Which firms benefit more from being located in a Science and Technology Park? Empirical evidence for Spain

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ABSTRACT

The aim of this work is to analyse the heterogeneous effect of Science and Technology Parks (STPs) on firms' innovation outcomes, contingent on firms' size and innovation effort. Despite the worldwide diffusion of STPs and the increasing literature aimed at analysing their effect on tenants' performance, empirical evidence on the heterogeneous effect of STPs location on different firms is very scarce. We use information for a representative sample of 39,722 Spanish firms, 653 of them located on 22 of the 25 official Spanish STP. Results show, on the one hand, that firm size is negatively related to an STP location effect and, on the other, that only a small amount of internal innovation effort is required to achieve a very high return from park location. However, firms without innovation efforts do not benefit from a park location. Finally, as internal innovation efforts increase, the park effect reduces, but is still at a high level.

Keywords: Science and Technology Parks, heterogeneous treatment effects, product innovation, firms' internal innovation capabilities, size.

Classification Code: O25, L25, R53

1. INTRODUCTION

Science and Technology Parks (STPs) are policy-driven agglomerations with a management entity, and include firms and several scientific and technology-intensive organizations. They aim at fostering local development by promoting innovation and competitiveness among tenant organizations. To achieve this, they promote and manage knowledge exchange across firms, universities, research organizations and markets, they foster growth in innovative firms and provide high value-added services and a location with a good infrastructure (IASP 2002).

Several studies measure the effect of STP location on indicators of firm performance, such as growth, profitability, survival, innovative output and cooperative behaviour, for a sample of park companies and a control sample of off-park companies, producing mixed results (for a review, see Vásquez-Urriago et al. 2014). A potential explanation for these contrasting results is that the effects are not homogeneous, that is, not all firms benefit equally from being located in a STP. The aim of this work is to analyse the non-linear heterogeneous effects of STPs on firms' innovation outcomes, contingent on their internal innovation capabilities.

We contribute to the literature in two ways. On the one hand, we contribute to the academic debate about which firms benefit more from location in an innovative environment. There are grounds for arguing that the internal innovation capabilities of firms influence the benefits achieved from location in an innovative environment (Lazerson and Lorenzoni 1999; Giuliani 2005; Hervas-Oliver and Albors-Garrigos 2009), although there is no agreement about the direction of the influence (Forman et al. 2008; Huang et al. 2012). On the other hand, we make a step forward in analyzing STPs' influence on firms' innovation outcomes, allowing for heterogeneous, non-linear effects contingent on firms' size and innovation efforts. While some previous studies have analysed some heterogeneous effects, to our knowledge none of the previous studies have accounted for non-linear effects, which are shown to be of great importance. More detailed knowledge of which firms benefit more from STP location is very useful for practitioners and policy makers.

We use the 2007 Spanish Innovation Survey, which included a question about whether the firm was located in a STP and, if so, which park. Our sample includes 39,722 firms, located in 22 out of the 25 official Spanish STP and guarantees a representative picture of the Spanish STP population. Methodologically, we rely on statistical and econometric techniques to analyse the causal effects of programmes or policies (so-called 'treatment effects'), with STP location being the "treatment".

The remainder of this paper is organized as follows: Section 2 reviews the existing literature on the relationship between firms' characteristics and the benefits of location in an innovative environment. Section 3 describes the data and variables and Section 4 explains the methodological approach. Section 5 discusses the results and Section 6 offers some concluding remarks.

2. BENEFITS OF LOCATION IN AN INNOVATIVE ENVIRONMENT, AND FIRM CHARACTERISTICS

Work in economic geography and research on industrial districts and regional agglomerations assume that location in an innovative environment guarantees access to and effective exploitation of the advantages provided by this context. That is, environmental benefits are understood as a ‘passive’ externality (Caniels and Romijn 2003). This approach, which does not consider firms’ characteristics, has been subject to criticisms. For example, Lazerson and Lorenzoni (1999) point out that one of the main weaknesses of most of the industrial district literature is the tacit assumption that firms are relatively homogeneous. Maskell (2001) highlights the absence of a microeconomic foundation in economic geography, and suggests integrating the notion of firm competences to generate a more coherent theoretical framework.

As a consequence, some authors have started to consider that not all the firms benefit homogeneously from location in an innovative environment, and to analyse which firms benefit more and which benefit less. Micro and meso approaches have been combined suggesting that location per se is not enough to benefit from an innovative environment, and that firms’ internal capabilities matter for and determine how external resources are accessed, exploited and combined (Caniels and Romijn 2003; Giuliani 2007; Forman et al. 2008; Hervas-Oliver and Albors-Garrigos 2009). Firm size and innovation effort, which are associated with the costs and benefits of using external sources of knowledge, are the characteristics most frequently employed to proxy for firms’ internal capabilities (Barge-Gil 2010).

Neither the theoretical arguments nor the empirical evidence agrees about the direction of the influence of firms’ internal innovation capabilities on the benefits to be obtained from an innovative environment. Jaffe’ seminal work (1986) suggested that the lower the internal R&D intensity, the lower the benefits from being located on an innovative environment. However, Acs and Audretsch (1987, 1998) show that, in some industries, firms with lower innovation capabilities are able to match the performance of firms with higher innovation capabilities because of their comparative advantage in exploiting the spillovers from knowledge in the environment. On the other hand, firms with higher level innovation capabilities will choose more self-centered innovation strategies.

The main argument supporting the view that firms with more internal innovation capabilities benefit more from innovative environments, lies in the concept of absorptive capacity. Absorptive capacity is defined as the ability to acknowledge the value of external knowledge, and to assimilate and apply it to the firm’s activities (Cohen and Levinthal 1990).[1] The idea is that internal innovation capabilities play a dual role: they generate new knowledge, and they

[1] Several different terms are used to express a similar idea, e.g. intrafirm technological learning (Caniëls and Romijn 2003), and knowledge bases (Giulani 2007).

develop absorptive capacity which increases the ability to benefit from external knowledge. Absorptive capacity is usually discussed in relation to firm size and internal R&D (Barge-Gil 2010), although some studies extend it to other firm activities such as marketing and general management (Hervas-Oliver and Albors-Garrigos 2009; Spithoven et al. 2011).

