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## Technological Forecasting &amp; Social Change

journal homepage: [www.elsevier.com/locate/techfore](http://www.elsevier.com/locate/techfore)

## The emerging role of university spin-off companies in developing regional entrepreneurial university ecosystems: The case of Andalusia

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## ARTICLE INFO

## Keywords:

Entrepreneurial university

University Spin-off

Regional entrepreneurial university ecosystem

## ABSTRACT

Universities play a strategic role as drivers of regional economic growth. One contribution is the establishment and support of University Spin-off companies (USOs), as a knowledge transfer mechanism, thus contributing to generating *entrepreneurial university ecosystems*. Recent literature points to this as a promising and emerging research area and policymakers are increasingly investing in universities to facilitate economic growth. This is based partially on the idea that a well-established or successful *entrepreneurial university ecosystem* automatically leads to the emergence of business ecosystems with subsequent benefits to the region. Using the knowledge spillover theory conceptual lens in combination with a social networks approach, this is explored in the region of Andalusia (Spain), centring on the *regional entrepreneurial university ecosystem* and in the role of the USOs. By means of a mixed-methods approach, we identified the main actors of the Andalusian *entrepreneurial university ecosystem* and found how the ecosystem is enacted, using a social network approach, and how the ecosystem promotes an *expansive wave effect* making the knowledge spillover possible to businesses beyond the *entrepreneurial university ecosystem*. This study confirms empirically that the USOs are main actors in the *entrepreneurial university ecosystem* and strengthen knowledge transfer, by relating with other businesses beyond this ecosystem; and expands the emergent ecosystem approach into the field of entrepreneurship.

### 1. Introduction

Policymakers worldwide are continually looking for effective mechanisms to stimulate their economies (Autio et al., 2014). In this sense, universities have been the focus of several policies (Morgan, 2007; Nicolaou and Birley, 2003) to stimulate the production and diffusion of new knowledge (knowledge transfer) and to act as catalysts of innovation across their regions (Nicolaou and Birley, 2003; Wright, 2014). Consequently, universities are increasingly adopting stronger entrepreneurial and innovative strategic profiles in order to provide wider social and economic benefits to their region (Siegel and Wright, 2015), thus giving birth to the *entrepreneurial university* (Clark, 1996, 1998a, 1998b, 2000; Clark et al., 2000; Davies, 1987; Etzkowitz, 1983). We define an *entrepreneurial university* as a university which is, in addition from teaching and research, also focused on the support of entrepreneurial activities by researchers and graduates, with strong connections with R&D centres (RDC), firms, science and technological parks, governments, and institutions. Therefore, it is a university, in general, oriented to the society as a regional actor (Etzkowitz, 2017). This new model of a university provides a supportive *ecosystem* to the

university community and its surroundings, in order to produce, diffuse, absorb, and use new knowledge that can give rise to University Spin-off companies (USOs) (Carree et al., 2014; Guerrero et al., 2014). Where USOs are for-profit firms based on university research (Philpott et al., 2011). These companies are an important vehicle of knowledge transfer from Universities that take advantage of innovations and creating new high quality employment and accelerating the productivity of regional economies (Hayter, 2016a; Lubik et al., 2013; Shane, 2004). Policymakers are increasingly investing in universities to foster the creation of innovative start-ups in the hope of producing areas of economic growth (Autio et al., 2014) and the resulting initiatives are predicated on the idea, using successful well-known examples such as Silicon Valley, that a well-structured *entrepreneurial university ecosystem* automatically leads to the emergence of successful *business ecosystems* (Clarysse et al., 2014; Engel and Del-Palacio, 2009, 2011). A successful *business ecosystem* is defined by *companies that work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovation* (Moore, 1993: 76). However, some studies have concluded that this hypothesis is not always supported. In this sense, Clarysse et al. (2014), after

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<https://doi.org/10.1016/j.techfore.2018.10.020>

Received 20 July 2017; Received in revised form 14 October 2018; Accepted 19 October 2018

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reviewing both concepts, analysed this assumption in the region of Flanders and found a disconnection between both ecosystems. They argued that policy in the Flanders region was focused more on bilateral links rather than on an ecosystem approach and called for more research in different contexts in order to compare their findings and clarify this assumption.

In this vein, the *Knowledge Spillover Theory of Entrepreneurship* (KSTE) (Acs et al., 2009; Hayter, 2013a) focused on individuals as “agents of knowledge” and their role in the knowledge spillover process (Acs et al., 2009). It embraces the assumption that new knowledge is the source of innovation, productivity and economic growth (Grant, 1996). New knowledge is created from the combination of existing knowledge, which depends on the ability of the actors to effectively and efficiently search for, access, transfer, absorb, and apply the knowledge (Borgatti and Cross, 2003). KSTE suggests that entrepreneurship is an important vehicle for the spillover of new knowledge and therefore critical to economic growth (Acs et al., 2009; Hayter, 2013a, 2013b). In this vein, social relationships and their networks, are essential in explaining the processes of knowledge production, diffusion, absorption, and use (Phelps et al., 2012). And USOs are embedded within social networks with other actors who provide them information and resources that are important for both, the venture success (Hayter, 2016b; Hoang and Antoncic, 2003; Nicolaou and Birley, 2003) and the emergence of the ecosystem (Hayter, 2013b, 2016a; Spigel, 2017). These ecosystems, supported by entrepreneurial universities, are termed in the literature as *entrepreneurial university ecosystems* (Graham, 2014; Hayter, 2016a) and have emerged as a promising research area (Autio et al., 2014; Graham, 2014; Hayter, 2016a; Siegel and Wright, 2015).

In this vein, and addressing previously mentioned calls for more research in the area, this study focuses on the *entrepreneurial university ecosystems*. In particular, it centres on how the different actors (university researchers/professors, USOs, and intermediaries), from an individual perspective, interact in a specific regional context; and how this is linked with businesses beyond this ecosystem. Accordingly, we combine KSTE with social network theory to link the micro-level, the entrepreneurial behaviour of the ecosystem participants; with the macro-level, the dynamics of the connectivity between the participants in an *entrepreneurial university ecosystem*. This study seeks to address the following research question (RQ), which includes three sub questions: *What is the role of social context (1), intermediaries (2), and USOs (3) in the development of regional entrepreneurial university ecosystems?*

After firstly analysing, using a social network approach, how the *entrepreneurial university ecosystem* is enacted in the region of Andalusia, this study makes a contribution to the entrepreneurship literature, regarding the role of USOs and other actors in the development of *entrepreneurial university ecosystems* and the relation with businesses beyond this ecosystem, testing and extending the emergent ecosystem approach. The main contribution of this study is the identification of an expansive *wave effect* which refers to the intensity of social networks links among participants located in different *entrepreneurial university ecosystems* through which knowledge spillover to other businesses occurs. Additionally, it answers the call for more empirical work in different regional contexts about ecosystems, showing the role of USOs and other intermediaries in the development of *entrepreneurial university ecosystems*.

## 2. Theoretical framework

### 2.1. Innovation system, innovation cluster, knowledge ecosystems and entrepreneurial ecosystems

The interest in analysing industries is not new, and closed concepts such as entrepreneurship policies portfolios (De-Filippo et al., 2015; Levie, 2014), regional clusters of entrepreneurs and specialized resources (McAdam et al., 2016), innovation ecosystems (Nambisan and Baron, 2013), national systems of entrepreneurship (Frenkel et al.,

2015), and entrepreneurial ecosystems of innovation (Autio et al., 2014; Clarysse et al., 2014; Graham, 2014) exist. Among the most relevant are innovation systems, clusters and ecosystems, which sometimes are used with interchangeable meanings in the literature, particularly the different terminologies associated with ecosystems.

The *innovation system model* was coined by Freeman (1982) and it is defined as *all important economic, political, social, organizational, institutional and other factors that influence the development, diffusion and the use of innovations* (Edquist, 2005: 182). Therefore, the components of the systems are these organizations and institutions, which create and commercialise the knowledge (Edquist, 2005; Lundvall, 2007).

