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Open Innovation and the mechanisms of governance in the Science and Technology Parks

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1 Introduction

The Open Innovation (OI) concept has been developed based on firms' context and their practices towards profiting from innovations. OI refers to "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries" (Chesbrough & Bogers, 2014, p. 17). It considers Research and Development (R&D) as an open system and suggests that valuable ideas can come from inside or outside the company. Therefore, it will allow the organization to sustain its competitive position in the industry value chain over time. West et al. (2014) point out that OI has been researched from different perspectives, although linkages to established theories and related phenomena are still emerging. Research on this field has predominantly addressed the firm or business unit as the unit of analysis, but there is a growing recognition that other levels of analysis need to be considered to understand its processes and outcomes. In this sense, considering the regional dynamics in terms of providing a favorable context for technological developments, OI and sustainable growth (West & Bogers, 2014; Bogers et al., 2017; Vlaisavljevic et al., 2020) might leverage an organization's OI strategies.

Going beyond the organizational level when exploring OI could not only generally deepen our understanding of the phenomenon, but it can also more specifically shed light on detailed processes and contingencies that determine the success or failure of OI (West & Bogers, 2014; Bogers et al., 2018a). In the context of OI, the relevance of inter-organizational networks has already been emphasized as a key factor in determining the ability to successfully innovate (Chesbrough, 2003; Van de Vrande et al., 2009).

As Chesbrough and Bogers (2014) proposed, the collaboration with a variety of external stakeholders and specialists leads the enterprises to identify and maintain valuable knowledge flows. In addition to the presence of a diverse set of stakeholders, the literature has emphasized that close geographical proximity within the region can provide positive and significant improvements to OI practices (Simard & West, 2006, West et al., 2006). In this sense, geographic proximity and local context are the main drivers of knowledge connectivity, which brings us to the importance of Science and Technology Parks (STPs). They are considered a distinct geographical environment in which social and institutional processes emerge. STPs provide an important network resource for technology-based firms, especially multinational enterprises (MNEs) search for valuable local intangible assests.

Nonetheless, a governance mode must be established to managing the process of collaboration among the different stakeholders located at the STPs. The governance of STPs may be of various forms, the most commons form is the presence of universities governing and operations STPs, but it might also be a business created by the private sector or even an organization jointly owned by the three sectors (university, enterprises and government) with a professional management team (Audy & Piqué, 2016; Silva et al., 2020).

The relationship between OI, STPs and governance has been partially stressed by previous studies. Villasalero (2014) emphasized the role of STPs as relevant mediators of knowledge flows between technology-based firms and universities. Felin and Zenger (2015), in turn, elucidated about the governance implications of OI and how firms efficiently manage and govern the process of assembling and organizing input to generate valuable outputs. Silva et al. (2020) asses how STPs promote OI and highlighted the role played by public policies. However, the literature still lacks an integrative perspective pointing out to how the different modes of governance in STPs can shape the mechanisms adopted in OI processes.

In this context, we present the following research question: how the governance of STP shapes the process and mechanisms of OI under the perspective of University/MNEs relationships? This paper aims to analyze how OI in STPs occur, considering the role of governance in this process. Therefore, it adopts a qualitative approach with an incorporated cross-country multiple case study. For this purpose, two STPs were studied and compared: Tecnopuc, located in Brazil and Polo Technologico Di Pavia, located in Italy.

This study addresses the process of OI in a higher unit of analysis by comparing and contrasting two different STPs located in advanced and developing countries with varying governance models. In this sense, we contribute to literature about OI in different levels of analysis in the context of STPs (Bogers et al., 2017; Dahlander et al., 2021) and their inter-organizational ecosystems (Chesbrough & Bogers, 2014; West et al., 2014; Bogers et al., 2017). Finally, we explore the flow of technological knowledge exchanged in the OI process in the STPs, conducting a comparative study of STPs in Brazil and Italy. By doing this, we demonstrate that varying modes of STPs governance present different triggers for OI practices between the stakeholders.

2 Literature Review

Phan et al. (2005) state that science parks and business incubators are a property-based organization with identifiable administrative centers focused on the mission on business acceleration through knowledge agglomeration and source sharing. There are different types of STPs all over the world. There is also not only one definition for the STPs, since various forms of STPs have been developed in different local and regional contexts.

STP is an organization managed by specialized professionals whose main aim is to increase its community's wealth by promoting the culture of innovation and the competitiveness of its associated businesses (International Association of Science Parks [IASP], 2018). It comprises various forms and may be created by different types of organizations such as universities, business associations, including or not local government participation (Pardilla-Pérez & Gaudin, 2014). Thus, it demands a very particular type of governance by fostering the partnership between the public and private and the set of organized networks. Previous studies have observed the governance systems adopted by different actors, focusing on the types of knowledge interchanged (Bogers et al., 2018b) and how the participants absorbed OI (West et al., 2014).

