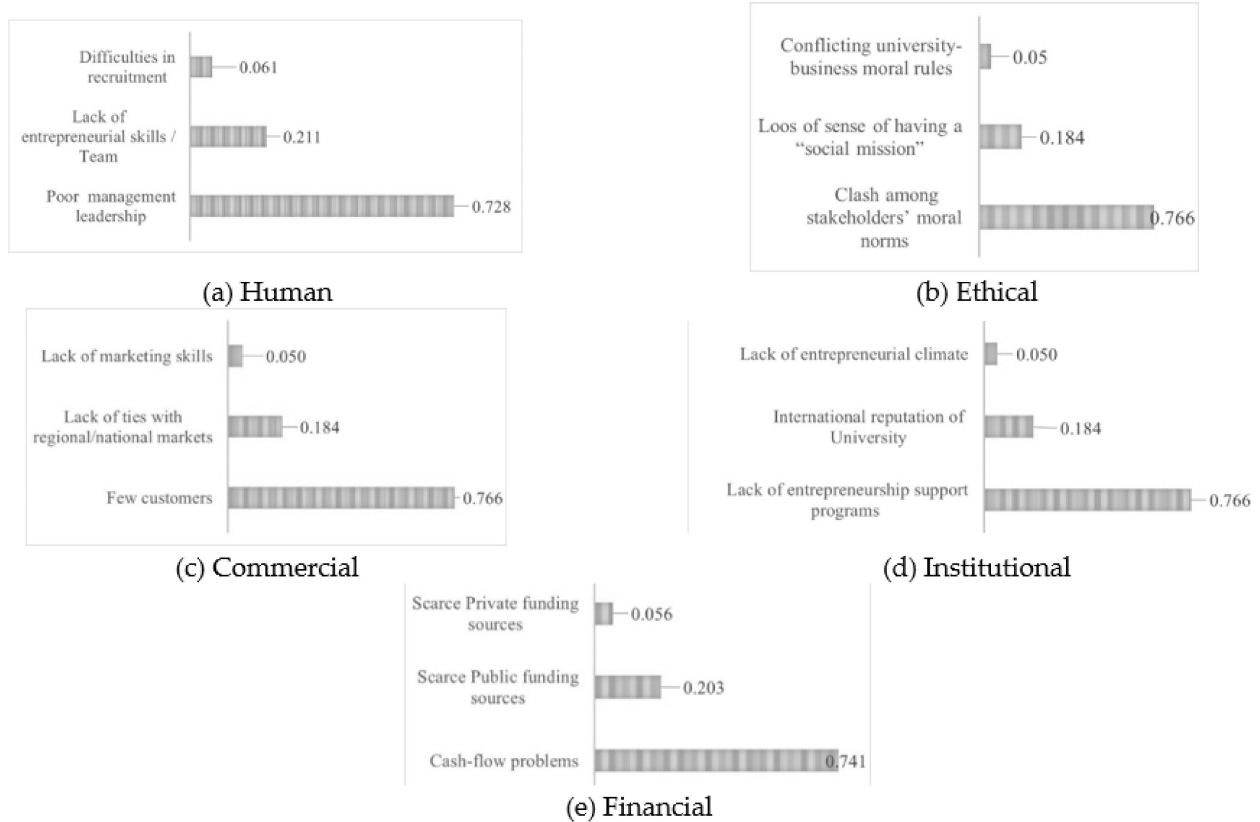
Figure 2 summarizes the main critical factors that inhibit the consolidation, performance, and sustainable development of the spin-offs at the mid-range university analyzed in the context of the current global crisis. Specifically, it illustrates the answer to our first research question by showing the relative importance and the associated weights of the main problems that hamper the day-to-day running of the spin-offs. In line with previous studies [15,45,46], our results show that the most significant constraints are related to human resources (0.475). In our study, these constraints are then followed by ethical challenges (0.259) and commercial problems (0.152). Since both ethical and commercial challenges are associated with the relationships between academic entrepreneurs and other actors, whether in markets or other contexts [47,61], they can be considered as problems that are closely linked to the limitations in human capital identified as the main factor hampering university spin-offs.