The *innovation cluster* consists of the agglomeration of interconnected companies in a particular field or industry, linked by commonalities and complementarities, which benefit from being geographically proximate to each other (Porter, 1998). Subsequently, Engel and Del-Palacio (2009) extended this theory suggesting that clusters are not isolated islands, and have built a new framework that supports global networks among innovation clusters. They argued that the most successful innovation clusters are often the most globally connected (Engel and Del-Palacio, 2011). Using the Silicon Valley as an example, Engel and Del-Palacio (2009) explained that entrepreneurs and new start-ups positioned into innovation clusters benefit from being co-located close to specialized organizations which disseminate best practices for entrepreneurship - such as universities, law firms specialized in IP right or licensing, financial institutions or investors (Clarysse et al., 2014).

As a consequence, new start-ups arise near to already established organizations due to the benefit from their location premium, which, over time co-evolve to a specialized knowledge-intensive industrial cluster (Engel and Del-Palacio, 2011; Whittington et al., 2009). These firms are termed, in the entrepreneurship literature, *anchor tenants* (Agrawal and Cockburn, 2003; Feldman, 2003; Powell et al., 2010), the specialized knowledge-intensive industrial cluster as a *knowledge ecosystem* (Clarysse et al., 2014) and when the stress is put on the entrepreneurial nature, *entrepreneurial ecosystem* (Spigel, 2017).

A *knowledge ecosystem* (Clarysse et al., 2014) is a specialized knowledge-intensive industrial cluster which includes a diversity of organizational forms interested in sharing value (Moore, 1993), an anchor tenant (Powell et al., 2010), and a cross-network alignment (Moore, 1993; Phelps et al., 2012). Notably, the physical proximity to knowledge generation reduces the cost of moving people and ideas, and generates knowledge externalities derived from sharing collective resources (Link and Scott, 2003; Van Looy et al., 2003; Whittington et al., 2009). As a result, participants have a collective learning and a faster innovation creation and diffusion (Baptista, 1998). The *knowledge ecosystem* that emerges around universities as anchor tenants are termed in the entrepreneurship literature as *entrepreneurial university ecosystems* (Graham, 2014; Hayter, 2016a; Siegel and Wright, 2015).

Finally, an *entrepreneurial ecosystem* is

*a combination of social, political, economic, and cultural elements within a region that support the development and growth of innovative startups and encourage nascent entrepreneurs and other actors to take the risks of starting, funding, and otherwise assisting high-risk ventures.*

(Spigel, 2017, 50)

These ecosystems have cultural (supportive culture, histories of entrepreneurship), social (worker talent, investment capital, networks, mentors and role models), and material attributes (policy and governance, universities, support services, physical infrastructure, open markets), based on how their benefits are created and governed (Spigel, 2017).

For clarity in this paper, we will consider the term *entrepreneurial university ecosystem* as being based on entrepreneurial universities as anchor tenants and, as previously mentioned, the study of it constitutes the aim of this paper.

## 2.2. Entrepreneurial university ecosystems

In the last twenty years, a general trend of universities adopting stronger entrepreneurship and innovation strategies has emerged - giving birth to the *entrepreneurial university* (Clark, 1996, 1998a, 1998b, 2000; Davies, 1987; Etzkowitz, 1983). This new model of university is characterized by a more direct role in stimulating local and regional economic growth (Guerrero et al., 2014; Thorp and Goldstein, 2013). The *knowledge ecosystem* that emerges around universities as anchor tenants are termed in the entrepreneurship literature as *entrepreneurial university ecosystems* (Graham, 2014; Hayter, 2016a; Siegel and Wright, 2015).

In this vein, academic entrepreneurship literature has studied the transformation of universities from a pure knowledge dissemination organization (Etzkowitz et al., 2000) to a major intermediary in the entrepreneurial process of commercialising science and technologies (Chen and Lin, 2017). More specifically, the literature has studied how far these models, applied to successful entrepreneurial universities, such as MIT in the USA or University of Cambridge in the UK (Graham, 2014), can be applied to other less commercially oriented universities to successfully promote academic entrepreneurship and achieve a lively *entrepreneurial ecosystem* (Grimaldi et al., 2011; Maia and Claro, 2013; Siegel and Wright, 2015; Wright et al., 2008a). Literature supports that differences in effectiveness between ecosystems is due to the context in which the university is embedded (Carayannis et al., 2016; Nelson, 2014). The context is understood as the combination of technology/industrial, organizational, institutional, and social characteristics, overlaid by the spatial and temporal characteristics of the area where the university is located (Autio et al., 2014). Furthermore, analysis of entrepreneurial universities located in new contexts that are not explored in literature is needed in order to contribute to this debate (Siegel and Wright, 2015).

Knowledge Spillover Theory of Entrepreneurship (KSTE) is a framework that has been used extensively to study firm location (Audretsch et al., 2005), strategic entrepreneurship (Agarwal et al., 2010), start-up rates at regional level (Boshuizen et al., 2009; Hellerstedt et al., 2014; Rodríguez-Gulías et al., 2017), and cooperation with universities (Fernandes and Ferreira, 2013; Wennberg et al., 2011). In particular, Hellerstedt et al. (2014) demonstrated how the characteristics of the economic and political *milieu* within each region influence the ratio of firm births, finding that knowledge spillover from universities and firm-based R&D strongly affect the start-up rates for both high-tech firms and knowledge-intensive services firms. In this context, KSTE focuses on the level of the individuals and their role in the knowledge spillover (Acs et al., 2009). Knowledge does not spillover “automatically” to other organizations, is instead subject to institutional, geographic, and cost constraints (Almeida and Kogut, 1999; Feldman, 2003) known as the *knowledge filter* (Acs et al., 2009). This is defined as *the gap between the investment in new knowledge and its commercialization* (Audretsch et al., 2014: 316), which leads to innovative activity and economic growth.

Universities or Research & Development Centres (RDCs) generate knowledge that often goes unexploited. KSTE suggests filling this gap through the process of starting a new firm that commercializes knowledge as a conduit for the spillover of new knowledge (Acs et al., 2009). It suggests entrepreneurship as an important vehicle for the spillover of new knowledge and therefore critical to economic growth (Acs et al., 2009; Hayter, 2013a). The investment alone in research universities is not sufficient to generate innovative activity and economic growth due to this *knowledge filter*. On the contrary, universities need to become more entrepreneurial to facilitate knowledge spillover for the commercialization out of universities (Audretsch et al., 2014).

In addition, University-focused Venture Capital firms (UVCs) are the specific financial intermediaries linked to universities, interested in investing in new technologies emerging from university research (Graham, 2014).

Finally, social relationships and their networks, are essential in explaining the processes of knowledge production, diffusion, absorption, and use (Phelps et al., 2012). And USOs are embedded within social networks with other actors who provide them information and resources important for both, the venture success (Hayter, 2016b; Hoang and Antoncic, 2003; Nicolaou and Birley, 2003) and the emergence of an ecosystem (Hayter, 2013b, 2016a; Spigel, 2017).

## 2.3. Business ecosystems

A *business ecosystem* is an economic community supported by a foundation of interacting firms and individuals that, over time, co-evolve their capabilities and roles, and align themselves with the directions set by a focal firm (Moore, 1993, 1996). The interaction among participants consists of simultaneous collaborative and competitive relationships, their connection is focused on value networks, participants can be geographically dispersed (Moore, 1993), and it emerges to allow firms to create value which no single firm could create by itself (Adner, 2006).

The connection between *entrepreneurial university ecosystems* and business ecosystems has recently attracted the attention of scholars and more research has been called for in this area (Clarysse et al., 2014; Engel and Del-Palacio, 2009, 2011). In this study, a combination of two theoretical perspectives is used to study the emergent ecosystem approach (Van de Ven and Poole, 1995). Following the recommendation of Hayter (2013a), we combine a social network theory in entrepreneurship with KSTE to link the micro-level, the entrepreneurial behaviour of the ecosystem participants, with the macro-level, the dynamics of the connectivity between the participants in an *entrepreneurial university ecosystem*. We use KSTE to help explain how faculty entrepreneurs produce, diffuse, absorb, and use new knowledge that lead to entrepreneurial initiatives (Carree et al., 2014; Guerrero et al., 2014; Guerrero et al., 2016) and understand networks as mechanisms for the knowledge spillover to occur (Hayter, 2013b, 2016a, 2016b; Hoang and Antoncic, 2003; Nicolaou and Birley, 2003; Phelps et al., 2012; Spigel, 2017), giving rise to an *entrepreneurial university ecosystem* with socio-economic impact. In addition, we also describe how the relationships of USOs, as typical entrepreneurial university ecosystem companies, with other businesses beyond this ecosystem can be considered as the emergence of future business ecosystems.

