RESEARCH EVOLUTION IN SCIENCE PARKS AND INCUBATORS: FOUNDATIONS AND NEW TRENDS

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Abstract

In this paper we undertake a quantitative review of the existing literature on parks and incubators to identify their foundations from a longitudinal perspective. To do so, we searched records in the SSCI database from 1990 to 2015 and identified 318 citing documents, which we split into 4 periods of 5 years each, to identify the interactions and path dependence that exist between different foundations of research. We evaluate the evolution of the theoretical foundations of this research line taking into account changes in citations over time. We also identify areas of future research closely connected with the theoretical foundations already identified. For this purpose, we used two bibliometric techniques— co-citation analysis and bibliographic coupling—that enable us to assess the thematic similarity between scientific publications based on overlaps in their referencing patterns.

Keywords: incubators, agglomeration, co-citation network, path dependence, bibliographical coupling.

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1. Introduction

Economists, regional scientists and management researchers have long been concerned with the contribution of science parks and incubators to the performance of firms and their prospects of survival (Mian 1997; Mian et al. 2016). The increased engagement in science parks and incubators is revealed by the fast-growing number of scientific publications dealing with their benefits, as well as the many special issues in high impact journals devoted entirely to the topic [*Technovation*, (2016, vol.50-51); *Journal of Business Venturing*, 2005, vol. 20 (2); *Research Policy*, 1998, vol. 26 (9)].

Part of the demand for this academic research line is driven by governments, which have been increasingly active in promoting conditions conducive to regional economic progress (Vásquez-Urriago, Á. R. Barge-Gil and Rico 2016; Zou and Zhao 2013). The phenomenon of parks was originated in the early 50s in the United States, with Stanford Research Park in Palo Alto California –Silicon Valley. This park was considered a paradigm of regional development policies and many governments tried to replicate its success in their own region. By the 60s and 70s the establishment of parks and incubators was extended in England and Japan and in the 80s a strong growth was observed in England, France, Germany, Sweden, Finland, Belgium and other economies of Southeast Asia (Zhang 2005).

Parks and incubators facilitate this regional progress by establishing localized mechanisms for shared resources and knowledge development (Oh et al. 2014). Underlying the development of parks and incubators worldwide there are findings that innovation activities are not equally distributed in space but production of new scientific and technological knowledge has a predominant tendency to cluster spatially (Saxenian 1996). There are high communication costs associated with the transmission of knowledge to distance, and parks and incubators provide firms with support to transmit technological knowledge that is complex, uncertain and non-codified form (Audretsch and Feldman 1996a; Polanyi 1966). As such, spatial proximity inside parks and incubators fully articulate knowledge flows among the actors of a regional innovation system (Zoltan J Acs et al. 2002; Diez-Vial and Fernández-Olmos 2015).

But parks and incubators serve many other agents involved with different interests and expectations. Universities expect parks and incubators to enable them to commercialize their technologies and to create an environment where new academic spin-off firms can thrive. In recent years, there has been a dramatic rise in entrepreneurial activity at universities, in the form of patenting, licensing, research joint ventures with private companies and the creation of spin-off companies. While licensing has traditionally been the most popular mechanism for the

commercialization of university-based intellectual property, universities are increasingly emphasizing the creation of new companies as a mechanism for commercialization (Degroof and Roberts 2004). Universities have also established technology transfer offices, which facilitate technological diffusion through the licensing of a university-based technology to an existing firm or new venture (Siegel et al. 2007).

Entrepreneurs and high-tech companies demand prestigious locations, access to support services provided by the park/incubator staff, and locally available experience and technical knowledge provided by the network of neighboring firms. In this sense, it has been observed a higher international network activity between firms of parks (Tang 2011). The management of the park/incubator has yet another interest: they need to establish the kind of policies that will attract the firms most likely to succeed, and to identify the best business models for transferring valuable knowledge and services (Mian et al. 2016). These different perspectives on the benefits offered by parks and incubators, along with the growing body of literature, have led to considerable theoretical variety: Economic geography, Strategy, Networks, Entrepreneurship, etc.

The growing number of articles on parks and incubators published in the last 20 years from different perspectives makes it difficult to track the evolution of this research field. Qualitative reviews and assessments of existing literature provide some useful orientation but tend to focus on a specific approach, such as incubators and entrepreneurship (Aernoudt 2004; McAdam et al. 2015), policy implications of science parks (Lockett et al. 2005; Storey and Tether 1998), and the role of the university (McAdam et al. 2015; Siegel et al. 2003). Similarly, empirical studies evaluating the benefits of parks and incubators have tended to focus on specific aspects, making it difficult to get an overview of the topic (Dettwiler et al. 2006; Ferguson 2004; Vázquez Urriago et al. 2014; Yang et al. 2009).

We believe that a longitudinal approach that incorporates these different theoretical perspectives and their interactions over time, would provide a useful analytical framework for understanding the benefits of parks/incubators. The variety of perspectives provides a rich framework built on different units of analysis, research objectives and methodologies. Nevertheless, it is necessary to take a comprehensive view of these different approaches, and on that basis to identify new directions for further research. In this paper, we aim to address both issues by undertaking a quantitative review of the existing literature on parks and incubators. In particular, we identify the foundations of parks and incubation research from a longitudinal perspective, taking into account the existence of interactions between different

research lines not only in the same period, but also over time. Secondly, we identify areas for future research that are closely connected with the theoretical foundations already identified. To this end, we use two bibliometric techniques— co-citation analysis and bibliographic coupling—to assess the thematic similarity between scientific publications based on overlaps in their referencing patterns.

The second section of the paper describes the data and methods used to obtain the articles included in the analysis. The third section presents the main results, while the fourth discusses the main results and the theoretical foundations identified in the co-citation analysis. Section 5 establishes the emerging research lines based on the bibliographical coupling analysis undertaken in the last 5 years (2011-2015). Finally, section 6 presents the main conclusions.

2. Data and method

2.1. Bibliographic database

We collected data from the Thomson-Reuters Social Science Citation Index (SSCI). The SSCI is a good data source widely used in bibliometric studies, and includes academic journals in the social science. We acknowledge that a wide range of databases are now available, such as Scopus or Google Scholar, but we wanted all our citing references to have a journal citation impact. In any case, we undertook a search using the same criteria in Scopus, and obtained results very similar to those obtained in SSCI.

In November 2015, we initially selected all documents that included the search terms “incubator*”; “science park*”; or “technology park*”, being the technical terms generally used in the literature, and obtained 5,997 documents. We refined the search to papers published in impact journals, as these are peer-reviewed and broadly cited. This restricted the sample to 4,351 papers. We then refined the search to publications in certain web of science subcategories that are related with management and economics: behavioral science (21), business (158 papers), economics (91), geography (50), management (154), planning development (86), and urban studies (45). These subcategories were chosen based on our approach, which was to map the evolution and state-of-the-art of science and technology parks in terms of their effect on firm and regional performance. This yielded 512 articles. However, some papers use these terms without referring to location and development, so we made a detailed analysis of all papers in two independent rounds of review, deleting many articles that had no relationship with firm and regional performance or that considered park in a marginal way. For instance, there were papers that only mentioned the park or incubator once, or that undertook the study with firms located

in incubators but there was no reference in the paper to this location. The final sample totaled 318 articles.

---Insert figure 1 around here---

The number of publications on science and technology parks and incubators has grown exponentially since the 1990s, as can be seen in figure 1. Before this date, few studies appear (7 publications), so we decided to date our study from 1990. We divided the sample into 4 periods of 5 years each. Bibliographic techniques allow us to identify trends, theoretical bases or groups of papers based on similarities in the articles cited. As citation habits change over time, these techniques perform best within a limited time frame, so it is reasonable to split the sample in sub-periods, as has been done in previous studies (Ramos-Rodríguez and Ruíz-Navarro 2004; Ronda-Pupo and Guerras-Martín 2010; Vogel 2012).

2.2. Co-citation analysis and bibliographical coupling

We applied both co-citation analysis and bibliographic coupling to this dataset. The basic assumption underlying both techniques is that the greater the degree of overlap in the referencing patterns of a pair of focal publications, the greater the relatedness or similarity between the publications. We applied both approaches because of their inherent complementarities (Meyer et al. 2014).

Co-citation analysis focuses on references or “cited documents”, considering them to be more related or similar the more often they are cited together. This technique recognizes the knowledge base of a field and the intellectual structure of existing research (Zupic and Čater 2015). Bibliographic coupling relates the citing papers of a dataset to each other on the basis of their shared references, so two papers or “citing documents” are more related or similar the more cited references they share. Since this technique focuses on citing papers, it deals with the research front, that is, the state-of-the-art of a scientific field (Kovács et al. 2015). Both analyses were carried out at the level of individual publications.

The article selection method described above is based on citing documents; however, in co-citation or bibliographical coupling, the database of cited documents must be reviewed and refined in order to identify the relatedness of articles. The 318 articles included in the final sample contain cited references. In order to homogenize the cited references and further refine our selection, we reviewed the name of the journals, since many of them had different abbreviations, deleted the second surname of the authors, and converted titles and names of

authors into lowercase. Papers that were in press when the citing document was published were corrected to include the actual year of publication and journal issue number. We also found and corrected some mistakes in the fields of the database in which years were given as author names. In the case of books, we followed the example of earlier authors, and changed the edition number of all books to the first edition number cited in our sample.

Once we had all revised the cited documents, articles with at least three citations were considered in the analysis. Similarly, citing references had to have at least three co-cited documents to be included. This decision is because we aim to identify not only the main research lines but also other minor group of studies. Previous studies have tended to establish a much higher minimum co-citation or coupling threshold, but the greater variability in topics, approaches and units of analysis in this research line generate a disperse citation structure that needs to be fully considered. To illustrate this point, the initial sample included 9,254 cited references, of which 7,495 are only cited once. As can be observed in table 1, this restriction gives 222 citing documents (68.3% of the sample) and 459 different cited documents (4.9% of the sample of cited references).

