

Article

Are Spanish TTOs Prepared to Innovation in a COVID Context?

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Abstract: The analysis of the characteristics of Technology Transfer Offices (TTOs) is particularly important as they constitute mediating units in the relationship between the market and university research. They are responsible for the transfer and exploitation of knowledge arising in the university context. Previous studies have been inconclusive as to the importance that the size, professionalisation or age of TTOs might have on the transfer process. However, the need to explore new markets, recognise new opportunities and identify potential customers points to the importance of TTOs having a dual exploitative and exploratory orientation and an extensive relational network. More recent research in the literature, based on ambidexterity and network theory, points to the impact that these variables could have on change management and innovation in uncertain and changing environments, such as those faced by TTOs in the current pandemic context. Therefore, the aim of this paper is to analyse whether Spanish TTOs, due to their ambidextrous orientation at the organisational and individual level, and their relational network with academic and market actors, are prepared to promote innovation in a COVID-19 context. Based on a cluster analysis of 29 Spanish TTOs, our results show that just a few of the Spanish TTOs surveyed would be prepared, from the perspective of ambidexterity and their relational capital, to promote innovation in a COVID-19 context. In conclusion, Spanish TTOs and their employees should focus more on ambidexterity and building extensive relational capital so that, through mentoring, training, incubation or the provision of various resources, they can help academics take advantage of the innovation opportunities offered by the changing and uncertain environment.

Keywords: TTOs; ambidexterity; network theory; market actors; academic actors; cluster analysis



Citation: Rodríguez-González, T.; Villanueva-Flores, M.; Fernández-Alles, M.; Díaz-Fernández, M. Are Spanish TTOs Prepared to Innovation in a COVID Context? *Sustainability* **2021**, *13*, 8688. <https://doi.org/10.3390/su13168688>

Academic Editors: Fernando Almeida, Francisco Miranda González and Francisco I. Vega Gómez

Received: 14 May 2021

Accepted: 31 July 2021

Published: 4 August 2021

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1. Introduction

The transfer of knowledge arising in universities and its commercial exploitation in the market, has gained considerable attention in recent years [1,2] as it is considered to be a source of innovation, competitiveness, new employment opportunities, as well as an economic and social development in the regions in which it operates [3–5]. Therefore, many universities have added this third mission to their strategic agenda so that research results can be known and used by industry [6–12]. For this purpose, they have established Technology Transfer Offices (TTOs) [4,13]. These units support the links between industry and research results, becoming key elements for innovation [14]. Across mentoring, incubation, training and networking, TTOs provide a number of critical resources for technology transfer [15,16]. These offices identify market opportunities, assist in the development of business plans, conduct market research and use their resources to build strong networks, reducing the barriers between academics and industry. They also encourage invention disclosures, manage patent grants, advise on appropriate commercialization strategies and assist academics in the commercialization process [15–18]. In the current context of the pandemic, where the innovative capacity of companies is considered crucial for their

competitiveness [19,20], TTOs must encourage investment in innovation through their relationships with industry. In this sense, TTOs play an important role, as they are seen [21] as catalysts for change and innovation, seeking to drive business strategies with a strong focus on innovation and internationalisation [22]. In this way, TTOs clearly act as intermediaries in innovation activities between universities and external actors, promoting the external commercialization of university research output [23]. The literature increasingly considers universities as drivers of innovation through these offices [3]. In this way, TTOs are units that drive innovation [24,25] for three main reasons. Firstly, with their advice, TTOs create academic spin-offs (ASOs) so that the investment made by these companies is reflected in the generation of employment, innovation and competitive advantages [26]. ASOs are considered an important driver in the renewal of industrial structures and a way to modernise industry [4]. Secondly, ASOs, created with the support of TTOs, are innovative because of the technological progress to which their commercialization process is linked [26]. They also solve the challenges related to climate and energy issues; sanitation; healthcare and welfare systems; the promotion of research-based professional practices; and the promotion of knowledge-based trade with industry [27]. Therefore, TTOs foster the innovation of the ASOs that are born out of them [5,28,29]. Thirdly, TTOs, with their patenting management, encourage investments in innovation and disseminate knowledge through patent publications [23]. Consequently, TTOs enhance innovation through the performances they generate. Therefore, it can be concluded that innovation speed is influenced by the resources and competence of TTOs, as these resources speed up the process of matching university inventions and industrial commercialization [23] (p. 3).

Although the literature shows that TTOs contribute to fostering innovation, few studies have analysed the variables or characteristics of TTOs that could favour a context conducive to innovation. On the one hand, numerous studies have focused on analysing certain characteristics of TTOs, related to their success or efficiency. These have studied the impact of the age of these units; their size; and the professionalisation or experience of their employees, on their successes [4,16,21,30–35]. However, the results of some of these investigations are inconclusive. In this regard, [31] we can conclude that neither the size nor the human capital of a TTO seems to influence innovation performance, raising the question of what other characteristics may be important. Some work has focused on analysing the organisational structures of TTOs and how these structures affect the transfer of these units [36]. Other work has focused on the ambidexterity of universities [37–39] and on highlighting the potential importance of a dual exploitative and exploratory orientation in transfer activities. However, there are no studies on the ambidexterity of TTOs, the units responsible for this transfer. The literature on organisational ambidexterity has pointed out that this concept is paramount to the success of organisational innovation [40–44], as ambidextrous companies encourage the pursuit of new ideas. This organisational ambidexterity has been defined as the ability to develop structures and processes that allow TTOs to carry out activities of “exploitation” and “exploration” simultaneously, at the individual or organizational level [45].

These companies base their success on their ability to explore new opportunities, engage in quality improvement, reduce costs, or improve what they offer, to keep their existing customers satisfied [46]. In the context of universities, ambidexterity arises to alleviate tensions between the pursuit of research excellence and the commercialization of that research [37–39]. One way for achieving this ambidexterity lies in the construction of dual structures that allow conflicting demands to be managed simultaneously. Such dual structures could include the creation of a TTO within the university [37], but the mere existence of a TTO is not sufficient to achieve innovation outcomes. Therefore, new features of TTOs, such as ambidexterity, need to be analysed. On the other hand, the networking literature argues that relational capital is another essential factor for innovation success, as it has been considered in the literature as an enabler of innovation [47–49]. In the context of academic entrepreneurship, previous work highlights the importance of networks with academic and market actors [16,50–55] for ASOs created, with the advice

of TTOs, to access critical resources [55]. Also, TTO networks that are made available to academics are considered important in the knowledge transfer process [56,57]. Thus, the TTOs use these networks and links to industry during the commercialization process [58].

