Science and Technology Parks and Cooperation for Innovation: Empirical evidence from Spain

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ABSTRACT

Science and Technology Parks (STPs) are one of the most important innovation policy initiatives. Previous studies show that location in a park promotes cooperation for innovation, but do not investigate whether this cooperation produces better results. We extend this literature by analysing the effect of location on an STP on the results of cooperation for innovation and the mechanism facilitating this effect. We rely on a much larger sample of firms and STPs than previous studies, and, where necessary, account for selection bias and endogeneity. The results show that location in an STP increases the likelihood of cooperation for innovation, and the intangible benefits of cooperation with the main innovation partner, due mainly to a more diverse relationship.

Keywords: Science and technology parks; cooperation; innovation; effect; agglomerations

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1. INTRODUCTION

Agglomerations of firms, universities and other knowledge-intensive organizations are beneficial for the generation and utilization of knowledge (Ponds et al., 2010; Boschma and Frenken, 2011). This has been used to justify the development of science parks, technology parks, science and technology parks, technopoles, innovation centres, research parks, science-based industrial parks, university research parks, as a component of public policy to stimulate innovation. These initiatives can be encompassed by the broad category of Science and Technology Parks (STPs) since they are all policy-driven and have a main common objective to promote cooperation and technology transfer, especially between firms and knowledge providers such as universities and research institutes (Hogan, 1996, Bigliardi et al., 2006).

Previous academic research mostly analyses the effect of location in an STP on firms' results and behaviour (Löfsten and Lindelöf, 2005; Fukugawa, 2006; Squicciarini, 2008). While the effect on results is unclear, the empirical evidence shows that the likelihood of cooperation for innovation between firms and knowledge providers increases. However, most existing studies use very small samples of firms and STPs.

The present work extends this literature in a number of ways. First, it focuses on analysing the influence of STPs on the results of cooperation, how STP effects are channelled, and how much they increase the likelihood of cooperation.

Second, it uses a substantially larger sample of firms and exploits the responses from a standard Community Innovation Survey (CIS) type questionnaire to evaluate the influence of STPs on cooperation. This allows the use of already tested covariates that capture the innovation behaviour of firms. This study relies on the 2007 Spanish Survey of Technological Innovation in Companies, undertaken by the Spanish Institute of Statistics (INE), and includes 39,722 companies which are representative of the size, sector and regional location of the population of Spanish companies, 653 of which are located in 22 of the 25 Spanish STPs.

Third, it takes account of endogeneity and sample selection bias problems. The former problem arises because firms are not randomly located in a STP: their location is the result of the firm's decision and the STP's agreement, and these decisions rely on partially unobservable factors.

The latter problem arises if the subsamples used are not representative of the population being analysed.

Fourth, it provides evidence for the Spanish case. STPs are a major Spanish innovation policy initiative; the first STPs were created in the 1980s and their number has grown considerably since then. Nevertheless, evidence on their performance is scarce (Vásquez-Urriago et al., 2014).

Our results show that, even after accounting for endogeneity, STPs are important for fostering cooperation for innovation. We find also that the intangible outputs from cooperation are higher for park firms for the main reason that their location facilitates the development of more diverse cooperative relationships.

The paper is organized as follows. Section 2 reviews previous arguments on the effect of proximity on cooperation behaviour, summarizes the empirical evidence on the role of STPs on cooperation, and provides a description of the Spanish context. Section 3 explains the methodological issues related to the empirical work; Section 4 presents the results of our analysis of the effect of STPs on the likelihood of cooperation; and Section 5 focuses on the effect of STPs on the results of cooperation and the main drivers of this effect. Section 6 presents the conclusions.

2. PREVIOUS LITERATURE

We first review the literature on the relationship between proximity and cooperation for innovation more generally before focusing on the more specific literature on STPs and cooperation for innovation. Finally, we provided a detailed description of Spanish STPs. We adopt an explicit interdisciplinary perspective since the main scholarly arguments on these topics come from various disciplines such as economics, geography, management and innovation studies.

2.1. Proximity and cooperation for innovation

The agglomeration of knowledge intensive organizations traditionally was considered a source of innovation (Marshall, 1890; Jacobs, 1970), but it was not until the early 1990s that research has focused on this effect in particular (Feldman and Kogler, 2010). An important reason for the influence of agglomeration on innovation is that agglomeration favours the initiation and development of linkages between different organizations (Baptista, 1998; Hervas-Oliver and Albors-Garrigos, 2009). The likelihood of establishing relationships is higher for firms in agglomerations; geographical proximity increases the chances of casual meetings and conversations that identify common interests and may lead to joint projects (Guillain and Huriot, 2001).

There is a lack of agreement about why relationships between co-located partners work better (Breschi and Lissoni, 2001; Dahl and Pedersen, 2004; Giuliani, 2007; Ibrahim et al., 2009). This debate is based on two main arguments. First, geographical proximity facilitates knowledge flows and, as a result, learning processes because closeness has a positive effect on the number of interactions (Torre and Gilly, 2000). Since tacit knowledge plays an important role in innovation processes (Polanyi, 1966), and frequent and repeated face-to-face contacts are key to its transmission (Baptista, 1998; Amin and Wilkinson, 1999), geographical proximity is a facilitator. Maskell and Malmberg (1999) argue that the higher the tacit component of the knowledge, the more important is geographical proximity for knowledge to flow between partners. Accordingly, innovation partnerships among firms in agglomerations should achieve higher flows of knowledge due to the more diverse relationships they enable.

Second, geographical proximity reduces uncertainty; it reduces search costs (Feldman, 1999) and increases the likelihood of explicit search for innovation partners (MacPherson, 1997). Also, it contributes to the building of trust which reduces the transaction costs involved in joint projects and results in more stable and longer lasting relationships (Bennet et al., 2000; Love and Roper, 2001). Longer relationships encourage the sharing of more valuable knowledge, resulting in a better adjustment between expectations and results, greater trust and increasing returns from collaboration (Izushi, 2003; Abramovsky and Simpson, 2011), especially in relation to intangible results (Barge-Gil and Modrego, 2011).