---Insert table 1 around here---

3. Results

We used biblExcel software to facilitate the bibliometric analysis of scientific literature. This software takes raw Web of Science bibliographic data and performs bibliometric calculations based on similarity matrixes between cited documents, for co-citation analysis, and citing documents for bibliographic analysis. The initial matrix obtained is based on the number of times two references are cited together for co-citation analysis, and the number of cited references that two articles cite for bibliographical coupling.

Table 2 presents a summary of the evolution of the co-citation network over the four five-year periods analyzed: 1996-2000; 2001-2005; 2006-2010; and 2011-2015. We calculated different cohesion measures based on the similarity between the cited references, measured as the number of times that two cited references appear together. As shown, the mean similarity of the cited references dramatically increased from 10.61 in the first period to 82.73 in the last period, on average, as includes the H-index (from 11 to 89 over the study period). Interestingly, this higher centrality and density was followed by a reduction in closure, from 0.71 to 0.58, which suggests that the research topic has opened up the theoretical base.

---Insert table 2 around here---

Nevertheless, we need to undertake a normalization of this relatedness measure originally based on counting the number of co-cites between cited documents or references. We chose the Salton cosine similarity (Salton and McGill 1983). This normalizes the matrix and compensates for different occurrence levels among items. Normalization is especially recommended for factor analysis because of its sensitiveness to scaling, which is important for this study. Once the normalized matrices for each sub-period were obtained, we identified subfields or factors using factor analysis performed in SPSS 22.0. We used exploratory factor analysis with principal component analysis as an extraction method, being the most frequently used technique for finding subfields in bibliometric studies. This extraction method is adequate, but requires the researcher to specify the number of factor in advance. In this study, we used the Kaiser stopping rule, based on choosing the number of factors with an eigenvalue of over 1. Nevertheless, this yielded too many factors, and the resulting grouping references did not provide useful guidance. Therefore, we observed the screen plot, representing the relationship between the relative magnitude of the eigenvalues and the number of factors, choosing the number of factors up to the transition point (Bryant et al. 1995). This criterion was combined with the evaluation of the total variance explained and the resulting factors, avoiding factors that had a low contribution to explain the variance, or included only two or three references. We chose to use a varimax rotation, as this attempts to fit (or load) the maximum number of references on the minimum number of factors.

The factor loadings represent the correlation between a given reference and the factor, that is, the extent to which the reference relates to that factor. References with a loading greater than 0.7 are considered a core contribution to the factor; while loadings lower than 0.32 are poor, so we did not take these last contributions into consideration (Vogel and Güttel 2012). References with loadings to more than one factor are considered. Since some references can contribute to different factors simultaneously, we did not force them to match with only one; instead, we considered them in all the factors, but weighting their contribution with the loading factor of the reference in each factor. Therefore, references that are relevant to more than one factor are not deleted but considered in our research.

In any case, to characterize the factors, we focused particularly on references that load to just one factor, and have a high loading value. We examined each group of cited documents to identify common themes and similarities in subject matter or approach, since this is a key driver of co-citation frequency. To reduce subjectivity, the authors worked independently to characterize each of the factors, and then worked together to find the most satisfactory

characterizations. There was a clear convergent interpretation by all co-authors. As described in the following section, we identified several factors in each of the four study periods.

---Insert table 3 around here---

In order to understand the evolution of the factors created in the co-citation analysis and to understand the evolution of the theoretical foundations, we first characterized the different groups or factors of references that appear in each period. Following network approach studies (Badar et al. 2015; Freeman 1979), we calculated several measures of centrality for each factor in each period, as shown in table 3, for the co-citation web of relationships. We based our analysis on the network established between cited documents: nodes are cited documents or references, and a connection between them exists only if they are cited together. We performed all calculations using UCINET software (Borgatti et al. 2003).

The number of references that load in each factor is a measure of centrality in terms of degree (column 1, Table 3). In this sense, the more references connected to the factor, the more central it is to that period. Nevertheless, we did not restrict each reference to a particular factor, as some references can have loadings higher than 0.32 (minimum threshold) in more than 1 factor, so we weighted each reference by its loading in the factor (column 2, Table 3). Column 3 shows the mean loading per reference, and indicates how tightly connected the cited references are to the factor as a mean. Column 4 shows the centrality of each reference included in the factor, weighted by its loading in the factor. Centrality of each reference is calculated as the number of direct ties between the cited reference and others, that is, the number of times it appears in the same reference list. As a result, the centrality of the factor measures the number of co-citations it has, taking into account the loading of each of these. Column 5 shows the intermediation of the factor. Intermediation is measured by the betweenness of each reference in the co-citation network. Betweenness is the extent to which a particular reference lies between various other references in the network (Freeman 1979), evaluating their role as ‘broker’ or ‘gatekeeper’, connecting different document referenced. The betweenness formula gives the expected value of the number of times a firm is on the shortest path connecting to other firms (Borgatti & Halgin, 2011). The betweenness of the factor is calculated by the weighted sum (load) of the betweenness of each co-cited reference included on it.

Secondly, we graphically show the evolution of the factors in the co-citation network over time. We calculated the number of shared references with a loading higher than 0.32 between each pair of factors, either from the same period or from different periods of time. Since we want to

understand how important these shared references were for the receiving factor, we weighted them by the number of total references in each period:

$$Path\ dependence_{ij} = \frac{Shared\ references_{ij}}{Total\ references_j}$$

Where *path dependence_{ij}* measures the references in factor *j* that are shared with (for the same period of time) or inherited from (from different periods of time) factor *i*; *Total references_j* is the number of references included in each receiving factor *j*. *Shared references_{ij}* is the number of cited referenced that are the same in factor *i* and factor *j*. By measuring path dependence from a period of time to another we are considering the inherited references across time, while measuring path dependence between groups of references in the same period we are measuring their mutual dependence based on sharing references.

We only consider references with a loading higher than 0.32, since lower loadings are very poor and could distort the results. Figure 2 shows the results obtained. Each node represents one of the factors previously identified in each period. Connections are shown as dots for path dependence between factors of the same period, and as a line for those in different period. Their value is the path dependence of each factor on all others. Appendix A shows the detailed data of this figure.

---Insert figure 2 around here---

Finally, having identified factors related with the theoretical evolution of the research line, we focused on emerging topics in the fourth period, 2011-2015. We undertook the same analysis as we did in co-citation analysis. We first create the web of connections between citing documents, then normalized them with the Salton cosine, performed the varimax rotation, and identified five factors: Internal relations, High-tech industries, Management, Support to entrepreneurs, and Knowledge. Table 4 shows the main characteristics of these factors, all with a similar number of associated citing documents (column 1) and total citing document loadings (column 2). Nevertheless, we observed that internal relations is the factor with the highest centrality, i.e. the papers included have more shared references and more loads (column 4) and the highest intermediation role (Column 5).

---Insert table 4 around here---

4. Evolution of the foundations in science parks and incubators

4.1. Emergence period: 1996-2000

This marks the emergence of research into science parks and incubators, with few papers on the topic published in this period: 33 papers published between 1996 and 2000. Previously, there were 25 publications in 17 years (1979-1995), and we therefore chose 1996 as the starting point for our analysis. We identified two main factors: “*Parks*” and “*Incubators*”. The “*Parks*” factor encompasses studies that focus on the importance of proximity to the university for high-tech firms in parks. Most of these studies focus on science parks, and evaluate to what extent the university can improve the firm’s innovative capacity by converting academic knowledge and local R&D into commercial products or processes (Luger 1991; Massey et al. 1992; Monck et al. 1988). The theoretical arguments are based on studies on small firms (Storey 1994) and previous studies on high-tech industries (Westhead and Storey 1994).

---Insert figure 3 around here---

The “*Incubators*” factor deals with the importance of incubators as an appropriate environment for the development of entrepreneurial projects, also focusing on high-tech firms, universities and small firms (Allen and Rahman 1985; Aydalot and Keeble 1988). These studies evaluate the incubator as a facility that provides resources, space, and consultancy services that may help small firms survive (Mian 1994; Smilor 1986). Comparing (in Table 3) the relevance of the *parks* versus *incubators* factors, we can observe that *parks* has more citations, and the centrality and intermediation role of the cited documents included is much higher than in the incubator. Figure 3 shows that in this period these factors are quite independent, with no relevant shared citations, even though they are interested in similar topics.

4.2. Growth period: 2001-2005

In this period, the number of papers published increased to 75, more than double the previous period. The most relevant factor has been called “*High Tech Industries*” and takes some of the references cited in both factors of the previous period: 8.6% from “*Parks*” (1996-2000) and 7.1% from “*Incubators*” (1996-2000) (figure 2). The research is mainly focused on small and new technology based industries (Bollinger et al. 1983; Little 1979; Rickne and Jacobsson 1999), connecting them with the benefits associated with location (Amirahmadi and Saff 1993; Mian 1994). Nevertheless, the theoretical arguments are expanded, including references associated with Economic Geography and agglomeration benefits (Feldman and Florida 1994; Fothergill and Gudgin 1979; Oakey et al. 1988; Taylor et al. 1973) as well as Strategy studies (Chandler and Hanks 1994; Grant 1991).

---Insert figure 4 around here---

The second factor from this period has been called “*University*”. It is also related to the “*Park*” factor (1996-2000) —11.6% of the references are from “*Park*”. The main issue in this factor is, as the previous one, to understand how the university benefits firms located in its proximity. Nevertheless, in this period other factors are also taken into account, such as the role of informal and formal connections inside the location (Bakouros et al. 2002; Colombo and Delmastro 2002; Vedovello 1997) and the innovation process of incorporating knowledge generated by the university into the firm (Phillimore 1999).

