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

Vásquez-Urriago, Angela and Barge-Gil, Andrés and Modrego, Aurelia

Universidad Carlos III de Madrid, Universidad Complutense de Madrid, Universidad Carlos III de Madrid

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Ángela Rocío Vásquez-Urriago
Research Assistant, Laboratory of Analysis and Evaluation of Technical Change
Carlos III University of Madrid
Email: angelvasur@yahoo.com,avasquez@eco.uc3m.es
Telephone number: 0034-916249302
Fax number: 0034-916245788
Address: Calle Madrid 126 (11.2.03), Getafe (28903), Madrid, Spain.

Andrés Barge-Gil
Assistant Professor, Department of Economic Analysis II (Quantitative Economics)
Complutense University of Madrid
Email:abarge@ccee.ucm.es
Address: Campus de Somosaguas, Pozuelo de Alarcón (28223), Madrid, Spain.

Aurelia Modrego Rico
Associate Professor, Department of Economics and Research Scientist, Laboratory of Analysis and Evaluation of Technical Change
Carlos III University of Madrid
Email:modrego@eco.uc3m.es
Address: Calle Madrid 126 (11.2.03), Getafe (28903), Madrid, Spain.

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 analyzing 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 et al. 2011). 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 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.[1] More detailed knowledge of which firms benefit more from such policy initiatives is of great importance 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.

[1] To our knowledge, the only study that considers the heterogeneous effect of STP location is Huang et al. (2012). However, it does not analyse non-linear effects.

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.[2]

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).[3] The idea is that internal innovation capabilities play a dual role: they generate new knowledge, and they increase 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

[2] Firms with higher level innovation capabilities will choose more self-centred innovation strategies.
[3] Several different terms are used to express a similar idea, e.g. intrafirm technological learning (Caniëls and Romijn 2003), and knowledge bases (Giulani 2007).

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 exploit 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 show 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, and there is little empirical evidence on the role of firms' characteristics. To our knowledge, only Huang et al. (2012) suggest that the effects are heterogeneous. They focus on the Taiwanese Information and Communication Technologies (ICT) industry, and allow for differing 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.

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 recent empirical literature on innovation uses indicators related to sales of innovative products as the dependent variables (for a review, see Vásquez et al. 2011); these indicators do not have the problems related to use of R&D, and numbers of patents and innovations. For example *R&D* is an input and not a good measure of output (Love and Roper 1999; Negassi 2004); *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); and *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 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] We define two different indicators: *Log of sales of new to the market products* (*introduced in the period 2005-2007*) *over total sales (per mile) in year 2007 (LNEWMAR)* [6] and *Log of total amount of sales (in 2007) from new to the market products (introduced in the period 2005-2007) over total employment (in 2007)(LNEWMARL).* The first has been used 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

[4] The specific characteristics of this sample are available on the INE webpage: http://www.ine.es/ioe/ioeFicha.jsp?cod=30061

[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 use log(1+X).

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. Our data include the names of STPs, allowing us to reclassify firm location in an STP according to objective criteria. 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.[7] We use log of total sales (in 2005) to proxy for size (*LSALES*) and log of total innovation expenses per employee (in 2007) 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). The descriptive statistics are presented in Table 2.

[7] In addition to R&D, innovation effort includes acquisition of machinery and equipment to innovate, acquisition of external knowledge (such as licences), design, innovation-related training, and marketing of innovative products.

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, 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] Importance is on the scale of 1(crucial) to 4 (unimportant).The indicator is equal to [$n\sum$/factors importance]

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</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>0.444</td><td></td><td>0.207</td><td>0.25</td><td>1</td></tr>
<tr><td colspan="2">Information obstacles</td><td>0.377</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</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 et al. 2011). Thus, treatment evaluations must take

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

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 et al. (2011) 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 so 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*[9], $\hat{\delta}$ is the estimate of the interaction between treatment and C_i; it shows how the effect of an on park location varies according to firms' internal innovation capabilities.

One important issue is the existence of non-linear interaction effects. To address this, we also analyse squared terms. We estimate the equations using ordinary least squares (OLS) and Tobit:[10]

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[9] Two different equations are estimated - for C = *LSALES* and for C = *LINN_EFFORT*.