The term governance was used in a broadly sense to designate complex decision-making processes leading to power-sharing between governors and governed, decentralization of authority and coordination and negotiation between social actors (Lastres & Cassiolato, 2003). In this sense, there are forms of local, public and private governance that can play an important role in fostering agglomerated producers' competitiveness. The benefits of agglomeration are not restricted to incidental external economies. Still, they may also include externalities generated by local agents' deliberate actions in fostering productive activities and stimulating the rapid knowledge diffusion (Humphrey & Schmitz, 2000).

Regarding to innovation process, STP provides a network, and high-tech companies depend on interactions facilitated by spatial clustering networks since the more R&D is inputted into a clustered space, the faster new technologies and products can be released (Hu et al., 2005; Löfsten & Lindelöf, 2002). STP's physical proximity is emphasized as an important condition, as it facilitates ongoing interactions and the development of personal relations (Bøllingtoft & Ulhøi, 2005). As proposed by Filatotchev et al. (2011), the higher level of network interactions enables firms with relatively weak internal resources to access complementary assets into the broader network.

2.1 OI Process

OI uses purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation. The model is labelled "open" because there are many ways for ideas to flow into the process and many ways for them to flow out into the market (Chesbrough & Bogers, 2014). Gao et al. (2020) point out OI as a dynamic process comprising human, technological and financial resources, which are present in the exchange flows between the players. Thus, OI mediates different players during the multiple phases of the innovation processes, involving different actors and resources at each phase.

OI takes the form of three distinct processes: outside-in, inside-out and coupled. The outside-in consists of enriching a company's own knowledge base by integrating suppliers, customers, and external knowledge sourcing. The inside-out process is the external exploitation of ideas in different markets, such as selling. The coupled process happens when the company links outside-in and inside-out ideas by working in alliances with complementary companies (Gassmann & Enkel, 2006).

In addition to the different types of OI flows, the literature shows that interrelationships between organizations can occur in different ways: structured or unstructured, formal or informal., informal or with some players and can also become a long-term partner or appear only for a certain period of time (Öberg & Alexander, 2019). Therefore, there are different paths to bond with other players, and also different openness levels. Instead of a dichotomy, openness is seen as a continuum, going from completely closed to completely open (Dahlander & Gann, 2010).

Openness is one of the key points of the OI approach. Organizational openness involves various actors connecting external knowledge sources to the organization's internal knowledge base. Thus, the boundaries of organizations are permeable, as there are inward and outward flows of ideas, resources, and people (Dahlander & Gann, 2010; Gao et al., 2020). Gao et al. (2020) also focuses on OI as a dynamic process in which several elements of innovation are combined, including human, technological and financial resources, internal mechanisms for activities innovation, and different actors in a collaborative ecosystem.

The literature has stressed the connection between R&D and openness, since internal and external knowledge sources might increase organizational innovative performance. Cohen and Levinthal (1989) draw attention to the R&D dual role, once when R&D is a strong source of knowledge, it creates absorption capabilities to assess knowledge from outside the organization as well (Dahlander & Gann, 2010).

Firms may also be part of regionally bounded clusters of competitive firms, which, in turn, can be considered as a subsystem of a regional (or national) innovation ecosystem. They work closely with suppliers of complementary products to complete the whole product offering (Teece, 1986) and, in many cases, firms must organize and lead an entire value network to support their specific innovations (Simard & West, 2006).

When we address different levels of analysis, OI morphs into a more complex concept. It organizes many players through multiple phases of the innovation process, as is the case in the acquisition, integration, and commercialization of innovation (Gao et al., 2020). Therefore, the operationalization of OI between collaborative networks and its capture of value and creation of value are extended to the community's level, meaning for alliances, ecosystems, and platforms (Chesbrough & Bogers, 2014).

Organizations and individuals are embedded in networks of knowledge flows that are guided by the formal institutionalized and informal relationships of those involved in innovative activities. Formal ties are contractually agreed upon and are more easily incorporated into an OI strategy, thus, informal ties provide an important pathway for flows of tacit knowledge and unforeseen knowledge opportunities (Murray, 2002). In this sense, networks can facilitate the efforts to commercialize internal technologies. We highlight STPs as providers of an important

environment for developing spatial clustering networks (Oliveira et al., 2022). The governance system of STPs involves the facilitation of interactions between the several actors, removing obstacles to entrepreneurship, and building up the capability, reputation, trust, and reliability among the regional partners (Hu et al., 2005; Löfsten & Lindelöf, 2002).

2.2 Governance of STPs and the OI Processes

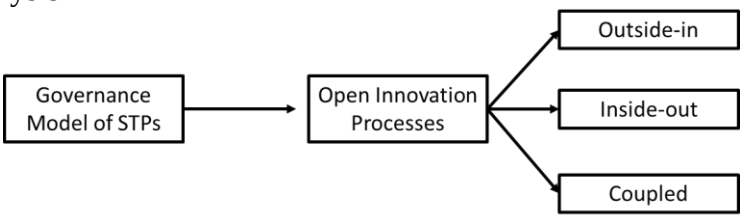
STPs are a specialized type of local agglomeration that provides a unique environment for accelerating technological innovation, nurturing new start-up firms, attracting investment and generating economic growth. They play an important role in the economic development through a dynamic and innovative mix of policies, programs, and offering high value-added services (Vásquez-Urriago et al., 2016; IASP, 2018) such as physical infrastructure, support services, and network relationships with other companies and with other centers of intensive research (Oliveira et al., 2022).

