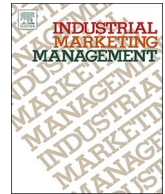




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The influence of the structure of social networks on academic spin-offs' entrepreneurial orientation

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ABSTRACT

This paper has been designed to analyse the impact of the structure of social networks on academic spin-offs' entrepreneurial orientation. We have specifically focus on both size and frequency of three different types of social networks: informal networks (composed of family and friends); market networks (composed of agents belonging to the business context); and university support networks (composed of university institutions and agents). With the premises of Resource Dependence Theory as theoretical background and drawing on a sample of 167 Spanish academic spinoffs, results of regression analysis have highlighted the positive influence of market networks and university support networks on the enhancement of academic spin-offs' entrepreneurial orientation, as well as the null impact exerted by informal networks. Our paper expands the research developed in the fields of academic entrepreneurship, social networks and Resource Dependence Theory and offers some suggestions to academic spin-offs' managers and university support institutions.

Subject classification codes

ME13
 ME10

1. Introduction

In the context of academic entrepreneurship, the role of entrepreneurial orientation (EO) could be especially relevant since academic spin-offs (ASOs), as a result of their specific nature (Knockaert, Ucbasaran, Wright, & Clarysse, 2011), may require the development of entrepreneurial strategies in order to commercially guide their innovations. In addition, ASOs often face extremely uncertain and competitive environments, in which the focus is on the discovery of new opportunities and the competitive development of innovations (Covin & Slevin, 1989; Rauch, Wiklund, Lumpkin, & Frese, 2009; Robertson & Chetty, 2000; Wiklund & Shepherd, 2005). Previous research has consistently posited that the adoption of entrepreneurial strategies could be crucial for the development of firms that compete in uncertain contexts (Covin & Slevin, 1998; Naman & Slevin, 1993) and, specifically, that ASOs could require the combination of EO and marketing skills for achieving success (Bray & Lee, 2000; Pérez & Sánchez, 2003; Steffensen, Rogers, & Speakman, 2000). Despite the recognition of its importance, there is a scarcity of research focused on analyzing the factors that could influence ASOs' EO.

The exhibition of high levels of EO may not be a simple task for ASOs. As a result of their non-commercial origins, access to resources and abilities necessary for enhancing proactive and innovative behaviours could be extremely difficult for these firms. For this reason, ASOs usually require the intervention of outside agents to obtain such resources and abilities (Clarysse, Wright, Lockett, Mustar, & Knockaert, 2007; Vohora, Wright, & Lockett, 2004). In this context and following the basic premises of the Resource Dependence Theory (RDT), ASOs' networks could be a key mechanism for reducing dependence on the external environment for accessing critical resources and abilities, counselling, legitimacy, and timely and relevant information (Demirkan, Deeds, & Demirkan, 2013; Hillman & Dalziel, 2003; Knockaert et al., 2011). In this regard, previous research has highlighted the crucial role of networks when it comes to facilitating the acquisition of technological, market, and entrepreneurial knowledge by firms, knowledge that could significantly enhance the entrepreneurial degree of a firm's strategies (Álvarez & Busenitz, 2001; Hoang & Antoncic, 2003; Ripollés & Blesa, 2006).

A review of the literature in the field of entrepreneurship reveals the emergence of an incipient – although still limited - research stream focused on the study of the impact of networks on the entrepreneurial behavior exhibited by organizations (Aldrich & Martinez, 2003; Bhagavatula, Elfring, Van Tilburg, & Van de Bunt, 2010; De Carolis & Saporito, 2006; Quan & Motoyama, 2010). While most of previous studies have been successful in capturing the positive relationship (e.g.,

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Elfring & Hulsink, 2003; Papagiannidis & Li, 2005; Partanen, M ller, Westerlund, Rajala, & Rajala, 2008), null or negative correlations have also been found (e.g. Gargiulo & Benassi, 1999; Johannisson, 1996; Witt, Schroeter, & Merz, 2008). Similar conclusions could be extracted if put our focus on the much more limited previous research that has examined the link between firms' networks and EO. Among the positive evidences, some authors have reported a positive impact of network usage as source of resources (Martins, 2016; Martins, Rialp, Rialp, & Aliaga-Isla, 2016); network capability (Zacca, Dayan, & Ahrens, 2015); functional background diversity among network board members (Thorgren, Wincent, & Anokhin, 2011); network size (Manev, Gyoshev, & Manolova, 2005); and network frequency (Ripoll s & Blesa, 2005). However, it is also possible to show some null or negative findings. Wang and Altinay (2012) found contradictory results in the relationship between the access to networks and firms' EO. Thorgren et al. (2011) were not able to demonstrate the existence of a significant relationship between the diversity of boards' insiders and outsiders on the network and EO. Lastly, Ripoll s and Blesa (2006) reported a negative relationship between network frequency and EO. In the specific context of academic entrepreneurship, the scarcity of previous empirical research is extremely more pronounced. To this respect, the work of Walter, Auer, and Ritter (2006), which found on the one hand, a positive correlation between network capability and EO and on the other hand, that network capability moderated positively the link between EO and ASO's performance, is the only exception. What underlies this review is that empirical research in this area is still limited and non conclusive and there is scope for more systematic comparative investigations (Hoang & Antoncic, 2003; Quan & Motoyama, 2010; Witt, 2004).

Taking into account the aforementioned limitations of previous research and drawing on RDT, this paper examines the impact that networks exert on the EO exhibited by ASO from a contingency approach. Specifically, we focus on two specific structural elements of networks: network size and the frequency of contacts between the focal actor and diverse agents. Both size and frequency have been consistently employed by previous research devoted to analyse the entrepreneurial behaviour of new firms (Hoang & Antoncic, 2003; Ruiz-Arroyo, Sanz-Espinosa, & del Mar Fuentes-Fuentes, 2015; Semrau & Werner, 2014), since both size and frequency reflect more properly than other structural elements such as density, centrality, or heterogeneity – which are more adequate to analyse the position of the focal actor within the network or the typology of the agents that compose the network -, the quantity and quality of the resources, abilities and information exchanged within networks (L pez-Mar n, Montilla, & Gironde, 2008; Ruiz-Arroyo et al., 2015; Witt, 2004). Drawing on the aforementioned idiosyncratic characteristics of ASOs and their lack of resources, abilities and knowledge for exhibiting entrepreneurial attitudes, the analysis of both the quantity and the quality of the resources, the abilities and the knowledge acquired through their networks could be especially relevant. Specifically, network size is defined as the number of direct ties among the firm and the rest of agents that compose the network (Hoang & Antoncic, 2003) and is expected to determine decisively the stock of resources, abilities and knowledge that ASOs could access, since each tie represents a conduit of information in such a way that the greater number of ties, the greater the number of conduits and consequently, the higher the likelihood of ASOs achieve the resources, abilities and knowledge that they need for enhancing their EO. In this line, Ruiz-Arroyo et al. (2015) argue that larger networks provide firms with a greater quantity of information, which increases the number and variety of entrepreneurial stimuli and therefore, the likelihood of firms exhibiting entrepreneurial attitudes. For its part, the frequency of contacts increases knowledge and resources embodiment and integration (Hansen, 1999; Reagans & McEvily, 2003), facilitates the creation of a pattern of interaction among the actors and contributes to enhance the trust within the networks, which increases substantially the quality of the resources, abilities and information exchanged (Laursen & Salter, 2006; Semrau & Werner, 2014; Sousa-Ginel, Franco-Leal, & Camelo-

Ordaz, 2017). Specifically, frequent contacts may favour the exchange of detailed, tacit and highly valuable information and knowledge about the industry and the existence of potential entrepreneurial opportunities, which is expected to serve as stimuli for firms enhance their EO (Coleman, 1988; Reagans & McEvily, 2003; Ruiz-Arroyo, Sanz-Espinosa, & Fuentes-Fuentes, 2015).

Our analysis of the structural elements of networks could belong to the field of ego network structure, representing the ASO the role of ego. Egocentric networks are defined from a focal actor's perspective only - ASO perspective -. Moreover, as the focal unit is a firm – the ASO - and the analysis comprises the analysis of its relationships with individuals and external organizations, we can conclude that our research level is inter-organizational (Phelps, Heidi, & Wadhwa, 2012).

With respect to the contingency factor, we have considered the type of network with whom ASOs maintain relationships. In this vein, previous research such as Quan and Motoyama (2010) have pointed out the relevance of examining the specific impact of the differentiated firms' networks. To this end, and taking into account the idiosyncratic features and backgrounds of ASOs, as well as the profile of the agents that could compose their networks, this research considers the existence of three different types of networks: informal networks (friends, family and colleagues); university support networks (science parks, incubators, Technology Transfer Offices (TTOs) and chairs of entrepreneurs); and industrial networks (agents related to the industrial context).

