

THE EFFECT OF SCIENCE AND TECHNOLOGY PARKS ON A FIRM'S PERFORMANCE: A DYNAMIC APPROACH OVER TIME

Abstract:

We argue that the benefits provided by locations inside science and technology parks evolve over time. Firms inside parks can improve performance due to certain advantages related to knowledge spillovers and shared resources that can be particularly useful in earlier stages of the industry life cycle. In these industries, local knowledge sharing is particularly useful because no standards are clearly established, as we have confirmed in a sample of 12,800 firms from the PITEC database, located either on- or off-park. We also find that young firms can benefit more from the park than more established businesses in terms of both business growth and innovative capacity. Although older firms have greater experience and investments that would increase their capacity to absorb external knowledge, their associated rigidities prevent them from incorporating changes into their structures.

Keywords: geographical concentration, age, industry life-cycle, growth, innovation, science and technology parks.

JEL codes: E32, O18, R58, M13

1. INTRODUCTION

Science and technology parks have been broadly considered as a valuable source of externally available resources and knowledge that help firms to increase their innovative capacity and foster their growth (Ferguson and Olofsson 2004; Löfsten and Lindelöf 2005). In this sense, abundant literature has evaluated park benefits by comparing on-park firms with off-park firms (Westhead 1997; Bakouros et al. 2002; Siegel et al. 2003a; Ferguson and Olofsson 2004; Dettwiler et al. 2006), but the results have not been conclusive. While some studies confirmed the benefits associated to park locations (Colombo and Delmastro 2002; Fukugawa 2006; Vásquez Urriago et al. 2014), some authors observed limited exchange of resources and knowledge among their members (Vedovello 1997; Bakouros et al. 2002), major difficulties in transferring scientific research and personnel from universities to their neighboring firms (Massey et al. 1992), and a low added value of the resources provided locally (Chan and Lau 2005).

These results tend to indicate that there are both contextual and structural factors of the location inside parks that change from a park to another that need to be taken into account. In this research we consider that part of these differences stems from the fact that the benefits associated with in-park locations are not constant over time. We argue that these benefits evolve as external or internal changes happen to the firm, and these changes should be considered in the analysis (Ahuja et al. 2012; Wang et al. 2013; Balland et al. 2013). As a consequence, our research objective is to look further into the benefits of locations inside parks across time, from a dynamic perspective. Rather than considering park benefits as constant and stable, we posit that they depend on two main aspects: the maturity of the industry where the firm competes, and the age of the firm.

Deepening on this research is relevant in order to better understand under which conditions parks can play a better role in promoting local innovation and firms' growth. As a consequence, both individual firms and government would be able to better establish when it makes sense to invest on park locations. Parks have been expected to play a more significant role for both young firms and emerging markets. Moreover, many parks have exit policies to encourage older firms to leave the park and set up outside and also have incentives to house high technology industries. This is the case of incentives based on subsidies for leasing premises, or mandatory replacement of these firms with others, younger or in emerging industries, whose need is perceived to be greater (Allen and Mccluskey 1990; Clarysse et al. 2005). In this sense, some questions arise that would need further research, such as: Can older

1 firms also benefit from location inside the park, like young ones? Can firms in mature
2 industries improve their performance inside the park? To what extent do the park's benefits
3 tend to diminish over time?
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5 Our analysis will contribute to the existing literature by incorporating a multi-theoretical
6 approach to explain the benefits associated with science and technology parks. We undertake
7 a dynamic perspective that considers the effect of time in clustered spaces incorporating the
8 contributions of different approaches such as the Resource-Based View (Barney 1991), the
9 knowledge-Based View (Kogut and Zander 1992), alliance network approach (Gulati 1998)
10 and Organizational Learning (Zahra and George 2002). Although there are several papers
11 adopting a temporal perspective, they tend to focus mainly on network-knowledge related
12 aspects, while understanding the benefits of the park requires a theoretical approach
13 comprehensive enough to incorporate the many different effects of the these locations (Mian
14 1997; McAdam and McAdam 2008; Vásquez Urriago et al. 2014). Moreover, these studies
15 are undertaken in locations, such as industrial districts, where firms tend to share the same
16 industry, markets and in many cases collective norms and values (Wang et al. 2008; McAdam
17 and McAdam 2008; Kukalis 2010). However, analyses in industrial districts cannot be applied
18 entirely to parks precisely because firms inside parks belong to very different industries and
19 they have different experiences and values.
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22 Also, this paper contributes by evaluating business performance in terms of both firm growth
23 (i.e. increase in both sales and employees), and innovation performance (total number of
24 innovations and innovations new to the market in the firm). Belonging to parks may affect
25 various aspects of company performance (Colombo and Delmastro, 2002; Löfsten and
26 Lindelöf, 2005; Mian, 1996; Vásquez-Urriago et. al, 2014), and there is some debate on the
27 most appropriate method for assessing park effectiveness (Siegel et al., 2003; Barbero et al.,
28 2012).. We consider that part of the lack of consensus in the previous literature might be
29 explained by different consequences of various performance dimensions, as it has been
30 suggested (Ferguson and Olofsson 2004). Company development strategies differ according
31 to their resource restraints and their own objectives (Chandler and Baucus 1996; Delmar et al.
32 2003), which is why it is recommended to use several performance dimensions.
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34 To test this objective, we have gathered data from 2007 to 2012 for the group of firms that
35 participated in the Spanish Technological Innovation Panel (known by the acronym PITEC in
36 Spanish). This database is particularly relevant to our research since it contains information
37 on approximately 12,800 firms, located either on-or off-park.
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This paper is structured into the following sections: the section following this introduction presents the theoretical framework and our proposed hypotheses. The third section deals with the empirical evidence we obtained, explaining the main characteristics of science parks, presents how variables are measured and discusses the main study results. Finally, the fourth section presents our conclusions as a discussion of the results and future research lines.

2. THEORETICAL FRAMEWORK

2.1. Parks, knowledge and performance

Much of the literature suggests that science and technology parks are important vehicles that can help firms launch new products and increase their growth potential (Ferguson and Olofsson 2004). Along with access to services, physical infrastructures and reputation effects, belonging to the park confers knowledge spillovers to their collocated firms that have been considered as fundamental for business success (Phan et al. 2005; Chan and Lau 2005). From an Intellectual Capital perspective, these benefits can be explained in terms of accumulation of a higher level of intellectual capital (Villasalero 2014). Along with physical resources, such as machinery, procedures or installations (Westhead and Batstone 1998), firms have access to human capital obtained by inter-firm human mobility between firms, hiring personnel from universities, such as researchers or graduate students, and also running training programs for existing staff (Vedovello 1997; Filatotchev et al. 2011). Firms can also improve their technological capital, mainly related to higher R&D capacity or increased patenting behavior (Villasalero 2014). But more importantly, firms can access resources and knowledge from other firms and institutions by establishing relationships with them. This relational capital facilitate firms' learning by either conducting knowledge through a network of participants or collectively creating new knowledge inside the network (Nahapiet and Ghoshal 1998; Moran 2005). It is the result of interactions, collaborations, trust and other social ties that favour the development of reputation and the exchange of localized knowledge among different firms and organizations, where interactions are non-hierarchical but based on different kind of relationships, such as commercial transactions, trust-based agreements, friendship interactions, formal agreements, etc. (Inkpen and Tsang 2005; Bell and Zaheer 2007).

Traditionally associated with the university and other higher education institutes, these interactions provide knowledge in terms of basic research and support that firms can turn into valuable new products, services or processes (Westhead 1997; Löfsten and Lindelöf 2005). More recently, the relevance has been pointed out of also considering local interactions, either

1 formal or informal, among collocated firms that foster mutual exchange of knowledge such as
2 technology, consultancy, or business skills (Hansson et al. 2005; Filatotchev et al. 2011). The
3 park's management team can also provide firms with business advice and services related to
4 financial and marketing skills (Mian 1997; Ferguson and Olofsson 2004) functioning as a
5 connecting agent for firms that are collocated with other organizations inside and outside the
6 park (Johannisson 1998; Westhead and Batstone 1998; Chan and Lau 2005).

