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The influence of innovation capacity and cooperation networks on the innovativeness of companies located in Brazilian technology parks

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The influence of innovation capacity and cooperation networks on the innovativeness of companies located in Brazilian technology parks

Corrected version

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The ideals that illuminated my path are
goodness, beauty and truth.

Albert Einstein

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RESUMO

Vargas, C. A. F. (2020). *A influência da capacidade de inovação e das redes de cooperação na inovatividade de empresas instaladas em parques tecnológicos brasileiros* (Tese de Doutorado). Faculdade de Economia, Administração e Contabilidade da Universidade de São Paulo, São Paulo.

Parques tecnológicos são ambientes de fomento à inovação tecnológica e geração de riqueza, por promoverem a sinergia entre empresas, instituições de ensino e pesquisa e órgãos governamentais. Suas características particulares criam um ambiente de estímulo à cooperação entre os diferentes atores presentes nesse ambiente, encorajando o investimento em atividades de pesquisa e desenvolvimento (P&D) e aproximando essas empresas de instituições de produção de conhecimento científico. A criação e estabelecimento de parques tecnológicos têm aumentado consideravelmente ao longo das últimas décadas, abrangendo diferentes experiências e modelos. Entretanto, na literatura científica, observa-se que há autores apontando que a efetividade dos parques tem apresentado resultados mistos (Lamperti, Mavilia e Castellini, 2017), especialmente, em relação à inovatividade das empresas residentes (Liberati, Marinucci, & Tanzi, 2016; Lindelöf & Löfsten, 2004; Radosevic & Myrzakhmet, 2009). O objetivo da pesquisa foi analisar as relações da Capacidade de Inovação e Redes de Cooperação para a Inovatividade de Empresas de Base Tecnológica (TBFs) instaladas e nas não instaladas em parques tecnológicos. Quanto aos métodos da pesquisa, adotou-se uma abordagem quantitativa, realizando uma *survey* eletrônica com os dois grupos de empresas identificadas como empresas *on-park* e empresas *off-park*. Após coleta de dados e tratamento da base de dados, obteve-se uma amostra não probabilística de 193 TBFs (88 empresas *on-park* e 105 empresas *off-park*). Para a análise dos dados, utilizou-se a técnica multivariada de regressão logística, considerando a "Inovatividade" como variável dependente. As variáveis independentes foram formadas pelos constructos: "Capacidade de Inovação", "Cooperação *Doing Using and Interacting* (DUI)", "Cooperação *Science Technology and Innovation* (STI)". Dentre os principais achados da pesquisa, destacam-se: a "Capacidade de Inovação" foi apurada com um efeito maior para a inovatividade nas empresas fora de parques do que nas empresas instaladas em parques; a "Cooperação DUI" foi observada como significante para maior inovatividade nas TBFs em parques; não foi verificado significância nos dois grupos na associação entre parceiros de STI e inovatividade. Os resultados encontrados permitem concluir que embora a Cooperação STI não resulta em retornos financeiros de curto e/ou médio prazo, que ela deva ser considerada uma parceria de longo prazo que pode trazer substantivos ganhos tecnológicos relacionados aos produtos desenvolvidos. Por fim, o estudo apresenta como originalidade a investigação do efeito parque tecnológico para a Inovatividade de TBFs, por meio da abordagem da Cooperação STI e DUI.

Palavras-chave: Capacidade de Inovação. Cooperação DUI. Cooperação STI. Inovatividade. Parques Tecnológicos.

ABSTRACT

Vargas, C. A. F. (2020). *The influence of innovation capacity and cooperation networks on the innovativeness of firms installed in Brazilian technology parks* (Tese de Doutorado). Faculdade de Economia, Administração e Contabilidade da Universidade de São Paulo, São Paulo.

Technology parks are environments that foster technological innovation and wealth generation, through synergy between firms, educational and research institutions and government. Its particular characteristics create an environment that encourages cooperation between the different actors present in this environment, encouraging the investment of firms in Research and Development (R&D) activities and bringing firms closer to science production institutions. The creation and establishment of technology parks has increased considerably over the past decades, encompassing different experiences and models. However, the effectiveness of the parks has shown mixed results (Lamperti, Mavilia e Castellini, 2017), especially in relation to the Innovativeness of resident firms (Liberati, Marinucci, & Tanzi, 2016; Lindelöf & Löfsten, 2004; Radosevic & Myrzakhmet, 2009). The purpose of this research was to analyze the relationships between the Innovation Capacity and Cooperation Networks for the Innovativeness of Technology-Based Firms (TBFs) installed and not installed in technology parks. For this, a quantitative approach was adopted, conducting an electronic survey with two groups of firms: on-park firms and off-park firms. After cleaning and processing the database, a non-probabilistic sample of 193 TBFs (88 on-park firms and 105 off-park firms) was reached. For data analysis, the multivariate logistic regression technique was used, whose dependent variable is Innovativeness. The independent variables were formed by the constructs: Innovation Capacity, Doing Using and Interacting (DUI) Cooperation, Science Technology and Innovation (STI) Cooperation. Among the main findings of the research, the following stand out: Innovation Capacity was found to have a greater effect on Innovativeness in firms outside of parks than in firms installed in parks; DUI Cooperation was observed to be significant for greater innovation in TBFs on-park; no significance was found in the two groups in the association between STI partners and Innovativeness.The results found allow us to conclude that the STI Cooperation does not result in short and/or medium term financial returns, but that it must be a long term partnership that can bring substantial technological gains related to the products developed. Finally, the study presents as originality the investigation of the technology park effect for the Innovativeness of TBFs, through the STI and DUI Cooperation approach.

Keywords**:** Innovation Capacity. DUI Cooperation. STI Cooperation. Innovativeness. Technology Parks.

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LIST OF ABBREVIATIONS

ANPROTEC	National Association of Entities for the Promotion of Innovative Ventures
ASSESPRO	Association of Brazilian Information Technology Firms
DUI	Doing, Using, and Interacting
FINEP	Financing Agency for Studies and Projects
IASP	International Association of Science Parks and Areas of Innovation
IBGE	Brazilian Institute of Geography and Statistics
ICT	Information and Communication Technology
LL	Log Likelihood
MCTIC	Ministry of Science, Technology, Innovations and Communications
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Squares
PINTEC	Technological Innovation Survey
R&D	Research & Development
RBV	Resource-Based View
ROC	Receiver Operating Characteristic
S&T	Science & Technology
SMEs	Small and Medium-Sized Enterprises
STI	Science, Technology, and Innovation
TBFs	Technology-Based Firms

SUMMARY

1 INTRODUCTION

Companies need to innovate, to compete, and gain market share. Companies that do not innovate are unable to remain in the market in the long term, or will not be leaders in their sectors. According to Jesús Nieto e Santamaría (2007), competition is leading companies to introduce products with a high degree of novelty. To create products and introduce new technologies, companies must constantly invest in activities that result in innovations. On doing this, they will not only be more competitive, but will have higher financial results than their competitors, which do not invest the same amount in innovative activities.

This context is equally important for small and medium-sized firms, which, despite their smaller size, also need to develop innovation capacity, investing in activities for this purpose. This ability to innovate will depend on how the company uses its internal resources to develop new products, adding value to the company and to the customer. To this end, companies must invest substantially in improving products and launching new ones; in the case of Technology-Based Firms (TBFs), this investment must be strongly directed towards Research & Development (R&D) activities.

Companies with high innovation capacity tend to launch innovative products and win new markets. Therefore, firms need to continually improve their internal capabilities to explore opportunities for developing new products that meet market needs (Szeto, 2000). Innovation capacity should not be only local, it is important that companies develop and introduce new processes, products, services, or ideas in international markets (Knight & Kim, 2009). By launching innovative products, TBFs are identified as companies that have a high innovation capacity. In addition, TBFs are known for being companies with a high qualification of human resources that develop knowledge-intensive products.

However, TBFs also have limitations for developing new products. In some cases, because they are small and medium-sized companies, they tend to have low legitimacy and credibility, for being new and little known in the market (Ferguson & Olofsson, 2004; Laurell, Achtenhagen, & Andersson, 2017). They may also have limited financial and human resources, which hampers investments in R&D and hiring qualified teams, both of them highly expensive (Tolstoy & Agndal, 2010). Also, R&D activities often involve the development of products with a long maturation cycle and high degree of uncertainty (Laurell, Achtenhagen, & Andersson, 2017; Tolstoy & Agndal, 2010).

To overcome such internal restrictions and market difficulties, TBFs seek support for R&D investment in cooperation networks (Gronum, Verreynne, & Kastelle, 2012). Van de Vrande et al. (2009) suggest adaptations in innovation processes of small and medium-sized companies, due to the lack of own resources to develop and sell new products, and, as a result, they end up more inclined to collaborate with other organizations. In high-tech sectors, as biotechnology, part of innovation is found in interorganizational social networks that support the evolution of companies and their community, as a whole (Powell, Koput, & Smith-Doerr, 1996).

The greater cooperation of TBFs with other companies and organizations tends to facilitate knowledge acquisition, which would be more difficult to reach it they acted alone, thus affecting the leverage of the company's own R&D. According to Tumelero, Sbragia, Borini and Franco (2015), as a TBF creates or increases external relationships, its opportunities and challenges are immediately shared, either through the exchange of tacit knowledge among people, or through knowledge encoded in technologies developed, licensed, or acquired. For Zeng, Xie and Tam (2010), the complexity of the innovation process leads small and medium-sized companies to use external cooperation networks more frequently.

Although collaboration between partners plays an important role in creating new products, its role in achieving innovations with a high degree of novelty is even more relevant (Jesús Nieto & Santamaría, 2007). Cooperation networks facilitate access to knowledge, and work as an input in the innovation process. However, for the company to innovate successfully, it needs internal capabilities that allow it to engage in activities necessary for innovation (O'Connor, Roos, & Vickers-Willis, 2007). Usually innovation networks are formed by groups of heterogeneous actors, including companies' representatives, technological centers and development organizations, and funding institutions, and the ability to interact with these networks becomes a decisive element for fostering innovation capacity (Doloreux, 2004).

Some initiatives for the promotion of cooperation networks for TBFs have been the creation and development of innovation environments, such as business incubators and technology parks. The strongest justification for the existence of technology parks is that companies can access services and receive support to successfully put new products in the market (Díez-Vial & Fernández-Olmos, 2015). Most TBFs established in parks are small and medium-sized, and some have been operating for a short time. Thus, belonging to the park provides companies with specialized services, shared resources and businesses, financial support, better reputation, and legitimacy (Ferguson & Olofsson, 2004; Siegel, Westhead, & Wright, 2003).

And it is precisely the benefits of cooperation networks that make up the main arguments in favor of technology parks and incubators. Given that technology parks provide a location that is close to customers, suppliers, researchers, and other organizations, TBFs will have a larger capacity to build cooperation networks that support their development (Löfsten & Lindelöf, 2005). For Díez-Vial and Montoro-Sánchez (2016), companies that receive knowledge from universities, through formal agreements and informal interactions, tend to increase their innovative capacity.

The geographic proximity between companies, universities, and other organizations that live in a technology park or a business incubator allows TBFs to have easy access to actors' relationship networks, which can collaborate to their R&D activities. Technology parks can also attract venture capitalists, in addition to companies having easier access to government research funding agencies. According to Schmidt, Balestrin, Machado and Bohnenberger (2016), companies that are located in technology parks have easy access to financial resources, which strongly influence the results of R&D projects.

The creation and implementation of technology parks have grown over the past decades. The rise of technology parks started at Silicon Valley, United States, and then spread to European countries, such as the United Kingdom and Sweden. Currently, promotion for the development of innovation environments is not restricted to developed countries, but reaches a high number of developing countries, with emphasis on Brazil.

According to the National Association of Entities for the Promotion of Innovative Ventures (ANPROTEC), the number of initiatives to implement technology parks and incubators in Brazil has increased considerably in recent decades (ANPROTEC, 2014). According to data from the Ministry of Science, Technology, Innovations and Communications (MCTIC), in 2000, there was a total of 10 technology park initiatives, involving all stages: project, implementation, and operation. In 2017, according to the last study on park indicators published by MCTIC (2019), there were 103 park initiatives, covering all development stages.

As for companies located in technology parks, Brazilian parks house a total of 1,337 companies, with a concentration in the South (36%), Southeast (35%), and Northeast (25%). Other important data, for understanding the panorama of this type of innovation environment, are the number of jobs created, since, in general, jobs in these firms are of higher qualification and compensation. Hence, Brazilian technology parks provide 39,050 jobs, distributed between park management (685) and established companies (38,365), as Chart 1 shows (MCTIC (2019).

Chart 1: Impacts generated by Brazilian technology parks

Region	*No. of Firms*	*No. of Jobs in Firms*	*No. of Jobs in Management*
Center-West	20	88	19
Northeast	342	9.353	115
North	19	130	16
Southeast	476	13.484	265
South	480	15.310	270
Total	*1.337*	*38.365*	*685*

Source: MCTIC (2019).

Regarding the education of employees at the parks, 37.3% achieved the technical level (high school) and 62.7% have a university degree or beyond (specialization, master or doctorate degree). However, professionals with master or doctorate degree are only 10.7% of the jobs created in the park, according to MCTIC (2019). In terms of revenue, there are no recent studies that measure the total income of these companies. These data confirm that the expansion of innovation environments and, in particular, of technology parks, is a trend in several countries (Hobbs, Link, & Scott, 2017), both emerging and developed.

A recent publication by Amoroso, Link and Wright (2019) estimated around 1,200 technology parks spread around the world, according to the definition of technology parks by the International Association of Science Parks and Areas of Innovation (IASP) - considered the main association in this area. The growth of the number of initiatives in innovation environments has also been followed by a fast increase in scientific publications that address their benefits (Diez-Vial & Montoro-Sanchez, 2017). Thus, there is a strong increase of the topic 'innovation environments', comprising the various players present in this type of ecosystem. And it becomes a gap for research and for the contribution of researchers who carry out investigations on technology parks and their impacts on socioeconomic development, for further formulation of public policies together with universities, companies, and the government.

1.1 DEFINITION OF THE PROBLEM SITUATION

Technology parks have been recognized as a fertile environment for the creation of high-tech companies (Squicciarini, 2009b), mainly due to their outstanding innovation capacity and the presence of a strong network of relationships. Their proximity to universities and research centers enables projects and ideas discussed in academia to become businesses.

Companies that are close to higher education institutions or research centers have easier access to equipment, laboratories, researchers, and professors. In addition, companies can recruit qualified employees more easily than if they were far from these innovation environments. According to Caldera and Debande (2010), universities with technology parks show a better performance in technology transfer than universities that do not have such environments, which suggests that knowledge agglomeration near universities has a positive effect on technology transfer.

Another positive factor provided by technology parks is the strong network of relationships among companies. According to Löfsten and Lindelöf (2005), by pertaining to a technology park, which is close to important customers, suppliers and researchers, TBFs can build networks that support their development. In small and medium-sized companies, social networks provide increased interaction among different actors, and represent a complementary answer to the insecurity resulting from the development and use of technologies (Zeng et al., 2010).

The establishment of cooperation networks between small and medium-sized companies is crucial for innovation (Gronum et al., 2012). Cooperation networks have been identified in several studies (Autio, 1997; Dettwiler, Lindelöf, & Löfsten, 2006; Zeng et al., 2010) as an important factor for companies' innovation capacity. The interaction with network companies is a source of technical knowledge absorption, in addition to knowledge provided by the university, which allows TBFs to increase their innovation capacity (Powell et al., 1996).

Most studies have pointed the contribution of cooperation networks to innovation in TBFs located in innovation environments (Colombo & Delmastro, 2002; Lindelöf & Löfsten, 2004). However, we highlight that some studies have indicated that contributions of cooperation networks in technology parks and incubators are not significant to TBFs' innovation (Felsenstein, 1994; Siegel et al., 2003; Vedovello, 1997; Wallsten, 2004; Westhead, 1997). Lamperti, Mavilia and Castellini (2017) state that despite the increasing diffusion of technology parks, there is a mixed evidence on their effectiveness in sustaining performance of resident firms and on the development of surrounding areas.

While many authors assume that small and medium-sized companies benefit from participation in cooperation networks and, in particular, can increase opportunities for activities related to innovation, the attributes of these networks are not fully defined yet (Jørgensen & Ulhøi, 2010). Díez-Vial and Fernández-Olmos (2015) argue the need for further studies on cooperation networks in technology parks, and their impact on the innovation capacity of companies settled in this environment. This research aims to understand the contribution of cooperation networks to TBFs' innovativeness, for those located in innovation environments. Thus, the research question that this thesis intends to answer is the following*: in TBFs located* *in technology parks, do Innovation Capacity and Cooperation Networks have a greater effect on Innovativeness, when compared to TBFs outside parks?*

1.2 RESEARCH OBJECTIVES

Next, we present the general and specific objectives of the research.

1.2.1 General Objective

The general objective of the research is *to analyze the relationships between Innovation Capacity and Cooperation Networks for Innovativeness of technology-based firms located inside and outside technology parks.*

1.2.2 Specific Objectives

a) To evaluate the effect of DUI and STI Cooperation Networks on Innovativeness of technology-based firms;

b) To evaluate the effect of Innovation Capacity on Innovativeness of technology-based firms;

c) To evaluate the effect of DUI and STI Cooperation Networks on Innovativeness in technology-based firms located inside and outside technology parks;

d) To evaluate the effect of Innovation Capacity on Innovativeness in technology-based firms located inside and outside technology parks;

e) To evaluate the effect of DUI and STI Cooperation Networks on the Headquarters of technology-based firms;

f) To evaluate the effect of Innovation Capacity on the Headquarters of technology-based firms.

2 THEORETICAL FOUNDATION

The theoretical foundation of this thesis covers the topics on cooperation networks, innovation capacity, innovation, and innovation environments.

2.1 COOPERATION NETWORKS

The survival of technology-based firms is not an easy task, given the need to develop high-tech products, while keeping revenues for investing in product development. TBFs still face a lack of legitimacy, as they are new companies that do not have yet a well-known brand in the market. Faced with these difficulties, TBFs can seek cooperation with other companies and players, such as suppliers, customers, and research institutes that can contribute to product development and achievement of new markets.

The literature on innovation indicates that in the last two decades there has been a systematic and critical change in the way companies engage in innovation activities (Zeng et al., 2010), and cooperation networks are an important source of knowledge and collaboration for seeking greater innovation in products and services (Diez, 2002). One of the main characteristics of current organizational environment is the need for companies to operate jointly (Olave & Amato Neto, 2001). Thus, organizational models based on association, complementarity, sharing, exchange, and mutual help emerge as a concrete possibility for business development, taking as reference the concept of networks, which emerged mainly from Sociology (Olave & Amato Neto, 2001).

Cooperation networks for innovation are generally formed by heterogeneous groups of players, which include representatives from companies, universities, technological centers, and development organizations (Pekkarinen & Harmaakorpi, 2006). According to Goes and Park (1997), interorganizational cooperation between different organizations of a given segment is a relevant factor that contributes to organizations' innovative process. Companies with more heterogeneous networks and strong relationship ties tend to be associated to better economic performance (Gronum et al., 2012).

2.1.1 Network Theory

We consider the relevance of the network theory for the contextualization of cooperation networks, one of the key concepts of this thesis. Hence, this chapter aims to present the network theory, restricting the theoretical support of the concepts associated to the understanding of cooperation networks' operation. These aspects will be discussed in the following subchapters.

Players in a relationship network are often criticized for having unlimited powers or being deprived of any room for maneuver (Callon, 1999). The author explains that economic agents are characterized by high skills' specificity and demand, calculating and seeking their own interests; the actor-network theory was developed to analyze situations when it becomes difficult to separate humans from non-humans, and their actors have different forms and competencies. This characteristic is considered to be precisely the strength of the actor-network theory on the explanation of economic markets' operation (Callon, 1999).

Any particular market is the consequence of unfolding, framing, internalization and externalization. The actor-network theory provides the operational explanation and the emergence of calculating agents. *Homo economicus* is not a pure invention, nor an impoverished view of a real person. In fact, it does exist, but it is the consequence of a process where economic science has an active role. Finally, the author's conclusion is that the actor-network theory has undergone one of the most difficult tests: that of the market (Callon, 1999).

Networks can have different interorganizational arrangements, such as decentralized networks - with autonomous governance, a leading organization, among others. Huggins, Johnston and Thompson (2012) distinguished between two forms of interorganizational knowledge networks: (1) alliance networks, through which companies collaborate to innovate; (2) contact networks, through which companies provide knowledge. According to the authors, networks in the form of an alliance usually formalize collaboration and joint ventures, and other types of 'contracts' that result in a frequent and repetitive interaction. On the other hand, contact networks consist of informal interactions between companies and other actors.

Some authors have explored the differences between formal and informal contacts, and their consequences for companies in different types of relationships. Jørgensen and Ulhøi (2010) presented a detailed longitudinal case study of a small business in the mobile commerce (m-commerce) sector. The case study resulted from a longitudinal study of small and medium-sized enterprises (SMEs) involved in new e-commerce ventures in Denmark. The case presented by the authors suggests that relatively informal relationships with members of pre-existing networks are much favorable to learning and knowledge behaviors necessary to build innovation capacity.

In addition, the authors claim that the traditional dichotomous conceptualization between weak and strong relationships may be inappropriate, in terms of capturing the type and nature of interpersonal relationships in network formation. They conclude that for young SMEs, with focus on innovation and, perhaps, in highly dynamic environments, such as e-commerce, there is the duty of developing and promoting network relationships at the beginning of their life cycle, in order to support learning, knowledge sharing, and innovation. Gronum et al. (2012) argued that weak ties make it difficult to transfer complex information and, in turn, strong ties limit the search for information on intra-organizational social networks.

Trust among companies has been a focal element of studies on cooperation networks, where its presence seems to be an important evidence of cooperation in interorganizational networks. De Clercq, Dimov and Thongpapanl (2010) found that trust allows a more successful exploitation of business opportunities when actors have full trust in each other, since there is less need to monitor or control a potential bad behavior and, therefore, more time to invest in knowledge exchange. Sydow and Windeler (2003) argued that trust is usually considered to be a constitutive property of relationship networks among companies in general, and of regional relationship networks of services, in particular. Although important, as a lubricant for organizational exchange, trust does not imply absence of control or absence of knowledge.

Players tend to organize themselves in networks when they perceive benefits in value creation collectively, and not only individually. These networks have the following attributes: (i) mutual commitment and trust; (ii) multidimensional and long-term relationships; and (iii) normative instead of contractual regulation of behavior (Ulhøi, 2009). Most organizations' networks have non-contractual, autonomous forms, and collaborative arrangements that are neither purely hierarchical nor purely marketing.

Organizational networks can have different forms, with no single format. Thus, they can vary significantly in terms of their arrangement, incentives, interdependence, nature of the exchange processes, and governance approaches. In addition, it is important to check organizational networks from the perspective of the results achieved, since networks must lead primarily to collective results, rather than exclusively individual results (Ulhøi, 2009).

2.1.2 STI and DUI Cooperation Networks

Literature shows some divisions on the classification of cooperation networks. The most usual way of referring to players in cooperation networks is as vertical and horizontal partners (Beers & Zand, 2014; Tsai, 2009). Vertical cooperation is about actors that are in the company's production and sales chain, such as suppliers, customers, competitors, among others. Horizontal cooperation, on the other hand, refers to players that traditionally are not in the company's production chain, such as research institutes, government bodies, and universities. Another classification found in the literature for cooperation networks regards science-oriented (research) and market-oriented partners (Du, Leten, & Vanhaverbeke, 2014; Gelsing, 1992). Finally, a new categorization, similar to partners oriented to science or to the market, has emerged in the literature, grouping cooperation networks by the modes *Science, Technology, and Innovation* (STI) and *Doing, Using, and Interacting* (DUI) (Fitjar & Rodríguez -Pose, 2013; González-Pernía, Parrilli, & Peña-Legazkue, 2015; Jensen, Johnson, Lorenz, & Lundvall, 2007; Sun & Cao, 2015).

The mode of cooperation through *Science, Technology, and Innovation* (STI) is characterized by the production and use of codified and technical scientific knowledge. In turn, cooperation through *Doing, Using, and Interacting* (DUI) is based on informal learning processes and knowledge based on experience (Jensen et al., 2007). Therefore, the STI cooperation mode is related to partners who have knowledge based on science, such as universities, research centers, and scientific laboratories, while the DUI cooperation mode is associated with customers, competitors, and suppliers (Parrilli & Heras, 2016).

Evidence was found that companies that combine STI and DUI modes are achieving a greater degree of innovation than those that rely exclusively on the DUI mode, that is, informal learning processes and knowledge based on experience (Thomä, 2017). Although it is true that both modes of interaction, through STI and DUI, are relevant, it seems that a more formal collaboration has a greater impact, especially regarding innovation performance (Fitjar & Rodríguez-Pose, 2013). The authors also highlight that companies that establish extra-regional ties with universities, research centers, and consulting firms, and, in particular, with suppliers and customers outside their region, tend to significantly increase their potential for product and process innovation.