On the other hand, there are three main arguments supporting the view that firms with lower internal innovation capabilities benefit more from an innovative environment. The first is that the risk of knowledge leakage is smaller for firms with fewer internal innovation capabilities (Audretsch and Feldman 1996; Chun and Mun 2012). The second refers to the 'need' effect: firms with limited internal capabilities are more motivated to access external resources (Shaver and Flyer 2000; Barge-Gil 2010). The barriers to internal R&D (high fixed costs, required critical mass, etc.) mainly affect small firms which are obliged to adopt alternative innovation strategies that put more emphasis on the management of the innovation process, and the exploitation of external knowledge (Rammer et al. 2009). Finally, small firms are usually quick to recognize opportunities in the environment and their small size allows them to be more flexible and to change their structures in order to benefit from these opportunities (Rogers 2004). For example, Spithoven et al. (2011) show that small firms and firms with low absorptive capability are able to use technology intermediaries in order to benefit from external knowledge. Thus, links with other agents are a crucial input for their innovation processes, and allow them to achieve similar performance to firms with higher internal innovative capabilities (Rammer et al. 2009; Nieto and Santamaría 2010). It has been shown that although small firms and firms with low levels internal R&D may be reluctant to use external sources of knowledge, once links are established they are used more intensively (Barge-Gil 2010).

To sum up, the importance of firms' internal innovative capabilities for benefiting from external knowledge has become a major research topic. However, there is a lack of agreement on the direction of the effect, with arguments supporting and rejecting positive and negative relationships. This points to the importance of empirical studies to show which effect prevails in the real world.

In the empirical literature focused specifically on the STP effect on firms' innovation outcomes, most studies assume homogeneity according to firms' characteristics (Colombo and Delmastro, 2002; Löfsten and Lindelöf, 2002; Siegel et al, 2003; Lindelöf and Löfsten, 2004; Dettwiler et al, 2006; Fukugawa, 2006; Squicciarini, 2008 and Yang et al., 2009; Vásquez-Urriago et al., 2014; Vásquez-Urriago et al., 2016). However, to our knowledge, only Huang et al. (2012) and Liberati et al. (2015) analyse heterogeneous effects[2]. Huang et al (2012) focus on the Taiwanese

[2] Other authors analyze only on-Park firms according to some characteristic. For example, Löfsten and Lindelöf (2005) find that academic spin-offs in Swedish parks establish more links with universities that private spin-offs from the same locations. Soetanto and Jack (2013) analyze small NTBFs located in UK business incubators and find that highly innovative firms establish closer links with other firms in the incubator and with universities. This is a different approach as no comparison with firms outside parks/business incubators is made. However, they emphasize the importance of taking account of firm heterogeneity.

Information and Communication Technologies (ICT) industry, and allow for different STP effects depending on the size and internal R&D capability of firms. They use regression analysis and linear interaction terms between STP location and these firms' characteristics. Their results suggest that smaller firms, and firms with fewer internal R&D capabilities benefit more from location in a STP, because it helps to attract excellent workers and specialized skills, and in the acquisition of technologies and funding for innovative projects. On the other hand, Liberati et al. (2015) analyze the Italian STP effect on hosted firms, using a representative sample of firms. They allow for different STP effect according to firm size and age. Their results indicate that STPs have a (significant) positive effect on sales and investment of the oldest and smallest firms[3].

3. DATA AND VARIABLES EMPLOYED

The data are from the 2007 Spanish Survey on Technological Innovation in Companies, managed by the National Statistical Institute (INE). This survey is modelled on the Community Innovation Surveys (CIS), and is conducted annually. The 2007 survey included a question about company location in a STP or not, and asked for detailed information on the general characteristics and innovation activities of the firm.

The sample population is 39,722 companies, representative of the size, sector and regional location of the population of Spanish companies.[4] They include firms located on 22 out of the 25 official Spanish STPs, which allows a representative picture of the Spanish STPs population.

3.1. Dependent variable

The dependent variable is sales from firms' product innovations (*NEWMAR*), and is defined based on the responses to a question in the survey on the percentage of company sales from product innovations that are new to the market. Most of the recent empirical literature on innovation uses indicators related to sales of innovative products as the dependent variables (for a review, see Vásquez-Urriago et al. 2014); these indicators do not have the problems related to use of R&D, and numbers of patents and innovations. As highlighted by Vásquez-Urriago et al, (2014), *R&D* investment is an input and not a good measure of output (Love and Roper 1999; Negassi 2004); while *patents* measure inventions (not innovation) that may or may not result in commercialization and economic advantage, and are very unequal across sectors (Griliches 1990; Love and Roper 1999; Faems et al. 2005). Finally, *number of innovations* does not necessarily equate with economic success (Negassi 2004). The benefits from using indicators based on sales from new products include: their applicability to all sectors, their

[3] In addition, they analyze park heterogeneity (age, property). Due to data availability restrictions, we were not able to address park heterogeneity in our study.

[4] The specific characteristics of this sample are available on the INE webpage: http://www.ine.es/ioe/ioeFicha.jsp?cod=30061. We were granted access to confidential data in secured places from the Spanish Institute of Statistics.

suitability for differentiating among types of innovations, and that they are continuous variables which is an advantage for econometric analysis (Kleinknecht et al. 2002; Negassi 2004)

It should be noted that we focus only on new-to-the-market products because they proxy for true innovation and exclude imitations (products new to the firm).[5] Following previous studies, we define two different indicators:

$$LNEWMAR = \log\left[1 + \left(\frac{salesnewproducts}{totalsales} * 1000\right)\right]$$

$$LNEWMARL = \log\left[1 + \left(\frac{salesnewproducts}{totalstaff}\right)\right]$$

Where *salesnewproducts* stands for the total amount of sales (in 2007) from new to the market products (introduced in the period 2005-2007), *totalsales* are total sales in 2007 and *totalstaff* are the number of employees in 2007[6]. LNEWMAR is based on the work by Brouwer and Kleinknecht (1996), Mairesse and Mohnen (2005), Laursen and Salter (2006), Falk (2007), Aschhoff and Schmidt (2008) and Czarnitzki and Hottenrott (2009) among others. However, it disadvantages firms where old products lines coexist with new ones. This problem is partially overcome by our second indicator, which can be understood as a measure of innovation 'productivity' (Tsai 2009; Frenz and Ietto-Gillies 2009).