Against this background, to be able to respond to the changes produced in the current pandemic context, ambidexterity, and the TTOs' relational networks, need to be decisive in boosting the innovation of these units. Therefore, the aim of this paper is to analyse whether Spanish TTOs, due to their ambidextrous orientation at the organisational and individual level, and their relational network with academic and market actors, are prepared to promote innovation in a COVID-19 context. The methodology used is based on a cluster analysis of 29 Spanish TTOs. The main finding shows that just a few of the Spanish TTOs surveyed would be prepared, from the perspective of ambidexterity and their relational capital, to promote innovation in a COVID-19 context.

The main added value of the paper is the contribution it makes to the literature on ambidexterity and networks, in the context of Spanish TTOs, which previous research has, so far, not focused on. Our results also have an important value in analysing the extent to which Spanish TTOs are prepared to promote innovation, by enriching previous research developed in the context of TTOs that failed to explain their transfer performance. In this sense, Spanish TTOs should work more on developing their ambidexterity, and on building a more developed relational network, to foster innovation in their performance, as in the case of the ASOs that arise from it. This paper also contributes to the literature the results of transfer offices, as well as ambidexterity and networks.

This paper is structured as follows: after the introduction, a literature review is presented, focusing on ambidexterity and relational capital. The different hypotheses are then presented, followed by the methodology and results. To conclude, there is a discussion of the results and the study's contributions and limitations.

2. Theoretical Background

Within the entrepreneurial ecosystem, TTOs play a key role. As actors that dynamise relations between academic and business contexts, they not only directly provide academic entrepreneurs with crucial resources and skills, but also facilitate their access to external actors that have these resources and skills [59,60]. Therefore, TTOs are units that, through different mechanisms, such as incubation, financing and consultancy, foster an entrepreneurial culture in universities. To this end, they conduct market research, use their resources to build strong networks, identify market opportunities and assist in the development of business plans, reducing the barriers between academics and industry [17,18]. Ultimately, they provide specific resources to academics such as: managerial resources; tangible technological resources (laboratories and equipment); and intangible technological resources (advice, testing, commercial resources, distribution channels, financial resources, knowledge and credibility) [15,16,32,61–68].

The relational networks provided for academics by TTOs, become a critical element for knowledge transfer [67]. Similarly, the literature on ambidexterity, both at the organisational level and in the context of universities, states that organisational ambidexterity fosters organisational innovation [37–39,41]. Thus, we believe that both characteristics of TTOs, ambidexterity and relational capital, must be considered for TTOs to be innovative and to adapt to the changes that the pandemic context presents.

2.1. Ambidexterity of Technology Transfer Offices

The literature on ambidexterity argues that successful companies need to be ambidextrous [69,70], as ambidexterity promotes organisational growth and adaptation [41]. Thus, with the main objective of companies being able to survive in the face of continuous environmental changes, ambidextrous organisations use their existing assets and capabilities and reconfigure them to address new opportunities [41]. Organisations must therefore exploit existing competencies and explore new ones; crucially, these two facets must be inseparable [71]. Furthermore, organisational ambidexterity is shown to be positively

associated with improvements in innovation [40,72–80]. Empirical evidence suggests that ambidexterity generally has a positive effect on firm performance, demonstrating that, for long-term success, companies should consider establishing dual structures [81].

The literature on entrepreneurial universities argues that, although universities have increasingly oriented their strategic plans towards the development of activities, related to the third mission [82], they must be ambidextrous (i.e., they not only need to be aligned, efficient and exploit research-related activities, but also need to commercialise this research) [37,42]. In this context, the establishment of the dual structures, proposed by [81], would take place through the establishment of TTOs [37]. Therefore, based on the literature on organisational ambidexterity, the challenge of ambidexterity faced by organisations and universities also affects TTOs.

Considering the importance of ambidexterity for innovation; the scarce research on ambidexterity in the university context [37–39]; the lack of studies on the ambidexterity of TTOs; and the existence of studies with inconclusive results on the characteristics of TTOs that affect their efficiency and success [16,17,30,32,83–85], the ambidexterity of TTOs needs to be considered.

Within ambidexterity, two types are analysed: the ambidextrous orientation of the TTOs and the individual ambidexterity of its employees. Firstly, ambidextrous orientation is defined as the ability of an organisation to adapt to changes in the environment and exploratory orientation, while simultaneously being aligned and efficient in responding to market demands and exploitative orientation [39]. Secondly, individual ambidexterity refers to the ability with which employees in organisations can simultaneously achieve both explorative and exploitative activities [86].

2.1.1. Ambidextrous Orientation of the Technology Transfer Offices

Given the claim of some authors [37–39] for the need to establish universities that are ambidextrous, and the lack of previous studies on the ambidexterity of TTOs, the concepts of organisational ambidexterity and the ambidexterity of universities must be extrapolated in the context of TTOs.

Inspired by the work of [46] on organisational ambidexterity, we propose that TTOs, with ambidextrous orientation, study the capacity of these units to exploit the services they offer (exploitative orientation), while simultaneously exploring new ideas and services to propose to academics and companies (exploratory orientation). Two clearly differentiated strategies to be implemented in the TTOs, are established. On the one hand, there is an exploitative orientation dedicated, among other activities, to improving quality, reducing costs and improving the reliability of the services offered to academics and companies by these offices. With this orientation, these TTOs also strive to make technological or marketing improvements to existing TTOs, in order to better adapt to the current environmental conditions and the needs of their customers. On the other hand, this exploratory orientation allows TTOs to be competent, responding proactively to changes in the context by searching for new innovations. It is a type of strategy mainly focused on the exploration of new ideas, the creation of innovative services, or the search for new markets for academics and companies at national and international levels. TTOs must strike a balance between both strategies, because if these units are mainly oriented towards exploration, they may lack the resources to sustain such efforts over long periods of time. This would result in TTOs not getting the returns on their knowledge: “an organisation that engages exclusively in exploration will ordinarily suffer from the fact that it never gains the returns on its knowledge” ([87], p. 105). Conversely, if a TTO primarily develops an exploitative orientation, its returns may be more proximate and predictable than a TTO that seeks exploration, although these are not necessarily sustainable, because they run the risk of obsolescence. In this way, the TTOs will be ineffective in adapting to major changes and, as a consequence, these offices “that engage exclusively in exploitation, will ordinarily suffer from obsolescence” [87] (p. 105).