[10] We report the OLS results because the marginal effects are directly provided. Also, empirically, marginal effects from non linear models, such as Tobit, are usually very similar to those obtained from OLS if the relevant values of the explanatory variables are used. Angrist and Pishke (2008) recommend using OLS to estimate treatment effects. The results for the Tobit models are similar to the results presented here and are available upon request from the authors.

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

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).

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

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

The reference technological sectoral level is high-tech manufacturing.
Standard errors in parentheses.
[a] p-value<0.01, [b] p-value<0.05, [c] p-value<0.1.

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.

The influence of size 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 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 assume linear effects, we find a similar effect of park location for firms of different sizes for *LNEWMAR*. However, if we analyse *LNEWMARL*, the park location effect increases with size. A firm that doubles in size will achieve around a 4% higher effect from park location. On the other hand, 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.*

[11] 156 euros for *LNEWMAR and* 517 euros for *LNEWMARL.*

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[a]	(0.110)	0.794[a]	(0.194)	0.285[a]	(0.107)	0.424[b]	(0.193)
SSTP *(LSALES-mean)	0.012	(0.019)	0.066[b]	(0.030)	-----	-----	-----	-----
LSALES-mean	0.015[a]	(0.002)	0.039[a]	(0.004)	-----	-----	-----	-----
SSTP * (LINN_EFFORT-mean)	-----	-----	-----	-----	0.071[a]	(0.021)	0.080[b]	(0.035)
LINN_EFFORT –mean	-----	-----	-----	-----	0.167[a]	(0.003)	0.323[a]	(0.005)
LINN_EFFORT	0.031[b]	(0.014)	0.125[a]	(0.025)	-----	-----	-----	-----
LINN_EFFORT ^2	0.016[a]	(0.002)	0.023[a]	(0.003)	-----	-----	-----	-----
LSALES	-----	-----	-----	-----	-0.012	(0.007)	-0.084[a]	(0.014)
LSALES^2	-----	-----	-----	-----	0.001[a]	(0.000)	0.007[a]	(0.001)
Group	0.104[a]	(0.020)	0.326[a]	(0.038)	0.059[a]	(0.021)	0.145[a]	(0.041)
Exporting behaviour	0.816[a]	(0.099)	1.667[a]	(0.190)	0.802[a]	(0.099)	1.561[a]	(0.190)
Low-tech manufac.	-0.473[a]	(0.074)	-0.961[a]	(0.141)	-0.540[a]	(0.074)	-1.077[a]	(0.141)
Medium-low-tech m.	-0.421[a]	(0.075)	-0.855[a]	(0.143)	-0.490[a]	(0.075)	-0.977[a]	(0.142)
Medium-high-tech m.	-0.199[b]	(0.079)	-0.356[b]	(0.150)	-0.264[a]	(0.079)	-0.470[a]	(0.150)
Knowledge intensity s.	-0.129	(0.079)	-0.483[a]	(0.148)	-0.118	(0.079)	-0.451[a]	(0.148)
No-knowle. intensity s.	-0.544[a]	(0.072)	-1.133[a]	(0.137)	-0.599[a]	(0.072)	-1.226[a]	(0.137)
Other sectors	-0.553[a]	(0.074)	-1.121[a]	(0.140)	-0.610[a]	(0.074)	-1.207[a]	(0.139)
Cost obstacles	0.359[a]	(0.056)	0.595[a]	(0.103)	0.375[a]	(0.056)	0.679[a]	(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[b]	(0.068)	0.351[b]	(0.136)	0.134[b]	(0.068)	0.293[b]	(0.135)
Downsized	0.072	(0.054)	0.109	(0.100)	0.077	(0.054)	0.127	(0.100)
Constant	0.374[a]	(0.074)	0.808[a]	(0.140)	0.787[a]	(0.079)	1.534[a]	(0.148)
F	338.19[a]		360.19[a]		336.52[a]		358.82[a]	
R2	0.22		0.23		0.22		0.23	
# of companies	39722							

The reference technological sectoral level is high-tech manufacturing.
Standard errors in parentheses.
[a] p-value<0.01, [b] p-value<0.05, [c] 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.