The most important contributions of this study are as follows. First, it contributes to the entrepreneurship network literature. This first contribution emerges from both the research contextualization and the use of a contingency approach. On the one hand, according to the new research trends posited by Lamine, Jack, Fayolle, and Chabaud (2015), we assume the need of contextualizing the research conducted in the field. Networks are crucial, but so is the context in which firms operates. If the agents or institutions that are part of the firms' context establish ties with them, this could be an opportunity for firms access relevant knowledge and resources in such a way that the context will clearly have an impact on the entrepreneurial process (Elfring & Hulsink, 2007; Hindle, 2010; Jack, 2005). Focusing on the specific context of academic entrepreneurship, ASOs often lack entrepreneurial competencies and are therefore a highly suitable context in which to study the role of networks on the exhibition of entrepreneurial behaviours by such firms (Rasmussen, Mosey, & Wright, 2015). As Rasmussen, Mosey, & Wright (2015: 431) argue, ASOs provide “an excellent setting to study network theory in action due to their technological complexity, fast moving market dynamics, growth struggles and re-directions”. On the other hand, we advance network research since this study applies a contingency approach to understanding the effects of the some structural characteristics of networks on EO. The contradictory results found in previous studies about the effects of the size of networks and the frequency of contacts on variables linked to EO point to the need to consider this perspective in order to gain a more fine-grained understanding of the implications of network structural elements (Phelps et al., 2012). In line with the recommendations of Lamine et al. (2015), our paper holds the need that entrepreneurship network research specifically takes into account the impact exerted by different network types. To this respect, our research helps to reconcile some divergent arguments of scholars about the role of different network types when it comes to examine the influence of networks' size and frequency on the development of firms' entrepreneurial behaviour. Lastly, this research also contributes to the literature on academic entrepreneurship. Some authors have argued the relevant role that both networks as well as EO play for the successful development of ASOs (Soetanto & Van Geenhuizen, 2009; Tietz, 2013; Walter et al., 2006). However, there is a noteworthy scarcity of research focused on understanding whether networks influence the development of entrepreneurial behaviours by ASOs (Walter et al., 2006).

This paper is structured as follows. First, we offer a literature review about the concept and dimensionality of EO and situate the research

within the RDT. Next, we establish the research hypotheses. Section 4 describes the research design and methodology. The main results obtained are then presented and the paper concludes with an overview of conclusions and implications.

2. Theoretical background

2.1. Entrepreneurial orientation

The concept of EO has been extensively analysed by previous research carried out within the field of entrepreneurship, so it could be considered as one of the central topics in such field (Rauch et al., 2009) and “the most widely used measure of entrepreneurial behaviour or tendency in the strategy and entrepreneurship literature” (Runyan, Ge, Dong, & Swinney, 2012: 819). While it is true that the EO construct is derived from the research on strategy making processes (Mintzberg, 1973), it is not until the seminal work of Miller (1983) when the topic begins to be widely analysed and discussed (Wales, Parida, & Patel, 2013).

The conceptualization and operationalization of EO have been the subject of a systematic research and intense debate in the literature (Covin, Green, & Slevin, 2006; Lumpkin & Dess, 1996; Lyon, Lumpkin, & Dess, 2000). Miller (1983: 771) described the entrepreneurial firms as those that “engages in product market innovations, undertake somewhat risky ventures, and are first to come up with proactive innovations, beating competitors to the punch”. Drawing on this, Covin and Slevin (1989) developed the most traditionally employed operationalization of EO, which considers EO as a variable constructed from three distinct dimensions: innovativeness, proactiveness and risk-taking propensity. Later, Lumpkin and Dess (1996), drawing on Miller’s (1983) conceptualization and prior research (Hart, 1992; MacMillan & Day, 1987; Zahra, 1993) described EO as a strategic orientation that reflects the propensity, behaviours and strategic processes that lead organizations to enter into new or established markets with new or existing products or services. Moreover, they argued for the convenience of including two additional dimensions - autonomy and competitive aggressiveness -.

While it is true that EO has been frequently analysed as a firm-level construct composed by three dimensions - innovativeness, proactiveness and risk-taking - (e.g. Hakala, 2011; Hughes & Morgan, 2007; Miller & Breton-Miller, 2011; Ruiz-Ortega, Parra-Requena, Rodrigo-Alarcón, & García-Villaverde, 2013; Schepers, Voordeckers, Steijvers, & Lavaren, 2014) it is not less true that the dimensionality of EO is still debated and remains unresolved, founding controversial arguments regarding the consideration of both autonomy and competitive aggressiveness as dimensions of EO. On the one hand, the critical research stream argues both the difficulty for creating and maintaining the autonomy at the firm level as well as the difficulty for linking the competitive aggressiveness to entrepreneurship in a universal way (Edmond & Wiklund, 2010). On the other hand, Lumpkin and Dess (1996) justify that both dimensions reflects differentiated behaviours. In the case of autonomy, they argue that it reflects the entrepreneurial spirit of the firm, whereas competitive aggressiveness describes the relation between the company and its competitors. In this line, some authors, such as Voss, Voss, and Moorman (2005), Edmond and Wiklund (2010), Pearce, John, Fritz, and Davis (2010), or Covin and Lumpkin (2011) reinforce these arguments, concluding not only that there are not unequivocal theoretical arguments that support the consideration of EO as a construct composed by three dimensions - innovativeness, proactiveness and risk taking - rather than by five dimensions - including autonomy and competitive aggressiveness -, but also the preference of authors by Covin and Slevin (1989)’s scale could explained by its ease of use.

Another interesting debate in the study of EO is referred to the uni- or multi-dimensionality of the construct. Miller (1983), Covin and Slevin (1989) and Knight (1997), among others, have argued the

unidimensionality of EO because an entrepreneurial firm would exhibit simultaneously innovativeness, risk-taking and proactiveness. However, more recent research stream has noted that the unidimensional measure of EO could not fully capture the distinct contribution of each dimension and suggested a multidimensional conceptualization of the construct (Covin et al., 2006; Kreiser, Marino, & Weaver, 2002; Lumpkin & Dess, 1996). While different theoretical arguments can be employed for supporting or rejecting both approaches, the literature review reveals on the one hand, that previous research has mostly empirically analysed EO as a unidimensional construct and on the other hand, the existence of some meta-analysis, which have not been able to reject the unidimensional character of the variable (Covin et al., 2006; Lee, Lee, & Pennings, 2001; Rauch et al., 2009).

In this paper, we draw on the conceptualization provided by Lumpkin and Dess (1996), which considers EO as a firm-level construct that describes the propensities, processes and behaviours that lead to entry into new or established markets with new or existing goods or services. Following their line, we consider that EO would be composed by five dimensions - innovativeness; proactiveness; risk-taking; autonomy; and competitive aggressiveness -. Innovativeness reflects a firm’s tendency to support new ideas and to foster creative processes that are aimed at developing new products and services (Walter et al., 2006). Proactiveness represents a forward-looking view, where firms try to develop new products or improvements on them, anticipating changes and opportunities that arise in the environment (Hughes & Morgan, 2007); risk taking encompasses the firm’s willingness to involve a higher level of resources in projects with uncertain results (Wiklund & Shepherd, 2003). Autonomy is the degree to which organizational players (individuals, teams) remain free to act independently, to make key decisions, and to pursue opportunities (Walter et al., 2006). Finally, competitive aggressiveness describes the notion of challenging competitors to achieve market entry or to improve market position (Walter et al., 2006).

According to Lumpkin and Dess (1996) and Voss et al. (2005), among others, we argue that the consideration of both autonomy and competitive aggressiveness as dimensions of the EO construct, responds to the need of capturing the full range of behaviours that lead to change in the ASOs. For these firms, which usually lack significant capabilities and knowledge for exhibiting entrepreneurial behaviours (Diáñez-González & Camelo-Ordaz, 2016), the inclusion of autonomy as a dimension of EO could be necessary since previous research has noted that autonomy is extremely related to the identification of opportunities that are beyond the organization’s current capabilities and knowledge (Kanter, North, Bernstein, & Williamson, 1990; Lumpkin, Cogliser, & Schneider, 2009). Similarly, the consideration of competitive aggressiveness could also be especially relevant for ASOs, which as a result of the innovative nature of the products and services that they usually commercialize, could be intensely affected by competitors (Shan, 1990). In this vein, as Walter, Auer, & Ritter (2006: 544) notes, “ASOs are frequently monitored by potential competitors, firms that may be capable of imitating products and/or services quickly on a large scale, or simply acquire the firm”.

Finally, with respect to the dimensionality of EO, we consider EO as a unidimensional construct, in which the previously described five dimensions would contribute together - although not necessarily with the same intensity - to firms’ EO. Through this approach, we understand EO as a sustained firm-level attribute represented by the singular quality that risk taking, innovative, proactive behaviours, autonomy and competitive aggressiveness have in common and therefore, we consider that the five sub-dimensions are equally reliable indicators of the higher order construct (George, 2011).