## 3. Data collection and research methods

### 3.1. Research setting

Applying Spigel's (2017) approach, we studied the *entrepreneurial university ecosystem* of Andalusia, as an ecosystem with its own cultural, social, and material attributes. Andalusia is a ‘moderate innovator’ region according to the Regional Innovation Scoreboard of the European Commission having increased its innovation performance over time (European Commission, 2017a). Andalusia has a population of 8,410,000 inhabitants, being the region with the largest population in Spain (National Statistics Institute of Spain, INE, 2017). It is the seventh biggest region in Europe, according to the regional NUTS classification (European Commission, 2017b). However, the Andalusian region is behind Spain and EU28 regions in several economic measures (see Table 1).

Since 1981, Andalusia has been an autonomous community, which decides its own innovation policy. In 2015, the expenditure on R&D in absolute terms in Andalusia was 1,477,000 million euros, 1.02% of its GDP (AAC, 2015). A wide range of actors and stakeholders are involved in the Andalusian *entrepreneurial university ecosystem* (knowledge generators, intermediate organizations, financial intermediaries, and public administrations) (see Fig. 1). As *knowledge generators*, there are 10 public universities (Almeria, Cadiz, Cordoba, Granada, Huelva, Jaen, Malaga, Pablo de Olavide de Seville, Seville, and Andalusian

**Table 1**

Andalusian statistics.

Source: Eurostats (2018). European Statistics. <http://ec.europa.eu/eurostat/web/main/home>.

	Andalusia	Average Spain
Primary income of private households by NUTS 2 regions (PPS per inhabitant 2015)	12,100.00 €	15,926.32 €
Real growth rate of regional gross value added (GVA) at basic prices by NUTS 2 regions (percentage change on previous year)	2.4%	2.61%
Regional gross domestic product (PPS per inhabitant in % of the EU28 average) by NUTS 2 regions	67	87
Regional gross domestic product (PPS per inhabitant) by NUTS 2 regions	19,500.00 €	25,252.63 €

Note: PPS: Purchasing Power Standards. All table is with 2015 data.

International University) and one private (Loyola Andalucía, which started its first academic course in 2013). Three of these universities (Granada, Malaga, and Seville) are in the top 10 in terms of patents development in Spain (CRUE, 2017). There are also 32 Technology Centres and 18 Research Institutes. In addition, as *intermediate organizations*, there are 215 Entrepreneurial Support Centres (located in 37 Centres of Entrepreneurship Development or CADEs), Technology Transfer Offices (TTOs), and 11 science and technology parks (PITA, Almeria; Agro-industrial, Cadiz; Technobahia, Cadiz; Rabanales 21, Cordoba, PCTH of Huelva; PTS of Granada; PTA, Malaga; PCT Cartuja 93, Seville; Aeropolis, Seville; Dehesa de Valme, Seville; and Geolit, Jaen). Also, there are *financial intermediates*, such as the Regional Development Agency (IDEA) or Invercaria (Public Venture Capital Companies). Finally, there are both *private sector* (European Business Centres or the Technology Corporation of Andalusia) and *public administrations* (local, regional and central government) bodies (OECD, 2010).

Public universities are a key knowledge agent, and one of the strengths of the R&D Andalusian system together with the Science and Technological Parks and the Innovation Centres (UPA, 2016). In 2015, the Andalusian scientific community was composed of a total of 2756 research groups which involve around 30,000 researchers, of which 83.9% worked in public universities (UPA, 2016). Its contribution towards the productive sector was achieved in several ways (see Table 2 for a data summary). Firstly, through teaching and training of qualified staff, secondly, through scientific production and thirdly, by generating of intellectual property. More recently, additional engagement between university researchers and companies has been developed, with the creation of companies linked to the knowledge generated at the university – known as University Spin-off companies (USOs), making the Universities more entrepreneurial. Finally, the public sector financial

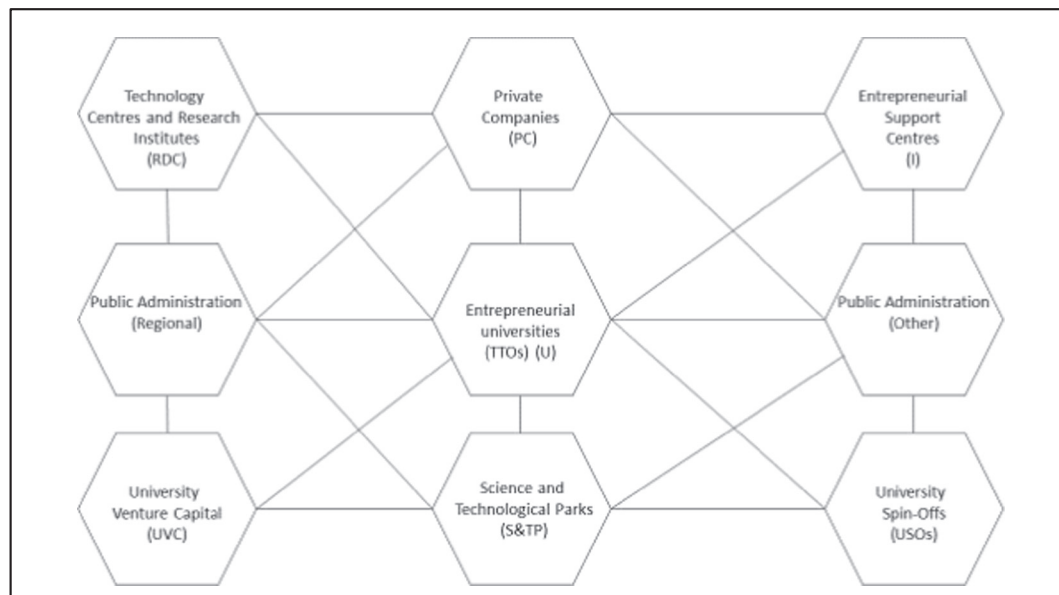
support for R&D in Andalusia is more prominent than the private sector. During 2015, the participation of the private sector in R&D expenditure was 36.8% compared to 63.7% by the public sector, paralleled to a national level of 53.1% private and 46.9% public expenditure (UPA, 2016).

### 3.2. Data collection

In order to obtain a list of USOs and key intermediaries as actors of the Andalusian regional entrepreneurial university ecosystem, the TTOs of the different Universities were contacted, several searches on internet conducted, and several relevant specific reports (e.g. AAC, 2015; CRUE, 2017) analysed. A combined database was then constructed. Six universities participated (answer rate 54.5%), including a broad range of USOs that vary widely in development, technological focus, and location (Almeria, Cadiz, Granada, Huelva, Malaga and Seville). These institutions were contacted by email with information about the research, explaining the objectives, and emphasizing the importance of participating in the study. A total of 48 individuals agreed to participate (40 USOs and 8 other relevant actors of the *entrepreneurial university ecosystem*).

Data was collected from direct contacts, in person or by phone and from secondary resources during a period of seven months (between 2012 and 2013). A Social Network Analysis (SNA) survey and an open-ended interview protocol were used.

Different types of secondary information resources were collected. In doing this, we guaranteed the depth and relevance of the data required to answer the research question proposed in this study (Jick, 1979; Stake, 2010; Yin, 2011). Documents from third parties were used to verify and expand information gained from the interviews, as well as

**Fig. 1.** Regional entrepreneurial ecosystem main actors.

**Table 2**  
Andalusian universities contribution to the productive sector in 2015.

Contribution	Data
Teaching and training activities	A total of 1,546,000 students were enrolled in Andalusia Public Education System: 83.3% Bachelor Degree, 10.8% Official Master Degree, and 3.2% PhD (AAC, 2015).
Scientific production	The 2756 research groups established in Andalusia generated 13,947 publications: 67.7% originated in public universities and the rest in research centres and private companies (UPA, 2016).
Registry of industrial property	929 requests were registered for new patent applications in its different variants: 442 national, 15 international, 199 patent cooperation treaty, and 273 utility models (AAC, 2015).
University-company collaboration	Andalusia region counted with 1952 companies involved in R&D activities which generated a total R&D expenses of 1487 thousand euros (AAC, 2015).

to provide important information about the context of the cases (information from annual guide publications about technology transfer, official statistics, government reports, books and journals publications, as well as corporate company web sites and *LinkedIn*).