Thus, for TTOs to have an ambidextrous orientation, they must jointly pursue both strategies, i.e., building on existing competencies through exploitation, while developing new innovative capabilities through exploration.

Based on the above, for TTOs to be ready for innovation in a pandemic context, they must have an ambidextrous orientation, and the following is therefore hypothesised:

Hypothesis 1 (H1). *Technology Transfer Offices are ambidextrous in orientation in a pandemic context.*

However, and following [86], one cannot ignore the way in which the members of an organisation, in our case the employees of TTOs, can influence the ability of these units to achieve a balance between exploitation and exploration. This fact leads us to address the individual ambidexterity of these units.

2.1.2. Individual Ambidexterity in the Technology Transfer Offices

The literature on ambidexterity defines individual ambidexterity as a “behavioural orientation towards combining exploration and exploitation, related activities within a certain period of time” [88], so that “individuals engage in exploration while carrying on exploitation by allocating time and resources between the two different activities” [89] (p. 467). Activities related to individual ambidexterity have been widely recognised as beneficial to individuals, and empirical results have shown that this ambidexterity enriches employees’ jobs, promotes their creativity, and thus their performance [88].

The concept of individual ambidexterity in an academic context is a very recent creation, so there are very few studies focusing on this issue and there are no studies dealing with individual ambidexterity in TTOs. In [39] (p. 9), individual ambidexterity is defined in an academic context as “the ability to which academic scientists can simultaneously achieve research publication and research commercialization at the individual level”. With limited time availability and scarce resources, ambidexterity drives academics to maintain an optimal balance between research, commercial exploitation or transfer activities. An individual’s ability to perform these often quite contradictory tasks is almost certainly linked with their desire to do so [90]. Motivation to pursue commercial products is not only a function of an individual’s utility, but is also linked to the individual’s perceptions of the compatibility of research commercialization with their professional career [37]. Thus, [39] conclude that: the greater the ability of university members to recognise the opportunity to exploit the results of their research, the greater the individual-level research ambidexterity in universities.

In the context of TTOs, as there are no studies focused on the analysis of this type of ambidexterity, we followed the suggestion of [69] (p. 81) in which states that “ambidextrous organisations need ambidextrous teams and managers”, so we considered it necessary for TTOs to be made up of ambidextrous employees. Firstly, according to [86], an exploitative orientation of individuals would lead employees of TTOs to perform activities known to them, which require their previous accumulated experience. In this way, the staff of these units encourage academics, with whom these offices have a close relationship, to disclose their inventions [16]. Second, an exploratory orientation of TTO employees could guide them to seek out new academics to become involved in the development and creation of ASOs, explore new markets, identify new potential customers, or engage in new activities that require acquiring new skills or knowledge. In turn, this search for new markets and customers would contribute to the recognition of innovative business opportunities, which could be exploited through the creation and development of ASOs, as well as through patenting and licensing.

Based on the above, we concluded that for TTOs to be prepared for innovation in a pandemic context, their workers must be ambidextrous, and we hypothesised the following:

Hypothesis 2 (H2). *Technology Transfer Offices are ambidextrous at the individual level in a pandemic context.*

2.2. Relational Capital of the Technology Transfer Offices

The networking literature starts from the premise that entrepreneurs who are immersed in a wide network of contacts have access to a wider range of resources [91–93].

Based on the literature on academic entrepreneurship [64,68,94–97], the relational networks of TTOs, as with those of ASOs, can be classified into networks with academic and market actors [58]. The relationships between TTOs and academic actors, such as with other universities, incubators and academics, allow access to mainly technological resources in the form of infrastructure; equipment and facilities; and information resources, such as academics' research and its transfer of results as patents. Relationships with market actors, such as investors (venture capital firms), government institutions, advisors, companies, customers and managers, or science and technology parks, become key elements for access to other financial, technological and managerial resources [15,16,32,61–68].

The literature analysing the relational capital of TTOs has shown that TTOs provide ASOs with a multitude of resources [9,15,16,65,68], many of them coming from the relational network they have built up since their creation. Thus, TTOs' relational networks with market actors are crucial for identifying commercialization partners, funding sources and support, and aligning research with industry needs [5] to identify new opportunities for innovation. In this way, TTOs that have a developed relational network, both in academia and the market, can leverage the skills and roles of universities within society, enabling co-operation between academics, technology centres and ASOs [22]. TTOs must not only be able to create these relational networks, but be able to identify possible relationships that may arise between academia and the market in order for knowledge transfer to occur more effectively [16].

Participation in these networks would be beneficial for both parties; academics could increase their research (e.g., the number of publications or patents) and companies could improve their innovation capabilities [57]. These relationships could be instrumental in fostering innovation, as these resources could facilitate the recognition of opportunities, the development of attractive business plans, the commercial viability of inventions, or simply intermediation. Consequently, relational networks are paramount to the success of innovation, and networks are important factors to consider in the knowledge transfer process [16,57].

The literature highlights the different ways of establishing TTOs' relationships. On the one hand, conferences and exhibitions are critical activities in the establishment of relationships between the scientific community and industry. On the other hand, the mobility of people (in research centres and other universities, etc.), or the establishment of informal contacts, together constitute the relational networks necessary to accelerate the process of knowledge transfer [16,34]. The bidirectional nature of knowledge transfer means that interaction with companies makes it possible to carry out better academic research, insofar as it provides first-hand knowledge of the needs that the industry intends to satisfy, with the creation of specific knowledge or technology.

For academic entrepreneurs, TTOs therefore become key relational network providers for obtaining resources for the transfer, entrepreneurship, and development of their innovation. Therefore, for TTOs to foster innovation in a pandemic context, they must have developed relational capital, both at the academic and market level. We therefore propose the following hypothesis:

Hypothesis 3 (H3). *Technology Transfer Offices have a developed relational network with academic and market actors in a pandemic context.*

3. Methodology

Population, Sample and Measures

For data collection, a questionnaire was sent to the directors and two managers in each of the 70 TTOs at the Spanish universities in the TTO Network (RedTTO). The questionnaire, previously tested with the director of the TTO of the research team's university, aimed to

identify whether the offices were ambidextrous and whether they had developed relational capital. For the process of sending and collecting the information, the directors of the TTOs were contacted by telephone; we obtained information from 29 TTOs (41.42% response rate). Three questionnaires were sent to each office, to be completed by the director and managers. When different responses were obtained from the same TTO, the degree of similarity between the responses obtained from the same office, was analysed. The TTOs in our sample responded to the questionnaires at the time of the pandemic.