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

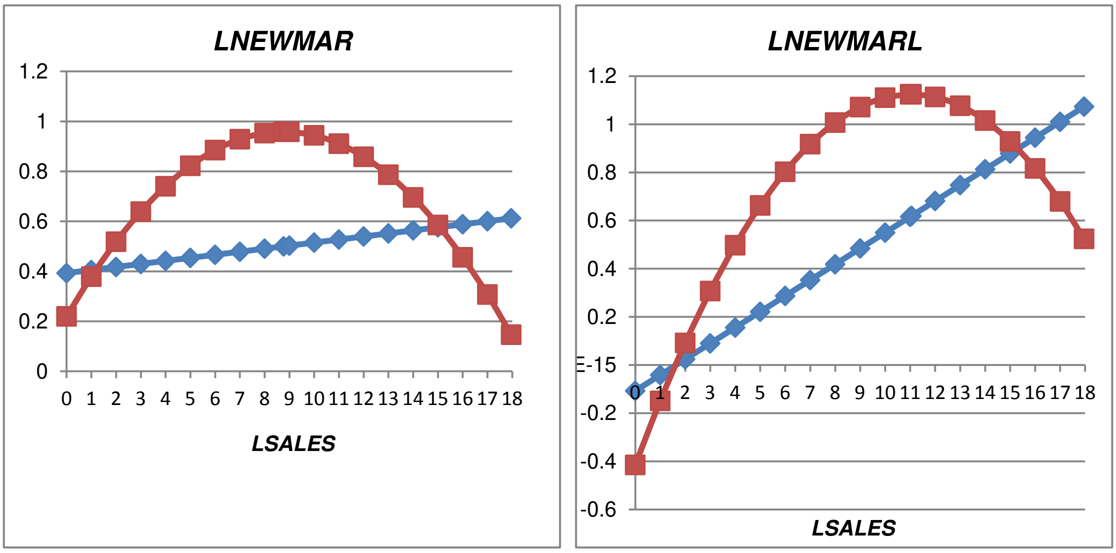
	Size				***Innovation Effort***			
	LNEWMAR		***LNEWMARL***		***LNEWMAR***		***LNEWMARL***	
SSTP	0.724^{a}	(0.136)	1.036^{a}	(0.226)	0.630^{a}	(0.205)	1.077^{a}	(0.356)
SSTP *(LSALES-mean)	-0.095^{c}	(0.049)	-0.067	(0.087)	-----	-----	-----	-----
SSTP *(LSALES-mean)^2	-0.010^{b}	(0.004)	-0.013^{c}	(0.007)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

The reference technological sectoral level is high-tech manufacturing.
Standard errors in parentheses.
^{a} p-value<0.01, ^{b} p-value<0.05, ^{c} p-value<0.1.

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 an 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] meaning that in practical terms smaller firms benefit more from STP location than larger firms (see graph A1 in Appendix). To illustrate, using 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). Effects for the different points are: 164.9%, 122.9% and 75.7% respectively, for €2million€, €10million and €50million (Graph A2). That is, the effect of being located in a STP for micro firms is more than double that for medium firms.

