ARTICLES

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THE ROLE OF SCIENCE AND TECHNOLOGY PARKS IN THE GROWTH OF SALES OF PORTUGUESE FIRMS

O Papel dos parques de ciência e tecnologia no crescimento das vendas das empresas portuguesas

El papel de los parques científico-tecnológicos en el crecimiento de las ventas de empresas portuguesas

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ABSTRACT

The role of science and technology parks (STPs) in economic development, and in particular in the growth of the firms, has received considerable attention from government policies in different countries. However, there is no consensus in the literature on whether the location in these parks has positive effects on firms' sales growth. This paper aims to extend the discussion on the effects of STPs by providing new empirical evidence. With this purpose, we use a sample of 553 Portuguese companies located in these infrastructures and a control sample of the same size. We use the Propensity Score Matching Procedure to match the samples and the analysis is carried out by the Generalized Method of Moments in dynamic panel data. The empirical analysis does not prove any statistically significant effect of the location of the firms in science and technology parks on their growth in sales.

Keywords: science and technology parks, sales growth, regional development, location effects, Propensity Score Matching.

RESUMO

O papel dos parques de ciência e tecnologia (PCT) no desenvolvimento econômico, especialmente no crescimento de empresas, tem merecido particular atenção por parte das políticas públicas dos diferentes países. Porém, na literatura não existe consenso sobre se a localização nesses parques tem efeitos positivos no crescimento em vendas das empresas. O objetivo deste artigo é alargar a discussão acerca dos efeitos dos PCT, proporcionando novas evidências empíricas. Para isso, utilizamos uma amostra de 553 firmas portuguesas localizadas nessas infraestruturas e uma amostra de controle de idêntica dimensão. O método de emparelhamento utilizado é o Propensity Score Matching (PSM), e a análise é efetuada com recurso ao método generalizado dos momentos em dados em painel dinâmico. A análise empírica não permite provar qualquer efeito estatisticamente significativo da localização das firmas em PCT sobre o seu crescimento em vendas.

Palavras-chave: *parques de ciência e tecnologia, crescimento das vendas, desenvolvimento regional, efeitos da localização, Propensity Score Matching.*

RESUMEN

El papel de los parques científico-tecnológicos (PCT) en el desarrollo económico y, en particular, en el crecimiento de las empresas ha merecido especial atención por parte de las políticas públicas de los diferentes países. Sin embargo, en la literatura no existe consenso sobre si la ubicación en estos parques tiene efectos positivos sobre el crecimiento en ventas de las empresas. El objetivo de este artículo es ampliar la discusión sobre los efectos de los PCT, proporcionando nuevas evidencias empíricas. Para ello, utilizamos una muestra de 553 firmas portuguesas ubicadas en estas infraestructuras y una muestra de control de idéntica dimensión. El método de emparejamiento utilizado fue el Propensity Score Matching y el análisis se realizó a través del método generalizado de los momentos en datos de panel dinámicos. El análisis empírico no permitió probar ningún efecto estadísticamente significativo de la ubicación de las firmas en PCT sobre su crecimiento en ventas.

Palabras clave: parques científico-tecnológicos, crecimiento de las ventas, desarrollo regional, efectos de la ubicación, Propensity Score Matching.

INTRODUCTION

The topic of Science and Technology Parks (STP) has shown a growing interest, materialized by the number of such infrastructures in different countries. The first STPs were born in the second half of the twentieth century, but it is in the twenty-first century that these infrastructures proliferate significantly (International Association of Science Parks [IASP], 2016; Lecluyse et al., 2019). In 2013, the European Commission (EC) estimated that the number of STPs located in Member States amounted to about 365 parks, hosting more than 40,000 firms and employing more than 750,000 people (European Commission, 2013). In Brazil, there are currently 93 STPs initiatives, with 58 of them already in the operational phase (Ministério da Ciência, Tecnologia e Inovações, 2021).

One of the main objectives of STPs, which justifies the public support they receive, is to enhance the performance of the companies located in them, thus acting as catalysts for regional development. However, and despite the increase of STPs, the scientific literature about these infrastructures is still in an expansion phase (Albahari et al., 2022; Hobbs et al., 2017; Lecluyse et al., 2019). Among the existing studies, those that analyse the effects of STPs on firms located there are still scarce. Moreover, the results of these studies are heterogeneous, and it is not clear whether there is an effective positive relationship between the location of firms in these infrastructures and their performance (Albahari et al., 2022; Hobbs et al., 2017; Lecluyse et al., 2019).

In their comprehensive literature review on STPs, Albahari et al. (2022) highlight the different sample sizes considered in the different studies as the main factor explaining the mentioned divergence of results: those researches with smaller samples tend not to find significant effects of STPs on firms. The statistical significance depends on the ratio between the estimated coefficient and the estimated standard deviation for this coefficient, which leads to small samples underestimating the effect of the independent variable (STP location) on the dependent variable (performance).