However, geographical proximity is necessary, but not sufficient for effective inter-organizational learning (Lane and Lubatkin, 1998). Following Knoben and Oerlemans (2006, p.80), other types of proximity may be relevant for cooperation: technological proximity, defined as ´the level of overlap of the knowledge bases of two collaborating actors` (Lane and Lubatkin, 1998) and organizational proximity, defined as ´the set of routines –explicit or implicit- which allows coordination without having to define beforehand how to do so. The set of routines incorporates organizational structure, organizational culture, performance measurements systems, language and so on` (Rallet and Torre, 1999) This broader notion of proximity influences the frequency and density (variety and duration) of interactions (Baptista, 1998; Torre and Gilly, 2000)

2.2. STPs and cooperation for innovation

STPs guarantee geographical proximity and encourage other types of proximity that fosters cooperation between firms and research and technology organizations.

Several empirical studies, focusing mainly on firm-university links, analyse the role of STPs on cooperation for innovation. Table 1 presents two main groups of studies. The first group is composed of case studies of STPs, which investigate whether location in an STP fosters university-industry links, inter-firm links and other links. These works analyse the behaviour of park firms and find that they frequently develop links with universities, other firms and other institutions.

The studies in the second group are mostly quantitative. They use matching techniques to develop a control group of off-park firms to allow the effect of location in a park to be estimated or they use comparative analysis. The evidence tends to show a positive effect of location in an STP on collaboration with local universities and firms. However, these studies mostly do not control for endogeneity of park location. The decision to locate in an STP might be related to the propensity to cooperate and these firms would have cooperated for innovation wherever they were located. This is an important consideration which could bias results. The exception is the study by Fukugawa (2006), which finds that STP location has an effect on firms' links with universities and is not restricted to local universities.

To sum up, these studies provide evidence that location in a park promotes cooperation for innovation. However, none of this work investigates the influence of an STP location on the results of cooperative projects. These results fall into the two groups (Barge-Gil and Modrego, 2011) of economic results (including sales, exports costs, profits, employment, internal R&D or productivity) and intangible results (including increased ability to formulate strategies, enhanced human resources and better management of information and relationships). Analysing the influence of STP location on the results of cooperative projects is the main focus of the present analysis.

Table 1: Studies analysing STPs and cooperation for innovation

Method	Study	Country	Sample[i]	Variables of cooperation	Results
Case study	Vedovello (1997)	UK	1 STP	**links between park firms and the host university**: - *informal links* (personal contacts, attendance at seminars, access to literature and equipment, etc.) - *human resources links* (sponsored student projects, recruitment of graduates, scientists and engineers, etc.) - *formal links* (research contracts, joint research, analysis and testing, etc.)	Significant presence of *informal* and *human resources* links in park firms
	Phillimore (1999)	Australia	1 STP	**links between park firms and the host university** (cf Vedovello, 1997) **links between park firms** (joint research, shared equipment, commercial transactions, social interaction)	Significant presence of both types of links in park firms
	Bakouros et al. (2002)	Greece	3 STPs	**links between park firms and local universities** (cf Vedovello, 1997) **links between park firms** (cf Phillimore, 1999)	Significant presence of *informal and human resources links* (firm-university) in all cases and of *formal links* in STPs Links (between firms) in commercial transactions and social interaction
	Brčić et al. (2010)	Croatia	5 STPs	**links between Park firms and others firms**	Significant presence of links with firms within the own STP and with off-park firms
	Basile (2011)	Italy	15 STPs	**links between Park firms and: universities, other firms, research centres, central and local government, venture capital institutions**	Significant presence of all types of links in Park firms, especially with universities and small technology firms

Matching or Comparative Analysis	Monck et al. (1988)	United Kingdom	183 park firms / 101 off park firms	**links between firms and local universities** (informal contact, employment of academics, sponsor research, recruitment of graduates, training, access to equipment, test / analysis, etc.)	effect (+) of park location on informal contact and access to equipment (but not on more formal links)
	Westhead and Storey (1995)	United Kingdom	183 park firms / 101 off park firms and 47 park firms / 48 off park firms)	**links between firms and local universities**	effect (+) of park location on links in general
	Löfsten and Lindelöf (2002, 2003, 2005); Lindelöf and Löfsten (2004)	Sweden	134 park NTBFs[II] / 139 off park firms	**links between firms and local universities** (R&D projects, basic and applied research, consultancy, discussions, equipment, R&D documents, recruitments, etc..)	Effect (+) of park location on all links. Among park NTBFs, more frequent links among academic NTBFs than corporate NTBFs
	Colombo and Delmastro (2002)	Italy	45 park NTBFs / 45 off park firms	**formal links between firms and universities** **formal links between firms' clients - suppliers and other firms** (commercial agreements, technological agreements)	Effect (+) of park location on total links (in general) and on links with universities
	Malairaja and Zawdie (2008)	Malaysia	22 park HT SMEs[III] / 30 off park firms	**links between firms and local universities** (informal contact, projects, employment of academics and consultancy, equipment, collaborative research)	More links in park firms, but no significant effects of park location
	Radosevic and Myrzakhmet (2009)	Kazakhstan	25 Park firms / 25 off Park firms	**Links between firms and universities**	Less links in Park firms

	Díez and Fernández (2015)	Spain	480 Park firms / 9466 off Park firms	**links between firms and: universities, other institutions**	Significant presence of links
Matching and regression	Fukugawa (2006)	Japan	74 park NTBFs / 138 off park firms	**Joint research between firms and HEIs[IV]** **Joint research between firms and local HEIs**	Effect (+) of park location on joint research with HEIs, although research partner of park firms unlikely to be in the same region

[I] number of parks analysed in case studies, and number of companies in other studies
[II] NTBF – New Technology Based Firm
[III] HT SMEs – High Tech Small and Medium Enterprises
[IV] HEIs – Higher Education Institutions

2.3. STPs in Spain

Spanish parks are a relatively recent phenomenon. Since the 1980s, STPs have been seen as initiatives that contribute to regional development via technology transfer and revitalization and diversification of the local industry. Efforts have been made to attract high-tech, often multinational firms to strengthen the dynamics of the local economic environment (Ondategui, 2001; Infyde iD, 2008). Spanish parks were originally technology rather than science parks. However, over the years, both new and existing parks have forged stronger relationships with universities via different mechanisms such as formal collaborative agreements, direct location of some research institutes within the park, or even entrance of universities on park property; Accordingly, they became Science and Technology Parks. Parks tend to specialize in innovation, knowledge creation and the transmission and promotion of collaboration between park and non-park actors (Infyde iD, 2008). Spanish STPs have also worked to create regional networks of STPs, aimed at strengthening regional systems of innovation (Romera, 2006).