11 Nevertheless, empirical evidence has not confirmed this positive influence of location inside a
12 park on a firm's performance (Westhead 1997; Colombo and Delmastro 2002; Ferguson and
13 Olofsson 2004; Dettwiler et al. 2006), finding that results were not conclusive. Contrary to
14 expected, some studies have found a low level of local interactions among firms in the park,
15 as few firms exchanged knowledge locally, although links that were formed tended to be
16 strong (Bakouros et al. 2002). The role of the university as a provider of local knowledge
17 spillovers has also been questioned, considering that basic academic research is not easily
18 absorbed by local firms and it has a long range perspective that is of little use for the
19 immediate problem-solving activities required by businesses (Quintas et al. 1992; Löfsten and
20 Lindelöf 2005). Finally, park management has not always demonstrated proactive behavior
21 when setting up systems which continually encourage development of local interactions or
22 promote external relationships (Westhead and Storey 1995). Many parks have been found to
23 be primarily a form of prestigious real estate generating few productive synergies (Bakouros
24 et al. 2002).

37 In this research, we consider this lack of empirical consistency to be based on differences in
38 the moment in time when the research takes place. We consider that the benefits associated
39 with the park change both in terms of the intensity in which they are available and their utility
40 for firms. We particularly consider that the industry life cycle, along with the age of the firm,
41 are determining factors in the evolution of knowledge spillover intensity and utility inside
42 parks.

48 **2.2. The industry life cycle**

51 The industry life cycle framework states that an industry has its own cycle of life (Vernon,
52 1966) evolving from an early formative stage where there is a supply of a new product with
53 relatively primitive design to more mature manufacturing and marketing techniques.
54 Throughout this process, firms within the industry learn about the production process as well
55 as the product, which reduces uncertainty, increases production efficiency, and adapts better

to client needs. As the industry evolves, there tend to be fewer innovations, mainly focused on improving product variety and production processes (Audretsch 1998; Wang et al. 2013).

This evolutionary interpretation of the industry over time affects park benefits (McAdam and McAdam 2008; Wang et al. 2013). In the first stages of the life cycle, there is greater heterogeneity among firms and industry standards have yet to be established. As the Resource-Based View (RBV) argues, firms differ in their endowment of valuable internal resources (Barney 1991), these differences peaking in the first stages of the industry life cycle (Karniouchina et al. 2013). The park can provide valuable resources in these first stages, when standards still are not tightly established (Eisingerich et al. 2010). For instance, firms can have improved access to human resources from other companies, by hiring and training a skilled and specialized workforce (McCann and Folta 2008), they can strength their own reputation in the new industry by being located proximate to other highly reputed firms of the park (Kalnins and Chung 2004), and they can also benefit from credit access and financial projects that are supported by local government and park management (Vedovello 1997).

More importantly, most valuable resources are intangible, i.e. based on knowledge, tacit knowledge, and they can be more easily either generated collectively or transferred between organizations inside a park (Podolny and Page 1998). Inside a park firms have access to different firms and organizations, from different industries and backgrounds, which is a great in terms of promoting the generation of wider variety of ideas that are needed for innovations at this stage (Hansson et al. 2005). The organizational learning and knowledge-based literature often focuses on the type of knowledge transferred, dividing knowledge into two types: explicit knowledge that can be codified, and tacit knowledge that is difficult to articulate (Polanyi 1966; Kogut and Zander 1992). Tacit knowledge tends to play a relatively more important role in generating innovation activity and fostering a firm's development, and it is also most relevant in the first stages of the life cycle (Boschma and Lambooy, 1999; Ter Wal, 2014). In these early stages there are no widely accepted standards with respect to product and process specifications, so that knowing "what consumers want and how it can be produced demands proximity to the knowledge sources" (Audretsch and Feldman 1996).

Specifically, scientific knowledge, provided by nearby universities and other higher education institutes, is of great value in these first life cycle stages, when this basic knowledge has yet to be disseminated to the broader community and is not yet available in readily accessible codified form (Zucker et al. 1998). In the same vein, local knowledge networks among similar firms, based on either formal agreements or informal interactions, requires proximity to be

transmitted in the early stages, before this knowledge can be codified and patented. Even in firms that have developed research collaboration with other firms, partners find it easier to produce innovative outcomes when they are close by (Audretsch 1998; Gittelman 2007).

While beneficial to an organization, tacit knowledge turns out to be quite difficult to transfer, as the Knowledge-Based View acknowledged (Grant 1996). Tacit knowledge requires of a conduit capable of being transmitted as it is gained through imitation and repetition, not through conscious analysis or explicit instruction (Langlois 1992). “This is because tacit knowledge can only be observed by its application and acquired through practice; its transfer between people is slow, costly and uncertain” (Grant, 1996:111). Transmitting this knowledge requires frequently interaction that proximity facilitates, often involve the development of an unique language or code, and may involve learning a set of values (Kogut and Zander 1992). In this sense, belonging to a park tends to reduce the communication and coordination costs associated to the transmission of tacit knowledge (Almeida and Kogut 1999; Levin and Cross 2004). This tacit knowledge tends to be highly contextual and uncertain, so its transmission requires both formal and informal meetings, conferences as well as face-to-face encounters (Bell and Zaheer 2007). Besides, in the event that firms develop shared values and norms, these communication costs will be further reduced. Geographical proximity also fosters developing trust among co-located agents based on similar values and shared backgrounds and routines (Expósito-Langa and Molina-Morales 2010). As a consequence, firms inside parks might increase their mutual trust which, in turn, increases a firm’s willingness to share their knowledge and absorb knowledge from others (Levin and Cross 2004).

As industry evolves to a mature stage, tacit knowledge plays a much less important role and geographical proximity to other sources of knowledge is not so relevant to make it transferable (Audretsch and Feldman 1996; Grant 1996). In the mature stage, most of the product’s technical aspects have become standardized, so it is easier for rivals to come by the knowledge (Teece 1986). As knowledge becomes explicit, it is more applied and specialized, so firms can benefit more from its innovations, but this also implies less ability to control knowledge flows and, hence, a greater risk of unintended knowledge spillovers and imitation by competing firms (Ter Wal 2014). This control problem might exist regardless of a firm’s location, requiring strict property rights (Liebeskind et al. 1996). Nevertheless, this problem could be heightened if firms co-located in the park have developed shared values and norms. If firms have developed similar values and backgrounds while having shared experiences, they would find it easier to understand and incorporate knowledge from other firms within the

1 park, reducing the knowledge appropriability (Baum and Mezias 1992; Shaver and Flyer 2000;
2 Canina et al. 2005).

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4 In addition, local knowledge sources and resources provided inside the park in mature
5 industries become less relevant because firms tend towards homogeneity, suffering a kind of
6 lock-in and ossification (Mcfadyen and Cannella 2004). Managers in the same industry tend
7 to be exposed to similar industry experiences and technical training, so there is a tendency to
8 homogeneity in their mental models and learning paths as industry evolves (Prahalad and
9 Richard 1986). The first stages of the life cycle require of rapid technological development
10 that is promoted by firms' learning of diverse sources of knowledge (Powell et al. 1996).
11 Following March (1991), the learning process of the firm can be broken down into two main
12 elements: explorative learning and exploitative learning. Explorative learning refers to a
13 firm's ability to identify, analyse, process, interpret and understand acquired external
14 knowledge. Exploitative learning refers to the application of the acquired knowledge and
15 relates to a firm's ability to incorporate this into new goods, systems or processes (Zahra &
16 George, 2002).

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18 While these two elements are necessary, explorative learning is most important in the first
19 stages of the life cycle, where experimentation, speed and flexibility are critical; and
20 exploitative learning is most useful in mature industries, with a higher orientation to cost,
21 efficiency and incremental innovations (Tushman et al. 1996). Similarly, a firm's ability to
22 absorb knowledge gained from the park can be mainly related to its skills for exploratory
23 learning (Expósito-Langa et al. 2011). Parks can be instrumental for the exploration of new
24 opportunities and for helping firms to move beyond their traditional views of the market and
25 technological trajectories (Lazaric et al. 2008). On contrary, as the industry matures, norms
26 and organizational routines in the industry are established, making them less aware of new
27 knowledge sources locally provided and more focussed on exploitative learning (Audretsch
28 1998; Gilsing et al. 2008)). Moreover, as the life cycle evolves firms tend to use established
29 procedures, based on previous investments in resources and refuse to see them as reversible
30 commitments (Teece et al. 1997; Ghemawat 2010). While these resources can provide them
31 with a distinctive skill, they also limit the capacity to change their internal resources
32 according to new procedures, ideas or market needs (Kraatz and Zajac 2001).

