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Exploring dyadic relationships between Science Parks and universities: bridging theory and practice

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Abstract

This paper delves into the dyadic relationships between Science Parks (SPs) and universities from the perspective of SPs. It explores various dimensions, including organizational functions, co-location, collaboration, management team activities, partnerships, and connections with university students and senior academics. A survey of 120 European SPs underscores the significance of having the University-Industry Liaison Office within the SP, fostering increased collaboration with the local university, providing career opportunities for university students, and promoting alumni network activities. Additionally, the proximity of universities and research institutions within a 50 km radius positively impacts the relationships between SPs and universities. Additionally, the paper offers several managerial implications. Establishing communication channels between SP management and universities fosters an environment that boosts the open exchange of ideas, collaborative discussions, and problem-solving. The alignment of SPs and universities' goals and objectives, particularly in areas such as research themes, industry partnerships, technology transfer, and talent development, further solidifies the mutually advantageous nature of these relationships, establishing a strong foundation for their enhancement. Within the SP environment, universities can closely collaborate with businesses, start-ups, and entrepreneurs, promoting innovation, commercializing research findings, and incubating spin-off ventures.

Keywords Dyadic relationships · Science Parks · Universities · Collaboration · Researchers · Students

JEL Classification L26 · O25 · O32 · O44 · R11 · R58

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1 Introduction

Science Parks (SPs) are strategically positioned near universities and research institutions, serving as key drivers of regional development by fostering collaboration and nurturing innovation (Germain et al., 2023). Within this paper, these SPs often establish dyadic relationships with universities, characterized by a mutual exchange of information, networks, and resources. A dyadic relationship between SPs and universities is defined as a mutually advantageous and close partnership. The term 'dyadic' denotes a two-way interaction, and these relationships are often marked by a significant exchange of information, resources, emotions, or influence. These partnerships typically embody a collaborative research alliance, involving joint research initiatives, access to a diverse talent pool comprising students and researchers, and the chance to stay abreast of the latest academic knowledge and research findings (ibid).

By nurturing and strengthening these partnerships, SPs and universities can collectively expedite scientific progress, drive innovation, and make a significant societal impact (Albahari et al., 2019, 2023; Link & Scott, 2003). Noticeable examples of such dyadic relationships are Cambridge Science Park, where its partnership with the University of Cambridge in the United Kingdom is marked by collaborative research initiatives, technology transfer efforts, and strong support for start-ups. Another case is the Research Triangle Park in the United States, which forges partnerships with multiple universities, including Duke University, the University of North Carolina at Chapel Hill, and North Carolina State University. These collaborations lead to the establishment of cooperative research centres, technology transfer offices, and programs facilitating the exchange of talent.

Prior research consistently emphasizes the vital role that SPs play in fostering collaborations with universities and research institutions and a substantial body of literature has been dedicated to the examination of various facets of R&D performance, collaboration, technology transfer, and knowledge spillovers. Notable authors and their influential works include Audretsch et al. (2005), and Djokovic and Souitaris (2008). Some studies have focused on specific dyads, such as university-industry partnerships or university-start-up interactions, to dissect their dynamics and impact (Felstenstein, 1994; Phongthiya et al., 2022). Studies conducted by Colombo and Delmastro (2002) and Aaboen et al. (2008) underscore the significance of these collaborative efforts in promoting innovation and disseminating knowledge. This transformation highlights how SPs have evolved from being mere physical spaces into dynamic ecosystems where research, entrepreneurship, and regional development intersect, facilitating the growth of a knowledge-based economy.

This study aims to examine the dyadic relationships between SPs and universities, focusing specifically on the perspective of SPs. This effort has the potential to deepen our comprehension of the SP role as a bridge between university and the regional innovation system. Although previous research has recognized the pivotal role of SP in the context of universities and regional innovation systems, a noticeable knowledge gaps persists in comprehensive research dedicated to unravelling the roles of universities and SPs within dyadic relationships.

Specifically, in the context of SPs, there is a significant dearth of research focusing on dyadic relationships between SPs and universities. These relationships distinguish themselves from typical networks due to their mutual exchange process (c.f. Germain, et al., 2023; Helmers, 2019). This research is meticulously tailored to address the current void in the literature surrounding SPs, networking dynamics, and dyadic relationships, all with the primary aim of shedding light on the pivotal role played by SPs in this underexplored domain. This study provides insights into how SPs shape their strategies and objectives within the dyadic relationship. Focusing on the SP perspective helps understand their role and strategies in collaboration. Furthermore, to achieve a more comprehensive understanding of the dyadic relationship, it is essential to consider the perspectives of other stakeholders, such as universities. This study has the following research question: *What is the design and structure of dyadic relationships between SPs and universities?*

This paper is structured as follows: Sect. 2 introduces the theoretical framework and hypotheses, Sect. 3 details the methodology and data, Sect. 4 presents the empirical findings and subsequent discussion, and finally, Sect. 5 provides the conclusions and implications.

2 Theoretical framing and hypotheses

The seminal definition of dyadic interaction, as proposed by Weitz (1981), views it as a mutual exchange between two parties, rooted in the attributes of both the seller and the customer. This understanding holds paramount significance in the elucidation of dyadic relationships, particularly within broader network contexts (Anderson et al., 1994; McLoughlin & Horan, 2000). Recent developments manifest in robust inter-organizational alliances between SPs and universities, strategically geared towards catalysing innovation (Etzkowitz & Klofsten, 2005). Such partnerships wield substantial potential, especially in knowledge-intensive sectors (Roukalainen & Igel, 2021).