Xie, Zeng and Tam (2010) identified five major cooperation partners for innovation in small and medium-sized companies: customers, suppliers, service providers, technology agencies, and competitors. According to the authors, vertical cooperation networks with customers and suppliers have more influence on the innovation process of small and medium-sized companies than horizontal cooperation with research institutions and universities.

In a study with SMEs, Lee, Park, Yoon and Park (2010) divided collaboration partners in two groups: companies and the market, and universities and research institutes. This division is very similar to the cooperation through STI and DUI modes. The authors investigated the level of partners' collaboration for innovation, which they classified in two types: technological acquisitions and strategic alliances. They found that SMEs prefer to collaborate with other companies for technological purchases, and with universities and research institutes for strategic alliances, although the number of alliances is relatively low.

In order to relate cooperation focused on innovation and the potential effects on companies' performance, Belderbos, Carree and Lokshin (2004) tested the impact of participation in R&D cooperations on the productivity growth of Dutch companies. They found a positive result, with different levels of relevance according to the type of partner. Collaboration with universities brought more significant results in the generation of radical innovations.

2.1.3 Cooperation Networks for Innovation

Cooperation networks have been identified, in several studies, as an important element of the innovation process (Gronum et al., 2012). Tether (2002) observed that companies that introduced at least one innovation in the market cooperated more significantly with suppliers, customers, and competitors, compared to organizations that had not introduced innovations. Likewise, Shan, Walker and Kogut (1994) found that the number of agreements with commercial companies has a significant influence on the number of patents granted to startups in the biopharmaceutical industry.

In studies on SMEs with relationship networks in China's industrial associations, Qiao, Ju and Fung (2014) argued that this type of network can improve efficiency and increase non-operating income, but requires higher management costs for SMEs. R&D and human capital are essential for SMEs to stimulate innovation. In addition, industrial associations' networks have a positive effect on SMEs. Thus, the authors conclude that there is a link between networks of associations and innovation in a competitive market.

In a study with Brazilian companies, based on data from the 2005 Technological Innovation Survey (PINTEC), on the effects of cooperation on innovation output and market performance, cooperation among companies in Brazil had a positive effect, and this effect was higher in the creation of new markets (Carvalho, 2010). Furthermore, Brazilian companies tend to cooperate in bolder projects, where the results are radical innovations. However, the author concludes that Brazilian firms still show little cooperation, and seldom use external sources of knowledge in the innovation process.

De Faria, Lima and Santos (2010) studied the importance of cooperation with partners for the development of innovation activities. The analyses showed that companies with high levels of absorptive capacity, export, and innovation intensity, and higher levels of appropriability, are more likely to participate in cooperation agreements for innovation. The authors also highlighted that close partners, such as companies of the same group or suppliers, are more effective in developing cooperation activities. They warned that technology also has a relevant role, given that companies with higher levels of technology tend to give more value to cooperation with partners (De Faria et al., 2010). This conclusion, regarding the more evident cooperation in companies of higher technological intensity, is a relevant fact, since technology-based firms, the unit of analysis of this study, operate precisely in technology-intensive sectors.

In a research with 93 Brazilian TBFs on cooperation, 76 (82% of respondents) declared developing some cooperation activity, with universities or research institutes, customers, consulting or engineering firms, suppliers, competitors, and others. Among these partners, universities and research institutes were the most active players in cooperating with TBFs (Côrtes, Pinho, Fernandes, Smolka, & Barreto, 2005). From this study, authors evaluated that the lack of partnerships between TBFs and companies, competitors, suppliers, and consulting and engineering firms results in little dense cooperation networks.

In addition, Côrtes et al. (2005) observed that universities and research institutes, by their own institutional nature, are partners little oriented towards ‘corporate’ R&D. In fact, science-oriented cooperation is not of the same nature as cooperation with market-oriented partners. It is important to stress that the company's technological intensity can contribute to a stronger or weaker orientation to cooperation with science-related partners. Albahari, Pérez-Canto, Barge-Gil and Modrego (2017) found that a high involvement with universities in technology parks is positively related to the number of filed patents, but negatively related to tenants' innovation sales.

In a research with Swedish manufacturing companies, Lööf and Heshmati (2002) found a strong association between customers, competitors, and organizations of the same group with innovation, and an insignificant relationship in collaborations with research organizations and innovation. On the other hand, many studies show the relevance of companies’ cooperation, especially technology-based firms, with universities and research institutes (Bozeman, 2000; Vuola & Hameri, 2006). Companies choose universities as partners for collaboration in cases of multiple problems and learning focused on projects that involve new areas of science and the expectation of long-term benefits, such as knowledge absorptive capacity and radical innovation (Maietta, 2015). Companies that operate in high-tech sectors, such as biotechnology, are highly dependent on this type of relationship with universities and research institutes (McMillan, Narin, & Deeds, 2000). In general, there is an important contribution both from universities and research institutes, as well as from suppliers, customers, and competitors for product or service innovation (Jensen et al., 2007).

In a longitudinal study of 1,435 small and medium-sized companies, Gronum et al. (2012) analyzed the contribution of relationship networks to innovation result and to companies' organizational performance. They identified four possible relationships in this construct: relationship between networks and innovation (path 1); innovation and organizational performance (path 2); networks and organizational performance (path 3); and networks and organizational performance mediated by innovation (path 4). The authors argue that relationship networks in small and medium-sized companies can develop a greater productive activity, such as innovation, which, in turn, would lead to better performance.

Gronum et al. (2012) noted that innovation serves as mediation between networks and performance, but not as a control factor between them. In this sense, the relationship between networks and performance is much smaller than the relationship between networks and innovation. Cooperation networks have a small positive relationship with sales growth, product variety, and service growth, but no relationship was identified with profitability and productivity growth.

2.1.4 Measuring Cooperation Networks

Gronum et al. (2012) identified, as potential partners for network cooperation, external accountants, financial advisers or banks, solicitors, business management consultants, other companies in the same industry, industry associations, Internal Revenue Service agents, other governmental bodies, etc. The players with whom companies sought more information or advice were external accountants, financial advisers or banks, and others in the same industry.

For measuring cooperation networks in small companies, Xie et al. (2010) used a 5-point scale for each type of partner that had cooperated with the innovation process. The authors used 11 cooperation players, which were technology agencies, customers, service providers, suppliers, public or private research institutions, venture capital organizations, industrial associations, government, universities, and foreign companies.

Another study on cooperation networks that deserves mentioning is Zeng et al.'s (2010), which groups cooperation partners into four different constructs. The first is cooperation between companies (customers, suppliers, and competitors). The second is cooperation with government agencies (department of innovation services, department of information services, and department of supervisory services). The third is cooperation with intermediation institutions (technological intermediaries, venture capital organizations, and industrial associations). Finally, the fourth group is cooperation with research organizations (universities, research institutes, and technical institutes). The authors measured the constructs using a 5-point Likert scale.

Some authors group cooperation networks by STI and DUI modes, and are not necessarily equal. Fitjar and Rodríguez-Pose (2013) propose seven dummies for each type of partner. In the case of DUI partners, the actors are companies of the same conglomerate, suppliers, customers, competitors, and consulting firms. STI partners, on the other hand, are universities and research institutes. The variables get a value of 1, in the case of collaboration with the partner in the last three years, and 0 otherwise.

Another option proposed in the analysis of cooperation networks through STI and DUI modes is to group according to three different types of partners: "STI.Exclusive" mode of cooperation (companies that only collaborate with science-based partners: universities, research centers, and scientific laboratories); "DUI.Exclusive" cooperation mode (companies that only collaborate with customers, competitors, and suppliers); and, "STI & DUI" cooperation mode (includes both types of cooperation simultaneously) (Parrilli & Heras, 2016). The authors also use dummies on the cooperation scale for each type of partner. Cooperation Networks will be measured through the concepts of STI and DUI modes of cooperation. Chart 2 shows the two forms of cooperation, with the types of partners and the authors that mention them.

Chart 2: STI and DUI Cooperation Networks

Cooperation Networks	Type of Partner	Authors
STI Cooperation	Research Institutes	Lee et al. (2010); Fitjar & Rodríguez-Pose (2013); Parrilli & Alcalde Heras (2016); Xie et al. (2010); Zeng et al. (2010)
	Universities	Lee et al. (2010); Fitjar & Rodríguez-Pose (2013); Parrilli & Alcalde Heras (2016); Xie et al. (2010); Zeng et al. (2010)
	Government or Technology Agencies	Lee et al. (2010); Xie et al. (2010)
	Institutions for tests, trials, and certifications	PINTEC (2016)
	Scientific laboratories	Parrilli & Alcalde Heras (2016)
DUI Cooperation	Competitors in industry	Lee et al. (2010); Fitjar & Rodríguez-Pose (2013); Parrilli & Alcalde Heras (2016); Xie et al. (2010); Zeng et al. (2010)
	Venture capital organizations	Xie et al. (2010); Zeng et al. (2010)
	Non-competitors in industry	Lee et al. (2010); Fitjar & Rodríguez-Pose (2013)
	Other firms in the same industry/conglomerate	Fitjar & Rodríguez-Pose (2013)
	Business service providers	Lee et al. (2010); Xie et al. (2010)
	Consulting firms	Fitjar & Rodríguez-Pose (2013)
	Suppliers	Lee et al. (2010); Fitjar & Rodríguez-Pose (2013); Parrilli & Alcalde Heras (2016); Xie et al. (2010); Zeng et al. (2010)

	Costumers/consumers	Lee et al. (2010); Fitjar & Rodríguez-Pose (2013); Parrilli & Alcalde Heras (2016); Xie et al. (2010); Zeng et al. (2010)
	Centers for professional qualification and technical assistance	PINTEC (2016)

Source: adapted by the author according to the references.

2.2 INNOVATION CAPACITY

Innovation capacity refers to a company's internal resources and the way it uses them to achieve a competitive advantage by launching new or modified products. Thus, it is necessary to reflect on the assumptions considered in RBV theory (Resource-Based View) and Dynamic Capabilities that support the concept of innovation capacity. RBV assumes that companies have heterogeneous and distinctive resources, and they sustain their competitive advantage by being valuable, rare, inimitable and non-substitutable (Barney, 1991).

Companies' resources include tangible and intangible assets and human resources, while capabilities refer to their ability to use these resources to develop productive activities (Grant, 1991). An issue for discussion on RBV is how to transform resources into value for the company (Sirmon, Hitt, & Ireland, 2007). To solve this problem, resource management should be used as a comprehensive process of structuring the company's resource portfolio, adding resources to build capabilities, and leveraging these resources to create and keep value for customers and owners.

2.2.1 Dynamic Capabilities and Innovation Capacity

The innovation process can be considered a sequence of tasks that are consistent for achieving the final artifact, represented by new products, services, and new technologies (Boly, Morel, Assielou, & Camargo, 2014). According to the authors, innovation capacity may be related to dynamic capabilities. Teece (2007) describes dynamic capabilities through the following attributes: (1) to feel and shape opportunities and threats; (2) to take advantage of opportunities; and (3) to keep competitiveness by increasing, combining and, when necessary, reconfiguring the company's tangible and intangible assets.

Dynamic capabilities are sources of competitive advantage for companies, and Teece and Pisano (1994) emphasize two aspects. First, dynamic capabilities operate in an environment of constant change. Second, they have the fundamental role of strategic management in adapting, integrating, and reconfiguring internal and external organizational abilities, resources, and functional skills for changing the environment.

In addition to dynamic capabilities, literature offers an extensive bibliography of research on capabilities or a mix of them, which are necessary to develop a particular type of innovation (Forsman, 2011). Boly et al. (2014) summarize the main capabilities mentioned in the literature, among which are: resource allocation capabilities; capabilities to identify competitors' strategies and meet market requirements for developing new products; capabilities to anticipate technological changes and manufacture new products by using an appropriate technological process; capabilities to respond effectively to unpredictable changes created by competitors and market forces; and capabilities to organize an internal learning process.

A company's capabilities are important in providing and sustaining its competitive advantage, and implementing a strategic management (Guan & Ma, 2003). Regarding innovation capabilities, they are a company's special asset, and a tacit and unmodifiable artifact, highly correlated with internal experiences and acquisition experiments. The ability to introduce products quickly and adopt new processes has become an important competitive factor. They rank seven dimensions for innovation capabilities: (1) learning capacity; (2) R&D capacity; (3) manufacturing capacity; (4) marketing capacity; (5) organizational capacity; (6) resource exploration capacity; and (7) strategic capacity.

Amit and Schoemaker (1993) distinguish between resources and capabilities. The first are stocks of available factors, which are owned or controlled by the company. They are converted into products or services by using a wide range of other company's assets and linking mechanisms, such as technology, information and incentive systems, among others. In contrast, capabilities refer to the company's ability to implement resources by using organizational processes to achieve a desired effect. In this case, capabilities are used as a mechanism of innovation capacity for attaining expected results, new products, and innovative services in the market.

Su, Peng, Shen and Xiao (2013) studied how to leverage technological and marketing capabilities. The authors consider that the influence of capabilities involves three processes: (1) mobilization, (2) coordination, and (3) implementation. Among the three processes, they highlight the coordination and implementation of technological and marketing capabilities, in order to assess how they can leverage positive results. Sirmon et al. (2007) describe that mobilization refers to the process of identifying capabilities; coordination is the integration of capabilities into effective configurations; and implementation refers to the appropriate use of capabilities to respond to changes in the external environment.

Innovation capacity, in turn, has its concept based on the use and implementation of capabilities for the creation of new products (Amit & Schoemaker, 1993; Dutta, Narasimhan, & Rajiv, 2005; Szeto, 2000). However, although innovation capacity has been extensively studied, it is still not clear in the literature how capabilities can anticipate innovation results. In this sense, Forsman (2011) indicates that the accumulation of existing knowledge plays an important role in innovation results. Companies with a low level of existing knowledge are unable to internalize and exploit external knowledge.

Some authors like Bell and Pavitt (1995), Calantone, Cavusgil and Zhao (2002), Lall (1992), and Reichert and Zawislak (2014) use the expression ‘technological capacity’ to refer to companies’ internal elements, assets, or resources that are used to achieve innovation. Such definitions may vary according to the authors, but the concepts of innovation capacity and technological capacity have very similar components and meanings. Therefore, this research also explored the concept of technological capacity.

O'Connor, Roos and Vickers-Willis (2007) worked with a distinction between innovation capability, which emphasizes results, and innovation capacity, which addresses the internal potential that allows innovation results. In the authors' view, a low potential of innovation capability would also result in little evidence regarding the innovation capacity for transforming resources and assets. They argue that there would be few innovative skills and attitudes, and it would be unlikely for companies to develop transforming assets, such as systems and processes, for stimulating and managing innovation.

2.2.2 Measuring Innovation Capacity

Innovation capacity has been directly related to R&D activities and their output, through new products (Kirner, Kinkel, & Jaeger, 2009). Thus, R&D is one of the main input indicators of innovation. According to Forsman (2011), this linear model of innovation emphasizes companies’ technological and scientific knowledge, and sees formal R&D activities as an indicator of the technological progress of firms.

According to Maravelakis, Bilalisz, Antoniadisy, Jones and Moustakisô (2006), most studies that measure innovation activities use the following criteria: research and development (R&D), number of patents, and count of higher or lower number of innovations. However, the task of applying these measures to small and medium-sized firms has many difficulties and can lead to wrong conclusions. To the authors, numbers referring to R&D only measure the input and not necessarily regard real results of innovation.

On the other hand, R&D evaluation is one of the most used criteria to identify innovative companies. The Oslo Manual (2005) argues that all R&D is considered an innovation activity. In addition, R&D is defined as a separate category that includes activities relevant to product, process, marketing, and organizational innovations, along with basic research. When a company builds its innovation capacity, it invests substantial resources in R&D, which involves the discovery of new products, the accumulation of knowledge stocks, and training of technical personnel (Zhou & Wu, 2009).

Besides being the most classic, R&D activities assume a prominent role, by actively affecting the technological innovation process of companies and dominating technologies' state of the art (Andreassi & Sbragia, 2002). The authors measured R&D intensity as inputs, such as financial resources allocated to R&D (operationally, R&D expenditures per revenue), and human resources allocated to R&D (operationally, number of doctors, masters, and graduates allocated to R&D, by number of employees).

Research institutions and universities are some of the partners that can support R&D activities, both in large and small companies. New innovative companies (firms up to six years old, with less than 250 employees, that invest more than 15% in R&D activities) are positively affected by the presence of highly qualified employees, by the company being part of a group, and by cooperating with others players (Audretsch, Segarra, & Teruel, 2014). The authors use the percentage of researchers and technicians who work at the company as a proxy for the company's ability to increase its R&D activity.

Cohen, Nelson and Walsh (2000) highlight some difficulties regarding the search for patents. First, technological opportunities vary substantially by industry, implying that some companies acquire few patents, although they put greater efforts in R&D. Second, not all inventions are patentable. Third, and, more important, many companies prefer to keep innovations secret, or try to be technological leaders, rather than file patents, due to cases where patents may be less effective mechanisms for appropriating R&D returns. In an attempt to overcome some of these limitations, Coombs and Bierly (2006) propose the use of measures such as citations generated by patents and checking the average number of scientific articles cited in patents.

Zhou and Wu (2009) argue that for quantitative measurement of innovation capacity, researchers can use measures such as R&D intensity and number of patents. Similarly, Renko, Carsrud and Brännback (2009) evaluate technological capacity through two items: (1) proportion of R&D expenditures in relation to total expenditure; and (2) number of patents. Studies by Coombs and Bierly (2006), García-Muiña and Navas-López (2007), and Tsai (2004) have also used R&D expenses and the number of patents to assess innovation capacity. Chart 3 shows the main variables used to measure input activities of innovation capacity.

Chart 3: Innovation Capacity Indicators

Activity	Variable	Authors
Innovation Capacity	Proportion of R&D expenses in relation to sales	Andreassi & Sbragia (2002); Coombs & Bierly (2006); Hall & Bagchi-Sen (2002); Zhou & Wu (2009)
	Resources alocated to R&D	Archibugi & Pianta (1996); Kim (1999); Tsai (2004); Figueiredo (2009)
	Average investment in R&D as percentage of sales	Madanmohan, Kumar & Kumar (2004)
	Existence of R&D area	Kim (1999)
	R&D projects	Panda e&Ramanathan (1996)
	Conducting R&D activities	Archibugi & Pianta (1996); Jin & Von Zedtwitz (2008)
	Human resources alocated to R&D	Andreassi & Sbragia (2002); Audretsch et al. (2014)

Source: adapted by the author according to the references.

Clearly, R&D activity is an appropriate input measure of technological capacity, especially with regard to that capacity created through internal learning (Coombs & Bierly, 2006). Also relevant is the study by Forsman (2011) on innovation capacity, where the author measures the construct through three indicators: R&D investment, degree of innovation capabilities, and external inputs for innovation through cooperation networks. Innovation capacity is measured by the following variables: (1) financial resources allocated to R&D; and (2) human resources allocated to R&D.

2.3 INNOVATION

Innovation has been identified as a decisive element for firms' competitiveness; it is assumed that more innovative companies tend to have better economic performance (Anderson, Potočnik, & Zhou, 2014; Jiménez-Jiménez & Sanz-Valle, 2011), thus, a better result for its shareholders. However, the concept of innovation is not restricted to companies, and has been widely used by society actors. According to Plonski (2005), innovation has been increasingly considered a strategy to redeem companies, regions, and nations from their chronic economic problems, and to promote their development.

Innovation has been interpreted from different angles, as an input, stimulus, process, or result, among others. The most comprehensive understanding of innovation is as a process (Plonski, 2005). Hence, the focus leaves the achievements and their effects, and turns into attitudes, behaviors, and practices, which give the company, organization, region, segment of society, or nation the dynamic capability of change, improving creative answers to challenges and attaining its strategic objectives (Plonski, 2005). Next, we address the definitions applied to the concept of innovation, in order to deepen the reflections on another concept of greater interest: innovativeness and its potential measurements.

2.3.1 Definitions of Innovation

Understanding innovation is a complex task, as it is a phenomenon that expresses itself in different ways, and there is no single framework to analyze it. According to Brito, Brito & Morganti (2009), one of the difficulties for assessing it is the lack of a model that relates the inputs of the innovation process, the internal processes of the company through which it processes the inputs (throughput), and the results or outputs of the innovation process.

There is no single concept about innovation, its definitions are diverse, and the constructs for explaining technological innovation in companies are also various. Among the most recognized studies in this area, the Oslo Manual stands out as a guiding work for the collection and interpretation of data on technological innovation. The Manual aims to guide and standardize concepts and methodologies, and orient building statistics and R&D indicators in developed countries.

It was published for the first time in 1990, and its second edition was in 1997, by the Organization for Economic Cooperation and Development (OECD). In the first two editions, it considered the definitions of technological innovation of product and process. In the third and last edition, launched in 2005, the definition of innovation was expanded, by adding the concepts of marketing innovation and organizational innovation. The Oslo Manual (2005) defines innovation as:

> An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization, or external relations (p. 55).

According to the Manual, product innovations involve significant changes in their potential and services. Process innovations represent significant changes in production and distribution methods. Marketing innovations regard the implementation of new marketing methods, including changes in the design and packaging of the product, in its promotion and placement, and in methods for establishing prices for goods and services. Finally, organizational innovations refer to the implementation of new organizational methods, such as changes in business practices, in the organization of the workplace, or in the company's external relations (Oslo Manual, 2005).

Innovation can also be classified according to its nature, by considering it more or less innovative. When innovation is of a non-transformational nature, adding some improvements in relation to products and services that already exist, it is called 'incremental innovation'. However, when it is disruptive, breaking the paradigms of what is on the market, it is considered a 'radical innovation'.

2.3.2 Innovativeness

There is no single definition for innovativeness; and there are different approaches for its analysis, and especially, distinct measurement constructs. In the literature, we find terminologies such as radical, really new, incremental, and discontinuous that are generally used to identify innovation (Garcia & Calantone, 2002). For Tajeddini, Trueman e Larsen (2006), the concept of innovativeness depends on the researcher's point of view.

Innovativeness is most often used as a measure, such as the degree of novelty of an innovation (Garcia & Calantone, 2002). "Highly innovative" products are seen as products with a high degree of novelty, and "little innovative" products are products in the opposite direction. The authors also claim that literature has made little progress to understand who defines the degree of novelty and what is considered new. They conclude that this definition of the nature of innovativeness has contributed to a lack of understanding on product development, due to different units of analysis.

Some authors highlight the relevance of the cultural background rooted in the company for its innovativeness. Hult, Hurley and Knight (2004) indicate that an entrepreneurial orientation is an important driver of innovativeness. Because innovativeness is critical for organizational success, entrepreneurship seems to be an important guideline that managers should promote. While market orientation and learning orientation may help managers to conceive better products, processes, and ideas, entrepreneurial guidance is likely to provide the incentive for these activities. According to the authors, entrepreneurial orientation incorporates proactivity, aggressiveness, and initiative that can encourage managers working in several innovation projects. Therefore, entrepreneurial guidance can be considered as the spark that ignites the company for an innovative action cycle.

Culture reflects norms, values, and beliefs that reinforce behaviors that are ultimately related to business performance. When specific guidelines are rooted in organizational culture, the intensity and consistency of behavior result are increased through situations, groups, and people within the company (Hult et al., 2004). Tajeddini et al. (2006) also emphasize innovativeness through organizational culture (values and beliefs) oriented towards innovation.

2.3.3 Measuring Innovativeness

In a study with TBFs in the biotechnology sector, Renko et al. (2009) measured innovativeness by the following items: (1) new products introduced by the company in the market; (2) initiated product development projects; and (3) final products that were developed in the last three years based on company inventions. The sum of these three items was used in the analysis of companies' innovativeness.

Bell (2005), in a research with Canada’s mutual fund companies, measured innovativeness through three dimensions: (1) introduction of new products; (2) introduction of new services; and (3) introduction of new technologies. The author concluded that factors such as companies located in industrial clusters and centrality in the management network contribute to the company's innovativeness, while institutional centrality linked to the network does not increase innovation.

Company's innovativeness can also be operationalized as the degree of innovativeness of the company's portfolio of new products. Talke, Salomo and Kock (2011) proposed a construct of innovativeness based on two factors - market novelty and technological novelty -, confirming Garcia and Calantone (2002) and Calantone, Chan, and Cui (2006). The authors defined four items for the two constructs, which describe to what degree the company's product portfolio includes innovations considered new, regarding the *status quo* of the market and technology’s perspective.

The study by Deshpande, Farley and Webster (1993), in large Japanese companies, stands out in the literature on innovativeness. The authors used the Capon, Hulbert, Farley and Martin (1988) scale, with five items, to measure innovativeness: (1) first in the market with new products and services; (2) last entrant in established, but growing markets; (3) entrant in a mature and stable market; (4) entrant in a declining market; and (5) at the forefront of technological innovation. This scale has an approach oriented to new products and to market’s maturity level, not focusing on organizational, cultural, or administrative aspects. Therefore, it tends to analyze innovativeness from the perspective of product output and the operation market (Ali, Krapfel, & LaBahn, 1995).