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57 *Hypothesis 1. "As industries mature, the positive effects of parks on performance tend to be*
58 *reduced".*

2.3. The age of the firm

It has been broadly considered among strategy and organization scholars that young firms have higher failure rates than established firms as they are especially vulnerable to obstacles in early development phases. This liability of newness (Stinchcombe 1965) is related to the founders' lack of knowledge about how to establish effective work roles inside the firm as well as a dearth of trustworthy relationships with other organizations, mainly their providers and clients. Young firms may also lack knowledge about what they can do or they may not be sufficiently endowed with the resources they need (Thornhill and Amit 2003). However, as literature on alliance networks has analyzed (Gulati 1998), young firms can compensate for these liabilities by having access to resources and stable relationships, which can make the difference in their chances of succeeding when launching new products on the market and their development (Baum et al. 2000). Research on networks is interested in understanding how the web of external relationships in which firms are embedded may influence in their behaviour and performance (Yli-Renko et al. 2001; Moran 2005). It builds on the general notion that economic actions are influenced by the social context in which they are embedded and that this context is configured by a myriad of relationships with different agents such as providers, clients, rivals, partners, universities, etc. (Owen-Smith and Powell 2004).

In this sense, science and technology parks have been considered as network of relationships among geographically concentrated firms and institutions that foster the development of young firms (Hansson et al. 2005). It is expected that locations inside this network would significantly reduce the hazards faced by a startup, resulting in differential innovative capacity and growth (Ferguson and Olofsson 2004). New firms lack legitimacy and reliability that are conferred by years of experience and that affect the perceived quality and reliability of their products and services among potential customers, suppliers, employees, collaborators and investors (Baum et al. 2000). Inside parks, firms mitigate this risk of newness by establishing formal or informal relationships with other firms and institutions (e.g. universities and other higher education institutes) with higher legitimacy and prestigious that are also located inside the park (Löfsten and Lindelöf 2005). Thanks to the presence of these institutions, as well as of larger and more experienced firms, parks can create a beneficial image and a higher legitimacy to the younger firms, making it easier the launch of their products (Felsenstein 1994; Ferguson and Olofsson 2004).

In addition, one major problem for young firms is that they need to develop a network of relationships that provide them with the necessary knowledge to promote their business

development (Schutjens and Stam 2003). Young firms need technical knowledge, related to new production processes, product development, or more efficient machinery; market knowledge such as client preferences, failures in the product offered or factors that influence sales evolution; and managerial knowledge related to how to run the business or integrate different activities and functions inside the firm (Sammarrà and Biggiero 2008). Inside parks, the existence of a network configured by firms in different development stages, and from varied industries, allows them to exchange their respective knowledge in a complementary way (Löwegren 2003). In a similar vein, the existence of an active park management can provide business advice and the experience of other organizations from inside or outside the park, and it can generate collective knowledge and learning among its members (McAdam and McAdam 2008). In general, this proximity to external knowledge sources is expected to improve young companies' performance allowing them to compensate their lack of internally developed technological capabilities with external sources. They also find it easier to incorporate new ideas and process internally as they have not yet developed strong routines or assets (Gopalakrishnan and Bierly 2006).

Nevertheless, as firms get older the benefits of the park are brought into question. In fact, many parks have developed exit policies that foster firms leaving the park when their incubation time is up – typically after two or three years. From the network perspective it has been pointed out that older firms would be less interested in developing local networks because they have already acquired their own experience and knowledge from their own products and markets. Instead of investing on local interactions with younger and less experienced firms, old firms can learn about the technological, managerial and competitive environments directly by their own experience. Moreover, they can establish relationships with distant agents that provide a source of knowledge they can use to improve their performance (Belso-Martinez, 2006; De Martino et al., 2006; Hendry et al., 2000).

From evolutionary theories (Nelson and Winter 1982) it has been also considered that as firms get older, they suffer a kind of liability of obsolescence, because older firms become inertial, inefficient and unresponsive to changes in their external environment (Henderson 1999). Firms tend to follow path-dependent learning processes, mainly rooted in their existing assets, routines and procedures, making it difficult to develop new processes (Teece et al. 1997). As firms age, they develop organizational principles that reduce their flexibility in terms of incorporating knowledge provided nearby (McCann and Folta 2011). Inside firms, core organizational routines are subject to inertial pressures that reduce firms' capacity to

introduce new practices that are far from their existing routines, languages and practices (Nelson and Winter 1982).

As a consequence, firms would become increasingly unable to generate new or important innovations as they age because their structures and routines become institutionalized over time. Moreover, there are political pressures inside firms – i.e. career interests, investment in specific clients, employees’ specialization in certain market niches, etc. – that also restrict the range of organizational actions (Sorensen and Stuart 2000). In this context, age would be negatively related to performance and the benefits of belonging to the park would be negligible. Young firms usually lack of these focused routines, being more flexible in their behavior and more eager to learn from others, and their employees have not invested much in their current organization, so they are not threatened by new external ideas. As firms become more rigid, they will become less sensitive to external knowledge sources that could imply developing new abilities in a certain domain (Gopalakrishnan and Bierly 2006).

Based on that, we can propose that:

Hypothesis 2. “As firms age, the positive effects of parks on performance tend to be reduced”.

3. EMPIRICAL EVIDENCE

3.1 Methodology

The data used in this research is from the Spanish Technological Innovation Panel (henceforth, PITEC)¹, an annual survey of the innovation activities of Spanish firms set up by the Spanish Statistical Office (INE), the Spanish Foundation for Science and Technology (FECYT), and the Cotec Foundation for Technological Innovation with the objective of providing data from the Community Innovation Survey (CIS). Although Spanish PITEC offers panel data from 2004, our study covers the 2007-2012 period because the science park location information is only available from 2007 onwards.

PITEC is suitable to examine the effect of the economic activity’s maturity and the firm’s age on firm performance when belonging to a science and technological park. First, it comprises a representative sample of the population of Spanish firms in the manufacturing and service sectors. Secondly, the PITEC provides the setup year so we may take into consideration the

¹ An open database available online http://icono.fecyt.es/PITEC/Paginas/descarga_bbdd.aspx

firm's age. Finally, this survey can identify whether a firm is located in a science and technology park.

Figure 1 presents the evolution of on- and off-park firms from 2007 to 2012 in PITEC, taking into account not only movements to and from the park, but also firms that just disappear or begin to exist in this period. Nearly seventy per cent of firms that were in science parks in 2007 survived to 2012. Eighteen percent of the 11,156 firms that were off-park had ceased trading by 2012.

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3.2 Operationalization of variables

Despite its relevance, research into a firm's performance suffers from lack of consensus on how to measure this construct (Delmar et al. 2003). We advocate using the same theoretical model on several performance dimensions, firm growth and firm innovation, treating them independently.

To measure firm growth, we calculated the annual average growth of employment and sales for each firm, as already done by prior research in this area (Brixy and Kohaut, 1999; Capelleras, Rialp, and Rialp, 2014; Evans, 1987):

$$SALES\ GROWTH = \log sales_t - \log sales_{t-1}$$

$$EMPLOYMENT\ GROWTH = \log employment_t - \log employment_{t-1}$$

where $\log sales_t$ and $\log employment_t$ are the logarithms of the values for sales and employment at time t and $sales_{t-1}$ and $employment_{t-1}$ are these values at time $t-1$. Thus, these variables measure a firm's sales or employment growth rate at time t with respect to time $t-1$, assuming an exponential growth trend.

We use absolute growth measures rather than relative measures because we try to evaluate annual changes in sales not conditioned by firms' size (we already control for it). Relative measures tend to ascribe higher growth to smaller firms, getting easily a high relative growth, while large firms would have more difficulties in reaching the same level of growth (Delmar, 1997; Gatrell and Reid, 2006). In our sample of firms, most of them are small and medium firms, thus, we have chosen an absolute measure. To measure firm innovation performance, we used the percentage of sales from new products, given that it reflects the success of new

businesses (Cassiman and Veugelers 2006). In particular, we used the variable *radical innovation capacity*, which measures the fraction of a firm's turnover pertaining to products new to the market, and the variable *innovation capacity*, which represents the fraction of a firm's turnover pertaining to products new to the firm or new to the market.

To measure the park effect we created a binary variable called *belonging to a park* that takes a value of 1 if the firm is located on a science and technological park and zero otherwise, following previous literature (Colombo and Delmastro 2002; Siegel et al. 2003b; Ferguson and Olofsson 2004; Yang et al. 2009).

Industry maturity was measured by a continuous variable that takes into account sales evolution over time, mainly according to Bos et al. (2013). Other authors have also used a sales based measurement although in a binary way (Audretsch, 1987, Nyström, 2005). In particular, we first estimated the following equation for every economic activity j :

$$\ln(S_{jt}) = \alpha_0 + \alpha_{1j} t + \alpha_{2j} t^2 + \varepsilon_{jt} \quad (1)$$

where $\ln(S_{jt})$ is the log of real sales in economic activity j at time t , and t and t^2 is time (1 in 2002) and time squared.