The measure of the ambidextrous orientation of TTOs was also based on previous research [46]. The measure consisted of 12 items, six to reflect the exploitative orientation and six to reflect the explorative orientation. An example of the first group of items described a TTO as a unit “committed to improving quality and reducing costs”, whilst an example of an item within the second group described the TTO as a unit that “bases its success on its ability to explore new ideas”.

The measure of the individual ambidexterity of TTOs was based on previous literature [86]. The measure consisted of eight items, four of them related to individual exploratory orientation. An example of one of these items is: “From your individual perception, indicate to what degree, as a consequence of the COVID-19 pandemic, is each worker in your TTO dedicated to seeking new teachers/researchers to become involved in the performance of the TTO at the national level”. The other four items related to individual exploitative orientation. An example of one of these items is: “From their individual perception, to what degree does each worker perform activities that require their accumulated experience”. The scales used are shown in Appendix A.

4. Results

The identification of groups of TTOs, with homogeneous behaviour and characteristics, was carried out using cluster analysis. This multivariate technique allows it to be determined whether, considering a series of relevant characteristics, it is possible to identify differentiated clusters of TTOs that comply with two main precepts: (i) that each set of TTOs is homogeneous, with respect to the variables used to form the cluster; and, (ii) that the clusters identified present a high degree of differentiation between them. For the cluster analysis, a series of variables were selected for their ability to characterise the cases by associating them with clusters, and for their versatility in adjusting to the particular objectives of cluster analysis [98].

As mentioned above, several responses were obtained from most of the 29 TTOs in the sample. It was therefore necessary to analyse the degree of similarity between the responses obtained from the same TTO, in order to aggregate them.

For this purpose, the Interrater Agreement ratio (rwg) was calculated. The rwg shows whether different respondents from the same organisation agree in their assessments of the exploratory and exploitative orientation, of both the TTO and its members, as well as their academic and market relational capital. The rwg was used to assess the agreement of the two or three respondents from the same TTO, and thus ensure the validity of aggregating responses, in cases where different people from the same company provided similar answers to our questionnaire [99].

The Interrater Agreement ratio, or rwg, was calculated for each of our variables following the procedure established by [100]. As seen in Table 1, in all cases, the rwg shows favourable ratios.

Table 1. Interrater Agreement (rwg).

	Exploratory Guidance TTOs	Operational Guidance TTOs	Individual Explorer Guidance	Individual Exploitative Orientation	No. of Academic Staff	Frequency of Academic Actors	No. of Market Actors	Frequency of Market Actors
rwg	0.9034	0.9123	0.8991	0.9507	0.8743	0.8858	0.9000	0.9396

To analyse the ambidextrous orientation of Spanish TTOs and individuals, and the degree of relational capital that these units possess, the hierarchical cluster methodology [101] was applied to identify similar characteristics. The hierarchical cluster methodology is suitable for this research as the number of clusters is not known a priori, our variables are quantitative, and the number of cases, at 29, is not high [102].

When applying the cluster analysis methodology, several variables were considered that met the requirements of versatility, appropriability and direct relationship between them [103]. These variables were the exploratory and exploitative orientation of the TTOs, the individual exploitative and exploratory orientation, and the academic and market relational capital of these offices. In all cases, the variables were measured using a 5-point Likert scale (1: very low degree and 5: very high degree).

When applying the cluster analysis, Ward's method and the Square Euclidean distance were used. These techniques were frequently used in these studies [102] as they allowed for maximum homogenisation of the clusters. First, it was analysed whether there were two different groups of TTOs, depending on their ambidextrous orientation. As can be seen in the dendrogram (Figure 1), two main clusters were identified, one composed of 13 ambidextrous TTOs, and the other containing 16 non-ambidextrous TTOs. Table 2 shows the composition of each of the clusters.

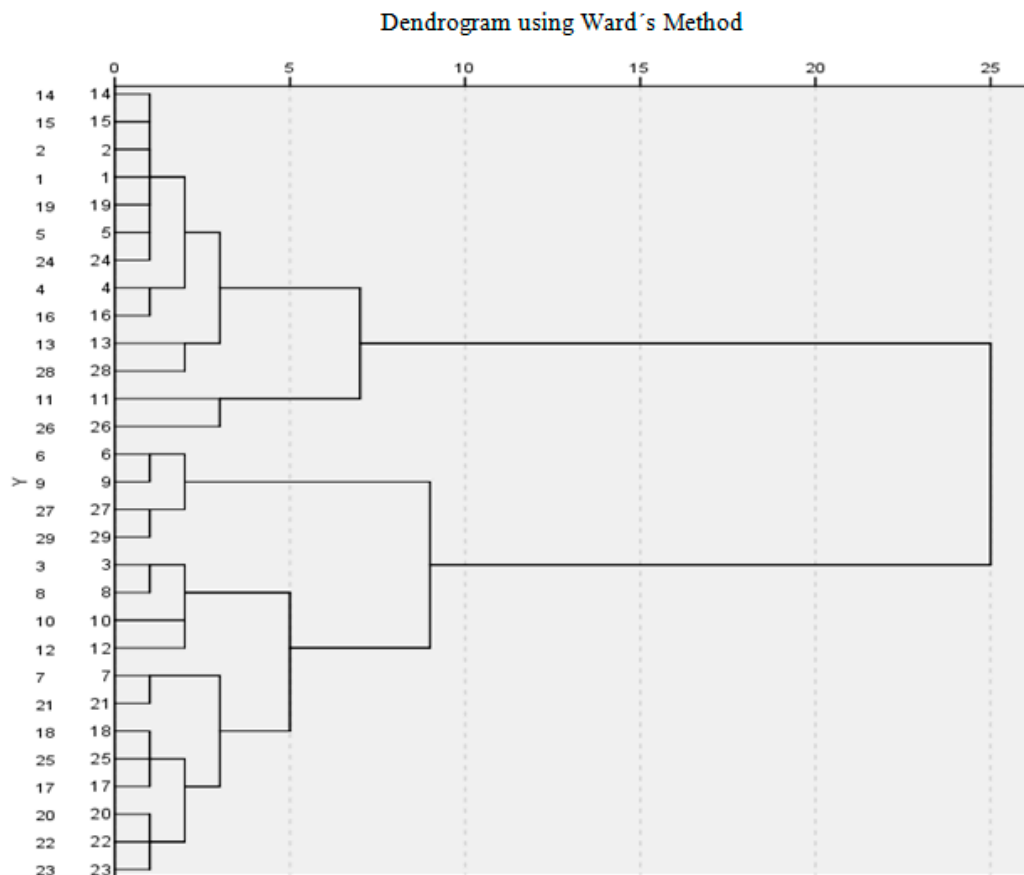


Figure 1. Dendrogram: Ambidextrous orientation of TTOs.