Calantone et al. (2006) observed the influence of product innovativeness on competitive advantage and profitability. In the aspect 'product advantage', they evaluated to what degree the offered product was superior to competing products. They measured product innovativeness through an item, on a scale from 0 to 10 points, based on the study by Ali, Krapfel and LaBahn (1995). These authors used the following item to measure product innovativeness: "evaluate how innovative is the product - its degree of innovativeness - compared to the products in your market area". Another relevant measure used to measure innovativeness was proposed by Zeng et al. (2010). The authors measured innovativeness performance through three items: (1) annual rate of new products' sale; (2) index of new products; and (3) index of modified products.

Andreassi and Sbragia (2004) investigated the determinants of the degree of innovativeness in Brazilian companies, ranking them according to the percentage of revenue from new or improved products. The results of the study revealed that the main factor for higher innovativeness was the technical team allocated to R&D, which has a significant relevance in launching successful products. In this research, innovativeness is defined as the innovation output, that is, innovativeness is measured as revenue from new or significantly improved products. Operationally, the dependent variable (Innovativeness) is measured as the annual proportion of new products' sales over total sales in the last three years (Zeng et al., 2010).

2.4 INNOVATION ENVIRONMENTS

Environments that foster the development of high-tech companies and, consequently, innovation, are commonly called innovation *habitats* or environments. They provide relevant conditions for sustaining the company-academy-government dynamics for systematic innovation (Zouain & Plonski, 2015). Innovation environments are places where there is synergy between teaching and research institutions, the business community, and the public power, combined with a set of local factors such as: urban infrastructure; agile media; population with a high level of education, among others (Zen & Hauser, 2005). Zouain and Plonski (2015) also highlight that, in principle, technology parks go beyond the physical reality of establishing academic laboratories, technology-based companies, R&D centers of multinational companies, and development agencies' offices.

Faced with the challenge of competing in a globalized economy, many countries have invested in innovation environments that can stimulate and develop new knowledge-intensive companies. Technology hubs, technology parks, and incubators comprise the range of initiatives that aim to bring different players together and create relationship networks to trigger innovation. For Park (2001), local networks and interactions among companies in specific areas are important for the exchange of tacit knowledge and for the creation of new knowledge that can be the basis of innovation.

Technology parks are seen as a means of supporting TBFs' innovation and growth activities (micro level), ensuring and facilitating interaction between companies, universities and research institutions (meso level) - thus contributing to economic growth in a given region (macro level) (Vásquez-Urriago, Barge-Gil, Rico, & Paraskevopoulou, 2014). Thus, technology parks have stood out as a relevant initiative to stimulate innovation environments. Such environments stand out for the presence of TBFs and for the strong proximity between companies and research centers. In addition, these ventures are characterized by the meeting and cooperation of different players (university, company, and government) in the pursuit of their own goals.

Universities and research centers play a critical role in the development of technology parks. They enable the knowledge created in laboratories to be transferred to the market, either through new companies, through technology licensing or through projects developed together with industry. Educational institutions still contribute to the qualification of human resources, essential to collaborate or undertake in TBFs. According to Ipiranga, Freitas and Paiva (2010), in the context of cooperation between university, company and government, the complementary concepts of 'entrepreneurial university' and 'academic entrepreneurship' stand out, where an academic institution goes beyond qualification, playing a role role in the country's innovation system and development.

2.4.1 Technology Parks

Technology parks are environments that gather different actors linked to companies and research and teaching institutions, whose feature is the collaboration for wealth creation, through technological innovations. Park experiences are not unique, and therefore can have very different definitions. Hence, it is important to contextualize the distinct nomenclatures that describe such environments.

There is a distinct set of terminologies that refer to the same object, technology parks. Such differences between nomenclatures may vary according to the region or country where this type of environment is located. In the United States, the term "Research Park" is more common, in Europe the concept of "Science Park" prevails, and in Asia it is "Technology Park" (Link & Scott, 2007). In Brazil, in addition to park managers and their associations, most studies name such environments as technology parks, including ANPROTEC. For this reason, the term ‘technology park’ is used in this research.

After this brief explanation on the terminologies of technology parks, it is important to understand the theoretical concept of this type of environment. There are several conceptual definitions of technology parks, due to their numerous experiences around the world, making almost impossible to have one definition that covers all the observed models. For Siegel et al. (2003), technology parks have particular goals regarding their relationship with and impact on companies and the region; thus, they do not necessarily achieve similar results and, as a consequence, their definitions may vary.

In terms of definitions, we highlight the concepts proposed by the main national and international associations of technology parks. In Brazil, ANPROTEC (2018) defines a technology park as ‘an industrial and service production complex, of scientific and technological basis, planned, formal, concentrated, and cooperative, which gathers companies whose production is based on technological research developed in R&D centers linked to the park’.

In international terms, IASP, the most important international association on innovation environments, defines a park as ‘an organization managed by specialized professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions’ (IASP, 2018).

We notice that both definitions are similar, but the concept proposed by IASP is wider, involving elements such as innovation culture and knowledge-based businesses. Also, in both definitions, the university is not a *sine qua non* condition to configure a technology park, despite the mention of R&D and knowledge-based institutions, which are strongly associated with the figure of the university. Technology parks show a strong heterogeneity of organization, expressed by the different levels of university’s involvement (Albahari et al., 2017). Chart 4 didactically illustrates the different types of associations between parks and universities, as proposed by these authors.

Chart 4: Definition of Parks’ Types

Park Definition	Type of Park	Characteristics
Science Park	Pure Science Park	Park where university has over 50% of the shares
	Mixed Science Park	Park where university is a minor shareholder

Technology Park	Technology Park with University	Park where university is not a shareholder, but has some of its research facilities inside the Park
	Pure Technology Park	Park where university is neither a shareholder nor has any research facility located there

Source: Adapted from Albahari et al. (2017).

In some technology parks, there are no associations with universities or research centers, and they operate as a "business hotel" (Fukugawa, 2006; Lindelöf & Löfsten, 2002), or, as proposed by Albahari et al. (2017), a pure technology park. It is important to stress that the interaction of companies and entrepreneurs with universities, centers or research institutes is a strongly unique feature, regarding technology parks (Diez-Vial & Montoro-Sanchez, 2017; Etzkowitz & Zhou, 2018; Colombo & Delmastro, 2002; Siegel et al., 2003; Westhead, 1997). Therefore, when we observe parks that are distant from research institutions, we must be careful with this type of environment, since such initiatives may be far from common sense on technology parks, and even from comprehensive definitions such as IASP's and ANPROTEC's.

2.4.2 University-business-government interaction

The triple helix, interaction between universities, companies, and government, has been extensively studied in technology parks' environments, considering the conditions that these environments provide for interorganizational cooperation. The development of technology parks requires the joint effort of academia, industry, and government, encouraging permeability between them, thus increasing innovation potential (Etzkowitz & Zhou, 2018).

In this context, intermediary organizations may be present - such as technology transfer offices, university incubators, and collaborative research centers - that address different dimensions of proximity, depending on previous experience of academic and industrial players, and the nature of the knowledge that is transferred (Villani, Rasmussen, & Grimaldi, 2017).

Each player has a particular role in the academic context, but all act as a bridge between the knowledge created at the university and the demands and needs of the business world. As for the perspective of facilitating university-business collaboration, technology transfer offices focus more on improving the cognitive and organizational dimensions, while incubators and research centers seek to reduce social and geographical distances (Villani et al., 2017).

University-business interaction is one of the main benefits stimulated by technology parks, but this interaction has not proved to be so simple. According to Vedovello (1997), the relationship between university and company has become more frequent and formal since the

1970s, along with government interest, which adopted policies to foster this interaction. The main arguments in favor of these environments are not just the synergy between companies and universities, which would generate benefits for both, but also the contribution to the country's competitiveness.

One of the main interests of companies in universities is the access to highly qualified professionals, whether the company is located or not in a technology park. Harper and Georghiou (2005) state that, for the majority of companies, the most immediate and visible contribution of a university is the qualification of human resources, including graduates and knowledge transfer they bring. Knowledge produced by a public innovation system - mainly, through its universities - can spread throughout the local economy, and connect research and industry communities through the educational channel of national innovation systems (Maietta, 2015).

Research is another topic of strong collaboration between both, and the benefits for the company are knowledge achievement in a certain area of interest, and access to skills and capacities it does not possess. For the university, the benefits are the proximity to real-life problems and, eventually, the use of some company's facilities and additional income, through research sponsored by firms (Harper & Georghiou, 2005).

In Brazil, university-business cooperation has also been regularly studied in the Management field, in order to understand the barriers and opportunities of this interaction. Government has an important role in improving this relationship, by formulating public policies and optimizing laws and regulations to make this interaction more natural and productive. The incentive to establish cooperative bonds is increasing, especially after the implementation of the Innovation Act, aiming to ensure excellence in thematic areas considered strategic for their potential to contribute to economic growth, improvements in population's living conditions and local companies' competitiveness (Ipiranga et al., 2010).

2.4.3 Technology-based Firms

TBFs are of key importance in the development of new technologies, by launching innovative products and services with high growth potential, in addition to the formation of a qualified team of employees. There is no single definition for TBFs in the literature, which leads to a more comprehensive understanding of this type of companies. In this sense, Andrade (2012) mentions as some of TBFs' attributes the high degree of technological knowledge by their human capital, R&D investments, and products and processes with relatively short lives.

Technology-based firms are recognized for their innovative character and high level of scientific or technical knowledge, with highly qualified employees. In this research, we define TBFs as companies that, by using intensive knowledge, develop innovative products or services for the market (Vargas, Rech, & Santos, 2016). Innovative products can be something new for the market, but also an incremental improvement of an existing product - the important aspect is the use of highly specialized knowledge to add value to a new or significantly modified product. Fontes and Coombs (2001) state that TBFs are created to develop and introduce new technologies and applications, which improve or replace existing technologies.

TBFs' value, as has often been appointed in academic and political circles, stems from their propensity to promote interactions with universities and, consequently, increase their innovation capacity (Fukugawa 2006; Colombo & Delmastro, 2002). However, the lack of a standard and precise meaning of these terms has triggered cognitive and operational difficulties in distinguishing this type of company from others (Toledo, Silva, Mendes, & Jugend, 2008). In general, the concept of technology-based firms comprises small and medium-sized companies, which use knowledge intensively to produce high-tech goods and services. These firms employ qualified human capital and develop radical and/or incremental innovations in their products, services, and processes. Chart 5 presents some of TBFs' main definitions.

Chart 5: Definitions of Technology-based Firms

Authors	Main Definitions
Machado, Pizysieznig Filho, Carvalho e Rabechini Junior (2001)	These firms use innovative technologies, have a high proportion of R&D spending, employ a high proportion of technical, scientific, and engineering personnel, and serve small and specific markets.
Fukugawa (2006)	Small firms that make big R&D investments and are not subsidiaries of established companies. Subsidiaries are defined as firms where the controlling company makes investments above 50%.
Bjørgum & Sørheim, (2015)	TBFs are firms oriented to growth and have limited internal resources.
Vargas et al. (2016)	Firms that use intensive knowledge to develop innovative products or services for the market.
FINEP (2018)	Firms of any size or sector, where technological innovation is the basis of their competitive strategy, and which develop products or processes that are technologically new or have significant technological improvements, compared to existing products or processes.

Source: adapted by the author according to the references.

The creation of these companies is related to results of applied research, where new or innovative products appear as potential solutions to problems of production or existing markets (Santos, 2005). Traditionally, the research process emerges from an identified problem or a market need that can be potentially solved by research and, consequently, developed and applied to customers (Hindle & Yencken, 2004).

Therefore, TBFs are closely associated with technical entrepreneurship, different from traditional sectors. For Dahlstrand (2007), the topic of technology-based entrepreneurship has gained importance by combining two subjects: technology and entrepreneurship. These companies are prone to internalize a specialized collection of technical knowledge related to their priority activities, and this collection is expanded and refined by employees, many of whom are specialized in R&D functions (Saemundsson & Candi, 2017).

Developing and marketing innovative and complex technologies is a challenging task, as it requires time and financial resources, and new companies - such as TBFs - have limited resources and need external funding to overcome the stage of product technology development (Bjørgum & Sørheim, 2015). Hence, it is common to observe government financing policies for TBFs' R&D activities. It is still possible for TBFs to get financing from venture capital companies, which in return receive a shareholder option in invested firms. These two fund sources can contribute to greater access to capital. Thus, improving the venture capital financing environment can lead to additional benefits for TBFs in accessing government R&D funds (Colombo, D'Adda, & Pirelli, 2016).

In addition to high technical knowledge, technology-based entrepreneurs stand out for their strong ties with universities and research institutes. Universities are important sources of scientific knowledge, and TBFs can gain access to new knowledge and resources through the development of relationships with higher education institutions (Löfsten, 2016). Furthermore, TBFs need to be engaged with companies of their production chain: customers, suppliers, consulting firms, and competitors, among others. A more motivated TBF will be more involved in cooperation with other companies and research institutions as channels for transferring knowledge that can be translated into innovation (Ramírez-Alesón & Fernández-Olmos, 2018).

2.5 RESEARCH HYPOTHESES

In this section we present the theoretical foundations and the respective research hypotheses. The hypotheses are anchored in empirical evidence from previous studies, which enable to argue and support the assumptions raised in this research. The hypotheses provide the link of the main topics addressed in the previous sections: Cooperation Networks, Innovation Capacity, Innovativeness, and Technology Parks.

2.5.1 Cooperation Networks and Innovativeness

Cooperation networks tend to affect positively the innovativeness of technology-based companies. In this section, we present evidence, found in the literature, that companies which cooperate with different partners (customers, suppliers, universities, among others) have a better performance regarding innovation. It is important to note that the literature on cooperation and innovation networks presents different and, in some cases, contradictory studies. But this fact does not prevent us from proposing research hypotheses that are based on relevant studies in the area, which, in turn, are based on empirical evidence.

Previous studies suggest that companies can advance towards product innovation through the integration of different collaborators, mainly suppliers, customers, competitors, and research organizations (Tsai, 2009). Schilling and Phelps (2007) suggest that companies that have established alliances in cooperation networks will have better innovative results than companies that do not present such characteristics.

Collaboration with different types of partners shows greater variety of the knowledge network, and increases the likelihood of achieving product innovation due to the diversity of knowledge that can be shared (Tsai, 2009). Jesús Nieto e Santamaría (2007) modeled a regression between product innovation and cooperation networks, and found a positive relationship between suppliers and product innovation. Belderbos, Carree, Lokshin, and Sastre (2015) highlight the importance of persistent collaboration for a significant effect on innovativeness. They also highlight the need for an 'incubation period', so that collaboration in activities such as R&D can have an effect on innovation performance.

Cooperation networks have proved to be a fundamental element for innovativeness in TBFs (Bellamy, Ghosh, & Hora, 2014; Chen, Chen, & Vanhaverbeke, 2011; Lee et al., 2010), which tend to have limited financial and human resources for product development activities (Bjørgum & Sørheim, 2015). Faced with this reality, cooperation networks become an alternative to internalizing R&D activities in technology-based companies (Thomä, 2017), and it is expected that TBFs that engage in cooperation networks will have better innovative performance. Based on this reasoning, we assume the following association between Cooperation Networks and Innovativeness:

H_1: Cooperation Networks are positively associated with Innovativeness in technology-based firms;

H_{1A}: DUI Cooperation Networks are positively associated with Innovativeness in technology-based firms;

H_{1B}: STI Cooperation Networks are positively associated with Innovativeness in technology-based firms.

2.5.2 Innovation Capacity and Innovativeness

Skills, knowledge, and experience are required to operate current systems and to make technical changes in technological capacity (Reichert & Zawislak, 2014). For Zhou and Wu (2010), a company's technological capacity is developed over time and accumulated through its experience. Bell and Pavitt (1995) understand that the efficiency of technological capacity is not only affected by the acquisition of external technology, but also by the ability to manage internal changes in the technology used for production.

Using the interaction between resources for innovation and knowledge accumulation within an interorganizational network, a company should work for creating mechanisms to improve innovation capacity, which benefits the R&D process for new products, not only meeting customers' needs, but creating new markets (Szeto, 2000). However, few studies recognize that innovation capacity can be developed and maximized, as part of a continuous enhancement of the company's competitiveness.

Reichert and Zawislak (2014) argue that technological capacity, as a company's skill based on its accumulated knowledge for carrying out a set of activities, results in new technological knowledge developed to achieve positive economic results. According to the authors, companies innovate because they expect to reach economic benefits from innovation. In many cases, profit is not achieved by launching new products. However, economic benefit can come incrementally, through adjustments in the production process, in the organizational structure, or even in marketing actions. All these actions lead to higher profit margins.

O'Connor, Roos and Vickers-Willis (2007) define innovation capacity as the resources and transformational intermediate assets that allow the company to engage in activities necessary for innovation. High levels of resources such as an innovative workforce and internal collaboration would be a clear evidence of the potential to transform ideas into practical results of innovation (O'Connor et al., 2007). Finally, another noteworthy study is by Prajogo and Ahmed (2006), who observed a significant relationship between factors of innovation management capacity and innovation performance. Based on this theoretical foundation, this research assumes as hypothesis the following association between Innovation Capacity and Innovativeness:

H_2: Innovation Capacity is positively associated with Innovativeness in technology-based firms;

2.5.3 Cooperation Networks and Innovativeness in Technology Parks

Innovativeness in companies settled in innovation environments has been measured mainly by the number of patents filed, and new products introduced in the market, when compared to a control group outside technology parks. According to Squicciarini (2009), the location of companies inside technology parks is positively related to the innovative performance of the tenants. This fact can be attributed to the interactions with different partners, and knowledge spillovers that co-location can trigger.

Lamperti et al. (2017) found that the presence of research centers is the key variable in supporting the innovative performance of on-park firms, while sales growth is not affected in any way. Regarding the innovative performance of patents, Squicciarini (2009) noted that companies become more likely to patent after settling in parks, given the total number of patents filed after joining the parks.

These findings confirm Colombo and Delmastro's (2002) research, whose data showed that companies located in technology parks and incubators produced, marginally, a better innovation result than non-resident companies in this type of environment, such as: 18% of the companies patented a new product or process, against 13% of those located outside the parks. Firms that are in new or mature parks were also identified as having a better innovative performance - measured by sales from products improved by employees (Albahari et al., 2018).

Yang et al. (2009) also found a higher number of patents in on-park companies, compared to off-park firms. These results give more support to the conclusion that companies located in that specific park had a better performance in innovation results. However, although much of the literature finds more significant results of patents in on-park companies (Colombo & Delmastro, 2002; Lamperti et al., 2017; Squicciarini, 2009; Yang et al., 2009), not all references that we found show such results. Lindelöf and Löfsten (2002) identify that on-park and off-park TBFs did not have significant differences in patents, respectively 32% and 36%.

Greater innovativeness in resident companies may be associated with the presence of research and teaching institutions, a striking feature of innovation environments. Díez-Vial and Fernández-Olmos (2015) stressed that companies with previous cooperation agreements with research institutions would benefit more from parks, since they could more easily incorporate the park's existing knowledge and improve their product innovation. In their sample with companies in innovation environments in Spain, those on-park showed higher innovative performance than those off-park.

Still, it is relevant to mention the studies by Lindelöf and Löfsten (2004), indicating higher technological innovation (changes in products and services) in off-park companies than in similar on-park firms. Although some studies do not show greater innovativeness of companies in parks, most of the literature does. Therefore, we expect on-park TBFs' Cooperation Networks to have a positive and greater effect on innovativeness, compared to similar companies that are not operating inside this type of environment. Thus, we propose the following research hypotheses:

H_3: Cooperation Networks are more positively associated with Innovativeness in firms located inside technology parks than those outside the parks;

H_{3A}: DUI Cooperation Networks are more positively associated with Innovativeness in firms located inside technology parks than those outside the parks;

H_{3B}: STI Cooperation Networks are more positively associated with Innovativeness in firms located inside technology parks than those outside the parks;

2.5.4 Innovation Capacity and Innovativeness in Technology Parks

Technology parks have been considered a means to foster innovation, where geographical proximity provides companies with the big benefit of space dimension, for the purpose of R&D overflowing (Squicciarini, 2008), which, consequently, should result in greater innovativeness. However, studies that investigate the influence of innovation capacity on innovativeness may present some contradictory aspects of this association, as the research by Huang, Yu and Seetoo (2012). For the authors, internal R&D capacity is positively associated with innovativeness, but companies with a lower capacity for internal R&D can better benefit from the location in technology parks or spontaneous clusters, to increase their innovativeness.

Companies located in technology parks tend to establish a stronger internal R&D strategy and greater innovation intensity than counterparts outside parks (Díez-Vial & Fernández-Olmos, 2015). The authors identified that companies settled in parks spend 63.7%

of the total value of R&D in internal R&D, while companies outside parks spend 39.4%. This can be explained by the presence of research structures within technology parks that induce companies to invest in R&D and favor their success in seeking innovations (Lamperti et al., 2017).

In research with companies paired inside and outside parks, results indicate that the decision to locate in a technology park can improve the innovative performance of TBFs that collaborate and export together (Ramírez-Alesón & Fernández-Olmos, 2018). TBFs in parks are younger, have a higher percentage of revenue from new products (22.02%) than companies outside parks (16.30%); and TBFs in parks have higher R&D intensity (53.06% versus 21.22%).

The location of a company in a technology park increases the probability of being an innovative company by 10 to 20 percentage points, and increases by 32 percentage points the revenue from new products (Vásquez-Urriago et al., 2014). Based on this theoretical foundation, we propose hypothesis H4, where Innovation Capacity has a positive and higher effect on the innovation of companies in parks than in companies outside parks:

H_4: Innovation Capacity is more positively associated with Innovativeness in firms located inside technology parks than in those outside the parks;

2.5.5 Cooperation Networks in Technology Parks

Technology parks are considered favorable environments for TBFs' development, as they gather different partners at the same place, providing a cooperation network that companies would hardly find elsewhere. Thus, companies residing in technology parks will have greater proximity to customers, suppliers, researchers, institutions, and other companies, which together can provide the necessary tools for the development of these firms (Lindelöf & Löfsten, 2004).

In general, parks seem to have a positive impact on the degree of collaboration and production of science and technology, which is concentrated in highly competitive regions (Minguillo, Tijssen, & Thelwall, 2015). However, industry-academia collaboration shows that companies resident in parks tend to collaborate with partners outside their local region, and do not necessarily cooperate with local higher education institutions.

For Löfsten and Lindelöf (2005), one of the important contributions of technology parks to academia is the opportunity to create companies based on research developed by the university. Siegel et al. (2003) state that one of the reasons for the favorable environment found by TBFs in parks is due to the vicinity of specialized services, resource sharing, proximity to highly qualified universities, and opportunities for cooperation with other tenants. This network of university-associated partners, as previously discussed, is a strong characteristic of the STI mode.

Under STI cooperation, Fukugawa (2006) showed that TBFs located in technology parks are more prone to involvement in joint research with research institutes than TBFs located outside parks. Colombo and Delmastro (2002) found that TBFs located in parks and incubators have easier access to public funds and a higher number of agreements with universities than companies outside this type of environment. In addition, they identified that incubated companies have a higher, but not significant, probability of involvement in technological agreements with business partners (customers, suppliers, and other companies).

Based on this reasoning, companies that are located in technology parks are expected to have a greater relationship network, mainly with universities, laboratories, and research institutes - STI Cooperation - than companies that do not operate in this type of environment. Thus, we assume the following association between cooperation networks and technology parks:

H_5: Cooperation Networks are positively associated with the Headquarters of technology-based firms located inside a technology park;

H_{5A}: DUI Cooperation Networks are positively associated with the Headquarters of technology-based firms located inside a technology park;

H_{5B}: STI Cooperation Networks are positively associated with the Headquarters of technology-based firms located inside a technology park;

2.5.6 Innovation Capacity in Technology Parks

Studies show a higher innovation capacity in companies located in technology parks. Yang, Motohashi and Chen (2009) found that the average R&D intensity in companies settled in parks is significantly higher than analogous companies outside parks, indicating that companies located in parks are more R&D intensive. Technology parks have a remarkable role in stimulating innovation and research-related investments among their tenants, who exhibit much higher levels of patent application and R&D spending than related companies not resident in this type of environment (Lamperti et al., 2017).

Although most studies show a greater capacity for innovation in TBFs located in parks, not all of them point significant differences between the two groups of companies. In this perspective, Colombo and Delmastro (2002) found no significant difference in the participation of R&D employees in the total workforce between on-park and off-park companies. Similarly, Westhead (1997) did not show significant distinctions between R&D spending - expressed as the proportion of total sales revenue - among companies in the two groups.