We construct a continuous measure of *industry maturity* by economic activity by considering the effect of an increase of t on the log of real sales and define economic activity j 's maturity at time t as:

$$M_{jt} = -\frac{\partial \ln(S_{jt})}{\partial t} = -[\alpha_{1j} + 2 \alpha_{2j} * t] \quad (2)$$

M_{jt} is decreasing in sales growth as it is derived from the negative sign of the equation (2). As a result, the highest values of M_{jt} represent economic activities with the lowest sales growth.

Table 1 shows the average economic activity-specific maturity estimates as well as the estimated coefficients from equation 1.

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We define a *firm's age* as the number of years elapsed since the year of establishment (Liskey, 2008).

We also control factors that are traditionally found to affect a firm's performance. First, we take into account the firm's innovation effort intensity. There is a lack of uniformity in how innovation is measured, encompassing a wide variety of methods throughout the literature,

such as R&D (O'Regan, Ghobadian, and Gallear, 2006), R&D intensity (Hitt, Hoskisson, and Kim, 1997) and R&D manpower (Sher and Yang, 2005). We use an input indicator, the *innovation expenditures* as a percentage of turnover. This indicator includes not only spending on internal and external R&D, but also non-R&D expenditures such as training, introducing innovation into the market and advertising (Díez-Vial and Fernandez-Olmos 2014).

Firm size also appears as a control variable in many empirical studies on business performance. Since large firms are more likely to exploit economies of scale (Mansfield, 1962) and to have broader pools of qualified human resources (Chen and Yang, 2009), this variable is expected to have a positive effect on business performance. In line with previous literature, we define firm size as the natural logarithm of the number of employees (Liskey, 2008).

3.3. Results

Preliminary analysis was conducted to determine the relationships between each of the explanatory variables used in the regression. Table 2 provides means and standard deviations of the variables as well as Spearman's correlations² for each pair. It demonstrates that innovation intensity, firm size, park, maturity and firm age tend to be correlated, but there is no severe multicollinearity.

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Firm growth

We conducted several tests to identify the best statistical model for each dependent variable of firm growth, *sales growth* and *employment growth*. We obtained similar results for both variables. We performed the Breusch-Pagan LM test and concluded that the panel model data is better than the pooled OLS model. Next we performed the Wooldridge test to choose between a fixed-effects and a random-effects model. The Wooldridge test rejects the fixed-effects model. Likewise, both autocorrelation and heteroskedasticity are detected in panel data analysis. Thus, we implement the panel corrected standard errors because, besides being

² The Kolmogorov-Smirnov test determined that the variables were not normally distributed, so we could not use Pearson's correlations.

autocorrelation and heteroskedasticity consistent, they are robust in terms of temporal dependence (see table 3).

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Firm innovation capacity

The standard regression approach is not appropriate when the distribution of the dependent variable exhibits censoring at zero, as happens in *innovation capacity* and *radical innovation capacity*. In a dynamic random effect framework, the Tobit model is applied for each one (see table 4).

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We have run four separate regressions for each dependent variable (*sales growth*, *employment growth*, *radical innovation* and *innovation*), to test the stability of the results. The first regression is the baseline model that only includes the control variables (Models I, V, IX and XIII). The second regression displays the independent variables without interaction variables (Models II, VI, X and XIV). The third regression is estimated with all the variables (Models III, VII, XI and XV) and finally the four regression is estimated with all the variables (Models IV, VIII, XII and XVI) but without quadratic effects for the variables age and maturity. We obtain stable results through each dependent variable.

For each firm performance measurement, there is a negative relationship between greater combined maturity and park location with greater firm performance, which supports Hypothesis 1. Likewise, the parameter estimate for the interaction *belonging to a park*firm age* was negative and significant³, following the logic of hypothesis 2.

The substantive results of the independent variables were identical to the different firm performance measurements, with the exception of *industry maturity*. A positive relationship between being located in a park and firm performance has been widely supported. We also found that maturity has a non-linear effect for firm growth, suggesting that less mature and more mature industries outperform in sales and employees those middle-mature industries. However, a greater level of maturity for the firm's economic activity resulted in worse firm innovation performance, and this negative effect is exponential. Finally, there is a quadratic relationship between firm age and firm performance, that is, younger and older firms

³ Model XV was nearly significant

outperform in firm performance (growth and innovation) those middle-aged firms (Almus and Nerlinger 1999).

With respect to the control variables, the variable innovation intensity, *innovation expenditures*, presents a different effect depending on the dependent variable: negative and significant with sales growth, positive and significant with employment growth, and not significant with both measures of innovation performance. Finally, greater firm size resulted in better firm performance on all measurements.

3.4. Discussion

Considering that the main objective of this paper is to evaluate the benefits of the park according to changes in the industry and the firm, we have evaluated them in terms of consequences to both firm growth and innovative capacity. In this sense, we firstly observed that belonging to a park has a positive effect on a firm's growth and innovation capacity, so these locations confer some advantage related to shared equipment, services, human resources, higher reputation and knowledge spillovers. Firms located inside a park can enjoy of human and technological capital, as well as relational capital created by local interactions with other firms and institutions. These results are coherent with previous studies (Lindelöf and Löfsten 2003; Dettwiler et al. 2006) although there is a lack of consensus about the effect of the park on a firm's profitability. The fact that we observe the same positive effect for variables related to growth and innovation is interesting as previous studies have pointed out that part of the lack of consensus is related to measurement differences (Siegel et al. 2003a; Barbero et al. 2012).

Maturity has a negative effect on firm growth and innovation because as the industry matures, the opportunities to increase sales and innovate tend to fall. Competitive intensity tends to increase and firms find it more difficult to introduce new products or processes that help them stand out against their rivals (Audretsch and Feldman 1996). Moreover, we observe that firms in the middle stages of maturity are the less likely to growth. Maturity has also significant quadratic relationships with innovation, being both coefficients of maturity and its square negatives. This finding suggests that, while firms' innovation capacity decreases with maturity, it does so at a faster rate during the later maturity years.

Belonging to the park does not attenuate this problem; on the contrary, it accentuates it. Proximity to other firms that might be direct rivals makes it easier for ideas and experience to be transmitted from one firm to other, putting the firm at risk of losing its advantage. The

opposite happens when the industry is growing as firms can obtain resources from the park and also benefit from the access to tacit knowledge exchange, so important in the first stages of the life cycle.

In their study on Ontario's winery industry, (Wang et al. 2013) found that concentrated spaces are more attractive to new investments in the growth stage of the industry. On the contrary, locations in concentrated spaces only prevent mature industry firms from disappearing. In his study on the semiconductor and pharmaceutical industries (Kukalis 2010) also confirmed that isolated firms outperformed clustered firms in the late stages of the industry life cycle.

The interaction term between age and park also has a negative effect on performance. Young firms, as expected, benefit most from local spillovers provided by the park, improving their capacity to grow and innovate. Abundant research has tested the park's benefit for young firms, particularly new technology based firms (Colombo and Delmastro 2002; Ferguson and Olofsson 2004; Dettwiler et al. 2006). Compared to mature firms, young firms have both more interest in learning from co-located firms and more flexibility to incorporate changes and new ideas into their existing assets and routines. Likewise some authors have pointed out that age of the firm may have a positive effect on innovation because older firms have accumulated experience and developed internal routines and procedures that make them more efficient and more able to include new versions of products or services (Sorensen and Stuart 2000). Nevertheless, empirical evidence tends to indicate that older firms may not benefit from the park that much, mainly due to rigidities and past investments. In other words, within a certain time inside the park, the benefits of this location become negligible. Previous empirical evidence on the relationship between age and innovation was not clearly stated and, in a certain way, this debate can be extended to the benefits of new knowledge on older firms (Sorensen and Stuart 2000).