3.2. Treatment variable

Our treatment variable is park location. The binary variable (*SSTP*) takes the value 1 if the firm is located in a park and zero otherwise. We consider only those parks recognized by the Spanish Association of Scientific and Technology Parks (APTE). This results in a sample of 653 on park firms (1.64% of total sample).

3.3. Internal innovation capabilities

We proxy internal innovation capabilities by size and innovation effort. Since SMEs face barriers to formal R&D activities (Rammer et al. 2009; Chun and Mum 2012), we use firm's innovation effort which, in addition to R&D, includes investment in other activities: acquisition of machinery and equipment to innovate, acquisition of external knowledge (such as licences), design, innovation-related training, and marketing of innovative products. We use log of total sales (in 2005) to proxy for size (*LSALES*) and log of total innovation expenses per employee (in 2007)

[5] For non-innovative firms (firms that did not introduce a new or significantly improved product in 2005-2007) 100% of their sales are categorized as unchanged or slighty improved products.
[6] Following Faems et al. (2005) and Laursen and Salter (2006), we calculate the log after adding one unity to the variable so that those firms with zero sales from new-to-the-market products are left with a zero after the log is applied. To minimize the impact of such transformation we multiply per mile instead of per cent.

to proxy for innovation effort (*LINN_EFFORT*). We use the squared terms to account for non-linear effects.

3.4. Control variables

Controlling for other firm characteristics that might be related to STP location and internal innovation capabilities is crucial to achieve unbiased estimates. Utilization of CIS-type data allows us to exploit a wide set of already tested covariates. We control for belonging to a group because group firms are expected to be more innovative than independent firms (Mohnen et al. 2006). We control also for export behaviour, because exporters face a more competitive environment which might influence innovation outcomes (Cassiman and Veugelers 2006; Mohnen et al. 2006), and for type of industry because firms in high tech industries benefit from higher technological opportunities (Klevorick et al. 1995). We include proxies for innovation obstacles which can affect innovation performance (Cassiman and Veugelers 2006). Finally, following Falk et al. (2007), we include dummy variables to control for new firm, increased income due to a merger, and reduced income due to closure or sale of parts of the firm (Table 1)[7]. The descriptive statistics are presented in Table 2.

Table 1: Definition of control variables

Group	Dummy variable is 1 if the company belongs to a group
Exporting behaviour	Share of export per total turnover, in 2005
Technological level of sectors of activity	7 dummy variables: high-tech manufacturing (reference category), medium-high-tech manufacturing, medium-low-tech manufacturing, low-tech manufacturing, knowledge intensity service, no-knowledge intensity service, other sectors[a]
Cost obstacles	Average measure of importance of the following factors as a barrier to innovation during 2005-2007: lack of internal funds, lack of sources of finance, high costs of innovating, market dominated by established enterprises[b]
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 markets, difficulty to find cooperation partners[b]
Newly established	Dummy variable is 1 if the company was established during 2005-2007
Merged	Dummy variable is 1 if turnover increased by 10% or more due to a merger with another company during 2005-2007
Downsized	Dummy variable is 1 if turnover decreased by 10% or more owing to sale or closure of part of the company during 2005-2007

[a] Classification of manufacturing and services (OECD, 2005). Other sectors are: agriculture; extractive activities; production and distribution of electricity, gas and water; construction.
[b] The survey codes importance on the scale from 1(crucial) to 4 (unimportant). We compute an indicator equal to [n / ∑ factors importance] and then reversed the code so that higher values of our indicator means more obstacles and lower levels mean lower obstacles.

[7] Our data does not provide any other measure for firm age. We acknowledge that the dummy variable for newly established firms is a very imperfect indicator for age.