The geographic configuration of STPs acts as a source for knowledge spillovers for different actors who are located nearby the park (Audretsch & Belitski, 2019). However, the operationalization and governance of STPs has different approaches: an organization created by the university; a business created by the private sector or even an organization jointly owned by the three sectors (university, enterprises and government) with a professional management team (Audy & Piqué, 2016; Gyurkovics & Lukovics, 2014).

The OI benefits may be more readily achieved at the regional level since networks' effect on innovation is boosted by geographic proximity and a rich base of scientific knowledge related to specific industries (Audretsch & Belitski, 2019; Simard & West, 2006). OI considers that valuable ideas come and go beyond the firm borders and is primarily concerned with leveraging external knowledge to improve internal innovation and, thus, the firm's economic performance (Chesbrough, 2012; Piller & West, 2014).

As proposed by Gassmann and Enkel (2006), OI may take the form of three different processes. The outside-in process enriches a company's own knowledge base by integrating suppliers, customers, and external knowledge sourcing. The Inside-out process, which is the external exploitation of ideas in different markets, selling IP and multiplying technology by channeling ideas to the external environment; and the coupled process that links outside-in and inside-out by working in alliances with complementary companies.

Figure 1
Framework of analysis



3 Method

The current study research is a qualitative approach using an incorporated cross-country multiple case study as a research strategy. Additionally, case studies are flexible research approaches and suited to a range of different types of research questions that can be used in all types of research: exploratory, descriptive or explanatory (Yin, 2017). Case design and preparation involve researcher-training, screening possible units of analysis, a pilot study and development of a research protocol (Yin, 2017). The pilot study was carried out from April to

May 2017 at Inovaparq - Science and Technology Park from Univille university, located in Joinville, Santa Catarina State, Brazil.

3.1 Cases Selection Criteria

According to Welch and Piekkari (2017), the cross-country case study's comparative nature increases the rigor through which knowledge is inferred, as it enables to identify differences and similarities across contexts. Then, the two STPs were theoretically sampled to provide contexts of maximum variation.

The screening of possible cases was developed considering the STPs associated with ANPROTEC – Brazilian Association of Science Parks with recognized performance in the academic and business environment. However, the main criterion was the existence of Multinational Enterprises stablished within the park and the governance model. A closer analysis was carried out among the fourteen most relevant Brazilian STPs that resulted in the five most representative STPs in Brazil. The final selection considered its regional importance, reliability and access.

In this sense, the Scientific and Technological Park of Pontific Catholic University of Rio Grande do Sul (PUCRS) - TECNOPUC was selected to be the case study in Brazil. Its operations started on 2001 and has currently 108 tenant companies and institutions. From these companies, 11 are relevant multinational enterprises, some of them with global presence. The STP is governed by the university, a non-profit organization.

The screening process in Italy adopted the same procedure in Brazil and started with an investigation of the most relevant STPs associated with APSTI - Il Network Nazionale dei Parchi Scientifici e Tecnologici. Five STPs in Lombardy region were selected and closely compared. The selected case was Polo Tecnologico di Pavia Srl that satisfied the criteria of having relevant MNEs among its tenant companies, a private (for profit) governance, regional importance and facilitated access. Polo Tecnologico di Pavia Srl is a company created by Durabo Spa in 2012 and has currently 44 tenant companies and, among them, 13 with international activities.

Pavia University is in Lombardy, one of the most industrialized and innovative regions in Europe. According to Lombardia (2018), the regional gross domestic product (GDP) accounts for some 20% of total Italian GDP. The region hosts 800.000 enterprises, corresponding to 15.5% of total national economic activities.

3.2 Data Collection

This research used multiple sources of evidence by a previous screening study, direct observations, information available on STP and MNE's websites and interviews. Since this is a cross-country case study, data collection was carried out in two distinct phases: first phase in Brazil, at Tecnopuc between July and August 2017. The interviewees were divided in two subunits of analysis to accomplish the research objectives: governance representatives and multinational enterprises established in the STPs. The second phase was carried out in Italy from October/2017 to February/2018, following the same logic. To have a better comprehension of the interviewees from Tecnopuc and Polo Di Pavia, table 1 congregates all participants of the study.