4. CONCLUSIONS AND FUTURE RESEARCH LINES

The results of this research demonstrate that the temporal dynamics underlying science and technology parks contribute to a better understanding of their benefits over time. These results can help managers decide whether to locate inside or outside the park. Although the park might be considered a source of valuable resources and knowledge for firms, the opportunities to incorporate them into existing activities depend on the novelty of new knowledge in the industry. As the industry matures, the knowledge becomes highly codified and standardized and proximity to new sources of ideas becomes less relevant. In a similar vein, older firms

1 find it difficult to incorporate new knowledge into their existing routines and procedures. As a
2 consequence, firms in mature industries or old ones should carefully consider the benefits that
3 these locations can imply.
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6 These results also have interesting policy implications, related to existing policies established
7 in many parks. Some parks do not set a limit to how long a firm stays in the park, so they can
8 stay as long as they consider useful. The logic of these policies lies in the idea that firms need
9 support to overcome their initial liabilities, but once they are established they should be able
10 to develop independently. In this research, we find similar conclusions although from another
11 point of view: there are few benefits to be gleaned after a certain period. As firms spend more
12 time in the park, the industry evolves and the firms age, so staying too long in the park does
13 not seem to help too much in terms of increasing a firm's growth and local innovation.
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17 Research results and its own limitations can also be considered as opportunities for new
18 research. First, in this study we have assumed that firms inside the park might benefit from
19 the same knowledge spillovers, but this is not necessarily the case. Each firm establishes a
20 different network of relationships providing a specific knowledge combination that can affect
21 their capacity to grow or innovate. In this research, we did not collect these detailed data, but
22 following Social Network Analysis (Ter Wal and Boschma 2009), an interesting research line
23 could be developed based on measuring these knowledge flows inside the park.
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27 In a similar vein, it would be interesting to evaluate the kind of relationships that firms
28 develop locally and if there is any change over time. Some studies point out that firms tend to
29 change relationships from informal to more formal but there are no conclusive results
30 (Audretsch 1998; Eisingerich et al. 2010). Moreover, it could be stated that the kind of
31 relationships that firms develop affect the extent to which they can exploit local externalities.
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35 We have undertaken the study comparing on-park and off-park firms across time, but it would
36 be interesting to evaluate other agglomerated spaces, such as industrial districts, that share
37 some of the benefits already identified in parks. Firms inside industrial districts tend to share
38 values, norms and experiences, making the sharing of tacit knowledge even easier, but also
39 increasing the risk of leaking codified knowledge in mature stages of the industry. Future
40 research could evaluate how this fact affects the relationships between life cycle and location
41 benefits.
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45 Finally, as a future research line we propose studying the age of the firm in a nonlinear way,
46 as we have already assumed in this study. Firms can grow very differently and age does not
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1 imply the same evolution. Previous studies have analyzed this evolution inside parks
2 (McAdam and McAdam 2008) pointing out how, depending on the stage, firms need different
3 kinds of resources to grow.
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FIGURES AND TABLES

Figure 1: Pitec database, 2007-2012

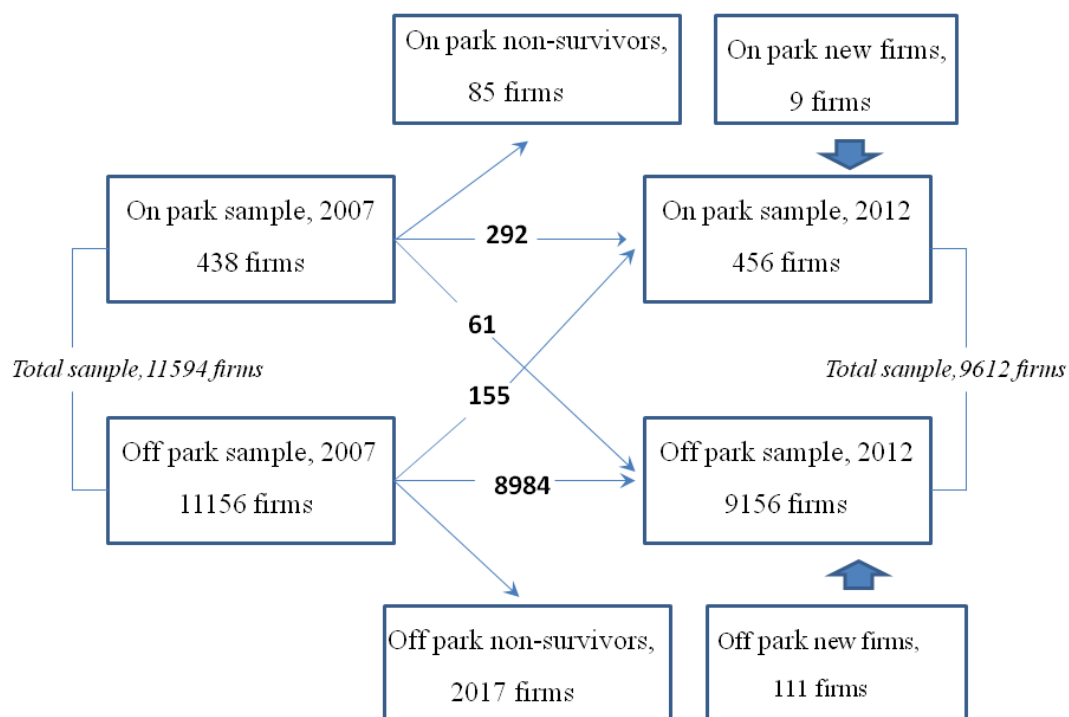


Table 1. Economic activity maturity calculation

	Classification of Economic Activities	α_0	α_1	α_2	R^2	M_{jt}
1	Mining, energy, water and waste activities	18.336***	0.101	-0.005	0.349	-0.066
2	Food, beverage and tobacco processing	18.058***	0.07***	-0.003**	0.905	-0.049
3	Textile, clothing, leather and footwear	16.949***	-0.009	-0.004*	0.932	0.037
4	Wood and cork, paper and graphic arts	18.454***	0.008	-0.015	0.772	0.097
5	Chemicals and pharmaceuticals	17.378***	0.068**	-0.003	0.846	-0.047
6	Rubber / plastics	16.575***	0.076*	-0.006*	0.384	-0.034
7	Miscellaneous non-metal mineral products	16.847***	0.209***	-0.022***	0.883	-0.055
8	Manufacture of fabricated metal products, except machinery and equipment	17.547***	0.181**	-0.014***	0.578	-0.083
9	Electronic, electrical and optical equipment	16.798***	0.152***	-0.014***	0.774	-0.054
10	Machinery and equipment	16.915***	0.105	-0.013*	0.624	-0.014
11	Transport equipment	17.783***	0.091***	-0.008***	0.599	-0.035
12	Miscellaneous manufacturing industries, repair and installation of machinery and equipment	16.218***	0.144***	-0.011***	0.803	-0.067
13	Transportation and storage	17.891***	0.132***	-0.008***	0.925	-0.076
14	Hospitality	17.793***	0.098**	-0.009**	0.522	-0.035
15	Information and communication	17.61***	0.136***	-0.008***	0.956	-0.08
16	Real estate services	18.321***	0.023	-0.017	0.629	0.096
17	Professional, scientific and technical activities	17.224***	0.208***	-0.011***	0.952	-0.131
18	Administrative and support service activities	16.800***	0.212***	-0.01**	0.929	-0.142
19	Arts, entertainment and recreation activities	16.647***	0.076	0.005	0.014	-0.111
20	Other services	15.237***	0.036	-0.001	0.058	-0.029

M_{jt} defined in Eq (1) is evaluated at mean value of t

***, **, * Coefficient significant at the 1, 5 and 10 percent level, respectively

Table 2. Spearman's correlations

Variables	1	2	3	4	5	6	7	8	9
1. Sales growth	1								
2. Employment growth	0.382*	1							
3. Radical innovation capacity	0.048*	0.060*	1						
4. Innovation capacity	0.042*	0.052*	0.668*	1					
5. Innovation expenditures	0.063*	0.104*	0.418*	0.495*	1				
6. Firm size	0.079*	0.085*	0.016*	0.002	-0.089	1			
7. Belonging to the park	0.037*	0.061*	0.095*	0.091*	0.207*	-0.032*	1		
8. Industry maturity	-0.086*	-0.093*	-0.027*	0.005	-0.089*	-0.044*	-0.094*	1	
9. Firm age	-0.052*	-0.066*	-0.029*	-0.015*	-0.106*	0.316*	-0.151*	0.262*	1
Mean	-0.023	-0.020	8.378	19.348	0.322	4.075	0.045	-0.058	26.049
Std. Dev.	0.230	0.149	21.355	33.220	20.342	1.733	0.208	0.064	20.249

* $p < 0.01$

Table 3: Random effects Panel Data Regressions. Dependent variables: sales growth and employment growth