In the case of the interviews, we ensured that the participants met the necessary environmental conditions to not affect the dynamics of the interview. Interviews ranged in length from 45 to 90 min in duration. During the interviews, all participants were assured of confidentiality both for the firm/institution and for the individual (Huber and Power, 1985).

As previously mentioned, two different tools were used for the data collection from the same respondents. Firstly, a SNA survey was administered to individuals agreeing to participate in the study. We asked some introduction and control questions, such as type of organization, number of academics involved in the activity, or a brief description of their job and main responsibilities. In doing this, we ensured that the interviewee belonged to the Andalusian *entrepreneurial university ecosystem* and was able to participate in this research (Yin, 2011). More questions were used to discuss about the relations of the interviewee with the different agents in terms of communication (not including just advertising or information). A list of the main intermediaries and agents involved in the *entrepreneurial university ecosystem* identified in the literature was provided to the interviewees; TTO, R&D Centre, USOs, other companies (Private Companies, PC), and other public (institutions) and, at the end, participants were encouraged to give examples. In doing so, we guaranteed the interviewee did not omit any contacts in their network (Yin, 2011). Additionally, the examples provided for them, helped us to better understand the network structure in which they were embedded (Yin, 2011).

Secondly, in-depth open interviews were conducted. An open-ended interview protocol based on the literature review was conducted and the accompanying research question mentioned. We asked about the benefits and challenges of the relationships mentioned in the SNA survey.

Table 3 provides information about the 48 participants (agents) of the Andalusia *entrepreneurial university ecosystem*: 40 USOs, three RDC, one incubator (I), two TTOs, one public UVC, and one private UVC (UVCp). In order to avoid the identification of the intermediaries, only the USOs are numbered. Most of the interviewees were male and CEOs of USOs from the IT and Health/Biomedicine sectors and senior managers of the knowledge intermediaries.

### 3.3. Data analysis

A mixed-method approach (Creswell, 2013) based on quantitative SNA (Borgatti et al., 2002; Borgatti and Foster, 2003; Hanneman and Riddle, 2005; McCarty and Molina, 2014) and qualitative analysis of in-depth interviews to key participants were used (Eisenhardt, 1989; Eisenhardt and Graebner, 2007; Gephart, 2004; Yin, 2011). First, SNA was used to diagrammatically represent and then analyse the *entrepreneurial university ecosystem* of Andalusia. This consisted of building the network and calculating different quantitative relationship indexes. Second, qualitative methods, based on in-depth interviews with key

actors of the ecosystem, were used to describe the contribution of these network contacts and the context in which the ecosystem analysed was embedded, as well as the perceptions on the effectiveness of the ecosystem. Finally, we followed the concurrent triangulation strategy to cross-validate the two sets of data (Creswell, 2013; Jick, 1979).

### 3.4. Data coding

To explore the social network, the UCINET software (Version 6.665, 4 Sept 2018) bundled with NetDraw (Borgatti et al., 2002) was chosen and relational data coming from a SNA survey (administered at the beginning of the open interview, and completed and checked during the whole interview) was used. For examples of recent studies which applied this methodology in the area see - Chen and Lin (2017) or Clarysse et al. (2014). UCINET software is a tool for social networks analysis that maps relations between individuals through their representation in a graph or network and that is instructed by the researchers to calculate qualitative data and estimate a number of quantitative relationship indexes (e.g., *degree centrality*, *degree centralization* and the *betweenness degree*) from qualitative data (Borgatti et al., 2002; Borgatti and Everett, 2000; Hanneman and Riddle, 2005). We will consider these concepts according to McCarty and Molina's (2014: 14) definitions: the *Degree Centrality* measures to what extent a node is highly degree-central, so it is directly connected to many other nodes; and the *Degree Centralization* of a network is a measure of the extent to which the network is dominated by a few degree central nodes. The *Closeness Centrality* refers to what extent a node is highly close-central, so it is connected by short paths to most other nodes; and the *Closeness Centralization* is a measure of the extent to which the network is dominated by a few close central nodes. Finally, the *Betweenness Centrality* considers if a node is highly between-central, so to what extent it lies on many geodesics (shortest paths) between nodes; and the *Betweenness Centralization* is a measure of the extent to which the network is dominated by a few between central nodes.

The data was codified according to the following intensity (0 no relations at all or very rarely, 0.5 rarely, 1 occasionally, 2 frequently, 3 very frequently). Then, a relationship matrix was built up on an Excel file, and once all the transcriptions were codified, the relationship matrix was introduced to the UCINET software. This relationship matrix was square and identical, meaning that it had the same number of rows than columns which represented the same actors. The rows showed the relationships that each actor had with other agents, and columns are all other agent relationships claimed by actors (Borgatti et al., 2002). The network is shown as an exploratory structural approach to the ecosystem, to see the main roles of the agents and their relationships. It was during the interview process, that more details about the different relations mentioned were obtained.

With this, we constructed the Andalusian *entrepreneurial university ecosystems* (see Fig. 2), where the relations between the different USOs, TTOs, R&D Centres, Incubators, and UVCs are represented. In addition, it is also included a representation of the connections of the *entrepreneurial university ecosystem* agents, mostly USOs, with PCs in order to develop business together. This was considered as an initial stage in

**Table 3**  
Summary of the analysed cases.

Agent	Province	Gender of the interviewee	Position of the interviewee	Sector	Year of set up
USO1	Malaga	Female	CEO	IT	2007
UVCp	Malaga	Male	CEO	IT	1993
RDC	Malaga	Male	Manager	IT	n.a.
USO4	Malaga	Male	Academic entrepreneur	IT	2008
USO5	Malaga	Male	CEO	IT	2007
I	Malaga	Female	Manager	Multi sector	n.a.
USO7	Malaga	Male	Academic entrepreneur	IT	2011
USO8	Malaga	Male	Manager	IT	1993
TTO	Malaga	Female	Manager	Multi sector	n.a.
USO10	Malaga	Male	CEO	IT	2001
UVC	All	Male	Manager	Multi sector	n.a.
USO12	Malaga	Male	CEO	Neurotechnology	2008
USO13	Malaga	Male	Academic entrepreneur	IT and health	2008
USO14	Malaga	Female	Academic entrepreneur	IT	2009
RDC	Malaga	Male	Manager	IT	n.a.
USO16	Malaga	Male	CEO	IT	2002
USO17	Malaga	Male	CEO	IT	2005
USO18	Malaga	Male	Academic entrepreneur	Archaeology	2003
USO19	Huelva	Male	CEO	Services	2007
USO20	Huelva	Male	Academic entrepreneur	IT	2009
USO21	Huelva	Male	CEO	Nuclear	2010
TTO	Huelva	Female	Manager	Multi sector	n.a.
USO23	Seville	Male	Academic entrepreneur	IT	2010
USO24	Seville	Male	Academic entrepreneur	IT	2010
USO25	Seville	Male	CEO	Energy, environment	2007
USO26	Seville	Male	CEO	Biomedicine	2009
USO27	Seville	Male	Academic entrepreneur	Technology for agrifood	2007
USO28	Seville	Male	CEO	Engineering	2007
RDC	Seville	Male	Manager	Biomedicine	n.a.
USO30	Seville	Male	CEO	Agriculture	2011
USO31	Granada	Male	CEO	Biotechnology and food	2006
USO32	Granada	Female	CEO	Biotechnology	2008
USO33	Granada	Male	CEO	Biotechnology	2006
USO34	Granada	Male	CEO	Health	2009
USO35	Granada	Male	CEO	Biotechnology	2011
USO36	Granada	Female	CEO	Biotechnology	2010
USO37	Almeria	Male	Academic entrepreneur	IT	2009
USO38	Almeria	Male	CEO	Services	2007
USO39	Almeria	Male	CEO	Services	2008
USO40	Almeria	Female	Academic entrepreneur	Services	2006
USO41	Almeria	Male	Academic entrepreneur	Services	2006
USO42	Almeria	Female	CEO	Health	2007
USO43	Almeria	Female	CEO	Health	2008
USO44	Almeria	Male	CEO	Engineering	2006
USO45	Cádiz	Female	CEO	Renewable energies	2009
USO46	Cádiz	Male	Academic entrepreneur	Engineering	2006
USO47	Cádiz	Female	CEO	Services	2005
USO48	Cádiz	Male	CEO	Agrofood	2008

Note: n.a.: not available.

the incorporation of these USOs to *business ecosystems*, not analysed directly in this paper.

