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The influence of Science and Technology Parks? characteristics on firms? innovation results

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Abstract

Science and Technology Parks (STPs) have generated a thriving debate between practitioners and policy makers on their effectiveness as instruments of innovation policy. STPs heterogeneity has been mainly disregarded in past studies. The main objective of this work is to analyze the influence of different STP characteristics on tenants' performance. Main results show that: (i) The age of the park has a non-linear effect on innovative performance. Firms located on younger and older STPs show better innovative performance. (ii) The dimension of a STP and the size of the management company positively affect the innovative performance of tenants, while the provision of services does not help firms in achieving better results and (iii) Firms in less technologically developed regions benefit more from being on-park, supporting the view of STPs as a local development policy instrument.

The influence of Science and Technology Parks' characteristics on firms' innovation results

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Abstract

Science and Technology Parks (STPs) have generated a thriving debate among academics, practitioners and policy makers on their effectiveness as instruments of innovation policy, but STPs' heterogeneity has been mainly disregarded in past studies. The aim of this work is to analyze the influence of different STP's characteristics on tenants' performance. Using data on 849 firms and 25 STPs respectively from the 2009 Community Innovation Survey for Spain and from a survey to STPs' managers we find that: (i) Firms located on younger and older STPs show better innovative performance. (ii) The dimension of a STP and the size of the management company positively affect the innovative performance of tenants, while the provision of services does not help firms in achieving better results and (iii) Firms in less

technologically developed regions benefit more from being on-park, supporting the view of STPs as a local development policy instrument.

1. Introduction

Science and Technology Parks (STPs) have drawn a notable attention between policymakers, registering a great diffusion all around the world (Wainova, 2009). STPs are policy-driven agglomerations (Huang et al., 2012) which are designed to encourage the formation and growth of on-site technology- and knowledge-based firms, and which have a management function that is actively engaged in achieving parks' goals.

In spite of their great diffusion and considerable investments, the debate regarding the effectiveness of this instrument of technology and innovation policy is still open. On the one hand some authors have argued that STPs do not have any relevant impact on firms' results as they do not succeed in encouraging the creation of synergies that could result in added value for tenants (e.g. Macdonald, 1987), questioning the STP model itself (Massey et al., 1992; Hansson et al., 2005) to such an extent that Quintas et al. (1992) talk about STPs as 'high-tech fantasies'. This view is supported by some empirical studies which do not find any significant differences between on- and off-park firms in terms of inputs of the innovative process (Westhead, 1997; and Colombo and Delmastro, 2002), output of the innovation activity (Löfsten and Lindelöf, 2002; and Colombo and Delmastro, 2002) or research productivity (Westhead, 1997).

On the other hand other authors have claimed that STPs can create a supportive environment for new knowledge- and technology-based firms, facilitating technology transfer, encouraging firms' growth, attracting firms involved in leading-edge technologies, and fostering strategic alliances and networks (Siegel et al., 2003; Hommen et al., 2006; Del Castillo Hermosa and Barroeta, 1998). Some empirical studies have shown that the on-park location creates externalities which could result in positive effect of the innovation activity of firms in terms of inputs of the innovation process (Fukugawa, 2006; Leyden et al., 2008; and Yang et al., 2009), higher research productivity (Siegel et al., 2003; and Yang et al., 2009) or higher likelihood to patent (Squicciarini, 2008, 2009).

We propose a possible explanation for reconciling these two contrasting views[1]: parks are heterogeneous. Some parks work well and manage to generate value for their tenants, while others do not. More generally, Siegel et al. (2003) have suggested that different "types" of STPs could have different impacts on their firms. Although literature on STPs is rapidly growing, to our knowledge there have been no attempts to systematically analyse which characteristics of STPs contribute to improve the performance of innovative firms. This paper is intended to fill this gap in the literature by assessing how several STP's characteristics,

[1] An alternative, complementary explanation could be that some firms benefit from being located in a STP while others do not. This issue has been recently explored by Barge-Gil et al. (2011) and Huang et al. (2012).

namely park's age, dimension, location and management affect the innovation performances of tenants.

To this end we have used two main data sources: the 2009 Community Innovation Survey (CIS) for Spain (available since 2011) and the Survey 2009 on the Characteristics and Results of Science and Technology Parks, an internal survey that the former Department of Science and Innovation of the Spanish government yearly supplied to Spanish STPs since 2008.

The rest of the paper is organised as follows: the next section reviews existing literature. The third section presents the data, the methodology followed and variables used. Empirical results are presented in the following section and discussed in section 5. In the last section the implications of the study are underlined and directions for further research provided.

2. Review of literature

As stated in the previous section, the analysis of the impacts that parks' heterogeneity has on innovative performance of firms represents a novelty in the literature on STPs. We have selected four different characteristics to analyze: the age and size of the park (which have traditionally been considered as factors related to organizational performance in different disciplines, e.g. Stinchcombe, 1965; Blau, 1970; Evans, 1987); the location of the park, which seems particular important, considering that STPs are geographically bounded instruments of technology and innovation policy and the management of the park, whose importance has been suggested in previous studies on STPs (e.g. Westhead and Batstone, 1999; Löfsten and Lindelöf, 2002)[2]. In what follows we discuss the potential influence of these STP characteristics on firm performance according to previous literature on STPs and, more generally, on agglomerations. As it will be shown, opposite arguments usually exist so that no clear hypotheses can be formulated. On the contrary, we find contradictory views that demand for the development of empirical evidence.