In recent decades, universities, as collaborative partners for SPs, have undergone a significant transformation (Albahari et al., 2018). Their evolving roles now span knowledge sharing, social innovation, advisory services, and technology transfer as they engage with society, businesses, and government (Kohn Rådberg & Löfsten, 2023; Soares, et al., 2020). This shift profoundly affects dyadic relationships between SPs and universities, fostering collaboration, knowledge exchange, and innovation support. By establishing dyadic relationships, SPs and universities can collectively create a supporting environment for entrepreneurship and business growth. Universities bring multidisciplinary expertise, talented researchers, and students to SPs, fostering innovation and yielding several essential benefits.

Efforts to support innovation include strategies like spin-off firms, knowledge transfer offices, entrepreneurial support, and establishing SPs (Zhu et al., 2022). Clarifying roles is essential for successful collaboration. Researchers aim for scholarly output, while firms seek practical insights (Farré-Perdiguer et al., 2016). Universities contribute academic expertise, while SPs facilitate application and commercialization, enhancing regional innovation systems (Theeranattapong et al., 2021). SPs provide valuable resources to firms, fostering R&D and innovation (Cheba & Hołub-Iwan, 2014; Ferguson & Olofsson, 2004). Co-located functions in SPs create an environment conducive to collaborative research, and nurturing entrepreneurship (Hommen et al., 2006). This underscores the importance of SPs and universities in fostering entrepreneurial activities. SPs play a vital role in fostering supportive infrastructure and collaborative organizational functions with universities, offering state-of-the-art facilities and technological resources to the firms situated within them. Hypothesis 1 can be formulated as:

Hypothesis 1 Coordination of organizational functions positively influences the dyadic relationship between SPs and universities.

The management function of SPs is integral to their effective operation and growth, engaging in diverse activities crucial for fostering innovation hubs. SPs play a pivotal role in facilitating collaborative environments that bring together researchers from universities and businesses (Grimaldi & Grandi, 2001; Olvera et al., 2020). These collaborative relationships amalgamate academic expertise with industry insights, addressing intricate challenges and propelling advancements in science and technology (Farré-Perdiguer et al., 2016; Felsenstein, 1994). To uphold competitiveness, SPs must strategically appoint capable individuals to their management teams (Löfsten et al., 2020), forming the basis for Hypothesis 2. The responsibilities of SP management teams encompass strategic planning, resource allocation, forging partnerships, and cultivating an environment conducive to innovation and collaboration. Additionally, the provision of specialized programs, workshops, and mentorship opportunities by SP management teams for students, faculty, and former university students actively fosters a continuous flow of graduates and partnerships with the local university. Hypothesis 2 can be formulated as:

Hypothesis 2 SP management team activities positively influences the dyadic relationship between SPs and universities.

Link and Scott (2020) conducted a comprehensive study investigating the complicated relationship between federal R&D funding and scientific productivity. Their findings underscored the significant impact of increased federal R&D funding, revealing that 79% of the rise in scientific publications per scientific personnel was directly attributed to this financial support. In the educational landscape, universities play a pivotal role in producing highly skilled graduates, while SPs complement this process by offering real-world experiential opportunities through internships, research collaborations, and projects with businesses. This symbiotic interaction not only fosters knowledge exchange but also contributes to the development of essential skills and innovation. Consequently, students benefit by enhancing their employability and entrepreneurial acumen, as highlighted in studies by Löfsten et al. (2020) and Cadorin et al. (2021). Hypothesis 3 can be formulated as:

Hypothesis 3 SP relationships with university students and senior academics positively influences the dyadic relationship between SPs and universities.

3 Empirical research

3.1 SP sample and data collection

This study is part of a larger research project aimed at examining relationships between SPs and the entrepreneurial ecosystem. At the outset of the project, a series of longitudinal case studies were conducted, investigating various SP-university relationships, with a particular focus on dyadic relationships related to talent attraction within SPs, where universities played a crucial role. These studies (cf. Cadorin, 2021) have contributed significantly to the preliminary understanding of this study, which is essential for shaping our research questions and constructs (Alvesson & Sandberg, 2022).

The questionnaire, with a focus on talent attraction and SP development (Cadorin et al., 2021), was open for responses until September of that year. Subsequently, in co-operation with IASP,[1] it was seamlessly integrated into the broader 2018 IASP General Survey on Science and Technology Parks and Areas of Innovation. This approach was designed to ensure the participation of a relevant and representative SP population in the survey. The sample comprises 59 SPs (IASP full members), representing a diverse geographic landscape with five parks from Brazil and the remaining from various European countries. The response rate for the survey stands at 50.4 percent. The inception dates of these parks span approximately two decades, ranging from 1983 to 2015. For a detailed breakdown, which presents an overview of response rates and establishment years of the included SPs (see Table 1). Among the 58 non-responding SPs, three are considered invalid for this study. Two functions as incubators, not SPs, and one holds the status of a "general contact" rather than a full IASP member.