Finally, in addition to the figure, a series of indicators were calculated in order to give a deeper explanation of the network structure (Borgatti et al., 2002; Borgatti and Everett, 2000). These indexes are explained in the next section of the findings.

### 3.5. Interviews analysis

To analyse the interviews, the *five-phase cycle* proposed by Yin (2011): compiling, disassembling, reassembling, interpreting, and concluding data, was followed. First, all the responses were recorded and transcribed and compiled into a formal database together with the archival data (Alvesson and Sköldbberg, 2000; Stake, 2010). This resulted in a total of 58 hours of interview recorded, and a document of 180 simple line spaced pages. Secondly, all responses were coded inductively (Jack and Anderson, 2002). For each participant, we composed a list of the benefits and challenges related to the relationships mentioned in the SNA survey. Then, all of them were compared

yielding multiple emergent themes regarding the contribution of the network contacts and the context in which the ecosystem was embedded (Glaser and Strauss, 1967; Silverman, 2000). In addition, the interpretation of the reassembled data was discussed by the researchers until a point of saturation was reached (Eisenhardt, 1989; Yin, 2011). Finally, quotations that supported each finding were carefully selected (Bansal and Corley, 2012) and a narrative approach was chosen for presenting the results of the qualitative data (Wolcott, 1990).

## 4. Findings

### 4.1. Identification and representation of the Andalusia entrepreneurial university ecosystem

Fig. 2 provides the identification of the main actors in the regional *entrepreneurial university ecosystem* and their relations, as well as the connection with private companies. It shows the position that each participant occupies in the ecosystem in each case. As can be observed in the Figure, the Andalusia *entrepreneurial university ecosystem* is well

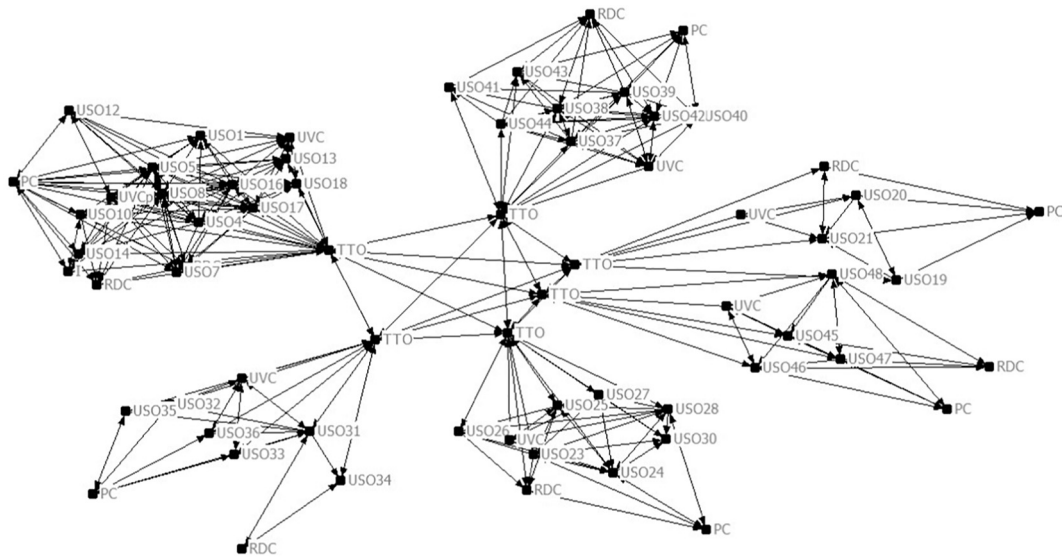


Fig. 2. Social network of the Andalusia entrepreneurial university ecosystem.

connected among TTOs which are at the heart of the ecosystem that include knowledge intermediaries such as UVC, Incubators, and R&D Centres, as well as USOs. These TTOs are located in the middle of the network acting as anchor tenants and transferring their innovations to the local industry through knowledge transfer, while USOs appear around these TTOs creating strong networks with intermediaries, which are located in different areas of the Andalusia region. The PCs are located mainly on the periphery of the network and only some USOs are connected to them. In other words, few USOs, in the *entrepreneurial university ecosystem*, connect to PCs, in the business ecosystem, to commercialise their products. As a final point, regarding the knowledge intermediaries, UVCs appear located between TTOs and the USOs to which they are connected, while the R&D Centres are located in the periphery of the network near the PCs.

As mentioned before, in addition to the networks, a series of indicators were calculated in order to give a deeper explanation of the network structure, both as a whole and to each individual agent.

The *Degree Centrality* was measured with the Freeman's approach, based on the out-degrees and the in-degrees of the network (Hanneman and Riddle, 2005) (see Table 4). The *Degree Centrality* is defined with two separate measures: Indegree (count of the number of ties directed to the node) and Outdegree (number of ties that the node directs to others). As the data is valued, the degrees (in and out) consist of the sums of the values of the ties (Borgatti et al., 2002). This *Degree Centrality* measures to what extent a node is highly degree-central, so it is directly connected to many other nodes, so if the agents of the network are ranked from the greatest to the lowest centrality, a rank order of the best connected individuals in the network is obtained. It was found that, in the first ten positions of the Indegree, they were nine intermediaries, in particular five TTOs and only one USO. This reflects how these intermediaries receive more communications in order to get information, advice, etc. In addition, in the first ten positions of the Outdegree, they were five USOs, reflecting how these agents are more active, behaving proactively when they look for communication with other agents. Regarding the *Degree Centralization* of the network, this is relatively low (13.95%), so the network is far from a *star* (centralization closes to 100%) and showing that there is not an intermediate agent that connects the other agents in the network (Hanneman and Riddle, 2005).

The *Closeness Centrality* refers to what extent a node is highly close-central, so it is connected by short paths to most other nodes and the *Closeness Centralization* is a measure of the extent to which the network is dominated by a few close central nodes (see Table 5). The node with the highest closeness centrality has the shortest distance to the other

nodes, on average, so it is useful to know the nodes who are best placed to influence the entire network most quickly. In the ecosystem analysed, the nodes with the highest closeness centrality regarding in and out communications are the TTOs, followed by USOs and, similarly to the already commented *Degree Centrality*, USOs have highest closeness centrality in the case of the out communications. For the network, the Network in-Centralization (40.33%) is similar to the Network out-Centralization (36.26%), but this reflects a lower centralization for out communications.

Finally, the *Betweenness Centrality* refers to the nodes one given node have to go through to access other nodes, so it considers a node is highly between-central (to what extent it lies on many geodesics (shortest paths) between nodes). The *Betweenness Centralization* is a measure of the extent to which the network is dominated by a few between central nodes. By finding the individuals who influence the flow around a system, this *Betweenness Centrality* is useful when a node gain from bridging between different nodes, for example, brokering between different types of nodes. Therefore, this *Betweenness Centrality* shows the ability of an actor to mediate communications between pairs of other agents, which is known as *agent communication control*. In the ecosystem analysed (see Table 6), TTOs are shown in the first positions of the ranking, as they are the connectors of the *ecosystem* between the different Universities. In addition, they are good intermediaries to connect agents of the network in terms of entrepreneurial activities. An explanation for this could be that, according to the existing legislation and institutional rules, the academic entrepreneur has to sign a contract with the private company in order to cooperate, and this contract has to be approved by the university through the TTO. Interestingly, TTOs are followed by USOs, who have a relevant presence in the first then position regarding this *Betweenness Centrality*, thus reflecting the active role USOs have in the network, as individuals who influence the flow around the ecosystem. Regarding the whole network, the *Betweenness Centralization* this is relatively low (38.68%) reflecting that the network is not dominated by a few between central nodes.