Regarding the role played by the government, Spanish STPs were usually created through regional initiatives and, by the 1990s, had spread to the majority of Spanish regions. This resulted in their receiving support from national government[1] in the form of national funding to purchase specialized equipment, develop the infrastructure and conduct R&D projects. STPs are seen as playing a key role in the national innovation system and are included in national R&D plans. Nevertheless, regional government support for STPs is still relevant.

It could be argued that in the 1990s Spanish STPs were closer to the ‘second generation’ of parks (OECD, 2011) since they were aimed at fostering regional industry, were located in urban environments and focused on the creation of new firms. In the 2000s, Spanish STPs have evolved towards the ‘third generation’, growing larger due to national support, and specializing in specific knowledge areas.

The development of Spanish STPs has some similarities with developments in other Mediterranean countries such as France and Italy. These STPs have three common characteristics. First, the parks are centrally planned and established as part of a regional

[1] Financial support from central government for the period 2000-2003 amounted to €300 million (Infyde iD, 2008) and increased to around €400 million over the 2004-2007 period (Spanish Ministry of Science and Innovation).

development policy. Second, their objectives go beyond R&D activities and involve programmes to improve production methods, general organization practices, etc. Third, although there is usually a university component in the STP structure, universities do not lead or control STP activities (Ondategui, 2001; Roure et al., 2005). These characteristics differentiate Spanish STPs from those established in the US, the UK and northern Europe.

3. METHODOLOGY AND DATA

The empirical work is divided in two parts. First, we analyse the effect of location in an STP on the likelihood of formal cooperation for innovation and on the results from formal collaboration agreements. Second, we examine how this effect emerges.[2]

Methodologically, we rely on the treatment evaluation literature, so that park firms are the treated group and non-park firms are the untreated group. We estimate the Average Treatment Effect (ATE), understood as the expected effect of treatment on an individual drawn randomly from the population (Wooldridge, 2002). The ATE is the expected difference in outcomes, with and without treatment (i.e. the expected difference between outcomes for the same firm, located in or outside a park).

This framework allows underlying assumptions to be made explicit. For example, when using mean differences between park and non-park firms to analyse the park effect, the underlying assumption is that location in an STP is completely random, which is an unrealistic assumption.[3] We make two alternative assumptions about the ways in which park and non-park firms differ, which allows us to determine whether different outcomes can be attributed to a park location rather than other firm characteristics.

First, if we assume that it is possible to observe the different characteristics of park and non-park firms, we can use a regression with controls (Equation I) or a regression with a propensity score[4] (Equation II):

[2] Investigation of the results of agreements is limited to relationships between firms and external sources of knowledge.

[3] On the one hand, firms decide whether they want to be located in an STP and, on the other, STPs usually have some conditions for belonging.

[4] The control variables are replaced by the estimated probability, according to these control variables, of the firm being located in an STP.

$$Y = \lambda + \alpha\,(SSTP) + \sum_{j=1}^{m} \beta_j X_j + u \quad \text{(I)}$$

$$Y = \lambda + \alpha\,(SSTP) + \pi\,[\hat{p}\,(X\ \ )] + u \quad \text{(II)}$$

where Y is an indicator of firm cooperation, $SSTP$ indicates location in an STP, X are covariates suggested by the previous literature (see Table 2), $\hat{p}\,(X\ \ )$ is the estimated propensity score, and $\hat{\alpha}$ is the ATE.

Second, if we suspect that some of the (non-random) differences between firms inside and outside parks are not observable, we need to apply alternative methods such as a control function approach (Equation III) or instrumental variables with propensity score (Equation IV):

$$\text{ATE} = E(Y \mid SSTP = 1) - E(Y \mid SSTP = 0) = \hat{\alpha} + \hat{\rho}\sigma \left[\frac{\phi\,(\gamma'_n X_n)}{\Phi\,(\gamma'_n X_n) * (1 - \Phi(\gamma'_n X_n))} \right] \quad \text{(III)}$$

Where ϕ is the normal density function and Φ is the normal distribution function (evaluated using the term in parenthesis which corresponds to the estimation obtained from a probit model[5]). $\hat{\rho}\sigma$ is the estimated coefficient of the so-called hazard; it acts as a control function to eliminate inconsistency in the standard regression, absorbing the correlation between treatment and the error term.

$$Y = \lambda + \alpha\,(SS\hat{T}P) + \sum_{j=1}^{m} \beta_j X_j + u \quad \text{(IV)}$$

[5] $\gamma'_n X_n$ is the probit estimation of $SSTP^* = \gamma_0 + \sum_{j=1}^{m} \gamma_{1j} X_j + \gamma_2\ Z - v$, where $SSTP^*$ is latent variable, which depends on the covariates X and on Z, which acts as an exclusion restriction.

where $\hat{SSTP}$ is the estimated treatment using the propensity score[6] as an instrument; and $\hat{\alpha}$ is the ATE.[7]

The data were extracted from the 2007 Spanish Survey of Technological Innovation in Companies undertaken by INE. This annual survey is modelled on the CIS. The sample population is 39,722 companies, representative of the size, sector and regional location of the population of Spanish companies.[8] The survey includes a question on location in a STP.