The aim of this paper is to investigate the existence of potential effects of STPs on the economic performance of the companies located there. The analysis focuses on growth, one of the most common indicators to assess business performance (Brush & Vanderwerf, 1992), and, in particular, on growth in sales, as it reflects the evolution of the firm's capacity to have its business accepted by the market (Spithoven & Knockaert, 2011). Taking into consideration the recommendation of Albahari et al. (2022), we used a sample of 553 firms located in STPs and a control sample of identical size, thus avoiding underestimating the effect of parks on firms' growth. In the 38 studies identified by Albahari et al. (2022), only 20% of the analyses use samples of more than 500 firms.

Another shortcoming identified in some of the existing literature is bias in the selection of control samples (Albahari et al., 2022). The management of STPs decides whether to admit a firm on the basis of its viability and business growth potential, so it may be assumed that firms located in STPs have already had better conditions than other firms even before locating in the

STPs. To avoid the risk of bias, the control sample used in this research was constructed using Propensity Score Matching (PSM) to control for firms' characteristics. A control sample with the most similar characteristics possible to the sample of firms located in STPs was thus obtained.

Thus, this paper not only aims to reach empirical results in a scope still little explored in the literature on STPs, but also aims to overcome problems identified in previous literature, using a large sample and reducing to a minimum the risk of bias through PSM.

The research takes Portugal as a case study. In that country, the STPs are born from 1991 on, but, similarly to what happens internationally, it is in the first decade of the 21st century that more parks are created, representing about 57.6% of the total number of parks between 1991 and 2015 (this calculation is the authors' own elaboration, resulting from the direct taking of information about the year of birth of each STP). According to the existing evidence (Albahari et al., 2022), there is no relationship between the type of STPs effects observed and the countries taken as case studies, so the results obtained from Portugal (or any other country) should be interpreted as extrapolable to other contexts.

The paper is structured as follows: firstly, the literature review is carried out and the research hypothesis is presented; secondly, the methodology followed is explained, including the application of the PSM, the definition of the variables and the specification of the model; thirdly, the results are presented; fourthly, the empirical results are discussed; and, finally, the final part presents the conclusions, limitations and suggestions for future research.

LITERATURE REVIEW AND RESEARCH HYPOTHESIS

According to the CE (2013), STPs aim to take on six functions: i) promotion of innovation and customer competitiveness, ii) provision of specific spaces and other services, providing local and regional economic development, iii) knowledge-based work, iv) technological start-up activity, v) investment in knowledge-based businesses, and vi) cluster development.

Theoretically, the location of firms in STPs may facilitate the introduction of resources that result into growth potential, not achieved by firms elsewhere. The resources would leverage economies of growth (Penrose, 1959), that is, economies available at firm level that allow profitable expansion/growth. Incidentally, one of the motivations related to the creation of STPs is associated with the growth and development of economic activity (EC, 2013), so sales growth is assumed as one of the most relevant variables of the expected outcome associated with the location of firms in these infrastructures (Ferguson & Olofsson, 2004; Lamperti et al., 2017; Liberati et al., 2016; Löfsten & Lindelöf, 2001, 2002; Monck et al., 1988). This contribution with local and regional economic development is what would justify the political support that, in the form of public funding, a significant number of STPs receive (Colombo & Delmastro, 2002; Ferguson & Olofsson, 2004; Stokan et al., 2015).

However, the literature on STPs is still expanding (Albahari et al., 2022; Hobbs et al., 2017; Lecluyse et al., 2019), and it is not clear the contribution of parks to the performance of the firms located there or, by extension, to the development of the regions in which they are

based. The topics analysed and the objectives of existing works are diverse, including: projects to create new STPs (Cricelli et al., 1997; Fikirkoca & Saritas, 2012), frameworks for assessing the performance of existing STPs (Hobbs et al., 2020; Meseguer-Martinez et al., 2021; Ribeiro et al., 2021), studies on the evolution trends and outcomes of concrete STPs or groups of STPs (Howard & Link, 2019; Kim & Jung, 2010; Yan et al., 2020), good practices and decisive factors for success (Berbegal-Mirabent et al., 2020; Correia et al., 2021), or the role of STPs in the regional or national economy (Albahari et al., 2019; Silva et al., 2020). In particular, there are some studies on the effects of STPs on firms located there, focusing on three dimensions: innovation performance (e.g.: Corrocher et al., 2019; Xue & Zhao, 2023), patterns of cooperation between firms (e.g.: Chan et al., 2010; Vásquez-Urriago et al., 2016) and economic performance. The most usual indicators of economic performance are profitability, productivity, employment growth and sales growth (Albahari et al., 2022).

As already mentioned, there is little research on the effect of STPs location on the growth of companies' sales. In fact, the few existing studies reach divergent results. The first relevant work on STPs is presented by Monck et al. (1988), which, despite not analysing sales growth, shows that firms that have been located in STPs for 10 years or more record a significantly higher turnover compared to firms not located in these parks. More recently, some works have found a positive effect of STPs on sales growth. In this regard, Löfsten and Lindelöf, in four studies, found that firms located in STPs recorded significantly higher growth rates in sales than firms located outside the parks (Lindelöf & Löfsten, 2002; Löfsten & Lindelöf, 2001, 2002, 2003). The results were further confirmed by Liberati et al. (2016) and by Díez-Vial and Fernández-Olmos (2017a).