Figure 2 graphically shows the two clusters obtained, as well as the degree of exploratory and exploitative orientation of each TTO and, therefore, their degrees of ambidextrous orientation.

From the above, we can conclude that Hypothesis 1 is partially confirmed, as not all TTOs have ambidextrous orientation.

Next, the same type of analysis was performed, using individual exploratory and exploitative orientation as discriminant variables. The dendrogram (Figure 3) shows two

large clusters composed of 19 TTOs in cluster 1 and 10 TTOs in cluster 2, which refer to TTOs composed of individuals without ambidextrous orientation, and TTOs composed of individuals with ambidextrous orientation, respectively.

Table 2. Ambidextrous orientation clusters of TTOs.

Cluster 1: Ambidextrous Orientation of TTOs	Cluster 2: Non-Ambidextrous Orientation of TTOs
University of La Laguna	European University of Madrid
University of the Balearic Islands	University of Almeria
Carlos III University of Madrid	University of Vigo
University of Alicante	University of Santiago de Compostela
University of the Basque Country	University of La Coruña
Polytechnic University of Valencia	San Antonio Catholic University of Murcia
University of Zaragoza	International University of Catalonia
University of Cadiz	Pablo de Olavide University
Rovira i Virgili University	University of Las Palmas de Gran Canaria
University of Cordoba	University of Oviedo
Complutense University of Madrid	University of León
University of Jaén	Autonomous University of Barcelona
Autonomous University of Madrid	National University of Distance Education (UNED)
	Antonio de Nebrija University
	University of Huelva
	Miguel Hernández University

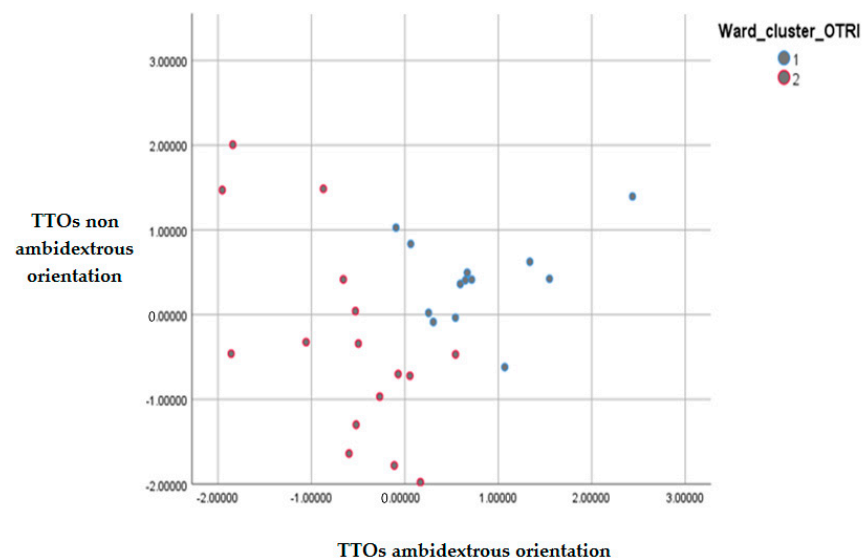


Figure 2. Graphical representation of ambidextrous orientation of clusters of TTOs.

Table 3 shows the composition of these two clusters, and Figure 4 shows the graphical representation of the clusters obtained, as well as the degree of exploratory and exploitative orientation of the individuals, i.e., the degree of ambidexterity of the members of the TTOs.

From this result, it can be concluded that Hypothesis 2 is partially confirmed, as not all TTOs have workers with ambidextrous orientation.