2.2. Networks and entrepreneurial orientation

Since its publication in 1978, the RDT has become one of the most influential theories in organizational theory and strategic management

(Hillman, Withers, & Collins, 2009). RDT characterizes the firms as open systems, dependent on contingencies in the external environment. As Pfeffer (1987) notes, firms are neither autonomous nor internally self-sufficient, but rather are constrained by a network of interdependencies with other agents in order to fill a lack of resources and capabilities in such a way that as a result of this interdependence as well as uncertainty generated by an ignorance of the future actions and attitudes of the agents with whom they interact, firms are usually immersed in a setting in which their success and survival are strongly conditioned by their ability to manage their dependence on the external environment (Kanter, 1979; Pfeffer, 1981; Ulrich & Barney, 1984).

In this regard, the literature has highlighted the important role played by management teams and boards of directors in the acquisition of, access to, or development of resources that are strategically relevant or scarce (Clarysse et al., 2007) and, more specifically, how the use of their networks can be especially relevant for diminishing the organization's dependence on market transactions (Gulati, 1995; Hillman & Dalziel, 2003). Consequently, networks - defined by Hoang and Antoncic (2003) as "a set of actors and some of relationships that link them" - are essential when it comes to obtaining relevant information about new businesses, services and external support, resources not available within the organization, and specific advice (Birley, 1986; Grandi & Grimaldi, 2003). Further, the achievement of those resources through networks could be more advantageous for firms than the acquisition of such resources through market transactions, which are usually characterized by a high degree of dependence (Dubini & Aldrich, 1991; Witt, 2004).

From the perspective of resource dependence, previous empirical research has shown the positive effect of networks on firms' development. Networks can be extremely useful for accessing some relevant resources such as financial capital or other physical assets (Hillman & Dalziel, 2003); advice and counsel (Carpenter & Westphal, 2001; Westphal, 1999); or legitimacy and reputation (Bazerman & Schoorman, 1983; Galaskiewicz, 1985). Moreover, networks provide communication channels and conduits of information between companies and external organizations, allowing the achievement of timely and valuable information and reducing transaction costs (Hillman & Dalziel, 2003). Specifically, links to external agents could provide firms with the mechanisms for both analysing the external environment (Useem, 1984) and accessing to strategic information and opportunities (Burt, 1983; Pfeffer, 1991), which could allow firms to engage in the process of entrepreneurial experimentation (Cooper, Gimeno-Gascon, & Woo, 1994; Manev et al., 2005).

In the specific context of academic entrepreneurship, some authors have previously noted the extreme uncertainty and environmental dependence that ASOs experience compared with other types of organizations (Knockaert et al., 2011; Walter et al., 2006). As a result of their academic origins, ASOs usually lack a series of resources and abilities necessary for acting entrepreneurially. Moreover, their early networks are often composed by a majority of academic ties and the specific nature of the technologies and knowledge commercialized by ASOs usually difficult the achievement of external funding (Diáñez-González & Camelo-Ordaz, 2016). These reasons explain the pronounced external dependence of ASOs and specifically, that the design and management of appropriate networks could contribute to diminish such dependence and uncertainty through the acquisition of a complete stock resources, abilities and information on new trends and ways to exploit them, increasing the options that ASOs overcome their inherent limitations and enhance their EO (Aldrich & Zimmer, 1986; Matsuno, Mentzer, & Özsomer, 2002). Supporting these arguments, Daily, McDougall, Covin, and Dalton (2002) found that the RDT premises holds up most consistently in new small firms than for larger or mature firms. For its part, Gulati, Nohria, and Zaheer (2000) reported that the use of managers' networks had the potential for reducing the external dependence and strengthening EO's firms. Similarly, Balkundi and Kilduff (2006) pointed out that firms' networks play an important role in creating and

increasing skills to innovate and make the first move by introducing new products and services.

In order to analyze the influence of networks on ASOs' EO under the main premises of RDT, our paper puts its focus on two networks' structural elements: size and frequency. On the one hand, network size reflects the probability of ASOs diminishing their external dependence, since the larger their networks, the higher the likelihood of obtaining the resources, abilities and information that they need for enhancing their EO from their own networks. However, as Lomi and Pattison (2006) suggest, the design of large networks with multiple ties could provoke the emergence of internal interorganizational dependencies within networks. For this reason, we also analyse the frequency of contacts within networks, since it is a measure of the degree of trust among the agents that compose a network and it has been frequently noted as a relevant mechanism for coordinating and managing the networks (Gardet & Mothe, 2012). In this vein, some authors such as Hansen (1999), Quan and Motoyama (2010), Schulz (2003) and Szulanski (1996) have demonstrated that frequent contacts allow the building of relationships based on trust and consequently, lead to more effective tacit knowledge and resources-sharing among actors. This could be especially relevant for ASOs, since previous research has highlighted that the entrepreneurial behaviour of the new firms that operate in environments characterized by high degrees of innovation and hostility is strongly influenced by the degree of trust, interaction and clarity with the agents that compose their networks (Allen, 1977; Tidd, 1997).

However, and in spite of these arguments, the prior empirical evidence is not unequivocal when it comes to examine the impact of both size and frequency on the behavior of the firms. Regarding network size, some research has demonstrated not only the existence of a positive relationship between network size and firms' success (Aldrich, Rosen, & Woodward, 1987; Collins & Clark, 2003; Hansen, 1995; Ostgaard & Birley, 1996), but also the positive impact of network size on firms' entrepreneurial behaviour. While most of this research has highlighted the influence of network size on the recognition of entrepreneurial opportunities (Ardichvili & Cardozo, 1999; Ardichvili, Cardozo, & Ray, 2003; Hills, Lumpkin, & Singh, 1997), some prior research has empirically demonstrated the positive influence of network size on EO (Manev et al., 2005). However, null or negative effects have also reported by previous research (Bhagavatula et al., 2010; Quan & Motoyama, 2010). For its part, network frequency has often been related to the strengthening of ties (Nahapiet & Ghoshal, 1998), which could lead to an improvement in fluency and clarity of communications and, consequently, to an increase in the efficiency of resource and information sharing (Aldrich, 1999; Zietsma, Winn, Branzei, & Vertinsky, 2002) as well as an improvement of firms' performance (Peltier & Naidu, 2012; Zhao & Aram, 1995). A small number of studies have obtained empirical evidence on the relationship between the frequency of contacts and the adoption of entrepreneurial behavior by firms. Hills et al. (1997) demonstrated the existence of a positive link between the frequency of contacts and the willingness of organizations to be alert to new entrepreneurial opportunities. Quan and Motoyama (2010) reported a significant and positive relationship between the frequency of attending meetings to outside agents and the exhibition of entrepreneurial behaviours by firms. Ripollés and Blesa (2005) found a positive relationship between network frequency in a sample of Spanish new ventures and the EO reported by them. Martins et al. (2016) found a significant and positive relationship between the firms' emphasis on using networks and the EO. Conversely, Ripollés and Blesa (2006) reported a negative influence of frequency of contacts on the EO reported by a sample of 119 Spanish new ventures.

In the light of the contradictory results provided by the limited previous empirical evidence, it could be suggested that the nature of the impact exerted by network size and frequency on firms' entrepreneurial behaviour is not universal. Therefore, the application of a contingency approach could help to shed light for understanding the consequences

of the design of networks, in terms of size and frequency of contacts, on ASOs' EO. For this reason, our paper suggests that the configuration of the structural elements of networks – size and frequency of contacts - is contingent to the network type with which firms maintain ties, that is, that different network types are able to provide ASOs with resources, knowledge, capacity and information, with high or low degrees of relevance and redundancy, in such a way that firms' EO could be affected. As previous literature noted, non-redundant knowledge and information contributes to enhancing the vision and capability of these firms to transform scientific discoveries into different commercially viable innovations (Bozeman & Mangematin, 2004; Gübeli & Doloreux, 2005; Mosey & Wright, 2007; Rasmussen, Mosey, & Wright, 2011; Soetanto & Van Geenhuizen, 2011; Vohora et al., 2004).