The proportion of employees with high technical capacity is also one of the indicators used to measure innovation capacity, as it measures R&D input efforts. Lindelöf and Löfsten (2002) noted that, in all TBFs surveyed, there was a high level of qualified scientists and engineers, although TBFs located in parks had a higher percentage of postgraduate employees than companies outside parks. Thus, literature shows that companies inside technology parks tend to have a higher innovation capacity, because they invest more in R&D (internal and external), and have a higher proportion of scientists and engineers for these activities. Therefore, we propose the following research hypothesis:

H_6: Innovation Capacity is positively associated with the Headquarters of technology-based firms located in a technology park;

3 METHODOLOGY

This chapter presents the adopted methodology, by describing the type of research, the conceptual model of the study and its relationships, and the research hypotheses, in an aggregated way. Next, it defines the dependent and the independent variables, tying them with the theoretical references and the type of data associated with them. Subsequently, it addresses the population and interest groups, as well as the procedures for data collection and treatment. Finally, the methodology chapter presents the binary logistic regression technique and the limitations of the chosen method.

3.1 RESEARCH TYPE

This research aims to analyze the relationships between Innnovation Capacity, Cooperation Networks and Innovativeness of TBFs located inside and outside innovation environments. The study has a quantitative focus, of a descriptive and confirmatory type. According to Hair, Babin, Money and Samouel (2005), descriptive research portrays a situation where the phenomena are usually depicted through the measurement of an event or activity. To do this, descriptive research frequently uses descriptive statistics techniques.

Among the research definitions presented by Sampieri, Collado and Lucio (2006), they propose a division of research types into exploratory, descriptive, correlational, and explanatory. In practice, any study can include elements from more than one of these four types of research. The present research has a more confirmatory type, not found in the definitions of Sampieri et al. (2006) and Hair et al. (2005), since our interest was to study data behavior and the relationship between variables, and the preparation of forecasts of the phenomenon of interest - through confirmatory multivariate techniques.

Temporally, the study can be classified as cross-sectional. According to Hair et al. (2005), this type of study provides the user with an overview or a description of the administrative elements at a given point in time. Data were collected at a single occasion and summarized statistically. The research was carried out through a survey, which is a research procedure for collecting primary data from individuals.

According to Hair et al. (2005), survey data collection methods fall into two broad categories: submission of a questionnaire for the respondent to answer, and the interview. The first method includes electronic surveys, and the second, the interview method, involves direct contact with the respondent, who is interviewed face-to-face. The survey method assumes that data are collected, results tabulated and summarized, and, based on statistical and multivariate modeling techniques, analyses and conclusions are produced.

The questionnaire was designed according to the variables of interest, the conceptual model, and theoretical foundation. For data submission and collection, we used the Question Pro platform, where we hosted the research. The researcher carried out pre-tests with TBF entrepreneurs, researchers and professors in the innovation area, and R&D managers - in total the questionnaire was sent to 12 professionals. From their feedback, we made adaptations and corrections, such as changes from open-ended questions to ranges and adjustments on the scales of questions' items.

The average response time for the questionnaire was 10 minutes. According to Hair et al. (2005), e-mail surveys are popular and cheap, take a short time, and generally produce high quality data. To increase sensitivity towards the research, we informed in the Research Letter that a complimentary ticket for the ANPROTEC national event will be drawn in 2020, and a report with the main results of the study will be sent to all respondent companies. Chart 6 shows some approaches to increase the rate of return in electronic surveys, which we used in this research.

Chart 6: Suggestions for data collection procedures

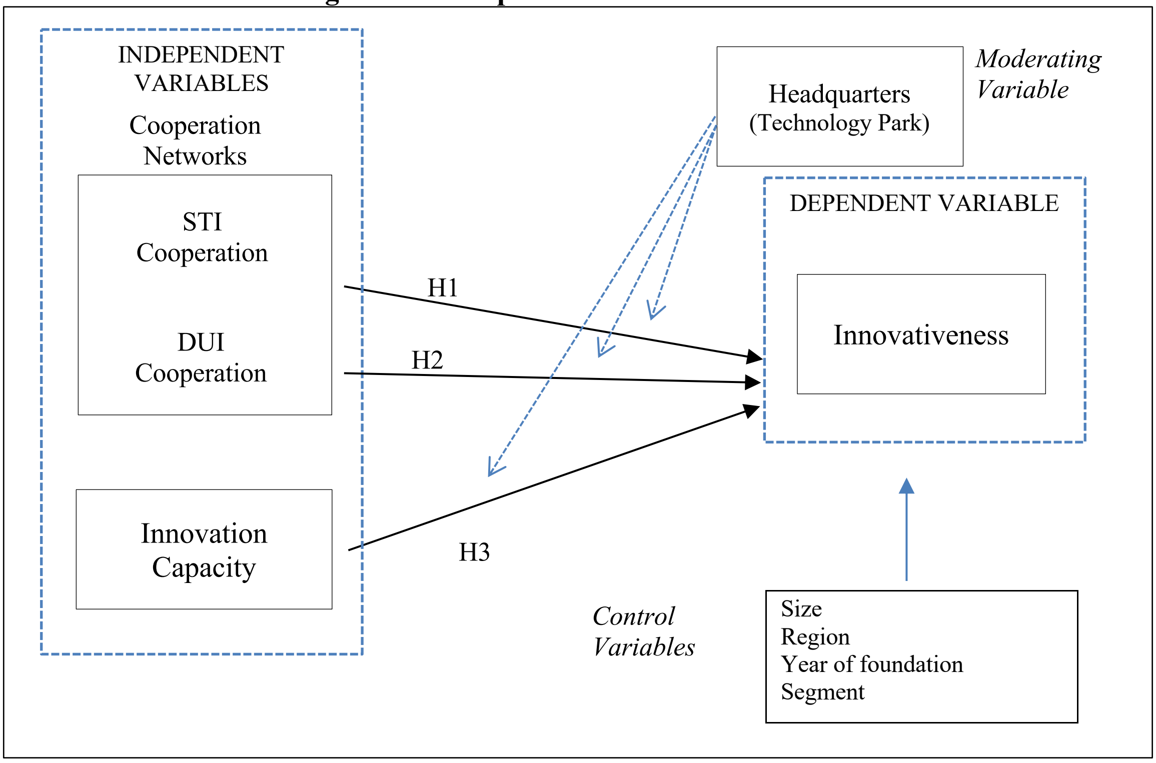
Recommendation	Description	Theoretical basis
Preliminary contact	Letter, e-mail, or telephone call in advance.	Hair et al. (2005)
Appeal	Persuasion of the survey recipient is important and has social or relevant value.	Hair et al. (2005)
Sponsors	Survey is sponsored by a relevant institution, such as a national organization or a prestigious university.	Hair et al. (2005)
Incentives	Non-monetary gifts, such as a summary of the findings or a ballpoint pen; monetary incentive like 1 dollar for a coffee.	Hair et al. (2005)
Service availability	Provide assistance to answer questions from respondents using a chat tool or e-mail.	Hair et al. 2005); V. & Guedes (2007)
Size of questionnaire	Use a pleasant format and presentation of the questionnaire. In addition, an objective and synthetic questionnaire.	Hair et al. (2005); V. & Guedes (2007)
Follow-up	If the rate of return is not satisfactory after the second week of the first submission, send the questionnaire again.	Granello & Wheaton (2004); V. & Guedes (2007)

Source: adapted by the author according to the references.

3.2 CONCEPTUAL MODEL

Based on the theoretical foundation and research hypotheses derived from literature's empirical evidence, this thesis presents the conceptual model of the research. The three major theoretical constructs are: Cooperation Networks, Innovation Capacity, and Innovativeness. Headquarters (Technology Park) is a moderating variable, which checks the effect of the park on resident companies, through two groups: the first, located outside a technology park, and the second located inside a Brazilian technology park. Figure 1 presents the Conceptual Model, showing the relationships between the constructs of this research.

Figure 1. Conceptual model of the research



Source: the author.

Cooperation Networks were separated into STI Cooperation Networks and DUI Cooperation Networks, involving cooperation with partners, such as customers, suppliers, competitors, universities, and research institutes, among others. Cooperation with partners is directly associated with companies' greater innovativeness (Tsai, 2009), so it is expected that TBFs with greater cooperation will have a better innovative performance.

Innovation Capacity, in turn, is also associated with companies' greater innovativeness. It has often been matched with companies' formal R&D activities and with innovation results through new products (Kirner et al., 2009). This linear model emphasizes technological and scientific knowledge and considers R&D efforts as an indicator of companies' technological progress (Forsman, 2011). Thus, it is expected that companies with higher levels of Innovation Capacity have greater Innovativeness.

Innovation environments stand out for the presence of companies with a high innovation capacity and for their close interaction with partners like universities and research institutes. In this research, innovation environments are identified as Brazilian technology parks in operation (ANPROTEC, 2018). The technology park is a moderating variable, to check the effect of the park on TBFs that are settled there. At this point, we resume all research hypotheses:

H_1: Cooperation Networks are positively associated with Innovativeness in technology-based firms;

H_{1A}: DUI Cooperation Networks are positively associated with Innovativeness in technology-based firms;

H_{1B}: STI Cooperation Networks are positively associated with Innovativeness in technology-based firms.

H_2: Innovation Capacity is positively associated with Innovativeness in technology-based firms;

H_3: Cooperation Networks are more positively associated with Innovativeness in firms located inside technology parks than those outside the parks;

H_{3A}: DUI Cooperation Networks are more positively associated with Innovativeness in firms located inside technology parks than those outside the parks;

H_{3B}: STI Cooperation Networks are more positively associated with Innovativeness in firms located inside technology parks than those outside the parks;

H_4: Innovation Capacity is more positively associated with Innovativeness in firms located inside technology parks than in those outside the parks;

H_5: Cooperation Networks are positively associated with the Headquarters of technology-based firms located inside a technology park;

H_{5A}: DUI Cooperation Networks are positively associated with the Headquarters of technology-based firms located inside a technology park;

H_{5B}: STI Cooperation Networks are positively associated with the Headquarters of technology-based firms located inside a technology park;

H_6: Innovation Capacity is positively associated with the Headquarters of technology-based firms located in a technology park;

3.3 RESEARCH VARIABLES

The main conceptual model of this research is based on the constructs: Cooperation Networks (DUI Cooperation and STI Cooperation) and Innovation Capacity, as independent variables; and, Innovativeness, as dependent variable or variable of interest. Headquarters is a moderating variable that checks the presence of TBFs in technology parks.

3.2.1 Dependent Variable

The dependent variable is the variable of greatest interest to the researcher, and usually is the one that is involved in the research question. The researcher's goal is to understand and describe the dependent variable, or explain its variability and, if possible, its predictability. Through the analysis of the dependent variable it is possible to find answers and solutions to the problem. To achieve this goal, the researcher is interested in quantifying and measuring the dependent variable, as well as other variables that influence this variable (Sekaran, 2000).

The defined dependent variable, Innovativeness, is measured through product innovation, as shown in Chart 7. In the questionnaire, the Innovativeness variable was measured as an ordinal categorical element. For using in the binary logistic regression (logit) of the variable Innovativeness, after data collection and treatment, the variable was divided into observations with lower Innovativeness (less than 30% of sales from new products introduced in the last three years) and observations with higher Innovativeness (more than 30% of sales from new products introduced in the last three years). Thus, we changed the ordinal categorical variable into a dummy variable, in order to adapt it to the assumptions of the logistic regression technique.

The Headquarters variable was also used as a dependent variable to test hypotheses H_5 and H_6 - the remaining hypotheses (H_1, H_2, H_3 and H_4) will be tested for the dependent variable Innovativeness, which is the main variable of interest in this thesis. The Headquarters variable is also used as a moderating variable, when the dependent variable is Innovativeness. For didactic purposes, in the chapters on Analyses and Discussion the first part of the tests will address the Innovativeness model, and the second part, the tests for the Headquarters model.

Chart 7: Dependent Variable

Construct	Variable	Definition	Groundso	Type of Data
Innovativeness	Product Innovation	Annual proportion of sales from new products over total sales, in the last three years	Adapted from Zeng et al. (2010)	*Dummy*
Technology Park	Headquarters	Firm is located in a technology park	Díez-Vial & Fernández-Olmos (2015)	*Dummy*

Source: the author.

3.2.2 Independent Variables

The independent variable is the one that affects the dependent variable, positively or negatively. When a dependent variable is present, we also have an independent variable, since we need one factor to explain the other (Sekaran, 2000). As shown in Charts 8 and 9, the independent variables are grouped into three constructs: Innovation Capacity, DUI Cooperation Networks, and STI Cooperation Networks. In terms of innovation capacity, traditionally, one of the most used input indicators is R&D spending (Díez-Vial & Fernández-Olmos, 2015).

Chart 8: Innovation Capacity Variables

Construct	Variable	Definition	Grounds	Type of Data
Innovation Capacity	External R&D	Percentage of annual gross operating revenue spent on external R&D	Gomez & Vargas (2009); Lokshin, Belderbos & Carree (2008)	Ordinal Categorical
	Internal R&D	Percentage of annual gross operating revenue spent on internal R&D	Gomez & Vargas (2009); Lokshin et al. (2008)	Ordinal Categorical

Source: the author.

The variables of the Cooperation Network are divided in two constructs, STI Cooperation and DUI Cooperation. The first is composed of variables related to research and knowledge production institutions, exclusively of a technical and scientific nature: research institutes, universities, scientific laboratories and institutions for tests, trials, and certifications.

The second is formed by variables related to different partners that make up the production chain in an immediate and cross-sectional way: venture capital organizations, business service providers, consulting companies, suppliers, and customers.

Chart 9: Cooperation Network Variables

Construct	Variable	Definition	Grounds	Type of Data
STI Cooperation	Research Institutes	Cooperation with research institutes	Fitjar & Rodríguez-Pose (2013)	Nominal category *(dummy)*
	Universities	Cooperation with universities	Fitjar & Rodríguez-Pose (2013)	Nominal category *(dummy)*
	Scientific Laboratories	Cooperation with scientific laboratories	Parrilli & Alcalde Heras (2016)	Nominal category *(dummy)*
	Institutions for tests, trials, and certifications	Cooperation with institutions for tests, trials, and certifications	PINTEC (2016)	Nominal category *(dummy)*
DUI Cooperation	Venture capital organizations	Cooperation with venture capital organization	Zeng et al. (2010)	Nominal category *(dummy)*
	Business service providers	Cooperation with business service providers	Lee et al. (2010)	Nominal category *(dummy)*
	Consulting firms	Cooperation with consulting firms	Fitjar & Rodríguez-Pose (2013)	Nominal category *(dummy)*
	Suppliers	Cooperation with suppliers	Fitjar & Rodríguez-Pose (2013)	Nominal category *(dummy)*
	Customers	Cooperation with customers	Fitjar & Rodríguez-Pose (2013)	Nominal category *(dummy)*
	Competitors	Cooperation with competitors	Parrilli & Alcalde Heras (2016)	Nominal category *(dummy)*
	Centers for professional qualification and technical assistance	Cooperation with centers for professional qualification and technical assistance	PINTEC (2016)	Nominal category *(dummy)*

Source: the author.

To form the variables of the presented constructs, we added the variables and divided by the average, as shown in the equations below. Next, we standardized them, thus shaping the construct variables used in the logistic regressions to test the research hypotheses.

$$Innovation\ Capacity = \frac{P\&Dint + P\&Dext}{2} \quad (1)$$

$$DUI\ Cooperation = \frac{concor + vet\_cap + prest\_s + consul + forn + client + cap\_pr}{7} \quad (2)$$

$$STI\ Cooperation = \frac{inst\_p + univ + labor + inst\_cert}{4} \quad (3)$$

3.2.3 Control and Moderating Variables

Control variables act as components of the main effect, and have the potential to relate to the dependent variable as much as the other factors that are on the other side of the equation (Atinc, Simmering, & Kroll, 2012). Control variables can be managed through manipulation of the experimental design, elimination or inclusion, and randomization. Usually, this variable is extraneous to the research, that is, it is not a focal variable of the study (Atinc et al., 2012). In this research, we chose the following control variables: company size, age, region, and sector. In logistic regression, the variables size, region, and sector are considered dummy, while the variable age, due to its quantitative nature, is continuous. Chart 10 illustrates the control and moderating variables, and their definition.

Chart 10: Control and Moderating Variables

Type of Variable	Variable	Definition	Grounds	Type of Data
Control Variables	Size	Number of employees	PINTEC (2016)	Ordinal categorical
	Age	Year of foundation	PINTEC (2016)	Discrete quantitative
	Region	Country state	ANPROTEC (2014)	Nominal categorical
	Sector	Sector Dummies	ANPROTEC (2014)	Nominal categorical
Moderating Variable	Headquarters (Technology Parks)	Firm is located in a technology park	Díez-Vial & Fernández-Olmos (2015)	Nominal categorical (Dummy)

Source: the author.

The moderating variable has a strong contingent effect on the relationship between independent and dependent variable. The presence of a third variable, in this case the moderating variable, changes the original relationship between the dependent and independent variables (Sekaran, 2000). Therefore, the Headquarters variable is the moderating variable of the study, because it has a strong effect on the relationship between Cooperation Networks and Innovation Capacity for Innovativeness, manipulating the effects between the independent variables and the dependent variable.

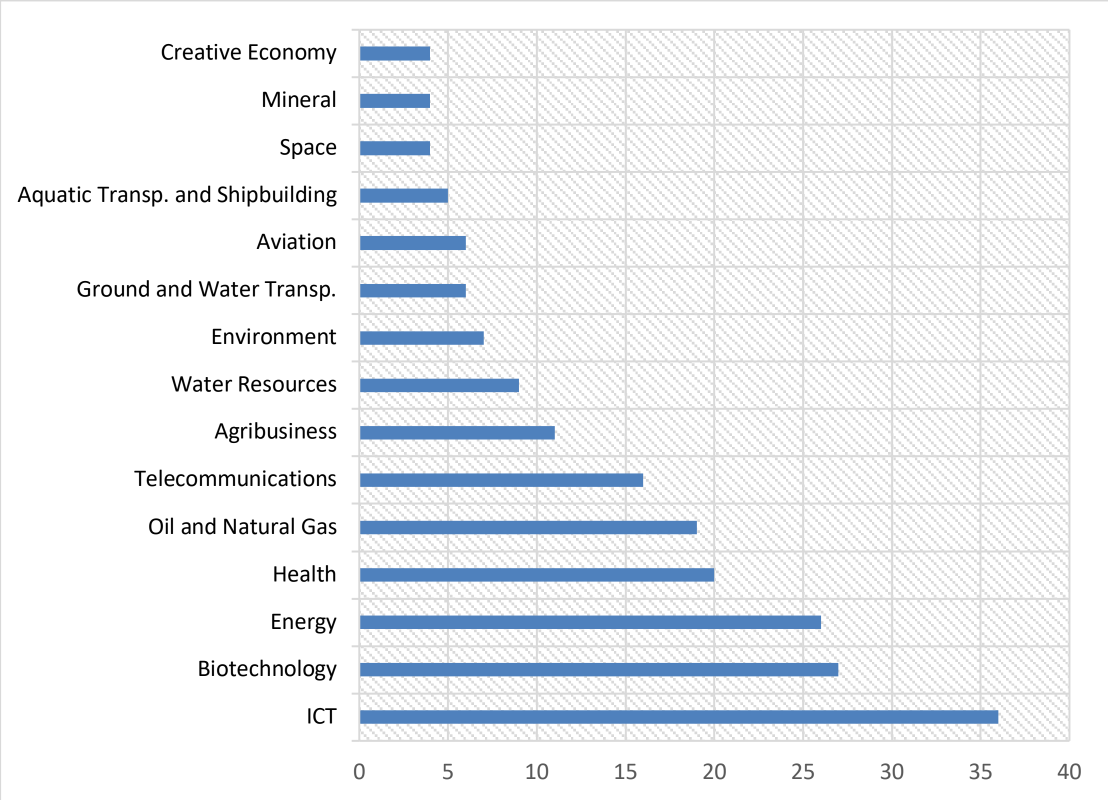
3.4 POPULATION AND SAMPLING

The population is the set of all elements of interest in a study, and the sample is a subset of the population (Anderson, Sweeney, & Williams, 2007). The sample of this research was composed of two groups of TBFs. The first group are TBFs located in technology parks, and the second group are TBFs located outside technology parks.

In the latest study on technology park indicators, released by MCTIC (2019), 43 technology parks were in operation, 23 were being implemented, and 37 were at the design stage. In this study, we also surveyed the parks' main areas of activity, which were Information and Communication Technology (ICT) (64%), followed by Energy (48%) and Biotechnology (46%). Such results are similar to the previous mapping of technology parks carried out by ANPROTEC (2014), showing a consistency of the thematic fields of these innovation environments (MCTIC, 2019). Figure 2 illustrates the operating panorama of technology parks with the main sectors identified by ANPROTEC (2014).

The first stage of data collection regarded companies located in parks – 'on-park'. To this end, the researcher contacted technology parks' management and asked for the list of companies that were settled there. In cases where the manager did not provide information on these companies, the researcher looked into the park's website and found those available. Next, he made contact with the companies' managers.

Figure 1: Parks' main areas of operation in Brazil



Source: ANPROTEC (2014).

After collecting data with companies located in technology parks, the second stage of data collection addressed TBFs located outside parks. To do this, the sample size and the representation of companies in the most significant sector - in this case ICT - was the main criterion for surveying off-park companies. The researcher asked the main business associations of the sector a list of associated companies, with the name of the manager in charge, e-mail, and telephone.

Regarding on-park companies, there are about 1,300 according to data collected in 2017 and 2018 by the MCTIC study (2019) - the latest research on technology park mapping and indicators. If incubated companies are not considered to be park-resident TBFs, this number tends to be lower. In a survey carried out with specialists and park managers, besides consulting technology park websites, we reached a conservative estimate of at least 800 TBFs located in Brazilian parks, thus excluding incubated companies that are inside parks.

For the TBF group of companies outside parks, the population is considerably higher. If we consider only the members of Assespro - Association of Information Technology Companies - the number of companies is around 2,000, in twenty Brazilian states (Assespro-SP, 2019). Therefore, only with companies affiliated to Assespro we almost achieve the double of the population of on-park companies. Based on the estimate of TBFs' population located in technology parks, we predicted a number of 180 valid answers, from 90 companies in each group.

The survey sampling was non-probabilistic, a convenience sampling, due to the difficulty of getting a complete list of companies located in parks, with the appropriate contacts and information from those in charge, in addition to the low response rate of companies' managers. In non-probabilistic sampling, the selection of elements for the sample is not necessarily made with the aim of being statistically representative of the population (Hair et al., 2005). Therefore, the probability of a member of the population be seleted is not known. Fávero and Belfiore (2017) recommend that the chosen sampling technique should have as parameter the research objectives, the acceptable error in the results, accessibility to population elements, the desired representation, the time spent, and the availability of financial and human resources.

Logistic regression is a more robust technique to use when satisfactory conditions for discriminant analysis are not met, especially in cases where the sample is small and the normality of the independent variables is not achieved (Hair et al., 2005). The objective of this research is not to make predictions, so that the sample is statistically representative of the population, but rather to test the influence of independent variables in relation to the variable of interest (Vittinghoff, Sen, & McCulloch, 2009). As for the sample size, if the study's objective is to achieve significant and interpretable marginal effects, although it is still an important consideration, it may not be such a big problem as previously thought by researchers (Bergtold, Yeager, & Featherstone, 2011).

3.5 DATA COLLECTION

Data collection was done through the Question Pro platform, between March and September 2019, divided in two phases: (1) collection in companies located in technology parks; (2) collection in companies located outside parks. The first phase started in March and lasted until mid-July. During this stage, the researcher hired a company specialized in data collection for support, regarding contact and information gathering from companies. Before contacting the firms, we prepared a list of those settled in technology parks, with name, telephone, website, and e-mail. We created this list by two channels: contact with the parks' management and access to their website, and the latter brought the best results.

At first, we sought the list of parks' management and, when possible, asked them to disclose the survey internally to resident companies. When we could not raise awareness for supporting the research, we tried to contact on-park companies through the park's website -

which in most cases has the name of the resident companies. Regarding the contact with companies, the most used procedure was the telephone, to invite them to participate in the research, followed by an e-mail with the letter and the research link, addressed to the manager in charge. After sending the first e-mail, we repeated it after a week, and if the company had still not answered, we made another phone call. At the end of the first phase, we got a total of 110 respondent companies - including incubated companies -, which was a number slightly higher than planned for on-park companies.

The second phase started in mid-July and ended in the second week of September. As the ICT sector was the most representative in the companies settled in technology parks (almost 40%[1] of the firms surveyed), we decided to choose this sector for the off-park group of firms, so that it would also be the most representative. We chose the Association of Brazilian Information Technology Companies to provide us with the list of these companies, since it is one of the national associations most active and representative of ICT firms.