Table 2: Description of variables

<table>
<tr><th colspan="2">VARIABLE</th><th>Mean</th><th>Median</th><th>Standard Deviation</th><th>Min.</th><th>Maxim.</th></tr>
<tr><td colspan="2">Dependent variable</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">NEWMAR</td><td>41.83</td><td>0</td><td>161.09</td><td>0</td><td>1000</td></tr>
<tr><td colspan="2">LNEWMAR</td><td>0.64</td><td>0</td><td>1.76</td><td>0</td><td>6.90</td></tr>
<tr><td colspan="2">NEWMARL</td><td>8157.22</td><td>0</td><td>67024.04</td><td>0</td><td>5087038</td></tr>
<tr><td colspan="2">LNEWMARL</td><td>1.25</td><td>0</td><td>3.33</td><td>0</td><td>15.44</td></tr>
<tr><td colspan="2">Treatment variable</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">SSTP</td><td>0.016</td><td>0</td><td>0.127</td><td>0</td><td>1</td></tr>
<tr><td colspan="2">Internal innovation capabilities</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">SALES</td><td>2.55e+07</td><td>2.58e+06</td><td>3.43e+08</td><td>0</td><td>5.10e+10</td></tr>
<tr><td colspan="2">LSALES</td><td>13.71</td><td>14.76</td><td>4.64</td><td>0</td><td>24.65</td></tr>
<tr><td colspan="2">INN_EFFORT [a]</td><td>4479.92</td><td>0</td><td>29834.72</td><td>0</td><td>4460000</td></tr>
<tr><td colspan="2">LINN_EFFORT</td><td>2.95</td><td>0</td><td>4.03</td><td>0</td><td>15.31</td></tr>
<tr><td colspan="2">Control variables</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Group</td><td>0.263</td><td></td><td>0.440</td><td>0</td><td>1</td></tr>
<tr><td colspan="2">Exporting behaviour</td><td>0.031</td><td></td><td>0.117</td><td>0</td><td>1</td></tr>
<tr><td rowspan="7">Technological level of sectors of activity</td><td>Low-tech manufacturing</td><td>0.166</td><td></td><td>0.372</td><td>0</td><td>1</td></tr>
<tr><td>Medium-low-tech manufacturing</td><td>0.135</td><td></td><td>0.341</td><td>0</td><td>1</td></tr>
<tr><td>Medium-high-tech manufacturing</td><td>0.097</td><td></td><td>0.296</td><td>0</td><td>1</td></tr>
<tr><td>High-tech manufacturing[b]</td><td>0.026</td><td></td><td>0.162</td><td>0</td><td>1</td></tr>
<tr><td>Knowledge intensity service</td><td>0.111</td><td></td><td>0.314</td><td>0</td><td>1</td></tr>
<tr><td>No-knowledge intensity service</td><td>0.345</td><td></td><td>0.475</td><td>0</td><td>1</td></tr>
<tr><td>Other sectors</td><td>0.118</td><td></td><td>0.323</td><td>0</td><td>1</td></tr>
<tr><td colspan="2">Cost obstacles</td><td>0.816</td><td></td><td>0.207</td><td>0.25</td><td>1</td></tr>
<tr><td colspan="2">Information obstacles</td><td>0.873</td><td></td><td>0.161</td><td>0.25</td><td>1</td></tr>
<tr><td colspan="2">Newly established</td><td>0.040</td><td></td><td>0.196</td><td>0</td><td>1</td></tr>
<tr><td colspan="2">Merged</td><td>0.018</td><td></td><td>0.133</td><td>0</td><td>1</td></tr>
<tr><td colspan="2">Downsized</td><td>0.016</td><td></td><td>0.129</td><td>0</td><td>1</td></tr>
<tr><td colspan="2"># of companies</td><td colspan="5">39722</td></tr>
<tr><td colspan="7">[a] Due to the presence of extreme values, we winsorized innovation investment (percentile 99) before generating the innovation effort
[b] This is the reference category in the regressions</td></tr>
</table>

4. METHODOLOGY

We rely on statistical and econometric methods to analyse the causal effects of programmes or policies,[8] (so-called ‘treatment effects’), drawing on the *Rubin Causal Model* (Wooldridge 2002) and the *Neyman-Rubin Counterfactual Framework* (Guo and Fraser 2010). In the present work, the ‘treatment’ is location in a park.

The main econometric problem in estimating treatment effects is selection bias, which arises when treated and non-treated individuals differ in other respects than treatment status (Imbens and Wooldridge 2009). This is expected to apply to STP firms because there are usually some conditions for park location (Vásquez-Urriago et al. 2014). Thus, treatment evaluations must

[8] For a revision of the literature, see Imbens and Wooldridge (2009) or Guo and Fraser (2010).

take account of which part of the observed difference in results might be attributed to treatment status rather than other differences across individuals (Guo and Fraser 2010)

If a difference is observed between treated and non-treated individuals, then regression analysis can be used to estimate treatment effects. The crucial assumption would be that, conditional on observed covariates, (X), there are no unobservable factors that simultaneously affect treatment assignment and potential results (*Conditional Independence Assumption).* For this method to be successful, it is important to have a wide set of covariates that are related to treatment assignment (Wooldridge, 2002). Fortunately, the Spanish Innovation Survey allows for a wide set of covariates. Also, Vásquez-Urriago et al. (2014) shows that regression analysis estimates of the average effects of Spanish STPs on innovation outcome yield similar results to those obtained by methods that relax the conditional independence assumption, such as instrumental variables. Regression analysis of average treatment effects is represented in equation (I):

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

where $\hat{\alpha}$ is the estimated effect of being located in a Spanish STP.

The main objective in this work is to analyse which firms obtain higher effects from being located in a STP. This means that treatment effect should be considered heterogeneous (Angrist, 2004) and that the previous equation should be rewritten as:

$$Y = \lambda + \alpha\,(SSTP) + \delta[SSTP * (C_i - \overline{C}_i)] + \theta(C_i - \overline{C}_i) + \sum_{j=1}^{m-i} \beta_j X_j + u \quad \text{(II)}$$

where C_i are firms' characteristics. In this work we will analyze the role played by firm's internal capabilities using two different variables: *LSALES* and *LINN_EFFORT,* Two different equations are estimated, for C_i=*LSALES* and for C_i=*LINN_EFFORT*. The partial effect of SSTP in equation (II) is now: $\hat{\alpha} + \hat{\delta}(C_i - \overline{C}_i)$. That is, the park effect is allowed to be different for firms with different characteristics C_i. If $\hat{\delta}$ >0, it means that the park effect is higher the higher the value of C_i. Conversely, if $\hat{\delta}$ <0, it means that the park effect is lower the higher the value of C_i. Finally, if $\hat{\delta}$ =0, it means that the park effect do not vary with C_i. We include the demeaned C_i so that $\hat{\alpha}$ still estimates the park average treatment effect[9].

[9] Note that, if C_i is not demeaned, $\hat{\alpha}$ would be the park effect for a firm with C_i=0

One important issue is the existence of non-linear interaction effects. To address this, we also analyse squared terms:

$$Y = \lambda + \alpha (SSTP) + \delta_1 [SSTP * (C_i - \overline{C}_i)] + \delta_2 [SSTP * (C_i - \overline{C}_i)^2] + \theta_1 (C_i - \overline{C}_i) + \theta_2 (C_i - \overline{C}_i)^2 + \sum_{j=1}^{m-i} \beta_j X_j + u \qquad \text{(III)}$$

In this case the partial effect of SSTP is: $\hat{\alpha} + \hat{\delta}_1 (C_i - \overline{C}_i) + 2\hat{\delta}_2 (C_i - \overline{C}_i)$. Accordingly, the influence of Ci is allowed to vary across different levels of Ci.

We estimate the above equations using ordinary least squares (OLS) and Tobit. We report the OLS results because OLS directly provides marginal effects. In practice, marginal effects from non-linear models, such as Tobit, are usually very similar to those obtained from OLS when values close to the average of the explanatory variables are used (Angrist and Pishke, 2008). The results for the Tobit models are similar to the results presented here and are available upon request from the authors.

