



Habitats dentro dos Ecossistemas: Efeitos Multicamadas dos Parques Tecnológicos e dos Ecossistemas sobre o Desempenho das Empresas Residentes

Resumo: A literatura sobre Parques Científicos e Tecnológicos (PCTs) tem reconhecido cada vez mais a heterogeneidade desses ambientes na forma como são estruturados em torno de diferentes mecanismos para fomentar o desempenho das empresas. No entanto, os PCTs não se estabelecem em um vácuo territorial. Pelo contrário, o desempenho das empresas também é influenciado pelas características distintas dos Ecossistemas Empreendedores (EE) locais. Utilizando um painel de dados entre 2015 e 2020, o estudo analisa como indicadores no nível do parque e do EE se relacionam com a geração de patentes e o crescimento do emprego no contexto de uma economia emergente, o Brasil. Os resultados revelam um cenário complexo no qual o desempenho tecnológico das empresas é impulsionado principalmente pelo nível de desenvolvimento dos componentes do EE. Além disso, efeitos positivos das características do parque (tamanho, afiliação universitária e tempo de permanência da empresa) sobre o desempenho inovador emergem apenas quando mediados por indicadores do EE. No que se refere ao crescimento, as empresas se beneficiam tanto do nível de maturidade do parque quanto da dinâmica do ecossistema local. Em termos de implicações, nossos achados sugerem que as políticas de inovação devem adotar uma perspectiva de capital paciente em relação aos parques. Por outro lado, também indicam que os PCTs podem enfrentar dificuldades para fomentar a mudança tecnológica, especialmente em regiões menos desenvolvidas de economias emergentes, ampliando, assim, padrões já existentes de assimetrias regionais.

Palavras-chave: Parques Científicos e Tecnológicos; Ecossistemas Empreendedores; Heterogeneidade; Desempenho das empresas; Política de inovação.

Código JEL: L26; O31; O32

Área Temática:

- 5.1 Inovação e empreendedorismo;
- 5.2 Empreendedorismo intensivo em conhecimento;
- 6.2 Políticas de Ciência, Tecnologia e Inovação;

Habitats within Ecosystems: Multilayered effects of Technology Parks and Ecosystems on Tenant firms' Performance

Abstract: Literature on Science and Technology Parks (STPs) has increasingly recognized the heterogeneity of these environments in how they are structured around different mechanisms to

foster firms performance. Yet, STPs do not take place in a territorial vacuum. Instead, the performance of companies is also influenced by the distinct characteristics of the local Entrepreneurial Ecosystems (EE). Using a panel dataset between 2015 and 2020, the study analyzes how park-level and EE indicators relate to patent generation and employment growth in the context of an emerging economy, Brazil. The results reveal a complex scenario in which firms' technological performance is primarily driven by the level of development of EE components. Additionally, positive effects of park characteristics (size, university affiliation, and firm tenure) on innovation performance emerge only when mediated by EE indicators. Regarding growth, firms benefit from both the maturity level of the park and the dynamics of the local ecosystem. In terms of implications, our findings suggest that innovation policies must adopt a patient capital perspective on parks. Conversely, it also suggests that STPs may struggle to foster technological change, especially in less developed regions of emerging economies, thus increasing existing patterns of regional asymmetries.

Keywords: Science and Technology Parks; Entrepreneurial ecosystems; Heterogeneity; Firms' performance; Innovation policy

1. Introduction

Among the mechanisms used to promote agglomeration effects, Science and Technology Parks (STPs) have gained considerable policy attention due to the potential benefits arising from the geographical proximity between firms—particularly small and medium-sized enterprises (SMEs)—and science and technology institutes, as well as R&D departments (Link & Scott, 2006; Vásquez-Urriago et al., 2014; Albahari, 2021; Anton-Tejon et al., 2024). These instruments have become widespread innovation policy tools designed to support firms in delivering high-tech innovations and fostering entrepreneurial activities within their local entrepreneurial ecosystems (Germain et al., 2023).

As a result of this widespread adoption, at both national and regional levels, innovation policies have increasingly structured STPs around different mechanisms to foster innovation and enhance firm competitiveness. More specifically, the literature on parks highlights that proximity to science and technology institutes and research centers can generate knowledge spillover effects for tenant firms (Albahari et al., 2017; Lamperti et al., 2017; Kang et al., 2025). Additionally, STPs may offer a range of strategic services aimed at strengthening the technical and managerial capabilities of firms (Ng et al., 2020). It is also expected that STPs vary in size and level of maturity, reflecting differences in their capacity to attend companies' demands (Albahari et al., 2018; Anton-Tejon et al., 2024).

Yet, STPs (and their respective effects) do not take place in a territorial vacuum. Instead, the performance of tenant firms is also influenced by the distinct characteristics of the local socioeconomic structure (Theeranattapong et al., 2021). In this regard and due to parks goal on improving mainly SME's performance, it can be argued that STPs operate within local entrepreneurial ecosystems (EEs) characterized by varying levels of maturity (Mello et al., 2020; Jacobson et al., 2024). However, the few quantitative studies that have examined how elements of local EEs affect firm performance within STPs have largely focused on regional technological intensity (Liberati et al., 2016; Albahari et al., 2018; Qi et al., 2024). In turn, EE literature has devoted scant attention to innovation habitats such as STPs, often treating them as ancillary institutions (Stam, 2015; Stam & van de Ven, 2021; Guerrero & Siegel, 2024).

However, there is a growing recognition that STPs need to be properly situated in this broader socioeconomic environment in order to understand the relevance of these ecosystem elements in shaping the performance of tenant firms (Poonjan & Tanner, 2020). So far, the literature that takes this embeddedness approach remains concentrated in developed countries, offering little guidance for these policy instruments in the context of peripheral or emerging markets (Albahari et al., 2023).