Graph 1: Effects of location in Spanish STPs by firm size



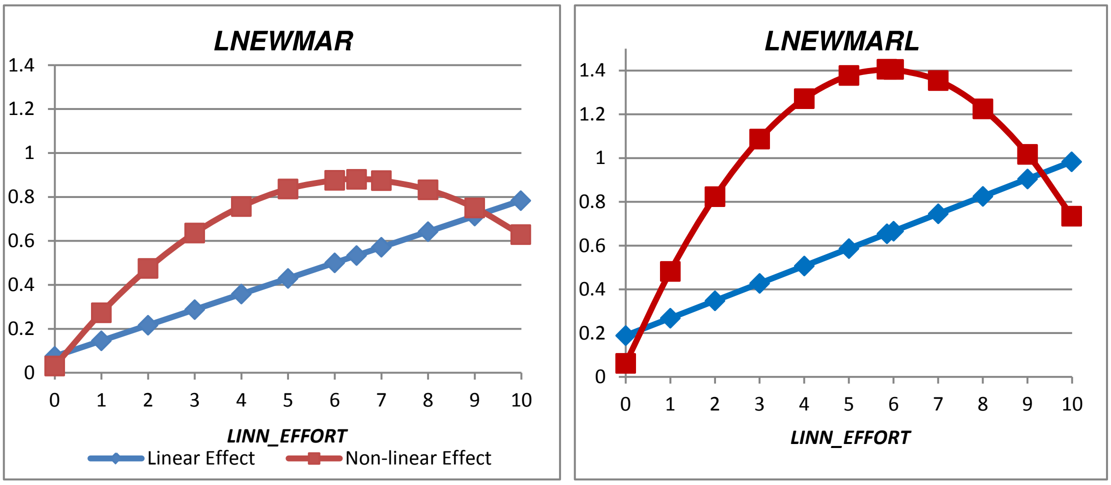
5.3.2. By innovation effort

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 2 shows the park location effect based on innovation effort taking account of linear and non-linear effects. For *LNEWMAR*, while

[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.

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 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 (Graph A3). 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 firm 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 figure are 20.8%, 121.1% and 165.5% respectively (Graph A4).

Graph 2: Effects of location in Spanish STPs by innovation effort



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). 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 need 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.

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 are quick to recognize opportunities in the environment and can be flexible enough to benefit from them (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.

It should be noted that it does not follow that large firms with focus heavily on innovation should not locate in STPs; they still get high and positive returns from park location. Also, it could be argued that their presence is crucial for smaller firms with lower levels of innovation effort to achieve very high returns from park location. An interesting line for future research would be to investigate park ecology to understand how it affects park effects.

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REFERENCES

Acs, Z. J., & Audretsch, D. B. (1987). Innovation, market structure, and firm size. *The Review of Economics and Statistics,* 69 (4), 567-574.

Acs, Z. J., & Audretsch, D. B. (1988). Innovation in large and small firms: an empirical analysis. *The American Economic Review,* 78 (4), 678-690.

Angrist, J., & Pishke, J. (2008). *Mostly Harmless Econometrics: an Empiricist's Companion*. Princeton, NJ: Princeton University Press.

Aschhoff, B., & Schmidt, T. (2008). Empirical evidence on the success of R&D cooperation – happy together? *Review of Industrial Organization,* 33, 41-62.

Audretsch, D.B., & Feldman, M.P. (1996). R&D spillovers and the geography of innovation and production. *American Economic Review,* 86(3), 630-645.

Barge-Gil, A. (2010). Open, semi-open and closed innovators. Towards an explanation of degree of openness. *Industry and Innovation,* 17(6), 577-607.

Brouwer, E., & Kleinknecht, A. (1996). Firm size, small business presence and sales of innovative products: a micro-econometric analysis. *Small Business Economics,* 8, 189-201.

Caniëls, M. C. J., & Romijn, H. A. (2003). Firm-level knowledge accumulation and regional dynamics. *Industrial and Corporate Change,* 12 (6), 1253-1278.

Cassiman, B., & Veugelers, R. (2006). In search of complementarity in innovation strategy: internal R&D and external knowledge acquisition. *Management Science,* 52, 68-82.

Chun H., & Mun S.-B. (2012). Determinants of R&D cooperation in small and medium-sized enterprises. *Small Business Economics,* 39, 419-436.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly,* 35 (1), 128-152.

Czarnitzki, D., & Hottenrott, H. (2009). Are local milieus the key to innovation performance? *Journal of Regional Science,* 49 (1), 81-112.

Faems, D., Van Looy, B., & Debackere, K. (2005). Interorganizational collaboration and innovation: toward a portfolio approach. *The Journal of Product Innovation Management,* 22, 238-250.

Falk, M. (2007). Cross-country and cross-industry patterns in the determinants of innovation output: evidence for 12 EU countries based on CIS 3 micro data. *The 2nd European Conference on Entrepreneurship and Innovation*. Utrecht School of Economics: University of Utrecht, Netherlands.

Forman, C., Goldfarb, A., & Greenstein, S. (2008). Understanding the inputs into innovation: Do cities substitute for internal firm resources? *Journal of Economics and Management Strategy,* 17(2), 295-316.