Table 1

Total interviews from Case 1 and Case 2

Interviewees Case 1	**Function**	**Date**
Interviewee T1	Projects and Negotiations Manager	jul/17
Interviewee T2	Rector's Representative	jul/17

Interviewee T3	Tecnopuc Director	aug/17
Interviewee T4	Development and Innovations Director	aug/17
Interviewee T5	Technology Management Agency Director	aug/17
Interviewee MNET1	P&D Manager	aug/17
Interviewee MNET2	Projects Manager	aug/17
Interviewee MNET3	Digital Innovation Director	aug/17
Interviewees Case 2	**Function**	**Date**
Interviewee P1	Managing Director	nov/17
Interviewee P2	Associate Professor in Innovation Management	dec/17
Interviewee P3	Vice-Rector for Knowledge Transfer	jan/18
Interviewee MNEP1	Project Managing Assistant	nov/17
Interviewee MNEP2	Chief Finance Officer	jan/18
Interviewee MNEP3	Senior Engineer	jan/18
Interviewee MNEP3A	Chief Executive Officer	jan/18
Interviewee MNEP4	Senior Analog Engineer	jan/18
Interviewee MNEP5	Founder and Chair	jan/18

Note: Research Data

3.3 Data Analysis

We control the study's reliability employing a research protocol, pre-test of the semi-structured interviews, and field report containing the transcription of the interviews and a coding report elaborated via software QSR NVivo®. The qualitative content analysis starts with an initial coding scheme but may not remain fixed during the analysis, but rather are refined through successive iterations between theory and data (Welch et al., 2011).

The process of content analysis of the qualitative data can occur through the codifications established a priori, a posteriori or both (Gibbs, 2009). Coding a priori can be derived from the researched literature, from previous studies or interview scripts. In this case, a predefined code list is constructed. When coding emerges from the text - a posteriori, the codes are constructed during the process analysis process. According to Yin (2017), the coding process consists of grouping the data units into the established categories and subcategories of the study that are parts of the transcripted interviews, field notes, and documents inserted into the particular frame established by the categories.

4 Presentation of Cases

4.1 Case 1: Tecnopuc, Brazil

STP of Pontific Catholic University of Rio Grande do Sul – Tecnopuc is a result from a strategic view of the university management to be recognized as an important research center. The emergence of this area of innovation has been built over decades based on a long-term vision and local and national partnerships. The role of federal government development agencies, especially FINEP and CNPq and the national "Informatics Law" (Law No. 8,248 / 1991) enabled the emergence of cooperative projects such as Technology Transfer Offices, Business Incubators and Technology Parks. According to Spolidoro and Audy (2008), since mid-1990s there was a considerable increase in the number of R&D projects carried out between PUCRS and local companies.

Tecnopuc started its operation in 2001, when the university acquired an area that belonged to the headquarters of the 18th Motorized Infantry Battalion of the Brazilian Army, adjacent to the university's central campus. The Center for Research and Development in Physics of PUCRS was the first unit of the university to be stablished in this new space

(Spolidoro & Audy, 2008). In 2016, Tecnopuc was awarded as the Best Scientific and Technology Park in Brazil by ANPROTEC and SEBRAE, together with Ministry of Science and Technology. In 2017 started implementing a new management and corporative governance model based on knowledge management. This new governance model aims to be more attentive to the relationship with external agents, society, and governments, as well as with business managers and investors, who are essential to generate new and innovative businesses.

4.2 Case 2: Polo Tecnologico Di Pavia, Italy

Polo Tecnologico di Pavia Srl is a company created by Durabo Spa to foster the development of innovative projects in the area of Pavia, engaging students, entrepreneurs and investors in its activities. It was created in 2012 with 14 hosted companies in a refurbished Magnetti Marelli plant to fulfill the needs of high tech companies searching for an innovative environment to develop their businesses. With the collaboration of Mind The Bridge Foundation, headquartered in San Francisco - California, on 2013, Polo Tecnologico launched the Incubation Program, which allowed business and entrepreneurial ideas to be turned into real firms. The governance at Polo Tecnologico di Pavia is very proactive and has a network of contacts with the university, Association of Engineers, APSTI, IASP. They are also part of the Advisory Board of Master in International Business and Entrepreneurship (MIBE) from Pavia University, one of the Polo's main partners.

Due to the local partnerships, mainly with the Pavia University, Polo Tecnologico is hosting three different university Masters inside the science park facilities. The master in Coding was completely designed by companies inside the STP, whose head of the program is a professor of coding at university of Pavia and at the same time is a developer for a company in the Polo Tecnologico. The STP has many university spin-offs, such as programs with the local association that provides complementary courses in coding and robotics on Saturdays.

Currently, among 24 science parks in Italy, Polo Di Pavia is considered one of the best STPs, according to APSTI. The Accelerator Program, which is run every three months, is developed in conjunction with the university Master in Business Administration and offers every year a scholarship for the winning student.

5 Results and Comparative Analysis

5.1 Governance of the STPs

According to Gyurkovics and Lukovics (2014), STPs present different features, although most establishments' primary activity is to promote innovation. Tecnopuc started operations during an atmosphere where the Brazilian government turned to the creation of mechanisms for the promotion of research and information technology, such as the "Porto Alegre Tecnópole" (1995), the Innovation Law (Law No. 8,248 / 1991) and funding mechanisms such as Funding Projects Agency (FINEP). On the other hand, the idea of Polo Tecnologico di Pavia came up in a mature research context where the Pavia University expressed the idea to have a STP to congregate its research projects and spin-offs. Table 2 illustrates a timeline for both cases.