Building on these considerations, this study contributes to the literature by providing empirical evidence on the effects of both internal park mechanisms and local entrepreneurial ecosystems characteristics on the performance of tenant firms within the context of an emerging economy. Brazil represents a particularly relevant case for this analysis, as STPs have been a central component of the country's science, technology, and innovation (STI) policies over the past three decades (Faria et al.,

2025). Specifically, we investigate how these factors relate to firm performance, measured by patent generation and employment growth.

Our study seeks to address the following research question: *what are the features of science and technology parks and of the local entrepreneurial ecosystem that influence the innovation and economic performance of resident firms in the context of a developing country?* To answer it, we rely on a novel panel dataset covering 54 Brazilian STPs located across 45 cities and 690 tenant firms over the period 2015 to 2020. This dataset combines firm-level information with park-level data -including size, age, university affiliation, and firm tenure, that is, the time a company has spent in park- as well as indicators of local entrepreneurial ecosystem characteristics -such as knowledge production, local competitiveness, talent availability, governance and networks, and an aggregate EE index. Additionally, it is important to emphasize that we focus on analyzing the relationship between STPs and EE on resident companies performance, which allows us to isolate the effect of these variables more effectively than would be possible if large firms were included in the sample.

2. Literature Review

Since their proliferation during the 1970s and 1980s, STPs have become the subject of numerous studies aiming to assess their impact and effectiveness, primarily through statistical comparisons of the economic and innovation performance of tenant firms. However, empirical results have shown mixed evidence for both types of performance (Albahari et al., 2023). More recently, the literature has pointed to the need to consider the heterogeneity of parks in order to better understand these mixed effects (Anton-Tejón et al., 2024). Specifically, many studies that have assessed the impact of STPs have focused only on the average effect of park presence on firm performance, without considering that park characteristics might influence the value-added of being located within an STP (Albahari et al., 2023).

In this regard, such heterogeneity can be understood along two dimensions: internal elements of the parks and factors related to the local entrepreneurial ecosystem (Poonjan & Tanner, 2020). Tenant firms may be located in parks that are structurally heterogeneous in terms of their internal mechanisms. In terms of empirical outcomes, for example, studies have identified that “university parks” affect resident firms differently from “non-university parks” (Albahari et al., 2017). Additionally, Liberati et al. (2016) found a positive effect of park age on sales performance, attributed to this long-term accumulation of experience in parks. When analyzing the effect of park size, Albahari et al. (2018) find that larger parks positively influence sales of innovative products and patenting activity, respectively.

Furthermore, STPs are not the outcome of geographically neutral policies, rather, they tend to reflect and be shaped by local capabilities. Given their local nature, STPs can act as intermediary actors within entrepreneurial ecosystems (EEs), improving the performance of technology-based firms in their locality and leveraging entrepreneurial activity (Alves et al., 2021; Germain et al., 2023). In this context, an EE can be understood as *“a set of interdependent actors and factors that are governed in such a way*

that they enable productive entrepreneurship” (Stam, 2015, p. 1765), where productive entrepreneurship is analyzed here as the number of high-growth nascent firms, high-tech firms, or innovative firms (Wurth et al., 2022).

In this context, the relationship between firms and ecosystems is shaped by social, economic, and institutional relations, which imposes limits on generalizations of their structures (Fischer et al., 2024). For example, Muñoz et al. (2022) analyzed six narrated attributes evaluated by local experts: policy support, place-specific local programs, financial support, cultural celebration, entrepreneurial learning, and market behavior. Alves et al. (2021), when analyzing the context of the São Paulo region in Brazil, split their variables into two broad macro-dimensions: the knowledge infrastructure and the socioeconomic system. Leendertse et al. (2022) and Stam and van de Ven (2021) analyzed ten joint indicators that compose an entrepreneurial ecosystem: Formal institutions, Culture, Networks, Physical infrastructure, Finance, Leadership, Talent, Knowledge, Demand, and Intermediate services. Regardless of the methods employed, the EE literature has pointed out that firms operate within a dense network of connections that contribute to the support and evolution of entrepreneurial and innovative businesses (Wurth et al., 2022), many of whose components are tied to territories (Fischer et al., 2025).

3. Methodology

3.1. Database

The objective of this research is to analyze the effects of both elements from STPs and their local ecosystems on the growth and patents generation performance of resident firms in an emerging country context. To this end, we collected longitudinal data covering the period 2015-2020 on park characteristics, resident firms, and the cities where the parks are located. Table 1 presents the description of all variables, and the correlation matrix is shown in Appendix A.

Data on technology parks were obtained from InovaData-BR, a platform maintained by the Brazilian Ministry of Science, Technology, Innovations and Communications (MCTI) for monitoring and developing Brazil's STPs and their resident companies and organizations. For firm-level data, we followed two approaches. First, we collected data from InovaData-BR regarding the unique national identifier of each resident company. Subsequently, using these identifiers, we gathered additional data from the OpenSense database. OpenSense is a private platform responsible for collecting and monitoring longitudinal data from public data sources on Brazilian ecosystems. Specifically, for firm size data, we used the Annual Social Information Report (RAIS) database, maintained by the Ministry of Labor and Employment, which is a public platform for collecting socioeconomic information on legal entities. Finally, data regarding the cities where the parks are located were collected from the Sebrae Index of Local Economic Development (ISDEL), a composite index consisting of five dimensions designed to quantitatively represent the development stage of Brazilian municipalities. These dimensions will be detailed next.