2.1. Effects of park's age

Many studies have analysed the relation between firms' age and innovative behaviour (see for instance Huergo and Jaumandreu, 2004), but surprisingly the impact that the age of the park has on firms' result has been mainly disregarded in previous studies on STPs, despite the common belief that the effect of agglomerations on firm innovation may vary over their life cycle (Pouder and St. John, 1996; Bresnahan et al, 2001).

[2] It should be also noted that the choice of the specific independent variables had to fulfil the requirement of a significant variability within our sample and thus not all the sources of potential heterogeneity could be included. For example the presence of a business incubator within a STP is considered by some authors (e.g. Colombo and Delmastro, 2002) a critical success factor for STPs; but this feature does not represent a source of heterogeneity in our sample because all the parks had at least one business incubator on-park. Similar considerations can be made for main industrial sectors of tenants (specialised versus non-specialised STP).

On the one hand, there are arguments supporting a positive effect of STP's age upon firm innovation performance. First, literature on agglomeration suggests that one of the main benefits of agglomerations lies in facilitating links with other organizations (Hervas-Oliver and Albors-Garrigos, 2009). These links generate better results as their duration increases (Izushi, 2003; Barge-Gil and Modrego, 2011) because repeated interactions reduce the cost of each future interaction by generating routines (Dahl and Pedersen, 2004), improve users' capacity to acknowledge and explain their requirements (Lambrecht and Pirnay, 2005) and contribute to generate mutual trust (Mayer et al., 1995) reducing the risk of dishonest behaviour (Narula and Hagedoorn, 1999). Second, according to literature on organizational learning, older organizations are more likely to employ accumulated knowledge and turn it into innovative activities and superior performances (e.g. Calantone et al., 2002; Decarolis and Deeds, 1999) so that the management function of a STP may improve its understanding of the needs of tenants (Gower et al., 1996), and consequently firms could take advantage by a more effective business support.

On the other hand, the age of the park could also have a negative repercussion on tenants' performance. There could be the risk, for older parks, of ossification of park's management routines, non-learning processes, blindness and conservatism which lead to worse performance (Durand and Coeurderoy, 2001) and would have negative repercussions on firms.

Empirical studies are scarce. Link and Scott have found a positive effect of park's age on park's total employment growth (Link and Scott, 2006), on the usefulness of the interaction with firms perceived by universities' administrators and on universities' patenting activities (Link and Scott, 2003). On the other hand, McCann and Folta (2011), who have included the age of the agglomeration as a control variable in their study on firms' performance differentials, have found that it has no effect or a negative one.

Accordingly, neither theoretical nor empirical literature provide a clear view on the effect of STP's age on tenants' innovation performance. We explore this issue empirically allowing for both positive and negative effects to coexist.

2.2 Effects of park's dimensions

The role played by dimension has been widely recognised by academic literature on agglomerations (Arthur, 1990; Beaudry and Breschi, 2003; Layson et al., 2008).

The classical argument states that the positive externalities generated by the co-location with other firms increase with the number of firms in the location (Arthur, 1990). For example, as the number of on-park firms increases, the stock of available knowledge (Beaudry and Breschi, 2003) which can cause these externalities also increases, having positive repercussion on firms' performance. Some authors have argued, however, that such positive effects only take place over a minimum critical size (Bakouros et al, 2002).

By contrast, firms within larger STPs can suffer diseconomies of agglomeration (Arthur, 1990). Congestion costs can be generated by competition both in input and output markets (Prevezer, 1997). In particular, on-park firms compete for available space (Chen and Huang, 2004) which is limited within a STP, for specialized workforce (Zucker et al., 1998) and for utility services

(Folta et al., 2006). Shaver and Flyer (2000) have suggested another possible explication for performance declining with dimension: larger agglomerations are less attractive for the most innovative firms owing to the risk of outgoing spillovers.

Empirical work is again scarce[3]. To our knowledge, only Squicciarini (2009) has analysed the influence of STP' size, finding that it positively affects tenant's patenting activity. On the other hand, some papers on agglomerations have found a positive association of dimension with some performance measures, such as probability of firm patenting (McCann and Folta, 2011) or firm growth (Beaudry or Swann, 2009). However, to our knowledge, the only paper specifically focused on analyzing the role of agglomeration's size on firms' performance is Folta et al. (2006), who have concluded that a non linear effect exists. Economies of agglomeration benefit firms in their ability to patent and to attract partners, but these effects decline and even become negative as the agglomeration gets large. In addition, firms are more likely to fail as a cluster gets larger, suggesting the existence of diseconomies of agglomerations (Folta et al., 2006).

As with age, neither theoretical nor empirical literature provide a clear view on the effect of STP's dimension on tenants' innovation performance. Discussion here has focused on the existence or not of a negative effect once the STP reach a critical dimension, while there exists some consensus on the existence of a positive effect of increasing STP dimension when STPs are small.

2.3 Effects of park's location

Location has been traditionally considered an important factor of success for firms innovation activities (McCann and Folta, 2008; Feldman and Kogler, 2010). The advantages for technology-based firms from being located in technologically developed regions have been studied almost one century ago by Marshall and can be resumed in 3 points: specialized labour, specialized inputs and knowledge spillovers (Prevezer, 1997). Although geographical proximity *per se* is neither a necessary nor a sufficient condition for knowledge spillovers (Boschma, 2005), its importance has been widely recognized in literature (see for instance Czarnitzki and Hottenrott, 2009) and a large body of literature claims that agents that are spatially close benefit from knowledge externalities (Boschma, 2005). As a consequence, it has been found that firms located in more advanced regions are more likely to be innovative (Johansson and Lööf, 2008).