Rio Grande do Sul and São Paulo were the states with highest representation in on-park firms. For this reason, the main lists of companies came from the associations (Assespro) of these two states - although we also sought lists of associates in other states, like Minas Gerais and Rio de Janeiro. In this second phase, we no longer used the services of the data collection company, and there was a change in the strategy for getting data, through the use of Linkedin[2]. The researcher made contact with firms' managers through his own profile on Linkedin, and reduced the contacts by phone and e-mail. The managers were added to this social network and invited to participate in the research. For those who agreed to take part, we sent the questionnaire link to their chat box on the social network, or sent by e-mail, when requested. When respondents - already connected to the researcher's network of contacts - did not answer the survey, there was a follow-up after one week, and a third reinforcement after another week, in case of no response. In the second week of September, we achieved a total of 120 complete responses, thus ending the data collection phase.

Adding the two groups, we collected data from 230 firms - inside and outside technology parks. Those companies not considered TBFs – did not develop products with technological content - such as marketing, communication, law or accounting firms, were excluded from the database. Those that answered the questionnaire twice, or did not complete it, were also discarded. At the end of the database treatment process, we got 211 valid responses.

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[1] Table 2 (descriptive analyses).

[2] *Linkedin Premium* - paid register to gain access to an unlimited number of profiles.

Of this amount, 88 companies are in technology parks, 18 in incubators, and 105 outside technology parks. Firms in incubators are associated with technology parks, since incubators are located inside or close to technology parks. For the purposes of this research, we preferred to exclude such incubated companies, as many of them are not mature yet, and are going through the critical phase of business survival. Therefore, the final number of observations in this survey is 193 companies.

3.6 LOGISTIC REGRESSION

This research uses binary logistic regression as a confirmatory multivariate technique. For multivariate statistical analysis, we used the STATA software, version 13. The regression techniques fall within what is known as dependency techniques, where there is an intention to estimate models (equations) that allow the researcher to study data behavior and the relationship between variables, and to make predictions on the phenomenon under study, with confidence intervals (Fávero & Belfiore, 2017). Thus, according to the authors, these are confirmatory techniques.

Logistic regression techniques are used when the phenomenon under study is qualitative and, therefore, represented by one or more dummy variables, depending on the number of possible answers (categories) of this dependent variable (Fávero & Belfiore, 2017). In this study, the variable of interest, Innovativeness, is presented in ordinal categorical form, and was transformed into a dummy, with 0 for the companies with less innovativeness and 1 for those with more innovativeness. The use of the dependent variable as a binary variable facilitates the interpretation and analysis of results, when compared to multinomial logistic regression.

The logistic regression techniques - binary and multinomial - are elaborated based on the maximum likelihood estimation. The main objective of binary logistic regression is to study the probability of occurrence of an event defined by Y that presents itself in a dichotomous qualitative form, based on the behavior of the explanatory variables (Fávero & Belfiore, 2017). Thus, one can have a vector of explanatory variables, with the respective estimated parameters:

$$Z_i = \alpha + \beta_1.X_{1i} + \beta_2.X_{2i} + ... + \beta_k.X_{ki}$$

Z is known as logit, α represents the constant, β_j (j = 1, 2, ..., k) are the estimated parameters of each explanatory variable, Xj are the explanatory variables (metrics or dummies), and the subscript i represents each sample observation. According to Fávero and Belfiore

(2017), binary logistic regression estimates the probability of occurrence of the event under study for each observation - and not the predicted values of the dependent variable. The binary logistic regression defines logit *Z* as the natural logarithm of the chance of an event occurring, so that:

$$Z_i = \ln\left(\frac{p_i}{1-p_i}\right)$$

Regarding the model's general statistical significance, as the dependent variable is qualitative, it makes no sense to discuss the percentage of its variance that is explained by the predictor variables (Fávero & Belfiore, 2017). Thus, in logistic regression models there is no R^2 adjustment coefficient, as in traditional regression models estimated by the method of ordinary least squares. Many researchers use a coefficient known as McFadden's pseudo R^2, whose expression is presented below:

$$pseudo\ R^2 = \frac{-2.LL_0 - (-2.LL_{máx})}{-2.LL_0}$$

However, its usefulness is quite limited and restricted to cases where the researcher has an interest in comparing two or more different models, given that one of the criteria for choosing the model is the measure of higher McFadden's pseudo R^2 (Fávero & Belfiore , 2017). Because the researcher used STATA, this program's outputs do not present Cox & Snell's pseudo R^2 and Nagelkerke's pseudo R^2, which are standard SPSS outputs. Fávero and Belfiore (2017) explain that, as McFadden's pseudo R^2, these two statistics (Cox & Snell's pseudo R^2 and Nagelkerke's pseudo R^2) show limitations for the analysis of the model's predictive power, and recommend the sensitivity analysis for this purpose, which we will discuss later.

Before addressing sensitivity analysis, it is important to comment on the χ^2 test, the first test for general assessment of the model's significance. The χ^2 test provides the researcher with an initial check on the existence of the model proposed, since, if all the estimated parameters β_j (j = 1, 2, ..., k) are statistically equal to zero, the changing behavior of each of the *X* variables will have absolutely no influence on the probability of occurrence of the event under study (Fávero & Belfiore, 2017). The statistics χ^2 has the following expression:

$$\chi^2 = -2.(LL_0 - 2.LL_{máx})$$

Similar to the F test, the χ^2 test assesses the joint significance of the explanatory variables, not defining which of them considered in the model is statistically significant in affecting the probability of the event's occurrence (Fávero & Belfiore, 2017). Hence, it is necessary to assess if each of the parameters of the binary logistic regression model is statistically significant. To do this, according to the authors, researchers should use Wald's *z* statistics to assess the statistical significance of each model's parameter. The nomenclature *z* refers to the fact that this statistics has a standard normal distribution. The hypotheses of Wald's *z* test for α and for each β_j (j = 1,2, ..., k) are the following:

$$H_0: \alpha = 0$$
$$H_1: \alpha \neq 0$$
$$H_0: \beta_j = 0$$
$$H_1: \beta_j \neq 0$$

Thus, the researcher's interest is to reject H_0, which states that the variable's parameters are equal to 0, and to confirm H_1, where the parameters are different from 0 and, therefore, it is possible to ensure that the variable is statistically significant (at a certain level of confidence) to increase or decrease the dependent variable of interest. Another test to be used to check the final model's well-fitting is the Homer-Lemeshow test, whose principle consists in dividing the database in 10 parts, through the deciles of the probabilities estimated by the last model created. Hence, a χ^2 test is developed to check if there are significant differences between the observed and expected frequencies in the number of observations, in each of the 10 groups.

According to Fávero and Belfiore (2017), the best performance indicator of a binary logistic regression model refers to the model's overall efficiency, which is defined based on the determination of a cutoff. The choice of the cutoff allows the model's sensitivity analysis through the measures of the model's overall efficiency, sensitivity, and specificity. The model's overall efficiency corresponds to the percentage of correct classification for a given cutoff. Sensitivity refers to the percentage of hits for a given cutoff, considering only the observations that are really events. Specificity, on the other hand, regards the percentage of hits, for an established cutoff, considering only observations that are not events. According to the authors, the most common graphs for sensitivity analysis are known as the sensitivity curve and the ROC (Receiver Operating Characteristic) curve. A model with a larger area under the ROC curve has a higher overall forecasting efficiency, combining all cutoff possibilities; therefore, its choice should be preferred, when compared to another model with a smaller area under the ROC curve.

To recap the main tests discussed in this section, according to Fávero and Belfiore (2017), we recommend that the researcher check the following tests to analyze the robustness of the tested model:

- Model with the highest value of the likelihood function logarithm or *LL* (*Log Likelihood*);
- Model with higher McFadden's pseudo R^2;
- Model with the highest level of significance by the Hosmer-Lemeshow's test (lower χ^2 statistics of this test);
- Model with the largest area under the ROC curve.

3.7 LIMITATIONS OF THE RESEARCH METHOD

Regarding the limitations of the research method, we can highlight the cross-sectional study, whose data collection and analysis refers to a single moment in time. Longitudinal studies can offer greater consistency in terms of testing theories, as they work with data for more than one period of time, enabling the collection of a more comprehensive database.

Due to the non-randomic sample - the selection of companies was made by convenience, due to the difficulties related to data collection mentioned in section 3.4 – we cannot generalize the results for all TBFs. Thus, it is not possible to statistically test the representation of the results for the whole population. Finally, data collection process also presented some limitations, mainly regarding the control of the respondents' answers. Although we have taken due care in the collection procedure, this is a phase when the researcher depends on the engagement of respondents and companies.

4 ANALYSES

This chapter is divided in two sections, Descriptive Analysis and Logistic Regression. In the first are the analyses of the companies' demographic issues - sector, country state and size - for which we used the absolute and relative frequency statistics. In the second section, we present the binary logistic regression results and analyses for the variables of interest, Innovativeness and Headquarters, together with the main tests of this multivariate technique.

4.1 DESCRIPTIVE ANALYSIS

Descriptive statistics describes and synthesizes the main attributes observed in a set of data, by using tables, graphs, and summary measures, which allows the researcher to have a better understanding of data behavior (Fávero & Belfiore, 2017). Descriptive statistics can include the study of a single variable (univariate descriptive statistics), two variables (bivariate descriptive statistics), or more (multivariate descriptive statistics). In this section, the analyses regard a single variable (univariate) or two (where the second variable is Headquarters).

Before exposing the analysis of the variables of interest to the research, it is relevant to present the respondents' profile in Table 1. It is possible to see the respondent's position (in absolute and relative frequencies). We expected employees in higher positions to have a higher quality of response, due to experience and knowledge of the company. Thus, 85% of the respondents had positions as partner, director, or coordinator - which shows a high quality of their profile.

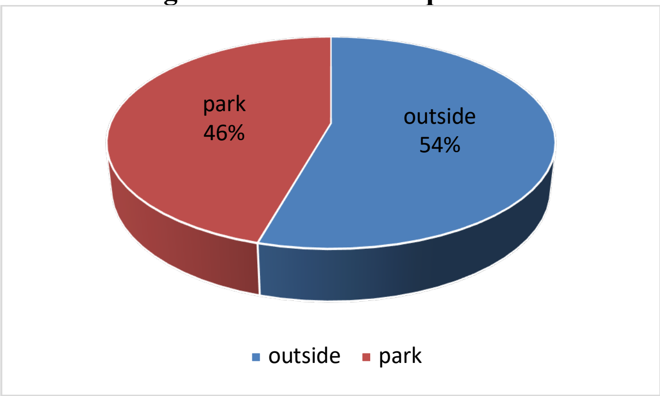
Table 1: Characterization of respondents

Characteristic	*Respondents*	
	absolute	relative
Position		
Administrative	7	3.6%
Analyst	2	1%
Researcher	3	1.5%
Coordinator	21	11%
Director	21	11%
Partner	130	67%
Other	9	5%

Source: the author.

Companies located in parks represent 46%, while companies located externally are 54% of the total companies surveyed, as shown in Figure 3. In absolute numbers, there were 88 firms in parks, and 105 outside, totaling 193 observations. Both groups are relatively balanced, with no significant disparity between the observations.

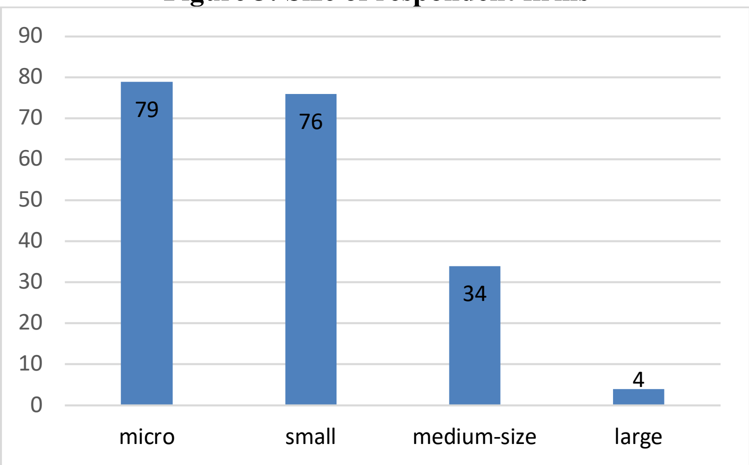
Figure 2: Firms' Headquarters



Source: the author.

Regarding firms' size, 80.3% are micro or small, 17.6% are medium-sized, and 2.07% are large. In absolute numbers, 79 are micro-firms, 76 are small, 34 are medium-sized, and 4 are large companies - as shown in Figure 4.

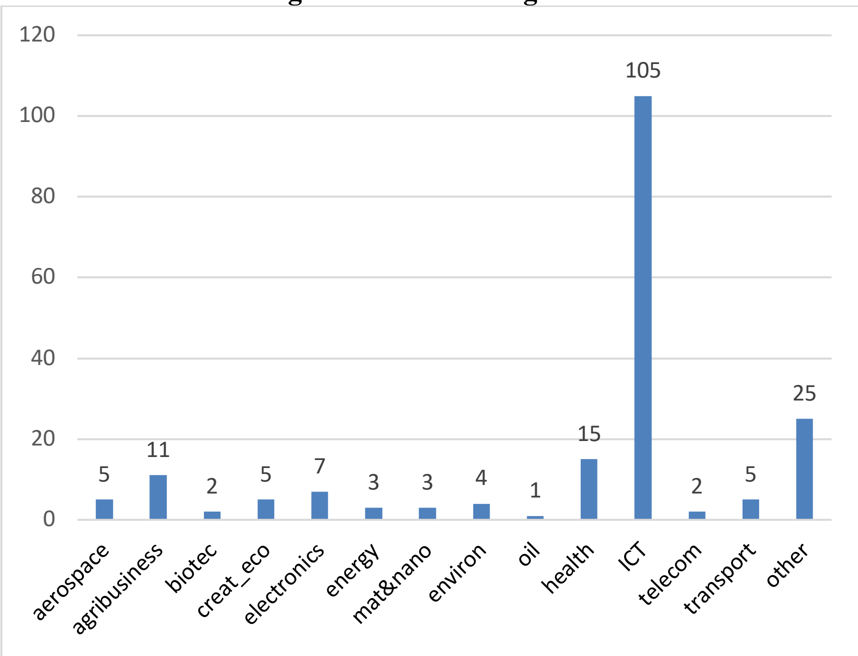
Figure 3: Size of respondent firms



Source: the author.

The predominant segment of the surveyed companies is ICT, with a relative frequency of 54.4%, followed by health, with 7.8%, agribusiness, with 5.7%, and electronics with 3.6%. It is also worth mentioning that for 12.5% of the companies, their segment was in the 'other' category. Figure 5 shows in absolute numbers the business segments of the companies surveyed.

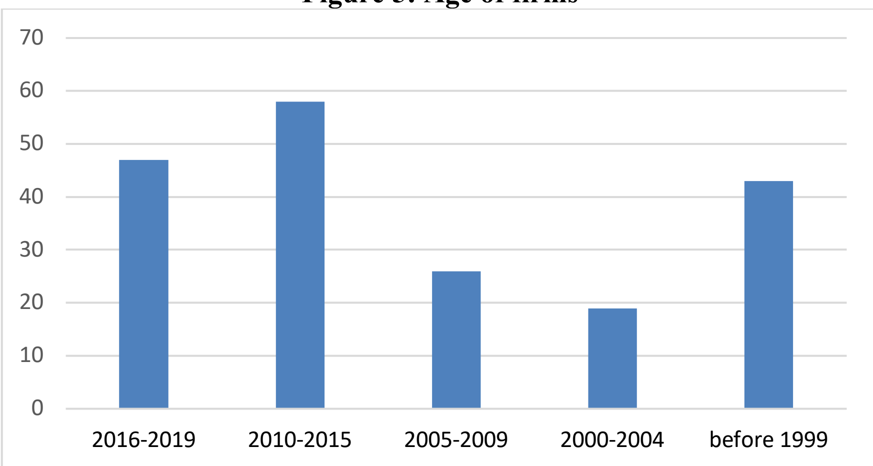
Figure 4: Business segment



Source: the author.

Firms' average age was 11.5 years old, or foundation in 2007.5. The standard deviation of their age was 9.98. In terms of relative frequency by age range, 24% of them were founded between 2016 and 2019, 30% between 2010 and 2015, 13% between 2005 and 2009, 10% between 2000 and 2004, and 22% in or before 1999 - as shown in Figure 6.

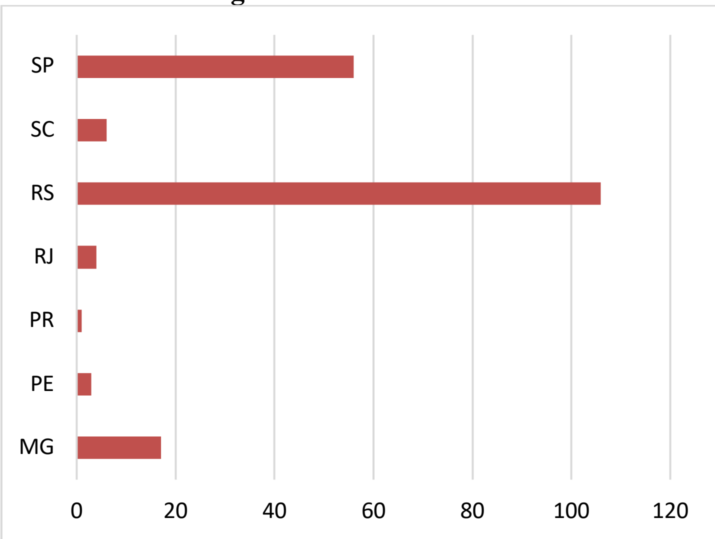
Figure 5: Age of firms



Source: the author.

Firms' location was mainly in the states of São Paulo (SP) and Rio Grande do Sul (RS): 54% were located in RS, 29% in SP, 8% in the state of Minas Gerais (MG), 3% in the state of Rio de Janeiro (RJ), and the remaining 4% in the states of Santa Catarina (SC), Paraná (PR), and Pernanbuco (PE). Figure 7 shows, in absolute numbers, the location of companies distributed by country states.

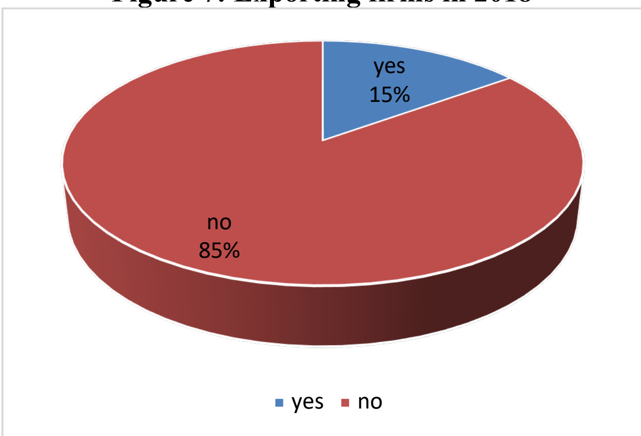
Figure 6: Firms' location



Source: the author.

Companies showed export activities in the year 2018. Only 15% of them had some export, while 85% made no sales abroad - as shown in Figure 8. Of the 26 exporting companies, the average percentage of export revenue in 2018 was 16%. This shows that the Brazilian firms surveyed are little internationalized, and their main source of revenue is the domestic market.

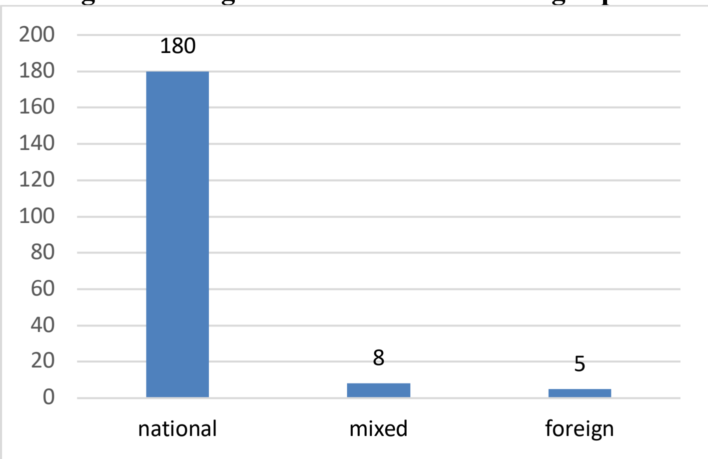
Figure 7: Exporting firms in 2018



Source: the author.

Regarding the source of the company's controlling capital, 93.2% of them have national control, while only 2.6% are foreign, and 4.1% have mixed control (national and foreign). Figure 9 shows, in absolute terms, the origin of the controlling capital. In line with the low number of exporting companies, they have little exposure to foreign capital, which indicates a low level of internationalization.

Figure 8: Origin of the firm's controlling capital



Source: the author.

After the description of the surveyed companies, it is also interesting to analyze the panorama according to the group of interest: companies in parks and outside parks, as shown in Table 2. The characteristics presented in the table are the control variables of the study (segment, size, region, and age). In terms of sector, the most representative is ICT, in both groups, and this segment is much larger (70%) in companies outside the parks. It is still worth noting that companies inside the parks have a greater representation of other segments (44%) than the outside group (22%).

Table 2: Characterization of *on-park* and *off-park* firms

Characteristic	*on-park* firms		*off-park* firms		Total	
	absolute	relative	absolute	relative	absolute	relative
Segment						
ICT	32	37%	73	70%	105	54.4%
Health	11	12%	4	4%	15	7.8%
Agribusiness	6	7%	5	5%	11	5.7%
Other segments	39	44%	23	22%	62	32.1%
Size						
Micro	55	62%	24	23%	79	40.9%
Small	25	28%	51	49%	76	39.4%
Medium-sized	7	8%	27	26%	34	17.6%
Large	1	1%	3	3%	4	2%
Region						
RS	67	76%	39	37%	106	54.9%
SP	15	17%	41	39%	56	29%
MG	1	1%	16	15%	17	8.8%
Other	5	6%	9	8%	14	7.3%
Age						
2016 to 2019	33	38%	14	13%	47	24.3%
2010 to 2015	28	32%	30	29%	58	30%
2005 to 2009	9	10%	17	16%	26	13.5%
2000 to 2004	9	10%	10	10%	19	9.8%
Before 1999	9	10%	34	32%	43	22.3%

Source: the author.

Most of the companies inside parks are micro and small (90%), while the group outside parks has a slightly smaller presence of these firms (72%). However, for medium-sized companies, TBFs located in parks are only 8%, as opposed to 26% outside parks. Regarding the location of companies in parks, 76% are in RS, 17% in SP, and only 7% in other states. For companies located outside parks, 39% are in SP, 37% in RS, and 23% in other states - showing greater diversity in terms of location.

Regarding companies' age, there are also differences between the two groups. Firms founded between 2010 and 2019 represent 70% of TBFs in parks, and 42% of TBFs outside parks; 10% of on-park companies were founded before 1999, while in firms outside parks this representation is 32%. In general, on-park companies tend to be younger and smaller. In addition, they tend to have a greater segment diversity, although the ICT sector is the most representative also in this group. We highlight that large companies have little representation in both groups, only 1 company on-park and 3 off-park.

Finally, Table 3 presents the range in percentage of scientists and engineers in on-park and off-park companies. First, this table shows if the companies studied have a high percentage of qualified human resources in their workforce - an important indicator for TBFs. By analyzing all firms, we see that most of them - 115 or 59.5% - have scientists or engineers between 1% and 20% of the total number of employees. Companies inside parks have a higher percentage of scientists (45.5% above 21% of the total staff), compared to 36.2% of companies outside parks. These results confirm that companies in parks have a higher percentage of highly qualified professionals compared to companies outside, although the differences are not so significant.

Table 3: Scientists and engineers in on-park and off-park firms

Scientists and engineers	*on-park* firms		*off-park* firms		all firms	
	absolute	*relative*	*absolute*	*relative*	*absolute*	*relative*
from 1% to 20%	48	54.5%	67	63.8%	115	59.5%
from 21% to 40%	9	10.2%	14	13.3%	23	11.9%
from 41% to 60%	7	7.9%	12	11.4%	19	9.8%
from 61% to 80%	7	7.9%	5	4.7%	12	6.2%
from 81% to 100%	17	19.3%	7	6.6%	24	12.4%
n	88	100%	105	100%	193	100%

Source: the author.

4.2 LOGISTIC REGRESSION

The logistic regression analyses are presented in four sections. In the first, the results of the variables are presented separately, that is, without adding the variables that make up the constructs (Innovation Capacity, DUI Cooperation, and STI Cooperation) in a single variable. This analysis allows us to study the variables independently, thus enabling a higher precision on the interaction between independent variables and the dependent variable. In the following section, we present the results of the logistic regression through the constructs proposed for Innovativeness, with all companies. In the third section, also through the constructs, we make the moderation with the two groups of companies (on-park and off-park) for Innovativeness. Therefore, we present the results for each of the groups, in order to compare the companies exposed to the "park effect" with the group that had no exposure to this type of environment (outside companies). And, in the fourth part, we show the results, through the proposed constructs, for the Headquarters variable.