Table 2

Cases 1 and 2 Timeline

Tecnopuc		Polo Tecnologico Di Pavia	
Year	**Fact**	**Year**	**Fact**
2001	Acquisition of land from Brazilian Army and Tecnopuc creation	2009	Acquisition of Magnetti Marelli old factory

2002	Dell Global Development Center stablishes at Tecnopuc	2010	Project of Polo Tecnologico Di Pavia
2003	Hewlett-Packard's R&D operation and Tlantic Software Factory stablishes at Tecnopuc.	2011	Plants restoring
2004	RAIAR Business Incubator was launched	2012	Polo Tecnologico di Pavia was officially opened with 14 hosted businesses
2006	Inovapuc	2013	Incubation Program with Mind the Bridge Foundation
2007	Center of Excellence in Research on Carbon Storage for the Oil Industry (Petrobras Project)	2015	Expansion of the facilities and co-working room
2015	Global Tecnopuc Offices – partnership with HP Inc.	2017	Joint Design of the Master in Coding
2016	Best Scientific and Technology Park in Brazil		
2017	Review of governance model based on knowledge management		

Note: Research Data

Both STPs have an important role in fostering new businesses and stimulating networking between established companies and the university. Table 3 summarizes Tecnopuc and Polo Di Pavia in numbers:

Table 3
Cases 1 and 2 general numbers

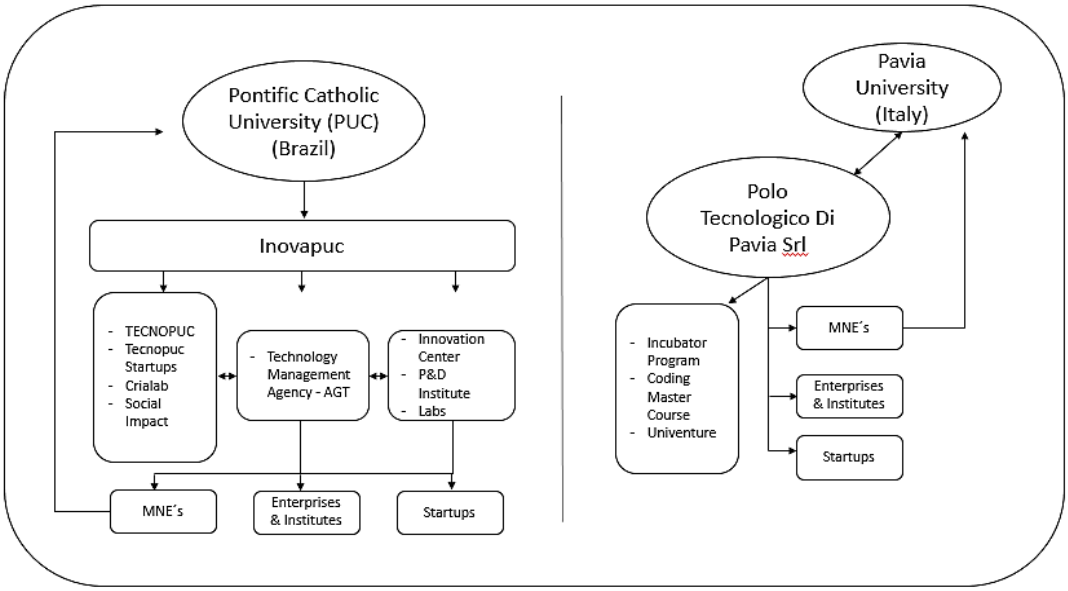
Features	Tecnopuc	Polo Tecnologico Di Pavia
Occupied surface (Sqm)	50,000	5,000
Nr. of STP employees	26	5
Nr. of Companies employees	6,500	350
Total Companies	108	44
- Companies/Organizations	89	44
- Start-ups	19	*
Companies with international activities	11	14

*Note*s. Total of 65 start-ups participated in the accelerator's program, although not all of them are formerly stablished within the STP.

It is possible to observe in Table 3 that both STPs present singular features and differences on facilities space and number of firms. Polo Tecnologico Di Pavia has a small administrative structure if compared to Tecnopuc, proportional with its operations. Additionally, it has 32% of its tenant companies with international activities against 10% from Tecnopuc. One possible reason is the proximity of the former with Milan, one of the most expressive economic and finance centers in Europe. The governance model for both STPs differs significantly. Tecnopuc is a non-for-profit entity that belongs to the local university and Polo Tecnologico Di Pavia is a private company. The governance model of cases 1 and 2 differs since building a STP came from different perspectives. Figure 2 shows the governance model comparative from both cases.

Figure 2

Governance Model from Tecnopuc (Brazil) and Polo Tecnologico Di Pavia (Italy)



Note. Elaborated by the authors.