There are two other factors that are more loosely connected to previous literature and have a lower impact than the previous ones, since they have around half the citations and centrality of the others. The first, “*Regional Innovation*” is the compilation of several studies that develop economic models to explain regional innovation systems (Cooke and Morgan 1998; Saxenian and Hsu 2001; Storper 1997). Several papers studying factors from a strategic perspective are included in this group (Porter 1985). The forth factor from this period is called “*Technology Transfer*”, and is comprised of several papers that deal with different mechanisms established by the university to transfer knowledge to industry, such as patents (Agrawal and Henderson 2002), start-ups (Shane and Stuart 2002), licensing (Thursby et al. 2001), and knowledge spillovers (Zucker et al. 1998)

4.2. Opening period: 2006-2010

In this period, research into parks and incubators reaches maturity, with the number of citing publications increasing to 101, and existing factors tend to increase in terms of the number of documents, and also to evolve. The most important factor from this period is “*Park Performance*”, which groups previous studies of “*Parks*” (1996-2000), “*University*” (2001-2005), and “*Technology Transfer*” (2001-2005). It also inherits Economic Geography theoretical background on agglomeration studies (Z. J. Acs and Audretsch 1988; Audretsch and Feldman 1996b; Jaffe 1989). The result is a factor with lower internal cohesion, measured by the mean number of loadings per reference (0.67 in table 3), compared to previous factors. The main purpose of this factor is to explain performance associated with location within a park, stemming from various advantages, many of which have been developed in previous periods (Ferguson 2004; Lindelöf and Löfsten 2003; Siegel et al. 2003). These studies focus on the university as a provider of different relationships (Appold 1995; Bakouros et al. 2002; Westhead and Storey 1995) and as a facilitator of technology transfer (Agrawal and Henderson

2002; Fukugawa 2006; Shane and Stuart 2002), in order to compensate for critical opinions (Massey et al. 1992; Monck et al. 1988). Nevertheless, there are also new advantages associated with the role of the park as a promoter of knowledge exchange among different members (Hansson et al. 2005; Löfsten and Lindelöf 2005).

---Insert figure 5 around here---

A second factor called “*Incubator Best Practices*” is an evolution of the factors of the emerging period - “*Incubators*” and “*Parks*” (1996-2000) - and “*University*” (2001-2005), although 60 of 105 selected references are new in this period. In other words, this factor introduces new theoretical arguments to existing research. The main objective of this factor is to evaluate the practice that can be most advantageous for both entrepreneurs-incubatees and the society in which they live (Abetti 2004; Hannon 2005; Rice et al. 1995). Among other things, they try to assess the degree of ownership intervention of incubation programs (Allen and Mccluskey 1990; Sherman 1999), their exit and graduation policies (Grimaldi and Grandi 2005; Smilor 1986), the management of incubation characteristics (Von Zedtwitz and Grimaldi 2006), the services and infrastructures provided (Abetti 2004), and the most successful internal relationships (Bøllingtoft and Ulhøi 2005; McAdam and Marlow 2007). There are also some papers that focus on the role of the university in knowledge transfer (Carayannis and Von Zedtwitz 2005; McAdam and McAdam 2008; Rothschild and Darr 2005) and some on entrepreneurial theory (Aernoudt 2004).

The third factor has been named “*University Technology Transfer Effectiveness*”, and comprises documents exploring the success of different mechanisms that universities use to transfer technology to industry (O’shea et al. 2005; Shane and Stuart 2002). These studies deal with the productivity of university technology transfer offices (Chapple et al. 2005; Debackere and Veugelers 2005; Jensen et al. 2003), the characteristics of academic entrepreneurs (Chrisman et al. 1995; Franklin et al. 2001; Siegel et al. 2007), and the performance of university spin-offs (De Coster and Butler 2005; Druilhe and Garnsey 2004). Along with this theoretical base, there are some references to open innovation literature (Chesbrough 2003) and Strategy (Penrose 1959). This factor only shares five of 64 references with the factor “*Technology Transfer*” (2001-2005), mainly because the objective in this period is to explain success, and not only existing mechanisms for transferring technology from the university. In addition, this factor shows a high internal compactness, with a mean loading per reference is 0.73 (Table 3), but is quite isolated from other factors (Figure 2).

There are two more, less relevant, factors in this period: the first is “*Strategy*”, a group of references that deal with the foundations of strategy in terms of access to valuable resources (Grant et al. 1988; Wernerfelt 1984), social capital (Burt 1992; Coleman 1988; Inkpen and Tsang 2005), and absorptive capacity (Cohen and Levinthal 1990; Zahara and George 2002). The last factor is “*Knowledge geography*”, which encompasses a group of papers that try to explain local competitiveness in terms of access to tacit knowledge not easily transferred (Amin and Cohendet 2004; Camagni 1991; Gertler 2003; Hsu and Saxenian 2000).

4.3. Consolidation period: 2011-2015

In this last period, we find a factor that we have named “*Business Support*”, which encompasses most of the citing references of this period. Underlying this factor is the idea that incubators, and to a lesser extent parks, can support new companies in their development process by providing business experience, knowledge and social support (Tötterman and Sten 2005). Incubators are understood as locally based institutions that provide intangible support to new, generally young, small, high-tech firms (Markley and McNamara 1995). This factor is partly an evolution of the “*Incubator best practices*” (2006-2010) found in the previous period, as 60 of 144 cited references are the same (Aerts et al. 2007; Hansen et al. 2000; Rice 2002). In this period, the focus moves from how incubators create added value for their firms to the role of the incubator as a network enabler for internal and external institutions (Hansen et al. 2000; Ratinho and Henriques 2010; Schwartz and Hornyh 2010; Venkatraman and Lee 2004). The benefits of the network are related with the transmission of business know-how (Smilor 1986), but they also foster relationships with others – social capital (Cooper et al. 2012; Scillitoe and Chakrabarti 2010; Tötterman and Sten 2005) - and establish cooperative agreements (Avnimelech et al. 2007; Rice 2002).

---Insert figure 6 around here---

This “*Business Support*” factor is also dependent on the theoretical foundations of the “*Park Performance*” (2006-2010) factor, sharing 56 out of 144 references from this factor. Comparing both factors, the focus has also moved to understanding the benefits of locations in terms of knowledge transfer (Patton et al. 2009), and understanding universities as technology transfer institutions (Etzkowitz and Leydesdorff 2000; Smilor 1987). Along with the different mechanisms used by the university to transfer knowledge –spin-offs, specific offices, licenses, etc.- the factor tries to identify university best practices in this process (Markman et al. 2005; Mian 1996; Phan et al. 2005; Vohora et al. 2004).

The second factor from this period is called “*Knowledge Acquisition and Innovation*”, grouping references that deal with how certain locations, mainly parks, can provide external sources of knowledge and improve local innovation (Hansson et al. 2005; Malairaja and Zawdie 2008; Yang et al. 2009). The park promotes and complements internal R&D investment with the provision of higher learning capacities or, at least, external sources of knowledge (Cassiman and Veugelers 2006; Fukugawa 2006; Lai and Shyu 2005). Most of the theoretical base in this factor has an economic geography base, considering parks as innovation-fostering milieus, where geographical proximity should favor R&D spillovers (Baptista and Swann 1998; Bathelt et al. 2004; Cooke and Morgan 1998; Link and Scott 2007). Nevertheless, these studies coexist with others that focus on knowledge transmission through localized networks of cooperation, social interaction, business relationships, etc. (Ahuja 2000; Giuliani and Bell 2005; Ter Wal and Boschma 2009). Thirty nine of the 80 cited documents in this factor come from the “*Park Performance*” (2006-2010) factor, most being studies that try to explain how firms inside parks improve their innovative capacity (Dettwiler et al. 2006; Lindelöf and Löfsten 2003).

Along with these factors are two more that are clear theoretical foundations from other research lines, “*Entrepreneurial University*” and “*Networks*”, which delineate theoretical foundations to understand the role of parks and incubators in improving performance. Many of the documents belong to “*Entrepreneurial University*”, and were already employed in previous stages, mainly to address the role of the university in promoting entrepreneurship: “*University Technology Transfer effectiveness*” (2006-2010), 10 out of 42 references in the present period (Lockett et al. 2005; Mustar et al. 2006; Wright 2007). There are also similar shared references with “*Park performance*” (2006-2010) factor (Castells 1994; Lindelöf and Löfsten 2004). This factor deals with the role that the university plays in emphasizing the creation of new companies to commercialize knowledge, technology or research developed within the university (Lockett et al. 2003; Siegel et al. 2007). They evaluate how firms can best commercialize intellectual property, which can take the form of spin offs (Pirnay and Surlemont 2003), the creation of venture capital (Heirman and Clarysse 2004), or the creation of an incubator structure (Moray and Clarysse 2005).

Finally, the factor “*Network*” deals with the role of inter-organizational relationships on knowledge transfer and assimilation. Twenty four out of 60 are the same papers found in “*Strategy*” in 2006-2010, mainly related to Knowledge-Base Perspective (Kogut and Zander 1992; Nonaka and Takeuchi 1995), Resource-Based View (Grant 1991; Penrose 1959) and absorptive capacity studies (Cohen and Levinthal 1990; Lane et al. 2006; Lane and Lubatkin

1998). The new cited papers of this factor focus on networks and cooperation agreements and their role as knowledge and resource sharing conduits (Dyer and Singh 1998; Gulati 1995; Powell et al. 1996; Yli-Renko et al. 2001). Only some of the references are specific for understanding these network connecting geographically concentrated agents (Almeida and Kogut 1999; Boschma and Ter Wal 2007).