	Sales growth					Employment Growth		
	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII	Model VIII
Constant	-0.075*** (0.003)	-0.048*** (0.004)	-0.049*** (0.004)	-0.056*** (0.004)	-0.090*** (0.002)	-0.058*** (0.003)	-0.059*** (0.003)	-0.065*** (0.003)
Innovation expenditures	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Firm size	0.013 (0.001)	0.010*** (0.001)	0.010*** (0.001)	0.009*** (0.001)	0.017*** (0.001)	0.014*** (0.001)	0.014*** (0.001)	0.014*** (0.001)
Belonging to a park		0.021*** (0.006)	0.024* (0.015)	0.029* (0.015)		0.019*** (0.003)	0.021** (0.008)	0.025*** (0.008)
Industry maturity		-0.083*** (0.023)	-0.076*** (0.023)	-0.133*** (0.018)		-0.040** (0.018)	-0.034* (0.018)	-0.070*** (0.013)
Industry maturity ²		0.587*** (0.173)	0.552*** (0.173)			0.346*** (0.129)	0.320** (0.128)	
Firm age		-0.001*** (0.000)	-0.001*** (0.000)	-0.000*** (0.000)		-0.001*** (0.000)	-0.001*** (0.000)	-0.000*** (0.000)
Firm age ²		0.000*** (0.000)	0.000*** (0.000)			0.000*** (0.000)	0.000*** (0.000)	
Belonging to a park*Ind. maturity			0.185* (0.107)	-0.199* (0.107)			-0.150*** (0.051)	-0.157*** (0.052)
Belonging to a park*Firm age			-0.001** (0.000)	-0.001*** (0.000)			-0.001*** (0.000)	-0.001*** (0.000)
Fit								
Prob > χ^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R-Squared	0.014	0.018	0.019	0.0177	0.030	0.030	0.030	0.0285

***, **, * Coefficient significant at the 1, 5 and 10 percent level, respectively

Table 4: Random-effects tobit models. Dependent variables: Newmer and new products

	Radical innovation capacity				Innovation capacity			
	Model IX	Model X	Model XI	Model XII	Model XIII	Model XIV	Model XV	Model XVI
Constant	-53.892*** (1.673)	-41.839*** (2.539)	-42.115*** (2.547)	-51.113*** (2.177)	-27.529*** (1.756)	-13.117*** (2.789)	-13.416*** (2.798)	-22.409*** (2.343)
Innovation expenditures	0.002 (0.008)	0.003 (0.009)	0.003 (0.009)	0.004 (0.009)	0.059 (0.046)	0.038 (0.029)	0.038 (0.029)	0.039 (0.031)
Firm size	1.135*** (0.346)	1.700*** (0.451)	1.749*** (0.451)	1.485*** (0.449)	1.700*** (0.380)	1.397*** (0.499)	1.446*** (0.498)	1.217** (0.496)
Belonging to a park		11.143*** (2.217)	10.352*** (4.880)	13.358*** (4.884)		13.141*** (2.549)	11.344** (5.649)	14.638*** (5.655)
Industry maturity		-115.708*** (9.698)	-112.998*** (9.740)	-86.953*** (7.097)		-160.879*** (10.147)	-157.866*** (10.199)	-115.813*** (7.694)
Industry maturity ²		-315.996*** (59.260)	-339.138*** (59.683)			-481.433*** (62.040)	-501.392*** (62.341)	
Firm age		-0.715*** (0.109)	-0.689*** (0.109)	-0.077* (0.045)		-0.672*** (0.123)	-0.647*** (0.123)	-0.065 (0.051)
Firm age ²		0.007*** (0.001)	0.007*** (0.001)			0.007*** (0.001)	0.006*** (0.001)	
Belonging to a park*Ind. maturity			-74.560** (27.128)	-60.876** (26.899)			-83.579*** (31.101)	-63.917** (30.939)
Belonging to a park*Firm age			-0.303* (0.175)	-0.361** (0.176)			-0.283 (0.205)	-0.331* (0.206)
Fit								
Prob > χ^2	0.005	0.000	0.000	0.000		0.000	0.000	0.000

***, **, * Coefficient significant at the 1, 5 and 10 percent level, respectively

Answer to reviewers

We would thank both reviewers' comments that had made to the previous version of the work, together with the possibility it offers us to develop a new version of the document in which we have tried to consider your suggestions. Undoubtedly, these comments are of great interest and contributed to clarify and improve certain aspects of work. Throughout this document we try to provide a response explanation of all the modification included in the new version of the paper. In order to facilitate the monitoring, we will maintain the same order adopted in the reviewers' letter.

Reviewer #1:

Introduction

Second and third paragraphs. Authors should briefly suggest why some parks fail in promoting interactions or transfers of knowledge as a suitable starting point to introduce the dynamic approach. Regarding the main aspects determining the benefits accrued by park's firms, authors relegate contextual and structural factors of the location (e.g heterogeneity, the role of the park leader/orchestrator, among others).

We have revisited the structure of the introduction following your suggestions and trying to explained the main problems of parks in promoting exchanges to the first paragraph of the introduction (page 2, paragraph, 1) and in the first section of the theoretical framework (page 4, paragraph, 2).

Fifth paragraphs. It seems that the evolution and the "life cycle" of the technological park falls aside of the main objectives the paper which appears strictly focused on the evolution of the firm. If so, this should be mentioned or included as a future research path.

We apologize for the misunderstanding. We have introduced more explicitly the life cycle of the industry as a main objective (page 2, second paragraph), consistent with the body of the paper.

Please include the organisation in charge of implementing the Spanish Technological Innovation Panel. Is it an open database?

The Technological Innovation Panel (PITEC)¹ is an annual survey of the innovation activities of Spanish firms set up by the Spanish Statistical Office (INE), the Spanish Foundation for Science and Technology (FECYT), and the Cotec Foundation for Technological Innovation with the objective of providing data from the Community Innovation Survey (CIS).

Following the referee's suggestion, we have added this information in the first paragraph of the methodology section (page 11) as a footonet: "An open database available online http://icono.fecyt.es/PITEC/Paginas/descarga_bbdd.aspx".

Theoretical framework

The initial part of the section is a little bit reiterative. Some suggestions already mentioned are repeated in this section. So, I would review both parts and clearly delineate the contents of each one.

We have streamlined and reorganized the paper to reduce this perception of being reiterative. In this new version of the paper we have changed the introduction section in order to focus on the main objectives and contributions of the paper, leaving the main advantages of the park for section 2.1. Also, in this section we deepen in the main problems faced by parks in promoting knowledge exchange (end of page 4 and page 5).

Regarding the industry life cycle and H1. Although I may share the underlying rationale supporting the Hypothesis, some relevant doubts come up:

a) In clusters, even certain doses of heterogeneity may exist, firms are relatively close in cognitive terms. However, in parks, differences between actors can be rather large leading to unsuccessful interactions or scarcely valuable knowledge sharing. So the robustness of this part of the hypotheses demands some degree of cognitive proximity within park firms. In other words, it could be just valid for some parks or subnetworks within the whole park.

Thanks for this comment. We have introduced this idea in the new version of the paper, when explaining why proximity may ease the transfer of tacit knowledge (first full paragraph, page 7) and also when dealing with the appropriability problem of explicit knowledge (end of page 7).

b) Regarding the maturity stage, I would again share your arguments if firms are systematically located in the park and evolve with the life cycle. But, your arguments weak if firms are new incumbents in advanced stages of the life cycle (e.g. a new innovative firm competing in traditional industries thanks to knowledge from University or technological centres), then the contribution of the park appears extremely relevant.

We partially agree with this comment of the reviewer. While it is true that firms can introduce incremental innovations in mature stages, our unit [o focus??? Unit suena rata] of analysis in this hypothesis is the evolution of the industry. We do not consider innovations introduced by a firm unless it implies a change in the industry in aggregated terms (such as a major disruptive innovation). In this sense, the arguments are based on changes introduced at industry level, and we have tried to clarify this point in the new version of the paper.

c) To some extent, your line of reasoning appears suitable for firms that evolve within the park, but not so much for firms that enter in advanced stages of the life cycle.

Since we assess the evolution of the industry, our arguments in this hypothesis mainly deals with changes in the industry and not the firm. For instance, tacit knowledge is most relevant in emerging industries and explicit knowledge and appropriability problems are most relevant in mature stages. Nevertheless, we agree with the reviewer that it could be that particular firms may not follow the expected life cycle and change their behavior.

Regarding the Age (H2). Again, the hypothesis appears extremely well substantiated. However, technological entrepreneurs usually exhibit solid technological capabilities, but limited managerial skills. In my view, this should be considered when building the hypotheses.