4.2.1 Logistic Regression for Innovativeness (independent variables)

Table 4 presents the results of logistic regression for the dependent variable, Innovativeness, with all surveyed companies (n = 193). In the first column are the independent variables, control variables, the constant, and the logistic regression tests. In the other columns, to the right, are the variables' coefficients and values of the statistical tests, according to the tested model. We ran five models: the first is the complete model with all independent variables; the second presents the variables of STI and DUI Cooperation; the third, shows only the variables of STI Cooperation; model 4, only the DUI Cooperation variables; and, finally, model 5, only the variables that make up Innovation Capacity. The sequence of the tested models is the same in all tables.

Table 4: Results with independent variables for Innovativeness (all firms)

	model 1	**model 2**	**model 3**	**model 4**	**model 5**
Internal R&D	0.528***	-	-	-	0.483***
External R&D	0.208	-	-	-	0.218
Competitors	-0.938**	-0.710*	-	-0.704*	-
Venture capital	0.91*	1.155**	-	1.128**	-
Service providers	0.655	0.527	-	0.510	-
Consulting	0.705*	0.575	-	0.672*	-
Suppliers	0.544	0.719*	-	0.735**	-
Customers	0.950*	1.305***	-	1.240***	-
Qualification Centers	-0.680	-1.061**	-	-1.024**	-
Research institutes	0.386	0.463	0.494	-	-
Universities	-0.081	-0.005	0.213	-	-
Laboratories	-1.416***	-0.881*	-0.837*	-	-
Certification institutions	0.289	0.295	0.445	-	-
Region	0.237	0.270	0.3209	0.246	0.176
Age	-.0205	-0.024	-0.025	-0.026	-0.027
Other segments	0.937**	0.709*	0.544*	0.636*	0.576*
Medium-sized and large	0.630	0.576	0.729	0.602	0.950*
Constant	-3.743	-2.110	-0.363	-2.012	-1.947
n	193	193	193	193	193
Pseudo R^2	0.256	0.171	0,053	0.156	0.142
χ^2 (Chi-Square)	68.31***	45.74***	14.33*	41.59***	38.11***
LL	-99.495	-110.782	-126.485	-112.854	-114.593

Note: *p < 0.1; **p < 0.05; ***p < 0.01.
Source: the author.

We observe, initially, that models 1, 2, 4 and 5 had a Chi-Square significance test with p-value less than 1% - this means that we can reject the null hypothesis that all parameters βj (j = 1, 2 ... 17) are statistically equal to zero at 1% level of significance for these models; that is, at least one independent variable in each model is statistically significant to explain the probability of the company having a higher Innovativeness. The Chi-Square test for model 3 showed significance for p-value less than 10%.

McFadden's pseudo R^2 test was higher in model 1, which is the model of greatest interest, as it is the complete model with all variables. It is important to remind, as discussed in section 3.6 (Logistic Regression), that the usefulness of pseudo R^2 is quite limited, and restricted to cases where the researcher wants to compare two or more different models. Finally, the Log Likelihood test had the highest value for model 1, which is one of the criteria suggested by Fávero and Belfiore (2017) for choosing the model. As for the control variables, only the variable 'other segments' (except the ICT sector) showed significance at 1%, for higher Innovativeness. Thus, we can conclude that companies outside the IT segment tend to have greater innovativeness.

In the analysis of the independent variables of the complete model, through the *P*-value of Wald's *z* statistics, we observe that for Innovation Capacity, only internal R&D was significant at 1% level for companies' greater Innovativeness. Regarding DUI Cooperation, the variable 'competitors' negatively affects greater Innovativeness, at 1% level of significance - because the coefficient sign is negative. The variables 'venture capital', 'consulting', and 'customers' had a positive influence on greater Innovativeness - all with a 10% level of significance. As for the variables of STI Cooperation, only 'laboratories' showed a negative significance, at 1% level, for greater Innovativeness.

Table 5 shows the results of the logistic regression for Innovativeness, with off-park companies (n = 105). As in Table 4, the models of logistic regression are in the same sequence, starting with the complete model (with all variables) and ending with model 5, with just the Innovation Capacity variables.

Table 5: Results with independent variables for Innovativeness (off-park firms)

	model 1	model 2	model 3	model 4	model 5
Internal R&D	0.673***	-	-	-	0.526***
External R&D	1.034**	-	-	-	0.714**
Competitors	-0.028	-0.529	-	-0.327	-
Venture capital	0.479	0.775	-	0.899	-
Service providers	0.928	1.013*	-	0.876*	-
Consulting	-0.039	0.272	-	0.355	-
Suppliers	-0.806	0.045	-	0.135	-
Customers	1.881**	1.905***	-	1.749***	-
Qualification centers	-0.486	-0.929	-	-0.838	-
Research institutes	-0.208	-0.002	-0.014	-	-
Universities	1.432	1.014	1.120*	-	-
Laboratories	-3.659***	-2.032***	-1.751**	-	-
Certification institutions	0.430	0.381	0.355	-	-
Region	0.462	0.250	0.143	0.095	0.029
Age	-0.036	-0.032	-0.029	-0.027	-0.042
Other segments	1.470*	1.098*	0.910*	0.743	0.708
Medium-sized and large	0.274	0.208	0.417	0.274	0.713
Constant	-5.008	-2.123	0.009	-1.892	-2.139
n	105	105	105	105	105
Pseudo R^2	0.395	0.222	0.099	0.157	0.216
χ^2 (Chi-Square)	56.85***	31.98***	14.37*	22.52**	31.07***
LL	-43.550	-55.981	-64.790	-60.712	-56.437

Note: *p < 0.1; **p < 0.05; ***p < 0.01.
Source: the author.

In terms of model adjustment, all tested models had a Chi-Square calculated with a minimum significance level for p-value below 10%, with models 1, 2 and 5 showing a significance level with p-value lower than 1%. The Chi-Square tests of model 4 showed a significance level of 5%, and of model 3 a significance level of 10%. The highest McFadden's pseudo R^2 was for model 1 (0.395), which also had the highest Log Likelihood (-43.550). Regarding the control variables, only 'other segments' showed a level of significance for greater Innovativeness in models 1, 2 and 3, for a p-value less than 10%. The other control variables were not significant to explain the dependent variable, in any of the tested models.

Regarding the analyses of the independent variables of model 1, the two variables Internal R&D (1%) and External R&D (5%) showed positive significance for higher Innovativeness. For the DUI Cooperation Networks construct, only the variable 'customers' showed significance at 5% level. As for STI Cooperation Networks, only the variable 'laboratories' showed a negative significance, at 1% level, for greater Innovativeness. It is worth mentioning that in model 3, only with the variables of STI Cooperation, 'laboratories' showed negative significance, at 1% level, and 'universities' showed positive significance, at 1% level, for greater Innovativeness.

Finally, Table 6 presents the outputs of the logistic regression for Innovativeness with on-park companies (n = 88). First, the Chi-Square test was significant at 1% level for models 1, 2 and 3, for model 5 at 5% level, and model 3 was not significant. Thus, model 3 (STI cooperation networks) did not present any variable with significance at p-value of 10%, which is the value with the least analysis restriction for Wald's *z* statistics.

Table 6: Results with independent variables for Innovativeness (on-park firms)

	model 1	model 2	model 3	model 4	model 5
Internal R&D	0.733***	-	-	-	0.424***
External R&D	0.017	-	-	-	-0.075
Competitors	-2.325**	-1.657**	-	-1.756**	-
Venture capital	1.663	2.314*	-	2.312*	-
Service providers	0.609	0.237	-	0.064	-
Consulting	1.069	0.876	-	1.037*	-
Suppliers	1.518**	1.571**	-	1.596**	-
Customers	0.169	1.049	-	1.067	-
Qualification centers	-2.443**	-2.185**	-	-1.784**	-
Research institutes	0.708	0.736	0.631	-	-
Universities	-0.924	-0.744	-0.379	-	-
Laboratories	-0.448	0.051	-0.109	-	-
Certification institutions	0.906	0.538	0.723	-	-
Region	-0.008	-0.009	0.137	0.188	0.103
Age	-0.010	-0.045	-0.052	-0.049	-.038
Other segments	1.157*	0.851	0.733	0.952*	0.864*
Medium-sized and large	1.157	1.279	1.358	1.377	1.560*
Constant	-4.061	-2.070	-0.539	-2.224	-1.772
N	88	88	88	88	88
Pseudo R^2	0.353	0.254	0.083	0.237	0.127
χ^2 (Chi-Square)	42.88***	30.94***	10.18	28.81***	15.42**
LL	-39.351	-45.324	-55.704	-46.385	-53.081

Note: *p < 0.1; **p < 0.05; ***p < 0.01.
Source: the author.

Regarding the control variables, similarly to the results of companies in parks, only the variable ‘other segments’ was positively significant, for models 1, 4 and 5 - all at 1% significance level. Thus, we can deduce that companies that operate in segments other than ICT are more likely to have greater Innovativeness.

The ‘Internal R&D’ variable showed significance at 1% level for greater Innovativeness - both in the complete model and in model 5. The ‘external R&D’ variable did not show significance for Innovativeness - unlike the complete model for TBFs outside parks, for which external R&D was also significant, in addition to internal R&D. For the variables related to DUI Cooperation Network, there is significance for the variables ‘suppliers’, ‘competitors’, and ‘qualification centers’. The first showed positive significance at 5% level for higher Innovativeness. The other two showed negative significance for Innovativeness - competitors at 1% level, and qualification centers at 5% level.

As for the STI Cooperation Network construct, there was no significance in any of the variables, neither in model 1, nor in models 2 and 3. It is important to highlight, when comparing the results of on-park and off-park companies, that in the first case there was a positive significance for ‘universities’ - in model 3 - and negative for ‘laboratories’ - in models 1, 2, and 3. The positive significance of universities for companies outside and their lack of significance for companies inside parks was not expected by the research *a priori*, because we assumed that this cooperation would be more influential on Innovativeness in on-park companies. However, the positive significance of ‘universities’ in Innovativeness was observed only in model 3, and not in model 2, and mainly in model 1, which is the reference model of analysis, because it is the complete model.

4.2.2 Logistic Regression for Innovativeness (all firms)

Table 7 presents the results of the logit for Innovativeness with all companies (n = 193), and the independent variables tested were Innovation Capacity, DUI Cooperation, and STI Cooperation. In addition to these variables, we also kept the four control variables presented before: ‘region’, ‘age’, ‘other segments’ and ‘medium-sized and large’. The tested models were: model 1 (complete); model 2 (STI and DUI cooperation); model 3 (STI cooperation); model 4 (DUI cooperation); model 5 (IC cooperation); and model 6 (only control variables). To check the models’ robustness, we present McFadden's pseudo R^2, Chi-Square, Log Likelihood, and Hosmer-Lemeshow tests, where the null hypothesis, the expected and observed frequencies are equal. The principle of the Hosmer-Lemeshow test is to divide the database into 10 parts using the deciles of the probabilities estimated by the last model generated. The ROC area test is also presented, whose higher values reveal greater overall forecasting efficiency.

Table 7: Result of the constructs for Innovativeness (all firms)

	model 1	model 2	model 3	model 4	model 5	model 6
Innovation Capacity	0.861***	-	-	-	0.865***	-
DUI Cooperation	0.521***	0.574**	-	0.159***	-	-
STI Cooperation	-0.301	-0.125	0.140	-	-	-
Region	0.157	0.252	0.279	0.281	0.170	0.240
Age	-0.034*	-0.031	-0.028	-0.030	-0.030	-0.029
Other segments	0.735**	0.625**`	0.457	0.569*	0.566	0.512
Medium-sized and large	0.855*	0.645	0.750*	0.634	0.955	0.784*
Constant	-0.062	-.091	-0.084	-0.083	-0.062	-0.093
n	193	193	193	193	193	193
Pseudo R^2	0.167	0.075	0.034	0.073	0.138	0.031
χ^2 (Chi-Square)	44.82***	20.05**	9.09	19.56**	36.83***	8.26*
LL	-111.242	-123.623	-129.104	-123.872	-115.237	-129.521
Hosmer-Lemeshow	6.58	6.47	5.13	3.79	11.09	6.85
Prob > chi^2	0.582	0.594	0.7439	0.875	0.196	0.5526
ROC	0.764	0.685	0.627	0.686	0.741	0.615

Note: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.
Source: the author.

First, for the Chi-Square test, only model 3 did not present any significant parameter at 10% level. Model 1 and model 5 presented some significant parameter at 1% level, and models 2 and 4 at 5% level. Model 1 showed the highest McFadden pseudo R^2 (0.167) and the highest Log Likelihood (-111.242), and model 5 also presented high pseudo R^2 (0.138) and Log Likelihood (-115.237).

All models presented a Hosmer-Lemeshow test with a χ^2significance higher than 5%; therefore, it did not reject the null hypothesis that the expected and observed frequencies are equal, at the 5% significance level. For the Hosmer-Lemeshow test, it is suggested to observe the smallest χ^2 as the best criterion for assessing the test. Thus, the smallest χ^2 were for models 4, 2, and 1, with the exception of model 3 that did not pass the model's Chi-square test. Finally, the most relevant test for determining the model's robustness, the area under the ROC curve, showed the best results for model 1 (complete) and model 5 (IC).

Regarding the control variables in model 1, 'other segments' showed a positive association with greater Innovativeness at 5% level of significance. 'Medium-sized and large' also showed a positive association with Innovativeness at 10% level. And 'age' was slightly associated, negatively, with Innovativeness at 10% significance level, and the association with the dependent variable only occurred in model 1.

The reference model for testing the hypotheses is model 1 (complete), the others are used for comparison and to deepen the analyses - and check the models' robustness. Innovation Capacity positively affects a greater Innovativeness, both in model 1 (complete) and in model 5 (only Innovation Capacity), at 1% significance level. Therefore, based on model 1, hypothesis H_2 was confirmed, where Innovation Capacity is positively associated with Innovativeness in TBFs. With regard to DUI Cooperation, both in model 1 and in models 2 and 3 - all with a significance level of 1% - cooperation with traditional partners positively influences a greater Innovativeness. Hence, we can confirm H_{1A} hypothesis, where DUI Cooperation Networks are positively associated with Innovativeness in TBFs.

On the other hand, for STI Cooperation, we found that in model 1 and models 2 and 3 there was no significance regarding association with Innovativeness. Therefore, H_{1B} hypothesis was rejected, where STI Cooperation Networks are positively associated with TBFs Innovativeness. Thus, hypothesis H_1 was partially confirmed, because according to the results of the logistic regression of the reference model (model 1), hypothesis H_{1A} was confirmed and hypothesis H_{1B} was rejected.

4.2.3 Logistic Regression for Innovativeness (group pairing)

Table 8 shows the results of the binary logistic regression for Innovativeness of companies outside parks (n = 105). For the tests of hypotheses H_3 and H_4, Table 8 was paired together with Table 9, which presents the results of the logistic regression for Innovativeness in companies inside parks (n = 88). Regarding the main statistical tests for companies outside parks, the Chi-Square test showed significance for the parameters of models 1, 4, and 5. Models 1 and 5 showed significance at 1% level, and model 4 at 10% level. McFadden's greatest R^2 was in model 1 (0.233), followed by model 4 (0.214). Regarding the highest Log Likelihood, again model 1 showed the highest likelihood function (-55.202), followed by model 4 (-56.545).

For the Hosmer-Lemeshow test, all models showed a χ^2 significance higher than 5%. Besides the test significance, models 3, 5, and 1 presented the lowest values of the χ^2 test, which is one of the criteria for its robustness. We observed that model 4 presented the largest χ^2 test and a significance for the test just above 5% - which demonstrates the worst result among the models for the Hosmer-Lemeshow test. Finally, the test of the area under the ROC curve showed the highest values for model 1 (0.811) and model 5 (0.791). Regarding the control variables, none of them showed significance for Innovativeness.

Table 8: Result of the constructs for Innovativeness (off-park firms)

	model 1	model 2	model 3	model 4	model 5	model 6
Innovation Capacity	1.240***	-	-	-	1.243***	-
DUI Cooperation	0.401	0.528**	-	0.475**	-	-
STI Cooperation	-0.302	-0.136	0.084	-	-	-
Region	0.032	0.030	-0.015	0.068	0.017	-0.049
Age	-0.038	-0.027	-0.029	-0.027	-0.039	-0.029
Other segments	0.948	0.739	0.600	0.661	0.725	0.646
Medium-sized and large	0.670	0.427	0.493	0.414	0.713	0.510
Constant	0.490	0.304	0.370	0.301	0.540	0.378
n	105	105	105	105	105	105
Pseudo R^2	0.233	0.071	0.034	0.069	0.214	0.033
χ^2 (Chi-square)	33.54***	10.26	4.90	9.94*	30.86***	4.74
LL	-55.202	-66.843	-69.523	-67.002	-56.545	-69.601
Hosmer-Lemeshow	7.52	8.02	1.75	15.21	6.95	8.40
Prob > chi^2	0.482	0.431	0.987	0.055	0.542	0.395
ROC	0.811	0.6689	0.626	0.672	0.791	0.613

Note: *p < 0.1; **p < 0.05; ***p < 0.01.
Source: the author.

Innovation Capacity showed a positive significance for greater Innovativeness, both in models 1 and 5, at 1% level. DUI Cooperation Networks showed positive significance for models 2 and 4, at a 5% level, but showed no significance for model 1. STI Cooperation Networks showed no significance for Innovativeness, in any of the tested models.

The results of the binary logistic regression for Innovativeness in companies on-park (n = 88) are presented below, according to the outputs of Table 9. The largest pseudo R^2 were for models 1, 5, and 4. The Chi-Square test was significant for models 1, 4, and 5 at 5% level of significance, and for model 2 at 10% level. Regarding the likelihood function test, the highest LL was for model 1 (-52.593), followed by model 5 (-54.255), and models 2 and 4 had practically the same LL (-54.833).

As for the Hosmer-Lemeshow test, all models showed χ^2 significance above 5%. The model with the lowest χ^2value was model 3 (3.77), followed by model 6 (5.17), and model 1 (6.02). The models that presented the highest value for the area under ROC curve were model 1 (0.741), followed by models 2 and 5, both with the same ROC area (0.711). Regarding the control variables, we highlight the variable ‘other segments’ with a positive significance for Innovativeness in models 1, 5, and 6 - all at 10% significance level. The variable ‘age’ showed negative significance for Innovativeness in models 2 and 4, at 10% level, and the ‘medium-sized and large’ variable showed positive significance for Innovativeness in models 5 and 6, also at 10% level.

Table 9: Result of the constructs for Innovativeness (on-park firms)

	model 1	model 2	model 3	model 4	model 5	model 6
Innovation Capacity	0.545**	-	-	-	0.583**	-
DUI Cooperation	0.515*	0.533*	-	0.526**	-	-
STI Cooperation	-0.145	-0.011	0.253	-	-	-
Region	-0.035	0.149	0.159	0.148	-0.044	0.187
Age	-0.052	-0.060*	-0.051	-0.060*	-0.043	-0.049
Other segments	0.900*	0.829	0.758	0.826	0.884*	0.813*
Medium-sized and large	1.237	1.129	1.356	1.128	1.557*	1.528*
Constant	-0.432	-0.360	-0.397	-0.358	-0.507	-0.466
n	88	88	88	88	88	88
Pseudo R^2	0.135	0.097	0.068	0.097	0.108	0.058
χ^2 (Chi-Square)	16.40**	11.82*	8.31	11.82**	13.07**	7.09
LL	-52.593	-54.883	-56.638	-54.884	-54.255	-57.249
Hosmer-Lemeshow	6.02	9.84	3.77	9.99	9.78	5.17
Prob > chi^2	0.645	0.276	0.876	0.266	0.280	0.739
ROC	0.741	0.711	0.678	0.711	0.708	0.665

Note: *p < 0.1; **p < 0.05; ***p < 0.01.
Source: the author.

Innovation Capacity showed positive significance for greater Innovativeness in models 1 and 5, at 1% level of significance - and with a coefficient of 0.545 in model 1. DUI Cooperation Networks were significant for greater Innovativeness in models 1, 2, and 4. In model 4 the level of significance was 5%, and in models 1 and 2 was 10%. The ‘STI Cooperation Networks’ variable, on the other hand, was not significant for Innovativeness in any of the three models tested.

Innovation Capacity had a greater effect on Innovativeness in off-park companies than in on-park. In both groups, the significance was positive, with 1% significance level, but for companies outside parks the Innovation Capacity coefficient was 1.240, while for companies resident in parks it was 0.545. Such difference between the coefficients implies a greater effect of the H_4 Innovation Capacity in companies outside parks for greater Innovativeness. Therefore, hypothesis H_4 was rejected, since the Innovation Capacity is more positively associated with Innovativeness in companies outside technology parks than in companies inside parks.

DUI Cooperation was positively significant for Innovativeness in companies inside parks, at 10% level of significance. As for companies outside parks, there was no significance of DUI Cooperation for Innovativeness. Thus, we conclude that H_{3A} was partially confirmed, as there was influence of DUI Cooperation on Innovativeness in companies inside parks, but not in companies outside parks. Therefore, we can say that *DUI Cooperation Networks are positively associated with Innovativeness in companies located in technology parks*.

Finally, STI Cooperation was not significant for Innovativeness in any of the groups of companies and the models tested for each group. Thus, hypothesis H_{3B} was rejected, since there was no association between the predictive variable and the variable of interest in the research. This result indicates that STI Cooperation is not significant for Innovativeness in TBFs. This research finding will be discussed below, but one of the reasons for this result may be the long-term cooperation with STI partners, which do not have a strong intention of launching new products in the short and medium term.

4.2.4 Logistic Regression for Headquarters (Technology Park)

The next results of the binary logistic regression are for Headquarters (on-park or off-park) of the companies surveyed (n = 193), as shown in Table 10. Therefore, option "1" is the company being inside a technology park, and option "0" is when it is located outside a technology park. The highest pseudo R^2 were for models 1, 2, and 3. The Chi-Square test was significant for all models at 1% significance level. The models with the highest LL were models 1 (-98.294) and 2 (-98.299). The Hosmer-Lemeshow test also showed that all models had a χ^2 significance above 5%. The lowest values for this test were for models 1 and 2. Finally, the model with the largest area under the ROC curve was model 1 (0.823), followed by model 2 (0.822).

We observed that control variables had a strong significance in almost all models tested. This situation may have occurred due to some differences in the characteristics of the two groups (inside and outside parks), which stem from the data collection phase - as shown in the descriptive analyses. We found that most companies inside parks are located in the RS State, the ICT segment prevailed in companies outside parks, and on-park companies were younger than those similar that were outside parks.

Hence, the 'region' variable (except RS) showed a negative significance for Headquarters in Technology Park in all models, at 1% level. The 'age' of the companies also showed a negative significance for Headquarters in Technology Park, at 5% level, in all models.

The control variable ‘other segments’ showed a positive significance for Headquarters in all models, at 1% significance level. The ‘medium-sized and large’ variable was not significant for Headquarters in any of the tested models.

Table 10: Result of the constructs for Innovativeness for Headquarters (Technology Park)

	model 1	model 2	model 3	model 4	model 5	model 6
Innovation Capacity	0.017	-	-	-	-0.005	-
DUI Cooperation	-0.506**	-0.503**	-	-0.245	-	-
STI Cooperation	0.509**	0.511**	0.268	-	-	-
Region	-1.745***	-1.740***	-1.717***	-1.780***	-1.756***	-1.757***
Age	-0.053**	-0.053**	-0.055**	-0.055**	-0.055**	-0.056**
Other segments	0.957***	0.956***	1.022***	1.118***	1.115***	1.114***
Medium-sized and large	-0.231	-0.234	-0.342	-0.167	-0.251	-0.251
Constant	0.722	0.722	0.723	0.696	0.702	0.702
n	193	193	193	193	193	193
Pseudo R^2	0.261	0.261	0.238	0.236	0.228	0.228
χ^2 (Chi-Square)	69.47***	69.46***	63.36***	62.89***	60.89***	60.89***
LL	-98.294	-98.299	-101.345	-101.582	-102.580	102.580
Hosmer-Lemeshow	3.02	4.40	5.43	6.17	4.36	5.02
Prob > chi^2	0.933	0.819	0.720	0.628	0.823	0.755
ROC	0.823	0.822	0.813	0.811	0.805	0.806

Note: *p < 0.1; **p < 0.05; ***p < 0.01.
Source: the author.

The Innovation Capacity variable was not significant for Headquarters in any of the tested models (models 1 and 5). Therefore, hypothesis H_6 cannot be confirmed, since we did not find that Innovation Capacity is positively associated with Headquarters of the technology-based firm in a technology park.