The agents with which ASOs interact could be classified into three groups of networks: informal networks (friends, family and colleagues); university support networks (university support institutions such as science parks, incubators, TTOs, and chairs of entrepreneurs); and industrial networks (agents who pertain to the industrial context). The consideration of these three types of networks emerges from the academic entrepreneurship literature (Gübeli & Doloreux, 2005; Mosey & Wright, 2007; Vohora et al., 2004). In this vein, taking into account the idiosyncratic features of ASOs, both industrial and university networks are expected to be especially relevant. Previous literature has highlighted the relevance of the networks established with agents belonging to university context, especially in the early stages of ASOs' development, as a result of the difficulties of ASOs for accessing industrial networks (Fernández-Alles, Camelo-Ordaz, & Franco-Leal, 2015; Mosey & Wright, 2007; Visintin & Pittino, 2014; Vohora et al., 2004; Zahra, Van de Velde, & Larrañeta, 2007). However, the prior research has also pointed out that the ability of ASOs to create commercial value from scientific discoveries may be improved by high levels of social capital outside the academic context because it facilitates the capability of synthesizing scientific knowledge with an understanding of the markets to which the knowledge might apply (Vohora et al., 2004; Zahra et al., 2007). In this line, some empirical evidences in the context of academic entrepreneurship such as Hayter (2015) have demonstrated the relevance of these networks, arguing that academic entrepreneurs are inheritors of both their own informal networks and the networks established in the university context.

With this typology as a starting point, research hypotheses are developed in order to analyse how the structural elements of each of these three networks influence ASOs' EO.

3. Hypotheses development

3.1. Informal networks

Informal networks refer to the range of actors who have been closely linked to entrepreneurs since even before the legal establishment of the firm. These agents are part of the inner circle of entrepreneurs' relationships and usually comprise family, friends, and colleagues (Granovetter, 1973).

Regarding network size, the literature has pointed that broad ties with a plurality of family and friends could be a major stimulus for the manifestation of entrepreneurial behaviors by organizations (Krackhardt, 1992; Uzzi, 1997). Previous research has provided empirical support for the impact of informal network size on firms' entrepreneurial behaviour. Bhagavatula et al. (2010) found that informal network size positively influenced the number of opportunities identified by a sample of Indian textile companies. Similarly, Quan and Motoyama (2010) demonstrated a positive relationship between the number of informal contacts and the entrepreneurial character of a sample of companies established in Silicon Valley. Two arguments seem to explain these results. On the one hand, the easy accessibility and availability of informal networks for these organizations as they often find great difficulty, especially during the earliest stages of

development, in accessing other networks (Hite & Hesterly, 2001). In this way, the resources, advice, or information required by nascent start-ups for the development of entrepreneurial behaviors may come from friends, family, and colleagues, who might constitute the only available source. On the other hand, the presence of some entrepreneurial model within informal networks has also been highlighted in the literature as an important catalyst for the development of entrepreneurial behaviors (Jack, Dodd, & Anderson, 2004; Ramos-Rodríguez, Medina-Garrido, Lorenzo-Gómez, & Ruiz-Navarro, 2010).

However, and in spite of the aforementioned arguments and empirical evidences, we consider that the specific nature of ASOs could advise again the establishment of relationships with a large number of contacts belonging their closer circles. As previous research has frequently pointed out, the academic origins and entailments of ASOs managers could provoke that these firms have broad stocks of scientific and technological knowledge and resources, but a very limited range of abilities for adopting entrepreneurial behaviours (Diáñez-González & Camelo-Ordaz, 2016; Knockaert et al., 2011). In this context, the design of broad informal networks could inhibit the exhibition of EO, because it is expected a highly degree of redundancy and similarity in the information, resources and knowledge provided by other academics and acquaintances. Following this argument, as informal networks size increases, the chance for an ASOs to identify a growing quantity of non-redundant knowledge related to the commercial applications of their discoveries decreases (Dyer, Gregersen, & Christensen, 2008; Ozgen & Baron, 2007). In this sense, Ripollés & Blesa (2005: 243) argue that entrepreneurs need a balanced personal network to better develop the EO. "To foster EO, the entrepreneurs need to access different resources to identify new entrepreneurial opportunities, as well as, the resources and competences needed to exploit these opportunities economically ahead of competitors, thus facilitating innovative and proactive performance, and a moderate risk-taking approach"

Regarding network frequency, previous literature has argued the importance of frequent contacts with informal networks for firms in order to capture efficiently the resources and support necessary for developing entrepreneurial attitudes (Quan & Motoyama, 2010). However, previous research is not unequivocal in this respect and some authors have found empirical evidence regarding the existence of a negative relationship between informal networks' frequency and firms' EO (Ripollés & Blesa, 2006). In this line, we propose that the more frequent the contacts with the agents that compose the informal networks, the lower the level of EO reported by ASOs. This is because the frequency of contacts increases the number of shared experiences among actors and results in an overlap between their knowledge bases (Lane & Lubatkin, 1998; Semrau & Werner, 2014). In this line, Wang & Altinay (2012: 9) noted that firms "that largely depend on family networks are likely to fall into the familiarity trap, which prevents the firm from exposing itself to new market opportunities, exploring new markets, products or new ways of doing things and undertaking risky ventures". In the specific context of ASOs, the idiosyncratic nature of these firms bring as a result that these firms need to expand their scope for searching the information, resources or knowledge that fosters their EO. If ASOs establish frequent interactions with their inner circles, it is likely to expect not only that they obtain the same and redundant information, knowledge and resources, but also that ASOs made the mistake of devoting too much time and efforts in strengthening their informal relationships, when it would be more desirable that they put their focus in other external agents.

Considering all these arguments, the following two hypotheses are proposed:

Hypothesis 1. a: There is a direct and negative relationship between informal network size and ASO's EO.

b: There is a direct and negative relationship between informal network frequency and ASO's EO.

3.2. University support networks

Previous literature has consistently pointed out that links with some university support institutions such as science parks, incubators, chairs of entrepreneurs, or TTOs could be of vital importance for new companies in general, and ASOs in particular, especially during their early stages of development (Baraldi, Ingemansson, & Launberg, 2014; Chan & Lau, 2005; Löfsten & Lindelöf, 2002; Pérez & Sánchez, 2003; Sá & Lee, 2012; Soetanto & Jack, 2013). The majority of research has highlighted the important role played by these agents in the implementation, performance, or survival of the organizations (Elfring & Hulsink, 2003; Pérez & Sánchez, 2003). Recent research has begun to point out that the development of entrepreneurial attitudes and behaviors by ASOs could be influenced by the support that they receive from these agents (Djokovic & Souitaris, 2008; O'Shea, Allen, Morse, O'Gorman, & Roche, 2007).

Drawing on the moderated redundant nature of the resources, knowledge and information provided by university support networks, our paper considers that the establishment of broad networks and frequent contacts with a range of actors and institutions from the university context could decisively enhance the exhibition of EO by ASOs, at least in the early stages of their life-cycle.

Regarding university support network size, several reasons could support this assertion. First, the university support institutions could provide ASOs with diverse resources and knowledge that ASOs often lack. Therefore, it is expected that such resources and knowledge are scarcely redundant with the base knowledge of ASOs and consequently, they could allow them to increase their focus on the entrepreneurial nature of their activities, especially during the early stages (Vohora et al., 2004). To this respect, Lockett, Siegel, Wright, and Ensley (2005) and O'Shea, Allen, Chevalier, and Roche (2005) have pointed out the relevance of the advisory and assistance provided by TTOs in topics such as the search and recognition of business opportunities, or the evaluation of the commercial potential of technologies on the likelihood that ASOs implement entrepreneurially oriented behaviours. Specifically, and drawing on the findings of O'Gorman, Byrne, and Pandya (2008), having the support of diverse university institutions could allow ASOs to acquire the market-related knowledge, which could be the starting point for the development of EO. Second, university support institutions often maintain direct ties with some relevant industrial actors such as investors, suppliers or other firms (Krücken, Meier, & Müller, 2007). Consequently, if ASOs are able to establish and maintain relationships with a number of university support institutions, it is expected that they can access more resources and knowledge provided by actors outside the university context and, therefore, with a lower degree of redundancy. Therefore, and taking into account that EO may be fostered through the search of new and non-redundant knowledge, information and resources, we propose that the higher the size of university support network, the higher the likelihood of an ASO to identify a growing quantity of non-redundant knowledge related to the commercial applications of their discoveries (Dyer et al., 2008; Hills et al., 1997; Ozgen & Baron, 2007).

Empirical evidence regarding the above arguments is extremely scarce and limited to the context of new technology-based companies. Lindelöf and Löfsten (2004) found a positive relationship between the number of new contacts made through the relationships maintained with science parks and the willingness of organizations to engage in innovative activities and proactive behaviors. Similar results were obtained by Scillitoe and Chakrabarti (2010), who showed that ties with university incubators positively influenced the size of firms' networks and, consequently, firms' innovativeness and proactiveness.

Regarding university support network frequency, the previous literature has emphasized the importance of establishing frequent ties with university actors for firms to exhibit entrepreneurial attitudes (Scillitoe & Chakrabarti, 2010). When interactions are frequent, university support institutions have better information about ASOs'

necessities and, consequently, are able to provide ASOs with the technical or market assistance they need to increase their predisposition towards innovative, proactive, and risky activities (Rice, 2002; Scillitoe & Chakrabarti, 2010). In addition, the establishment of frequent contacts increases knowledge embodiment and integration (Hansen, 1999; Reagans & McEvily, 2003). Frequent contacts among the ASO and the university support institutions network facilitate a pattern of interaction among the actors, contributing to the development of shared understanding and common routines or ways of working together, increasing the likelihood that knowledge integration will be effective (Grant, 1996; Laursen & Salter, 2006; Semrau & Werner, 2014).