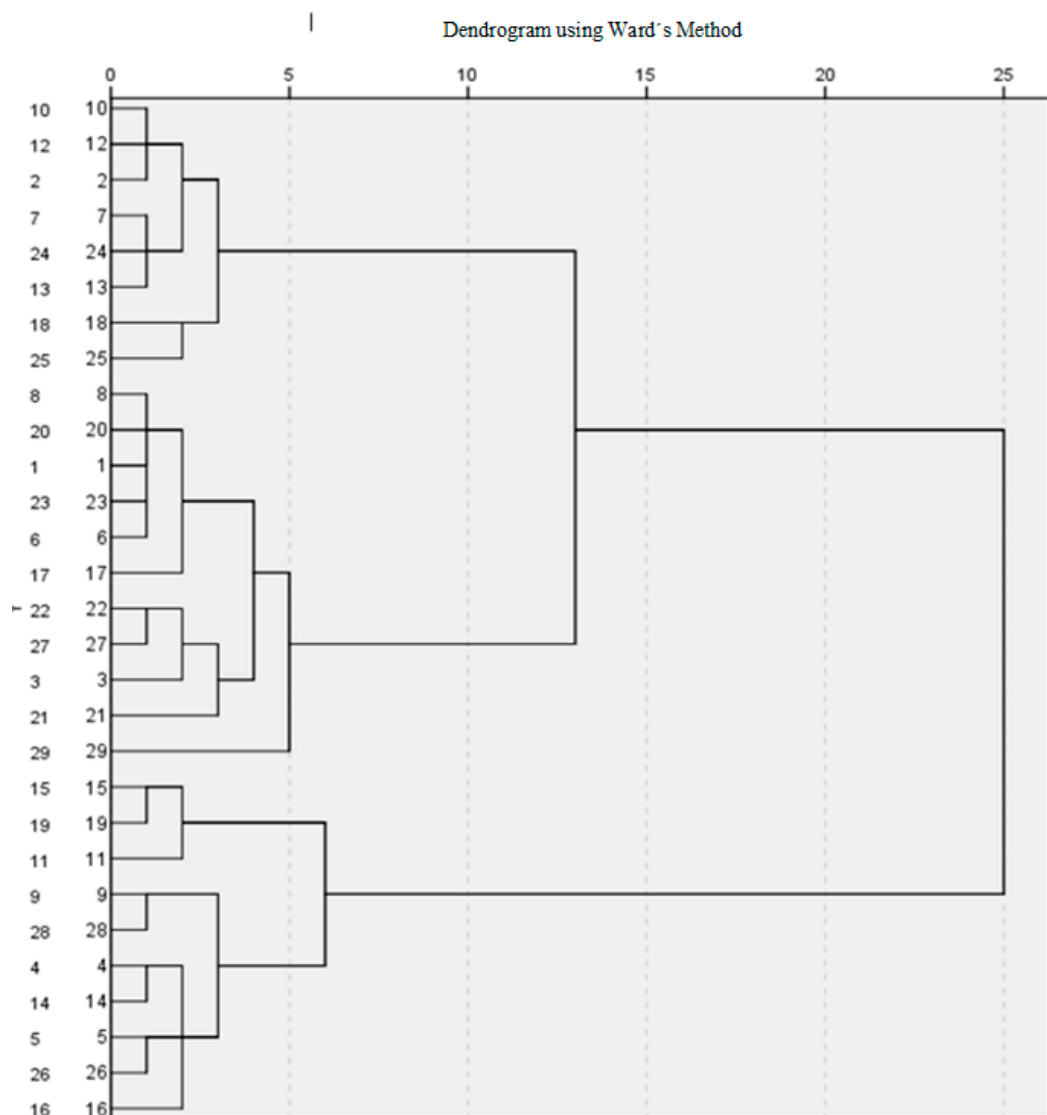


Figure 3. Dendrogram: Individual ambidexterity.

Table 3. Individual ambidexterity clusters.

Cluster 1: TTOs with Individuals with No Ambidextrous Orientation	Cluster 2: TTOs with Ambidextrously Oriented Individuals
University of La Laguna	Carlos III University of Madrid
University of the Balearic Islands	University of Alicante
European University of Madrid	University of La Coruña
University of Almeria	University of the Basque Country
University of Vigo	University of Zaragoza
University of Santiago de Compostela	University of Cadiz
San Antonio Catholic University of Murcia	Rovira i Virgili University
International University of Catalonia	University of Cordoba
Polytechnic University of Valencia	University of Jaén
Pablo de Olavide University	Autonomous University of Madrid

Table 3. Cont.

Cluster 1: TTOs with Individuals with No Ambidextrous Orientation	Cluster 2: TTOs with Ambidextrously Oriented Individuals
University of Las Palmas de Gran Canaria	
University of Oviedo	
University of León	
Autonomous University of Barcelona	
National University of Distance Education (UNED)	
Complutense University of Madrid	
Antonio de Nebrija University	
University of Huelva	
Miguel Hernández University	

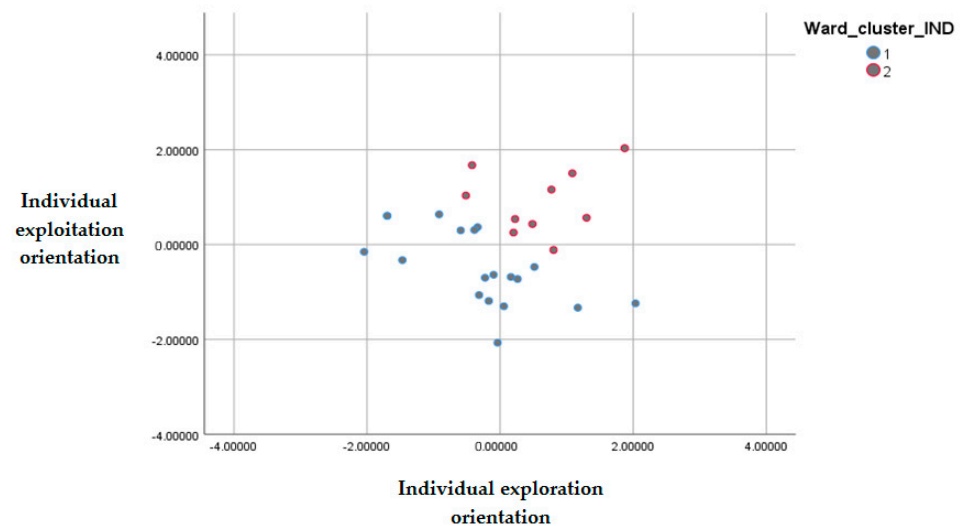


Figure 4. Graphical representation of individual ambidexterity clusters.

Finally, a new cluster analysis was performed with the discriminant variables being the academic and market relational capital of the TTOs. As shown in the dendrogram (Figure 5), there are two large sets of TTOs composed of 15 offices with low relational capital in cluster 1, and 14 TTOs with a high relational capital in cluster 2.

Table 4 shows the composition of each of the two clusters identified. Figure 6 shows the graphical representation of the clusters obtained, and the level of development of the TTOs' relational capital.

Finally, we conclude that Hypothesis 3 is partially confirmed, as not all TTOs have developed relational capital.