**Figure 2.** Relative importance of the criteria and the associated weights.

On the other hand, institutional support and access to financial resources, typically critical factors in the launch of any kind of business, not least university spin-offs [22,44,45], turn out to be less significant in comparison with human, ethical, and commercial challenges.

Figure 3 illustrates the responses obtained with respect to our second research question. Particularly, it presents a more fine-grained analysis of the previous critical factors or difficulties—human, ethical, commercial, institutional, and financial—according to the corresponding sets of subcriteria [70,71], which consider more specifically the kinds of challenges within each critical factor that academic entrepreneurs face in the everyday running of their business.



**Figure 3.** Relative importance of the criteria and sub-criteria and the associated weights.

From the analysis, it becomes clear that the biggest problem associated with human capital concerns poor management. In this respect, our analysis confirms what studies in other university contexts have pointed out [47,48], specifically, that academic entrepreneurs

struggle to find an effective way to manage the human conflicts that emerge among members of the founding team. Consequently, despite their discoveries and innate knowledge and the high expectations placed on university-based companies to lead the way towards more technologically sustainable economies and societies [7,8,11], the academic entrepreneurs interviewed found themselves unable to use their capacities to maximize the innovation marketed by the spin-off. However, contrary to what is generally reported in the literature [15,45], the lack of entrepreneurial skills seemed to be a far less important issue, at least in comparison with poor management (0.728 and 0.211, respectively). Difficulties in recruitment, despite being a potential challenge in the context of big universities [46], were barely perceptible in our study (0.061). This peculiarity was likely due to the small size of the spin-offs and the lack of other job opportunities for recent graduates, who tended to fill positions in the university-based companies.

Regarding ethical challenges, the results suggest that while the differences between the norms governing the academic and business contexts were not a significant problem for academic entrepreneurs, the resultant change in role—from researcher pursuing an academic career by teaching and researching to entrepreneur commercializing their technology and knowledge through products and services in the business world [15]—together with the different ethical behaviors implied by these roles, were important concerns for academic entrepreneurs, which could end up affecting the spin-off's outcomes. Such might be the case, for example, of academic entrepreneurs who, as researchers, dedicate a lot of time to thinking about and researching new technologies for solving environmental problems, but find that the dynamics of day-to-day business life demand rapid solutions and scaling up of the impact [60,61]. In other words, as has been pointed out in the literature [15], the integration of business routines into a busy academic life may become problematic, to the point where it might limit the researcher's motivation to work for the growth of their spin-off.

With respect to commercial challenges, it is important to note that beyond the difficulties that might be associated with the creation of links with local/regional markets or with the founding teams' marketing skills [14,47,48], the crucial factor lies in the difficulties of achieving a critical mass of customers. To put it bluntly, no matter how good the technology or scientific discovery might be, there is simply not enough demand to maintain regular business throughout the year. In this regard, the length of time required for new technological products to become known to their potential customers [37,38] might be a major obstacle for university-based companies. In addition, the optimism that often characterizes both academic entrepreneurs and higher education institutions [12,15–21] might have led these actors to place too much faith in business plans that overestimate the value of the core business idea and technological innovation, while issues related to the market, such as barriers to entry or distribution channels, remain underappreciated.

The commercial problem described above is, in turn, connected to the problem of cash flow, which was identified as the biggest challenge within the financial area (74.1% according to the AHP results). Interestingly, the limited availability of private sources for funding was not identified as an important barrier to effectively commercializing university technologies, despite previous studies having recognized it as such [15,28]. Finally, in terms of institutional support, the key issue was, in accordance with much literature on this topic [14,52], the lack of support measures for university spin-offs rather than any specific characteristics of the university, such as its prestige and research orientation or the lack of an entrepreneurial culture.