5. RESULTS

5.1. Homogeneous effects

Before analysing heterogeneous effects, we provide the results of the estimation of equation I, considering homogeneous effects (Table 3).

The results show that park location has a positive and significant effect on firms' innovation output. The size of the effects is important: firms located in parks have around 71% more sales from new products and around 94% more sales of new products per employee[10].

The influence of size on firms' innovation output is U shape, but with a very low critical point,[11] so that the effect is mainly positive and increasing in size. The influence of the innovation effort is positive and increasing. For the other covariates, we find that belonging to a group and exporting have a positive effect on sales from new to the market products, but belonging from a

[10] As dependent variables are log(x+1), the corresponding effect, in percentage, is: $\exp(\alpha) - 1$, where α is the coefficient of *SSTP*. For example, in the case of *LNEWMAR*, the effect is calculated as: exp(0.538)-1.

[11] 243 euros for *LNEWMAR* and 517 euros for *LNEWMARL.* These critical points are calculated as follows. For example, the critical point (*LSALES**) is as $LSALES^* = \exp\left(\frac{\beta_{LSALES}}{2\beta_{LSALES^2}}\right) - 1$, where β_{LSALES} is the coefficient of *LSALES* and β_{LSALES^2} is the coefficient of *LSALES*^2.

non-high tech industry has a negative effect. These results are in line with previous studies (Klevorick et al. 1995; Cassiman and Veugelers 2006; Mohnen et al. 2006). The effect of cost obstacles is positive, in line with Pellegrino and Savona (2013), while we find no significant effect for information obstacles. Finally, recently merged firms have better innovation outcomes, while we find no effect for downsized firms.

5.2. Heterogeneous linear effects

We start the analysis of heterogeneous effects assuming that they are the linear (equation II). Table 4 shows the results for firm size and innovation effort.

When we analyse heterogeneous linear effects, the park location effect increases with size when the dependent variable used is *LNEWMARL:* a firm that is twice as large will achieve around a 4% higher effect from park location. On the other hand, with *LNEWMAR* no heterogeneous effects are found. Regarding innovation effort, the STP location effect increases with firm innovation effort, regardless of the indicator used. If the firm doubles its innovation effort it will achieve around a 4.3% higher effect of park location for *LNEWMAR* and around a 4.8% higher effect for *LNEWMARL.*

Table 3: Effects of location in Spanish STPs, on firms' innovation product (homogeneous effects)

	LNEWMAR		***LNEWMARL***	
SSTP	0.538***	(0.109)	0.664***	(0.184)
LSALES	-0.022***	(0.007)	-0.100***	(0.013)
LSALES^2	0.002***	(0.000)	0.008***	(0.000)
LINN_EFFORT	0.022	(0.014)	0.092***	(0.025)
LINN_EFFORT ^2	0.017***	(0.002)	0.026***	(0.002)
Group	0.055**	(0.021)	0.014***	(0.040)
Exporting behaviour	0.778***	(0.099)	1.523***	(0.189)
Low-tech manufacturing	-0.477***	(0.074)	-0.977***	(0.140)
Medium-low-tech manufacturing	-0.426***	(0.075)	-0.876***	(0.142)
Medium-high-tech manufacturing	-0.204***	(0.079)	-0.374**	(0.149)
Knowledge intensity service	-0.123	(0.079)	-0.461***	(0.147)
No-knowledge intensity service	-0.545***	(0.072)	-1.142***	(0.136)
Other sectors	-0.551***	(0.073)	-1.114***	(0.136)
Cost obstacles	-0.386***	(0.056)	-0.698***	(0.103)
Information obstacles	0.049	(0.064)	0.093	(0.118)
Newly established	0.025	(0.055)	-0.156*	(0.093)
Merged	0.149**	(0.068)	0.317**	(0.135)
Downsized	0.077	(0.054)	0.128	(0.099)
Constant	0.223***	(0.079)	0.468***	(0.149)
F	340.38***		362.77***	
R2	0.23		0.23	
# of companies	39722			

High-tech manufacturing is the reference category for sectors.
Standard errors in parentheses.
***p-value<0.01, ** p-value<0.05, * p-value<0.1.

Table 4: Effects of location in Spanish STPs on firms' innovation product (heterogeneous linear effects)

	Size				Innovation Effort			
	LNEWMAR		LNEWMARL		LNEWMAR		LNEWMARL	
SSTP	0.560***	(0.110)	0.794***	(0.194)	0.285***	(0.107)	0.424**	(0.193)
SSTP *(LSALES-mean)	0.012	(0.019)	0.066**	(0.030)	-----	-----	-----	-----
LSALES-mean	0.015***	(0.002)	0.039***	(0.004)	-----	-----	-----	-----
SSTP * (LINN_EFFORT-mean)	-----	-----	-----	-----	0.071***	(0.021)	0.080**	(0.035)
LINN_EFFORT –mean	-----	-----	-----	-----	0.167***	(0.003)	0.323***	(0.005)
LINN_EFFORT	0.031**	(0.014)	0.125***	(0.025)	-----	-----	-----	-----
LINN_EFFORT ^2	0.016***	(0.002)	0.023***	(0.003)	-----	-----	-----	-----
LSALES	-----	-----	-----	-----	-0.012	(0.007)	-0.084***	(0.014)
LSALES^2	-----	-----	-----	-----	0.001***	(0.000)	0.007***	(0.001)
Group	0.104***	(0.020)	0.326***	(0.038)	0.059***	(0.021)	0.145***	(0.041)
Exporting behaviour	0.816***	(0.099)	1.667***	(0.190)	0.802***	(0.099)	1.561***	(0.190)
Low-tech manufac.	-0.473***	(0.074)	-0.961***	(0.141)	-0.540***	(0.074)	-1.077***	(0.141)
Medium-low-tech m.	-0.421***	(0.075)	-0.855***	(0.143)	-0.490***	(0.075)	-0.977***	(0.142)
Medium-high-tech m.	-0.199**	(0.079)	-0.356**	(0.150)	-0.264***	(0.079)	-0.470***	(0.150)
Knowledge intensity s.	-0.129	(0.079)	-0.483***	(0.148)	-0.118	(0.079)	-0.451***	(0.148)
No-knowle. intensity s.	-0.544***	(0.072)	-1.133***	(0.137)	-0.599***	(0.072)	-1.226***	(0.137)
Other sectors	-0.553***	(0.074)	-1.121***	(0.140)	-0.610***	(0.074)	-1.207***	(0.139)
Cost obstacles	-0.359***	(0.056)	-0.595***	(0.103)	-0.375***	(0.056)	-0.679***	(0.104)
Information obstacles	0.046	(0.064)	0.083	(0.118)	0.058	(0.064)	0.109	(0.118)
Newly established	0.054	(0.055)	-0.041	(0.093)	0.073	(0.055)	-0.076	(0.093)
Merged	0.158**	(0.068)	0.351**	(0.136)	0.134**	(0.068)	0.293**	(0.135)
Downsized	0.072	(0.054)	0.109	(0.100)	0.077	(0.054)	0.127	(0.100)
Constant	0.374***	(0.074)	0.808***	(0.140)	0.787***	(0.079)	1.534***	(0.148)
F	338.19***		360.19***		336.52***		358.82***	
R2	0.22		0.23		0.22		0.23	
# of companies	39722							
High-tech manufacturing is the reference category for sectors. Standard errors in parentheses. ***p-value<0.01, ** p-value<0.05, *p-value<0.1.								