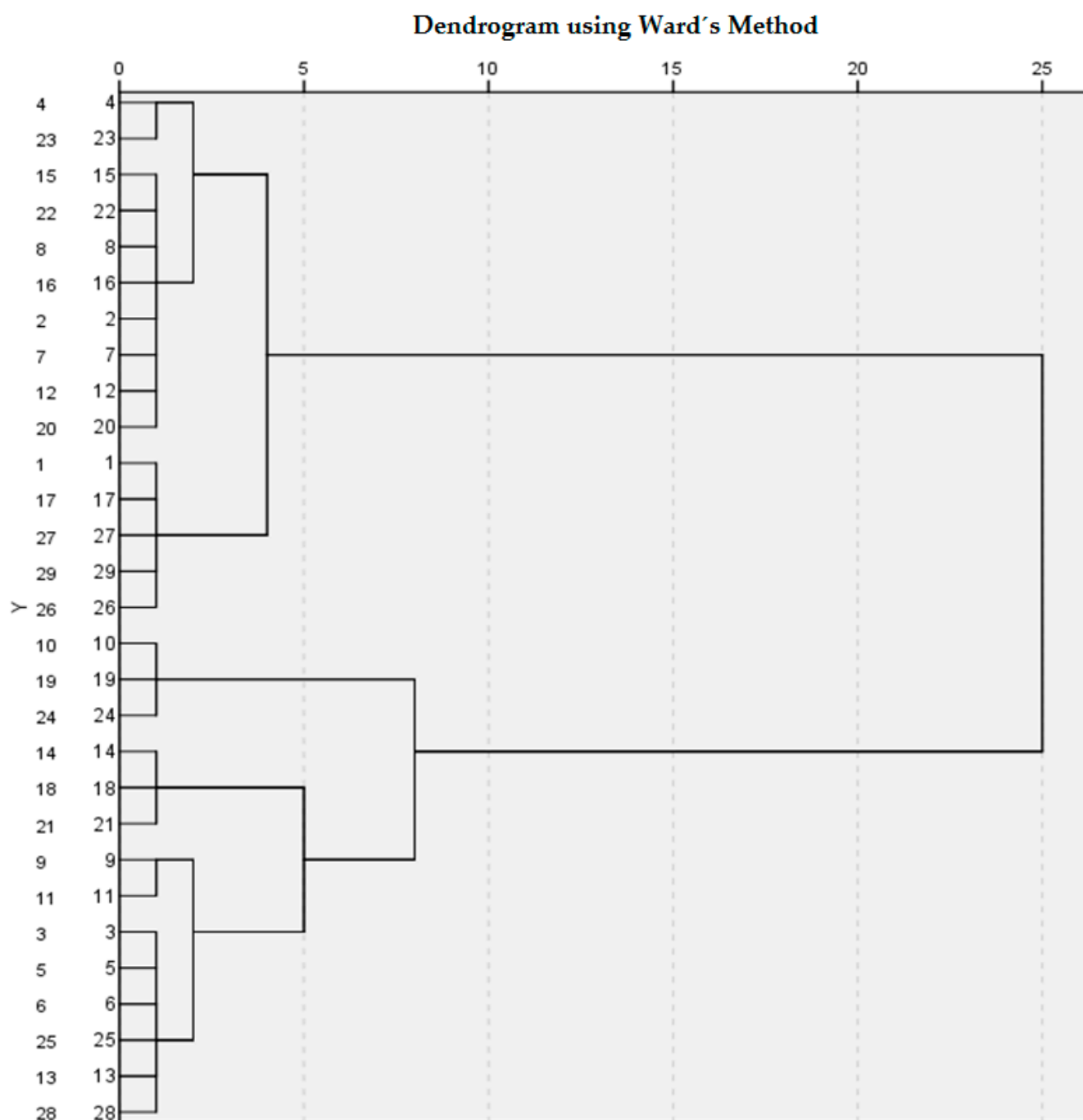


Figure 5. Dendrogram: relational capital.

Table 4. Relational capital clusters.

Cluster 1: Low Relational Capital	Cluster 2: High Relational Capital
University of La Laguna	European University of Madrid
University of the Balearic Islands	University of Alicante
Carlos III University of Madrid	University of Almeria
University of Vigo	University of La Coruña
University of Santiago de Compostela	San Antonio Catholic University of Murcia
International University of Catalonia	University of the Basque Country

Table 4. Cont.

Cluster 1: Low Relational Capital	Cluster 2: High Relational Capital
University of Cadiz	Polytechnic University of Valencia
Rovira i Virgili University	University of Zaragoza
Pablo de Olavide University	University of Las Palmas de Gran Canaria
University of Oviedo	University of Cordoba
Autonomous University of Barcelona	University of León
National University of Distance Education	Complutense University of Madrid
University of Jaén	Antonio de Nebrija University
University of Huelva	Autonomous University of Madrid
Miguel Hernández University	

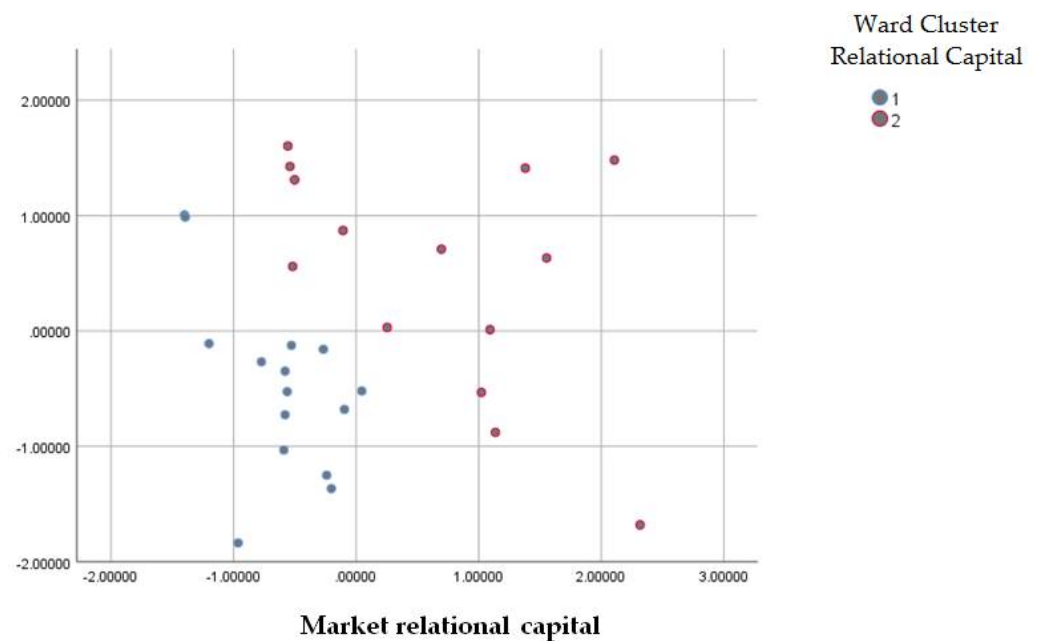


Figure 6. Graphical representation of relational capital clusters.

5. Discussion and Conclusions

The literature has shown that ambidexterity and relational capital are two essential characteristics of innovative organisations. Consequently, for TTOs to enhance innovation, they must have an ambidextrous orientation, at both the organisational and individual level, as well as developed academic and market relational capital. Companies that cooperate with TTOs innovate four times more than those that do not cooperate, significantly influencing the implementation of new products [104]. Thus, these offices become key intermediaries for academics, as they support ASOs in their creation and development. They also provide resources and information that could be determinant for the innovation of co-operating companies, so that the innovative efforts of ASOs are closely linked to external sources of knowledge, such as TTOs [22].

Some Spanish ASOs have responded to the changes brought about by the pandemic, with high levels of innovation in their products and services. ASOs from diverse sectors, such as biotechnology, culture and information technology, have taken advantage of the opportunities offered by the new context. The fact that ASOs do not lose their link with their parent company has led us to believe that the reason why some ASOs have responded to these changes, is found in the characteristics of the TTOs with which they have been linked since their creation. Indeed, [105] assume a positive relationship between the existence of

TTOs and innovation, as business managers and academics often see TTOs as an enabler for the successful commercialization of intellectual property rights.