After extracting all firm-related data, we had a total of 2,952 observations from 690 companies. To make the sample more homogeneous and to focus our analysis away from large business groups, we removed all companies that had any observation with 1,000 or more employees during the analyzed period, following the approach of Corrocher et al. (2019). Thus, our final sample consisted of 2,796 observations from 658 companies. Additionally, this group of firms, SMEs, is more closely linked to entrepreneurial activity (Stam, 2015) which represents a central focus of STPs (IASP, 2024).

3.2. Variables

3.2.1. Dependent

Since the spread of STPs in the 1980s, they have become the subject of studies seeking to measure their impacts and effectiveness, primarily by comparing the economic and innovation outcomes of resident firms (Albahari et al., 2023). We use *patents applications* as a proxy to innovation performance, which is one of the most common measures of innovation (Acs et al., 2002). Patents applications can be used as an early indicator of innovation activity and technological development, particularly in the absence of more informative proxies such as R&D data. However, it is important to mention that patents are imperfect measures of innovation, because not all inventions are patentable and they don't necessarily reflect economic value of the invention. Nonetheless, it is a variable extensively used in the STPs literature (Lindelöf & Löfsten, 2002; Liberati et al., 2016; Corrocher et al., 2019; Anton-Tejon et al., 2024; Kang et al., 2025). Patent data were extracted from the OpenSense database, which sources from the National Institute of Industrial Property (INPI), measuring annual patent applications per firm.

Secondly, we use *employment growth rate* as a proxy to economic performance. To construct the variable, we subtracted firm i size at time t by firm i size at time $t-1$. We opted to use absolute growth measures instead of relative measures since we are evaluating annual changes in firms' employment not conditioned by their size. By doing this, we control bias in relative measures to attribute higher growth to smaller firms. Since our sample is composed primarily by SME, we have chosen an absolute measure, just as previous studies (Diez-Vial & Fernández-Olmos, 2017; Arauzo-Carod et al., 2018). Size data were extracted from the Annual Social Information Report (RAIS): a mandatory socioeconomic report instituted by the Brazilian government to collect and monitor labor market data.

3.2.2. Independent variables

As demonstrated in the literature, empirical studies analyzing the impact of STPs on firms' performance present a mixed pattern of results. In this context, specialized literature argues that we must examine the specific conditions under which firms are impacted by STPs (Albahari et al., 2023). Accordingly, our explanatory variables are divided into two levels: park-level variables and cities entrepreneurial ecosystem level variables (Poonjan & Tanner, 2020).

3.2.2.1. Park level

Park Size is a continuous variable and reflects the overall number of tenants located inside each

park in each year, intended to capture potential agglomeration effects (Corrocher et al., 2019). We expect positive and significant coefficient, given our assumption that the greater the Park size the greater the likelihood of agglomeration effects¹. The variable *university ownership* is a binary variable reflecting the segmentation in the literature between university-based and non-university-based parks. Based on Albahari et al. (2017), we expect a positive effect of this variable on the innovation performance and a negative one on economic performance. Lastly, the continuous variable *Park age* measures the park's age since its founding up to the respective year, reflecting the different maturity levels of these environments and capacities accumulation in STPs (Anton-Tejon et al., 2024)². Secondly, we included the continuous variable *Firm Tenure*, which measures the number of years since a firm entered the park up to the year of analysis (Squicciarini, 2009). It is expected that more mature parks (Park age) and firms with longer tenure within STPs may benefit from the network effects generated by these environments and due to accumulation of capacities and knowledge.

3.3.2.2. *Entrepreneurial Ecosystem level*

Recent literature reviews highlight the importance of local social, economic, and institutional contexts for the performance of firms located in STPs (Theeranattapong et al., 2021; Poonjan & Tanner, 2020). More specifically, the literature has increasingly highlighted STPs as key elements of entrepreneurial ecosystems (Germain et al., 2023). Literature on ecosystems has pointed out that firms operate within a dense network of connections that contribute to the support and evolution of entrepreneurial and innovative businesses (Wurth et al., 2022), many of whose components are tied to territories (Fischer et al., 2025). To capture these components, we utilize both the composite ISDEL index³ as a proxy of EE and its five constituent dimensions.

1. *Talents* – The presence of human capital encompasses individuals' skills, knowledge, and experience—essential for both entrepreneurial activity (Stam & van de Ven, 2021) and innovation (Feldman & Kogler, 2010). The entrepreneurial ecosystems literature broadly examines human capital, assessing general local education, entrepreneurship-specific human capital, and human capital for science and technology activities (Leendertse et al., 2022). Thus, the variable *Talents* Reflects the stock of creative and entrepreneurial capacity in a territory, measured by the quantity and quality of firms, entrepreneurs, and population education levels. This dimension comprises three subdimensions: Education, Entrepreneurial Education, and Business Conditions.

2. *Networks* – Both Saxenian (1996) and Storper (2018) demonstrate the importance of trust-based relationships and shared values and beliefs in Silicon Valley for fostering collaboration networks among local actors and identifying technological and business opportunities. These social dynamics within a defined space determine a community's interest in new technologies or industries (Feldman & Kogler, 2010), and the alignment among actors is seen to shape how organizations operate in EE (Spigel, 2017). The variable *Networks* represents informal institutions, including networks of entrepreneurs and firms that collaborate to advance collective interests and facilitate dialogue with local stakeholders. It

includes two subdimensions: Business Networks and Solidarity Values.