All Spanish STPs included in our analysis are registered under the Association of Science and Technology Parks of Spain (APTE), created in 1989. APTE includes only STPs that fulfil the following characteristics: ownership of physical space and infrastructure to support innovation; provision of training and support for the development of knowledge based firms; formal cooperation with universities and research centres; and a managing organization responsible for technology transfer. These conditions exclude from APTE spontaneous clusters (i.e. clusters with no established managing organization) and industrial parks that are neither technology oriented nor related to a scientific institution. Hence, our focus on the STPs belonging to the APTE considerably reduces the heterogeneity among our units of analysis. In 2007, APTE included 25 STPs and more than 3,800 firms and related entities.

Accordingly, we constructed a dichotomous variable (*SSTP*) that takes the value 1 if the company is located in an STP belonging to APTE, and 0 otherwise: 653 companies (1.64% of the sample) are located in a Spanish STP.[9] The appendix to the survey includes questions on the characteristics of cooperation with the firm's main innovation partner. The responses to these questions allow deeper analysis of the influence of STP location on cooperation results.

[6] In this case the propensity score is the estimated probability of the firm being located in an STP in function of the control variables and an instrumental variable.
[7] For more methodological details, see Wooldridge (2002) and Vásquez-Urriago et al., (2014).
[8] The specific characteristics of this sample are available on the INE webpage: http://www.ine.es/dynt3/metadatos/es/RespuestaDatos.htm?oe=30061. Data were analysed in secure environments at INE. Access to confidential information was not provided; e.g. we do not know the names or addresses of firms.
[9] These firms are located in 22 of the 25 STPs in Spain that were included in the APTE in 2007.

4. LOCATION IN AN STP AND THE LIKELIHOOD OF COOPERATION FOR INNOVATION

The dependent variable for the first part of the empirical analysis is a dummy variable that takes the value 1 if the firms engaged in formal collaboration for innovation during the period 2005-2007, and zero otherwise:[10] 4,695 firms (11.8% of total sample) were involved in a formal collaboration. The definition of a formal cooperative agreement follows the definition in the OECD Oslo Manual.[11] Potential partners include suppliers, customers, competitors, consultants and private knowledge intensive business firms, universities, public research centres and technology institutes.[12]

Several firm specific factors have been shown to influence the likelihood of cooperation for innovation. CIS data have been used to analyse what determines the likelihood of cooperation for innovation, and several controls have been found to be relevant for explaining cooperation. Barge-Gil (2010) provides a review of these studies and the indicators used. These covariates should be included to avoid biased results (because they also may be correlated with STP location). In addition, their inclusion improves estimation precision. Thus, we include the general characteristics of firms (size, belonging to a group, export intensity, dummy for new firms, incidence and technology level of the sector) and the characteristics of the innovation process (innovation effort, and cost and information obstacles). Table 2 provides definitions of the variables and Table 3 provides summary statistics.

[10] The survey asked firms whether they had engaged in innovation activities in the period. Only those firms responding positively (regardless of the success of these efforts) are considered potential candidates for cooperation, i.e. firms that do not engage in innovation activity do not cooperate for innovation.

[11] Innovation co-operation involves active participation in joint innovation projects with other organizations. These may be other enterprises or non-commercial institutions. The partners need not derive immediate commercial benefit from the venture. Contracting-out of work that does not involve active collaboration is not considered to be co-operation. Co-operation is distinct from sourcing open information, and acquisition of knowledge and technology, in that all the parties involved must take an active part in the work (OECD and Eurostat, 2005, p.79)

[12] We do not distinguish partner location. On the one hand, our main interest is in analysing the ‘general’ cooperation pattern of firms, i.e., their ability to enter in and benefit from cooperative agreements. On the other hand, the survey does not provide information on partner locations so we do not know whether partners are located in the park or elsewhere. Related evidence from an official survey of STP firms shows that 628 out of 776 (81%) cooperating STP firms cooperate with organizations in the same STP; so we can assume that most cooperative links observed are intrapark links. However, this is an issue that deserves further exploration. (For more information on this survey, see www.idi.mineco.gob.es.)

Table 2: Definition of covariates

General Company Characteristics	
Company size	Total turnover in 2005 (in logarithmic: natural logarithm of (1+indicator)). The square of this variable is also included.
Exporting behaviour	Share of export per total turnover in 2005.
Group	Dummy variable: 1 if the company is part of a group.
Newly established	Dummy variable: 1 if the company was established in 2005-2007.
Merged	Dummy variable: 1 if turnover increased by 10% or more as a result of a merger with another company during 2005-2007.
Downsized	Dummy variable: 1 if turnover decreased by 10% or more owing to the sale or closure of part of the company during 2005-2007.
Technological level of sectors of activity	7 dummy variables: high-tech manufacturing, medium-high-tech manufacturing, medium-low-tech manufacturing, low-tech manufacturing, knowledge intensity service, no-knowledge intensity service, other sectors.[I]
Companies` Innovation Activity	
Innovation effort	Expenditure on innovation activities in 2007 (‘000 euros per employee).
Cost obstacles	Average measure of importance of the following factors as barriers to innovation during 2005-2007: lack of internal funds, lack of sources of finance, high costs of innovating, market dominated by established enterprises.[II]
Information obstacles	Average importance of the following factors as barriers to innovation during 2005-2007: lack of qualified personnel, lack of information on technology, lack of information on the markets, problems finding cooperation partners.[II]

[I] Classification of manufacturing and services (OECD, 2005). Other sectors: agriculture; extractive activities; production and distribution of electricity, gas and water; construction.
[II] Importance ranked on the scale from 1(crucial) to 4 (unimportant).The indicator is equal to [n / ∑ factors importance]