Other studies, however, come to the opposite conclusion. In this sense, Westhead and Storey (1994), Ferguson and Olofsson (2004) and, more recently, Lamperti et al. (2017) and Díez-Vial and Fernández-Olmos (2017b) find no statistically significant evidence confirming that firms located in STPs record higher sales growth than those located outside parks. In fact, Arauzo-Carod et al. (2018) find a negative average effect of STPs on sales growth for firms located there, although parks are more beneficial for high-growth firms.

Methodologically, part of the referred studies rely on mean comparison analyses (Ferguson & Olofsson, 2004; Lindelöf & Löfsten, 2002; Monck et al., 1988; Westhead & Storey, 1994), while others carry out different types of regression analyses (Arauzo-Carod et al., 2018; Díez-Vial & Fernández-Olmos, 2017a, 2017b; Lamperti et al., 2017; Löfsten & Lindelöf, 2001, 2002, 2003) to control for individual firm characteristics and avoid potential endogeneity problems.

Albahari et al. (2022) recently conducted an extensive review of the literature on STPs, in which they explore the causes of the heterogeneity of results obtained by studies about the effects of parks on company performance. They found that those researches that analyse small sample sizes are less likely to find statistically significant effects of STPs location on firm performance. The explanation is that, since statistical significance depends on the relationship between the estimated coefficient and the estimated standard deviation for that coefficient, samples composed of few companies might underestimate the effect of the independent variable (STP) on the dependent variable (performance). Additionally, Albahari et al. (2022) also draw attention

to the risk of bias in the selection of control samples (firms outside STPs). Theoretically, the firms that are admitted to STPs already start from good conditions in terms of growth potential and business viability, so one could expect greater growth from them than from firms located outside the STPs.

The aim of this paper is to provide new empirical evidence to broaden the current discussion about the effects of STPs on firm performance and, specifically on sales growth, a topic for which the few existing studies have obtained divergent results. In doing so, we try to overcome the issues identified in the literature review that could be the source of the current lack of consensus on the existence, or non-existence, of effects. To do so, we used a large sample of 553 firms located in STPs, thus avoiding a potential underestimation of park effects. In this sense, it should be noted that, in the 38 papers identified by Albahari et al. (2022) on the effects of STPs on firm performance, only 20% of the analyses use samples of more than 500 firms. On the other hand, the PSM method is used for sample matching, and the analysis is carried out using the generalised method of moments in dynamic panel data. This allows for especially robust empirical results, given that problems of bias are avoided when constructing the control sample, and individual characteristics of firms that may influence growth are controlled for. Taking as a reference the literature reviewed, the following research hypothesis is formulated:

H1: The location of Portuguese firms in STPs positively influences their sales growth.

METHODS

Sample construction

For the construction of the sample, in a first phase, the existing STPs in Portugal were identified through the register of the Portuguese Association of Science and Technology Parks (TecParques). Twenty-six STPs were identified. To identify the companies located in the STPs we use the Iberian Balance-Sheet Analysis System (SABI for its acronym in Portuguese) database to perform a search based on the zip codes of the identified parks' locations and taking 2002-2014 as study period. This database of Bureau Van Dijk (BVD) and Informa contains general information and annual accounts for thousands of Portuguese companies.

The selection of 2002-2014 as the study period responds to two criteria. Firstly, it is a period of expansion of the STPs in Portugal and of the number of companies located there, which allows guaranteeing that the sample has a high number of observations and, therefore, the statistical significance results are robust (Albahari et al., 2022). Second, it is a period that comprises an economic expansion phase (2002-2007) and a recession phase (2008-2014), avoiding the bias that would result from considering only a single phase of the economic cycle (Díez-Vial & Fernández-Olmos, 2017b).

In order to include in the sample only companies incorporated under one of the corporate forms foreseen in the Commercial Companies Code; non-corporate entities (such as associations and cooperatives), firms whose corporate purpose does not have a commercial or industrial nature, as is the case of Holding Companies, and branches of foreign firms were excluded. Likewise, only companies with a start-up equal or posterior to 1991, the year the first STPs was created, were considered. Finally, those companies with economic activity code (CAE, for its Portuguese acronym) of food supply and similar were excluded, as they are only located in the STPs to offer food and beverage services to the companies in the park. After this process, the final sample of firms located in STPs consisted of 591 entities.

In a second phase, a control sample was created consisting of firms not located in STPs, with similar characteristics to the firms located in STPs. Companies that met the following criteria were selected in SABI: having a economic activity code (CAE) equal to at least one of the companies in the sample of firms located in STPs, having a date of incorporation equal to or greater than 1991, being located in at least one of the regions where the firms in STPs are located, and not being any of the firms that integrate the sample of firms located in STPs. For the construction of the control sample, non-corporate entities, such as associations and cooperatives, as well as holding companies and branches of foreign firms, were also excluded.