3. *Governance* – Formal institutional support reflects the "rules of the game in society" (North, 1990). The entrepreneurial ecosystem literature emphasizes the importance of public service provision, corruption levels, government efficiency, and transparency for entrepreneurship (Stam & van de Ven, 2021). The variable *Governance* captures a shared vision for the future developed through participatory and democratic processes, along with a strategic economic development plan. It consists of four subdimensions: Articulation, Fiscal Management, Planning, and Social Participation and Control.

4. *Knowledge Production* - It is expected that the local productive structure and the presence of science and technology institutions influence the performance of local firms through knowledge generation processes and spillover effects. Regarding the former, Fischer et al. (2024) argue that entrepreneurial opportunities may arise from the co-location of firms operating in complementary sectors or from the cross-fertilization of ideas among actors from different sectors and technological domains (Beaudry & Schiffauerova, 2009). Additionally, universities and research institutions are considered key drivers of innovation and entrepreneurship (Feldman & Kogler, 2010), fostering scientific knowledge creation and the emergence of knowledge-intensive firms (Schaeffer et al., 2023). The *Knowledge Production* variable assesses how territories organize their economic activities to generate income and wealth. Its sub-dimensions include Productive Structure, Innovation, Consumption and Credit Potential, Sanitation, and Environmental Impact.

5. *Competitiveness* – The economic geography literature indicates that more developed regions offer greater diversification opportunities in both complex and unrelated sectors (Françoso et al., 2024). Similarly, the entrepreneurial ecosystem (EE) literature highlights that local productive complexities serve as a source of entrepreneurial opportunities (Fischer et al., 2024). Spiegel's (2017) findings demonstrate how the local productive structure shapes the interactions and dynamics among ecosystem actors. The *Competitiveness* variable assesses the actions required for a territory to position itself competitively, with sub-dimensions including Complexity, International Trade, Tourism and Creative Economy, and Connectivity.

Entrepreneurial Ecosystem - The aggregate ISDEL index is used as a proxy to EE and quantitatively represents the level of development of Brazilian municipalities, based on the average of its five dimensions.⁴ It is expected that firms benefit from the structures provided by the local entrepreneurial ecosystem. Accordingly, we expect positive effects from both the overall level of ecosystem development and its individual dimensions on the performance of tenant firms.

Additionally, to account for the heterogeneity among firms in STPs, we included five control variables related to firms, as *size*, *age*, *public subsidies for Research Development & Innovation (RD&I)* activities in the last five periods, *technological intensity* using OECD sector classifications, *imports* frequency. Finally, we included year and Brazilian macro-region controls.

Table 1 -Variables

Variables	Description
Dependent	
Patents	Number of patent applications by year and firm
Growth	Firm growth, measured as the variation in the number of employees between $t-1$ and t
Independent	
Park	
Park size	Park size, measured as the number of tenant organisations in year t
Park age	Park age, measured as the number of years since the park's establishment in year t
University-owned	Ownership structure: dummy variable equal to 1 if the park is university-owned, and 0 otherwise
Firm tenure in STP	Firm tenure in the park, measured as the number of years the firm has been in the park
Entrepreneurial Ecosystem	
Knowledge Production	The manner in which organizations and institutions within the territory organize their economic activities to generate income and wealth
Competition	The set of actions required for the territory to position itself competitively in external environments
Talents	Quantity and quality of formal and entrepreneurial education in the territory
Networks	Formal and informal networks of entrepreneurs and firms that come together to act collectively in pursuit of their interests
Governance	Comprised of a shared vision of the future, developed in a participatory and democratic manner with the entire community, and of a Strategic Economic Development Plan that translates this vision into action
Entrepreneurial Ecosystem index	Average index of the city's entrepreneurial ecosystem
Control variables	
size	Number of firm employers in year i
age	Number of current firm age in year i
imports	Dummy variable equal to 1 if the firm imported in year t
Public RD&I support	Dummy variable equal to 1 if the firm received any public funding related to R&D&I activities within the last five years
high tech	Dummy variable equal to 1 if the firm belongs to a high-tech sector according to the OECD classification
med high	Dummy variable equal to 1 if the firm belongs to a medium-high-tech sector according to the OECD classification
med	Dummy variable equal to 1 if the firm belongs to a medium-tech sector according to the OECD classification
med low	Dummy variable equal to 1 if the firm belongs to a medium low-tech sector according to the OECD classification
low	Dummy variable equal to 1 if the firm belongs to a low-tech sector according to the OECD classification

Note: elaborated by the authors.

3. Results

Descriptive statistics for our sample of 658 on-park companies (Table 2) indicate that only 30% of observations are located in university-based parks. The average park age is 11.14 years, with an average size of 89 firms. On average, resident firms have remained in the parks for five years, and the host municipalities exhibit an average economic development index of 0.72 (maximum of 0.86). These

figures outline the typical profile of Brazilian STPs in our sample: on average, firms are located in relatively young and small parks and have spent only a few years in these environments. Moreover, the high standard deviation associated with park characteristics underscores substantial heterogeneity in terms of park structures. In contrast, the relatively high average value of the EE index, combined with its low standard deviation, suggests that parks and their resident firms are concentrated in more mature local ecosystems. In Appendix B, we provide a mapping analysis of the distribution of observations, patents and average growth rates across Brazilian regions.