5.3. Heterogeneous non linear effects

We turn now the attention to heterogeneous non-linear effects. Table 5 shows the results.

5.3.1. By size

The results suggest that there is a non-linear relationship between firm size and effect of park location (Table 5, columns 1 and 2). Graph 1 plots this relationship comparing it with the one obtained under the linear assumption.[12] We see that taking account of non-linear effects is crucial. For *LNEWMAR*, when linear effects are considered a not significant relationship is observed. However, when non-linear effects are analysed we obtain a clear inverted U-shaped relationship. It should be noted that the maximum effect is obtained for very small sized firms (*LSALES* = 8.77, i.e. sales of €6,500)[13] (Graph 1A), meaning that in practical terms smaller firms benefit more from STP location than larger firms (Graph 1B). To illustrate, if we use the thresholds proposed by the European Commission to classify firms as micro, small, medium and large, we find that the STP location effect would be 90% for a firm with sales of €2million, 55.2% for a firm with €10million and 20.57% for a firm with sales of €50milion. When the linear, non-significant effects are analysed these figure are: 76.8%, 80.3% and 83.9%, respectively. For the dependent variable *LNEWMARL*, the results are similar. Again, we find an inverted U shaped effect with a very low critical point (in this case, around €63,000) (Graph 2A). Effects for the different points are: 164.9%, 122.9% and 75.7% respectively, for €2million€, €10million and €50million (Graph 2B). That is, the effect of being located in a STP for micro firms is more than double that for medium firms.

5.3.2. By innovation effort

The results suggest that there is also a non-linear relationship between firms' innovation effort and effect of park location (Table 5, columns 3 and 4). Graph 3 shows the park location effect based on innovation effort taking account of linear and non-linear effects. For *LNEWMAR*, while park location effect clearly increases with innovation effort when linear effects are considered, analysis of non linear effects shows that the effect is U shaped. The turning point again corresponds to a quite low level (*LINN_EFFORT* = 6.47, i.e. innovation expenses of €643 per employee). In the case of innovation effort it is important to recall that 63.5% of firms in STPs are not involved in innovation. To illustrate, the park location effect is 3.1% for firms with no innovation efforts, 135% for firms with innovation efforts of €2,000 per employee, and 89.8% for

[12] All graphs plot the STP effect for observations below the 99th percentile.
[13] Note that 9.04% of firms report zero sales. Most are new firms.

firms with an innovation effort of €20,000 per employee.[14] When the linear effect is analysed these figures are: 7.8%, 84.8% and 117.6% respectively.

When the dependent variable is *LNEWMARL* the main results hold, with the turning point at around €346 per employee. The park location effect becomes 6.47% for firms with no innovation efforts, 261.9% for firms with an innovation effort of €2,000 per employee and 114.2% for firms with an innovation effort of €20,000 per employee. Under the linear effect assumption, these figures are 20.8%, 121.1% and 165.5% respectively (Graph 4).

To sum up, the effect of location on a STP clearly depends on firms' size and innovation effort, and the relationship is non-linear. In relation to size, we find that smaller firms benefit much more than large firms from park location, which is in line with Huang et al. (2012) and Liberati et al. (2015). Regarding innovation effort, it should be noted that firms with no internal innovation efforts do not benefit from being located in a STP. However, only a low level of innovation effort is needed to achieve a STP location effect and, in fact, the maximum effect is achieved at relatively low levels of innovation effort (around €350-650 per employee). As innovation effort increases, the effect of being located in a STP decreases, but remains at a high level.

[14] An innovation effort of €20,000 per employee corresponds to percentile 95, while an innovation effort of €2,000 euros per employee is around percentile 78 in the distribution of firms' innovation effort.