In order to guarantee the quality of the data of the companies of the control sample, the following restrictions were additionally placed on the observations to be included in the sample: existence of profits on sales in the period of analysis, presenting an asset value greater than zero and presenting a positive value of equity. In this way, it is ensured that all companies analysed have effective activity during the period of analysis.

By applying the conditions and restrictions presented, a control sample with an initial size of 137,915 firms not located in STPs was obtained.

Propensity Score Matching a sampling method

To matching the sample of companies located in STPs and the control sample, we use the PSM, proposed by Rosenbaum and Rubin (1983) as a statistical method to study the causality effects related to a specific treatment, in order to minimize the evaluation bias of these effects from a set of observable data. To the best of our knowledge, there are no previous works in the literature on STPs that apply the PSM, besides the work developed by Stokan et al. (2015), which apply the methodology to the study of the differential effect on the growth of companies that were in incubators, before the others.

PSM had its origin in the statistical literature and shows a close connection with the experimental context. In fact, these methods have been widely used in clinical trials and in the evaluation of economic policy interventions (Becker & Ichino, 2002). As Caliendo and Kopeinig (2008) mention, in this type of study the first problem that arises relates to the fact that we intend to know the difference between the outcome of a group with and without treatment; in

the case of this study, companies located in STPs and not located in STPs. The impossibility of observing at the same time the business results of the same group of firms in both situations (with and without treatment) leads to the need to find a comparable group that allows us to evaluate the impact of the treatment variable, i.e. the impact of the STP location. The choice of the comparable group integrates a selection bias, but the use of PSM allows reducing this bias to a minimum by matching observations with and without treatment that are as similar as possible (Caliendo & Kopeinig, 2008; Dehejia & Wahba, 2002).

Following Caliendo and Kopeinig (2008), the PSM was developed in four steps: i) evaluation of the propensity score (PS), ii) choice of the matching algorithm, iii) verification of the common support region, and iv) evaluation of the matching quality.

To estimate the PS of each firm located in STPs and those that are eligible to be part of the control sample (i.e. the 137,915 firms that meet the criteria defined in the process presented above) - step (i) - a binary model was chosen (in which the explained or dependent variable is a dummy variable), considering that what is under analysis is the probability of the firm being located in a STP or not. Given that it is not expected that there are significant differences in the binary models applied (Caliendo & Kopeinig, 2008), it was decided to apply logistic regression (Logit model).

The independent variables chosen to integrate the PSM are the variables used by other authors who, despite not using this method for the pairing, used other methods to do the sample matching (Lamperti et al., 2017; Liberati et al., 2016; Löfsten & Lindelöf, 2001, 2002). Thus, first, we use the variable Age, of discrete quantitative type, calculated in the reference year 2015 and taking the value 1 for all firms born in 2014, the value 2 for firms born in 2013, and so on. Second, the Sector variable, of nominal qualitative type, corresponds to the sector of economic activity (CAE Rev. 3) at two digits in which the firm is registered. Finally, the variable Region, of nominal qualitative type, corresponds to the region where the firm is located. The logistic regression model applied is the following: $P\ (park_i = 1) = P\ (Age_i, Sector, Region_i)$.

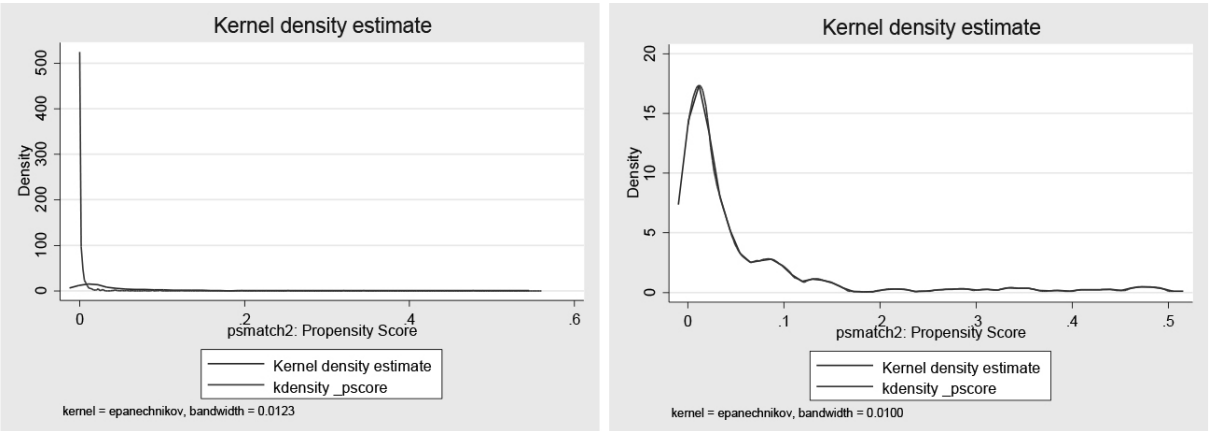
Based on the estimated PS, each firm located on STPs is matched with a firm from the control sample, by applying the Nearest Neighbour (NN) method - step (ii). The algorithm was applied without replacement, so as to guarantee the matching of the control group with a single firm located in PCT. For this purpose, it was ensured that the order of the data was random, given that the calculations depend on the order of the data (Caliendo & Kopeinig, 2008).