A comparative analysis used an independent sample t-test to compare means between two distinct groups (respondents and non-respondents) of the same variable. Reliability was ensured through Levene's test for variance equality and a two-tailed significance T-test for means equality. The findings indicate the only significant difference between responding and non-responding parks is their founding years, with a significance level of 0.05. There were no significant differences in total employees or park management structures between the two groups.

3.2 The questionnaire

The questionnaire development involved a systematic two-step process. Initial discussions within the research team aimed to quantitatively measure various dimensions. Subsequently, a pretesting phase, involving both a former and the present CEO of Linköping SP in Sweden, identified and resolved potential ambiguities and misunderstandings. The verification process involved CEOs, aligning with the expected respondent profile. The questionnaire underwent validation by experienced professionals within the association, making it ready for integration into the annual IASP questionnaire. A link to the online survey was dispatched to 120 full-member parks, with IASP managing reminders and interactions with park managers. While questionnaires exhibit strong reliability, the structured format can affect validity. The data was collected from 59 SPs, which introduces inherent sample bias due to non-random sampling. This bias affects external validity concerning the complete population of 345 IASP full-member SPs worldwide in 2018. Furthermore, selection bias can impact internal validity by influencing the robustness of conclusions.

3.3 Variables

Analysis considered a comprehensive set of 19 variables, including 15 independent variables, three control variables, and one performance-related aspect of dyadic relationships between SPs and universities. These variables, along with references, are listed in Table 2. Most items were assessed using 1–5 Likert-type scales to capture nuanced insights. Given the complexity of SP managers' perspectives, these measures serve as approximations rather than rigid categorizations, recognizing the intricacies of their viewpoints. The 15 independent variables are grouped into three dimensions, as outlined in Table 2.

[1] IASP, the International Association of Science Parks and Areas of Innovation, is a global network with a mission to drive growth, internationalization, and effectiveness for its members.

Table 1 Descriptive statistics of the surveyed SPs, 2018

1. SPs—Sample and response rate:							
N (population): 120	No valid SPs: 3						
n (response): 59[a]	Response rate (%): 50.43						
No response: 58							
2. SPs—Business data[b]							
	Response[c] 59 parks			No response[c] 58 parks			
	n	Mean	Std	n	Mean	Std	Sig. (2-tailed)
SP start year	59	1997.64	8.92	56	2001.75	10.96	0.029*
Total number of firms in each park	59	157.88	129.92	55	358.15	1706.01	0.370
Total number of employees in each park	58	3742.33	5188.57	33	3335.48	4788.97	0.713
Park management in each park[d]	59	22.85	22.29	34	17.38	25.10	0.280
3. SP location							
Your Park/Area is located[e]:	*Mean*	*Std*					
On a university (or other Higher Education Institution) campus:	0.27	0.45					
On land or premises owned by a government:	0.30	0.46					
On land or premises owned by a private firm:	0.14	0.35					
Other:	0.29	0.46					
Research institute localized in the SP:	0.08	0.27					
Incubator localized in the SP:	0.77	0.43					
The SP´s core activity is business incubation:	0.27	0.45					

*p < 0.05

[a]The sampling resulted in a response of 59 parks of which five in Brazil, one in Austria, one in Bulgaria, two in Denmark, two in Estonia, one in Finland, six in France, two in Germany, two in Greece, four in Italy, one in Latvia, one in Lithuania, two in Poland, three in Portugal, one in Serbia, one in Slovenia, six in Spain, five in Sweden, one in Switzerland, two in the Netherlands, six in Turkey, and four in United Kingdom

[b]Among the surveyed 59 SPs, small and medium-sized firms are predominant. Micro firms constitute the majority at 55%, while larger firms with over 249 employees make up 3.46% of the total. An observation is that local firms within these SPs are primarily micro or small enterprises, with approximately 86.2% falling in the small firm category (1 to 49 employees). However, size can be measured in several different ways, but do not have access to financial data in this study. These firms represent a wide range of industries, spanning technology sectors like electronics, biotechnology, energy, chemistry, computer science, healthcare, and more. This diversity underlines the comprehensive spectrum of innovation and expertise within these SPs

[c]IASP has assisted in providing data for the SPs that have responded and haven't responded

[d]Number

[e]Yes (1), No (0)

Table 2 Independent variables used in the study

A. SP–university[1]: organizational functions, co-location, and collaboration

Definition: SPs serve as dynamic platforms fostering interaction between firms and universities. This interaction assumes a pivotal role in facilitating a symbiotic relationship that extends to the training and recruitment of skilled personnel for the firms within these parks, SPs facilitate the development of supportive infrastructure, organizational functions in collaboration with universities, providing cutting-edge facilities and technological resources to located firms. Additionally, SPs establish partnerships with universities, research institutions, and industries, fostering a dynamic environment for knowledge exchange and collaboration. This holistic approach underscores the multifaceted contribution of SPs in nurturing innovation, entrepreneurship, and collaborative ventures at the interface of academia and industry

References: Felstenstein (1994), Vedovello, (1997), Link and Scott (2003), Salvador and Rolfo, (2011), Díez-Vial and Montoro-Sánchez (2016), Farré-Perdiguer et al. (2016), Soares et al. (2020), Theeranattapong et al. (2021), Phongthiya et al. (2022)