5. New trends in science parks and incubators

Once the foundations of the research about science parks and incubators had been systematized, we present the main research lines interest in the literature. In doing so, we analyzed citing documents in the last period under evaluation, 2011-2015. As shown in table 4, the most relevant factor is “*Internal relations*”, which includes the citing documents with the greatest centrality (Column 4) and the greatest intermediation role (column 5). This factor includes several papers exploring how internal webs of relationships foster local exchange of knowledge, experiences and ideas, and as a consequence, how these relationships increase firms’ performance. The advantages of the park are closely connected with relationships developed internally, which can vary in terms of the kind of relationship developed: trust-based cooperation (Ebberts 2014), informal interactions (Giaretta 2014), formal agreements (Motohashi 2013; Schwartz 2013), among others. The role played by different park/incubator agents, such as incubators directors (Patton 2014), entrepreneurs (Ebberts 2014; Soetanto and Jack 2013), the university (Essig 2014; Lundqvist 2014; Somsuk and Laosirihongthong 2014), or the government (Tang et al. 2014) in fostering valuable relations is still under debate. Each of these agents can provide business experience, assistance, support, exchange of ideas and practices and scientific knowledge, but it is unclear under which conditions they may work best.

---Insert figure 7 around here---

The second most relevant factor of citing documents has been denominated “*Support to Entrepreneurs*”, which has a similar level of centrality than the previous one, but a much lower intermediation role. This means that this factor is compounded by citing references with a high level of overlap with other papers in the citing network, but with no brokerage role, i.e., connecting citing articles that otherwise would have few cited documents in common. The main objective of this research is to understand how parks/incubators can help entrepreneurs launch their business, referring to them as “entrepreneurial-enabled environments” (Schwartz 2011). They focus on different mechanisms that can help entrepreneurs overcome their liability of newness: level of investments and local support (McAdam and Marlow 2011; H. Zhang and

Sonobe 2011), university support (Salvador and Rolfo 2011), local networking strategies (Sá and Lee 2012; Spithoven and Knockaert 2011), training programs (Rezaei et al. 2012), and the development of an innovative community (Borgh et al. 2012).

The factor “*High-tech industries*” has great centrality and plays an intermediation role between papers, but contains almost half the number of papers in the previous factors. The main objective is also to explain performance, taking either a regional unit of analysis (Jongwanich et al. 2014) or a firm perspective (Cheng et al. 2014; Díez-Vial and Fernandez-Olmos 2014). These studies focus on the role that parks/incubators play in attracting and benefiting high-tech firms, and tend focus on different aspects, such as services provided (Malek et al. 2014), R&D support (Jongwanich et al. 2014), and knowledge and resources (Khorsheed and Al-Fawzan 2014; M’Chirgui et al. 2015).

The third factor, “*Management*” has a similar centrality to the previous factor, but a higher level of intermediation. This means that the citing papers that load to this factor have many similarities with other citing papers, but are also paths for connecting citing papers that would not otherwise be connected. This brokerage role is illustrated by citing papers-nodes that are connected to nodes that load to other factors, mainly “*Internal relations*”, “*High-tech industries*” and “*Support to entrepreneurs*”. This factor focus on the management of park/incubators, understanding these locations as a whole (Albahari et al. 2013). This factor tends to establish different incubator or park typologies in order to identify those that can best benefit the firm located in the park (Barbero et al. 2012; Bruneel et al. 2012; Fikirkoca and Saritas 2012). They focus on services, policies and internal characteristics of the park/incubator in order to explain success factors, giving the managers of the park/incubator a central role (Clausen and Rasmussen 2011; Cooper et al. 2012).

The least significant factor is “*Knowledge*”, which tends to focus on the knowledge network developed inside the park to explain firm innovative capacity. The citing articles that configure this factor have a low loading, which may imply that this perspective tends to complement others. In this sense, the factor has low centrality but a high level of intermediation with other papers in terms of cited documents. These papers tend to adopt a knowledge based view (Martin-Rios 2014; Marvel 2012; Sullivan and Marvel 2011) or a social capital perspective (Díez-Vial and Montoro-Sánchez 2014) to understand the network behavior of firms inside parks and its impact on competitiveness (Liu et al. 2014; Tang 2011).

6. Conclusions

In this paper, we aim to address both issues by engaging in a quantitative review of the existing literature on parks and incubators. We first identified the foundations of parks and incubation research from a longitudinal perspective, taking into account the interactions that exist between different research lines, not only in the same period but over time. Secondly, we identified areas for future research that are closely connected with the theoretical foundations already identified. To this end, we use two bibliometric techniques— co-citation analysis and bibliographic coupling—that have enabled us to assess the thematic similarity between scientific publications based on overlaps in their referencing patterns.

In doing so, we have provided a framework that will give greater insight into the benefits that parks and incubators provide for the different agents involved, mainly governments, universities, start-ups, high-tech companies, entrepreneurs, and park/incubator managers. Underlying these different approaches is a variety of theoretical perspectives, each with its own assumptions and units of analysis that can be of great help in developing new research. For instance, Economic Geography tends to take the location as the unit of analysis, assuming that location externalities would appear in proximity (Audretsch and Feldman 1996a). Entrepreneurial perspectives focus on the environment conducive to undertaking and developing new businesses (Aernoudt 2004). The Network Perspective focuses on the role played by different relationships and interactions in the development of co-located firms (Balland et al. 2013). Lastly, management literature focuses on the internal characteristics of the firms and how they can affect local externalities (Grimaldi and Grandi 2005). We believe that these approaches have a complementary rather than competing role, and understanding their mutual contributions has enabled us to map the literature of science parks and incubators.

We have also contributed to existing literature on bibliographical studies by applying a social network analysis to the web of relationships developed in both cited and citing documents. Following recent studies (Kovács et al. 2015), we have applied useful networks measures to give greater insight into the evolution and connections developed between different research topics over time. In this sense, we present future research lines and foundations for research resulting from a path dependent process defined after 20 years of research. Past relationships developed between these different approaches, as well as their relative relevance to science park and incubator literature –i.e. their centrality and intermediation in the web of references– map existing and future lines of research.

As a summary of the research developed in parks and incubators in Management and Economics, we identified a trend toward higher openness and consolidation of theoretical base. While at the beginnings there were two clear groups of studies dealing with parks and incubators separately, time has mixed them up. Also, new references from different approaches such as knowledge based view, Strategy, entrepreneurial university or networks have been incorporated. This consolidation has provided new research lines that focus on internal characteristics of the firm, its strategy and knowledge; the importance of supporting entrepreneurs, and the key role that these locations can play in high technology based firms.

References

- Abetti, P. A. (2004). Government-Supported Incubators in the Helsinki Region , Finland : Infrastructure , Results , and Best Practices. *Journal of Technology Transfer*, 29, 19–40.
- Acs, Z. J., Anselin, L., & Varga, A. (2002). Patents and innovation counts as measures of regional production of new knowledge. *Research Policy*, 31(7), 1069–1085. doi:10.1016/S0048-7333(01)00184-6
- Acs, Z. J., & Audretsch, D. B. (1988). Innovation in large and small firms: an empirical analysis. *The American Economic Review*, 78(4), 678–690.
- Aernoudt, R. (2004). Incubators: Tool for Entrepreneurship? *Small Business Economics*, 23(2), 127–135. doi:10.1023/B:SBEJ.0000027665.54173.23
- Aerts, K., Matthyssens, P., & Vandenbempt, K. (2007). Critical role and screening practices of European business incubators. *Technovation*, 27(5), 254–267. doi:10.1016/j.technovation.2006.12.002
- Agrawal, A., & Henderson, R. (2002). Putting patents in context: Exploring knowledge transfer from MIT. *Management Science*, 48(1), 44–60.
- Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly*, 45(3), 425–455.
- Albahari, A., Catalano, G., & Landoni, P. (2013). Evaluation of national science park systems: a theoretical framework and its application to the Italian and Spanish systems. *Technology Analysis & Strategic Management*, 25(5), 599–614.
- Allen, D. N., & Mccluskey, R. (1990). Structure, policy, services, and performance in the business incubator industry. *Entrepreneurship: Theory and practice*, winter, 61–78.
- Allen, D. N., & Rahman, S. (1985). Small business incubators: A positive environment for entrepreneurship. *Journal of Small Business Management*, 23, 12.
- Almeida, P., & Kogut, B. (1999). Localization of knowledge and the mobility of engineers in regional networks. *Management Science*, 45(7), 905–917. doi:10.1287/mnsc.45.7.905
- Amin, A., & Cohendet, P. (2004). *Architectures of knowledge: Firms, capabilities, and communities*. Oxford: Oxford University Press on Demand.

- Amirahmadi, H., & Saff, G. (1993). Science parks: A critical assessment. *Journal of Planning Literature*, 8(2), 107–123.
- Appold, S. J. (1995). Agglomeration, interorganizational networks, and competitive performance in the U.S: Metalworking sector. *Economic Geography*, 71(1), 27–54.
- Audretsch, D. B., & Feldman, M. P. (1996a). R&D spillovers and the geography of innovation and production. *American Economic Review*, 86(3), 630–640.
- Audretsch, D. B., & Feldman, M. P. (1996b). Innovative clusters and the industry life cycle. *Review of Industrial Organization*, 11, 253–273.
- Avnimelech, G., Schwartz, D., & Bar-El, R. (2007). Entrepreneurial high-tech cluster development: Israel's experience with venture capital and technological incubators. *European Planning Studies*, 15(9), 1181–1198.
- Aydalot, P., & Keeble, D. (1988). *High technology industry and innovative environments: the European experience*. Routledge.
- Badar, K., Hite, J. M., & Ashraf, N. (2015). Knowledge network centrality, formal rank and research performance: evidence for curvilinear and interaction effects. *Scientometrics*, 105(3), 1553–1576. doi:10.1007/s11192-015-1652-0
- Bakouros, Y. L., Mardas, D. C., & Varsakelis, N. C. (2002). Science park, a high tech fantasy?: an analysis of the science parks of Greece. *Technovation*, 22(2), 123–128. doi:10.1016/S0166-4972(00)00087-0
- Balland, P. A., De Vaan, M., & Boschma, R. A. (2013). The dynamics of interfirm networks along the industry life cycle: The case of the global video game industry, 1987-2007. *Journal of Economic Geography*, 13(5), 741–765. doi:10.1093/jeg/lbs023
- Baptista, R., & Swann, P. (1998). Do firms in clusters innovate more? *Research Policy*, 27(5), 525–540. doi:10.1016/S0048-7333(98)00065-1
- Barbero, J. L., Casillas, J. C., Ramos, A., & Guitart, S. (2012). Revisiting incubation performance. *Technological Forecasting and Social Change*, 79(5), 888–902. doi:10.1016/j.techfore.2011.12.003
- Bathelt, H., Malmberg, A., & Maskell, P. (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography*, 28(1), 31–56. doi:10.1191/0309132504ph469oa
- Bollinger, L., Hope, K., & Utterback, J. M. (1983). A review of literature and hypotheses on new technology-based firms. *Research Policy*, 12(1), 1–14.
- Bøllingtoft, A., & Ulhøi, J. P. (2005). The networked business incubator—leveraging entrepreneurial agency? *Journal of Business Venturing*, 20(2), 265–290. doi:10.1016/j.jbusvent.2003.12.005
- Borgatti, S. P., Cross, R., College, B., & Hill, C. (2003). A Relational View of information seeking and learning in social networks. *Knowledge Creation Diffusion Utilization*, 49(4), 432–445. doi:10.1287/mnsc.49.4.432.14428
- Borgatti, S. P., & Halgin, D. S. (2011). On Network Theory. *Organization Science*, 22(5),