Freeman, C., & Soete, L. (1997). *The Economics of Industrial Innovation* (Third Ed.). London:The MIT Press.

Frenz, M., & Ietto-Gillies, G. (2009). The impact on innovation performance of different sources of knowledge: evidence from the UK Community Innovation Survey. *Research Policy,* 38, 1125-1135.

Giuliani, E. (2007). The selective nature of knowledge networks in clusters: evidence from the wine industry. *Journal of Economic Geography,* 7, 139-168.

Guo, S., & Fraser, M. (2010). *Propensity Score Analysis. Statistical Methods and Applications*. Advanced Quantitative Techniques in the Social Sciences Series, 11. SAGE Publications.

Hervas-Oliver, J. L., & Albors-Garrigos, J. (2009). The role of the firm's internal and relational capabilities in clusters: when distance and embeddedness are not enough to explain innovation. *Journal of Economic Geography,* 9, 263-283.

Huang, K.-F., Joseph Yu, C.-M., & Seetoo, D.-H. (2012). Firm innovation in policy-driven parks and spontaneous clusters: the smaller firm the better? *The Journal of Technology Transfer,* 37 (5), 732-754.

IASP (2002). *International Board of Directors*, Association of Science Parks and Areas of Innovation – IASP, February 6, 2002.

Imbens, G., & Wooldridge, J. (2009). Recent developments in the econometrics of program evaluation. *Journal of Economic Literature,* 47, 5-86.

Jaffe, A. (1986). Technological opportunity and spillovers of R & D: evidence from firms' patents, profits, and market value. *The American Economic Review,* 76 (5), 984-1001.

Kleinknecht, A., Van Montfor, K., & Brouwer, E. (2002). The non-trivial choice between innovation indicators. *Economics of Innovation and New Technology,* 11, 109-121.

Klevorick, A., Levin, R., Nelson, R., & Winter, S. (1995). On the sources and significance of interindustry differences in technological opportunities. *Research Policy,* 24, 185-205.

Laursen, K., & Salter, A. (2006). Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal,* 27, 131-150.

Lazerson, M. H., & Lorenzoni, G. (1999). The firms that feed industrial districts: A return to the Italian source. *Industrial and Corporate Change,* 8 (2), 235-266.

Love, J., & Roper, S. (1999). The determinants of innovation: R&D, technology transfer and networking effects. *Review of Industrial Organization,* 15, 43-64.

Mairesse, J., & Mohnen, P. (2005). The importance of R&D for innovation: a reassessment using French survey data. *Journal of Technology Transfer,* 30, 183-197.

Maskell, P. (2001). The firm in economic geography. *Economic Geography,* 77 (4), 329-344.

Mohnen, P., Mairesse J., & Dagenais, M. (2006). Innovativity: a comparison across seven European countries. *Scientific Series*, CIRANO.

Negassi, S. (2004). R&D co-operation and innovation a microeconometric study on French firms. *Research Policy,* 33, 365-384.

Nieto, M. J., & Santamaría, L. (2010). Technological collaboration: bridging the innovation gap between small and large firms. *Journal of Small Business Management,* 48 (1), 44-69.

OECD (2005). *OECD Science, Technology and Industry Scoreboard 2005*. OECD Publishing.

Pellegrino, G., & Savona, M. (2013). Is money all? Financing versus knowledge and demand constraints to innovation. *UNU-MERIT Working Paper* 2013-029.

Rammer, C., Czarnitzki, D., & Spielkamp, A. (2009). Innovation success of non-R&D-performers: substituting technology by management in SMEs. *Small Business Economics,* 33 (1), 35-58.

Rogers, M. (2004). Networks, firm size and innovation. *Small Business Economics,* 22, 141-153.

Shaver, J., & Flyer, F. (2000). Agglomeration economics, firm heterogeneity, and foreign direct investment in the United States. *Strategic Management Journal,* 21, 1175-1993.

Spithoven, A., Clarysse, B., & Knockaert, M. (2011). Building absorptive capacity to organise inbound open innovation in traditional industries. *Technovation,* 31, 10-21.