Tecnopuc is university-centered with a strong process of cooperation and interaction between its various stakeholders. In this sense, Tecnopuc is a subunit from the university, meaning that it does not have legal personality. The governance of the park runs through a solid innovation mechanism called "INOVAPUC" - The Innovation and Entrepreneurship Network, formed by a series of internal entities and laboratories that gives support to the innovative projects. This mechanism makes the STP an important agent that provides the interconnection between MNEs, other enterprises and the university. In order to the companies be part of the STP, they must develop a project within the university, which primarily has to be a research one, although the governance is opening up other possibilities such as internships and teaching projects. Therefore, the relationship between the MNEs and the STP is induced; meaning the project development with the university is based on a contractual clause.

On the other hand, Polo Tecnologico Di Pavia governance model represents a private company that saw an opportunity to bring together an available downtown land (old Magnetti Marelli's plant) and the tenant companies do not have an obligation to develop projects within the university. The governance is proactive and has a network of contacts such as Association of Engineers and Association of Italian Science Parks (APSTI). They are part of the Advisory Board of Master in International Business and Entrepreneurship (MIBE) from Pavia University.

Löfsten and Lindelöf (2002) highlight the relationship between the tenant companies in parks and universities is a key feature of STPs. Guadix et al. (2016) recommend that governance should focus on the organization of a large number of acts of collaboration between hosted companies. Henriques et al. (2018) suggest that the presence of a university close to knowledge-based firms in STPs helps to create an atmosphere that fosters innovation, thus generating positive impacts on the region, despite the difficulties of the non-linear process of innovation.

In terms of a network of relations between MNEs and other tenant companies, despite Tecnopuc governance has a specific program that fosters these relations (Sinergy Accelerator's Program), few of them regard it as important or have benefitted from it. The main relation of the MNEs occurs with the university. This situation is the same result for Polo Di Pavia, where the main MNEs relation is with the university – many of them without the governance interference. However, it is also important to note that, in Tecnopuc's case, there are relations in the same value chain (customer/supplier relationship) due to the complexity and size of this

environment. This result is in line with Albahari et al. (2017), that suggest there are no robust evidences of an influence of the type of the park (university or private owned) in regards to cooperation relations.

5.2 OI Processes

Many scholars on OI state that this approach has been applied well beyond the concept as defined by Chesbrough (Dahlander & Gann, 2010; Huizingh, 2011). Chesbrough (2003) assigned OI as one single term to a collection of practices already used by the organizations. Thus, the OI approach has become a kind of umbrella that directs, integrates, and connects a variety of existing activities that make it possible, in both the academic and professional scope, for us to rethink the strategies for innovation of the world in a network (Huizingh, 2011). This means that it is through OI that the companies perceive the most permeable of organizational limits, where there is a greater focus on shared flows of knowledge and external interrelationships.

In the OI concept, companies actively seek for knowledge inputs from outside and inside the companies borders, leveraging inter-organizational activities also in local regions or ecosystems (Bogers et al., 2017; Chesbrough & Bogers, 2014). Our results show that, related to the OI processes (Gassmann & Enkel, 2006), the inside-out process is less frequent and happens in terms of sharing information - non-pecuniary with indirect benefits as proposed by Dahlander and Gann (2010). This process was found at Tecnopuc only (See Table 4).

In both cases, MNEs apply the outside-in process to obtain new information or to complement internal capacity, mainly in terms of skilled labor (students) or even highly specialized labor coming from the university knowledge spillovers. Chesbrough and Brunswicker (2014) and Mortara and Minshall (2011) also showed that inbound OI practices are far more used mainly to fuel the innovation pipeline, and outbound practices are limited in number and scope and less regarded by the companies. On the other hand, Cassiman and Valentini (2016) suggest that buy and sell innovations (outside-in and inside-out) are complementary activities and engaging in one activity increases the return from the other in terms of R&D productivity and the ability to build well-developed external connection channels increases the efficacy of inbound OI (Wang et al., 2015).

Table 4
OI Processes in STP

Category	Sub-Category	Illustrative Quotes	Findings
Tecnopuc	Coupled Process	"There is this company that makes shopping center parking gates and they already have the MNET3 software inside that is being tested in a parking lot in Porto Alegre" (Governance T1);	The OI coupled process is quite characteristic in the relation University-MNE, occurring some joint initiatives between Enterprises-MNEs.
		"Companies got together and decided that they wanted to have a seminar about it (people with disabilities). So, there is an example of OI, of spontaneous interaction that happened" (Governance T3).	
		"When there are concepts in that are not very settled, we can rely on Crialab (design thinking lab) to assist on this process, to help with market validation, whether the idea makes sense or not" (R&D Manager – MNET1).	