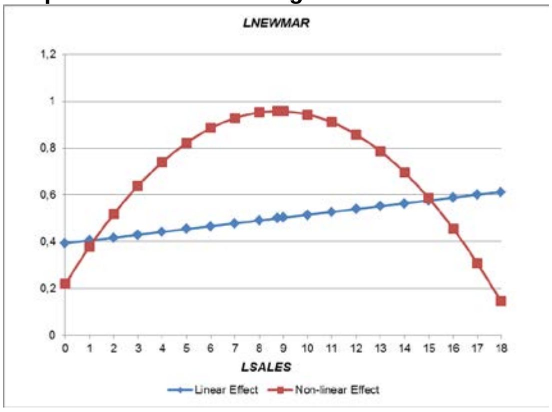
Table 5: Effects of location in Spanish STPs on firms' innovation product (heterogeneous non-linear effects)

	Size				***Innovation Effort***			
	LNEWMAR		***LNEWMARL***		***LNEWMAR***		***LNEWMARL***	
SSTP	0.724***	(0.136)	1.036***	(0.226)	0.630***	(0.205)	1.077***	(0.356)
SSTP *(LSALES-mean)	-0.095**	(0.049)	-0.067	(0.087)	-----	-----	-----	-----
SSTP *(LSALES-mean)^2	-0.010**	(0.004)	-0.013**	(0.007)	-----	-----	-----	-----
LSALES-mean	0.040***	(0.005)	0.131***	(0.010)	-----	-----	-----	-----
(LSALES-mean)^2	0.002***	(0.000)	0.009***	(0.001)	-----	-----	-----	-----
SSTP * (LINN_EFFORT-mean)	-----	-----	-----	-----	0.143***	(0.045)	0.227***	(0.079)
SSTP * (LINN_EFFORT-mean)^2	-----	-----	-----	-----	-0.020**	(0.010)	-0.039**	(0.017)
LINN_EFFORT –mean	-----	-----	-----	-----	0.118***	(0.005)	0.244***	(0.009)
(LINN_EFFORT –mean)^2	-----	-----	-----	-----	0.017***	(0.002)	0.027***	(0.003)
LINN_EFFORT	0.022	(0.014)	0.090***	(0.025)	-----	-----	-----	-----
LINN_EFFORT ^2	0.017***	(0.002)	0.027***	(0.003)	-----	-----	-----	-----
LSALES	-----	-----	-----	-----	-0.023***	(0.007)	-0.102***	(0.014)
LSALES^2	-----	-----	-----	-----	0.002***	(0.000)	0.008***	(0.001)
Group	0.053**	(0.021)	0.133***	(0.041)	0.055***	(0.021)	0.139***	(0.041)
Exporting behaviour	0.775***	(0.099)	1.515***	(0.190)	0.780***	(0.099)	1.527***	(0.190)
Low-tech manufac.	-0.478***	(0.074)	-0.973***	(0.140)	-0.476***	(0.074)	-0.974***	(0.140)
Medium-low-tech m.	-0.428***	(0.075)	-0.873***	(0.142)	-0.426***	(0.075)	-0.874***	(0.142)
Medium-high-tech m.	-0.204***	(0.078)	-0.370**	(0.149)	-0.205***	(0.078)	-0.375**	(0.149)
Knowledge intensity s.	-0.126	(0.079)	-0.459***	(0.147)	-0.125	(0.079)	-0.461***	(0.147)
No-knowle. intensity s.	-0.548***	(0.072)	-1.141***	(0.137)	-0.547***	(0.072)	-1.141***	(0.137)
Other sectors	-0.552***	(0.073)	-1.113***	(0.139)	-0.552***	(0.073)	-1.113***	(0.139)
Cost obstacles	-0.386***	(0.056)	-0.700***	(0.104)	-0.387***	(0.056)	-0.699***	(0.104)
Information obstacles	0.050	(0.064)	0.098	(0.118)	0.049	(0.064)	0.094	(0.118)
Newly established	0.036	(0.055)	-0.117	(0.093)	0.025	(0.055)	-0.152	(0.093)
Merged	0.147**	(0.068)	0.315**	(0.135)	0.147**	(0.068)	0.314**	(0.135)
Downsized	0.078	(0.054)	0.127	(0.100)	0.079	(0.054)	0.131	(0.100)
Constant	0.334***	(0.074)	0.653***	(0.140)	0.427***	(0.084)	0.952***	(0.158)
F	307.01***		327.27***		306.70***		326.79***	
R2	0.23		0.23		0.23		0.23	
F (*SSTP * (C_i –mean).* SSTP * *(C_i –mean)^2*)	2.77**		4.85***		6.50***		4.28**	
# of companies	39722							

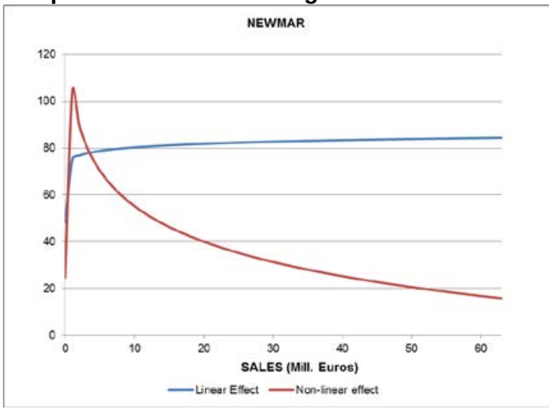
High-tech manufacturing is the reference category for sectors.
Standard errors in parentheses.
***p-value<0.01, **p-value<0.05, *p-value<0.1.

Graph 1: Effects of location in Spanish STPs on sales of new-to-the-market products by firm size

Graph 1A: Variables in logs

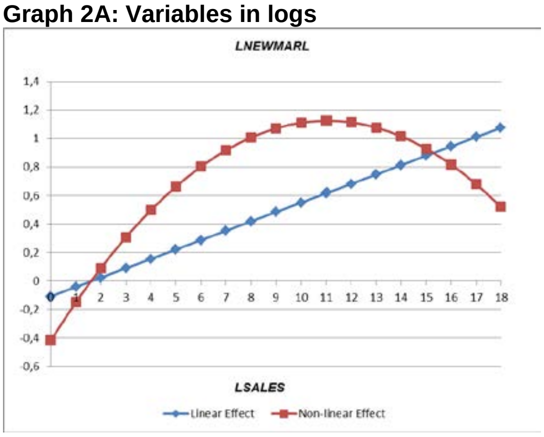


Graph 1B: Variables in original values

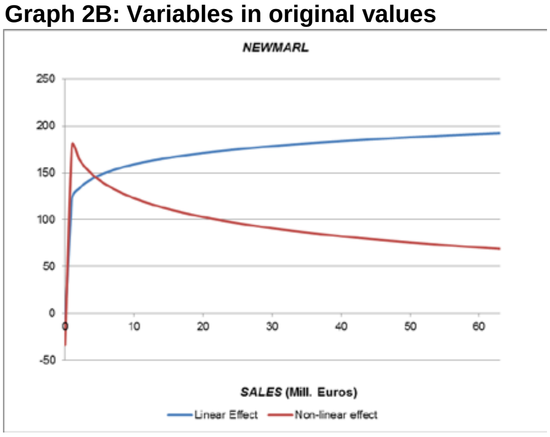


Graph 2: Effects of location in Spanish STPs on sales per employee of new-to-the-market products by firm size