Table 3: Summary Statistics

	Mean	S.D.	Min.	Max.
General Company Characteristics				
Company size	13.71	4.64	0	24.65
Company size^2	209.55	83.75	0	607.91
Exporting behaviour	0.031	0.117	0	1
Group	0.263	0.440	0	1
Newly established	0.040	0.196	0	1
Merged	0.018	0.133	0	1
Downsized	0.016	0.129	0	1
Technological level of sectors of activity: *high-tech manufacturing*	0.026	0.162	0	1
medium-high-tech manufacturing	0.097	0.296	0	1
medium-low-tech manufacturing	0.135	0.341	0	1
low-tech manufacturing	0.166	0.372	0	1
knowledge intensity service	0.111	0.314	0	1
no-knowledge intensity service	0.345	0.475	0	1
other sectors	0.118	0.323	0	1
Companies` Innovation Activity				
Innovation effort	4.47	29.83	0	4460
Cost obstacles	0.444	0.207	0.25	1
Information obstacles	0.377	0.161	0.25	1
# of observations	39722			

Table 4 presents the results. The first row shows the percentage of park and non-park firms cooperating for innovation: 45% of park firms and 11% of off-park firms cooperate.

The second and third rows show the results of the regressions with controls (Equation I) and propensity score (Equation II). Estimations were performed using probit and Ordinary Least Squares (OLS). The results show that the effect of STP location is positive and significant, regardless of the estimation method used. The likelihood of cooperation increases by some 16-18 percentage points for the average firm (17-20 points for the median firm).

The fourth and fifth rows show the results for the control function (Equation III) and the instrumental variables with propensity score approaches (Equation IV).[13] Both methods require an additional variable (instrument) related to the likelihood of being located in a STP (inclusion restriction), but not the likelihood of cooperation (exclusion restriction). We use an indicator for the supply or 'availability' of space in an STP: the percentage of firms located in an STP in the firm's region.[14] This variable is calculated based on information from the APTE on the number of firms in each park, and data published in the Central Companies Directory (DIRCE) based on the regional business census.

We would expect this variable to comply with both restrictions. On the one hand, it has a positive effect on the propensity to locate in a park.[15] On the other hand, the availability of STPs in the firms' region is not *per se* a significant explanatory factor for firm cooperation for innovation. In addition, this variable is exogenous to the firm since firm mobility across regions is very low.

[13] We performed two tests for exogeneity; the results did not allow us to reject the endogeneity assumption. We followed the procedure described in Wooldridge (2003, p.483) and performed a Hausman test to compare the coefficients of the OLS and the two-stage OLS (2SLS) regressions. The results are presented in the Appendix.
[14] Alternatively, we used the number and dimensions (in m^2) of the STPs in each region; the results did not change.
[15] The first-stage F-statistic test (Staiger and Stock,1997) confirms that this instrument is strong (F = 157.85, see Bascle, 2008, p.295-296 for details of this test), i.e. is strongly correlated with *SSTP*.

Table 4: ATE estimation of location in Spanish STPs, on cooperation for innovation

Dependent variable	*Cooperation* [I]					
Estimation Method	**Companies in an STP**		**Companies outside an STP**		**Difference**	
Mean differences	45.02		11.26		33.75[a]	(0.012)
	OLS		**Probit** [II]			
			Mean		Median	
Regression with controls (Equation I)	0.22[a]	(0.012)	0.16[a]	(0.018)	0.20[a]	(0.021)
Regression with propensity score (Equation II)	0.21[a]	(0.012)	0.18[a]	(0.020)	0.17[a]	(0.019)
Control function (Equation III)	0.21[a]	(0.007)	0.15[a]	(0.000)	0.16[a]	(0.000)
IV with propensity score (Equation IV)	0.80[a]	(0.087)	0.16	(0.103)	0.21[c]	(0.125)
# of observations	39722					

[I] *cooperation* = dummy: cooperation for innovation in 2005-2007.
[II] Marginal effects shown in probit models.
Standard errors in parentheses.
[a] p-value lower than 0.01, [c] p-value lower than 0.10.
All controls from table 2 are included in the regressions.

Both methods confirm the previous results. Location in an STP positively influences the probability of cooperation. Also, the size of the effect is similar: around 15-16 percentage points using the control function approach, and 16-21 percentage points using the instrumental variables method.[16]

The results for the control variables are presented in Table 5. They are mainly in line with the findings summarized in Barge-Gil (2010). Size, exporting, being part of a group, technological level of the industry, innovation effort and obstacles are all positively related to the probability of cooperation.

[16] Probit estimations with instrumental variables give consistent coefficient estimations, but not consistent standard errors (Adkins, 2012). This explains the non-significance of the effect when using probit with instrumental variables, despite its similar size. This problem does not arise with OLS and the coefficients are significant.

Table 5: Results for control variables for likelihood of cooperation

	Dependent variable	*Cooperation* [I]					
	Estimation Method	*Regression with controls (Equation I)*		*Control function (Equation III)*		*IV with propensity score (Equation IV)*	
General Company Characteristics	*Company size*	-0.08[a]	(0.00)	-0.08[a]	(0.00)	-0.08[a]	(0.00)
	Company size ^2 [II]	0.005[a]	(0.00)	0.005[a]	(0.00)	0.005[a]	(0.00)
	Exporting behaviour	0.68[a]	(0.06)	0.68[a]	(0.06)	0.67[a]	(0.06)
	Group	0.33[a]	(0.02)	0.33[a]	(0.02)	0.32[a]	(0.02)
	Newly established	0.23[a]	(0.04)	0.22[a]	(0.04)	0.21[a]	(0.05)
	Merged	0.04	(0.06)	0.05	(0.06)	0.04	(0.06)
	Downsized	-0.31[a]	(0.07)	-0.30[a]	(0.07)	-0.31[a]	(0.07)
	low-tech manufacturing	-0.50[a]	(0.04)	-0.53[a]	(0.05)	-0.49[a]	(0.05)
	medium-low-tech manufacturing	-0.45[a]	(0.04)	-0.48[a]	(0.05)	-0.44[a]	(0.06)
	medium-high-tech manufacturing	-0.20[a]	(0.04)	-0.23[a]	(0.05)	-0.19[a]	(0.05)
	knowledge intensity service	0.09[b]	(0.04)	0.09[b]	(0.04)	0.09[c]	(0.04)
	no-knowledge intensity service	-0.64[a]	(0.04)	-0.67[a]	(0.04)	-0.63[a]	(0.05)
	other sectors	-0.59[a]	(0.05)	-0.61[a]	(0.05)	-0.57[a]	(0.06)
Inn. Act.	*Innovation effort*	0.004[a]	(0.00)	0.008[a]	(0.00)	0.008[a]	(0.00)
	Cost obstacles	0.94[a]	(0.04)	0.94[a]	(0.04)	0.93[a]	(0.05)
	Information obstacles	0.15[b]	(0.06)	0.16[a]	(0.06)	0.15[b]	(0.06)
Constant		-1.54[a]	(0.05)	-1.55[a]	(0.06)	-1.54[a]	(0.06)
Chi2		3684.89[a]		3459.66[a]		3809.75[a]	
# of observations		39722					