These arguments may be extended to STPs. Parks located in technologically developed regions may benefit from the same location advantages through extra-park relationships and spillovers. They may even foster these advantages, constituting excellence poles (Chorda, 1996) and attracting innovative firms from elsewhere (Mello and Rocha, 2004).

But STPs can also be raised in less developed regions (Siegel et al., 2003), with the aim to compensate the lack of valuable inputs in these regions, to constitute enclaves of innovation

[3] Some authors (Quintas et al., 1992; Lee and Yang, 2000; Colombo and Delmastro, 2002; Kihlgren, 2003; Chen and Huang, 2004; Chan and Lau, 2005; Hu, 2007) have proxied the dimension of STPs using the number of firms, but they used this data only for descriptive purposes.

(Felsenstein, 1994) and to improve the overall image of the region (Sternberg, 2004; Del Del Castillo Hermosa and Barroeta, 1998). That is, they may create a technologically developed space in a lagging region. In addition, when competition is mainly local, firms located in STPs may gain greater advantage over their competitors in the region. This would not happen in more advanced areas where STP's effects could be rather limited as firms can find favourable framework conditions elsewhere (Sternberg, 2004).

The regional context has been explicitly taken into account in few empirical studies. Link and Scott (2005; 2006) have used macroregional dummies and have not found any significant effect of STP's location on performance. Fukugawa (2006) has used the number of universities and public research institutes in the region to control for the interregional variation in technological opportunities: his findings are somewhat contradictory[4].

Again a clear indication of the influence of the regional context upon STPs results cannot be drawn from existing studies. The debate regarding whether STPs work better acting as innovation enclaves in less developed regions or as excellence centres in advance ones is still open.

2.4 Effects of management's characteristics

The official definition of STPs given by the International Association of Science Parks (IASP, 2002) makes reference to the management function of STPs. This feature is one of the main differences between STPs and other agglomerations. It has been argued that the existence of a formal integrated management structure gives a more secure basis for firms' long-term development (Westhead and Batstone, 1999). Cabral (1998) has stated that a strong managerial team for the parks, with established or recognized expertise, is a characteristic shared by all successful parks, and Colombo and Delmastro (2002) have recognised the importance of the internal organization, stating that is should be lean and agile. Firms, specially the youngest, often suffer several constraints that make it difficult to reach their economic potential (Monck et al, 1988); these include management capacity, finance and weakness in sales and marketing (Storey and Tether, 1998a). The common view is that STPs' on-site management can be determinant in building that supportive environment that helps firms to overcome these constraints (Löfsten and Lindelöf, 2002) by providing business advice and services related to financial and marketing support to firms (Storey and Tether, 1998b; Heydebreck et al., 2000) through its management team (Westhead and Batstone, 1998). Some authors have criticised STPs for not providing such services, to such an extent they called them "firm hotel" (Löfsten and Lindelöf, 2002).

On the other hand, some authors believe that the added value of an on-park location does not come from the active hands-on support given by the park's management. According to some studies based on surveys to tenants firms, managers choose the on-park location mainly for

[4] He has found that firms located in STPs in regions with more universities and public research institutes were less likely to develop regional links with these organizations but, however, they were more likely to develop joint research with universities and public research institutes outside the region. The author does not provide explanations for this finding.

the prestige and image of the site, an easier access to universities/research centres facilities and the prestige of being linked to them (Monck et al., 1988; Westhead and Batstone, 1998). These features do not need a particularly active park management. In addition, as tenant organizations can, to a certain extent, be considered as captive customers, the service could be of lower quality (Rienzner and Testa, 2003).

In this paper, we analyse how two main characteristics of the STP management, namely the dimension of the management team and the provision of services to firms, influence innovation performance.

3. Data, methodology and variables definition

3.1. Data

Multiple data sources have been employed to perform this study. We have combined data on firm level from the 2009 Spanish Community Innovation Survey (CIS), published in 2011, with data from STPs' characteristics from the Survey 2009 on the Characteristics and Results of Science and Technology Parks, an internal survey that the former Department of Science and Innovation of the Spanish government yearly supplied to Spanish STPs[5].

The CIS for Spain (published in 2011) is managed by the Spanish National Statistics Institute (INE) and has a mandatory character. It collects very detailed information on the characteristics of the innovation process of firms and, since 2007, it includes a question on the possible on-park location of the firm. In its 2009 version, 37.201 firms, representative of the Spanish business structure, had been surveyed; of them 849 firms were located on 25 STPs[6] in 12 different Spanish regions.

While previous studies have been mainly based on few parks (e.g. Yang et al. 2009; Malairaja and Zawdie, 2008; Chan et al., 2010; Bakouros et al., 2002; Felsenstein, 1994) or on a higher number of parks, but small sample of firms (e.g. Squicciarini, 2008, 2009; Fukugawa, 2006; Colombo and Delmastro 2002; Westhead, 1997; Westhead and Storey, 1995; Siegel et al., 2003; Löfsten and Lindelöf, 2002) we combine a large sample of firms and parks, allowing us to observe greater park heterogeneity and to properly control by firm characteristics using a wide set of covariates.

A further advantage of using CIS is that, being modelled upon the European Community Innovation Survey, it facilitates comparisons with other studies using CIS in other countries.