Table 2 -Descriptive statistics

Variables	Mean	Std. Dev.	Min	Max
Dependent				
Patents	0,04	0,29	0,00	6,00
Growth	0,20	3,79	-1,00	197,00
Indepedent				
Park				
Park size	89,33	91,11	1,00	302,00
Park age	11,14	6,44	0,00	32,00
University-owned	0,30	0,46	0,00	1,00
Firm tenure in STP	5,14	5,00	0,00	30,00
Local context				
Knowledge Production	0,58	0,08	0,29	0,79
Competition	0,73	0,08	0,38	0,86
Talents	0,51	0,10	0,21	0,70
Networks	0,71	0,08	0,40	0,88
Governance	0,71	0,08	0,37	0,85
Entrepreneurial Ecosystem	0,73	0,08	0,38	0,86
Control variables				
size	69,87	118,51	1,00	938,00
age	15,97	10,58	0,00	54,00
imports	0,21	0,41	0,00	1,00
Public RD&I support	0,09	0,29	0,00	1,00
high tech	0,46	0,50	0,00	1,00
med high	0,22	0,41	0,00	1,00
med	0,07	0,25	0,00	1,00
med low	0,08	0,27	0,00	1,00
low	0,18	0,38	0,00	1,00

Note: elaborated by the authors.

The aim of the empirical exercise is to provide evidence on the determinants of the intensity of firms' innovative activity and economic performance, based on the impact of park-specific and local context specific variables through regression analysis on longitudinal data. In terms of econometric analysis, Table 3 presents the results of the analysis of the effects of park-level characteristics on annual patent applications for resident SMEs. Each park attribute is analyzed separately, with the final column showing the effect of all park-related variables. Table 4 presents the effects for the entrepreneurial ecosystem (EE) components on patent generation. Each EE component is examined independently given

the high correlation among the ecosystem variables. Additionally, for both Tables 3 and 4, we analyze the effects for the lagged parks variables and for the aggregate EE index in the last model. Firm-level characteristics are included as control variables. As a robustness check, we tested whether the inclusion of different variables affected the results.

Regarding firm-level controls, our results show that firm size and age have positive and negative, respectively, but statistically insignificant effects on patent generation. Similarly, no significant effects are observed for import frequency. Conversely, a positive and highly significant effect (p value < 0.01) is found for receiving public R&D support in all models. Moreover, firms in low tech (p value < 0.05 for model 2 and beyond) and medium-low-tech (p value < 0.1 for model 2 to 5) sectors demonstrate a negative and a positive relation to firms' propensity to patent compared to high-tech sectors (reference group), respectively. The positive effect of medium low aligns with the findings of Furtado and Carvalho (2005) regarding the Brazilian context, where medium-low-tech sectors tend to engage more actively in innovation activities.

Regarding park-level characteristics (Table 3), we find a negative and statistically significant relationship (p value < 0.01 for all models) between park size and patent output in firms, suggesting potential diseconomies of agglomeration. This result is consistent to the findings of Corrocher et al. (2019) in the Italian context for the same variable. As parks grow larger, increased competition among resident firms for limited resources may reduce innovation outputs. No significant effects are observed for university affiliation, which contrasts with the Spanish context (Albahari et al., 2017) and with expectations for the Brazilian case, given the importance of the segmentation between university-based and non-university-based parks (Bolliger et al., 2025). Regarding age, no positive effects of park maturity on innovation performance are identified, consistent with Lamperti et al. (2017), in Italy. Finally, no positive effects are found for the number of years a firm has been embedded in the park.

Turning to the EE components (Table 4), Knowledge Production and Talent stand out with positive and statistically significant effects (p value < 0.05 and p value < 0.01 , respectively). Intriguingly, Competition shows a negative but not significant effect. Meanwhile, Governance, Networks, and the aggregate EE index display positive but statistically insignificant effects. Differently, in model 12, the lagged EE composite index becomes significant at the 10% level. Overall, these results suggest a positive relationship between firms' innovative performance and the components of the EE, differently from findings in Albahari et al. (2018) and Liberati et al. (2016).

Given that positive direct effects are not observed for parks variables, we hypothesize that these effects may be mediated by the surrounding entrepreneurial ecosystem. Table 5 explores the interaction between park characteristics and all the components of EE. In each model, we present the interaction between park characteristics and ecosystem variables, beginning with knowledge production, competition, governance, networks, and talent, and concluding with the overall EE index. Regarding the

results, we find a positive effect of firms' tenure when mediated by the level of local competitiveness (p-value < 0.05), by the presence of local talent (p-value < 0.1), and by the overall EE index (p-value < 0.1). Additionally, we observe positive effects of park size when mediated by local competitiveness, also at the 10% level. Interestingly, both ecosystem competitiveness and park size variables exhibited negative effects when analyzed in Tables 3 and 4, although statistical significance emerged only for park size. Finally, we also detect a positive effect of being located in a university-based park when mediated by the level of local ecosystem networks (p-value < 0.1). Overall, these results suggest that the heterogeneous characteristics of parks positively influence firms' innovative performance only when mediated by the maturity of the surrounding entrepreneurial ecosystem. Interesting, this is a novel finding for the STPs literature.