Four conclusions can be drawn from the obtained results.

Firstly, half of the TTOs surveyed, namely 13 TTOs, had an ambidextrous orientation. This leads us to conclude that just a few of the TTOs are prepared, in this respect, to promote innovation.

Secondly, 10 TTOs were individually ambidextrous, i.e., the employees of these offices were prepared to encourage innovation. Moreover, nine of the offices with individual ambidexterity also had an ambidextrous orientation. Specifically, with the exception of the TTO of the University of Coruña, all of the Spanish TTOs surveyed with an ambidextrous orientation also had individual ambidexterity. The results obtained on the ambidexterity of the TTOs cannot be compared with previous literature, as there were no studies of this type in the context of TTOs. However, other studies, developed in the context of companies, concluded that ambidexterity endowed TTOs with dual structures, and employees with the ability to work towards exploration and exploitation [37–39,46,69,70], resulting in a greater ability to support innovation [40,73,75–80].

Thirdly, from analysing the relational networks of the Spanish TTOs in the study, almost half had high relational capital, despite the opportunities for innovation that these relationships provided, not only to the TTOs themselves, but also to the ASOs. For example, in the current pandemic context, TTOs' relationships with market actors (such as government institutions related to research, e.g., CSIC (Consejo Superior de Investigaciones Científicas–The Spanish National Research Council), CIMCYC (Centro de Investigación Mente, Cerebro y Comportamiento–The Mind, Brain and Behaviour Research Centre) or CITIC (Centro Andaluz de Innovación y Tecnologías de la Información y las Comunicaciones–The Andalusian Centre for Innovation and Information and Communication Technologies), or to public health, such as the Carlos III Institute) would be crucial for the innovation by ASOs. Consequently, as indicated in the literature, having a developed relational capital would be beneficial for enhancing innovation, as the relationships that these units maintain with academics and industry allow for the identification of new innovative opportunities [16,57].

Fourthly, only seven Spanish TTOs, out of the 29 analysed, were found to have an ambidextrous orientation, individual ambidexterity and a high relational capital, in both academic and market actors. Therefore, Spanish TTOs still have a long way to go to become ambidextrous, to develop relational capital that enables innovation, and to provide advice, training, incubation or the provision of various resources to help ASOs take advantage of the innovation opportunities offered by the changes and uncertainty of the current environment.

Several contributions are obtained from this work. Firstly, it deepens the analysis of TTOs, comparing new characteristics of these units, such as ambidexterity, with previous research on size, age and professionalisation. Secondly, this study makes an important contribution to the literature on ambidexterity, in the context of TTOs, where there are no works that analyse the exploratory and exploitative orientation of units, which, by their nature, are destined to exploit university knowledge and identify new markets, customers or uses. Thirdly, this work responds to previous claims that there is a need for more studies to evaluate the importance of these offices, for technology transfers between universities and companies [106]. Fourthly, rather than explaining how TTOs and their characteristics influence the achievement of transfer performance [34], other hitherto overlooked TTO characteristics have been analysed to improve innovation, which are key, above all, for the ASOs created with their advice. Moreover, a contribution is made to the literature on TTO networks in the Spanish context as, although there are works that study the relational networks of TTOs [22,66], there are no studies on relational networks focused on TTOs in Spanish universities.

These findings have practical implications for the management of universities and TTOs, as the results show that not all these offices are ambidextrous and have developed

relational capital. Therefore, both the exploitative and exploratory orientation of these units, and their employees, as well as the relations of these offices with academic and market actors, should be enhanced.

This study has a limitation that could lead to a future line of research. This limitation, lies in the size of the population of TTOs in Spanish universities, which makes it difficult to apply other statistical techniques, e.g., structural equation modelling with PLS. One possibility, as suggested by [66], is to develop panel data that would allow the study to be extended over several years.

Another future line of research would be to broaden the field of study, by considering samples from other European countries, which would allow us to carry out comparative work. It would also be interesting to make an in-depth analysis of the ASOs that have innovated during the pandemic, and to study whether they have indeed been created and developed under the umbrella of ambidextrous TTOs, and with developed relational capital.

Author Contributions: The authors have contributed to every part of the article in this way. The conceptual part on TTO has been developed by M.F.-A. The conceptual part on Ambidexterity has been developed by T.R.-G. and M.V.-F. Statistical development has been worked on by M.D.-F. Finally, the discussion and conclusions has been developed by M.F.-A., T.R.-G. and M.V.-F. All authors have read and agreed to the published version of the manuscript.

Funding: This work has been co-financed by the 2014–2020 ERDF Operational Programme and by the Department of Economy, Knowledge, Enterprise and Universities of the Regional Government of Andalusia. Project reference: FEDER-UCA18-107689. The translation was made possible with the help of INDESS (University Institute for Sustainable Social Development, of the University of Cadiz).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Regarding ambidextrous orientation, the final measure consisted of 12 items in which respondents were asked to assess their firm's orientation (exploratory and exploitative) using a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Table A1. Ambidextrous Orientation.

Ambidextrous Orientation	
Exploratory Orientation	Exploitative Orientation
(a) looks for novel technological ideas by thinking “outside the box” for companies and/or academic	(a) commits to improve quality and lower cost
(b) bases its success on its ability to explore new technologies	(b) continuously improves the reliability of its products and services
(c) creates products or services that are innovative to the TTO	(c) constantly surveys existing customers’ satisfaction
(d) looks for creative ways to satisfy its customers’ needs (companies and/or academics)	(d) improves what it offers to keep its current customers satisfied
(e) aggressively ventures into new national market segments	(e) carries out activities that encourage the use of services aimed at current customers
(f) actively targets new national customer groups	(f) increases the levels of automation in its operations

Regarding individual ambidexterity, the final measure consisted of 8 items in which respondents were asked to assess their individual’s orientation (exploratory and exploitative) using a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Table A2. Individual Ambidexterity.

Individual Ambidexterity	
Individual Exploratory Orientation	Individual Exploitative Orientation
(a) search for new academics to be involved in the performance of the TTO	(a) perform activities where a lot of experience had been accumulated by them
(b) search for new markets, companies, sectors with which to sign agreements	(b) perform activities which serve existing customers with existing services/products
(c) perform activities requiring some adaptability on his/her part	(c) perform activities where it is clear to him/her how to conduct them
(d) perform activities requiring him/her to acquire new skills or knowledge	(d) perform activities primarily focused on achieving short-term goals

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