The work of Scillitoe and Chakrabarti (2010), based on a sample of 42 Finnish technological startups, found a positive relationship between the frequency with which these firms had contacts with university incubators and the firms' ability to acquire the necessary assistance to increase their willingness to engage in innovative behaviors.

Considering these arguments, the following hypotheses are proposed:

Hypothesis 2. a: There is a direct and positive relationship between university support network size and ASO's EO.

b: There is a direct and positive relationship between university support network frequency and ASO's EO.

3.3. Industrial networks

According to Mosey and Wright (2007), industrial networks comprise those agents outside the academic and informal contexts, including venture capital (VC) firms, consultancy firms, governmental agencies, customers, and suppliers.

Previous literature has noted that the establishment of broad networks with industrial actors could provide firms with access to a variety of approaches, information, perspectives, and non-redundant and different insights from those provided by their closest environment and with the potential for strengthening the exhibition of entrepreneurial behaviors (Burt, 1992, 1997; Hargadon, 2002). In this vein, McEvily and Zaheer (1999) and Nicolaou and Birley (2003) pointed out that broad industrial networks could facilitate the discovery of entrepreneurial opportunities through access to crucial resources, information, and a margin of time for firms develop their research activities. Bhagavatula et al. (2010) found empirical evidence that industrial network size positively influenced the number of entrepreneurial opportunities recognized by a sample of Indian start-ups.

In the specific context of ASOs, the establishment of broad networks with industrial agents could have an extremely crucial relevance. As previous research has noted, firms with abundant and non redundant resources and knowledge or at least, with the possibility of accessing to diverse resources and knowledge, are more likely to exhibit higher degrees of EO (Martins, 2016; Wiklund, 1998). In this vein, the aforementioned scarcity of certain resources and knowledge that ASOs often exhibit, as well as the high likelihood of redundancy of the resources and knowledge obtained from the inner circles, bring as a result that the exhibition of EO by ASOs depends strongly of the number of industrial actors with whom they interact. Among the resources and knowledge provided by these external actors, previous literature has emphasized both the specific knowledge related to potential uses of their new technology, identification of markets, and prototype and product design as well as critical financial and technological resources (Rasmussen et al., 2015; Vohora et al., 2004).

Regarding industrial network frequency, previous literature has pointed out the relevance of increasing industrial network frequency for firms obtaining significant benefits (Kale, Singh, & Perlmutter, 2000; Tiwana, 2008) and enhancing their EO (Ripollés & Blesa, 2006). The underlying reason could lie on the cultural distance that exists between ASOs and industrial actors. In this vein, differences in motivation, behaviour, and organizational cultures between ASOs and industry agents

could be significant barriers for the transfer of knowledge, information and resources between them, which makes more time and effort necessary (Hornig & Hsueh, 2005; López-Martínez, Medellín, Scanlon, & Solleiro, 1994; Lyles & Salk, 1996; Mowery, Oxley, & Silverman, 1996; Santoro, 2000; Siegel, Waldman, & Link, 2003; Simonin, 1999). Under these circumstances, the redundancy produced by frequent contacts between ASOs and industrial actors would be especially beneficial since the contacts would intensify understanding among the parties involved. Consequently, industrial actors could be more able to provide firms with complementary and non-redundant information and knowledge (Bouty, 2000; Krackhardt, 1992), which could be especially relevant for ASOs enhancing their EO. Some authors have found empirical evidence regarding the positive impact of industrial network frequency on firms' entrepreneurial behaviours. Nicolaou and Birley (2003) demonstrated that the strengthening of the relations with industrial agents had a significant impact on entrepreneurial opportunities. Similarly, Landry, Amara, and Lamari (2002), in a study conducted with a sample of 440 Canadian companies, found that the frequency with which these firms maintained relationships with agents belonging to their industrial networks influenced their propensity toward the development of highly innovative behaviors.

These arguments lead to the formulation of the following hypotheses:

Hypothesis 3. a: There is a positive and direct relationship between industrial network size and ASO's EO.

b: There is a positive and direct relationship between industrial network frequency and ASO's EO.

4. Methodology

4.1. Sample and data collection

The population of this study consists of ASOs founded in Spain between 2003 and 2011. To identify and obtain contact data, we addressed the 67 Spanish TTOs (TTO Network Report, 2011) through certified mail, electronic mail, and telephone. For those cases in which the above information was not enough, we used complementary sources such as annual reports elaborated by incubators, technological parks, or chairs of entrepreneurs. Then we built a database of 555 Spanish ASOs. We designed two questionnaires based on a review of the literature. The questionnaires were pretested through interviews with founders and managers of seven ASOs, whose suggestions were incorporated into the final questionnaires. The surveys were carried out in March - June 2012. Both questionnaires were sent via electronic mail. Thus, we collected the responses of 112 managers belonging to 95 ASOs. In order to obtain the double response in all ASOs and increase the response ratio, we personally phoned the rest of ASOs and we sent again the email to those firms that manifested their interest by the research. Most of questions contained in both questionnaires were different. The reason is that we were interested to collect a broad range of information of diverse nature. Thus, in order to assure that each question was answered by the most adequate manager, the questions related to academic context, the process of the start-up of the firm and the nature of the knowledge and/or technology transferred composed the first questionnaire. For this reason, this questionnaire, which was composed by 25 questions, was sent to the main academic founder; that is, the main researcher who actively participated in the ASO's foundation and, in addition, was a member of the management team at the moment of the survey. For those cases in which the main researcher was no longer a member of the management team or it was not possible to contact him/her, another academic manager answered the questionnaire. For its part, the second questionnaire mainly contained questions related to firms' operations as well as objective, financial and demographic information. Considering its nature, the second questionnaire, which was composed of 22 questions, was sent to the ASO's CEO, who might come

from an academic or non-academic context. When the ASO's CEO presented an academic profile, we did not send the questionnaire to her/him; rather, we contacted a non-academic manager. Only for those cases in which none of the management teams' members came from non-academic contexts (28.1% of the sample) the questionnaire was sent to an academic manager - different from the member who answered the first questionnaire - who actively participated in decision-making and therefore had a wide perspective on the management of the firm. Moreover, we also included some repeated questions in both questionnaires. With this, we aimed to obtain the team perspective regarding certain questions, which had a prominent subjective character. Specifically, questions were referred to perceptual factors, conflict within management team and EO. Once the questionnaires were collected, we had usable and double responses from 167 ASOs (30.1% response rate).

The ASOs in the sample employed an average of 7.2 people and were 3.4 years old at the time of the survey. Almost half of the ASOs in the sample (48.5%) were in biotechnology, research and development, or chemical industries.

To investigate the potential for non-response bias, T-test comparisons of responding versus non-responding firms based on age and number of employees were conducted. No significant differences between the two groups were found, leading us to conclude that a no-response bias was not a likely threat to analysis.

Lastly, we also controlled for common method bias (CMB). Following Podsakoff, MacKenzie, Lee, and Podsakoff (2003) recommendations, we developed two different actions: (1) procedural remedies, considering potential biases in the design of the study and, (2) specific statistical analyses to assess the extent the data obtained are affected by CMB.

With respect to the procedural remedies, we explained ASOs managers the mechanisms developed to certify the anonymity of their responses. Additionally, we included an introductory paragraph in the survey to explain the academic objective of the research. With this, we aimed to avoid socially desirable, lenient or acquiescent responses (Podsakoff et al., 2003).

Moreover, we statistically controlled the potential CMB, performing the Harman's single-factor test. Results of the unrotated factor solution revealed that several factors were obtained and that the first extracted factor explained the 25.21% of the overall variance. Consequently, CMB seems not to be a serious concern in our study.

4.2. Measures

4.2.1. Dependent variable

EO has been measured using a six-item, five point Likert scale developed by Walter et al. (2006). The scale contains six items referred to the five dimensions of firm's EO: autonomy, proactiveness, innovativeness, risk-taking, and competitive aggressiveness. We have selected this scale for two main reasons. On the one hand, this scale is composed by six items that have been largely used by other researchers. Specifically, three items have been adapted from Dess, Lumpkin, and Covin (1997), whereas the other three items were based from Lumpkin and Dess (1996). On the other hand, this scale has demonstrated its applicability for the specific context of ASOs. The questions were addressed to two members of the management team, who had to answer regarding the extent to which the ASO exhibited an entrepreneurial predisposition (1: none; 5: a large degree). Drawing on previous research focused on firms' management teams (Hirst, Van Knippenberg, & Zhou, 2009; Wales, 2007), the mean of the individual responses within each team was used as the team-level variable. However, the level of within-team agreement, which refers to the degree to which ratings from individuals are interchangeable (Cohen, Doveh, & Nahum-Shani, 2009; Kozlowski & Hattrup, 1992; Tinsley & Weiss, 1975) was assessed before the individual measures were combined to form the team-level variables (Amason, 1996; Smith et al., 1994). To this end, within-team

Table 1
Types of networks. Factor analysis based on the frequency of contacts.
Source: Own elaboration.