Additionally, some of the arguments about inertia and obsolescence do not exclusively apply to park's firms. Indeed, older firms may also become unresponsive to environmental changes also outside the park. I humbly think that authors should look for a more specific endorsement of their hypothesis. Perhaps, from a network perspective, older firms probably diminish interactions with smaller units located in the park due to networking cost and limited potential benefits from incoming knowledge (particularly of business and managerial nature).

We are grateful for this comment of the reviewer. First, we have introduced a reference to the necessity of considering not only technological but also managerial capabilities. In particular, we explain that the local network allows young firms to obtain technical, market based and managerial knowledge (Samarra and Biggiero, 2008) (beginning of page 10). Secondly, we have introduced the argument of older firms from the network perspective to better justify hypothesis 2 (page 10, first full paragraph).

Reference:

Samarra, A. and Biggiero, L. (2008), “Heterogeneity and specificity of inter-firm knowledge flows in innovation networks”, *Journal of Management Studies*, Vol. 45 No. 4, pp. 800–829.

Analysis

The statistical analysis appears carefully conducted and results rather robust. However, I would suggest authors to control (if possible) for alternative geographical locations such industrial clusters or districts. By doing so and considering the research gap highlighted at the very beginning of the paper, authors can undoubtedly bridge between cluster and parks literature (new research path?). Furthermore, I would like to see the results once controlled for the sector.

We agree with the referee that controlling for alternative geographical locations such industrial clusters or districts could be very interesting, but we believe this would depart substantially from our research line. We establish theoretical arguments based on parks and their unique characteristics, and not on clusters or industrial districts. Also, there would be empirical problems to undertake this research: we have longitudinal data along 6 years based on the database PITEC, and we do not know of any longitudinal database with similar data for clusters or industrial districts. In any case, we have introduced these ideas as a future research line (end of page 18).

With respect to control for the sector, we have already control it by its maturity, as done in many Industrial Organization papers (Karniouchina et al., 2013). Our original view is that controlling for the sector could be redundant, taking into account that maturity of the sector has already been included in the model.

In any case, we have followed the referee’s suggestion and we have used the OCDE classification to control the sector. The OECD classification classifies the industries into four categories based on R&D intensities as follows: high-technology industries, medium-high technology industries, medium-low technology industries and low-technology industries (see table I):

Table I: ISIC REV. 3 TECHNOLOGY INTENSITY DEFINITIONS

Classification of manufacturing industries into categories based on R&D intensities

High-technology industries Aircraft and spacecraft Pharmaceuticals Office, accounting and computing machinery Radio, TV and communications equipment Medical, precision and optical instruments	Medium-high technology industries Electrical machinery and apparatus, n.e.c. Motor vehicles, trailers and semi-trailers Chemicals excluding pharmaceuticals Railroad equipment and transport equipment, n.e.c. Machinery and equipment
Medium-low-technology industries Building and repairing of ships and boats Rubber and plastics products Coke, refined petroleum products and nuclear fuel Other non-metallic mineral products Basic metals and fabricated metal products	Low-technology industries Manufacturing, n.e.c.; Recycling Wood, pulp, paper, paper products, printing and publishing Food products, beverages and tobacco Textiles, textile products, leather and footwear

Source: OECD Directorate for Science, Technology and Industry; Economic Analysis and Statistics Division

In the table II we show the correspondences of PITEC codes (we remind the reviewer that PITEC is the survey used in this paper) with National Classification of Economic Activities 2009 and OECD classification by the National Statistics Institute. This correspondence is realized by the National Statistics Institute of Spain.

Table II: Sectors of activity

ID Pitec	Sector	CNAE2009	Classification of sectors into categories based on R&D intensities according to OECD classification
0	Agriculture, hunting, forestry and fishery	1,2,3	Low-technology industry
1	Extractive industries	5,6,7,8,9	Low-technology industry
2	Petroleum industries	19	Medium-low technology industry
3	Food, beverages and tobacco	10,11,12	Low-technology industry
4	Textile industry	13	Low-technology industry
5	Ready-to-wear Clothes	14	Low-technology industry
6	Leather and footwear	15	Low-technology industry
7	Wood and cork	16	Low-technology industry
8	Pulp and paper	17	Low-technology industry
9	Printing and graphic arts	18	Low-technology industry
10	Chemistry	20	Medium-high technology industry
11	Pharmacy	21	High-technology industry
12	Rubber and Plastics Industry	22	Medium-high technology industry
13	Non-metallic mineral products manufacturing	23	Medium-high technology industry
14	Metallurgical Sector	24	Medium-high technology industry
15	Metal manufacturing sector	25	Medium-high technology industry
16	Computer, electronic and optical products	26	High-technology industry
17	Material and equipment industry	27	Medium-high technology industry
18	Machinery and Equipment Manufacturing Industry	28	Medium-high technology industry
19	Motor vehicle sector	29	Medium-high technology industry
20	Shipbuilding sector	301	Medium-high technology industry
21	Construction Aeronautics and Space	303	High-technology industry
22	Other transportation equipment	30	Medium-high technology industry
23	Furniture	31	Low-technology industry
24	Other manufacturing activities sector	32	Medium-high technology industry
25	Repair and installation of machinery and	33	Medium-low technology industry

	equipment		
26	Energy and water	35,36	Medium-low technology industry
27	Solid waste management and soil decontamination	37,38,39	Medium-low technology industry
28	Building sector	41,42,43	Medium-low technology industry
29	Trade sector	45,46,47	Medium-low technology industry
30	Transport and storage sector	49,50,51,52,53	Medium-low technology industry
31	Hospitality industry	55,56	Medium-low technology industry
32	Telecommunications industry	61	Medium-low technology industry
33	Programming Consulting and Other Activities	62	Medium-low technology industry
34	Other Information Services	58,59,60,63	High-technology industry
35	Financial and insurance sector	64,65,66	Medium-low technology industry
36	Real state activities	68	Medium-low technology industry
37	R&D activities	72	High-technology industry
38	Other activities	69,70,71,73,74,75	Medium- low technology industry
39	Administrative Activities and Auxiliary Services sector	77,78,79,20,81,82	Medium- low technology industry
40	Education (Exc.)	85	Medium- low technology industry
41	Health and social work activities	86,87,88	Medium- low technology industry
42	Arts, entertainment and recreation activities	90,91,92,93	Medium- low technology industry
43	Other services	95,96	Medium- low technology industry

Source: The National Statistics Institute

We create four variables to control the sector:

High-technology industry: 1 if the firm belongs to high-technology industry; 0 otherwise

Medium-low technology industry: 1 if the firm belongs to medium-low technology industry; 0 otherwise

Medium-high technology industry: 1 if the firm belongs to medium-high technology industry; 0 otherwise

Low-technology industry: 1 if the firm belongs to low-technology industry; 0 otherwise

And thus added three dummies variables in the model, high-technology industry, medium-high technology industry and medium-low technology industry (they are interpreted with respect to the fourth implied on for the reference group, i.e., low-technology industry).

However, when we estimate the models, they are omitted due to collinearity. In the following table we some a pair of examples:

Table III

	Radical innovation capacity	Innovation capacity
Constant	-42.114*** (2.547)	-13.416*** (2.798)
Innovation expenditures	0.003 (0.009)	0.038 (0.029)
Firm size	1.749*** (0.451)	1.446*** (0.498)
Belonging to a park	10.352** (4.880)	11.344 (5.650)**
Industry maturity	-112.998***	-157.866***

	(9.740)	(10.199)
Industry maturity ²	-339.138***	-501.392***
	(59.683)	(62.342)
Firm age	-0.689***	-0.647***
	(0.109)	(0.123)
Firm age ²	0.007***	0.006***
	(0.001)	(0.001)
Belonging to a park*Ind. maturity	-74.560***	-83.579***
	(27.128)	(31.101)
Belonging to a park*Firm age	-0.303*	-0.283
	(0.175)	(0.205)
Mediumlowtechnology	0	0
	(omitted)	(omitted)
Mediumhightechnology	0	0
	(omitted)	(omitted)
Hightechnology	0	0
	(omitted)	(omitted)
Fit		
Prob > χ^2	0.000	0.000

Therefore, we concluded that adding the proposed controls for sector is not necessary.

Reference:

Karniouchina, E. V, Carson, S.J., Short, J.C. and Jr, D.J.K. (2013), “Research notes and commentaries extending the firm vs. Industry debate: does industry life cycle stage matter?”, Strategic Management Journal, Vol. 34 No. February, pp. 1010–1018.