DUI Cooperation was negatively significant for Headquarters in the park, in models 1 and 2, at 5% level. This means that higher levels of DUI Cooperation are associated with companies located outside technology parks. Thus, we can say that DUI Cooperation Networks are negatively associated with TBFs Headquarters located in a technology park. Therefore, hypothesis H_{5A} was rejected. The results for STI Cooperation were positively significant for Headquarters in the technology park in models 1 and 2, both at 5% significance level. Thus, using model 1 as a reference, hypothesis H_{5B} was accepted: *STI Cooperation Networks are positively associated with the Headquarters of technology-based companies located in a technology park.*

Chart 11 provides a summary of the status of the research hypotheses proposed and tested in this study. To confirm or reject the research hypotheses, as detailed in the analyses, we checked the p-value of the Wald *z* test to assess the statistical significance of each parameter in the model. It is also important to stress that the statistical significance found in the studied variables implies keeping the other variables that were included in the tested models.

Chart 11: Research hypotheses

Code	Research Hypotheses	Status
H_1	*Cooperation Networks are positively associated with Innovativeness in technology-based firms;*	partially confirmed
H_{1A}	*DUI Cooperation Networks are positively associated with Innovativeness in technology-based firms;*	confirmed, for p-value <0,01
H_{1B}	*STI Cooperation Networks are positively associated with Innovativeness in technology-based firms;*	rejected, not significant
H_2	*Innovation Capacity is positively associated with Innovativeness in technology-based firms;*	confirmed, for p-value <0,01
H_3	*Cooperation Networks are more positively associated with Innovativeness in firms located inside technology parks than those outside the parks;*	partially confirmed
H_{3A}	*DUI Cooperation Networks are more positively associated with Innovativeness in firms located inside technology parks than those outside the parks;*	partially confirmed, for p<0,1
H_{3B}	*STI Cooperation Networks are more positively associated with Innovativeness in firms located inside technology parks than those outside the parks;*	rejected
H_4	*Innovation Capacity is more positively associated with Innovativeness in firms located inside technology parks than in those outside the parks;*	rejected
H_5	*Cooperation Networks are positively associated with the Headquarters of technology-based firms located inside a technology park;*	partially confirmed
H_{5A}	*DUI Cooperation Networks are positively associated with the Headquarters of technology-based firms located inside a technology park;*	rejected
H_{5B}	*STI Cooperation Networks are positively associated with the Headquarters of technology-based firms located inside a technology park;*	confirmed, for p<0,05
H_6	*Innovation Capacity is positively associated with the Headquarters of technology-based firms located in a technology park;*	rejected, not significant

Source: the author.

5 DISCUSSION

In this chapter we discuss the empirical results of the study, based on the hypotheses and research objectives. The purpose is to debate the most relevant findings and compare them with the literature – aiming to deepen reflections on the research on TBFs and technology parks. Equally to the Analysis chapter, we discuss the results in three moments: first with the tests for Innovativeness with all companies; then, pairing the on-park and off-park groups for the variable Inovativeness; finally, with all companies for the dependent variable Headquarters.

5.1 INNOVATIVENESS FOR TBFs

The hypotheses related to the association between Cooperation Networks (DUI and STI) and Innovation Capacity for TBFs Innovativeness, with all companies surveyed, are H_1 (H_{1A} and H_{1B}) and H_2. On Innovation Capacity, we checked its positive influence on Innovativeness - confirming hypothesis H_2. Thus, we expected that the Innovation Capacity, measured by internal and external R&D, would have a positive effect on companies' innovative performance. As the company invests more in the production of new knowledge (development of new products), its innovative results will be the main output of this investment. This result is in line with much of the literature, where investment in R&D is critical for higher revenue from new products (Audretsch et al., 2014; Kirner et al., 2009; O 'Connor et al., 2007; Reichert & Zawislak, 2014).

The Innovation Capacity is the center of the development of new technologies and, therefore, where most of the company's tacit knowledge is, and has as main objective the marketing of new products. According to Forsman (2011), the accumulation of existing knowledge plays an important role in innovation results. And such results, in terms of innovation, can only be achieved by TBFs that constantly invest in R&D. For O'Connor, Roos and Vickers-Willis (2007), a low innovation capacity would lead to low innovation performance results, since it would be unlikely that companies would develop transforming assets such as systems and processes to stimulate and manage innovation.

It is also worth mentioning that TBFs allocate most of their expenditures in internal R&D, compared to external R&D. We observed that 55.9% of companies invest 5.1% or more in internal R&D activities, while only 15.03% of companies invest 5.1% or more in external R&D activities - which was already expected: a higher expenditure in internal development. In addition, internal R&D had a positive and significant effect on Innovativeness, when we tested the model (Table 4) with all independent variables (without the formation of the Innovation Capacity construct). In a study on the configuration of R&D in Innovativeness and the moderating role of R&D, Berchicci (2013) indicates that companies with more external than internal R&D activities show a decline in their innovative performance. However, the author observes that companies that rely on external R&D activities have better innovative performance, but up to a certain point. The fact that most of the companies in this study are small and medium-sized, can make external R&D more difficult, because of the small R&D structure and limited resources for this type of investment.

In terms of the DUI Cooperation Network, there was a positive effect on TBFs' Innovativeness. These findings confirm the importance of cooperation with traditional partners to increase Innovativeness, even in the case of technology companies. On the other hand, curiously, there was no significant association between STI Cooperation Networks and Innovativeness. Therefore, hypothesis H_{1A} was accepted, and hypothesis H_{1B} was rejected.

Traditionally, DUI Cooperation is the most usual for companies, and is the type of cooperation with the largest number of partners. In this study, DUI Cooperation is formed by seven partners (competitors, venture capital, service providers, consulting, suppliers, customers, and professional qualification centers), while STI Cooperation is composed of four partners (research institutes, universities, laboratories, and certification institutions). In terms of using this cooperation, we found that 82.4% of the firms have two or more DUI partners, while in STI cooperation 38.4% of companies cooperate with two or more partners. This panorama makes it clear that even for TBFs, most of the partners are in market-oriented cooperation. In this perspective, studies like Xie et al.'s (2010) found, as most frequent partners for innovation cooperation in SMEs, customers, suppliers, service providers, technology agencies, and competitors - that is, all partners related to the DUI mode.

We can also infer that cooperation with Brazilian companies through the STI mode is small, since only 61.6% of the companies cooperate with one or no partner focused on research, even in the case of TBFs - where this approach could be greater. According to Lee et al. (2010), SMEs prefer to collaborate with other companies through technological purchases, and favor collaboration with universities and research institutes instead of other companies for strategic alliances, although the number of alliances is relatively low. In fact, with the results of the analysis of DUI and STI modes, the research confirms the greater influence of DUI partners in cooperation activities - the next issue is to analyze the effect of these two modes of cooperation on innovation.

In the analysis of the effect on Innovativeness, DUI Cooperation was significant for a better innovative performance. Usually, market-oriented partners are the main institutional collaborators of traditional or non-technological companies. In the case of TBFs, literature has also mentioned these partners as decisive for innovation, and our findings also reinforce the importance of cooperation with these partners for greater Innovativeness. The results, presented in Table 7, show that a higher number of DUI partners and, consequently, a larger variety of partners oriented to the market, results in higher levels of Innovativeness. According to Chen et al. (2011), the diversity and intensity of relationships with DUI partners are positively related to Innovativeness - and the authors recommend that companies open their innovation process to seek greater innovation. Therefore, empirical results indicate that companies should seek greater cooperation in their innovation process with different actors that form the DUI Cooperation Network.

The non-influence of STI Cooperation on Innovativeness shows that greater cooperation with STI partners is not determinant for a better innovative performance. The lack of a significant effect may be due to the fact that STI partners are not as effective, and work with a long term horizon - especially in small and medium-sized technology-based firms. Among some reasons for that, there may be a slowness for partnerships with research institutions, which demand detailed project designs, not usual in cooperation with DUI partners. Even in informal cooperation, the lack of agility of STI partners can be a negative factor, given that institutions and their professionals act differently, since their objective is the production and dissemination of science. According to Du et al. (2014), science-oriented partnerships are associated with higher project revenue when freely managed, which is not the case with projects managed with this type of partner through a formal process of project management.

Based on the results, we can infer that, even in TBFs, DUI Cooperation remains the most relevant for innovation results, when compared to STI. These results are not unprecedented in the literature, since most studies indicate that vertical cooperation partners are the most relevant for innovative performance. In this perspective, it is worth mentioning Zeng et al. (2010), who identified that vertical cooperation with customers, suppliers, and other companies plays a stronger role in SME’s innovation process than horizontal cooperation with research institutions, universities, and government agencies. These results do not invalidate STI Cooperation for Innovativeness, but show that the benefits of this cooperation should be studied from a long-term perspective and also include the size and, especially, the firm’s segment.

5.2 INNOVATIVENESS FOR TBFs ON-PARK AND OFF-PARK

The effect of Innovation Capacity and Cooperation Networks (DUI and STI) on Innovativeness, with the moderation of the technology park, presented mixed results in terms of what was proposed by the research hypotheses. However, before analyzing these associations it is important to observe the intensity of the variables studied, to find out if there are significant differences between the two groups of companies (on-park and off-park).

Regarding R&D spending, 14.7% of companies residing in parks invest 5.1% or more in external R&D activities, and 56.82% invest 5.1% or more in internal R&D activities. As for off-park companies, 15.24% have an expenditure equal to or higher than 5.1% in external R&D activities, and 55.24% have expenditures equal to or greater than 5.1% in internal R&D activities. We observe that companies' expenses - with internal and external R&D - were very similar. These results are interesting, as they do not indicate that on-park TBFs are investing more in their R&D and, therefore, in their innovation capacity. Such evidence goes against studies such as Lamperti et al.'s (2017), who state that the presence of a research structure within technology parks encourages R&D investment - which in fact was not observed. Thus, we can say that the fact that a company is inside a park does not ensure that it will have higher R&D investment (internal and external).

Although common sense leads to the assumption that on-park companies will have higher investments in R&D than off-park companies, some studies show that there are divergences. Colombo and Delmastro (2002) did not identify significant differences in the participation of R&D employees in the workforce of companies located inside and outside parks. And Whesthead (1997), in turn, did not find differences between R&D expenses, measured by the proportion of total sales revenue, between on-park and off-park firms.

Resuming the association between the constructs, according to the results of Tables 8 and 9, Innovation Capacity has a greater effect on Innovativeness in companies outside parks than in those inside parks. For this reason, hypothesis H_4 was rejected, since we expected that TBFs in parks would experiment a greater effect of Innovation Capacity on higher Innovativeness. Therefore, contrary to what was assumed, companies in parks do not experience a greater effect of Innovation Capacity on greater Innovativeness. Based on the results, off-park companies use and articulate better the largest inputs of internal capacity for greater innovation outputs. This result contradicts some studies in the literature, such as that of Vásquez-Urriago et al. (2014), who comment that the location of a company in a park increases the likelihood of it being more innovative. On the other hand, Colombo and Delmastro (2002) did not find significant differences in the inputs and outputs of innovation measures for companies inside and outside innovation environments.

DUI Cooperation was significant for greater Innovativeness in companies within parks, but was not significant for companies outside parks. Thus, we considered that hypothesis H_{3A} was partially confirmed. Results demonstrate that companies residing in parks benefit from DUI partners for increasing their innovative performance, which was not seen in companies outside parks. This result shows that companies in parks do not only depend on cooperation with STI partners, but can also use traditional cooperation (DUI) to leverage their innovation - given that technology parks are often associated, incorrectly, as exclusive environments for partners linked to research, such as universities and research institutes.

When observing the DUI Cooperation in on-park and off-park companies, we noticed that companies outside parks have a relatively stronger cooperation, which varies according to the partner - as shown in Table 11. It is worth mentioning that both groups of companies have a weak cooperation with competitors (19.4% in on-park companies and 23.8% in off-park firms). Among the main differences between the two groups are cooperation with venture capital organizations (8% in on-park companies and 24.8% in off-park), consulting (45.5% in on-park companies and 56.2% in off-park), and suppliers (47.8% in on-park companies and 55.3% in off-park). Partnership with venture capital organizations was greater for firms outside parks, an evidence that is contrary to what was expected from the literature in the field. In general, results show that companies outside parks have a more intense cooperation with DUI partners, but that, as shown by the results of the logistic regression, had no significant effect for greater Innovativeness.

Table 11: DUI Partners

DUI Partners	*on-park* firms				*off-park* firms			
	do not cooperate		cooperate		do not cooperate		cooperate	
	absolute	*relative*	*absolute*	*relative*	*absolute*	*relative*	*absolute*	*relative*
competitors	71	80.6%	17	19.4%	80	76.2%	25	23.8%
venture capital	81	92%	7	8%	79	75.2%	26	24.8%
service providers	31	35.2%	57	64.8%	37	35.2%	68	64.8%
consulting	48	54.5%	40	45.5%	46	43.8%	59	56.2%
suppliers	46	52.2%	42	47.8%	47	44.7%	58	55.3%
customers	16	18.2%	72	81.8%	20	19%	85	81%
qualification centers	72	81.8%	16	18.2%	82	78%	23	22%
n	88	100%	88	100%	105	100%	105	100%

Source: the author.

STI Cooperation was not significant for Innovativeness, both in companies residing in parks and outside parks. Thus, hypothesis H_{3B} - which assumed that the effect of STI Cooperation was higher on Innovativeness in companies in parks, when compared to companies outside parks - was rejected. This is an important finding of the research, although there was no significance of the constructs. Based on this result, STI mode is not relevant for innovation in TBFs, both for on-park and off-park companies. These results also confirm the lack of association (STI and Innovativeness) with the analyses made for all companies - whose hypothesis H_{1B} was also rejected. Thus, such data allow us to reflect that cooperation with partners linked to science does not have a short and medium term effect on innovative performance, as supposed. A possible explanation for these results is that STI cooperation is more engaged in radical innovations, which have a longer development and maturity time to achieve. According to Maietta (2015), companies engage in cooperation with universities focused on projects on new areas of science and long-term vision, which can lead to radical innovations. When we measure innovation results with metrics such as number of patents, on-park companies have shown superior results than companies outside parks. Albahari et al. (2017) note that high involvement with universities in technology parks is positively related to the number of patents, but negatively associated with innovation sales by resident companies.

When we analyze the intensity of STI partners for on-park and off-park companies, as shown in Table 12, in general, companies in parks show greater cooperation. Cooperation with universities (61.4% in on-park companies and 38.1% in off-park), research institutes (46.6% in on-park companies and 27.7% in off-park), and laboratories (26.2% in on-park companies and 16.2% in off-park) stand out. The 'certification institution' partner showed a slightly greater cooperation for companies outside parks (20% off-park and 18.2% on-park). The results confirm that TBFs in parks interact more with STI partners, mainly universities and research institutes. Hence, parks seem to have a positive effect in promoting the relationship between companies and partners oriented to research. However, a wide cooperation with STI partners did not have a positive effect on innovation, as previously discussed.

Table 12: STI Partners

STI Partners	*on-park* firms				*off-park* firms			
	do not cooperate		cooperate		do not cooperate		cooperate	
	absolute	*relative*	*absolute*	*relative*	*absolute*	*relative*	*absolute*	*relative*
research institutes	47	53.4%	41	46.6%	76	72.3%	29	27.7%
universities	34	38.6%	54	61.4%	65	61.9%	40	38.1%
laboratories	65	73.8%	23	26.2%	88	83.8%	17	16.2%
certification institutions	72	81.8%	16	18.2%	84	80%	21	20%
n	88	100%	88	100%	105	100%	105	100%

Source: the author.

Based on the empirical results of on-park and off-park groups, it is important to resume the research question of this work: *in TBFs located in technology parks, do Innovation Capacity and Cooperation Networks have a greater effect on Innovativeness, when compared to TBFs outside parks?* In DUI Cooperation, there was a positive effect on Innovativeness in companies inside parks, but not for companies outside parks. In STI Cooperation, there was no significant effect on Innovativeness, in either group. Finally, we found that Innovation Capacity had a greater effect on Innovativeness in companies outside parks. Therefore, most results were contradictory, and it is not possible to say that companies operating in parks are able to articulate their resources and partners to achieve higher levels of innovation. It is still relevant to say that the STI mode - as already mentioned - was also not significant for Innovativeness in the test with all companies (on-park and off-park), since this mode of cooperation could be the great differential for on-park TBFs.

In agreement with the criticism of this thesis‘ introduction, the results of parks‘ effect were mixed - this was precisely the reason for this research opportunity. Although most articles show evidence that parks have a positive effect on cooperation and innovation of resident companies (Colombo & Delmastro, 2002; Lindelöf & Löfsten, 2004), some important and recent studies show that this debate is far from finished (Liberati, Marinucci, & Tanzi, 2016; Siegel et al., 2003; Radosevic & Myrzakhmet, 2009). Based on the evidence from this research, questions about the effectiveness of parks for Innovativeness remain open – there are contributions from a network of DUI partners for innovation, but there are gaps on STI cooperation for greater innovation.

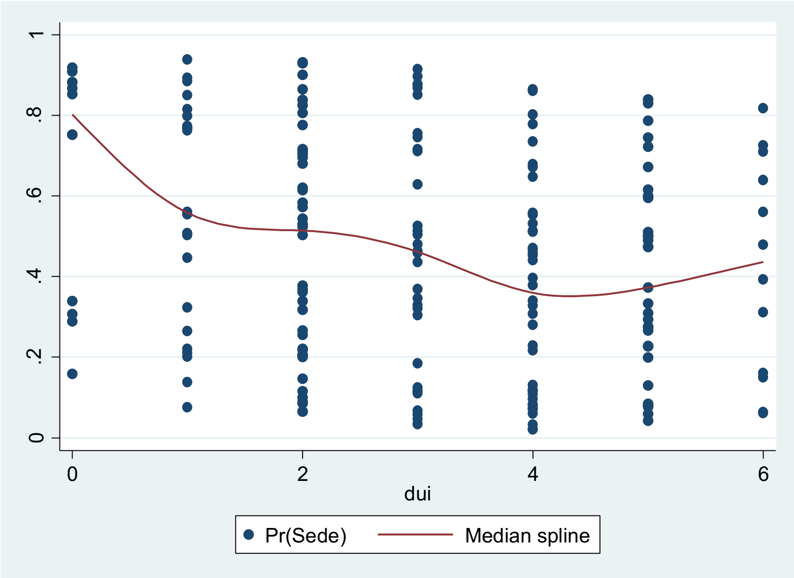
5.3 HEADQUARTERS FOR TBFs

In this final section, we discuss the effect of the levels of Cooperation Networks (DUI and STI) and Innovation Capacity on the Headquarters of the researched TBFs (inside or outside technology parks), according to the results presented in Table 10. Hypothesis H_6, which assumes that higher levels of Innovation Capacity will be positively associated with Headquarters (Technology Park) was not confirmed. Thus, it is not possible to conclude that companies with higher levels of Innovation Capacity will be associated with Headquarters inside technology parks. At the same time, it is also not possible to confirm the hypothesis to the contrary - that companies with greater innovation capacity will be associated with Headquarters location outside a technology park.

It is important to remember that differences in investment in internal and external R&D between the two groups of companies were not significant - on-park companies invested an average of 3.10 in internal R&D and 1.52 in external R&D; off-park companies invested an average of 3.12 in internal R&D and 1.53 in external R&D. Díez-Vial and Fernández-Olmo (2015) found that companies in parks tend to establish a stronger internal R&D strategy than their counterparts outside parks - which was not found in this study. Our results are interesting, since *a priori* we expected that TBFs in parks would be more engaged in R&D activities than companies outside parks. However, results must be examined carefully, since it is also not possible to prove that companies outside parks are associated with higher investments in R&D.

As for Cooperation Networks, we found that DUI Cooperation is associated with companies outside parks. Therefore, hypothesis H_{5A} was rejected, given that DUI Cooperation is not positively associated with firms' Headquarters located in a technology park. Based on this result, we can assume that companies outside parks seek greater cooperation with partners through the DUI mode, perhaps because they are companies that already have a natural market orientation and are not used to partnerships with universities and research institutes. Thus, TBFs outside parks can take a more pragmatic approach to Cooperation Networks, seeking partners that will benefit them objectively, for specific problems - not betting on long-term cooperation, for more radical innovations. Figure 10 shows the probability of occurrence of park Headquarters in relation to the number of DUI partners. The higher the number of partners, the less likely the company will be in a park. However, above five partners there is a slight increase in the probability of the company being in a park.

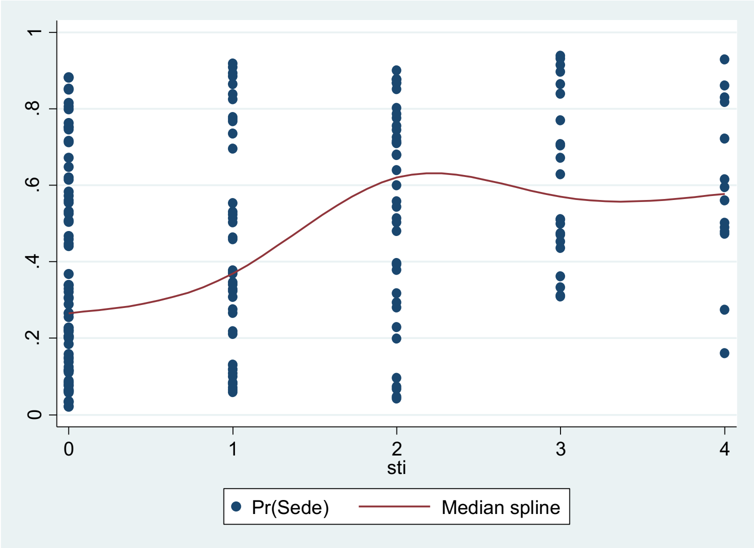
Figure 9: Probability of headquarters location *versus* DUI Cooperation



Source: the author.

Hypothesis H_{5B} was confirmed, since STI Cooperation Network is positively associated with TBFs' Headquarters located in a technology park. This result shows that the largest cooperation network with STI partners for the location of companies in a technology park is significant - demonstrating that companies in parks cooperate more with agents linked to science than similar companies outside parks. Such findings are in line with most of the literature on studies with on-park and off-park companies (Fukugawa, 2006; Lamperti et al., 2017), and confirm common sense, that companies in parks have a closer proximity to universities, research institutes, and laboratories. Figure 11 shows the graph of the probability of occurrence of park Headquarters in relation to STI partners. The growth in the number of partners increases the likelihood that the company will be in a technology park. However, when the firm has more than two partners, the probability of it being in a park reaches stabilization.

Figure 10: Probability of headquarters location *versus* STI Cooperation



Source: the author.

Fukugawa (2006) observes that TBFs located in parks are more prone to develop cooperation with partners linked to science than analogous companies outside parks. As a result, companies operating in parks tend to seek greater relationship with STI partners, while companies outside parks have greater proximity to DUI partners. Technology parks, in turn, in addition to acting as mechanisms to foster technology-based entrepreneurship, also provide greater intersection between the academic environment and companies - an interaction that, currently, has been highly demanded by a part of society.

6 CONCLUSIONS

Technology parks are heterogeneous environments, with different stages of maturity. However, the combination of certain attributes, such as proximity and interaction with STI partners, allows a definition of this environment in order to advance studies on this type of interorganizational venture. In general, most of the literature strengthens the importance of parks for companies' competitiveness, and, in particular, for innovation. However, there are outstanding studies that question the effectiveness of parks and their contribution to innovation. This work aimed to fill precisely this knowledge gap, by progressing the discussions on this type of innovation environment - with the objective of analyzing the relationships between Innovation Capacity and Cooperation Networks for the Innovativeness of Technology-Based Firms located inside and outside technology parks.

This dissertation presents as novelty the investigation of the technological park effect on TBFs Innovativeness, through the STI and DUI Cooperation approach. Some complementary contributions of the study can also be mentioned: assessment of partners that have the greatest effect on companies' innovative performance; knowledge progress on technology parks, relevant ventures for the planning and design of public policies in Science & Technology (S&T); an essential topic for job and wealth creation, which, in turn, can arouse passions, both for support and disapproval of these ventures.

For the proposed conceptual research model - where Innovation Capacity and Cooperation Networks (DUI and STI) positively influence TBFs Innovativeness - we found that both DUI Cooperation and Innovation Capacity have positive effects on Innovativeness. However, the same was not found with STI partnerships, indicating that a higher number of partners is not related (positively or negatively) to Innovativeness. Therefore, we can conclude that the conceptual model was partially validated by research results. They confirm the importance for companies to have a wide network of partners oriented to the market - such as suppliers, customers, consulting firms, venture capital companies, among others - for a better innovative performance, as well as the relevance of R&D investment to achieve superior results in terms of innovation.

On the other hand, STI Cooperation was not significant for Innovativeness. This is an important result of the research, and deserves the final comments on its implications. STI partners are focused on the production of science and qualification of human resources, and do not operate with a market logic; therefore, they do not establish their activities looking for profit. The positive side of cooperation with STI partners is the engagement in projects that involve highly specific knowledge and the development of disruptive technologies. However, the results lead the researcher to consider that this cooperation does not result in short or medium term financial returns, and it should be a long-term bet with the goal of significant gains in technological terms.