Agents	Group 1	Group 2	Group 3	Communality
Other academics	0.623	0.090	0.091	0.766
Friends and family	0.601	0.054	0.128	0.741
Science parks	– 0.157	0.766	0.114	0.701
University support institutions	0.279	0.740	0.012	0.704
Venture capital firms	– 0.264	0.225	0.801	0.788
Consultancy firms	0.253	0.196	0.798	0.732
Customers and suppliers	0.120	0.118	0.762	0.701
Governmental agencies	0.401	0.163	0.752	0.755
Percentage of variance	0.201	0.266	0.331	0.798
Cronbach's alpha	0.622	0.732	0.844	

Bold items represent the indexes that allow us to establish three groups of agents.

agreement was assessed with the reliability Within Groups on j number of items, also known as the $r_{WG(j)}$ (James, Demaree, & Wolf, 1993). Such index is developed on a scale from 0 to 1, with scores above .70 considered to demonstrate agreement within the team (Ensley & Hmieleski, 2005). The $r_{WG(j)}$ was 0.88 for EO, thus demonstrating an appropriate inter-rater reliability.

The results of the factor analysis support considering EO as a unidimensional construct since it reports an appropriate level of internal consistency ($\alpha = 0.853$) and a correct sampling adequacy (Kaiser-Meyer-Olkin Test (KMO) = 0.834). The percentage of total variance explained rises to 64.55%.

4.2.2. Independent variables

4.2.2.1. *Type of network.* Drawing on Mosey and Wright (2007), eight relevant agents have been identified: VC firms; consultancy firms; governmental agencies; customers and suppliers; science parks; university support institutions; family and friends; and other academics.

In order to determine the different types of networks with whom academic ASOs maintain their relationships, a factor analysis has been carried out based on the frequency with which ASOs had contacts with each of the agents. Table 1 provides the details of the analysis.

The factor analysis accounts for 79.8% of the variance. As recommended by Hair, Black, Babin, Anderson, and Tatham (2006), all factor loadings are greater than 0.40, and all communalities exceed 0.50. As can be seen, agents can be clearly grouped into three different types of networks. The first is called an informal network and contains friends, family, and other academics (Cronbach's alpha = 0.622). The second group is conceptualized as a university support network and includes university science parks and university support institutions (Cronbach's alpha = 0.732). The third group is known as an industrial network and is composed of venture capital firms, consultancy firms, governmental agencies, and customers and suppliers (Cronbach's alpha = 0.844).

4.2.2.2. *Network size.* Drawing on Aldrich et al. (1987) and Aldrich and Reese (1993), the size of the network is measured by a continuous variable that indicates the number of different agents with whom ASOs have relevant contacts for their development.

4.2.2.3. *Frequency of contacts.* Following Scillitoe and Chakrabarti (2010), the variable is measured by asking about the frequency with which the ASO interacts with agents that compose its network. A Likert scale of 5 points was used, in which 1 refers to less than one monthly contact and 5 indicates multiple daily contacts. The individual frequencies were summed and grouped in order to determine the frequency with which the ASO establishes relationships with each of the three types of networks as part of its global network.

4.2.3. Control variables

Four control variables were considered in this empirical analysis.

First, research in the field of entrepreneurship has pointed out the role that management team size could play in the development of EO through an increase in the range of options, ideas, and innovative approaches available to firms (Rauch et al., 2009). Management team size was measured by a continuous variable, which quantifies the number of members that are part of the ASO's management team. ASO age has also been controlled since the establishment and maintenance of relationships is a process that consumes a lot of time and, consequently, ASOs could decide to vary their business objectives or priorities throughout their lifecycle (Roberts, 1990; Walter et al., 2006). ASO age was measured by a continuous variable corresponding to the number of years from the official date of establishment of an ASO (Wiklund & Shepherd, 2005). Thirdly, industry was categorized using a binary variable that takes the value 1 for companies in the biotechnology, chemical, or research and development industries and 0 in other fields. This distinction follows the line marked by previous research such as Vendrell-Herrero and Ort n- ngel (2010) and Vohora et al. (2004) and is consistent with the classification established by the Center for Industrial and Technological Development (CITD). The information regarding both the start-up date and the industry of the firms was obtained through some annual reports elaborated by incubators, technological parks and chairs of entrepreneurs. Lastly, in order to control for firm size, the respondents were finally asked how many individuals worked in the ASO at the present time, including owners and members of management teams. Firm size has been consistently analysed in previous research, since large organizations have more resources to conduct entrepreneurial activities (Walter et al., 2006; Wiklund & Shepherd, 2005).

4.3. Analysis and results

Tables 2 and 3 contain, respectively, the main descriptive statistics and correlations between variables. As can be observed in Table 3, the values of the bivariate correlations between the variables are less than 0.5 and, consequently, it seems that collinearity problems could be rejected. Furthermore, analysis of the variance inflation factors (VIF) reveals that these factors do not reach the boundaries at which multicollinearity is considered a likely threat ($VIF < 5$) (Hamilton, 2006). Thus, the possible existence of multicollinearity between the variables is rejected.

The statistical technique used to contrast the research hypothesis was multiple regression analysis. Table 4 contains the results. Two models were specifically designed. Model 1 only includes the control variables, while the independent variables are introduced in Model 2 in order to analyse the impact of such variables on ASOs' EO.

Model 1 shows that the control variables explained 6.7% of the variation in the EO reported by the ASOs. Management team size ($\beta = 0.197$; $p < 0.05$), ASO age ($\beta = 0.233$; $p < 0.05$) and ASO size ($\beta = 0.271$; $p < 0.05$) positively influenced the manifestation of this strategic orientation. Model 2 reveals that the introduction of the

Table 2
Descriptive statistics.
Source: Own elaboration.

Variable	Mean	s.d.	Min.	Max.
[1] EO	3.981	0.604	1	5
[2] Informal network's size	10.491	33.998	0	400
[3] Informal network's frequency	1.838	0.925	1	5
[4] University network's size	2.053	1.606	0	12
[5] University network's frequency	2.188	1.153	1	5
[6] Industrial network's size	26.814	31.021	0	218
[7] Industrial network's frequency	2.324	0.751	1	5
[8] ASO's age	3.419	2.176	0	8
[9] Management team's size	3.047	1.689	1	9
[10] Biotech, chemistry of R&D industry	0.455	0.499	0	1
[11] ASO size	7.287	7.288	1	47

Table 3
Bivariate correlations.

Variable	1	2	3	4	5	6	7	8	9	10	11
EO	1										
Informal network's size	0.112	1									
Informal network's frequency	0.120	0.134*	1								
University network's size	0.209*	0.164	0.215	1							
University networks' frequency	0.249*	0.056	0.060	0.381	1						
Industrial network's size	0.178**	0.070	-0.003	0.197***	-0.096	1					
Industrial network's frequency	0.234*	0.049	0.254	0.295*	0.247*	0.071**	1				
ASO's age	-0.047	-0.156	-0.050	-0.124	-0.136	0.271*	0.169	1			
Management team's size	0.012**	-0.042	-0.072	0.052	0.091*	0.034**	0.010	0.039	1		
Biotech, chemistry of R&D industry	0.238**	0.005	0.225	0.127	0.232	0.208	0.206*	-0.027	0.088	1	
ASO size	0.136*	0.269**	0.059	0.138*	0.066	0.242**	0.071	0.023	0.278**	0.033	1

Source: own elaboration.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

explanatory variables caused a substantial improvement in the explanatory power of the model (adjusted $R^2 = 18.1\%$; $p < 0.001$).

With regard to the tests of the hypotheses, the results extracted from Model 2 first reveal that, in contrast to our hypotheses, neither informal network size ($\beta = 0.093$; $p > 0.1$), nor informal network frequency ($\beta = 0.023$; $p > 0.1$) seem to exert any influence on the ASOs' EO. Consequently, both [Hypothesis 1a](#) and [b](#) are rejected. It is possible to note a positive and significant impact of university support network size on the ASOs' EO ($\beta = 0.177$; $p < 0.05$), supporting [Hypothesis 2a](#). Similar results can be obtained regarding the analysis of the influence of university support network frequency on the ASOs' EO since, as can be seen, a significant and positive association between the two variables was found ($\beta = 0.164$; $p < 0.05$). Therefore, this result supports [Hypothesis 2b](#). Model 2 also shows the existence of a highly significant and positive relationship between industrial network size and the ASOs' EO ($\beta = 0.288$; $p < 0.001$), providing empirical support to [Hypothesis 3a](#). Similarly, [Hypothesis 3b](#), which predicted the existence of a positive relationship between industrial network frequency and the ASOs' EO, is also supported ($\beta = 0.251$, $p < 0.01$).