Table 3 – Patent analysis –STPs elements

	1	2	3	4	5
size	0.141(0.121)	0.144(0.122)	0.140(0.121)	0.151(0.123)	0.117(0.141)
age	-0.070(0.247)	-0.083(0.248)	-0.026(0.263)	-0.019(0.264)	0.071(0.336)
fin pub	1.126***(0.337)	1.099***(0.335)	1.119***(0.336)	1.115***(0.336)	1.169***(0.396)
Low tech ^a	-1.835***(0.797)	-1.910***(0.805)	-1.922***(0.803)	-1.883***(0.806)	-1.672***(0.841)
Med low ^a	0.961*(0.502)	0.956*(0.504)	0.960*(0.499)	0.986*(0.505)	0.838(0.577)
Med ^a	-0.125(0.639)	-0.148(0.643)	-0.138(0.639)	-0.141(0.641)	-0.440(0.790)
Med high ^a	0.067(0.426)	0.042(0.429)	0.044(0.425)	0.085(0.433)	0.185(0.499)
imports	0.350(0.337)	0.346(0.339)	0.352(0.337)	0.327(0.342)	0.404(0.406)
Park Size	-0.425****(0.162)	-0.472****(0.171)	-0.475****(0.169)	-0.466****(0.170)	
Park Age		0.271(0.265)	0.337(0.288)	0.294(0.301)	
Firm's Tenure			-0.119(0.197)	-0.113(0.197)	
Uni park				0.204(0.421)	
Park Size t-1					-0.597****(0.201)
Park Age t-1					0.348(0.330)
Firm's Tenure t-1					-0.204(0.224)
Uni park t-1					-0.067(0.483)
_cons	0.267(1.010)	-0.075 (1.056)	-0.195(1.070)	-0.228(1.082)	0.225(1.324)
II	-329.484	-328.943	-328.763	-328.65	-257.737
N	2796	2796	2796	2796	2138

Note: Standard errors in parentheses; a. The reference category is high tech; All regressions include year and regional dummies. *p<0.05, **p<0.01, ***p<0.001

Table 4 – Patent analysis – Entrepreneurial Ecosystem elements

	7	8	9	10	11	12
size	0.127(0.124)	0.157(0.125)	0.119(0.123)	0.120(0.122)	0.135(0.125)	0.111(0.124)
age	-0.125(0.254)	-0.188(0.255)	-0.133(0.254)	-0.138(0.253)	-0.055(0.260)	-0.094(0.256)
fin pub	1.101****(0.344)	1.121****(0.346)	1.070****(0.345)	1.061****(0.348)	1.052****(0.341)	0.981***(0.408)

Low tech ^a	-1.886** (0.812)	-1.841** (0.800)	-1.863** (0.803)		-1.914** (0.811)	-	1.683** (0.845)
				-1.861** (0.802)	-2.100*** (0.814)	1.202** (0.539)	1.083* (0.609)
Med low ^a	1.375** (0.548)	1.022** (0.509)	1.114** (0.524)	1.096** (0.518)	0.775(0.536)		
Med ^a	-0.107(0.668)	-0.260(0.649)	-0.242(0.655)	-0.269(0.653)	-0.479(0.669)	-0.241(0.660)	-0.582(0.803)
Med high ^a	-0.019(0.448)	-0.021(0.436)	0.001(0.443)	-0.007(0.440)	-0.066(0.445)	0.018(0.446)	0.122(0.510)
imports	0.342(0.341)	0.445(0.340)	0.413(0.343)			0.350(0.347)	0.245(0.413)
				0.416(0.343)	0.326(0.339)		
Knowledge Production	6.783** (3150)						
Competition		-7.789(6.040)					
Governance			1.134(3.371)				
Networks				0.649(3702)			
Talents					17.522*** (5.216)		
EE						9.142(6.585)	
EE (t-1)							15.369* (8.540)
_cons	-3.538** (1.630)	3.590 (3.531)	-1.363 (1.937)	-1.161(2.307)	-8.808*** (2.569)	-5.398(3.452)	-8.635* (4.558)
II	-330.730	-331.961	-333	-332.729	-327.230	-331.766	-260.480
N	2796	2796	2796	2796	2796	2796	2138

Note: Standard errors in parentheses; a. The reference category is high tech; All regressions include year and regional dummies. *p<0.05, **p<0.01, ***p<0.001.

Table 5 - Patent analysis – Interaction

	13	14	15	16	17	18
size	0.152(0.126)	0.186(0.132)	0.159(0.124)	0.165(0.126)	0.157(0.126)	0.146(0.129)
age	-0.017(0.270)	-0.120(0.283)	0.011(0.268)	-0.049(0.274)	0.052(0.271)	-0.019(0.276)
fin pub	1.170*** (0.350)	1.227*** (0.352)	1.091*** (0.339)	1.050*** (0.341)	1.058*** (0.343)	1.164*** (0.350)
Low tech ^a	-1.830** (0.822)	-1.817** (0.817)	-1.901** (0.812)	-1.784** (0.815)	-	-1.845** (0.833)
					2.105*** (0.814)	
Med low ^a	1.243** (0.547)	1.024* (0.548)	0.975* (0.514)	1.035** (0.505)	0.732(0.529)	1.232** (0.547)
Med ^a	-0.005(0.671)	-0.241(0.674)	-0.183(0.646)	-0.065(0.656)	-0.458(0.668)	-0.126(0.673)
Med high ^a	0.139(0.456)	0.056(0.450)	0.075(0.436)	0.145(0.440)	-0.033(0.441)	0.114(0.456)
imports	0.185(0.351)	0.148(0.362)	0.303(0.345)	0.383(0.354)	0.271(0.348)	0.149(0.361)
Park Age	-1.967(1.738)	-3.950* (2.097)	0.489(1932)	1.810(2.092)	-1.570(0.966)	-3.072(2.575)
Park Size	2.103(2.983)	4.846(3.689)	0.971(3203)	0.631(3.186)	1.064(1.946)	2.230(4.441)
Firm's Tenure	-0.632(1.397)	-5.399** (2.203)	0.849(1764)	-4.046(2.463)	-2.156** (1.075)	-4.841* (2.647)
Uni park	-1.536(3.465)	-0.315(4.005)	0.671(3526)	-7.451(4.750)	-1.458(2.059)	-3.473(4.901)
Knowledge Production	0.411(14458)					
Competition		-18.947(15.625)				
Governance			11.908(12.892)			
Networks				-1.988(8.029)		
Talents					4.167(10.263)	
EE						-10.883(20.973)