- Borgh, M., Cloudt, M., & Romme, A. G. L. (2012). Value creation by knowledge-based ecosystems: evidence from a field study. *R&D Management*, 42(2), 150–169.
- Boschma, R. A., & Ter Wal, A. L. J. (2007). Knowledge networks and innovative performance in an industrial district: The case of a Footwear District in the south of Italy. *Industry & Innovation*, 14(2), 177–199.
- Bruneel, J., Ratinho, T., Clarysse, B., & Groen, A. (2012). The evolution of business incubators: Comparing demand and supply of business incubation services across different incubator generations. *Technovation*, 32(2), 110–121.
- Bryant, F. B., Yarnold, P. R., & Grimm, L. G. (1995). Principal-components analysis and exploratory and confirmatory factor analysis. In F. B. Bryant, P. R. Yarnold, & L. G. Grimm (Eds.), *Reading and understanding multivariate statistics* (pp. 99–136). Washington, DC: American Psychological Association.
- Burt, R. S. (1992). *Structural holes: The social structure of competition*. Cambridge: Harvard University Press.
- Camagni, R. (1991). Local milieu, uncertainty and innovation networks: towards a new dynamic theory of economic space. In R. Camagni (Ed.), *Innovation networks: Spatial perspectives*. London: Belhaven Press.
- Carayannis, E. G., & Von Zedtwitz, M. (2005). Architecting gloCal (global–local), real–virtual incubator networks (G-RVINs) as catalysts and accelerators of entrepreneurship in transitioning and developing economies: lessons learned and best practices from current development and business incubation . *Technovation*, 25(2), 95–11.
- Cassiman, B., & Veugelers, R. (2006). In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. *Management Science*, 52(1), 68–82.
- Castells, M. H. (1994). *Technopoles of the World: the Making of the Twenty-first Century Industrial Complexes*. London: Routledge.
- Chandler, G. N., & Hanks, S. H. (1994). Market attractiveness, resource-based capabilities, venture strategies, and venture performance. *Journal of Business Venturing*, 9(4), 331–349.
- Chapple, W., Lockett, A., Siegel, D. S., & Wright, M. (2005). Assessing the relative performance of UK university technology transfer offices: parametric and non-parametric evidence. *Research Policy*, 34(3), 369–384.
- Cheng, F., van Oort, F., Geertman, S., & Hooimeijer, P. (2014). Science Parks and the Co-location of High-tech Small-and Medium-sized Firms in China's Shenzhen. *Urban Studies*, 42098013.
- Chesbrough, H. (2003). The logic of open innovation: managing intellectual property. *California Management Review*, 45(3), 33–58.
- Chrisman, J. J., Hynes, T., & Fraser, S. (1995). Faculty entrepreneurship and economic development: The case of the University of Calgary. *Journal of Business Venturing*, 10(4), 267–281.

- Clausen, T., & Rasmussen, E. (2011). Open innovation policy through intermediaries: the industry incubator programme in Norway. *Technology Analysis & Strategic Management*, 23(1), 75–85.
- Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1), 128–152. doi:10.2307/2393553
- Coleman, J. S. (1988). Social Capital in the creation of Human Capital. *American Journal of Sociology*, 94(supplement: Organizations and Institutions), S95–S120.
- Colombo, M. G., & Delmastro, M. (2002). How effective are technology incubators? Evidence from Italy. *Research Policy*, 31, 1103–1122.
- Cooke, P., & Morgan, K. (1998). *The associational economy: Firms, region and innovation*. Oxford: University Press Oxford.
- Cooper, C. E., Hamel, S. A., & Connaughton, S. L. (2012). Motivations and obstacles to networking in a university business incubator. *Journal of Technology Transfer*, 37(4), 433–453.
- De Coster, R., & Butler, C. (2005). Assessment of proposals for new technology ventures in the UK: characteristics of university spin-off companies. *Technovation*, 25(5), 535–543.
- Debackere, K., & Veugelers, R. (2005). The Role of Academic Technology Transfer Organizations in Improving Industry Science LinksBy. *Research Policy*, 34(3), 321–342.
- Degroof, J.-J., & Roberts, E. B. (2004). Overcoming Weak Entrepreneurial Infrastructures for Academic Spin-Off Ventures. *The Journal of Technology Transfer*, 29(3/4), 327–352. doi:10.1023/B:JOTT.0000034126.23592.23
- Dettwiler, P., Lindelöf, P., & Löfsten, H. (2006). Utility of location: A comparative survey between small new technology-based firms located on and off Science Parks—Implications for facilities management. *Technovation*, 26(4), 506–517. doi:10.1016/j.technovation.2005.05.008
- Díez-Vial, I., & Fernández-Olmos, M. (2015). Knowledge spillovers in science and technology parks: how can firms benefit most? *Journal of Technology Transfer*, 40(1), 70–84. doi:10.1007/s10961-013-9329-4
- Díez-Vial, I., & Fernandez-Olmos, M. (2014). Knowledge spillovers in science and technology parks: how can firms benefit most? *Journal of Technology Transfer*, 40, 70–84.
- Díez-Vial, I., & Montoro-Sánchez, Á. (2014). Social capital as a driver of local knowledge exchange: a social network analysis. *Knowledge Management Research & Practice*, 12, 276–288. doi:10.1057/kmrp.2014.7
- Druihe, C., & Garnsey, E. (2004). Do academic spin-outs differ and does it matter? *The Journal of Technology Transfer*, 29(3–4), 269–285.
- Dyer, J. H., & Singh, H. (1998). The Relational View: Cooperative strategy and sources of interorganizational competitive advantage. *The Academy of Management Review*, 23(4), 660–679.

- Ebbers, J. J. (2014). Networking behavior and contracting relationships among entrepreneurs in business incubators. *Entrepreneurship Theory and Practice*, 38(5), 1159–1181.
- Essig, L. (2014). Ownership, Failure, and Experience: Goals and Evaluation Metrics of University-Based Arts Venture Incubators. *Entrepreneurship Research Journal*, 4(1), 117–135.
- Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and “Mode 2” to a Triple Helix of university–industry–government relations. *Research Policy*, 29(2), 109–123.
- Feldman, M. P., & Florida, R. (1994). The geographic sources of innovation: Technological infrastructure and product innovation in the United States. *Annals of the Association of American Geographers*, 84(2), 210–229.
- Ferguson, R. (2004). Why firms on science parks should not be expected to show better performance the story of twelve biotechnology firms. *International Journal of Technology Management*, 28(3/4/5/6), 470–482. doi:10.1504/IJTM.2004.005305
- Fikirkoca, A., & Saritas, O. (2012). Foresight for science parks: the case of Ankara University. *Technology Analysis & Strategic Management*, 24(10), 1071–1085.
- Fothergill, S., & Gudgin, G. (1979). *The job generation process in Britain*. London: Centre for Environmental Studies.
- Franklin, S. J., Wright, M., & Lockett, A. (2001). Academic and surrogate entrepreneurs in university spin-out companies. *The Journal of Technology Transfer*, 26(1–2), 127–141.
- Freeman, L. C. (1979). Centrality in social networks conceptual clarification. *Social Networks*, 1, 215–239.
- Fukugawa, N. (2006). Science parks in Japan and their value-added contributions to new technology-based firms. *International Journal of Industrial Organization*, 24(2), 381–400. doi:10.1016/j.ijindorg.2005.07.005
- Gertler, M. S. (2003). Tacit knowledge and the economic geography of context, or the undefinable tacitness of being (there). *Journal of Economic Geography*, 3(1), 75–99.
- Giaretta, E. (2014). The trust “builders” in the technology transfer relationships: an Italian science park experience. *The Journal of Technology Transfer*, 39(5), 675–687.
- Giuliani, E., & Bell, M. (2005). The micro-determinants of meso-level learning and innovation: evidence from a Chilean wine cluster. *Research Policy*, 34(1), 47–68. doi:10.1016/j.respol.2004.10.008
- Grant, R. M. (1991). The resource-based theory of competitive advantage: implications for strategy formulation. *California Management Review*, (33), 114–135.
- Grant, R. M., Jammine, A. P., & Thomas, H. (1988). Diversity, diversification and profitability among British manufacturing companies. *Academy of Management Journal*, 31(4), 771–801.
- Grimaldi, R., & Grandi, A. (2005). Business incubators and new venture creation: an assessment of incubating models. *Technovation*, 25(2), 111–121. doi:10.1016/S0166-