#### 4.2. Analysis of the interviews

In this section, we provide a deeper explanation of the Andalusian *entrepreneurial university ecosystem*, regarding the benefits and challenges of the relationships analysed previously. In doing this, we show the contribution of the networks by providing a better understanding of the context in which the regional *university ecosystem* is embedded. We analysed all the transcripts and present a summary of the analysis in

**Table 4**  
Degree Centrality of the network.

Order Indeg	Agent	Indeg	Outdeg
1	TTO	43.500	40.500
2	UVCp	30.000	30.000
3	USO8	30.000	30.000
4	TTO	26.500	23.500
5	UVC	24.000	27.000
6	PC	23.500	23.500
7	TTO	22.500	19.500
8	TTO	22.000	19.000
9	TTO	21.500	18.500
10	RDC	21.500	9.500

Order Outdeg	Agent	Outdeg	Indeg
1	TTO	40.500	43.500
2	USO16	40.500	12.500
3	USO5	34.500	16.500
4	USO17	31.500	15.500
5	UVCp	30.000	30.000
6	USO8	30.000	30.000
7	UVC	27.000	24.000
8	TTO	25.000	19.500
9	USO39	25.000	12.500
10	UVC	24.000	21.000

Note: Indeg: indegree; Outdeg: outdegree.

**Table 5**  
Closeness Centrality.

Agents ranking	InClose	Agents ranking	OutClose
TTO	0.550	TTO	0.528
TTO	0.520	TTO	0.500
TTO	0.516	TTO	0.496
TTO	0.512	TTO	0.493
TTO	0.504	TTO	0.485
TTO	0.500	TTO	0.482
USO8	0.395	USO5	0.388
UVCp	0.384	USO8	0.386
USO1	0.377	USO16	0.384
RDC	0.377	USO17	0.384

**Table 6**  
Betweenness Centrality.

Agents ranking	Betweenness	nBetweenness
TTO	1761.518	41.061
TTO	1226.520	28.590
TTO	1148.817	26.779
TTO	1046.300	24.389
TTO	827.500	19.289
TTO	722.833	16.849
USO21	132.083	3.079
USO31	110.100	2.566
USO8	82.100	1.914
USO46	76.500	1.783

this section following the three sub research questions proposed about the role of social context (1), intermediaries (2), and USOs (3) in the development of regional entrepreneurial university ecosystems.

#### 4.2.1. Social context

Once the USOs entered the market, collaboration projects with other USOs, R&D Centres and other companies were among the most frequently mentioned and the more successful activities they undertook. Firstly, the collaboration with other USOs consisted mainly in carrying out public research projects. Secondly, we also identified USOs which 'did not really have too many direct deals with companies, only with

research centres' (USO21). These USOs were in the health and biomedicine sectors, and worked providing R&D Centres part of the technology they used in their activities, 'there is a spin-off in the university with which we maintain a close contact because they develop new technologies we can apply' (RDC). Finally, less frequently, we also found USOs that mentioned contacts to other companies as clients. Only a few mentioned other companies as providers. Among the most successful cases were some companies that, having failed while trying to develop a product, requested what they needed from a USO, 'usually they ask for a finished product that has an investigation behind [it]' (USO26). A relative low number of USOs mentioned the collaboration with other companies to develop or support new products and satisfy customer needs, 'we are specialized in the development of machinery. For the role of manufacturing, and marketing we delegate it to collaborating companies. We contact them on a daily basis' (USO37). Another example was the academic entrepreneur of a USO, who argued, 'there are companies already consolidated that have put money on the table to finish our technological platform' (USO24). In some cases, these contacts came from international borders, 'we have five UK partners waiting for us to choose one of them to distribute our products' (USO23). Therefore, these companies are the most strongly connected with business ecosystems. However, they are far from leading one of them, because they act mainly as providers of other companies already consolidated, 'actually we created the USO because we saw that there was some interest from other companies' (USO18).

In summary, this shows the contribution of USOs to the development of a well-established or successful entrepreneurial university ecosystem in Andalusia that contributes to strengthen already existing business ecosystems, although not necessarily located in their same area.

#### 4.2.2. Intermediaries of the ecosystem

As one barrier highlighted by USOs, at organizational and institutional level, it was the lack of proactivity of the TTOs and public UVCs. Regarding TTOs, USOs argued that 'we contacted the TTO at the beginning, when we started the company to formalize our activity, but no longer' (USO38). Later, they mentioned this contact for requesting information about academic partners, new lines of financing, training activities, or technological offers. In other words, Andalusian TTOs were used as an information intermediary and as a place to formalise their activity



**Table 7**  
Summary of the interviews analysis.

Research sub question	Social context	Intermediaries	USOs
Main characteristic	It is highly institutionalised.	They provide support.	They need help in order to overcome the barriers.
Other findings	Public research projects promote the entrepreneurial process in the ecosystem.	UTTOs are mandatory intermediaries in the knowledge transfer process and should be more proactive.	They contribute to knowledge spillover.
	There are relevant connections between USOs and RDCs.	The UTTOs manage intellectual property and patents, and organize events to stimulate social contacts.	They are key agents to activate innovation in the region and connect ecosystems.
	USOs consider PCs as customers.	UVCs provide funding, advice, and network support.	The main perceived barriers from USOs are lack of management and experience, lack of financial resources, and bureaucracy.

instead of using it as an organization or institution that promotes entrepreneurship. As the CEO of a USO mentioned, *‘what we tried with the TTO was the same that we tried with other public institutions, such as Incubators, and in fact, we did not obtain anything. It was all about getting interviews with companies to talk about our products’* (USO30). When TTOs were asked about their most frequent activities, they referred to patents and IP processes, and organising events to stimulate social networks.

To address this problem, other public institutions were mentioned, such as public UVCs. These institutions provided different instruments to help the founding team to develop the USO (mainly advice and funding). TTOs mentioned *‘having good relationships with the public UVC which help us in some situations. For example, developing plans for companies of researchers that have no clue about how to develop them; and also with business incubators’* (TTO).

In this sense, the public UVCs confirm that role, arguing that *‘we basically help to outsource the University technology to the market through the creation of companies’* (UVC). They explained that in many cases, when the founding team came to them asking for help, they realised that the technology they were using was extremely valid for immediate market application. However, they required a transition and someone who was able to implement this technology into a product. Then, *‘we make integration activities providing USOs with resources in which they are not specialized and in which they lack the necessary know-how’* (UVC). In addition, USOs also *‘contacted the public UVC for other things, such as communication, as they gave them much diffusion’* (USO31). However, this intermediary was not a proactive institution due to their passive role in waiting for USOs to contact them instead of looking for new entrepreneurial opportunities. Finally, a UVCp was also identified as part of a business group interested in diversifying its business activities by investing in university research.

#### 4.2.3. The role of USOs

From the participants' point of view, they agreed that a USO is a formula to bring to market what actually happens in the Universities, contributing to the knowledge spillover, and a fundamental element to activate innovation. As the CEO of a USO affirmed, *‘University must be the sociological engine of any society’* (USO19). In addition, a TTO mentioned *‘a lot of scientific and technological knowledge has been created in [the] University. Some of it oriented to produce new knowledge and other useful resources or services for the society. If that knowledge remains at this University, it has no purpose. We have to look for mechanisms to transfer it to the society, and this is the USO role’* (TTO). However, all of them mentioned that it needs to be improved, *‘as a concept seems to me extraordinary; the problem is that we don't have the tools for making it possible’* (USO43).

Most of the USO interviewees agree on the barriers they had to overcome to develop their USOs. Among the most mentioned were university bureaucracy and differences between the academic and business culture. They also mentioned the lack of personal resources, such as management knowledge; financial resources, such as funding;

support from universities and regional governments, and proactivity from the TTOs. As a CEO from a USO explained, *‘USOs are not very well developed and they suffer from the bureaucracy and a completely different pace of Universities, compared to companies’* (USO48). In addition, the difficulty of understanding the business culture and proper knowledge for right decisions in developing the USOs was mentioned. Also, the lack of management experience or knowledge was mentioned: *‘many USOs tend to disappear because they have no proper management’* (USO24). In some cases, one option was to hire an experience CEO, or surrogate entrepreneur (Mosey and Wright, 2007). However, *‘because of the lack of maturity, the company did not have the resources to hire some managers’* (USO24). Another possibility, frequently mentioned, was to contact public UVCs, *‘the UVC gives us mainly two things: financing for the project, and support for running the USOs, such as a network of contacts’* (USO26). These two mechanisms were mentioned as the most effective to overcome the barriers when developing their USOs.