KP*Park Size	3.310(3.671)					
KP*Park Age	-4.039(6.429)					
KP* Firm's Tenure	1.259(3.033)					
KP*Uni Park	3.708(7.463)					
Comp.*Park Size	6.447*(3788)					
Comp.*Park Age	-8.270(6.609)					
Comp.* Firm's Tenure	9.752**(4.024)					
Comp.*Uni Park	1.420(7.345)					
Gov.*Park Size	-1855(3.643)					
Gov.*Park Age	-1266(5.984)					
Gov.* Firm's Tenure	-1878(3.353)					
Gov.*Uni Park	-0.970(6.602)					
Net.*Park Size	-3.883(3.767)					
Net.*Park Age	-0.304(5.895)					
Net.* Firm's Tenure	7.075(4.435)					
Net.*Uni Park	14.238*(8.581)					
Tal.*Park Size	2.804(2.249)					
Tal.*Park Age	-1469(4.403)					
Tal.* Firm's Tenure	4.809*(2481)					
Tal.*Uni Park	3.805(4.650)					
EE*Park size	5.434(5.098)					
EE*Park Age	-4.260(8.758)					
EE* Firm's Tenure	9.499*(5.257)					
EE*Uni Park	7.907(9.685)					
_cons	0.077(6.594)	10.544(8.745)	-6.437(6.913)	0.361(5.797)	-3.080 (4.713)	5.556(10.593)
II	-326.461	-323.890	-327.874	-325.799	-320.250	-325.167
N	2796	2796	2796	2796	2796	2796

Note: Standard errors in parentheses; a. The reference category is high tech; All regressions include year and regional dummies. *p<0.05, **p<0.01, ***p<0.001.

Next, Tables 6 and 7 present the results of the System GMM panel regression models focusing on SMEs' growth. The models are structured similarly to the patent analysis, examining both park characteristics and EE components.

Regarding firm-level controls, firm size has a negative and significant effect on growth, whereas firm age has a positive and significant effect. When analyzing park-level effects (Table 6), the findings differ from those observed for patenting. First, park size has a positive effect in Model 19 at the 10% level. However, this effect becomes insignificant from Model 20 onward, once park maturity level is introduced. With respect to park maturity, its effect becomes more significant when firm tenure is controlled for: the p-value decreases from less than 0.1 in Model 20 to less than 0.05 from Model 21 to 23. Similar results for maturity level are found in Liberati et al. (2016) for revenue performance in resident firms. University affiliation shows no significant effect nor does firms' tenure. Overall, the results indicate that larger and, more importantly, more mature parks may provide better conditions for business expansion.

Regarding EE components (Table 7), the results indicate that both competition and networks exhibit positive effects (p-value < 0.1). Similarly to the innovative performance models, the lagged aggregate EE index also shows a positive effect on firm growth at the 5% level. These results are consistent to recently positive effects of local ecosystem variable on Chinese parks growth (Qi et al., 2024). In other words, firms located in STPs situated within more developed ecosystems along these dimensions outperform firms located in less developed ones, *ceteris paribus*⁵.

Table 6 – Growth analysis– STPs elements

	19	20	21	22	23
l.growth	0.328*** (0.109)	0.301*** (0.098)	0.312*** (0.096)	0.306*** (0.092)	0.352*** (0.105)
l.size	-0.442** (0.193)	-0.366** (0.155)	-0.417** (0.163)	-0.396** (0.154)	-0.475*** (0.176)
l.age	0.322* (0.173)	0.252* (0.141)	0.314** (0.150)	0.292** (0.141)	0.367** (0.168)
fin pub	-0.021(0.142)	-0.003(0.135)	-0.008(0.137)	-0.014(0.134)	-0.026(0.136)
l.imports	-0.148(0.128)	-0.132(0.129)	-0.147(0.127)	-0.147(0.128)	-0.161(0.126)
Low tech ^a	-0.090(0.107)	-0.102(0.094)	-0.121(0.108)	-0.123(0.102)	-0.147(0.115)
Med low ^a	0.126(0.147)	0.092(0.119)	0.106(0.141)	0.096(0.132)	0.099(0.146)
Med ^a	0.091(0.130)	0.084(0.112)	0.089(0.130)	0.079(0.121)	0.091(0.135)
Med high ^a	0.050(0.103)	0.047(0.085)	0.051(0.102)	0.048(0.094)	0.052(0.105)
Park Size	0.094* (0.057)	0.032(0.037)	0.032(0.043)	0.017(0.039)	
Park Age		0.142* (0.079)	0.187** (0.091)	0.193** (0.090)	
Firm's Tenure			-0.038(0.034)	-0.040(0.032)	
Uni park				-0.113(0.087)	
Park Size t-1					0.015(0.041)
Park Age t-1					0.201** (0.093)
Firm's Tenure t-1					-0.054(0.043)
Uni park t-1					-0.133(0.098)
constant.	0.334* (0.184)	0.197(0.152)	0.165(0.180)	0.228(0.174)	0.332*(0.184)
Obs	2138	2138	2138	2138	2138
Instruments	33	34	35	36	36
AR1	0	0	0	0	0
AR2	0.154	0.218	0.153	0.168	0.105
Hansen	0.326	0.359	0.270	0.266	0.382

Note: Standard errors in parentheses; a. The reference category is high tech; All regressions include year and regional dummies. *p<0.05, **p<0.01, ***p<0.001