3.2. Methodology

The model we use to assess the effect that STPs' characteristics have on innovation performance of firms can be synthesized by the equation:

[5] Although the central government in not directly involved in any STP's initiative, this survey has acquired a mandatory nature in order to have access to governmental funding for STPs. In very few cases, the data were completed through phone contact with park managers.

[6] We have considered within the STP's sample only those STPs that were *full members* of the Association of Science and Technology Parks of Spain (APTE) at least two years in advance (2007).

$$Y = \alpha + \beta\ \text{STP's}_{\text{Characteristics}} + \gamma\ \text{Controls} + \varepsilon \qquad (1)$$

The model has been estimated using OLS regression with controls and clustering standard errors by park[7]. We test the robustness of results to different definitions of the dependent variable and some of the independent variables. We estimate this model for the sample of firms located in STPs alone as, obviously, we cannot observe STP's characteristics of firms outside STPs.

3.3 Variables definition

Each component of the equation (1) is explained hereafter.

3.3.1 Dependent variable - lnewmerl

We measure the innovation performance of on-park firms using the amount of sales per employee registered in 2009 from new to the market products introduced in the last two years (2007-2009). This data is available for each firm as it is one of the questions of the survey. This indicator has been often used in recent studies on innovation (for a review see for instance Vásquez-Urriago et al., 2011) as it is argued to overcome the typical problems of others indicators such as patents, R&D expense or number of innovations (Smith, 2006).

Operationally the dependent variable *lnewmerl* is the logarithm of the sales obtained from new to the market product/service per employee.

3.3.2 Independent variables (Science and Technology Parks' characteristics)

STPs' characteristics included in our model are summarized in Table 1 and explained in this section.

TABLE 1 APPROXIMATELY HERE

The age of the STP (*age*, number of years since the establishment of the park) has been used together with its quadratic form (*ageq*) to explore the existence of non linear effects.

lnfirms is the log of the number of tenants of the park at the end of the previous year (2008) and proxies the dimension of the park. In addition, we test the robustness of results to the utilization of the geographical extension of the park (measured in squared meters) as a different indicator of the park's size. We also explore the existence of non linear effects.

To measure the level of technological development of the environment surrounding the park, we aim for an indicator related with innovation or R&D with a high geographical disaggregation level. A suitable indicator would have been the provincial R&D expenditure over GDP. Given the unavailability of this indicator we have opted for using the number of

[7] We also have estimated Tobit models. Results are very similar. We decided to present OLS estimation because they provide direct and constant marginal effects, allowing for easier comparison across models. Results of Tobit models are provided in appendix.

patent application per million inhabitants[8] in the province where the park is located, which has been drawn from the 2009 official statistics of the Spanish Office of Patents and Trademarks[9]. We are aware of the problems in using patents as indicators of innovation activity (Griliches, 1998) so that robustness checks have been carried out with different variables as proxies of the level of technological development of the environment: the Gross Domestic Product per capita of the province where the park is located (*provGDPpp*); the number of patent application per million inhabitants on a regional level (*lpatinhabregion*, log) and the regional R&D effort (*reg_r&d*), measured by the regional total internal R&D expenditure[10] over GDP.

The independent variables related with the characteristics of the management of the park are: a) *lstaffr*, the number of full-time equivalent employees in the park's management company per 100 tenants (log); b) *international*, a dummy variable which takes the value 1 if the park's management provides services to foster internationalization of its tenants, 0 otherwise; c) *consult*, a dummy variable which takes the value 1 if the park management provides legal, commercial and/or fiscal issues consulting services to its tenants, 0 otherwise.

3.3.3 Definition of covariates

The good choice of covariates is essential to perform an effective multiple regression analyses as it allows us to explicitly control for those factors that simultaneously affect the dependent variable and the variables of interest, so that their effect can be interpreted as *ceteris paribus*.

Following previous studies that have used the CIS (for a review see Vásquez-Urriago et al., 2011), we can use two groups of covariates as determinants of innovation: general firms' characteristics (i.e. total turnover, exports, industrial sector, firm's age) and more innovation-specific firms' characteristics (i.e. innovation effort and perceived obstacles to innovate).

The list of covariates used in this paper is shown in Table 2.

TABLE 2 APPROXIMATELY HERE

We use lags for turnover, exports and innovation effort (they refer to 2007 figures) to avoid simultaneity problems between covariates and the dependent variable.

Table 3 presents descriptive statistics of the variables used in our models for the 849 on-park firms in our sample.

TABLE 3 APPROXIMATELY HERE

4. Results

[8] The number of inhabitants in the province has been obtained by the official INE population census.

[9] The Spanish Office of Patents and Trademarks is the public body in charge of patents and trademarks application and registration in Spain.

[10] Regional R&D internal expenditure has been obtained by the "2008 R+D Statistics" of the National Statistics Institute.

4.1 Main results

Main results are provided in Table 4. First column shows results without taking into account STP's characteristics as a baseline for comparison. We see that our results agree with previous literature on the large importance of firm's innovation effort (Czarnitzki and Hottenrott, 2009; Frenz and Ietto-Gillies, 2009 and Tsai, 2009) and firm's age (Czarnitzki and Hottenrott, 2009) as well as on the insignificant influence of industry when other factors are accounted for (Frenz and Ietto-Gillies, 2009 and Faems et al., 2005). In addition, no significant effect is found for size, nor for exports and obstacles.

TABLE 4 APPROXIMATELY HERE

Second column shows that STP's characteristics are very important for explaining firms' sales from new products. Main results are explained below.