1. SP shares some scientific infrastructures with the university (labs, equipment, etc.). (1/0)
2. SP shares some services with a university (1/0)
3. University research groups are located in the SP (1/0)
4. The University-Industry Liaison Office is located within the SP (1/0)
5. SP has some agreements with a university (for example, encouraging research, entrepreneurship, employment opportunities, etc.) (1/0)
6. SP has 0 formal relationships with any universities (1/0)
7. Increased collaboration between SP firms and the local university (1–5)
8. Career opportunities by staying at the university, for example working in a lab, or starting a postgraduate course (1–5)

B. SP management team activities and partnerships with universities

Definition: SP management teams engage in a diverse array of activities crucial for the effective operation and growth of the innovation hubs. Their responsibilities span strategic planning, resource allocation, partnerships and fostering an environment conducive to innovation and collaboration. Moreover, SP management teams often offer specialized programs, workshops, and mentorship to students, faculty and former university students. The SP management team and its local university offer a frequent flow of graduates and partnerships

References: Cabral (1998), Löfsten and Lindelöf, (2002), Etzkowitz (2008), Albahari et al. (2018), Löfsten et al. (2020), Cadorin (2021)

9. The management team carries out activities in partnership with the university to enhance informal relationships between students and firms in the SP (1–5)
10. The management team carries out activities in partnership with the university to enhance informal relationships between faculty and firms in the SP (1–5)
11. The management team promotes activities to reach out and attract former university students (alumni network) (1–5)

C. SP relationships to university students and senior academics

Definition: SPs maintain valuable relationships with both university students and senior academics, contributing to a vibrant ecosystem of innovation and collaboration. For university students, SPs offer experiential learning opportunities through internships, research projects, and exposure to real-world industry challenges. In the case of senior academics, SPs serve as conduits for translating academic research into tangible applications. Collaboration with SPs allows senior academics to explore commercialization prospects for their research findings, driving innovation and contributing to societal impact. This interaction also promotes knowledge exchange, enabling academics to stay informed about industry trends and challenges. The network of connections with universities and their students includes activities such as organizing recruitment fairs and events aimed at engaging the university's alumni network

References: Vedovello (1997), Florida (1999), Etzkowitz (2008), Mellander and Florida (2011), Martin-Rios, (2014), Thunnissen and Van Arensbergen (2015), Löfsten et al. (2020)

Table 2 (continued)

12. Establishing a relationship with undergraduates and university students (1–5)
13. The local university is the primary source of talents for SP firms (1–5)
14. Interacting directly with student communities is the most efficient way to reach out and attract university students (1–5)
15. The presence of the SP in social media contributes to establishing a relationship with senior academics (1–5)
D. Control variables
The inclusion of the three control variables serves the purpose of isolating the impacts of number of universities located in the area, SP age and SP management team size. These consist of measures of alternative data from IASP questionnaire
16. Number of universities and research institutions located within 50 km (number)
17. SP—age (years)
18. SP—park management (number of employees)

1/0 = Yes/No

In this study, a dyadic relationship between SP and university is defined as "a mutually beneficial and close partnership between the two entities". In this context, "dyadic" implies a two-way interaction and these relationships are typically characterized by a significant exchange of information, resources, emotions, or influence. They can manifest in various contexts, such as interpersonal relationships, business partnerships, or academic collaborations. Dyadic relationships often emphasize the interdependence, reciprocity, and the impact of one party on the other within the relationship. The dependent variable, assessed from the SP perspective in SP-university relationships, measures "SP services promoting knowledge exchange and joint projects between SP tenant firms and the university." It evaluates the effectiveness of SP services in facilitating collaboration, rated on a 1 to 5 scale. It's the park managers who responded to the survey, and naturally, there's a risk of overestimation in their answers. However, the survey doesn't primarily focus on the relationship between SPs and universities; it encompasses many other areas under different headings. The questions are neutrally formulated as much as possible. The study also primarily addresses dyadic relationships from an SP perspective. Instead of answering the question as required, respondents may base their responses on what is usual or normal, a single event rather than all relevant occasions, or make an estimation (Clark & Schober, 1992).

Using data from the same set of self-report questionnaires for simultaneous data collection raises concerns regarding common method variance. This concern becomes particularly notable when both the variables under investigation, whether they are dependent or explanatory, are derived from the perspectives of the same group of participants (Podsakoff & Organ, 1986). Furthermore, Podsakoff et al. (2012) investigated diverse sources of common method variance, the presentation method of questionnaire items to respondents, the arrangement of items within the questionnaire's context, and the potential influence of the broader context.

In this study, measures were taken to mitigate the potential bias introduced by common method variance. Specifically, the risk of common method bias was minimized by adopting distinct headings and sections throughout the questionnaire. This strategic approach aimed to create clear demarcations between different questionnaire items, reducing the likelihood of participant response patterns influenced by the survey's structure.

4 Analysis and discussion

4.1 Statistical analysis

In the current study, correlation analysis and regression analysis will be utilized. However, the sample size is small (59 SPs), which may impact the statistical results. Generally, for small sample sizes, the calculated magnitude of a correlation is unstable. However, a correlation coefficient of 0.3 is considered sizeable (Cohen, 1992). When determining the sample size, researchers won't have prior knowledge about whether the assumption for Pearson correlation is fulfilled or not (Bonett & Wright, 2000). The aim is to get significant result ($p < 0.05$) with sufficient power to detect at least correlation coefficient of 0.4. Therefore, the minimum required sample size for such a study is 46 (Bujang & Baharum, 2016). According to (Fraenkel et al., 2012), a correlational study's minimum acceptable sample size is at least 30. Additionally, they state that data from samples smaller than 30 may not reflect the degree of correlation. Since normality should be considered on a parametric test like a Pearson r, the central limit theorem suggests at least 30 observations (Bonett & Wright, 2000).