To reduce, as far as possible, the realization of inadequate pairings related to possible high distances between the PS, a maximum distance between PS, also called calliper, of 0.000005 was established. The attribution of this calliper resulted from a balance between the number of pairings and their quality, given that the smaller the calliper, the fewer the number of companies that could be matched between the two sub-samples. The use of this calliper also allows for a significant reduction in any problems related to compliance with the condition of existence of a common support region.

The verification of the common support region - step (iii) - is carried out from the graphic analysis of the matching procedure carried out. Figure 1 shows the graphs with the distribution

of PS before and after the matching process, verifying an overlapping of the distributions of the firms included in the sample in STPs and the firms of the control sample. The overlapping reflects the high quality of the matching through the PSM.

Figure 1. Distribution of Propensity Scores before (above) and after (below) the matching process



Source: Elaborated by authors.

Subsequently, the common support region was established, comparing the minimum and maximum PS. The condition of existence of a common support region resulted in the elimination of 38 companies located in STPs for which the model did not find support, decreasing the number of companies located in STPs in the sample from 591 to 553.

To assess the quality of the matching - step (iv) -, we tested whether the sample of firms located in STPs and the control sample were significantly different in the mean values of the variables before and after the matching process. The absence of statistically significant differences between the samples for most variables demonstrates that the PSM allowed reducing or eliminating the differences existing before the matching.

Taking into account the results displayed, we conclude that the matching process used is appropriate, fulfilling the conditions of its application: i) conditional independence for the covariates used in the regression model to calculate the PS, and ii) existence of a common support region for the two sub-samples, as shown by the two graphs presented before and after the application of the matching process using PSM.

Variable definition

One of the components analysed and commonly used in the literature to assess corporate results is growth (Brush & Vanderwerf, 1992). This variable is measured in different ways in the literature (Delmar et al., 2003), sales is one of the most frequently employed, given the fact that it simultaneously reflects the short and long term changes of firms and that it can be easily obtained (Zhou & Wit, 2009).

Sales are considered the preferred measurement for analysing the growth of companies (Delmar et al., 2003) because, in addition to the ease of access, it applies to firms regardless of the sector of activity, the degree of integration and the degree of fixed capital intensity. It is an indicator that reflects business autonomy and market acceptance of the business (Spithoven & Knockaert, 2011). Moreover, in instrumental terms, growth in sales as an outcome variable has two relevant advantages (Ferguson & Olofsson, 2004): i) the reliability associated with the objectivity of its measurement, and ii) the comparability that it provides, per se, for different studies.

In a similar way to the work of Colombo and Delmastro (2002), Lamperti et al. (2017) and Liberati et al. (2016), the variable is measured by the natural logarithm of sales. The notation used follows that presented by Amezcua (2010) for incubated entities, according to which the dependent variable *GROWTH* is constructed as the natural logarithm of the difference in the *SIZE* of the firm:

$$GROWTH_{i,t} = ln(SIZE_{i,t}) - ln(SIZE_{i,t-1}) = ln\left(\frac{SIZE_{i,t}}{SIZE_{i,t-1}}\right) \quad (1)$$

Considering the equation above, the growth of sales (*GSALES*) of firm *i* corresponds to the difference between the natural logarithms of its net sales and services rendered at time *t* and its net sales and services rendered at time *t-1*, which is equivalent to the natural logarithm of the growth rate of net sales and services rendered.

The main explanatory variable that will allow us to empirically evaluate the hypothesis presented (H1) is the dichotomous variable *PARK*, which indicates the location of the firm taking the value of 1 if it is located in a STP, and the value 0 otherwise.

Considering the literature related to the study of STPs, sales growth can be explained by different variables related to business characteristics, among which are age (Lamperti et al., 2017; Löfsten & Lindelöf, 2002), sector of economic activity (Liberati et al., 2016; Löfsten & Lindelöf, 2001, 2002), and size (Lamperti et al., 2017).

Löfsten and Lindelöf (2002) and Lamperti et al. (2017) argue for a negative relationship between age and sales growth, justified with the fact that younger firms have higher growth rates. The inverse relationship is confirmed by the works of Zhou and Wit (2009) in studying the determinants and dimensions of firm growth in the field of industrial economics. However, the relationship is not linear over the life of firms, considering the weight of newness as stated by Bøllingtoft and Ulhøi (2005), as well as the weight of adolescence or the weight of senescence and obsolescence (Hannan, 1998). Thus, a positive relationship is expected between the natural logarithm of the firm's age (in years) and sales growth; and a negative relationship between the natural logarithm of the firm's age squared and sales growth.