Polo Di Pavia	Coupled Process	"Some colleagues of mine are doing lessons for students at university, because if there is a specific subject, the university calls them to present" (Projects Managing Assistant – MNEP1).	The OI coupled process is quite characteristic in the relation University-MNE, however, mostly in the academic segment.
		"We are trying to set a formal path from the university to the company, so all the companies doing these together should give some guidelines to understand which is the requirement of the industry" (Senior Analog Engineer (MNEP4).	
		"The creation of the "Master in Digital Innovation & Entrepreneurship", in collaboration with the local University, aimed at shaping a new professional profile with humanities, technological and managing skills" (Chair – MNEP5).	
Tecnopuc	Inside Out Process	"We share a lot of knowledge here in Tecnopuc, in the communities and this is part of our values, not only to be consumers of technologies, but to create trends and participate" (Projects Manager - MNET2).	The inside Out process is less frequent, but happens in terms of sharing information, not selling IP. MNEs usually apply the outside in process to obtain new information or to complement internal capacity.
Tecnopuc	Outside In Process	"We have already worked openly, even making calls for proposals throughout Brazil (...) the good news is that it brings new information that the company is not aware of" (R&D Manager – MNET1). "We have internal demands and we look for partners we recognize as excellent in the field" (R&D Manager – MNET1).	
		"In some cases they also seek, this is a situation that has appeared recently, as a form of complementarity" (Governance T5).	
Polo Di Pavia	Outside In Process	"So, seventy people from engineer from the university developing for MNEP4 in Pavia" (Governance P1).	The outside in process happens in terms of skilled or high-specialized labor.
		"We have a small collaboration with a professor there who has coming here and he has done some training, he is specialized in a very particular area" (Senior Engineer – MNEP3).	

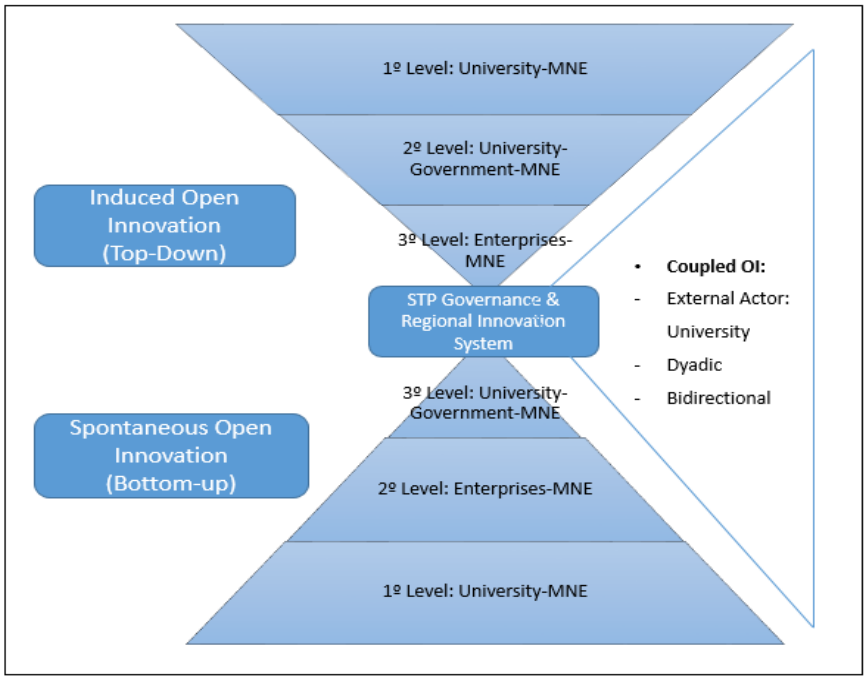
Notes. Research data.

The acquiring inbound innovation (outside-in) type (Dahlander & Gann, 2010) involving pecuniary exchange to gain access to resources and specific knowledge is characteristic from both cases Tecnopuc (university governance) and Polo Di Pavia (private governance), being an induced (the former) or spontaneous form (the second). However, results show that it is in the coupled process archetype where OI emerges more frequently. In Tecnopuc case, the coupled cooperation happens at various forms (see Table 4). It can be cooperation between commercial partners, such as testing technology, non-pecuniary collaborations between various partners on the same segment, or jointly developments with the university – representing the majority of cases. This is mainly due to two reasons: the contractual clause, where MNEs need necessarily to develop research or academic projects with the university and the obligations derived from the IT Law linked with the national system of innovation. Indeed, as suggested by De Beule and Van Beveren (2019), science-based partnerships have been growing in scale and scope over time, partially stimulated by government policies to promote public private research partnerships. On the other hand, at Polo Di Pavia, the coupled process

happens most frequently in teaching programs such as developing joint technical training and start-up competitions and acquiring high-end skilled labors for jointly developments.

The overall data show that process and outcome (Dahlander & Gann, 2010) fits on the category of private OI, where the outcome is closed (proprietary innovation), but the process is opened up, i.e., includes the involvement of external partners and tends to be dyadic (Chesbrough et al., 2014). It means the main partner is the university in both cases, independently of the governance model. Results also slightly differ from De Beule and Van Beveren (2019) where technology-creating subsidiaries (innovations new to the firm and new to the market) have an enhanced access to both industry-based and science-based partners. In the case of technology-creating subsidiaries located inside STPs that participated on this research, they have an enhanced access to science-based partner, represented by the university.