[I]*cooperation* = dummy: cooperation for innovation in 2005-2007.
[II] Size effect is mainly positive as the minimum likelihood of cooperation is reached for values around 1,327€-1.524€ in firms' sales.
High technology manufacturing is used as baseline category.
Equation II uses the propensity score instead of control variables
Standard errors in parentheses.
[a] p-value lower than 0.01, [b] p-value lower than 0.05, [c] p-value lower than 0.10.
SSTP is included in every regression.

5. LOCATION IN AN STP AND THE RESULTS FOR COOPERATION FOR INNOVATION

We have shown that location in an STP increases the likelihood of cooperation for innovation. In this section, we analyse whether cooperation yields better results for firms located in an STP and examine the potential reasons for this[17].

5.1. Data and variables definition

The data in this section are from an Appendix to the Spanish CIS Survey introduced in 2007. It contains questions addressed only to cooperating firms that declared that their main innovation

[17] For a review on the general effects of cooperation for innovation see, for example, Barge-Gil (2013).

partner in the period 2005-2007 was an External Knowledge Source (EKS). EKS include the following types of partners: universities, public research centres, technology institutes and private knowledge intensive services providers. The focus on EKS in this study is justified because one of the main purposes of STPs is increasing the flows of knowledge between EKS (especially, but not exclusively universities) and on-park firms. The questions in the Appendix relate exclusively to the main partner, which reduces the attribution problem faced by empirical studies that analyse cooperation more generally (Barge-Gil and Modrego, 2011).

The Appendix questions were responded by 1,820 firms (38.8% of firms cooperating in the 2005-2007 period), 150 of which are located in STPs (i.e. 51% of STP cooperating firms). They asked about the characteristic of the relationship with the main innovation partner (e.g. length of the relationship, and types of activities) and about the intangible and economic results obtained (see Table 6). Firms were asked to evaluate the results on a Likert scale.[18]

We constructed average values and first factor indicators based on this information:

- Average value of intangible results from cooperation with the main innovation partner (*Effects*);

- Average value of economic results from cooperation with the main innovation partner (*Impacts*);

- First factor[19] from the intangible results for cooperation with the main innovation partner (*Fac_Effects*);

- First factor from the economic results for cooperation with the main innovation partner (*Fac_Impacts*).

[18] Where 0 = absence of impact, 1 = low impact, 2 = intermediate impact, 3 = high impact. Likert scales have been criticized because they introduce measurement error induced by subjective responses (Levin et al., 1987). These indicators were tested by comparing the quantitative responses in the case of economic results (Barge-Gil and Modrego, 2011). The results were very similar suggesting that use of a Likert scale is not affecting the results. Also, we used average values and factor analysis to check the robustness of results to different methods of aggregating the information obtained from the Likert scores.

[19] We conducted principal component analysis and extracted the first factor. All 8 intangible results were included. A similar strategy was followed for the economic results.

Table 6: Indicators for results from cooperation for innovation

Intangible results from cooperation for innovation	
Strategies	Enhanced ability to define and plan innovation activities (*effect1*)
	Better market understanding (*effect2*)
Human Resources	Learning and staff training in new areas (*effect3*)
	Enhanced ability for teamworking and knowledge sharing (*effect4*)
Information management	Enhanced ability to retrieve and use information (*effect5*)
	Improved relationship between firm's R&D and other departments (*effect6*)
Relationships management	Improved utilization of other ESK (*effect7*)
	Improved access to public programs of public funding for innovation (*effect8*)
Economic results from cooperation for innovation	
Sales (*impact1*)	
Exports (*impact2*)	
Production costs (*impact3*)	
Profits (before taxes) (*impact4*)	
Employment (*impact5*)	
Internal R&D (*impact6*)	
Productivity (*impact7*)	

Table 7 presents the descriptive statistics for these indicators. On average, firms consider the impact on the economic results of their main partner to be quite low, and the impact on intangible results to be low to intermediate.

To understand why cooperation might produce different results for park and off-park firms, we defined two additional variables to capture the arguments proposed in the literature.

First, diversity of the relationship (*Diversity*) is measured as the number of different activities engaged in during the period analysed. The activities considered are: training, laboratory testing services, technological consultancy, managerial consultancy and research and development and the indicator is in the range 1 to 6. Second, length of the relationship (*Length*) is measured as the number of years since the cooperation started (in logs)[20] (see Table 7).

[20] This variable had 20 missing values. We checked whether the results were sensitive to the exclusion of these observations and we found them to be very similar.