- Gulati, R. (1995). Does familiarity breed trust? The implications of repeated ties for contractual choice in alliances. *Academy of Management Journal*, 38(1), 85–112. doi:10.2307/256729
- Hannon, P. D. (2005). Incubation policy and practice: building practitioner and professional capability. *Journal of Small Business and Enterprise Development*, 12(1), 57–75.
- Hansen, M. T., Chesbrough, H. W., Nohria, N., & Sull, D. N. (2000). Networked incubators. Hothouses of the new economy. *Harvard business review*, 78(5), 74–84, 199. <http://www.ncbi.nlm.nih.gov/pubmed/11143156>
- Hansson, F., Husted, K., & Vestergaard, J. (2005). Second generation Science Parks: From structural holes jockeys to social capital catalysts of the Knowledge society. *Technovation*, 25(9), 1039–1049.
- Heirman, A., & Clarysse, B. (2004). How and why do research-based start-ups differ at founding? A resource-based configurational perspective. *The Journal of Technology Transfer*, 29(3–4), 247–268.
- Hsu, J. Y., & Saxenian, A. (2000). The limits of guanxi capitalism: transnational collaboration between Taiwan and the USA. *Environment and Planning A*, 32(11), 1991–2005.
- Inkpen, A. C., & Tsang, E. W. K. (2005). Social capital, networks, and knowledge transfer. *Academy of Management Review*, 30(1), 146–165. doi:10.5465/AMR.2005.15281445
- Jaffe, A. B. . (1989). Real Effects of Academic Research. *American Economic Review*, 79(5), 957–970.
- Jensen, R. A., Thursby, J. G., & Thursby, M. C. (2003). Disclosure and licensing of University inventions: “The best we can do with the s**t we get to work with.” *International Journal of Industrial Organization*, 21(9), 1271–1300.
- Jongwanich, J., Kohpaiboon, A., & Yang, C. H. (2014). Science park, triple helix, and regional innovative capacity: province-level evidence from China. *Journal of the Asia Pacific Economy*, 19(2), 333–352.
- Khorsheed, M. S., & Al-Fawzan, M. A. (2014). Fostering university–industry collaboration in Saudi Arabia through technology innovation centers. *Innovation*, 16(2), 224–237.
- Kogut, B., & Zander, U. (1992). Knowledge of the firm , combinative capabilities , and the replication of technology. *Organization Science*, 3(3), 383–397.
- Kovács, A., Van Looy, B., & Cassiman, B. (2015). Exploring the scope of open innovation: A bibliometric review of a decade of research. *Scientometrics*, 104, 951–983. doi:<http://dx.doi.org/10.2139/ssrn.2391665>
- Lai, H. C., & Shyu, J. Z. (2005). A comparison of innovation capacity at science parks across the Taiwan Strait: the case of Zhangjiang High-Tech Park and Hsinchu Science-based Industrial Park. *Technovation*, 25(7), 805–813.
- Lane, P. J., Koka, B. R., & Pathak, S. (2006). The reification of absorptive capacity: A critical review and rejuvenation of the Construct. *Academy of Management Review*, 31(4), 833–

- Lane, P. J., & Lubatkin, M. (1998). Relative absorptive capacity and interorganizational learning. *Strategic Management Journal*, 19, 461–477.
- Lindelöf, P., & Löfsten, H. (2003). Science Park Location and New Technology-Based Firms in Sweden – Implications for Strategy and Performance. *Small Business Economics*, 20, 245–258.
- Lindelöf, P., & Löfsten, H. (2004). Proximity as a resource base for competitive advantage: University–industry links for technology transfer. *The Journal of Technology Transfer*, 29(3–4), 311–326.
- Link, A. N., & Scott, J. T. (2007). The economics of university research parks. *The Journal of Technology Transfer*, 23(4), 661–674. doi:10.1093/icb/grm030
- Little, A. D. (1979). *New Technology-Based Firms in UK and Federal Republic of Germany*. London: Wilton House Publications.
- Liu, X., Lu, J., & Choi, S. J. (2014). Bridging knowledge gaps: returnees and reverse knowledge spillovers from Chinese local firms to foreign firms. *Management International Review*, 54(2), 253–276.
- Lockett, A., Siegel, D. S., Wright, M., & Ensley, M. D. (2005). The creation of spin-off firms at public research institutions: Managerial and policy implications. *Research Policy*, 34(7), 981–993. doi:10.1016/j.respol.2005.05.010
- Lockett, A., Wright, M., & Franklin, S. (2003). Technology transfer and universities' spin-out strategies. *Small Business Economics*, 20(2), 185–200.
- Löfsten, H., & Lindelöf, P. (2005). R&D networks and product innovation patterns—academic and non-academic new technology-based firms on science parks. *Technovation*, 25, 1025–1037. doi:10.1016/j.technovation.2004.02.007
- Luger, M. I. (1991). *Technology in the garden: Research parks and regional economic development*. North Carolina: Univ of North Carolina Press.
- Lundqvist, M. A. (2014). The importance of surrogate entrepreneurship for incubated Swedish technology ventures. *Technovation*, 34(2), 93–100.
- M'Chirgui, Z., Guerfali, A., Lamine, W., & Ben Aïssa, M. S. (2015). Boosting new venture projects through incubator development programme. *Applied Economics Letters*, 22(6), 436–440.
- Malairaja, C., & Zawdie, G. (2008). Science parks and university–industry collaboration in Malaysia. *Technology Analysis & Strategic Management*, 20(6), 727–739.
- Malek, K., Maine, E., & McCarthy, I. P. (2014). A typology of clean technology commercialization accelerators. *Journal of Engineering and Technology Management*, 32, 26–39.
- Markley, D. M., & McNamara, K. T. (1995). Economic and fiscal impacts of a business incubator. *Economic Development Quarterly*, 9(3), 273–278.
- Markman, G. D., Phan, P. H., Balkin, D. B., & Gianiodis, P. T. (2005). Entrepreneurship and

- university-based technology transfer. *Journal of Business Venturing*, 20(2), 241–263.
- Martin-Rios, C. (2014). Why do firms seek to share human resource management knowledge? The importance of inter-firm networks. *Journal of Business Research*, 67(2), 190–199.
- Marvel, M. (2012). Knowledge acquisition asymmetries and innovation radicalness. *Journal of Small Business Management*, 50(3), 447–468.
- Massey, D., Quintas, P., & Wield, D. (1992). *High-Tech fantasies: Science parks in society, science and space*. London: Routledge.
- McAdam, M., & Marlow, S. (2007). Building futures or stealing secrets? Entrepreneurial cooperation and conflict within business incubators. *International Small Business Journal*, 25(4), 361–382.
- McAdam, M., & Marlow, S. (2011). Sense and sensibility: The role of business incubator client advisors in assisting high-technology entrepreneurs to make sense of investment readiness status. *Entrepreneurship & Regional Development*, 23(7–8), 449–468.
- McAdam, M., & McAdam, R. (2008). High tech start-ups in University Science Park incubators: The relationship between the start-up's lifecycle progression and use of the incubator's resources. *Technovation*, 28(5), 277–290.
doi:10.1016/j.technovation.2007.07.012
- McAdam, M., Miller, K., & McAdam, R. (2015). Situated regional university incubation: A multi-level stakeholder perspective. *Technovation*, *In Press*, 1–10.
doi:10.1016/j.technovation.2015.09.002
- Meyer, M., Grant, K., Morlacchi, P., & Weckowska, D. (2014). Triple Helix indicators as an emergent area of enquiry: A bibliometric perspective. *Scientometrics*, 99(1), 151–174.
doi:10.1007/s11192-013-1103-8
- Mian, S. A. (1994). US university-sponsored technology incubators: an overview of management, policies and performance. *Technovation*, 14(8), 515–528.
- Mian, S. A. (1996). Assessing value-added contributions of university technology business incubators to tenant firms. *Research Policy*, 25(3), 325–335.
- Mian, S. A. (1997). Assessing and managing the university technology business incubator: An integrative framework. *Journal of Business Venturing*, 12, 251–285.
- Mian, S. A., Lamine, W., & Fayolle, A. (2016). Technology Business Incubation: An overview of the state of knowledge. *Technovation*, 50, 1–12.
- Monck, R. B., Porter, P. R., Quintas, D. J., & Storey, P. W. (1988). *Science parks and the growth of high technology firms*. London: Croom Helm.
- Moray, N., & Clarysse, B. (2005). Institutional change and resource endowments to science-based entrepreneurial firms. *Research Policy*, 34(7), 1010–1027.
- Motohashi, K. (2013). The role of the science park in innovation performance of start-up firms: an empirical analysis of Tsinghua Science Park in Beijing. *Asia Pacific Business Review*, 19(4), 578–599.
- Mustar, P., Renault, M., Colombo, M. G., Piva, E., Fontes, M., Lockett, A., & Moray, N.