Regarding the economic sector of activity, Monck et al. (1988) classify firms belonging to high-technology sectors compared to the others and conclude that those firms have substantially

higher sales growth levels. Löfsten and Lindelöf (2001, 2002) conclude that there is no statistically significant relationship between sector and sales growth.

In this work, sectors were classified into two groups: one group including sectors classified as belonging to high-tech or medium-high-tech industries and high-tech knowledge-intensive services (Eurostat, 2020; Instituto Nacional de Estatística, 2012), and another group including the remaining sectors. Thus, we used a dummy variable that takes the value of 1 if the firm is active in any of the high-tech manufacturing or high-tech services sectors and 0 otherwise.

Regarding the economic rationale of the relationship between firm size and corporate outcome, the literature presents two different lines that support both the existence of a positive relationship and a negative relationship between the variables.

The positive relationship is based on the resource and capability theory introduced by Penrose (1959), according to which larger firms have a greater number of resources and a greater absorptive capacity to conduct research and development in advanced technologies that enable the creation and development of new products. The negative relationship between firm size and business outcome is economically supported by the fact that smaller firms exhibit greater flexibility and innovative dynamism, growing at higher rates than larger firms (Hallin, 1987; Hansen, 1998; Zhou & Wit, 2009). The work of Lamperti et al. (2017) does not conclude on the existence of any relationship between the variables size and sales growth that is statistically significant. In this paper, size is measured by the logarithm of net turnover and the logarithm of the number of employees.

Model specification

In the estimated model, the dynamic panel data methodology is applied, which is one of the main contributions of this work, as there are no references in the literature on STPs that use this methodology.

The choice of dynamic models with panel data rests on three fundamentals, related to i) the nature of the variable to be explained, ii) controlling for specific characteristics of the firms included in the sample, and iii) the relationship between dependent and independent variables. The model is specified as follows:

$$GSALES_{i,t} = \beta_1 GSALES_{i,t-1} + \beta_2 PARK_i + \beta_3 NLAGE_{i,t} + \beta_4 NLAGESQUA_{i,t} + \beta_5 NLEMP_{i,t} + \beta_6 HIGHTECHTOTAL_i + \square_i + \square_t + \square_{it} \quad (2)$$

where the error term is composed of the individual firm-specific effect (α_i), of λ_t that measures the temporal effect through the different dummy variables, so that the effect of the

macroeconomic variables is controlled, and ε_{it} that translates into the random disturbance incorporated in the model.

In the model, the dependent variable itself is included as an explanatory variable with a lag of one period ($GSALES_{i,t-1}$). The variable $PARK_i$, which is the main independent variable in this paper and which indicates whether the firm is located in a STP or not, is accompanied by a set of other control variables related to the business characteristics identified in the previous heading.

For the analysis, we used the generalized method of moments, applying the GMM system estimator through the xtabond2 command in the statistical software STATA (Roodman, 2009). The models were validated using different statistical tests in accordance with the literature. Thus, the absence of correlation between the instruments and the error term was tested with the consequent validation of the instruments through Hansen J test for overidentification (Hansen J statistic). In addition, the AR(2) statistic (Arellano & Bond, 1991) is calculated to test the absence of second order autocorrelation in the residuals.

RESULTS

Descriptive analysis

Sales growth is analysed during the period 2002-2014, using the variable *GSALES*. Table 1 presents the values of the original variable (*SALES*) and the annual net growth rates before the logarithmic transformation of the variables (*GSALES WITHOUT LN*).

Table 1. Descriptive statistics - Dependent variable

Variable	Obs.	Mean	std. dev.	Min.	Max.
SALES (thousands of euros)	2 260	606,801	2 451,535	0,010	50 977,990
GSALES WITHOUT NL	1 724	2,029	14,86	-0,994	366,629
GSALES	1 724	0,225	0,99	-5,195	5,907

Source: Elaborated by authors.

The average net turnover (*SALES*) of the firms located in STPs in the period considered amounts to 606,801 euros, and the average annual sales growth rate in these firms (*GSALES WITHOUT LN*) amounts to 202.9%. The summary of the mean and median values for net turnover over the period of analysis is presented in Table 2.

Table 2. Mean and median values over the analysis period

YEAR	*SALES*		*GVENDAS WITHOUT NL*	
	Mean	Median	Mean	Median
2002	2 602,805	644,844		
2003	3 604,738	798,464	-5,0%	-4,4%
2004	1 880,431	324,166	11,2%	-7,3%
2005	1 185,172	357,486	428,8%	2,5%
2006	566,503	149,879	34,2%	3,2%
2007	567,323	141,328	237,3%	19,7%
2008	659,145	150,285	269,5%	30,0%
2009	700,973	152,375	72,2%	13,5%
2010	661,684	152,398	238,0%	7,9%
2011	573,173	146,792	194,4%	7,7%
2012	561,711	137,804	340,4%	11,5%
2013	462,676	100,099	104,2%	2,8%
2014	501,215	113,180	206,1%	18,0%

Source: Elaborated by authors.