In order to clarify the findings a summary of the most relevant ones is included in Table 7.

## 5. Discussion

The research shows three distinct contributions related to the research question), which includes three sub questions: *What is the role of social context (1), intermediaries (2), and USOs (3) in the development of regional entrepreneurial university ecosystems?*

First, concerning the role of social context, we provide insight to the academic entrepreneurship literature analysing the importance of the context (Autio et al., 2014; Carayannis et al., 2016 ; Leih and Teece, 2016 ; Nelson, 2014) of *entrepreneurial university ecosystems* (Grimaldi et al., 2011; Maia and Claro, 2013; Siegel and Wright, 2015; Wright et al., 2008a). Considering the results of the analysis of the perceptions of the main actors of the ecosystem (about the effectiveness of the *entrepreneurial university ecosystems* in the regional context), our findings show that the differences between the effectiveness of such policies can be explained by the context in which universities are embedded (Carayannis et al., 2016; Leih and Teece, 2016; Nelson, 2014). The analysed context is highly institutionalised, public research projects play an important role, and USOs connect with RDCs and PCs. It was noted that universities could be entrepreneurially oriented but that legislation could sometimes be a barrier to the development of connections between the *entrepreneurial university ecosystem* and businesses beyond this ecosystem. The analysis showed that at the heart of the *entrepreneurial university ecosystem* were well-connected USO networks, which arose through informal interactions between them rather than by facilitation from intermediaries. More specifically, USOs wanted support, advice and funding from these intermediaries. The industry/technology context was also highlighted giving an important role to the entrepreneurial university in the region (Guerrero et al., 2016) and confirmed USOs as a crucial mechanism to bring to market innovations discovered by researchers (Grimaldi et al., 2011; Siegel and Wright, 2015). On the other hand, the organizational and institutional contexts

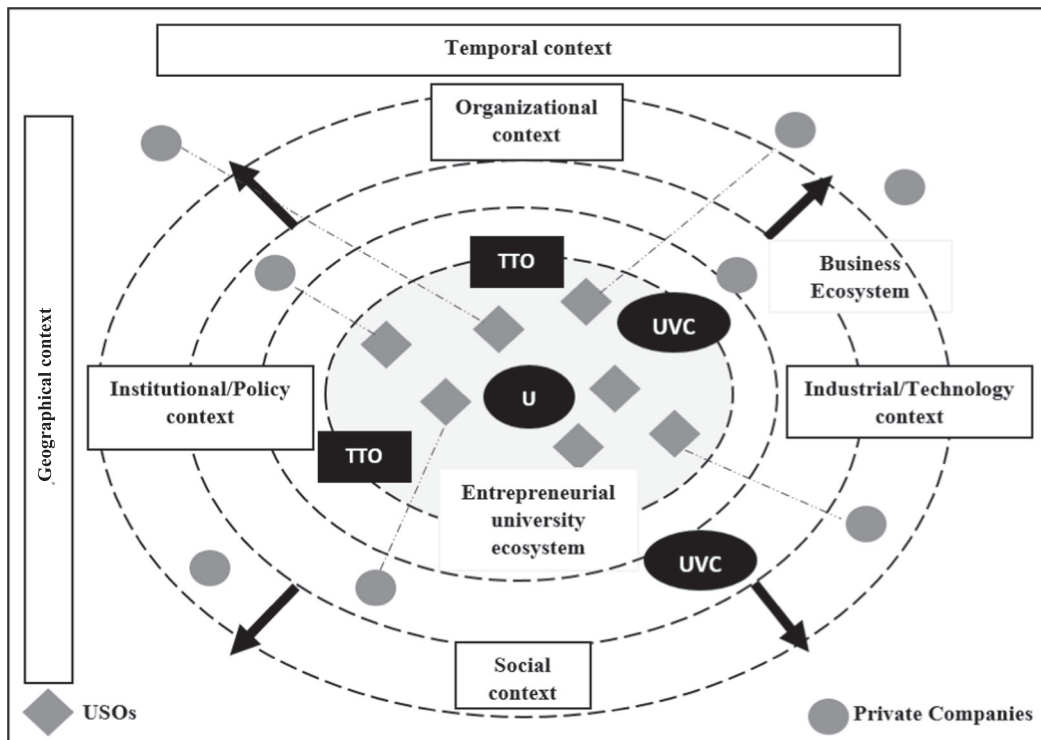


Fig. 3. The expansive wave effect.

were emphasised as being not proactive in encouraging the creation of USOs (Carayannis et al., 2016; Nelson, 2014).

Second, regarding the second sub question, about intermediaries, TTOs (as mandatory intermediaries, they provide intellectual property management and stimulate social contacts) and UVCs (UVCs and UVCp, as financial intermediaries, provide funding, advice, and network support) appeared as complementary organizations that support academic entrepreneurship activities, also at institutional level (Samila and Sorenson, 2010). In fact, UVCs were the organizations in charge of helping USOs in terms of gaining resources and management skills. However, they were less active regarding looking for new opportunities to entrepreneurship (Wright et al., 2008a). In addition, referring to the relationships between the *entrepreneurial university ecosystems* and the future participation of USOs in business ecosystems, we only explored how entrepreneurs and new start-ups positioned in *entrepreneurial university ecosystems* benefitted from being co-located close to specialized organizations that already exist to disseminate best practices for entrepreneurship (such as universities, law firms specialized in IP right or licensing, financial institutions or investors) (Engel and Del-Palacio, 2011). In this regard, this research extends different aspects of the KSTE approach. According to this theory, the context is relevant to analysing the entrepreneurial process, and we show how entrepreneurial universities, thanks to their new orientation, are able to generate high knowledge contexts through specific actions. First, by specifically supporting the creation of new businesses (USOs) and we identified the proactive role of these USOs (see Centrality measures). Second, by collaborating with other institutions in the region (government, science and technological parks). Third, by the creation of new structures (intermediaries) such as UVCs, as intermediaries in the regional entrepreneurial process, with a relevant presence in the showed ranking of the *Degree Centrality* of the network and, with a relatively lower presence, in the *Closeness Centrality* of the network. Consequently, they enhance the knowledge spillover needed to commercialise innovations by overcoming the existing knowledge filters. This role is developed in different ways depending on the main actors of the ecosystem involved. In this vein, we also identified actors, such as TTOs, who developed a

role of knowledge broker when receiving communications, but with a relatively lack of proactivity or commercial orientation (see Centrality measures).

Third, respecting the third sub question about the role of USOs in the development of *regional entrepreneurial university ecosystems*, we partially tested the hypothesis established by Engel and Del-Palacio (2009, 2011) and analysed by Clarysse et al. (2014), in the region of Andalusia adding knowledge to the entrepreneurship literature in social networks and knowledge spillover theories. In particular, we responded to the call for more empirical work in different regional contexts (Clarysse et al., 2014; Engel and Del-Palacio, 2009, 2011), by providing evidence of how the main actors of the *entrepreneurial university ecosystem* were connected. In this vein, the major contribution of this study is the identification of a *regional entrepreneurial university ecosystem*, which stimulates USOs, as knowledge transfer mechanisms, to contact businesses, contributing with their innovation technologies (Clarysse et al., 2014). For example, in the centrality of the network measures a proactive role of these USOs were found, they contribute to knowledge spillover and are key agents to activate innovation in the region and connect ecosystems. However, they need help in overcoming their perceived barriers (e.g., lack of management and experience, lack of financial resources, and bureaucracy). In addition, we contribute to fill the gap of what is termed as *entrepreneurial university ecosystem* (Hayter, 2016a), by describing and analysing in detail one exemplar, and helping scholars to differentiate this concept from other ecosystem concepts mentioned in the entrepreneurship literature, such as business ecosystems (Autio et al., 2014; Clarysse et al., 2014; Oh et al., 2016). Our findings show, with a regional example, the different components of a *regional entrepreneurial university ecosystem* and explain how USOs connect through the dynamics of their activities with businesses beyond this ecosystem (Clarysse et al., 2014; Engel and Del-Palacio, 2009, 2011).