## 5. Conclusions

In recent years, the need for academics to engage in entrepreneurial activities has arisen, in part, from the demand for modern universities to become entrepreneurial universities [19,20] and to increase their contribution to the transition from traditional to more environmentally friendly economies [7]. In this respect, there has been a recognition of the positive role that university spin-offs can play by commercializing the scientific knowledge

and technology generated by the university [7–9]. However, the complexity of the process required to create a spin-off coupled with the complex environment in which academics work today [25] have together increased the challenges that university-based companies face in order to survive and develop in the market [32,33].

In this paper, we have investigated the main challenges that the university spin-offs from a Spanish university face following the global crisis that began with the unexpected events related to the COVID-19 pandemic. By using the AHP method [68,70], we categorized the main challenges into five clusters of criteria relating to human, financial, commercial, institutional, and ethical issues. In a second phase, and using an integrated fuzzy approach, we identified and categorized the importance of these criteria and sub-criteria. The results obtained have shown that the greatest challenges for the university spin-offs analyzed are issues associated with human capital, particularly the lack of proper management, alongside those related to ethical decision-making, and more specifically, when academic entrepreneurs' ethical values and those that prevail in the business context clash. Other critical factors hindering the consolidation and success of university spin-offs are cash flow problems associated with a lack of demand for the commercialization of the products, services, or processes, and insufficient support measures.

Considering these outcomes, we conclude that finding a proper balance between managerial and technical competence among the members of the founding team is crucial to the consolidation and success of university spin-offs. To this end, we suggest that university practices for supporting the creation of university-based companies need to be more active in the area of management instead of prioritizing the difficulties associated with the launch of the spin-off. This might help academic entrepreneurs face some of the ethical challenges that may emerge in their relationships with their stakeholders, such as customers, suppliers, or staff from the industry. Moreover, since commercialization is an essential stage within the innovation and management process, and taking into account the difficulties that academic entrepreneurs have in adopting a commercial identity [15], additional support for academics in the form of professional mentoring in management and commercial practices might lessen their challenges, especially when they are trying to exploit business opportunities. For as long as academic entrepreneurs lack these competences and support, the difficulties of succeeding in their entrepreneurial role increase, as does the risk of the failure of their spin-off.

Nonetheless, it is important to recognize that this study has been limited to identifying and prioritizing the critical factors facing spin-offs in a particular university context. There are also limitations regarding the number of spin-offs that were analyzed. Undoubtedly, a wider range of data on university spin-offs would help to increase the value of the analysis. This was an exploratory study, primarily aimed at clarifying the critical resources and responsibilities to which greater attention should be paid in order to help the spin-offs from a mid-range university to consolidate and survive in the current global crisis. Nevertheless, there is room for future studies to investigate other contexts which may provide information from a greater number of spin-offs. Further, while we have shed some light on this issue, we have not explored how the different difficulties are specifically linked to the consolidation, performance, and sustainable development of the spin-offs, nor how they affect sustainable development at large. Further studies might develop these aspects by adopting the focuses taken in other research, such as the study of the influence of a particular aspect in the development of spin-offs over time e.g., [54], the reasons behind some of these problems e.g., [47], or the individual entrepreneurial factors that might be analyzed, e.g., [80], and affect sustainable development more directly; indeed, we encourage scholars to do so.

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**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** Not applicable.

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**Appendix A. AHP Questionnaire**

Data related to the main difficulties associated with the everyday activity of the spin-off/start-up in the current period (post-COVID and high uncertainty).

The scale (1–9) must be used to assess the relative importance of each factor (A) over the other (B), in terms of the difficulty/challenge that it supposes in your daily business life.

*Example:*

Numeric Scale	Explanation
1	A and B implies the same challenge.
3	A is moderately more challenging than B.
5	A is strongly more challenging than B.
7	A is very strongly more challenging than B.
9	A is absolutely more challenging than B.
2, 4, 6, 8	Represents between values, such that 8 corresponds to a value more than 7 and less than 9 for A.