The mean values of net turnover for the sub-sample of companies located in STPs fall sharply from 2002 to 2006, apparently remaining stable between 2006 and 2014. As the average values are calculated based on a different number of available data throughout the years, this descriptive analysis is biased, as shown by the average growth rates throughout the period, which are significant and translate into average annual values that are mostly above 100%.

Analysing the evolution of the median of the variable *SALES*, it can be concluded that a significant part of the firms located in STPs present low net turnover, between 100 thousand euros and 150 thousand euros, and that the growth rates of the variable (*SALES WITHOUT LN*) are positive for all the periods from 2004 onwards, and with variable rates throughout the period under analysis.

According to the data presented in Table 3, the firms located in PCT present, on average, significantly higher levels of net turnover (*SALES*) than the firms included in the control sub-sample, there being statistical evidence to reject the null hypothesis of equality of means between the two sub-samples. In addition, according to the *t*-test presented in the previous table, the average growth of net turnover (*GSALES*) is significantly higher in firms located in STPs.

Table 3. Difference in means between samples

Variable	Parks (1)		No parks (0)		t	P valor
	Mean	std. dev.	Mean	std. dev.		
SALES	606,801	2 451,535	278,559	614,744	-6,376***	0,000
GSALES WITHOUT NL	2,029	14,864	1 864,423	79 349,110	0,975	0,330
GSALES	0,225	0,993	0,147	1,025	-2,313**	0,021

Note: *p<0,1; **p<0,05; ***p<0,01

Source: Elaborated by authors.

The dependent variable *GSALES* maintains a negative and significant correlation with firm age (*NLAGE*) and age squared (*NLAGESQUA*), as shown in the correlation matrix for the overall sample presented in Table 4.

Table 4. Corrections matrix - Global sample

	GSALES	NLAGE	NLAGESQUA	NLEMP	NLSALES
GSALES	1				
NLAGE	-0,2908*	1			
NLAGESQUA	-0,2476*	0,9511*	1		
NLEMP	0,0109	0,3407*	0,3273*	1	
NLSALES	0,1831*	0,3916*	0,3622*	0,6756*	1

Note: *p<0,1; **p<0,05; ***p<0,01.

Pearson correlation coefficients between the dependent variables and the continuous independent variables included in the empirical analysis.

Source: Elaborated by authors.

Multivariate analysis

The specified model *GSALES* considers the lagged dependent variable with a 1-period lag ($GSALES_{i,t-1}$), the main explanatory variable (*PARK*), the control variables relating to firm characteristics (*NLAGE*, *NLAGESQUA*, *NLEMP* or *NLSALES*, respectively, and *HIGHTECHTOTAL*), as well as the dummy variables controlling for the time effect (*YR*A*).

The second order autocorrelation of residuals is considered to be ruled out, considering the results of the *AR(2)* test performed. Likewise, Hansen's *J* test shows that orthogonality conditions can be considered to exist, thus validating the instruments chosen as there are no overidentifying problems. The results of the model are presented in Table 5.

Table 5. Results of the estimated model GVENDAS

Variable	GVENDAS	Variable	*GVENDAS*
$GSALES_{i,t-1}$	0,122	*YR2011A*	-0,048
	(0,072)		(0,047)
PARK	0,003	*YR2012A*	0,05
	(0,003)		(0,035)
NLAGE	-0,36	*_CONS*	0,134
	(0,313)		(0,321)
NLAGESQUA	0,062		
	(0,070)	*Dummies* years	Yes
NLEMP	0,094*	Nº obs.	2.494
	(0,040)	Nº firms	634
HIGHTECHTOTAL	0,002	Instruments	94
	(0,003)	Degrees of freedom	12
YR2007A	0,323*	F Test	7,66
	(0,134)	F p-val.	0
YR2008A	-0,12	AR(1) Test	-4,96
	(0,076)	AR(1) p-val.	0
YR2009A	-0,017	AR(2) Test	0,34
	(0,060)	AR(2) p-val.	0,732
YR2010A	-0,025	*J* Hansen statistic	90,55
	(0,050)	J Hansen p-val.	0,219

Note: *p<0,1; **p<0,05; ***p<0,01.
Corrected standard errors are shown in brackets.
Source: Elaborated by authors.

DISCUSSION

As shown by the data presented in Table 5, no statistically significant effect of the main independent variable related to the location of the firm in STPs (*PARK*) on firm growth, measured by sales growth (*GSALES*), is found.

Regarding the research hypothesis (H1) of this paper, the model reveals that there is no statistical evidence to reject the hypothesis of growth equality between firms located in STPs and the others. Likewise, the data from the model shows that the variables where the one-period lag for growth in turnover ($GSALES_{i,t-1}$) is applied do not affect the growth of the companies studied with statistical significance.