Table 7: Summary statistics. Composite indicators for results and characteristics of cooperation for innovation

	Summary Statistics			
Variables	Mean	S.D.	Min.	Max.
Effects	1.49	0.64	0	3
Fac_Effects	2.48e-09	1	-2.29	2.30
Impacts	1.14	0.62	0	3
Fac_Impacts	-2.31e-09	1	-1.78	2.95
Diversity	2.80	1.32	1	6
Length	1.32	0.80	0	4.20
# of observations	1820			

5.2 Location in an STP and the results for collaboration for innovation with an EKS

The aim is to estimate the effect of location in an STP; therefore, we use the set of control variables from Table 2. Cooperation characteristics are not included; because they are likely to be affected by location in a park so their inclusion would invalidate interpretation of the coefficient of STP as the ATE (Wooldridge, 2003; Angrist and Pischke, 2009). However, they may explain the effects of a park location, which is something we explore later.[21]

We need to account of sample selection bias. The sample in this case is a selected sample based on the firms that responded to the Appendix questions, and whose main innovation partner is an EKS. We account for this issue by employing a Heckman estimation. To identify the model, we used regional supply of EKS.[22] The Mills ratio is insignificant and we found no evidence of sample selection.[23]

In relation to endogeneity, previous studies suggest that, if a subsample of innovators is used, STP location is no longer endogenous (Vásquez-Urriago et al., 2014). We applied the same instrument as before and the Hausman test did not reject the exogeneity hypotheses, thus, our choice of OLS estimation (i.e. we estimate only equations I and II).[24]

[21] It is possible that other covariates (e.g. innovation effort) are also affected by STP location. What matters is the ceteris paribus effect that we want to estimate. We are interested in whether the effect of cooperation is the same, inside and outside an STP, for firms with similar characteristics (e.g. innovation effort). The total effect of STP location on cooperation results will be higher if innovation effort is increased by STP location and positively affects results.

[22] We used information from CRUE and Eurostat to build two indicators: regional university income from applied research, over regional gross internal product and regional employment in R&D industries (CNAE digit 73) over total regional employment.

[23] Heckman estimations are available upon request from the authors.

[24] The test might fail meaning that endogeneity cannot be ruled out completely, but since we have no evidence of it, we decided to employ OLS because our sample is now smaller and the loss of precision caused by an instrumental variables approach would be important.

Table 8 presents the results**.** The first three rows show the mean values for intangible and economic results related to park and non-park firms. The values are higher for firms in STPs (1.68 vs 1.47 for *Effects* and 1.27 vs 1.13 for *Impacts*). The fourth and fifth rows show the results of the regressions with controls, and the propensity score. Both methods reveal a positive and significant effect of STP location on the intangible results of cooperation: location in an STP increases the effect by around 0.13-0.16 (almost a quarter of a standard deviation). This result is robust to average or first factor analysis. We found no effect of location in a park on the economic results from cooperation.

The results for the control variables are presented in Table 9. First, among the general characteristics, size has a positive and significant effect on the intangible results of cooperation. Exports have a positive effect on the economic results from cooperation whereas low tech manufacturing and services have a negative effect. Second, for companies´ innovation activity, the effects of innovative effort and obstacles are positive for both results.

Table 8: ATE estimation of location in Spanish STPs, on results from cooperation for innovation

	Dependent variable	***Effects***	***Fac_Effects***	***Impacts***	***Fac_Impacts***
Means difference	**Companies in an STP**	1.689	0.297	1.278	0.209
	Companies outside an STP	1.479	-0.026	1.133	-0.018
	Difference	0.209[a] (0.055)	0.323[a] (0.084)	0.145[a] (0.053)	0.228[a] (0.085)
Regression with controls (Equation I)		0.137[b] (0.057)	0.212[b] (0.088)	0.084 (0.054)	0.132 (0.086)
Regression with propensity score (Equation II)		0.159[a] (0.055)	0.247[a] (0.086)	0.084 0.054)	0.133 (0.086)
	# of observations	1820			

OLS estimations.
Standard errors in parentheses.
[a] p-value lower than 0.01, [b] p-value lower than 0.05.
All controls from Table 2 are included in the regressions.

Table 9: Results for control variables for results from cooperation for innovation (Equation I)

	Dependent variable	Effects		Fac_Effects		Impacts		Fac_Impacts	
General Company Characteristics	*Company size*	-0.02[c]	(0.01)	-0.03[c]	(0.02)	0.001	(0.01)	0.003	(0.02)
	Company size ^2 [I]	0.001[b]	(0.00)	0.002[b]	(0.00)	-0.000	(0.00)	-0.000	(0.00)
	Exporting behaviour	-0.04	(0.08)	-0.07	(0.13)	0.31[a]	(0.09)	0.47[a]	(0.14)
	Group	-0.04	(0.03)	-0.07	(0.05)	-0.01	(0.03)	-0.01	(0.05)
	Newly established	0.07	(0.07)	0.09	(0.11)	0.00	(0.07)	0.00	(0.11)
	Merged	-0.02	(0.10)	-0.03	(0.16)	0.07	(0.11)	0.11	(0.17)
	Downsized	-0.30[b]	(0.13)	-0.47[b]	(0.21)	-0.01	(0.14)	-0.03	(0.22)
	low-tech manufacturing	-0.08	(0.07)	-0.12	(0.11)	-0.23[a]	(0.07)	-0.37[a]	(0.11)
	medium-low-tech manufacturing	0.02	(0.07)	0.02	(0.11)	-0.07	(0.07)	-0.11	(0.11)
	medium-high-tech manufacturing	-0.09	(0.07)	-0.14	(0.11)	-0.10	(0.07)	-0.16	(0.11)
	knowledge intensity service	0.06	(0.06)	0.10	(0.10)	-0.13[b]	(0.06)	-0.20[c]	(0.10)
	no-knowledge intensity service	-0.02	(0.07)	-0.04	(0.11)	-0.35[a]	(0.07)	-0.55[a]	(0.11)
	other sectors	-0.01	(0.07)	-0.02	(0.12)	-0.32[a]	(0.07)	-0.52[a]	(0.12)
Inn. Act.	*Innovation effort*	0.001[b]	(0.0005)	0.001[b]	(0.0008)	0.001[b]	(0.0006)	0.002[b]	(0.0007)
	Cost obstacles	0.25[a]	(0.09)	0.38[a]	(0.14)	0.14[c]	(0.08)	0.20	(0.13)
	Information obstacles	0.27[b]	(0.12)	0.41[b]	(0.20)	0.24[c]	(0.13)	0.39[c]	(0.20)
Constant		1.25[a]	(0.10)	-0.38[b]	(0.16)	1.11[a]	(0.10)	-0.06	(0.16)
F		4.09 [a]		4.14 [a]		6.59 [a]		6.47 [a]	
R2		0.0345		0.0348		0.0598		0.0585	
# of observations		1820							

[I] The size effect is mainly positive on *Effects* and *Fac_Effects* (the respective critical points are €2,103 and €1,769of firm sales).
High technology manufacturing is used as the baseline category.
Standard errors in parentheses.
[a] p-value lower than 0.01, [b] p-value lower than 0.05, [c] p-value lower than 0.10.
SSTP is included in every regression.