First, STP's age shows a U-shaped relationship with performance. Firms in younger and older STPs perform better than firms in middle-aged STPs, with the minimum point found at around 18 years. We interpret this two-faced result in the following way: on the one hand, it agrees with those arguing that older STPs perform better due to the accumulation of knowledge and of common experience of interactions. Such a process takes quite a long time and account for the upward slope in the U-curve. On the other hand, we have a downward slope when STPs grow towards middle-age. We speculate that this result may reflect the existence of a short term impact of being located in a STP. This impact exists for a variety of reasons probably more related to marketing than to innovation. For example, reputational issues or visibility allow firms to gain new customers just for being located in a STP. This effect vanishes with time and it takes years for it to be replaced by the longer term effect driven by knowledge and trust accumulation.

Second, firms in larger STPs perform better. When squared terms are included[11], no evidence of congestion effects is found, although it should not be discarded that STPs on our sample do not reach such a large dimension to allow them to exist. We find that a 1% increase in number of firms is related to a 0.45% increase in sales of new products per employee. A different, related indicator of dimension is the geographical size of STP, as many arguments in the literature are related to geographical space. We deal with this indicator in column 3. Again, we observe a positive effect and no evidence of congestion effects. Results show that a 1% increase in STP's squared meters is related to a 0.11% increase in sales of new products per employee.

Third, we analyse STP's management. We find that the larger the management entity, the better the results by firms located in the STP. No evidence of non linear elasticity is found. More precisely a 1% increase in management staff is related to a 0.43% increase in sales of new products per employee. A different picture is provided by the services they provide to tenants. Internationalization services are not found to have an effect, while the effect of

[11] Available upon request.

consultancy services is negative. These results could be explained by the lower quality of the services provided by the management compared with those available in the market. Accordingly, the positive influence of having a strong management entity is not driven by their provision of direct services to firms but by other reasons, such as helping to create an environment conducive to innovation, enhancing entrepreneurs' networks, facilitating technology transfer and augmenting firms' reputation.

Finally, we deal with the influence of where the STP is located. In column 2 we use as indicator the number of patents per million inhabitants in the province where the STP is located. We find a negative effect on firm performance suggesting that STPs perform better in less developed provinces. We test the robustness of this result using different indicators of development: gross domestic provincial product per capita (column 4), regional patents (column 5) and regional R&D effort (column 6). All these indicators show negative and significant effects, with the exception of gross domestic product, which shows negative, non significant, effects. These results agree with the view that STPs can be instruments of innovation-policy for less developed regions (Siegel et al., 2003), which compensate the lack of valuable inputs in these regions and constitute enclaves of innovation. On the other hand in more advanced regions STP effect could be rather limited as firms can find favourable framework conditions elsewhere (Felsenstein, 1994; Siegel et al., 2003; Sternber, 2004).

4.2 Robustness checks and further results

The dependent variable aims at reflecting the innovativeness of each firm. Previous analyses in the literature have used different ways to define it, such as percentage of sales from products new to the market (Laursen and Salter, 2006; Falk, 2007), a transformation of this last indicator[12] (Klomp and van Leuween, 2001, Mohnen et al., 2006 and Raymond et al., 2006) or the total amount of sales from products new to the market. In this subsection we explore if the results are robust to the use of these different ways of defining the dependent variable. The names of the variables are respectively *lnnewmer*, *ltnewmer* and *linnovsales* (all in logs).

Table 5 shows these results. It can be seen that all the main results hold. The influence of age follows an inverted U-shape, size of STP and the size of the STP's management entity show a positive influence while provision of consultancy services shows a negative one. Finally, the degree of development of the province shows a negative effect[13].

TABLE 5 APPROXIMATELY HERE

5. Discussion and conclusions

[12] This variables is obtained by using the formula: $\log\left(\frac{\text{newmer1}}{1-\text{newmwer1}}\right)$, where *newmer1=newmer*/100

[13] This negative influence is also obtained with the different indicators of province/regional development.

The aim of this paper is to empirically assess the influence of STPs' characteristics of STPs on the innovative results of tenants. In particular we have studied how the age of the park, its dimension, its management and the location of the park in a more or less developed environment affect the innovativeness of tenants.

The first important conclusion that can be drawn from our study is that STPs' characteristics, which have been mainly disregarded in past studies, affect the innovative results of firms.

More precisely, we find that the age of the park has a non-linear effect on innovative sales. Firms in younger and older parks outperform those in middle-aged parks. This finding can be explained with a twofold impact of being located on-park: an initial short-term positive impact generated by a greater visibility, prestige of the location and other reasons mainly related to marketing issues; and a long-term positive effect most likely due to the accumulation of knowledge, organizational learning, better understanding of tenants' needs and more effective business support. This result reconciles the two contrasting views found in the literature: the short-term effect confirms the arguments of those who think STPs are prestigious locations for innovative firms, while the existence of a long-term positive effect supports the view of STPs as instruments of innovation policy.

Regarding STP's size, firms in larger parks outperform those in smaller parks. This finding indicates the existence of economies of agglomeration, probably due to a greater knowledge stock within larger parks, which facilitate knowledge spillovers. We do not find any evidence of congestion effect, although it is possible that the largest STP in our sample is not large enough to suffer from them.

The size of the management team of the STPs positively affects the innovative performance of tenants. Nonetheless this positive impact cannot be explained by the services provided by the management of the park: general consultancy services have a negative impact and services aimed at foster internationalisation have no significant effects on firms' innovation. A possible explanation of these findings is that a larger management team helps firms in achieving better results, for example, augmenting an entrepreneur's network and facilitating technology transfer, but, when services are concerned, the best choice for tenants could be to buy services they need from the best providers which could differ from the management of the park.