These results are similar to those obtained by Monck et al. (1988), Westhead and Storey (1994), Ferguson and Olofsson (2004), Lamperti et al. (2017) and Díez-Vial and Fernández-Olmos (2017b). On the other hand, the statistical evidence obtained in this study does not support the results of Lindelöf e Löfsten (2002), Löfsten e Lindelöf (2001, 2002, 2003), Liberati et al. (2016) and Díez-Vial and Fernández-Olmos (2017a), who found positive effects of PCT location on sales growth. It is especially interesting to highlight that these results do not fit the conclusion obtained by Albahari et al. (2022), so it is more likely that those researches using extended samples find significant effects of STP location. With regard to the control variables, the model evidences that there is no statistically significant relationship between the *NLAGE* variables and the dependent variable *GSALES*. Likewise, there is no statistically significant relationship between the *NLAGESQUA* variable and the dependent variable, stating that any non-linear relationship between the variables does not present statistical significance.

Regarding firm size, a statistically significant positive relationship can be verified in the model presented. Firm size is analysed through the variables *NLEMP* and *NLSALES*. The positive relationship between the variables related to size and sales growth (*GSALES*) meets Penrose's (1959) theory of resources and capabilities. Larger firms are able to obtain greater resources which, when invested, provide greater growth. The freeing up of resources is particularly important so that firms can achieve a minimum efficient scale that allows them economic profits that can be directed towards their own growth. The positive relationship can also be found in the work developed by Colombo and Delmastro (2002), for the size of firms incubated in STPs at start-up.

The model also shows that there is no statistically significant positive relationship between the variable *HIGHTECHTOTAL* and the dependent variable *SALES*.

Concluding the analysis of the relationship of the variables presented in the model, the estimated coefficients for the time variables, included in the model to integrate the macroeconomic aspects common to all the companies in each of the years analysed, do not demonstrate statistical significance in general terms.

CONCLUSIONS

Research about the effects of STPs on firms' performance has obtained divergent results, with the existence of significant effects remaining unclear (Hobbs et al., 2017; Lecluyse et al., 2019). A possible explanation for the lack of consensus would be related to the type of methodologies followed in the studies and notably the use of small sample sizes (Albahari et al., 2022). This study examines the effects of location in STPs on firms' growth measured in sales. A sample of 553 Portuguese firms located in STPs and a control sample of identical size over the period 2002-2014 are used. The PSM method is used to match the sample, which allows minimizing the estimation bias and ensuring the reliability of the results. The analysis is carried out using the generalised method of moments in dynamic panel data, controlling for those individual characteristics of firms that may influence their growth.

Considering the global sample, constituted by all firms (located inside and outside STPs), we concluded that there is no statistical evidence supporting a positive relationship between location in STPs and growth. This conclusion, drawn from the results of the estimation applying the generalised method of moments, is valid for sales growth, measured by the natural logarithm of net turnover. The conclusion is ratified, when the lag of one period for sales growth is presented, verifying that this lag incorporated in the model does not affect in a statistically significant manner the results obtained. In conclusion, the evidence shows that firms do not register significantly higher growth simply because they are located in STPs.

Some studies have suggested that, although STPs do not have positive effects on firms located there in general, they could have positive effects for certain types of firms, for example, those in a high-growth phase (Arauzo-Carod et al., 2018). Similarly, the existence of effects could also depend on the characteristics of each STP, for example, the type of agents involved or the services offered (Woolley & MacGregor, 2022). These explanations are consistent with the results obtained in this study.

The absence of statistical evidence confirming positive effects of STPs on firm performance raises the question of the role of STPs and the effective results associated with the strong investment that governments directly or indirectly make in these infrastructures. Considering that STPs are seen as instruments for local and regional economic development, the results of a significant part of empirical studies continue to show that there is no statistical significance between the location of firms in STPs and their growth. It is necessary to further explore the effects of STPs according to the characteristics of the park and the types of firms, identifying those more likely to obtain beneficial results from locating in parks. This would allow public managers to be more restrictive in the selection of parks and firms that are supported, better targeting efforts and thus achieving greater impact on regional development.

Limitations and future research

The main task for future research concerning the effects of STPs on firm growth is to explore the causes of the absence of significant effects of locating in parks. In this sense, the statistical evidence of this study does not prove that there are positive effects in general; but there may be certain types of firms that benefit from locating in parks. However, little is known about the characteristics that would make a company likely to obtain such benefits, which makes necessary to further investigate this topic.

Moreover, it should be noted that the data available in SABI on the different variables for each of the companies limited the size of the sample, and it is not possible to ensure that all the data collected is free from the distortions inherent in a database such as SABI. Nevertheless, considering the number of observations per variable, which results from the product of the number of years analysed by the number of companies, it is assumed that any distortion has no relevant effect on the analysis carried out.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

AUTHORS' CONTRIBUTION

Júlio Paulo da Silva Martins: Conceptualisation, data curation, formal analysis; Research; Methodology; Visualisation; Writing - original draft.

María Jesús Rodríguez-Gulías: Conceptualisation, data curation, formal analysis; Research; Methodology; Supervision; Validation.

David Rodeiro-Pazos: Conceptualisation, data curation, formal analysis; Research; Methodology; Project management; Resources; Programmes; Supervision; Validation; Writing - revision and editing.

Raul Rios-Rodríguez: Research; Supervision; Validation; Writing - original draft; Writing - revision and editing.