5.3 Why park firms show better intangible results from cooperation?

As discussed in Section 2, an important outcome of proximity is more diverse and longer lasting relationships. Thus, location in an STP could influence the characteristics of firm-EKS cooperations, which might explain why firms on STPs achieve higher intangible results from such cooperation. We explore this in two steps. First we regress the characteristics of the relationships (diversity and length) on location in an STP, and the covariates. Second, we include the characteristics of the relationship in the previous regression to check for changes in the coefficient of STP.

Table 10 shows the results of the first step. Location in an STP positively influences the diversity (by 0.4 or around one-third of a standard deviation) and length (by around 20%) of the relationship.

Table 10: Influence of Spanish STPs on the characteristics of cooperation for innovation

Dependent Variable	Coefficient of *SSTP*	
Diversity	0.397[a]	(0.116)
Length	0.204[a]	(0.069)
# of observations	1820 / 1800 [l]	

OLS estimations with all the covariates.
Standard Errors in parentheses.
[a] p-value lower than 0.01.
[l] If *Length* is the dependent variable, the number of observations is 1800.

Table 11 presents the effects of adding relationship diversity and length to the regression in Table 8. We first include diversity and then length separately, and then include both characteristics together. In all three cases, diversity and length are significant at 1%, meaning that they positively influence the intangible results from cooperation. The coefficient of STP is much lower when relationship diversity is included, but is not affected by relationship length. This suggests that most of the effect of location in an STP on the intangible results from cooperation is due to more diverse relationships of firm located in an STP.

Table 11: Effect of Spanish STPs on the intangible results from cooperation, taking account of diversity and length of the relationship

Dependent variable	***Effects***	***Fac_Effects***
Including *Diversity*		
Regression with controls	0.064 (0.051)	0.101 (0.080)
Regression with propensity score	0.073 (0.056)	0.114 (0.087)
Including *Length*		
Regression with controls	0.120[b] (0.057)	0.187[b] (0.088)
Regression with propensity score	0.131[b] (0.057)	0.204[b] (0.089)
Including *Diversity* and *Length*		
Regression with controls	0.063 (0.052)	0.099 (0.081)
Regression with propensity score	0.072 (0.057)	0.114 (0.088)
# of observations	1820 / 1800[l]	

OLS estimations.
Standard errors in parentheses.
[b] p-value lower than 0.05.
All controls from Table 2 are included in the regressions.
[l] 1800 observations if length is included.

6. CONCLUSIONS

This paper analysed the effect of location in an STP on the likelihood and results of cooperation for innovation and explored the mechanism of this influence. Previous studies analyse the influence of STPs on the likelihood of cooperation, using small samples of firms and STPs, and usually ignoring endogeneity and sample selection issues. The present study contributes by analysing the influence of STPs on both the likelihood of cooperation and on the results of cooperation. We use a very large sample of firms located in several different STPs; the characteristics of the data allow us to use a large set of already proven covariates and, where necessary, to account for endogeneity and sample selection issues.

Our results show that location in an STP has a positive effect on the likelihood of cooperation for innovation. The magnitude of the difference is between 15 and 21 percentage points. This result extends the previous empirical evidence by showing that STPs foster formal cooperation by on-park firms.

We show also that location in an STP positively affects the intangible results of cooperation with the firm's main innovation partner. However, we found no effect of location in an STP on the economic results from cooperation. We explored why the intangible results from cooperation are better for park firms and found that it is likely due to the higher diversity of their relationships with the main partner. Several studies have highlighted the importance of diverse relationships with innovation partners, that include both R&D and non-R&D activities (Preissl, 2006; D'Este and Patel, 2007) and that non-R&D activities have a positive effect on innovation results (Barge-Gil et al., 2011).

It should be noted that the results from cooperation are measured over the short term so some caution is required when interpreting this result. It might be that, in the medium term, several other effects – especially economic ones – will emerge (Ham and Mowery, 1998). Another limitation of this study is data availability. However, both these shortcoming represent directions for future research. For example, it would interesting to know more about the specific collaboration patterns of firms located in an STP, e.g. how these collaborations are formed, the characteristics of collaboration partners, and the role played by the STP management in the collaborative relationship.

To sum up, we have provided evidence that location in an STP increases the likelihood of cooperation for innovation, and increases the intangible results from cooperation with the main innovation partner. Our results suggest also that the effect of STP location on the intangible results from cooperation is driven mainly by the more diverse relationships established by on park firms.

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Appendix

Table A1: Tests of exogeneity of the treatment (*SSTP*)

Dependent variable [I]	***Cooperation***	
I. Wooldridge (2003) [II]		
$\hat{v}$ coefficient	-1.35[a]	(0.196)
II. Hausman Test [III]		
Chi2	47.11[a]	(0.000)
# of observations	39722	

[I] *cooperation* = dummy: cooperation for innovation in 2005-2007.
[II] Standard Errors in parentheses. (v are residuals from the reduced form of the *SSTP* equation, and are included in the structural equation; If $\hat{v}$ coefficient = 0, *SSTP* is exogenous).
[III] Prob>chi2 in parentheses. (The null hypothesis is that *SSTP* is exogenous).
[a] p-value lower than 0.01.