4.4. Multi-group analysis

Finally, a multi-group analysis was performed in order to analyse the potential effect of industry in the relations between the structural elements of the three types of networks and the EO reported by ASOs. To this end, the sample was split into two groups of firms based on the firms' industry. Specifically, the first group was composed by 76 companies belonging to the biotechnology, chemical, or research and development industries, whereas the second group included 91 firms which operated in other industries. This distinction follows the line marked by previous research such as [Vendrell-Herrero and Ortín-Ángel \(2010\)](#) and [Vohora et al. \(2004\)](#) and is consistent with the classification established by the CITD. As can be seen in [Table 5](#), the t -tests are not able to confirm the existence of significant differences between both groups of firms and therefore, industry does not seem to exert any differentiated effect on the relationships between the structural elements of networks and the EO exhibited.

4.5. Post-hoc analysis

Before discussing these findings, the results of an analysis performed

Table 4
Results of multiple regression analysis.

Variables	Model 1		Model 2	
	Entrepreneurial orientation		Entrepreneurial orientation	
	Coefficient β	t-value	Coefficient β	t-value
Management team's size	0.212*	2.751	0.199*	1.914
ASO's age	0.041	0.551	0.101	1.283
Biotech, chemistry of R&D industry	0.269*	3.273	0.228*	2.051
ASO size	0.271*	3.354	0.239*	2.093
Informal network's size			0.099	1.226
Informal network's frequency			0.021	0.285
University network's size			0.188*	1.779
University network's frequency			0.169*	1.527
Industrial network's size			0.297***	3.773
Industrial network's frequency			0.243**	2.801
Constant	-0.138	-0.673	-0.149	-0.663
R^2	0.096		0.213	
Adjusted R^2	0.067		0.181	
ΔR^2			0.114***	
F-statistic	3.351*		3.591**	

Standardized coefficients are reported.

Source: own elaboration.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Table 5
Multi-group analysis.
Source: Own elaboration.

Direct causal effect	Group 1		Group 2		z-score
	Estimate	P	Estimate	P	
Informal networks' size → EO	0.179	0.121	0.182	0.136	n.s.
Informal networks' frequency → EO	0.221	0.129	0.141	0.132	n.s.
University network's size → EO	0.363	0.003	0.387	0.003	n.s.
University network's frequency → EO	0.312	0.003	0.322	0.003	n.s.
Industrial network's size → EO	0.507	0.000	0.588	0.000	n.s.
Industrial network's frequency → EO	0.499	0.000	0.502	0.000	n.s.

Standardized coefficients are reported.

in addition to the tests of the hypothesized relationships discussed above will be presented. This post-hoc analysis disaggregated the ASOs' networks types, with the purpose of identifying potential differences in the each type of agent on the EO exhibited by the firms. However, results of both ANOVA tests and Levene's tests form homogeneity of variance indicate the absence of significant differences. Results are presented in [Tables 6 and 7](#).

5. Discussion and conclusions

The main objective of this paper was to analyze the impact that the structural elements of ASOs' networks exert on the EO exhibited by these firms through a contingency approach. To this end, the agents who compose the circle of relations of ASOs have been grouped into three different types of networks (informal, university support, and industrial), with the size and frequency of contact of each specific network being analyzed.

First, the results obtained show that the size of informal networks is not significantly related to ASOs' EO – [Hypothesis 1a](#). This finding seems to indicate that informal networks may lack a variety of sources of information, resources and knowledge, which are necessary and relevant for promoting EO. The reason is that such information, resources and knowledge could be highly redundant. However, and contrary to expected, informal network size does not inhibit EO, but does not influence such strategic orientation. Equally, our hypothesis – [Hypothesis 1b](#) – that predicted a negative impact of informal network frequency on ASOs' EO, as a result of an expected increase in overlap or redundancy between the knowledge bases, has not been supported. An overall interpretation of these findings could be based on the scarce relevance that the knowledge, resources and information provided by the agents that compose informal networks have for ASOs. To this respect, it is reasonable to think that the redundant character has less explanatory power than the lack of relevance. The relationships that ASOs maintain with informal networks could play a residual role since the agents that

are part of such networks do not provide ASOs with the knowledge related to potential uses of their new technology, the identification of markets and the product design, which are all factors that can contribute to enhancing firms' EO. In this line and focused on the academic entrepreneurship context, [Vohora et al. \(2004\)](#) argued that ASOs could increase their entrepreneurial behaviour whether they are able to maintain significant ties with agents external to the closer environment since it allows that scientific knowledge could be complemented by the identification and understanding of the markets where such knowledge will be offered ([Sousa-Ginel et al., 2017](#)). These results are consistent with some research that points out the scarce incidence of emotionally close agents for the enhancement of firms' entrepreneurial attitudes ([Hills et al., 1997](#); [Ibarra, 1993](#)). The qualitative research of [Jack \(2005\)](#) found that informal networks were not robust enough to deal with the impact of industrial forces on firms' business activities and that they could limit the entrepreneurs' ability to realize entrepreneurial opportunities.

Second, with respect to the role played by university support networks size and frequency, our results show that, in line with [Hypotheses 2a and b](#), both exert a significant and positive impact on ASOs' EO. However, in the light of the results obtained, it is important to note that such effect is significantly lower than that reported by industrial network structural elements. These findings could highlight the relevance of maintaining broad networks and frequent contacts with the agents that compose these networks. The reason is that such university support actors could provide ASOs with the access to diverse and new industrial agents, sources of information and assistance, which could have enough potential for stimulating entrepreneurial behaviours ([Lindelöf & Löfsten, 2003](#); [Montoro-Sánchez, Mora-Valentín, & Ortiz-de-Urbina-Criado, 2012](#); [Soetanto & Jack, 2013](#)). Supporting this argument, the values of the correlation indexes ($r_{\text{industrial network size} - \text{university network size}} = 0.197$; $p < 0.001$; $r_{\text{industrial network frequency} - \text{university network size}} = 0.295$; $p < 0.001$; $r_{\text{industrial network frequency} - \text{university network frequency}} = 0.247$; $p < 0.05$) could suggest that both the number of university support institutions with which ASOs maintain relationships as well as the frequency of such contacts could determine not only the number of industrial agents who would compose ASO networks, but also the quality of such relationships. In this vein, several previous investigations have identified the provision of new external relationships as the most relevant activity of the university support institutions ([Hirai, Watanabe, & Inuzuka, 2013](#); [Sá & Lee, 2012](#); [Scillitoe & Chakrabarti, 2010](#)).

Finally, as [Hypotheses 3a and b](#) predicted, the results have shown that both industrial network size and frequency exert a significant and highly positive influence on ASOs' EO. The importance of industrial agents mainly lies in their ability to provide firms with valuable and non-redundant information, knowledge and resources, which would reduce the environmental uncertainty and facilitate the discovery of new entrepreneurial opportunities ([Granovetter, 1983](#); [McEvily & Zaheer, 1999](#)). Thus, our findings show that for the development of EO, a rise in the number of contacts with industry actors may increase the

Table 6
ANOVA test and Levene's test. Groups of agents.
Source: Own elaboration.

		Sum of squares	df	Mean square	F	Sig.	Levene statistic	Sig.
Informal networks	Between Groups	158.132	156	1.014	1.288	0.348	1.761	0.135
	Within Groups	7.868	10	0.787				
	Total	166.000	166					
University networks	Between Groups	155.035	156	0.994	0.906	0.637	0.929	0.432
	Within Groups	10.965	10	1.097				
	Total	166.000	166					
Industrial networks	Between Groups	157.837	156	1.012	1.239	0.378	1.004	0.421
	Within Groups	8.163	10	0.816				
	Total	166.000	166					

Table 7
ANOVA test and Levene's test. Individual agents.
Source: Own elaboration.