Regression analyses involving one dependent variable and one independent variable typically necessitate a minimum of 30 observations. As a general guideline, for every additional independent variable introduced into the equation, it's advisable to include at least 10 more observations. Green (1991) outlines a requirement of at least 200 observations for conducting any regression analysis. Additionally, Green references a rule from Tabachnick and Fidell (2001), which suggests, albeit with some caution as noted by Green, that while aiming for 20 observations per variable would be ideal, the minimum necessary should be five observations per variable. The minimum number of observations depends on various factors, such as the expense of data collection and the objective—whether it's the minimum required for significance testing or achieving a specific level of precision in parameter estimates. In this study, there are 15 independent variables and hence, due to the small sample size, caution must be exercised in drawing conclusions from the regression analysis.

An initial factorability assessment used Pearson correlation analysis. Table 3 shows correlations among the 15 independent variables, control variables, and SP services facilitating knowledge exchange and collaborative projects between SP tenant firms and universities. From Table 3, it's evident that seven independent variables (4, 7, 8, 9, 10, 11, and 13) are significant to the dependent variable. These include variables related to SP-university dimensions, SP management team activities, and partnerships with universities. The strongest positive correlations ($p < 0.01$) exist between SP services facilitating knowledge exchange and collaborative projects between SP tenant firms and universities (variables 4 and 7–10). These variables measure SP management team's efforts to promote informal partnerships between universities, students, and firms. The other variables relate to increased collaboration, career opportunities at universities, and the location of The University-Industry Liaison Office within an SP.

Two control variables, Number of universities and research institutions within 50 km (variable 16) and SP age (years, variable 17), also hold significance for SP services (variable 19). The control variable measures proximity and shows a correlation with SP services for knowledge exchange and joint projects. For the control variables, there are two significant correlations. A positive correlation implies that as one variable increases, the other variable also increases. Conversely, in a negative correlation, as one variable increases, the other variable decreases. This correlation matrix highlights interrelationships between

Table 3 Correlation matrix on the variable level

Variables	Mean	Std	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. SP shares some scientific	0.610	0.492																		
2. SP shares some services	0.576	0.498	.440**																	
3. University research groups are	0.610	0.492	.359**	.370**																
4. The University-Industry Liaison	0.356	0.483	.449**	.494**	.231															
5. SP has some agreements with	0.831	0.378	−.083	.161	−.083	.147														
6. SP has 0 formal relationships	0.034	0.183	.150	−.029	.150	.252	−.165													
7. Increased collaboration between	4.424	0.645	.094	.192	.310*	.226	.087	.022												
8. Career opportunities by staying	3.949	0.918	.223	.103	.223	.275*	−.025	.113	.211											

Table 3 (continued)

Variables	Mean	Std	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
9. Activities in partnership with	4.288	0.696	.082	.209	.233	.305*	.189	− .078	.260*	.131										
10. Activities in partnership with	4.288	0.696	.132	.408**	.132	.305*	.123	− .078	.298*	.185	.751**									
11. Promotes activities to reach	3.610	1.000	.106	.078	.176	.221	− .086	.074	.179	.598**	.263*	.337**								
12. Establishing a relationship with	4.085	0.772	.088	.005	.088	.149	− .009	.102	.168	.250	.371**	.275*	.155							
13. The local university is the prim	3.644	1.030	.300*	.205	− .006	.363**	− .025	.157	.359**	.181	.242	.170	.097	.234						
14. Interacting directly with stud	3.848	0.906	.135	.274**	.019	.284*	− .228	.032	.376**	.073	.290*	.372**	.257*	.216	.366**					
15. The presence of the SP within	3.492	0.935	− .101	.011	− .026	.102	− .102	.103	− .179	.170	.044	− .009	.153	.323*	− .012	.090				
16. Number of universities and res	7.797	4.298	− .030	− .065	.003	.168	.031	− .057	− .191	.010	− .055	− .107	− .063	.016	.007	− .185	− .133			

Table 3 (continued)

Variables	Mean	Std	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
17. SP–age	20.170	8.857	−.004	.013	.122	−.059	−.089	.039	−.256	−.116	−.204	−.218	−.057	−.098	−.343**	−.164	.200	−.263*		
18. SP–park management	22.848	22.291	.186	.038	−.006	.085	.164	.133	.062	−.195	.022	−.004	−.455**	.180	.038	−.068	−.120	.131	.070	
19. SP services to promote the exchange	4.288	0.720	.079	.202	.079	.444**	.182	.056	.361**	414**	.416**	.485**	.517**	.234	.303*	.148	.016	.259*	−.281*	−.012

*p < 0.05; **p < 0.01

variables and provides insights into their associations' strength and direction. Many SPs have established collaborative partnerships with local universities, emphasizing academia-SP engagement.

Regression analysis was utilized to predict values using linear equations. Table 4 presents an overview of the statistical analysis's second step, involving four regression models based on various sets of independent variables. Models 1 to 3 exclude control variables, while Model 4 includes them. These models aim to uncover statistical relationships between the dependent variable, SP services for knowledge exchange and joint projects, and independent variables.