Graph 2A: Variables in logs

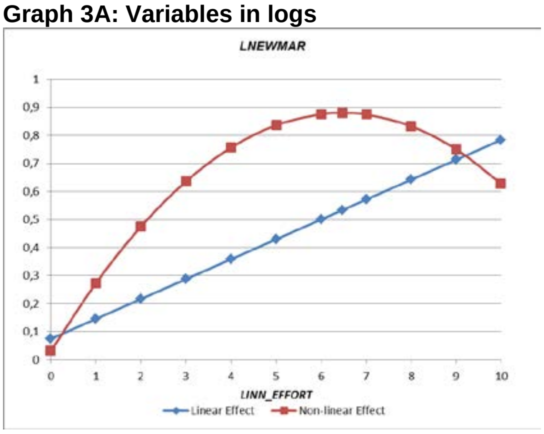


Graph 2B: Variables in original values

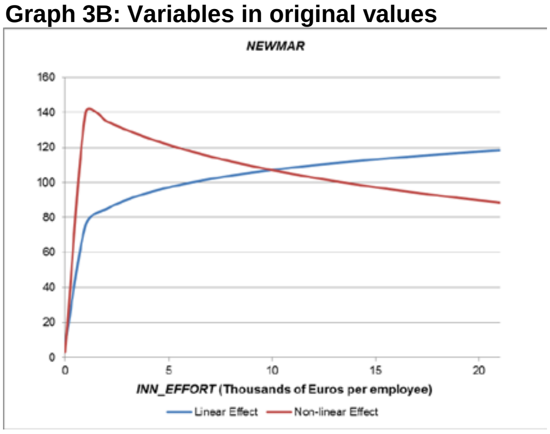


Graph 3: Effects of location in Spanish STPs on sales of new-to-the-market products by innovation effort

Graph 3A: Variables in logs

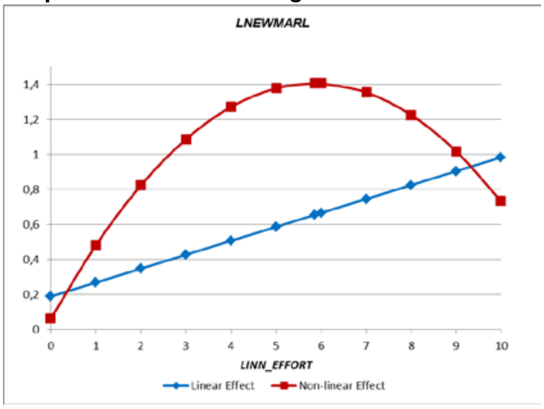


Graph 3B: Variables in original values

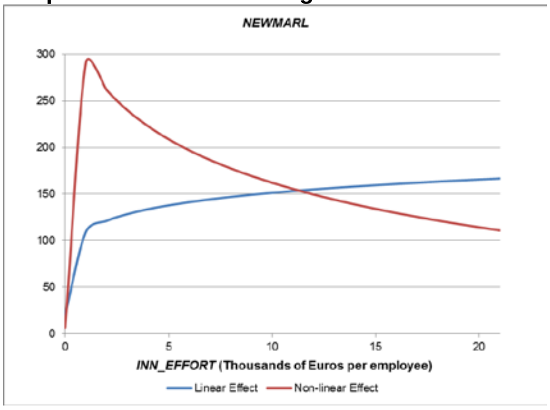


Graph 4: Effects of location in Spanish STPs on sales per employee of new-to-the-market products by innovation effort

Graph 4A: Variables in logs



Graph 4B: Variables in original values



6. CONCLUSIONS

The aim of this work was to analyse which firms benefit more from being located in a Science and Technology Park. We make two main contributions to the literature. We contribute to the open debate about which firms benefit more from location in an innovative environment and we advance analysis of STP influence on firms' innovation outcomes by allowing for heterogeneous, non-linear, effects contingent on firms' characteristics as opposed to previous analyses which focus mainly on homogeneous effects.

We focus on sales from new-to-the-market product as the indicator of innovation outcome and take advantage of the Spanish Innovation Survey, which in year 2007 included a question about location in a park, and which park. Our final sample includes 39,722 firms, of which 653 are located in 22 of the 25 official Spanish STP, which guarantees a representative picture of the Spanish STP population.

Our results show that park location has a high, positive effect on firms' innovation outcomes, and that this effect varies with firms' internal innovation capabilities. In addition, we show the importance of taking account of non-linear effects. On the one hand, we find that firms of all sizes benefit from STP location, although small firms benefits more than large firms This result agrees with the view that small firms benefit more than large firms from innovative environments (Rogers 2004; Rammer et al. 2009).

On the other hand, the results for innovation effort to some extent reconcile the views in the current debate on the role of internal innovation capabilities. Firms without innovation efforts barely benefit from park location, providing evidence that some level of absorptive capacity is needed to benefit from location in a STP. However, just a small amount of internal innovation effort achieves very high returns from park location. As internal innovation efforts increase, the park effect decreases but remains still at a high level.

This study is not without limitations. For example, we do not know the channels through which the smaller firms and the firms with low innovation effort achieve very high returns from park location. It could well be that large firms presence is a key driver. An interesting line for future research would be to investigate park ecology to understand how effects take place. Other limitation is that, due to data availability restrictions, we were not able to account for park heterogeneity. This is also an interesting line for future research. Finally, we could not observe longitudinal data. This means that within firm variation in park location could not be used to estimate the park effects. They are based upon variation across firms only. Other interesting line for future research would be to compare firm performance before and after entering a park if such data are available.

Acknowledgments

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