Figure 3
OI Process in STPs



Note: elaborated by the authors.

Finally, our data revealed that OI processes and collaboration in STPs present specific characteristics as proposed on Figure 3. The overall process is divided into two categories: firstly, the induced OI (top-down) in the case of the university governance model, where the MNE necessarily needs to develop a research or academic project within the university. Secondly, the spontaneous OI (bottom-up) in the case of private governance, the MNE searches for collaborations in a spontaneous way, without the obligation of developing research projects with the university. However, in spite the governance models influence the cooperation among the tenant companies weather induced or spontaneously, it is the regional innovation system that provides the differences on the cooperation types intensity (second level and third level) while the MNEs influence the OI processes.

On the spontaneous OI (SOI) category, linked to a developed country, the 1st level happening most frequently is the collaboration developed between the university and the tenant MNEs in research or academic projects. The second level from the SOI category corresponds to the collaborative projects happening between the tenant enterprises and MNEs. The 3rd level of the SOI happening less frequently, is the collaboration between the university, government and MNEs, since they are less dependent on government funding.

On the opposite side, the induced OI (IOI) category, linked with a developing country, the 1st level happening more frequently is the collaboration developed between the university and the tenant MNEs in research or academic projects – same as SOI. The second level of the IOI category is constituted by the collaboration projects happening between the university, government and MNEs. This is due to the IT law where benefitting companies need to apply 4% on R&D in the country. The latest, the 3rd level of the IOI happening less frequently, is the collaboration happening between the tenant enterprises and MNEs. These types of collaborations are in line with the MNE's strategic goals.

5 Conclusion

This study sheds light on the OI literature, analyzing how OI process occurs in the context of STPs. In this sense, we provide several contributions to academics, professionals, and policymakers. First, our unit of analysis supersedes the single organization and involves multi-organizational connections and their interdependencies. Second, we explore the flow of technological knowledge exchanged in the OI process in the STPs, conducting a comparative study of STPs in Brazil and Italy. Last but not least, we explore a cross-country comparison between different governances of STPs, elucidating the OI processes in each one.

The cooperation between University-MNEs that is the most common type of collaboration in both cases, even though presenting different triggers. Since the university governs Tecnopuc, it is an MNE obligation to develop collaborative projects with the university. It is a contractual clause, so there is a direct influence on this issue. Polo Di Pavia does not present this obligation, but governance exerts an important role in fostering and creating interaction opportunities. The collaboration mediated by the governance tends to be more academic with teaching and social programs. The collaboration developed directly by the MNEs tends to be in the research field. Thus, evidence shows that governance models in the STPs shape cooperation and OI processes.

Related to the OI processes (Gassmann & Enkel, 2006), the inside-out is less frequent and shares non-pecuniary information (Dahlander & Gann, 2010). The acquiring inbound innovation (outside-in) type involving pecuniary exchange to gain access to resources and specific knowledge is characteristic from both cases in Brazil and Italy. Our results show that it is the coupled OI process that emerges more frequently, at Tecnopuc case, it can be of various forms: cooperation between commercial partners, such as testing technology, non-pecuniary collaborations between partners on the same segment, or jointly developments with the university – representing the majority of cases. The coupled OI process is mainly due to two reasons: the contractual clause derived from the university governance model and the obligations derived from the IT Law linked with the National System of Innovation. At Polo Di Pavia, the coupled process happens most frequently in academic programs such as development of jointly technical training and start-ups competitions and in terms of acquiring high-end skilled labors for jointly developments. Most specifically, the coupled OI tends to be dyadic (Chesbrough et al., 2014), whose main partner is the university, independently of the governance model and bidirectional, meaning the innovation is created within each organization.

Finally, we identified that OI processes in STPs present specific characteristics: firstly, the induced OI (top-down) in the case of the university governance model, where the MNE necessarily needs to develop a research or academic project within the university. Secondly, the spontaneous OI (bottom-up) in the case of private governance, where the MNE searches for collaborations in a spontaneous way, without the obligation of developing research projects with the university.

As for the practical contributions for managers, this study shows how relevant it can be for the MNEs to invest in a STP given the rich context and possibilities of knowledge spillovers. In this sense, our study reinforces previous results shown in the literature (Santos & Mendonça, 2017) that STP knowledge spillovers nurture innovation and economic performance. Governance members of STPs also must be attentive to the importance of bringing complementary enterprises to foster collaboration between tenant companies. Finally, this study contributes to policymakers in the design of STPs initiatives.

Since this is a cross-country case study under a qualitative approach, it is relevant to expand the investigation to test the propositions in a quantitative study between tenant companies located in STPs. Most specifically how these companies perceive collocation in a collaborative, rather competitive environment and under which conditions firms tend to (or not) collaborate themselves also addressing the non-disclose and IP protection issue. Further research could investigate the relationship between OI, the size of the tenant companies, and the time of establishment within the park, associated with the typology of collaboration networks inside and outside STPs.

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