- Comparing A and B, if two factors imply the same challenge for the everyday business life, choose 1.
- If the issue on the right implies a greater challenge/difficulty for your everyday business life, then choose corresponding value on the right and vice versa.
- Note that, you can choose only one value in each row.

Factors	Importance of the Issue/Difficulty																Factors	
A	9	8	7	6	5	4	3	2	<del>1</del>	2	3	4	5	6	7	8	9	B
A	9	8	7	6	5	4	3	2	1	2	3	<del>4</del>	5	6	7	8	9	C
B	9	8	7	6	5	<del>4</del>	3	2	1	2	3	4	5	6	7	8	9	C

Following the previous example, assess which one of the following pair of factors implies a bigger (or in case similar) challenge/difficulty for the everyday activity of your spin-off/start-up in current times.

- Human factors
  - Poor management: Limitations in the capability to efficiently manage human problems among the members of the team and/or in the capacity of knowledge management to enhance the spin-off’s innovation.
  - Lack of skills: Lack of entrepreneurial skills and unbalanced skills of team.
  - Difficulties in recruitment: Limitations in the capability to recruit and retain high-skilled employees (with a strong educational background in science, engineering, and management).

Factor/Difficulty	Challenges—Human Factors																Factor/Difficulty	
1.1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	1.2
1.1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	1.3
1.2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	1.3

## 2. Financial factors

- 2.1. Private funding sources: Challenge in attracting external venture capital support.
- 2.2. Public funding sources: Challenge in applications for receiving state (public) subsidies.
- 2.3. Cash-flow: Challenge in maintaining regular activities that provide the necessary cash-flow to face current expenses.

Factor/Difficulty		Challenges—Financial Factors															Factor/Difficulty	
2.1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	2.2
2.1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	2.3
2.2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	2.3

## 3. Commercial factors

- 3.1. Challenge to contact with internal/external commercial markets: Lack of opportunities to meet with local/regional/national or foreign businesses that might collaborate with my spin-off.
- 3.2. Challenges in marketing (and digital marketing) skills to attain the market target: Challenge in marketing skills and use of social media as marketing instruments that attract potential customers.
- 3.3. Few customers: Lack of a critical mass of customers for the product/service.

Factor/Difficulty		Challenges—Commercial Factors															Factor/Difficulty	
3.1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	3.2
3.1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	3.3
3.2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	3.3

## 4. Institutional factors

- 4.1. International reputation of university: Lack of research orientation, tangible resources, prestige, and reputation at the university/institution.
- 4.2. Entrepreneurship support programs: Lack of incubators, accelerators, technology parks, or support measures to support entrepreneurship.
- 4.3. Lack of entrepreneurial culture and climate within university and departments.

Factor/Difficulty		Challenges—Institutional Factors															Factor/Difficulty	
4.1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	4.2
4.1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	4.3
4.2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	4.3

## 5. Ethical factors

- 5.1. Loss of sense of having a “social mission”: Lack of sense of achievement; loss of the sense of “having a social mission to be of greater help to society”; failure in achieving the expected standards of excellence.
- 5.2. Conflicting university-business ethical norms: Conflicting norms and directives between the entrepreneurial and academic life.
- 5.3. Clash with stakeholders’ ethical behaviours: Conflicts between academic entrepreneurs’ personal ethical values and stakeholders’ (e.g., specific customers, partners, competitors, public institutions) ethical demands in unexpected situations.

Factor/Difficulty		Challenges—Ethical Factors															Factor/Difficulty	
5.1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	5.2
5.1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	5.3
5.2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	5.3

## 6. General problems related to . . .

Factor/Difficulty		Bigger Challenge																Factor/Difficulty	
Human	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Financial	
Human	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Commercial	
Human	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Institutional	
Human	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Ethical	
Financial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Commercial	
Financial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Institutional	
Financial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Ethical	
Commercial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Institutional	
Commercial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Ethical	
Institutional	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Ethical	

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