All four models were statistically significant at the 0.01 level, with relatively high adjusted R-squares. Significant relationships were identified between the dependent variable and (i) the presence of a University-Industry Liaison Office within the SP, (ii) increased collaboration between SP firms and the local university, (iii) career opportunities at the university, (iv) activities to attract former university students (alumni network), and (v) the control variable: Number of universities and research institutions within 50 km. Hypotheses 1 and 2 were partially supported, while hypothesis 3 was not supported. To ensure the robustness of the regression analyses, a statistical test confirmed the absence of multicollinearity (see Table 5 in the Appendix). Apart from impacting the accuracy of correlation coefficient estimates, sample size also plays a role in diagnosing multicollinearity, potentially impacting the determination of cause-and-effect relationships between traits. One issue with small samples is therefore multicollinearity. Despite this, our statistical analysis did not reveal any signs of multicollinearity. Table 5 include the collinearity statistics (Tolerance and Variance Inflation Factor, VIF). Typically, a VIF exceeding 5 is indicative of multicollinearity, and a tolerance below 0.20 is concerning (Fox, 1991; O'Brien, 2007). The VIF and tolerance are interrelated statistics used to detect collinearity in multiple regression. They rely on the R-squared value derived from regressing one predictor against all other predictors in the model. Tolerance represents the reciprocal of the VIF. In summary, Table 4 illustrates the relationships between variables, control variables, and the dependent variable, a critical component of this study's analytical framework.

4.2 Discussion

This study aims to examine the dyadic relationships between SPs and universities, focusing specifically on the perspective of SPs. While previous studies have acknowledged the crucial role of SPs in this context, there remains a considerable gap in comprehensive research dedicated to uncovering the specific roles played by universities and SPs within these relationships. The empirical findings shed light on the factors influencing joint projects between tenant firms and universities within SPs. Four key variables, assessed through regression models, play a significant and positive role in facilitating these collaborative services. Additionally, the control variable, which measures the geographical proximity of the SP to nearby universities and research institutes (within a 50 km radius), also holds significance. Geographical proximity is a recognized influential factor in shaping networks, enabling technology-based firms to access advice, financial support, and innovative ideas with ease. However, it's important to note that proximity alone does not guarantee superior performance, as previous research has emphasized (Feser et al., 2008).

Universities and their alumni networks play a pivotal role as talent hubs, enabling knowledge exchange and joint projects with SP tenant firms. They actively promote recruitment fairs and events to engage their alumni (Cadorin et al., 2021), facilitating the

Table 4 Regression analysis. Dependent variable: SP services to promote the exchange of knowledge and development of joint projects between SP tenant firms and the university

Variables	Full sample $n = 59$			Full sample with control variables
	Model 1***	Model 2***	Model 3***	Model 4***
1. SP shares some sientific infrastructure	−0.213 (0.200)	−0.138 (0.183)	−0.216 (0.192)	−0.167 (0.191)
2. SP shares some services with a university	0.036 (0.207)	−0.074 (0.211)	0.006 (0.220)	0.088 (0.207)
3. University research groups are located in	−0.145 (0.192)	−0.151 (0.186)	−0.174 (0.205)	−0.277 (0.198)
4. The University-Industry Liaison Officer is	0.555* (0.217)	0.444* (0.206)	0.482* (0.208)	0.273 (0.213)
5. SP has some agreements with a university	0.163 (0.225)	0.211 (0.210)	0.063 (0.230)	0.054 (0.219)
6. SP has 0 formal relationships with a univ	−0.111 (0.475)	0.030 (0.437)	−0.051 (0.441)	0.075 (0.431)
7. Increased collaboration between SP firms	0.270 (0.134)	0.200 (0.125)	0.220 (0.147)	0.301* (0.148)
8. Career opportunities by staying at the univ	0.249* (0.094)	0.091 (0.103)	0.043 (0.108)	0.034 (0.101)
9. Activities in partnership with the university		0.041 (0.177)	0.012 (0.190)	0.056 (0.179)
10. Activities in partnership with the university		0.227 (0.188)	0.268 (0.193)	0.247 (0.182)
11. Promotes activities to reach out and attract		0.221* (0.096)	0.271** (0.099)	0.332*** (0.104)
12. Establishing a relationship with undergrad			0.066 (0.113)	−0.008 (0.110)
13. The local university is the primary source of			0.099 (0.090)	0.081 (0.087)
14. Interacting directly with student communities			−0.200 (0.107)	−0.168 (0.101)
15. The presence of the SP in social media contributes to			−0.044 (0.090)	0.027 (0.088)
16. Number of universities and research institutions located				0.047* (0.020)
17. SP—age (years)				−0.002 (0.010)
18. SP—park management (number of employees)				0.004 (0.004)
Intercept	1.977*** (0.649)	0.980 (0.702)	1.271 (0.790)	0.239 (1.020)
Adjusted R square	0.285	0.409	0.419	0.494

Unstandardised coefficient betas and standard errors (between parentheses)

*$p < 0.05$; **$p < 0.01$; ***$p < 0.005$

seamless integration of emerging talent with SPs and resident businesses (ibid). SPs create a conducive ecosystem for firms to establish collaborative networks, enhancing talent management strategies (Hu, 2008). Enhanced collaboration between SPs and local universities significantly enhances knowledge exchange and joint projects (Colombo and Delmastro, 2002; Lindelöf & Löfsten, 2004; Johnston and Huggins, 2016). SPs offer access to funding sources, grants, and venture capital to support university research and innovation. Another crucial variable is the career opportunities within the university, such as lab work and postgraduate courses. SPs attract talented individuals, including researchers, entrepreneurs, and industry professionals, benefiting university research, faculty positions, and collaborative projects. SPs promote an entrepreneurial and innovation-oriented culture, aligning with universities' mission to foster creativity and entrepreneurial thinking (Florida, 1999; Löfsten et al., 2020).