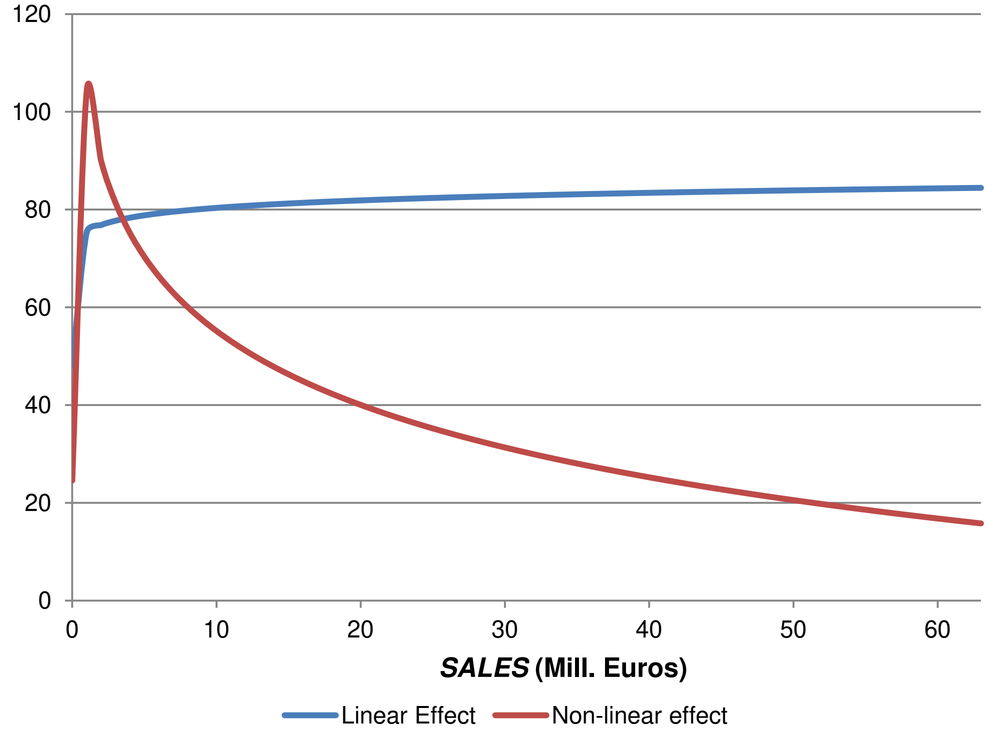
Tsai, K. (2009). Collaborative networks and product innovation performance: toward a contingency perspective. *Research Policy,* 38, 765-778.

Vásquez, A., Barge-Gil, A., Modrego, A., & Paraskevopoulou, E. (2011). The impact of science and technology parks on firms´ product innovation: empirical evidence from Spain. *MPRA Paper* 30555, University Library of Munich, Germany.

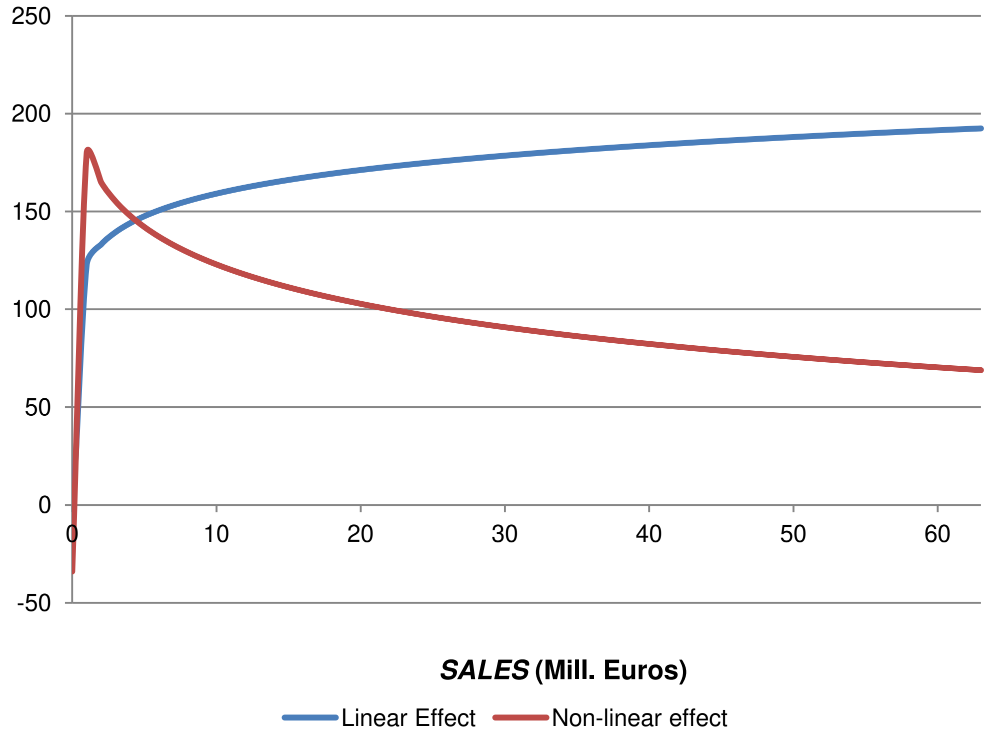
Wooldridge, J. (2002). *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA, London: MIT Press.