		Sum of squares	df	Mean square	F	Sig.	Levene statistic	Sig.
Other academics	Between Groups	258.261	156	1.656	1.057	0.507	1.812	0.132
	Within Groups	15.667	10	1.567				
	Total	273.928	166					
Friends and family	Between Groups	152.492	156	0.978	0.605	0.904	0.881	0.439
	Within Groups	16.167	10	1.617				
	Total	168.659	166					
Science parks	Between Groups	351.302	156	2.252	1.047	0.515	0.765	0.462
	Within Groups	21.500	10	2.150				
	Total	372.802	166					
University support institutions	Between Groups	272.785	156	1.749	0.912	0.632	0.799	0.479
	Within Groups	19.167	10	1.917				
	Total	291.952	166					
Venture capital firms	Between Groups	127.151	156	0.815	0.670	0.853	1.113	0.337
	Within Groups	12.167	10	1.217				
	Total	139.317	166					
Consultancy firms	Between Groups	272.746	156	1.748	1.399	0.291	0.619	0.538
	Within Groups	12.500	10	1.250				
	Total	285.246	166					
Customers and suppliers	Between Groups	199.805	156	1.281	1.365	0.308	1.667	0.198
	Within Groups	5.417	10	0.542				
	Total	205.222	166					
Governmental agencies	Between Groups	227.083	156	1.456	1.333	0.323	1.588	0.224
	Within Groups	10.917	10	1.092				
	Total	238.000	166					

chance an ASO has of obtaining diverse complementary knowledge related to opportunity recognition, identification of markets, product/service improvement needs, and user information about how the innovations may be used (Ismail et al., 2010; Rasmussen, 2011; Vohora et al., 2004; Yli-Renko, Autio, & Sapienza, 2001). In this vein, as Burt (1992, 1997) and Simsek, Lubatkin, and Floyd (2003) suggested, firms that have at their disposal a large amount of non-redundant information may have a high volume of diverse and useful information that can be used as a basis for the development of ideas and activities with a high level of innovation and risk. Following this line, Ripoll s and Blesa (2005) found that broad networks with industrial agents positively affected the EO of a sample of new Spanish firms as a result of the richness of the information provided.

Moreover, our results have revealed a significant enhancement in the degree of EO reported by ASOs when relationships with industrial agents occur with high frequency. This finding highlights the importance of establishing common links with industrial players in order to build a climate of mutual trust (Uzzi, 1997). As a result of their low visibility and the high risk inherent in their activities, ASOs would need to increase the frequency of contacts with these industrial actors in order to strengthen the ties and transform the benefits derived from the utilization of varied and high-quality information in higher levels of EO. Research conducted by Hirai et al. (2013), using a sample of 79 Japanese ASOs, found a positive relationship between the frequency with which such firms interacted with a number of advisers from the industrial context and the development of a capacity to guide their actions toward the specific needs of the market.

An overall interpretation of the results suggests the relevance of the appropriate design of the different network types – in terms of size and frequency – for the development of ASOs' EO. Specifically, as our findings have revealed, ASOs should devote their main efforts to build broad industrial networks with frequent interactions, although they should not obviate the relevance of maintaining broad and frequent university networks. Conversely, ASOs should try to decrease the number of ties and the frequency of contacts with the agents that compose their informal networks.

5.1. Contributions to the theory

This paper presents some contributions to both RDT research and academic entrepreneurship research. On the one hand, our research allow us to attend the recent demands of RDT researchers, since as the literature review of Hillman et al. (2009) suggests, scholars should try to integrate RDT and contingency approach in order to analyse which environmental contingencies influence the behaviour and performance of the firms. Specifically, the findings obtained from the utilization of a contingency approach show the convenience of integrating the agents with which ASOs maintain relations into different types of networks, providing interesting conclusions about the association between the structural elements of each of these networks and the entrepreneurial behavior exhibited by ASOs. In addition, this research contributes to the further development of RDT because it highlights that the importance of firms' networks as key elements in reducing dependence with respect to external agents may be reflected in the firm's inclination toward the development of entrepreneurial behaviour. To this respect, most previous studies only considered the role of networks as mechanisms with the capacity to reduce the dependence of firms on the external environment and influence organizations' performance (Hillman & Dalziel, 2003). For this reason, our findings allow us to reach new conclusions that differ from those traditionally provided by the literature. On the other hand, our paper also attends the demands of some academic entrepreneurship researchers, which claims for the development of more advanced research linking networks and entrepreneurship. As Rasmussen, Mosey, & Wright (2015: 431) point out, ASOs provide "an excellent setting to study network theory in action due to their technological complexity, fast moving market dynamics, growth struggles and redirections". To this respect, our research within the academic entrepreneurship context extends the emerging research stream focusing on the role of different network types on ASOs' behaviour (Rasmussen et al., 2015; Semrau & Werner, 2014) and allow us to highlight the relevance of analysing the impact of networks' structural elements on ASOs' EO, where previous research has not addressed such relationships.

5.2. Managerial implications

Our managerial implications are addressed to both ASOs' management teams as well as university support institutions. On the one hand, an overall interpretation of the results suggests that ASOs' management teams strongly need to access actors from the industrial context since such agents could provide ASOs with the resources, the abilities, and the knowledge necessary for ASOs enhance their degrees of EO. For this purpose, the design of large industrial networks with frequent contacts seems to be revealed as an effective mechanism. In addition, in the light of our results, ASOs' management teams should not obviate the relevance of the resources and especially, the ties that university support institutions could provide. Conversely, ASOs' management teams should try to distance themselves from their closer contexts – other academics, friends and family – since the development and exhibition of entrepreneurial attitudes by ASOs seems to require a series of resources, abilities and knowledge that are not possessed by such informal ties. On the other hand, university support institutions should be aware of its importance as facilitators, both directly, and indirectly, of a number of resources and information that seem vital to the entrepreneurial behaviour of ASOs. In this respect, in addition to the creation of an appropriate environment for the establishment of common relations with ASOs, it is necessary to note that university support institutions should develop a crucial role as facilitators of the mutual understanding between academic entrepreneurs and industrial agents in order that ASOs could broaden and enhance the trust in the relations with such agents. To this end, the development of programs, activities, or workshops in which ASOs' managers and agents from the industrial context could share mutual experiences and necessities could be an appropriate starting point.

5.3. Limitations and suggestions for future research

This research also has several limitations that should be noted. Although this research follows the premises of previous research (Martins & Rialp, 2013; Ripollés & Blesa, 2006) and explores the relationship between networks and EO in the same direction, the cross-sectional nature of our data requires caution when drawing causal inferences because the relationships may be susceptible to endogeneity. Therefore, the development of a longitudinal study for analysing the relevance of a causal direction could be relevant and constitute a future line of research. Second, the analysis of the structural aspects of the network dimension has been developed using size and frequency of contacts as measures. The consideration of other measures, such as the position of ASOs in their networks, or the heterogeneity of such networks, might extend the results of this study and offer an interesting research opportunity. Third, our data could suffer from a survivor bias. According to some authors such as Denrell (2003) and Wiklund and Shepherd (2011), the presence of risk-taking as one of the dimensions that compose the construct EO could lead to misleading interpretations of the results obtained. For this reason, Wiklund and Shepherd (2011) recommend that samples includes both failed as well as successful firms. Unfortunately, our sample only contains ASOs that operated in the markets when the survey was carried out and consequently, survivor bias could be a threat. Lastly, this paper has not considered the stage of an ASO's life cycle when analysing the differential impact of each of the types of networks on the EO of firms. According to recent literature (Lamine et al., 2015; Rasmussen et al., 2015), it could be relevant to consider the different stages of the ASOs' lifecycle since this factor could affect the design of networks' structural elements. To this respect, future research might consider an examination of the specific impact of the structural elements of both university support networks and industrial networks on the EO of ASOs that are in the development phase, as well as the influence of industrial network's structural elements on the entrepreneurial behavior of ASOs that are consolidated.

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Appendix A. Measures

Entrepreneurial orientation (Questionnaires 1 and 2)

To what extent do the following statements apply to your organization's style?

(1: statement does not apply at all; 5: statement applies completely).

- In this organization, entrepreneurial behaviour is a central principle.
- In this organization, people are dynamic.
- In this organization, innovation is emphasized above all.
- In this organization, people are willing to take risks.
- In this organization, willingness to continuous progress is the joint foundation.
- In this organization, people are eager at being always first to market.

Networks' size (Questionnaire 2)

Please, indicate the number of each of the following types of agents with whom the academic spin-off maintain relationships:

- Friends and family.
- Other academics.
- University support institutions (Technology Transfer Offices, Chairs of Entrepreneurs...).
- Technological parks.
- Advisers and consulting firms.
- Intellectual property agencies.
- Competitors.
- Suppliers and customers.
- Venture capital firms and other investors.

Frequency of contacts (Questionnaire 2)

Please, indicate the frequency of the contacts between the academic spin-off and the following agents: (1: less than one contact per month; 5: multiple daily contacts).

- Friends and family.
- Other academics.
- University support institutions (Technology Transfer Offices, Chairs of Entrepreneurs, ...).
- Technological parks.
- Advisers and consulting firms.
- Intellectual property agencies.
- Competitors.
- Suppliers and customers.
- Venture capital firms and other investors.
- Government and regional public agencies.
- Professional and business associations.

Management team size (Questionnaire 2)

Please, indicate the number of members of the management team of the academic spin-off:

Firm size (Questionnaire 2)

Please, indicate the number of employees (including owners and members of the management team) who are currently working for the academic spin-off:

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