Through partnerships with SPs, universities can promote entrepreneurship, establish incubation programs, and provide mentorship. This enhances the relevance of their research and educational programs, creating opportunities for joint projects, internships, and job placements. A reputable university within an SP enhances the park's credibility, attracting investors, industry leaders, and fostering collaborations at regional, national, and international levels. One significant variable in this context is the presence and role of a University-Industry Liaison Office located in the SP. Universities traditionally engage in external collaborations and industry partnerships. Within the SP environment, universities can work closely with firms, start-ups, and entrepreneurs, fostering innovation, commercializing research, and incubating spin-off ventures. Many universities also offer entrepreneurship programs, incubators, and accelerators that support start-ups. By establishing a University-Industry Liaison Office within the SP, these entrepreneurship support services are extended to the park's ecosystem, encompassing mentoring, training, access to funding, and creating a conducive environment for innovative startups and entrepreneurial activities.

Figure 1 (see below) succinctly encapsulates these noteworthy statistical findings including all results from the regression analysis. This discussion underscores the importance of not only the physical proximity of SPs to universities but also the strategic presence of liaison offices and the support environment within SPs for fostering successful collaborative ventures between tenant firms and universities.

In dyadic relationships between SPs and universities, a notable power imbalance often tips in favour of universities, primarily due to their established reputation, intellectual property rights, and research capabilities. While resource sharing holds great promise, efficiently utilizing and sharing these resources can be challenging. Universities may face constraints on resource sharing, such as academic priorities, funding limitations, or administrative obstacles, which can hinder the full realization of collaborative potential, particularly for smaller SP-based firms. Furthermore, universities and SPs often exhibit distinct organizational structures, cultures, and priorities, with universities emphasizing research and academics, while SPs and affiliated firms prioritize commercialization and industry engagement. To bridge these gaps and foster effective collaboration, it becomes crucial to establish a shared understanding and common goals through robust communication and collaboration frameworks.

Intellectual property rights and knowledge ownership can also introduce complexities into SP-university relationships. Universities often uphold strict IP policies and commercializing university research can be a lengthy and intricate process, potentially discouraging collaboration and delaying technology and knowledge transfer to SP industry partners. Moreover, universities emphasize publishing research papers and advancing theoretical knowledge, while SP firms require practical solutions and immediate market applicability.

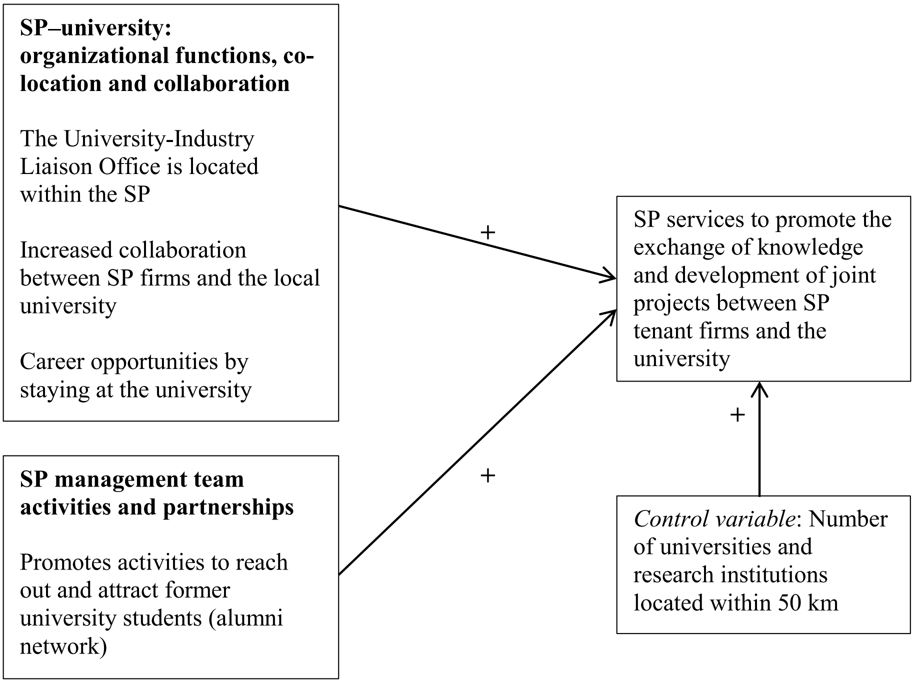

Fig. 1 Significant findings—summary1

Striking a balance between academic rigor and practical implementation is vital for successful collaboration. Regular evaluation, feedback mechanisms, and a willingness to adapt and evolve the collaboration over time can help mitigate these weaknesses and promote robust and sustainable dyadic relationships between SPs and universities.