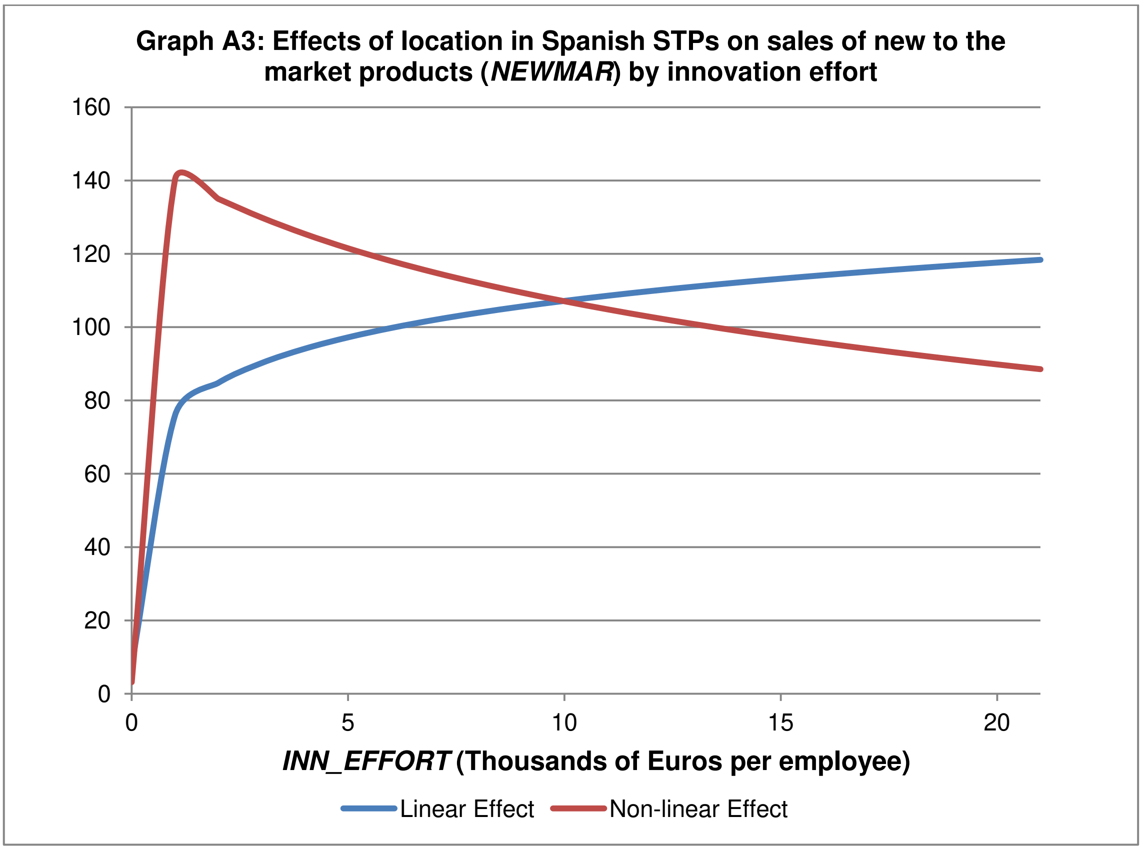
ANNEX

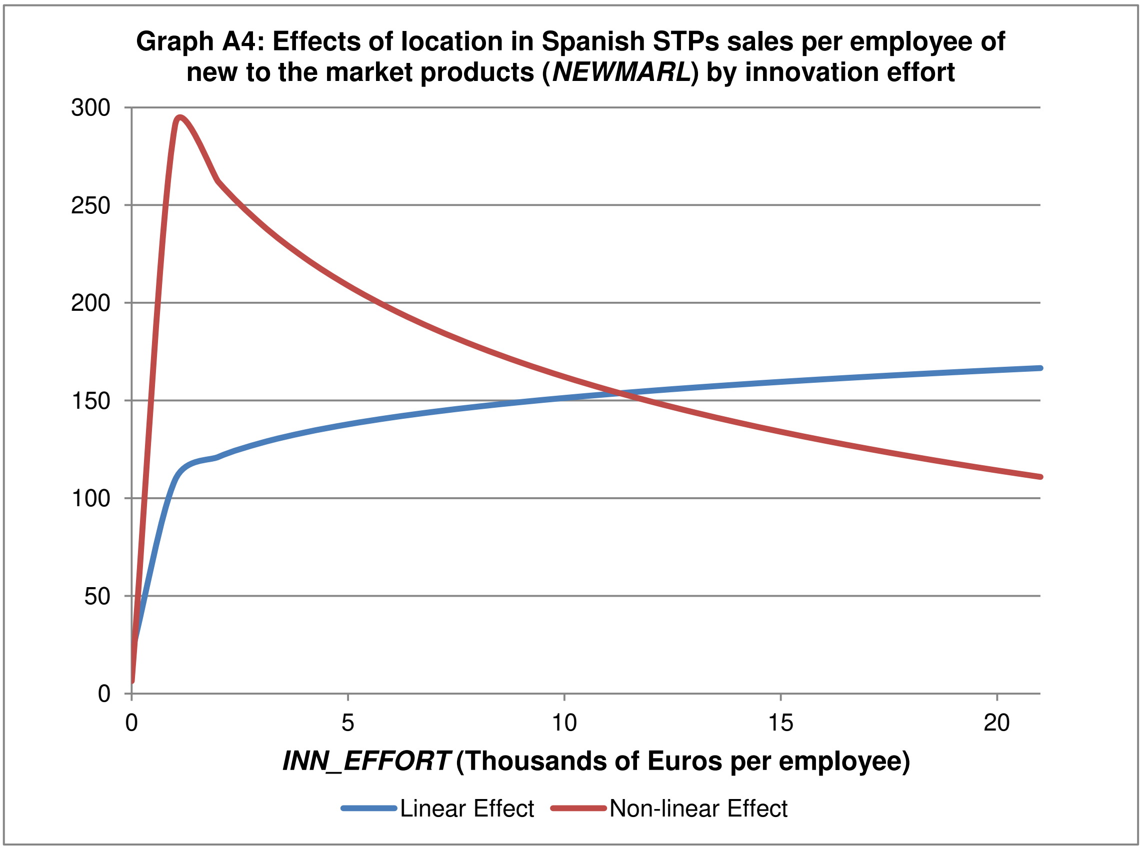
Graph A1: Effects of location in Spanish STPs on sales of new to the market products (*NEWMAR*) by firm size



Graph A2: Effects of location in Spanish STPs on sales per employee of new to the market products (*NEWMARL*) by firm size




Graph A3: Effects of location in Spanish STPs on sales of new to the market products (NEWMAR) by innovation effort
160
140
120
100
80
60
40
20
0
0
5
10
15
20
INN_EFFORT (Thousands of Euros per employee)
Linear Effect
Non-linear Effect


Graph A4: Effects of location in Spanish STPs sales per employee of new to the market products (NEWMARL) by innovation effort
300
250
200
150
100
50
0
0
5
10
15
20
INN_EFFORT (Thousands of Euros per employee)
Linear Effect
Non-linear Effect