- (2006). Conceptualising the heterogeneity of research-based spin-offs: A multi-dimensional taxonomy. *Research Policy*, 35(2), 289–308.
- Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. Oxford: Oxford University Press.
- O'shea, R. P., Allen, T. J., Chevalier, A., & Roche, F. (2005). Entrepreneurial orientation, technology transfer and spinoff performance of US universities. *Research Policy*, 34(7), 994–1009.
- Oakey, R. P., Rothwell, R., & Cooper, S. (1988). *The management of innovation in high-technology small firms: innovation and regional development in Britain and the United States*. London: Pinter.
- Oh, D. S., Phillips, F., Park, S., & Lee, E. (2014). Innovation ecosystems: A critical examination. *Technovation*, 54, 1–6. doi:10.1016/j.technovation.2016.02.004
- Patton, D. (2014). Realising potential: The impact of business incubation on the absorptive capacity of new technology-based firms. *International Small Business Journal*, 32(8), 897–917.
- Patton, D., Warren, L., & Bream, D. (2009). Elements that underpin high-tech business incubation processes. *The Journal of Technology Transfer*, 34(6), 621–636.
- Penrose, E. T. (1959). *The Theory of the Growth of the Firm*. Oxford, UK: Oxford University Press.
- Phan, P. H., Siegel, D. S., & Wright, M. (2005). Science parks and incubators: observations, synthesis and future research. *Journal of Business Venturing*, 20(2), 165–182. doi:10.1016/j.jbusvent.2003.12.001
- Phillimore, J. (1999). Beyond the linear view of innovation in science park evaluation An analysis of Western Australian Technology Park. *Technovation*, 19(11), 673–680. doi:10.1016/S0166-4972(99)00062-0
- Pirnay, F., & Surlemont, B. (2003). Toward a typology of university spin-offs. *Small Business Economics*. *Small Business Economics*, 21(4), 355–369.
- Polanyi, M. (1966). *The tacit dimension*. New York: Anchor Day Books.
- Porter, M. E. (1985). *Competitive advantage: creating and sustaining superior performance*. New York: Free Press.
- Powell, W. W., Koput, K. W., & Smith-Doerr, L. (1996). Interorganizational and the collaboration locus of innovation: Networks of learning in Biotechnology. *Administrative Science Quarterly*, 41(1), 116–145.
- Ramos-Rodríguez, A.-R., & Ruíz-Navarro, J. (2004). Changes in the intellectual structure of strategic management research: a bibliometric study of the Strategic Management Journal, 1980–2000. *Strategic Management Journal*, 25(10), 981–1004. doi:10.1002/smj.397
- Ratinho, T., & Henriques, E. (2010). The role of science parks and business incubators in converging countries: Evidence from Portugal. *Technovation*, 30(4), 278–290.

doi:10.1016/j.technovation.2009.09.002

- Rezaei, M., Shamsaei, F., Mohammadian, I., & Van Vyve, M. (2012). A heuristic method to schedule training programs for Small and Medium Enterprises. *European journal of Operational research*, 217(3), 600–608.
- Rice, M. P. (2002). Co-production of business assistance in business incubators: an exploratory study. *Journal of Business Venturing*, 17(2), 163–187.
- Rice, M. P., Matthews, J. B., & Kilcrease, L. (1995). *Growing new ventures, creating new jobs*. Quorum.
- Rickne, A., & Jacobsson, S. (1999). New technology-based firms in Sweden-a study of their direct impact on industrial renewal. *Economics of innovation and new technology*, 8(3), 197–223.
- Ronda-Pupo, G. A., & Guerras-Martín, L. Á. (2010). Dynamics of the scientific community network within the strategic management field through the Strategic Management Journal 1980-2009: The role of cooperation. *Scientometrics*, 85(3), 821–848. doi:10.1007/s11192-010-0287-4
- Rothschild, L., & Darr, A. (2005). Technological incubators and the social construction of innovation networks: an Israeli case study. *Technovation*, 25(1), 59–67.
- Sá, C., & Lee, H. (2012). Science, business, and innovation: understanding networks in technology-based incubators. *R&D Management*, 42(3), 243–253.
- Salton, G., & McGill, M. (1983). *Introduction to modern information retrieval*. McGraw-Hill College.
- Salvador, E., & Rolfo, S. (2011). Are incubators and science parks effective for research spin-offs? Evidence from Italy. *Science and Public Policy*, 38(3), 170–184.
- Saxenian, A. (1996). *Regional advantage*. Harvard University Press.
- Saxenian, A., & Hsu, J. Y. (2001). The Silicon Valley–Hsinchu connection: Technical communities and industrial upgrading. *Industrial and corporate change*, 10(4), 893–920.
- Schwartz, M. (2011). Incubating an Illusion? Long-Term Incubator Firm Performance after Graduation. *Growth and Change*, 42(4), 491–516.
- Schwartz, M. (2013). A control group study of incubators' impact to promote firm survival. *The Journal of Technology Transfer*, 38(3), 302–331.
- Schwartz, M., & Hornyh, C. (2010). Cooperation patterns of incubator firms and the impact of incubator specialization: Empirical evidence from Germany. *Technovation*, 30(9–10), 485–495. doi:10.1016/j.technovation.2010.05.001
- Scillitoe, J. L., & Chakrabarti, A. K. (2010). The role of incubator interactions in assisting new ventures. *Technovation*, 30(3), 155–167.
- Shane, S., & Stuart, T. (2002). Organizational endowments and the performance of university start-ups. *Management Science*, 48(1), 154–170.
- Sherman, H. D. (1999). Assessing the intervention effectiveness of business incubation

- programs on new business start-ups. , 4(2), 117. *Journal of Developmental Entrepreneurship*, 4(2), 117–133.
- Siegel, D. S., Westhead, P., & Wright, M. (2003). Assessing the impact of university science parks on research productivity: exploratory firm-level evidence from the United Kingdom, 21, 1357–1369.
- Siegel, D. S., Wright, M., & Lockett, A. (2007). The rise of entrepreneurial activity at universities: organizational and societal implications. *Industrial and Corporate Change*, 16(4), 489–504.
- Smilor, R. W. (1986). *New business incubator*. Lexington Books.
- Smilor, R. W. (1987). Commercializing technology through new business incubators. *Research Management*, 30(5), 36–41.
- Soetanto, D. P., & Jack, S. L. (2013). Business incubators and the networks of technology-based firms. *Journal of Technology Transfer*, 38(4), 432–453.
- Somsuk, N., & Laosirihongthong, T. (2014). A fuzzy AHP to prioritize enabling factors for strategic management of university business incubators: Resource-based view. *Technological Forecasting and Social Change*, 85, 198–210.
- Spithoven, A., & Knockaert, M. (2011). The role of business centres in firms' networking capabilities and performance. *Science and Public Policy*, 38(7), 569–580.
- Storey, D. ., & Tether, B. . (1998). Public policy measures to support new technology-based firms in the European Union. *Research Policy*, 26(9), 1037–1057. doi:10.1016/S0048-7333(97)00058-9
- Storey, D. J. (1994). *Understanding the small business sector*. University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship.
- Storper, M. (1997). *The regional world: Territorial development in a global economy*. Guilford Press.
- Sullivan, D. M., & Marvel, M. R. (2011). Knowledge Acquisition, Network Reliance, and Early-Stage Technology Venture Outcomes. *Journal of Management Studies*, 48(6), 1169–1193.
- Tang, M. F., Lee, J., Liu, K., & Lu, Y. (2014). Assessing government-supported technology-based business incubators: evidence from China. *International Journal of Technology Management*, 65(1–4), 24–48.
- Tang, Y. K. (2011). Influence of networking on the internationalization of SMEs: Evidence from internationalized Chinese firms. *International Small Business Journal*, 266242610.
- Taylor, C. T., Silberston, A., & Silberston, Z. A. (1973). The economic impact of the patent system: a study of the British experience. *CUP Archive*, 23.
- Ter Wal, A. L. J., & Boschma, R. A. (2009). Applying social network analysis in economic geography: framing some key analytic issues. *Annals of Regional Science*, 43(3), 739–756. doi:10.1007/s00168-008-0258-3

- Thursby, J. G., Jensen, R., & Thursby, M. C. (2001). Objectives, characteristics and outcomes of university licensing: A survey of major US universities. *Journal of Technology Transfer*, 26(1–2), 59–72.
- Tötterman, H., & Sten, J. (2005). Start-ups business incubation and social capital. *International Small Business Journal*, 23(5), 487–511.
- Vásquez Urriago, A. R., Modrego, A., Barge-Gil, A., & Paraskevopoulou, E. (2014). The impact of science and technology parks on firms' radical product innovation. Empirical evidence from Spain. *Journal of Evolutionary Economics*, 24(4), 835–873.
- Vásquez-Urriago, Á. R. Barge-Gil, A., & Rico, A. M. (2016). Which firms benefit more from being located in a Science and Technology Park? Empirical evidence for Spain. *Research Evaluation*, 25(1), 107–117.
- Vedovello, C. (1997). Science parks and university-industry interaction: Geographical proximity between the agents as a driving force. *Technovation*, 17(9), 491–531. doi:10.1016/S0166-4972(97)00027-8
- Venkatraman, N., & Lee, C. (2004). Preferential linkage and network evolution: a conceptual model and empirical test in the U.S. video game sector. *The Academy of Management Journal*, 47(6), 876–892.
- Vogel, R. (2012). The Visible Colleges of Management and Organization Studies: A Bibliometric Analysis of Academic Journals. *Organization Studies*, 33(8), 1015–1043. doi:10.1177/0170840612448028
- Vogel, R., & Güttel, W. H. (2012). The Dynamic Capability View in Strategic Management: A Bibliometric Review. *International Journal of Management Reviews*, 15(4), n/a-n/a. doi:10.1111/ijmr.12000
- Vohora, A., Wright, M., & Lockett, A. (2004). Critical junctures in the development of university high-tech spinout companies. *Research Policy*, 33(1), 147–175.
- Von Zedtwitz, M., & Grimaldi, R. (2006). Are Service Profiles Incubator-Specific? Results from an Empirical Investigation in Italy. *The Journal of Technology Transfer*, 31(4), 459–468.
- Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal*, 5(2), 171–180.
- Westhead, P., & Storey, D. . (1995). Links between higher education institutions and high-technology firms. *Journal of Management Science*, 23, 345–360.
- Westhead, P., & Storey, D. J. (1994). *An assessment of firms located on and off science parks in the United Kingdom*. London: HM Stationery Office.
- Wright, M. (2007). *Academic entrepreneurship in Europe*. Edward Elgar Publishing.
- Yang, C.-H., Motohashi, K., & Chen, J.-R. (2009). Are new technology-based firms located on science parks really more innovative? *Research Policy*, 38(1), 77–85. doi:10.1016/j.respol.2008.09.001
- Yli-Renko, H., Autio, E., & Sapienza, H. J. (2001). Social capital, knowledge acquisition, and