Table 7 – Growth analysis - Entrepreneurial Ecosystem elements

	24	25	26	27	28	29	30
l.growth	0.238** (0.094)	0.259*** (0.094)	0.312*** (0.107)	0.318*** (0.105)	0.296** (0.106)	0.230** (0.084)	0.283*** (0.096)
l.size	-0.274* (0.162)	-0.310* (0.160)	-0.436** (0.198)	-0.431** (0.194)	0.398** (0.199)	-0.261* (0.139)	-0.360** (0.172)
l.age	0.181(0.149)	0.214(0.150)	0.328* (0.183)	0.321* (0.178)	0.294(0.184)	0.170 (0.131)	0.260(0.160)
fin pub	0.016(0.146)	-0.013(0.149)	0.005(0.144)	-0.018(0.149)	0.016(0.143)	0.007 (0.150)	0.030(0.140)
l.imports	-0.110(0.134)	-0.154(0.139)	-0.136(0.122)	-0.148(0.126)	-0.126(0.128)	-0.118 (0.133)	-0.140(0.128)
Low tech ^a	-0.067(0.093)	-0.072(0.090)	-0.109(0.117)	-0.101(0.105)	-0.090(0.107)	-0.070 (0.089)	-0.095(0.102)
Med low ^a	0.084(0.121)	0.073(0.121)	0.101(0.154)	0.103(0.141)	0.101(0.141)	0.068 (0.116)	0.074(0.130)
Med ^a	0.072(0.119)	0.075(0.115)	0.121(0.147)	0.100(0.136)	0.095(0.132)	0.064 (0.114)	0.097(0.129)
Med high ^a	0.036(0.090)	0.054(0.088)	0.051(0.111)	0.041(0.102)	0.041(0.103)	0.037 (0.086)	0.050(0.098)
Knowledge Production	0.928(0.679)						
Competition		3.316* (1.937)					
Governance			1.507(1.003)				
Networks				2.989* (1.675)			
Talents					-0.122(0.494)		

Entrepreneurial Ecosystem	2.207 (1.523)						
Entrepreneurial Ecosystem t-1	3.960*(2.321)						
constante	0.056 (0.269)	-1.385(0.985)	-0.091(0.380)	-1.001(0.765)	0.670*(0.350)	-0.647 (0.678)	-1.486 (1.065)
Obs	2138	2138	2138	2138	2138	2138	2138
Instruments	33	33	33	33	33	33	33
AR1	0	0	0	0	0	0	0
AR2	0.451	0.396	0.209	0.180	0.241	0.518	0.295
Hansen	0.226	0.217	0.298	0.367	0.276	0.217	0.279

Note: Standard errors in parentheses; a. The reference category is high tech; All regressions include year and regional dummies. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

4. Concluding remarks

In recent years, emerging countries have been developing local-based instruments aimed at reducing regional disparities (Frick & Rodríguez-Pose, 2025). STPs have entered the political agenda of these countries, seeking to emulate the knowledge spillover effects and the innovation and entrepreneurship dynamics found in STPs of advanced economies. Due to their dissemination across different regions and countries, the literature on parks has argued that these environments are heterogeneous, both in terms of their internal mechanisms and the characteristics of the entrepreneurial ecosystems in which they are present (Albahari et al., 2023). Based on this argument of heterogeneity, this study analyzed the effects of different dimensions at the level of parks and entrepreneurial ecosystems on the innovation and growth performance of tenant firms, mainly SMEs, in the context of an emerging country. The results reveal a complex scenario in which technological performance is primarily driven by the level of development of EE components. Additionally, positive effects of park characteristics (size, university affiliation, and firm tenure) only emerge when mediated by EE indicators. Regarding growth, firms benefit from both the maturity level of the park and the dynamics of the local ecosystem.

In terms of practical implications for STI policies, our results point to two key considerations for public policy. Regarding the positive effect of park maturity in firms' growth rates, as highlighted by Antón-Tejon et al. (2024), this effect implies that innovation policy should adopt a patient-capital and long-term perspective (Mazzucato, 2018) to support the maturation of STPs. Based on these findings, we advocate that public funding for place-based policies needs to be insulated from political cycles, since parks' effects may be limited in the short run and especially for younger ones. This is an important guidance for parks in emerging countries: according to survey data collected for the year 2023 (Faria et al., 2025), financial constraints faced by Brazilian parks have hindered investments in critical operational resources, including infrastructure works (90%), facility maintenance (79%), labor expenses (57%), and the provision of services to resident firms (57%).

Second, an important point raised by our findings is the possibility that science and technology parks may contribute in an idiosyncratic manner to peripheral localities, as opposed to more developed

localities within an emerging country. In less-favoured contexts, these parks may primarily foster the maturation and competitiveness of firms within their entrepreneurial ecosystems, even if they exert little influence on firms' innovation rates. By contrast, the role of these environments in promoting innovative activities tends to be confined to localities with more mature ecosystems. In this regard, given the potential interdependencies between parks, their broader regional socioeconomic systems, and the innovative performance of resident companies, our findings suggest that place-based policy strategies should move away from “one-size-fits-all” perspectives.

Several limitations merit acknowledgement. First, although our findings indicate that park components have limited effects on the innovative capacity of tenant firms, further research employing causal inference methods—such as propensity score matching, difference-in-differences, or instrumental variables—is necessary to robustly estimate the treatment effect of being located in an STP in an emerging country. Additionally, the study was unable to fully explore localized variables beyond the five core dimensions. Future research should incorporate additional economic geography variables to better capture territorial influences on firm performance. Third, entrepreneurial ecosystems are not isolated spatial systems without external connections or fixed territories (Fischer et al., 2025). Thus, future studies could analyze the relationship between STPs and the spatially fluid concept of ecosystems, considering non-local linkages. Fourth, data limitations prevented a deeper examination of internal park elements, as the offer of business services.

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