5 Conclusions and limitations of the study

This study has highlighted the pivotal role of dyadic relationships between SPs and universities. These relationships are actively nurtured, serving as catalysts for innovation, knowledge transfer, and economic growth. The complex and multifaceted nature of these dyadic relationships underscores their fundamental significance, clearly influencing the progression of knowledge exchange and the collaborative development of projects. Effective communication emerges as the prerequisite for establishing and sustaining these robust dyadic relationships. The establishment of regular communication channels between SP management and universities fosters an environment that encourages the free exchange of ideas, collaborative discussions, and effective problem-solving. Additionally, the creation of platforms within SPs to showcase university research and technologies generates industry interest and fosters potential collaborations. The alignment of SPs' and universities' goals and objectives, particularly in areas such as research themes, industry partnerships, technology transfer, and talent development, further reinforces the mutually beneficial nature of these relationships, providing a solid foundation for their enhancement (Klofsten et al., 2019).

From a managerial standpoint, cultivating strong SP-university relationships demands deliberate efforts and collaborative initiatives. Encouraging student engagement within SPs, providing entrepreneurship programs, incubation facilities, and mentorship opportunities can significantly enhance the commercialization of innovation. Implementing initiatives such as innovation challenges and hackathons can effectively bridge the gap between academia and industry, fostering collaboration and generating novel ideas. Effective communication, involving clear channels and collaborative meetings, is crucial for robust dyadic relationships between SPs and universities. Showcasing university research and technologies within the SP can generate industry interest and collaborations. Aligning SP and university goals, including research themes, industry partnerships, technology transfer, and talent development, is crucial for mutual benefits.

To address the limitations of this study, it is crucial to consider an extended scope of research into the relationships between SPs, firms, and universities, with a particular focus on firm-level dynamics. Broadening the research scope can yield valuable insights into how these interactions manifest in diverse contexts and regions. Furthermore, the survey data used in this study is confined to a single year, which points to the potential benefits of exploring the multidimensionality of interaction processes over an extended period. This suggests the importance of consistently utilizing longitudinal studies to gain valuable insights into the evolution and adaptation of these processes over time. Given the evolving nature of these relationships, an extended observation can unveil nuanced changes and adaptations in this interaction.

Moreover, solely relying on questionnaires for all data in a statistical analysis introduces weaknesses and constraints. Without direct observation or data validation, assessing the accuracy and reliability of questionnaire-gathered information is challenging. Certain aspects of the research topic may be better assessed using alternative methods, such as interviews or observations, to capture nuanced or complex aspects. Additionally, the study's sample exhibited inherent bias, lacking a fully objective representation of SPs due to the absence of random sampling, introducing a potential limitation.

This study, adopting a SP perspective, may highlight specific knowledge transfer and innovation mechanisms aligned with their objectives. This emphasis can impact knowledge exchange efficiency. Viewing the dyadic relationship from the SP perspective may lead to a more favourable portrayal of their contributions and influence the reporting of their role. Results may reflect the SP's resource allocation priorities and collaboration strategies, affecting resource distribution within the relationship. This perspective may also underscore how SPs position themselves to attract businesses, start-ups, and talent through their university connections.

Another limitation is the small sample size. It's sufficient for correlation analyses, but when it comes to regression analysis, one must be cautious about drawing overly extensive conclusions. In this study, there are 15 independent variables so given the sample size, it's crucial to be cautious in interpreting the regression analysis results. The minimum number of observations required depends on several aspects, whether it's for significance testing or achieving a certain precision in parameter estimates. Moreover, the minimum number of observations is contingent on different factors, such as data collection expenses and the objective—whether it's the minimum needed for a significance test or to reach a particular level of accuracy in parameter estimates. In future studies, to gain a more comprehensive understanding of SP-university dyadic partnerships, researchers should aim to incorporate the viewpoints of all key stakeholders involved in these collaborations, including universities and tenant firms. This holistic approach will provide a more balanced and comprehensive perspective on the partnerships and their overall outcomes.

Appendix

See Table 5.

Table 5 Collinearity statistics

Variable	Model 1		Model 2		Model 3		Model 4	
	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
1	0.663	1.508	0.654	1.529	0.583	1.715	0.513	1.948
2	0.601	1.663	0.477	2.098	0.431	2.320	0.423	2.362
3	0.717	1.394	0.630	1.588	0.510	1.962	0.477	2.095
4	0.580	1.725	0.535	1.868	0.515	1.941	0.428	2.336
5	0.883	1.132	0.841	1.190	0.688	1.454	0.661	1.512
6	0.852	1.174	0.830	1.205	0.803	1.245	0.733	1.365
7	0.847	1.180	0.805	1.242	0.569	1.757	0.490	2.039
8	0.866	1.155	0.588	1.700	0.532	1.879	0.524	1.908
9			0.346	2.887	0.297	3.365	0.293	3.414
10			0.308	3.243	0.288	3.473	0.283	3.537
11			0.567	1.763	0.533	1.875	0.415	2.409
12					0.680	1.471	0.631	1.584
13					0.608	1.645	0.566	1.765
14					0.550	1.817	0.538	1.859
15					0.734	1.363	0.674	1.485
16							0.618	1.617
17							0.622	1.608
18							0.562	1.778

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