The last relevant finding of this study is that STPs perform better in less technologically developed areas. This means that STPs have a higher impact on tenants' performance when the level of technological development of the area where the park is located is lower. This finding supports the role of STPs as instruments of innovation policy in less developed regions, where parks can constitute enclaves of innovation. The competitive advantage of being located on-park is less pronounced in more advanced regions, where firms can find favourable framework conditions elsewhere.

These results have several implications for policy-makers, STPs and firm managers and for further academic research.

First, our findings suggest that financial aids for STPs could be more effective when not indiscriminate. The existence of long-term effects of parks on firms' innovation performance and the fact that the on-park location is more beneficial for firms in less developed regions support the view of STPs as instruments of technology and innovation policy.

Second, this study provides indications also for parks' managers. Efforts to increase STP's size seem beneficial for tenants while the provision of consulting services has not been helpful for firms, when not counterproductive. They are also of help for firms' managers. On the one hand, it would help on the decision to location inside an STP and to select the most appropriate STPs. On the other, it suggests that, once in a STP, they should considerate buying those services they need from the best provider, which probably is not the park's management.

Finally, although, literature on STPs has rapidly grown in last years it has been mainly concerned with estimation of average effects. This study shows that heterogeneous effects exist and that they are systematically related to some STP characteristics. We believe that further studying the heterogeneity of parks can contribute to add valuable knowledge. For example, STPs demographics or the role played by universities and research institutes are interesting lines of research. It would also be of great interest to jointly analyse firms' and parks' heterogeneity so that more context-specific strategies could be developed.

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TABLES

Table 1. STPs' characteristics

Characteristic	Label	Description
Age	age	Age of the STP (years)
	ageq	Age of the STP (quadratic)
Dimension	lnfirms	Number of tenant organizations in 2008 (log)
Location	lpatinhabprov	Number of patent applications per million inhabitants in the province (log)
Management	lstaffr	Number of full-time equivalent employees in the Park's management company per 100 tenants
	international	1 if the Park provides services to foster internationalization of firm, 0 otherwise
	consult	1 if the Park provides advice on legal, commercial and fiscal issues, 0 otherwise

Table 2. Covariates

Characteristic	Label	Description
Size	lsales07 lsales07_2	Turnover in 2007 (log) Turnover in 2007 (log, quadratic)
Exports	x_s07	Exports over turnover in 2007
Industrial sector	high mediumhigh mediumlow low kis nkis restact	Technological level of industrial sector (0,1) (following OECD Science, Technology and Industry Scoreboard) 7 dummies: high-tech manufacturing, medium-high-tech manufacturing, medium-low-tech manufacturing, low-tech manufacturing, knowledge intensity service, no-knowledge intensity service, other sectors
Age	lfirmage	Firm age (years, log)
Innovation effort	lrdexpen_emp	Expenditure on innovation activities in 2007 per employee (thousand euros)
Cost obstacles to innovation	costobst	Perceived average importance of the following factors as a barrier to innovation during 2007-2009: - lack of internal funds - lack external funds - high costs of innovating - risk costs due to uncertain demand of innovative products and services (scale: 1 – 4; 1 very important; 4 unimportant)
Information obstacles to innovation	infobst	Perceived average importance of the following factors as barriers to innovation during 2007-2009: - lack of qualified personnel - lack of information on technology - lack of information on the markets - difficulty to find cooperation partners (scale: 1 – 4; 1 very important; 4 unimportant)

Table 3. Descriptive statistics (849 observations)

Variable	Mean	Std.Dev.	Min.	Max.
Dependent variables				
newmerl	14387.06	43567.13	0.00	607684.40
newmer	16.21	29.50	0.00	100
tnewmer	589.12	2354.91	0.0001	9997.34
linnovsales	1347258	1.07e+07	0	2.34e+08
Independent variables – *STPs' characteristics*				
age	15.59	5.12	6.00	24.00
nfirms	224.40	218.10	2	1436
sqmeters(1)	1145,5	865,5	6,5	2841,0
patinhabprov	82.98	32.46	11.92	131.21
patinhabreg	77.61	28.04	37.00	159.05
provGDPpp	24.79	5.33	17.08	34.49
reg_r&d	1.39	0.47	0.35	2.00
staffr	27.75	68.32	0.00	1550.00
international	0.64	0.48	0	1
consult	0.26	0.44	0	1
Control variables – *firms' characteristics*				
lsales08	12.11	5.59	0.00	20.74
x_s07	0.03	0.12	0.00	0.95
restact	0.04	0.20	0.00	1.00
low	0.036	0.19	0.00	1.00
mediumlow	0.034	0.18	0.00	1.00
kis	0.64	0.48	0.00	1.00
mediumhigh	0.08	0.27	0.00	1.00
nkis	0.09	0.28	0.00	1.00
rdexpen_emp	32878.32	68140.92	0.00	915000.00
costobst	0.55	0.20	0.25	1.00
infobst	0.39	0.13	0.25	1.00
firmage	12.64	12.00	1.0	152

(1) thousands.

Table 4. Influence of parks' characteristics on innovation. Main specification.