Discussion

In my view, author should clearly highlight the main novelties of the paper since the beginning of this section, relegate endorsement of previous findings. Additionally, some previous literature included in this section needs to be mentioned early (introduction or theoretical framework).

We have included some comments about previous literature used in the theoretical framework while we have also tried to highlight the contribution of the paper (mainly first paragraph of the discussion, page 16).

Reviewer #2: I have enjoyed the reading of this paper and I consider the objectives addressed valuables. The dynamic analysis of the advantages derived from park membership is an interesting question and the dataset used to test these issues are appropriate.

We do really thank your comments and we have to answer them in the following lines.

*Some guidelines to improve the manuscript are provided as follows:
Major comments*

1. Introductory section. The introduction is somewhat long and I think it could be improved by focusing on (a) detailing the research gap; (b) discussing the research question and its importance; (c) describing the work done; and (d) presenting the contribution. No more than 4 to 5 paragraphs are usually necessary to accomplish a brief and appealing introductory

section. The main arguments are there, my suggestion is just a matter of better overall organization of those arguments.

We have reduced and focused the introduction following your suggestions. In particular:

- (a) Detailing the research gap. Please refer to the first paragraph of the new version.
- (b) Discussing the research question and its importance. Second and third paragraph deal, respectively, with the main objective of the paper and its relevance.
- (c) Describing the work done; and (d) Presenting the contribution. Fourth and fifth paragraphs deal with the contributions of the paper connecting them with the work done previously and how we try to improve it.

2. Section 2.1 could benefit from classifying on-park advantages from an intellectual capital perspective revolving around physical, technological, human and relational capital (see Journal of Intellectual Capital Special Issue on Science Parks and Incubators, 2014, 15(4)).

Thanks for this suggestion. The new version of this section has much improved thanks to this comment. We have introduced the intellectual capital perspective, playing more attention to the relational capital as this is the main advantage of parks (page 4, second paragraph).

3. In sections 2.2 and 3.2, the major arguments are linked to the nature of knowledge (tacit vs. explicit), similarity of firms (heterogeneous vs. homogeneous) and organizational change (adaptive vs. inert). Firstly, I recommend the authors to go deeper into these interesting arguments. Secondly, make explicit the theories which are based on. For example, the analysis of how knowledge varies across the industry life cycle is based in the knowledge-based of the firm (KBV), whereas the arguments as regards firms' heterogeneity derive from the resource-based view of the firm (RBV). I would suggest the authors to consider the role of organizational learning (explorative vs. exploitative) in order to address more explicitly evolutionary issues and the frame the discussion of lock-in in this overarching theoretical approach. The explicit acknowledgement that a multi-theoretical perspective is adopted would make more valuable the intended contribution.

We have followed your suggestions for these sections and we do really believe that the paper has much improved. Thanks! In particular, we have introduced the following changes:

- In section 2.2. (hypothesis 1):
 - We have introduced the RBV to explain heterogeneity among firms and how firms need of resources is higher in the first stages of the industry (page 6, first full paragraph).
 - The knowledge-based-view is also introduced to explain the coordination and communication costs of knowledge (page 7, last full paragraph)
 - Organizational learning and explorative and exploitive learning differences are introduced to explain the differences in the usefulness of the park across the life cycle (page 8).
- In section 2.3. (hypothesis 2):
 - We have included the network perspective to explain how older firms may be reluctant to establish local relationships (last full paragraph of page 10).
 - We have included Nelson and Winter (1982)'s arguments to explain the higher inflexibility of older firms (end of page 10 and beginning of page 11).
- Finally, we have included as a main contribution of the paper that a multi-theoretical perspective is adopted (first full paragraph of page 3).

4. *Please justify better the hypothesis 2b. I wonder whether it could simply be eliminated.*

Following the reviewer's suggestion, we have deleted hypothesis 2b.

5. *As robustness tests, I would like to see models with squared terms for Age and Maturity (Table 3 and 4). Please, do not change Tables 3 and 4 in the case the results proved to be non-significant. A brief mention would be enough, but I would like to see the output of these models for review purposes.*

Following reviewer's suggestion, we have run the models including age and maturity in square terms. As the reviewer suggest, they are significant and we have included them in the new version of the paper (pages 30 and 31, tables 3 and 4).

Minor comments

6. *The figure 1 provides clarity into important sample issues, so I congratulate the authors.*

We thank the reviewer for this comment.

7. *Please check the specification of sales growth and employment growth in section*

Following the referee's suggestion, we have checked the specification of sales growth and employment growth. In order to create our two dependent growth variables, we follow prior research in this area as we had explained in the paper (e.g., Capelleras, Rialp, & Rialp, 2014):

$$SALES\ GROWTH = \log sales_t - \log sales_{t-1}$$

$$EMPLOYMENT\ GROWTH = \log employment_t - \log employment_{t-1}$$

where $sales_t$ and $employment_t$ are the values for sales and employment at time t and $sales_{t-1}$ and $employment_{t-1}$ are the these values at time $t-1$. Thus, these variables measure a firm's sales or employment growth rate at time t with respect to time $t-1$, assuming an exponential growth trend. We have explained it a bit better in the text (end of page 12).

3.2. *Are the authors using an absolute measure of firm's growth? In that case, please provide an appropriate motivation (other than the reference to previous studies).*

We use absolute growth measures rather than relative measures because we try to evaluate annual changes in sales not conditioned by firms' size (we already control for it). Relative measures tend to ascribe higher growth to smaller firms, getting easily a high relative growth, while large firms would have more difficulties in reaching the same level of growth (Delmar, 1997; Gatrell and Reid, 2006). In our sample of firms, most of them are small and medium firm, thus, we have chosen an absolute measure (end of page 12, beginning of page 13). A reference to using absolute growth was added to the paper.

References

- Delmar, F. (1997). *Measuring growth: methodological considerations and empirical results*. In R. Donckels, & A. Miettinen (Eds.), *Entrepreneurship and SME Research: On its Way to the Next Millennium: 199-216*. Aldershot, England: Ashgate
- Gatrell, J., Reid, N. (2006). *A geographic perspective on economics, environments and ethics*. Springer, The Netherlands.

8. *The rationale behind the measure of industry maturity is not evident from the equation used to derive it. I suggest a common sense explanation to account for the mathematical specification.*

We apologize for the lack of clarity. We have extended the explanation of the measure of industry maturity in order to make it clearer and easier to understand (end of page 12).

9. *I would move the descriptive statistics to the section devoted to reporting the results. In this regard, I would like to see all the correlations, including those involving the control variables. Why do the authors measure firm size as the natural logarithm of the number of employees and then report the correlation with the following acknowledgement: "Size is without logarithmic transformation". I would suggest to report descriptives and correlations in the same way as they are used in the statistical analyses. One final question: why the Spearman coefficient instead of the Pearson coefficient? Assuming this is an intended decision, a footnote in Table 2 providing a brief motivation will be welcome.*

Following the referee's suggestion, we have moved the descriptive statistics to the section "results" (page 14).

We agree with the referee that it is interesting to show all the correlations, including those involving the control variables. In this new version, we report descriptive and correlations of all the variables involved in the same way as they are used in the statistical analysis, i.e., with logarithmic transformation for the variable size (page 28, table 1).

The Kolmogorov-Smirnov test determined that the variables were not normally distributed, so we could not use Pearson's correlations. Instead, we calculated Spearman's correlations. We have added a footnote in table 2 as referee suggests (page 14).

10. *The authors describe specifications in the operationalization section (ways of measuring the variables). In the remainder of the paper, I suggest the use of what is measured instead of how it is measured. For example, PARK is a measure of park membership; INNINT is a measure of innovation intensity. Theories are based on variables, not specific ways of measuring those variables.*

We have changed the names in order to incorporate the concept and not its operationalization. In particular:

- Sales growth and employment growth do not change
- Innovation capacity is measured by both: radical innovation capacity, which measures the fraction of a firm's turnover pertaining to products new to the market; and Innovation capacity, which is the fraction of a firm's turnover pertaining to products new to the firm or new to the market.
- Park has been renamed as belonging to a park
- Maturity is now industry maturity
- Control variables are now: firm size, firm age, and innovation expenditures

11. *In the first paragraph of section 3.4., I wonder whether the authors refer to firm's performance or firm's profitability.*

To avoid confusion we have changed the term with firm growth and innovative capacity (last paragraph on page 16).

Final comment

This paper is a robust candidate for publication in the JEEC and the changes suggested are realizable, so I look forward to receiving the revised version of the manuscript. All the best to authors.

We really appreciate this comment.