More specifically, the entrepreneurial process is accelerated by high mobility of resources (people, technology/know-how, business practice, and capital) (Mercan and Göktaş, 2011) and, as a result, new technologies are rapidly developed, tested and commercialised,

creating new high quality employment and accelerating the productivity of regional economies (Hayter, 2016a; Lubik et al., 2013; Shane, 2004). It was also evident that, on occasions, these technologies are acquired or shared by established companies that integrate them into their products (Clarysse et al., 2014; Engel and Del-Palacio, 2011). These established companies are located in business ecosystems which can be geographically dispersed (Moore, 1993). Therefore, the connection between USOs located in an *entrepreneurial university ecosystem* and the established company located inside business ecosystems (not analysed in this paper) generate what could be called, an *expansive wave effect* that contributes to reinforcing the business ecosystem - becoming part of them and contributing to their innovation (see Fig. 3). In addition, Fig. 3 shows this *expansive wave effect* as discontinuous circles, which involve the connection or knowledge spillover between USOs in the *entrepreneurial university ecosystem* and the established Private Companies located in the business ecosystem and considers the different contexts in which both companies are located. Consequently, it is possible to conclude that USOs have an emerging role in *university entrepreneurial ecosystems* and also linking them to the business ecosystems, acting as true spillovers.

From the social network theory perspective, this research proposes that entrepreneurial universities, in a regional context, develop networks that support the entrepreneurial process. The novelty of this paper is that, thanks to the variety of actors analysed inside the regional *entrepreneurial university ecosystem*, it is possible to contribute in the context of the social network theory describing the structure of the networks and the centrality, one of the less studied aspects of social networks in the entrepreneurship process in the context of the ecosystem emergence (Hayter, 2013b, 2016a; Spigel, 2017). This research describes the structure of the social network developed in a regional *entrepreneurial university ecosystem* (consisting of USOs, TTOs, Incubators, UVCs and RDCs) and also the structure of the connections between this knowledge ecosystem and the business ecosystem. In terms of centrality, TTOs receive more communications than other agents do in order to get information, advice, etc. These institutions have a formal role (by regulation, they are mandatory intermediaries for knowledge transfer contracts where faculty members are involved) and should connect the *entrepreneurial university ecosystem* and businesses beyond this ecosystem. However, the USOs are the better connected participants compared with the other actors. Thus, these agents are more active than others are and, importantly, they work cooperatively. USOs are embedded within social networks with other actors who provide them information and resources that are important for venture success.

## 6. Conclusion

Regional *entrepreneurial university ecosystems* are key structures for economic growth. The role of social context, intermediaries, and USOs in the development of *regional entrepreneurial university ecosystems* have been analysed in Andalusia, a regional innovation system consolidated and supported especially by public institutions. In conclusion, the entrepreneurial universities in one region, Andalusia, influence the development of *regional entrepreneurial university ecosystems* through the promotion of USOs, as one of the knowledge transfer mechanisms, which emerge with a proactive role in the ecosystem. However, in the analysed social context, entrepreneurial universities should develop a more proactive role, through intermediaries like TTOs and UVCs, collaborating with USOs. These USOs need advice and funding from the intermediaries in the *entrepreneurial university ecosystem*. The mentioned more proactive strategy should promote knowledge transfer process, by reinforcing the relations of USOs with businesses beyond the *entrepreneurial university ecosystem* and intensifying the expansive wave effect that produces the transformation of inventions into successful innovations. For example, TTOs are located in the middle of the network acting as anchor tenants and transferring their innovations to the

local industry, but mainly on one direction. More bidirectional actions are needed, and the TTOs need also to work directly and closely with PCs in order to, e.g., match the best USOs to collaborate with.

Moreover, USOs need advice and funding from the intermediaries in the *entrepreneurial university ecosystem*. This more proactive strategy should promote knowledge transfer process, by reinforcing the relations of USOs with businesses beyond the *entrepreneurial university ecosystem* and intensifying the expansive wave effect that produces the transformation of inventions into successful innovations into the market. USOs are embedded within social networks with other actors who provide them information and resources but they identified several barriers to their success, such as lack of management knowledge and financial resources, and bureaucracy. In terms of social context, new flexible regulations according to the innovation transfer activities, more financial support and advice through UCVs or incubators could incentive the nascent of more spin-offs companies in the entrepreneurial university, or produce and advantage in the mature ones. The USOs have to be transformed in strong bridges that, as *knowledge-hubs*, adopt a central position in the network, helped by the intermediaries (TTOs, UVCs, UVCps, Is, among others) and connect the *entrepreneurial university ecosystem* and the business ecosystems actors.

This study answers the call for more empirical work in different regional contexts and adds knowledge to the entrepreneurship literature in social networks and knowledge spillover theories. It makes a contribution to the entrepreneurship literature, regarding the role of social context, intermediaries, and USOs in the development of *entrepreneurial university ecosystems* and the relation with businesses beyond this ecosystem, testing and extending the emergent ecosystem approach. The main contribution of this study is the *expansive wave effect* which refers to the intensity of social networks links among participants located in different *entrepreneurial ecosystems* through which the knowledge spillover occurs.

## 7. Implications

This study has important implications for university managers and policymakers. For university managers, this research has three main implications. First, the promotion of USOs is the most relevant mechanism for bringing research to the market and activating innovation from the university, confirming the role of the entrepreneurial university as regional development engine. Second, more proactive TTOs and less bureaucracy are needed. Third, UVCs and UVCps are relevant for financing and supporting the *entrepreneurial university ecosystem*. In terms of managerial implications for the governance of entrepreneurial universities, it is possible to say that attracting human resources with a commercial orientation and international and multidisciplinary knowledge and establishing alliances with science and technology parks could improve the effectiveness of the *entrepreneurial university ecosystem*.

For policymakers, it is relevant to understand that an *entrepreneurial university ecosystem* strengthens the already existing businesses, as USOs start relations with them, contribute with their innovative technologies, and may become part of existing business ecosystems. We did not study directly these business ecosystems, however, we could say that, in the context studied, USOs are far from creating new business ecosystems led by their technology (Clarysse et al., 2014). In this light, TTOs could be excellent intermediaries to connect different agents of the network in terms of entrepreneurial activities, in particular USOs and other businesses. However, they currently occupy relatively passive positions in relation to the entrepreneurship connectability, together with UVCs, which also show a passive role in waiting for USOs contacts instead of looking for new opportunities to entrepreneurship. USOs are a crucial mechanism to bring to market what is discovered by researchers. However, the organizational and institutional context are emphasised for not being proactive in encouraging the connections of USOs with other agents of the ecosystem. We invite policymakers to rethink the

role of TTOs and UVCs.

## 8. Limitations and further research

Three limitations have been identified in this study, which in highlight opportunities for future research studies. The first limitation is that we did not include data directly obtained from the business ecosystems. Our study is based on the information provided by participants embedded in the *entrepreneurial university ecosystem*, and their connections with businesses beyond this ecosystem. They provide information about the relations with other businesses, as private companies. This helped us to understand the emergence of the business ecosystem and the relation with the *entrepreneurial university ecosystem*, but not the business ecosystem itself, and we consider the data used valid for this exploratory research. However, further research should include additional relational data collected from participants embedded in the business ecosystem and those who contact USOs for establishing commercial relationships. This would also provide insight into other companies' opinion regarding the products and services that USOs deliver, as well as the benefits and disadvantages of such collaboration.

The second limitation is that the size of our sample can be considered relatively representative. As mentioned before, this is an exploratory study which provides insight to policymakers in guiding their regional policies in the right direction, as well as future studies. In this sense, an international comparative study between the Andalusian *entrepreneurial university ecosystem* and ecosystems located in other regions would also provide policymakers new insights and ways to address their policies, while considering the differences in the context of both regions. Examples of international ecosystems in literature are the UK (Graham, 2014) and New York in the US (Hayter, 2016a).

Finally, the third limitation of this study is that we did not consider the effects of academic mobility over the *entrepreneurial university ecosystem*. Entrepreneurial mobility literature has shown the benefits from location of returnee entrepreneurs, in terms of their spillover effects in promoting innovation, in their home country (Wright et al., 2008b). In this sense, different challenges are seen in terms of its contribution to the *entrepreneurial university ecosystem* and in its connection to business ecosystems, given that many entrepreneurial universities are continually improving their international research profiles (Grimaldi et al., 2011; Siegel and Wright, 2015). Therefore, we encourage scholars to develop future research considering the academic mobility in their analysis of *entrepreneurial university ecosystems*.

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