	(1) lnewmerl	(2) lnewmerl	(3) lnewmerl	(4) lnewmerl	(5) lnewmerl	(6) lnewmerl
age		-0.576***	-0.479**	-0.496***	-0.528***	-0.546***
		(0.129)	(0.164)	(0.106)	(0.119)	(0.103)
ageq		0.016***	0.014**	0.015***	0.016***	0.017***
		(0.004)	(0.005)	(0.003)	(0.004)	(0.003)
lnfirms		0.452*		0.366*	0.426*	0.370**
		(0.169)		(0.134)	(0.158)	(0.120)
lpatihabprov		-0.665**	-0.516			
		(0.219)	(0.268)			
lstaffr		0.427**	0.380**	0.396**	0.336*	0.358**
		(0.122)	(0.126)	(0.134)	(0.136)	(0.123)
international		0.065	0.221	0.167	0.128	0.190
		(0.369)	(0.431)	(0.377)	(0.401)	(0.349)
consult		-1.136*	-1.131*	-0.815	-0.725	-0.861*
		(0.424)	(0.420)	(0.403)	(0.450)	(0.385)
lsales07	0.038	0.035	0.034	0.038	0.036	0.036
	(0.036)	(0.034)	(0.035)	(0.034)	(0.034)	(0.034)
x_v07	1.232	1.320	1.366	1.240	1.266	1.256
	(1.100)	(1.137)	(1.109)	(1.140)	(1.128)	(1.133)
restact	-1.562	-1.706	-1.620	-1.720	-1.731	-1.756
	(1.302)	(1.292)	(1.278)	(1.302)	(1.292)	(1.303)
low	-0.409	-0.483	-0.349	-0.484	-0.441	-0.532
	(1.042)	(1.042)	(1.021)	(1.036)	(1.034)	(1.041)
mediumlow	-0.410	-0.442	-0.582	-0.403	-0.401	-0.486
	(1.428)	(1.381)	(1.407)	(1.380)	(1.381)	(1.387)
mediumhigh	-0.477	-0.505	-0.530	-0.506	-0.467	-0.574
	(0.906)	(0.885)	(0.879)	(0.886)	(0.890)	(0.879)
kis	-0.903	-1.035	-0.924	-1.036	-1.038	-1.091
	(0.812)	(0.784)	(0.796)	(0.780)	(0.785)	(0.780)
nkis	-0.391	-0.562	-0.422	-0.542	-0.518	-0.591
	(0.856)	(0.861)	(0.854)	(0.857)	(0.865)	(0.863)
lrdexpen_emp	0.379***	0.382***	0.378***	0.382***	0.382***	0.389***
	(0.042)	(0.040)	(0.040)	(0.041)	(0.040)	(0.042)
costobst	1.197	1.112	1.107	1.145	1.156	1.088
	(0.847)	(0.851)	(0.853)	(0.874)	(0.851)	(0.852)
infobst	0.864	0.670	0.693	0.765	0.683	0.730
	(1.238)	(1.239)	(1.227)	(1.223)	(1.221)	(1.217)
lfirmage	0.813**	0.833**	0.860**	0.812**	0.809**	0.815**
	(0.256)	(0.240)	(0.243)	(0.245)	(0.243)	(0.245)
provGDPpp				-1.037		
				(0.537)		
lpatinhabreg					-0.599*	
					(0.252)	
reg_r&d						-1.604**
						(0.474)
lsqmeters			0.107			
			(0.106)			
N	849	849	849	849	849	849
r2	0.112	0.124	0.120	0.123	0.123	0.125

Marginal effects; Standard errors in parentheses
(d) for discrete change of dummy variable from 0 to 1;
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5. Different dependent variables.

	(1) lnnewmer	(2) ltnewmer	(3) linnovsales
age	-0.258***	-0.586***	-0.735***
	(0.044)	(0.155)	(0.156)
ageq	0.007***	0.015**	0.021***
	(0.001)	(0.004)	(0.005)
lnfirms	0.163**	0.427*	0.660**
	(0.051)	(0.170)	(0.231)
lpatinhabprov	-0.384***	-0.960***	-0.820**
	(0.067)	(0.227)	(0.286)
lstaffr	0.174***	0.495***	0.543**
	(0.044)	(0.132)	(0.165)
international	0.024	0.064	0.075
	(0.098)	(0.305)	(0.505)
consult	-0.596***	-1.511*	-1.300*
	(0.145)	(0.547)	(0.588)
lsales07	0.003	-0.026	0.067
	(0.014)	(0.042)	(0.042)
x_v07	0.324	0.726	1.577
	(0.372)	(1.134)	(1.591)
restact	-0.494	-1.393	-2.680
	(0.446)	(1.259)	(1.730)
low	0.102	1.047	-1.039
	(0.412)	(1.154)	(1.407)
mediumlow	-0.259	-0.789	-0.440
	(0.478)	(1.287)	(1.998)
mediumhigh	-0.118	-0.401	-0.728
	(0.358)	(0.933)	(1.180)
kis	-0.198	-0.752	-1.387
	(0.304)	(0.802)	(1.035)
nkis	-0.133	-0.060	-1.181
	(0.306)	(0.913)	(1.146)
lrdexpen_emp	0.139***	0.411***	0.510***
	(0.011)	(0.032)	(0.054)
costobst	0.256	0.533	1.014
	(0.321)	(0.998)	(1.075)
infobst	0.365	1.485	1.024
	(0.445)	(1.411)	(1.672)
lfirmage	0.169	0.516	1.460***
	(0.091)	(0.293)	(0.318)
N	849	849	849
r2	0.120	0.107	0.133

Marginal effects; Standard errors in parentheses
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix 1. Main specification. Tobit estimations.