- knowledge exploitation in young technology-based firms. *Strategic Management Journal*, 22(6–7), 587–613. doi:10.1002/smj.183
- Zahara, A. A., & George, G. (2002). Absorptive capacity: a review, reconceptualization, and extension. *Academy of management Review*, 27(2), 185–203.
- Zhang, H., & Sonobe, T. (2011). Development of science and technology parks in China, 1988-2008. *Economics: The Open-Access, Open-Assessment E-Journal*, 5.
- Zhang, Y. (2005). The science park phenomenon: development, evolution and typology. *International Journal of Entrepreneurial Behavior and Research*, 5(1/2), 138–154.
- Zou, Y., & Zhao, W. (2013). Anatomy of Tsinghua University science park in China: Institutional evolution and assessment. *Journal of Technology Transfer*, 39(5), 663–674. doi:10.1007/s10961-013-9314-y
- Zucker, L. G., Darby, M. R., & Armstrong, J. (1998). Geographically localized knowledge: Spillovers or markets ? *Economic Inquiry*, 36(1), 65–86.
- Zupic, I., & Čater, T. (2015). *Bibliometric Methods in Management and Organization. Organizational Research Methods*. doi:10.1177/1094428114562629

Figure 1. Evolution of publications in science and technology parks and incubators

Source: SSCI

Table 1. Number of citing and cited documents (*minimum frequency of 3*)

	1996-2000	2001-2005	2006-2010	2011-2015
Citing documents	15	55	80	72
Cited documents	26	148	258	241

Table 2. Cohesion evolution of the co-citation networks

	1996-2000	2001-2005	2006-2010	2011-2015
Average degree	10.61	50.74	70.41	82.73
H-Index	11	63	82	89
Degee centralization	0.36	0.48	0.45	0.52
Density	0.42	0.34	0.27	0.34
Closure	0.71	0.72	0.56	0.58
Average distance	1.71	1.68	1.75	1.66
SD distance	0.73	0.53	0.48	0.48
Compactness	0.69	0.66	0.63	0.67

Networks of co-cited references. Unit of analysis: the network. Raw counts of co-cited documents. *Average degree*: The average degree in the underlying graph. *H-Index*: the largest number x such that there are x vertices of degree at least x in the underlying graph. *Density*: number of edges divided by the maximum number possible, note the diagonal is ignored. *Closure*: The number of non-vacuous transitive triples divided by number of paths of length 2. *Average distance*: average geodesic distance amongst reachable pairs. *SD Distance*: standard deviation of the geodesic distances amongst reachable pairs. *Compactness*: the mean of all the reciprocal distances.

Table 3. Clusters in co-citation analysis

Factors	(1) N° cited documents	(2) Sum of loadings	(3) Loading/ cited documents	(4) Centrality	(5) Intermediation	(6) Sum of citations in the period
<i>2015-2011</i>						
Business Support	144	111.97	0.78	26,783.78	131.47	894
Knowledge Acquisition and Innovation Networks	80	51.11	0.64	12,212.69	56.36	433
Entrepreneurial University	60	38.43	0.48	9,168.59	44.63	259
	42	28.48	0.36	6,810.81	32.90	227
<i>2010-2006</i>						
Park Performance	121	81.30	0.67	38,048.17	703.15	732
Incubator Best Practices	104	66.81	0.64	32,024.20	521.97	651
University Technology Transfer Effectiveness	63	46.98	0.73	21,397.17	383.93	314
Strategy	56	42.91	0.75	20,733.07	427.31	240
Knowledge Geography	24	13.46	0.54	6,192.92	97.34	94
<i>2005-2001</i>						
High Tech Industries	70	57.66	0.82	8,082.09	260.03	386
University	43	23.56	0.55	3,306.41	163.27	255
Regional Innovation	20	11.17	0.56	1,469.79	41.58	89
Technology Transfer	19	11.69	0.62	1,601.76	59.50	74
<i>2000-1996</i>						
Parks	14	10.30	0.74	219.08	49.46	62
Incubators	11	8.72	0.79	185.32	9.98	36

- (1) Number of cited documents or reference with loadings >0.32 in each factor.
- (2) Sum of the loadings of the cited documents for each factor (higher than 0.32).
- (3) Loading per each cited document in each period (higher than 0.32).
- (4) Centrality of the factor = centrality of each cited reference*loading of the reference on the factor (higher than 0.32).
- (5) Intermediation of the factor= Betweenness of each cited reference*loading of the reference on the factor (higher than 0.32).
- (6) Number of times that the cited documents of each factor appear in each period without restriction of minimum cites.

Figure 2. Path dependence evolution of co-citation factors

Each node represents a factor in the co-citation network. Size of the nodes: centrality of the references included in the factor. Colour of the nodes: each period. Relationships represent the path dependence between factors, measured by the % of shared references that one factor transmit/share to the other of the total references they have. Dot lines: connections between factors of the same period. Only connections higher than the media (6.33) have been presented.

Table 4. 2011-2015 Factors in bibliographical coupling analysis

Factors	(1) N° citing documents	(2) Sum of loadings	(3) Loading/ citing documents	(4) Centrality	(5) Intermediation
Internal Relations	16	11.01	0.69	289.00	719.19
High Tech Industries	18	10.76	0.60	192.33	324.95
Management	15	9.58	0.64	191.48	420.24
Support to Entrepreneurs	18	10.45	0.58	231.90	412.36
Knowledge	15	7.47	0.50	55.70	132.78

(1) Number of citing documents with loadings >0.32 in each factor.

(2) Sum of the loadings of the citing documents for each factor (higher than 0.32).

(3) Loading per each citing document in each period (higher than 0.32).

(4) Centrality of the factor = centrality of each citing document*loading of the citing document on the factor (higher than 0.32).

(5) Intermediation of the factor= Betweenness of each citing reference*loading of the reference on the factor (higher than 0.32).

Figure 3. Co-citation network and factors: 1996-2000

Nodes: Cited references (minimum 3 co-cites). Lines: Documents are cited together. Square blue: Parks; Up triangle black: Incubators; circle pink: not linked to a node (two good loads or non-relevant load in any factor).

Figure 4. Co-citation network and factors: 2001-2005

Nodes: Cited references (minimum 3 co-cites). Lines: Documents are cited together. Square blue: High Tech Industries; Up triangle black: University; Box white: Regional Innovation; Down triangle green: Technology Transfer; circle pink: not linked to a node (two good loads or non-relevant load in any factor).

Figure 5. Co-citation network and factors: 2006-2010

Nodes: Cited references (minimum 3 co-cites). Lines: Documents are cited together. Square blue: Park Performance; ; Up triangle black: Incubator Best Practices; Box white: University Technology Transfer Effectiveness; Down triangle green: Strategy; Diamond brown: Knowledge geography; circle pink: not linked to a node (two good loads or non-relevant load in any factor) (Knowledge geography do not appear due to the low co-citation level)

Figure 7. Bibliographical coupling factors: 2015-2011

Square node: factor of citing documents, circle node: citing documents. Size of the circle node: degree in the citing network (number of times the citing document share references with other citing documents). Connecting lines: loadings of each cited on the factors (pondered by the loading value). Minimum loading factor >0.32.

Appendix

Table A. Number of shared references between factors in co-citation network

Factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Out-Degree	In-Degree	Betweenness
1. Business Support (2011-2015)	-	46.25	20.00	45.24	-	-	-	-	-	-	-	-	-	-	-	111.49	178.46	1.93
2. Knowledge Acquisition and Innovation (2011-2015)	25.69	-	26.67	40.48	-	-	-	-	-	-	-	-	-	-	-	92.84	238.75	1.53
3. Networks (2011-2015)	8.33	20.00	-	-	-	-	-	-	-	-	-	-	-	-	-	28.33	113.34	0.00
4. Entrepreneurial University (2011-2015)	13.19	21.25	-	-	-	-	-	-	-	-	-	-	-	-	-	34.44	209.52	0.00
5. Park Performance (2006-2010)	39.58	48.75	8.33	30.95	-	66.35	41.27	7.14	20.83	-	-	-	-	-	-	263.20	131.41	2.96
6. Incubator Best Practices (2006-2010)	41.67	33.75	6.67	16.67	57.02	-	25.40	10.71	12.50	-	-	-	-	-	-	204.39	138.47	2.96
7. University Technology Transfer Effectiveness (2006-2010)	12.50	11.25	8.33	28.57	21.49	15.38	-	12.50	-	-	-	-	-	-	-	110.02	101.59	0.39
8. Strategy (2006-2010)	5.56	5.00	36.67	7.14	3.31	5.77	11.11	-	12.50	-	-	-	-	-	-	87.06	58.92	2.38
9. Knowledge Geography (2006-2010)	0.69	3.75	-	2.38	4.13	2.88	-	5.36	-	-	-	-	-	-	-	19.19	70.84	0.17
10. High Tech Industries (2001-2005)	8.33	7.50	1.67	7.14	11.57	13.46	9.52	3.57	-	-	0.93	-	5.26	-	-	88.95	30.00	1.98
11. University (2001-2005)	10.42	21.25	1.67	14.29	18.18	18.27	4.76	7.14	4.17	12.86	-	30.00	31.58	-	-	174.59	65.11	7.09
12. Regional Innovation (2001-2005)	1.39	7.50	-	4.76	4.13	3.85	-	3.57	16.67	-	13.95	-	-	-	-	55.82	50.00	0.62
13. Technology Transfer (2001-2005)	5.56	5.00	3.33	9.52	5.79	3.85	7.94	7.14	-	1.43	13.95	-	-	-	-	63.51	36.84	0.00
14. Parks (1996-2000)	3.47	7.50	-	2.38	4.96	4.81	-	-	4.17	7.14	11.63	15.00	-	-	-	61.06	0.00	0.00
15. Incubators (1996-2000)	2.08	-	-	-	0.83	3.85	1.59	1.79	-	8.57	4.65	5.00	-	-	-	28.36	0.00	0.00

Relationships represent the strength of the connections between factors, measured by the % of shared references that one factor transmit to the other of the total references they have. Dot lines: connections between factors of the same period.