	(1) lnewmerl	(2) lnewmerl	(3) lnewmerl	(4) lnewmerl	(5) lnewmerl	(6) lnewmerl
age		-1.462***	-1.118*	-1.284***	-1.370***	-1.366***
		(0.329)	(0.443)	(0.252)	(0.328)	(0.261)
ageq		0.041***	0.032*	0.038***	0.040***	0.041***
		(0.010)	(0.013)	(0.008)	(0.010)	(0.008)
lnfirms		1.408**		1.204***	1.352***	1.221***
		(0.430)		(0.351)	(0.402)	(0.325)
lpatihabprov		-1.651**	-1.258			
		(0.600)	(0.785)			
lstaffr		1.072*	0.864*	1.008*	0.851	0.906*
		(0.430)	(0.418)	(0.445)	(0.458)	(0.428)
international		0.007	0.471	0.276	0.181	0.313
		(0.923)	(1.207)	(0.966)	(1.021)	(0.908)
consult		-2.409*	-2.595*	-1.733	-1.521	-1.770
		(1.131)	(1.156)	(1.025)	(1.147)	(1.021)
lsales07	0.107	0.106	0.096	0.114	0.108	0.111
	(0.103)	(0.098)	(0.101)	(0.098)	(0.098)	(0.098)
x_v07	3.308	3.550	3.728	3.338	3.409	3.386
	(2.459)	(2.564)	(2.475)	(2.585)	(2.548)	(2.557)
restact	-4.340	-4.624	-4.387	-4.620	-4.731	-4.714
	(3.591)	(3.540)	(3.477)	(3.576)	(3.545)	(3.577)
low	-0.718	-0.898	-0.532	-0.960	-0.864	-1.030
	(2.733)	(2.738)	(2.606)	(2.739)	(2.732)	(2.747)
mediumlow	0.154	0.315	-0.299	0.439	0.403	0.257
	(3.275)	(3.116)	(3.231)	(3.118)	(3.106)	(3.145)
mediumhigh	-0.707	-0.753	-0.871	-0.760	-0.683	-0.919
	(1.931)	(1.842)	(1.835)	(1.839)	(1.851)	(1.828)
kis	-1.683	-1.932	-1.695	-1.935	-1.955	-2.047
	(1.755)	(1.657)	(1.690)	(1.648)	(1.661)	(1.652)
nkis	-0.407	-0.622	-0.383	-0.584	-0.551	-0.686
	(2.017)	(2.011)	(1.989)	(2.001)	(2.013)	(2.008)
lrdexpen_emp	1.211***	1.225***	1.204***	1.220***	1.223***	1.231***
	(0.144)	(0.143)	(0.141)	(0.141)	(0.143)	(0.142)
costobst	3.202	3.237	3.081	3.256	3.292	3.109
	(2.159)	(2.125)	(2.128)	(2.204)	(2.129)	(2.151)
infobst	3.028	2.546	2.593	2.861	2.658	2.809
	(3.307)	(3.289)	(3.269)	(3.246)	(3.235)	(3.236)
lfirmage	2.209***	2.277***	2.346***	2.207***	2.206***	2.198***
	(0.617)	(0.558)	(0.579)	(0.565)	(0.565)	(0.562)
provGDPpp				-2.578		
				(1.329)		
lpatinhabreg					-1.461*	
					(0.704)	
reg_r&d						-3.537**
						(1.225)
lsqmeters			0.188			
			(0.311)			
N	849	849	849	849	849	849
r2						

Standard errors in parentheses

(d) for discrete change of dummy variable from 0 to 1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix 2. Different dependent variables. Tobit estimations.

	(1) lnnewmer	(2) ltnewmer	(3) linnovsales
age	-0.595***	-1.179	-1.906***
	(0.113)	(0.784)	(0.427)
ageq	0.016***	0.028	0.053***
	(0.003)	(0.023)	(0.013)
lnfirms	0.505***	0.255	1.962***
	(0.144)	(0.490)	(0.583)
lpatihabprov	-0.817***	-3.223**	-2.101**
	(0.198)	(1.084)	(0.799)
lstaffr	0.428**	0.937*	1.382*
	(0.156)	(0.472)	(0.578)
international	0.031	0.513	-0.008
	(0.294)	(1.335)	(1.237)
consult	-1.165**	-4.604*	-2.900
	(0.400)	(1.854)	(1.545)
lsales07	0.022	-0.199	0.171
	(0.036)	(0.127)	(0.127)
x_v07	1.162	-4.248	4.443
	(0.867)	(5.726)	(3.501)
restact	-1.587	-0.817	-6.746
	(1.261)	(3.820)	(4.763)
low	0.109	7.521*	-1.791
	(1.021)	(3.213)	(3.721)
mediumlow	-0.010	-8.166**	0.607
	(1.117)	(3.151)	(4.311)
mediumhigh	-0.194	-2.614	-1.055
	(0.715)	(2.234)	(2.450)
kis	-0.481	-1.928	-2.539
	(0.636)	(2.262)	(2.192)
nkis	-0.161	2.204	-1.412
	(0.724)	(2.611)	(2.676)
lrdexpen_emp	0.454***	1.631***	1.622***
	(0.048)	(0.211)	(0.190)
costobst	0.990	-2.422	3.689
	(0.778)	(2.710)	(2.749)
infobst	1.098	6.251	3.452
	(1.181)	(4.041)	(4.371)
lfirmage	0.639**	-0.116	3.516***
	(0.208)	(0.995)	(0.724)
N	849	849	849
r2			

Standard errors in parentheses
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$