For Díez-Vial & Montoro-Sánchez (2016), companies that receive more knowledge from universities have academic spin-off links or long-term relationships with these teaching and research institutions. In this perspective of STI Cooperation, it is recommended to analyze the degree of technology complexity (degree of innovation) and the financial return from new or significantly modified products. The analysis of the product technology being developed is important, as companies may be more focused on the development of technology than on its introduction on the market - and input and output indicators often do not show the global understanding of the process innovation, despite being critical indicators.

Two other aspects that should be taken into account for cooperation with partners linked to science are the segment of activity and companies' size. Results indicate that companies operating in segments other than ICT have a greater effect on companies' Innovativeness. In the biotechnology sector, for example, traditionally, companies have a closer relationship with universities and research institutes; consequently, they are more dependent on these institutes (McMillan, Narin & Deeds, 2000). The survey results also show that medium-sized and large companies are more associated with Innovativeness - and this (the size of companies), can influence STI and DUI cooperation, and innovation. Hence, companies' size should also be considered in studies on Cooperation Networks.

With regard to the main results of Technology Park's moderation, Innovation Capacity was found to have a greater effect on Innovativeness in companies outside parks than in on-park firms. Therefore, companies outside parks articulate better their internal capabilities for a greater innovative performance - showing higher effectiveness in allocating their resources related to R&D. This is an important finding of the research, and should help companies inside parks to analyze their R&D expenditures and management, which we will further address in the practical implications of the study.

Comparing the two groups for Cooperation Networks, there was no significance in both groups regarding the association between STI partners and Innovativeness. Thus, as observed in the tests with all companies, where there was no significance between these constructs, the same was observed when the groups were paired by companies' location. Such results show that the park effect needs to be further studied when the variables involve cooperation networks and innovative performance of companies. Ramírez-Alesón and Fernández-Olmos (2018) mention that the benefits of a technology park depend not only on the access to scientific knowledge through proximity to laboratories and research centers, but also on the technological resources and strategies established at each TBF.

On the other hand, DUI Cooperation was significant for greater innovation in on-park TBFs, while in off-park TBFs this association was not significant. These results confirm the hypothesis that companies in parks with a larger network of DUI partners have greater Innovativeness. Therefore, they show that parks are not an exclusive environment for fostering partnerships linked to science. In this sense, one recommendation for future studies is to investigate the location of cooperation partners (DUI or STI) in companies inside parks, since many of their partners may be located outside the park or in the surrounding area - making the discussion about the direct and indirect effects of the parks even more complex.

Regarding the preferred cooperation mode for greater innovation, the results of the research indicate that DUI Cooperation tends to be more effective for companies to achieve a higher percentage of revenue from new or improved products. These results are in line with the evidence about cooperation with partners linked to the market being more decisive for companies' innovation. Xie et al. (2010) argue that vertical cooperation networks with customers and suppliers have a greater influence on the innovation process in small and medium-sized companies than horizontal cooperation with research institutions and universities.

Regarding the association between Innovation Capacity and firms' Headquarters, there was no statistical significance. However, for Cooperation Networks, there was significance in their association with companies' Headquarters. For this relationship, we found that a larger network of STI partners is associated with companies' Headquarters in the technology park, while companies with a larger network of DUI partners are associated with Headquarters outside a park - the latter is opposite to what was assumed. These results confirm the theory that technology parks promote interaction between companies and universities. However, the results indicate that companies outside parks tend to have a larger cooperation network oriented to DUI partners. Based on these results, we can conclude that greater cooperation oriented to the STI mode can lead to less intense cooperation with DUI partners. Conversely, a greater relationship with DUI partners and, therefore, weaker with STI partners can also occur - in this case, with companies outside parks. Although more evidence is needed in this regard, companies with greater cooperation intensity with STI partners may have a greater focus on the development of the technology itself, while companies with greater DUI cooperation already have a greater orientation towards development and technological solutions for the market.

Based on the results and analyses of this research, but also throughout the process of building this study, it is timely to bring some practical implications and recommendations to those mainly interested in the topic: managers and shareholders of technology parks, TBFs, and science and technology policy makers. Technology parks have been the object of public policies in many countries that seek to increase products' added value, create jobs and, consequently, increase income. In addition, parks are recognized as innovation environments that expand synergies with teaching and research institutions, fostering technology entrepreneurship. For technology park managers, we make the following recommendations:

- Approximate the relationship among companies in the park, by bringing firms that operate in the same chain, as suppliers and customers, to the park environment;
- Foster cooperation between companies and universities, including a unit or a research and teaching institution within the park;
- Bring to the park environment venture capital companies, so that TBFs can have access to this important resource for their growth;
- Have a strategic guideline for the main operating sectors of the park, and a long-term planning;
- Facilitate and foster access to qualified human resources to all players in the park.

Despite different experiences, with distinct operating models, parks can and should foster cooperation with STI partners, especially universities and research institutes. It is highly recommended that parks have research and teaching institutions within their area of operation, to directly or indirectly promote resident companies' R&D. Otherwise, the park will be more similar to a business center than to a technology park – a not uncommon situation for many parks. We also make some considerations for companies that are inside parks, or may be interested in this type of venture:

- R&D investment is critical to increase firms' Innovativeness;
- Market-oriented partners (vertical cooperation) are important for the development and lauching of new products; therefore, for firm's innovation;
- Science-oriented partners are relevant for radical innovations, and these must be carried out through long-term partnerships;
- Seek partnerships with *venture capital* companies, especially for small and medium-sized firms that need investment to expand their service production;

- Customers and suppliers should be the main partners for product incremental innovations. Hence, firms should work closely with these partners in product development;
- Hiring qualified human resources (engineers and scientists) increases the firm's innovation capacity for developing products with greater technological innovation.

Partnerships with research institutions must be seen as long-term projects, aiming at a strong technological gain. To this end, companies must have a product portfolio that guarantees financial stability, since cooperation with STI partners is unlikely to bring returns in the short and medium term. However, if this cooperation is successful, the company will have a great potential for financial reward, as this product will have greater added value. Given that technology parks are environments that foster technological innovation, some recommendations are pertinent to government policy makers, within the scope of parks, and more broadly of S&T:

a. Investment in training qualified human resources is the basis for the development of high complexity R&D in technology-based firms;
b. Increasing the number of scientists, masters, and PhDs in companies' R&D activities;
c. To secure resources to teaching and research institutions and laboratories, for developing projects with firms;
d. To design incentive policies for locating teaching and research institutions in technology parks;
e. Policies to support R&D development in small and medium-sized enterprises;
f. Policies to support venture capital investment in small and medium-sized companies;
g. Policies to support the internationalization of technology parks and incubators;
h. Cooperation policies between technology parks and incubators, in order to connect and align these two environments for the common goal of fostering technological innovation.

Public policies are fundamental for structuring planning that allows the implementation and development of technology parks, within the context of building and constant improvement of innovation ecosystems. Considering that parks are not isolated ventures, they should be thought and planned within the context of S&T policies, by directing resources and defining priorities to raise the qualification of human capital and add more value to products and services offered by companies. Finally, it is important to highlight that S&T policies should be in line with the main environmental issues, for a sustainable socio-economic development in the long term.

For future studies, we suggest to research the location of the cooperation of STI and DUI partners in companies inside technology parks. Another important aspect to take into account in studies with on-park and off-park firms is the type of technology park where the companies are located (pure science park or technology park, for example). We also recommend to investigate, in addition to the size of the companies' cooperation network, the intensity of that cooperation. And, in particular, the depth of the relationship between companies and research and teaching institutions, in order to identify the degree of complexity of the products under development and, consequently, the nature of the innovation.

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ANNEXES

ANNEX A– RESEARCH LETTER

Research FEA/USP on Cooperation Networks in Technology-based Firms

Dear Sir/Madam,

It is with great satisfaction that we invite you to participate in the research "Cooperation Networks for Innovation", which is being carried out for a doctoral thesis at the School of Economics and Administration of the University of São Paulo (FEA-USP). The objective of the study is to evaluate the cooperation of partners for companies' innovation.

The information obtained through this questionnaire will be used only for academic purposes, and research data will be analyzed in an aggregated form and with feedback to the participating companies. The average response time for this questionnaire is 10 minutes.

A complimentary ticket to Anprotec's national event (National Association of Entities for the Promotion of Innovative Ventures) will be drawn among the responding companies. The event will take place in Gramado/RS, from September 21 to 24, 2020

We kindly ask you that questions be answered by the firm manager (or someone indicated by him/her).

We thank you in advance for your collaboration, and make ourselves available.

Respectfully yours,

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ANNEX B - QUESTIONNAIRE

PART 1 – FIRM PROFILE

1. Company name: ____

2. Location (Country State): (Select)

3. Year of foundation: _______

4. Origin of the firm's controlling capital:
( ) National
( ) Foreign
( ) National and foreign (Mixed)

5. Firm's main sector of operation:
( ) Aerospace
( ) Agribusiness
( ) Biotechnology
( ) Creative Economy
( ) Electro-electronics
( ) Energy
( ) Materials and Nanotechnology
( ) Environment and Climate
( ) Mineral
( ) Oil and Natural Gas
( ) Water resources
( ) Health and Life Sciences
( ) Information and Communication Technology (ICT)
( ) Telecommunications
( ) Ground and Aquatic Transportation
( ) Other: _________________

6. Choose the option that caracterizes your company's size:
( ) Micro (0-9 employees)
( ) Small (10 to 49 employees)
( ) Medium-sized (50 to 499 employees)
( ) Large (more than 500 employees)

7. The firm made exports in 2018?:
( ) Yes
( ) No – *Skip to question 9*

8. In affirmative case, what was the percentage of sales with exports in relation to total sales, in 2018? _______ (proportion in %)

9. What is the percentage (%) of employees with Master and PhD degrees in relation to the total number of employees?
employees with Master degree ____%
employees with PhD degree ____%

10. Firm headquarters is located in:
( ) technology park
( ) incubator
( ) outside a technology park or incubator – *Skip to question 12.1*

10.1 How long (in years) has the firm been located in a technolgy park or incubator: _______ (number)

PART II – INNOVATION CAPACITY

* *Internal Research & Development (R&D)* comprises the work undertaken systematically, with the objective of increasing knowledge collection and the use of this knowledge to develop new or substantially improved products or processes. The design, building, and testing of prototypes and pilot facilities are often the most important phase of R&D activities. It also includes software development, provided it involves technological or scientific progress.

11.1 Percentage of anual gross operating revenue spent with Internal R&D in 2016:
( ) less than 0.1%
( ) between 0.1% and 5%
( ) between 5.1% and 10%
( ) between 10.1% and 15%
( ) more than 15.1%

11.2 Percentage of anual gross operating revenue spent with Internal R&D in 2017:
( ) less than 0.1%
( ) between 0.1% and 5%
( ) between 5.1% and 10%
( ) between 10.1% and 15%
( ) more than 15.1%

11.3 Percentage of anual gross operating revenue spent with Internal R&D in 2018:
( ) less than 0.1%
( ) between 0.1% and 5%
( ) between 5.1% and 10%
( ) between 10.1% and 15%
( ) more than 15.1%

12. Percentage of qualified scientists and engineers working in R&D activities in 2018, in relation to the total number of employees:
( ) between 0.1% and 20%
( ) between 21% and 40%
( ) between 41% and 60%
( ) between 61% and 80%
( ) between 81% and 100%

* External R&D are the activities (described above) made by another organization (companies or technogy institutions) and acquired by the firm.

13.1 Percentage of anual gross operating revenue spent with External R&D in 2016:
( ) less than 0.1%
( ) between 0.1% and 5%

( ) between 5.1% and 10%
( ) between 10.1% and 15%
( ) more than 15.1%

13.2 Percentage of anual gross operating revenue spent with External R&D in 2017:
( ) less than 0.1%
( ) between 0.1% and 5%
( ) between 5.1% and 10%
( ) between 10.1% and 15%
( ) more than 15.1%

13.3 Percentage of anual gross operating revenue spent with External R&D in 2018:
( ) less than 0.1%
( ) between 0.1% and 5%
( ) between 5.1% and 10%
( ) between 10.1% and 15%
( ) more than 15.1%

14. Estimated spending (R$) in Total R&D (internal and external) in 2018:
____________ (number)

PART III – COOPERATION NETWORKS

* Cooperation for innovation means active participation in joint R&D projects and other innovation projects with another organization (company or institution). This does not necessarily imply that the parties involved achieve immediate commercial benefits. Simply hiring services from another organization, without its active collaboration, is not considered cooperation.

In case of cooperation, choose 1, and in case of no cooperation, choose 0.

15.1 In the last three years, the firm has developed or is developing some project/activity in cooperation with the following agents:
( ) Research Institute
( ) University
( ) Scientific laboratories
( ) Competitors
( ) Venture capital organizations
( ) Business service providers
( ) Consulting firms
( ) Suppliers
( ) Customers
( ) Centers for professional qualification and technical assistance
( ) Institutions for tests, trials, and certifications

PART VI – INNOVATIVENESS

**New products are unprecedented or improved products launched by the firm.*

16. Proportion of sales in 2018 from new products introduced in the market in the last three years (2016-2018)
( ) between 0.1% and 15%
( ) between 16% and 30%
( ) between 31% and 50%
( ) over 51%

17. Number of patents filed and/or registered by the firm in the last three years: _______

18. What was the anual gross revenue in 2018? :
( ) up to R$ 360 thousand
( ) between R$ 361 thousand and R$ 1.2 million
( ) between R$ 1.3 million and R$ 4.8 million
( ) between R$ 4.9 million and R$ 16 million
( ) above R$ 17 million

19. What was the growth percentage of gross revenue between 2015 and 2018? :
( ) less than 0.9%
( ) between 1% and 20%
( ) between 21% and 40%
( ) between 41% and 60%
( ) more than 61%

20. Number of new or significantly improved products launched by the firm in the last three years (2016-2018):
(.) none ---- *Skip to question 21*
(.) one
(.) two
(.) three
(.) four or more

20.1 In affirmative case, new or significantly improved products can be classified as:
( ) new to the market
( ) new to the firm

PART IV – RESPONDENT PROFILE

21. What is your position in the company?

( ) Administrative
( ) Analyst
( ) Developer/Researcher
( ) Supervisor/Coordinator
( ) Owner partner
( ) Director
( ) Other position

22. Complete name: ____________________________________

23. E-mail: ________________________________

ANNEX C –SENSIBILITY AND ROC CHARTS

BASE 193

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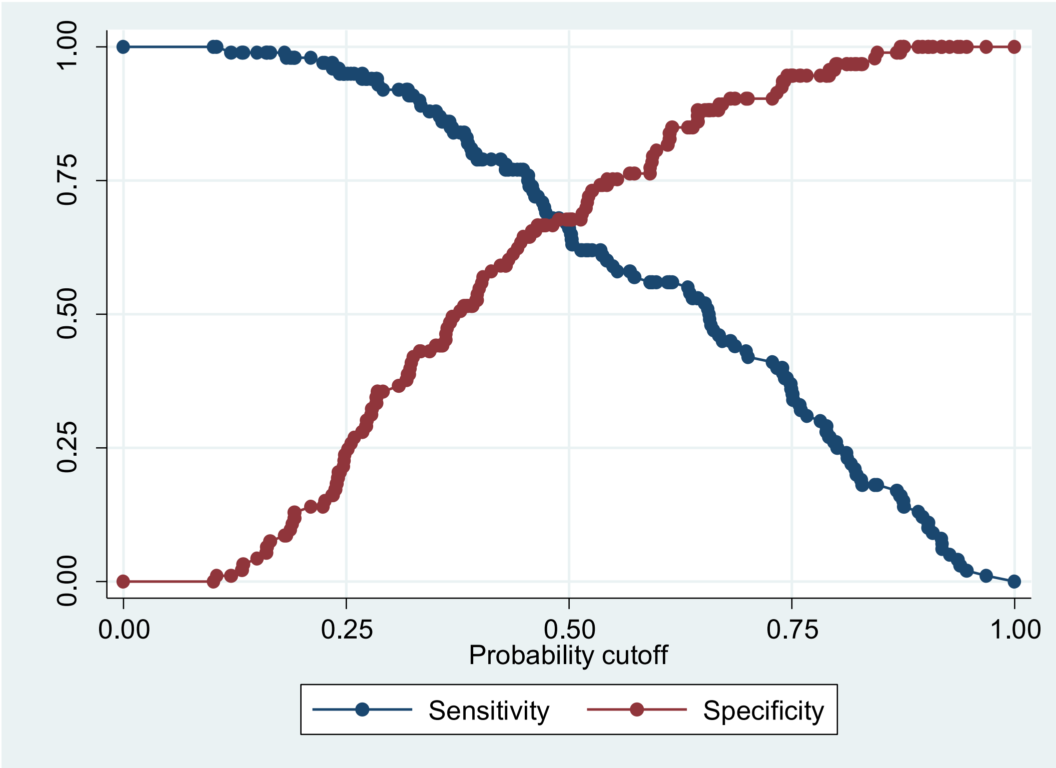

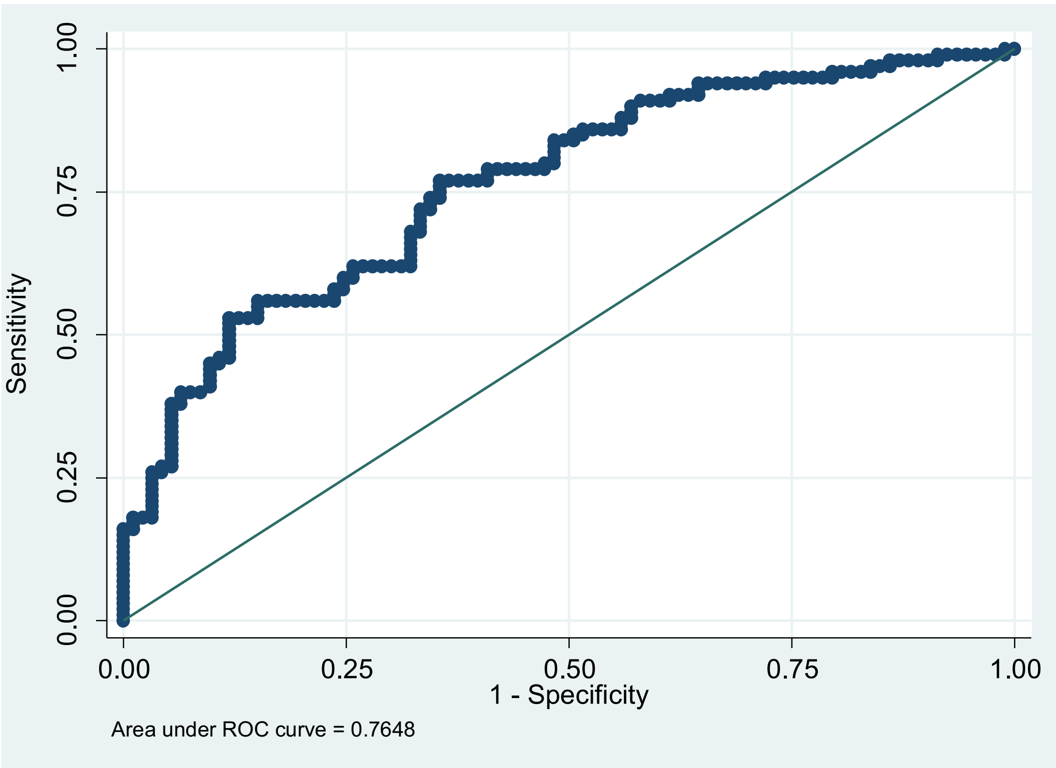

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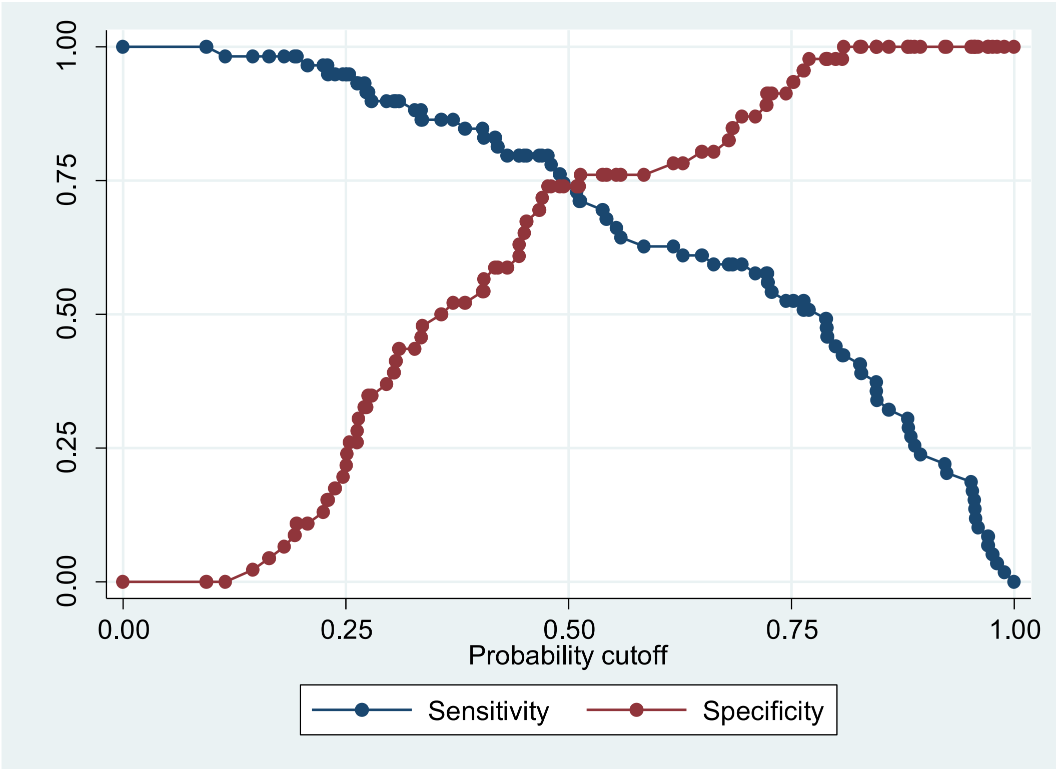
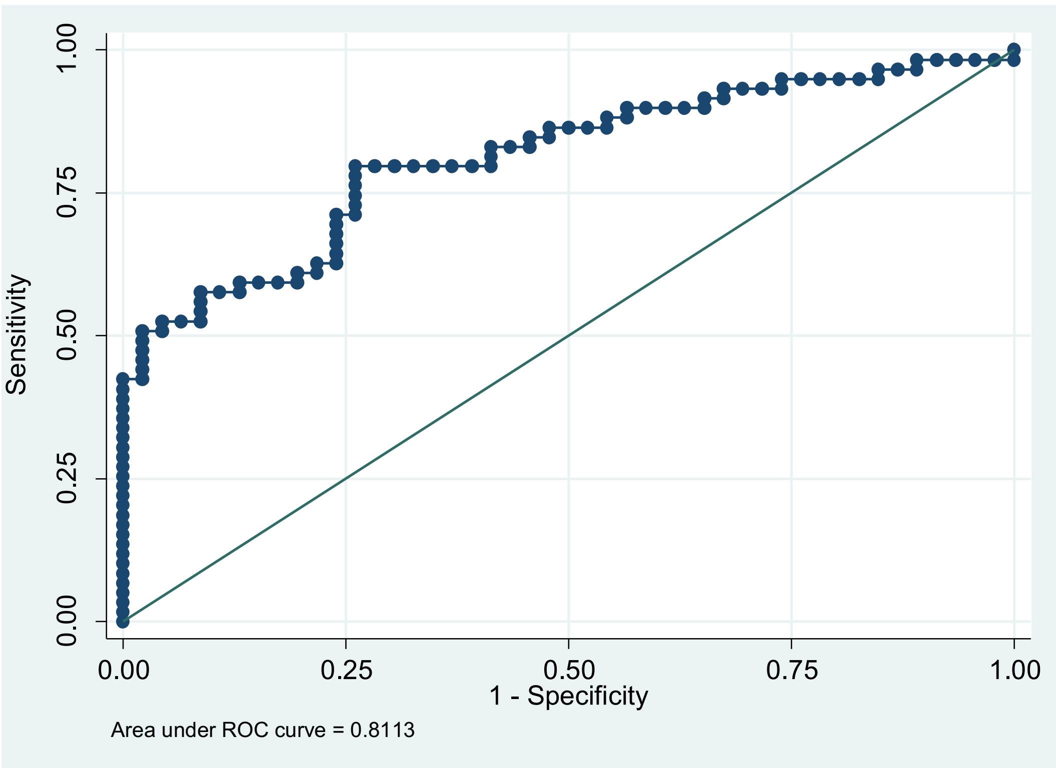
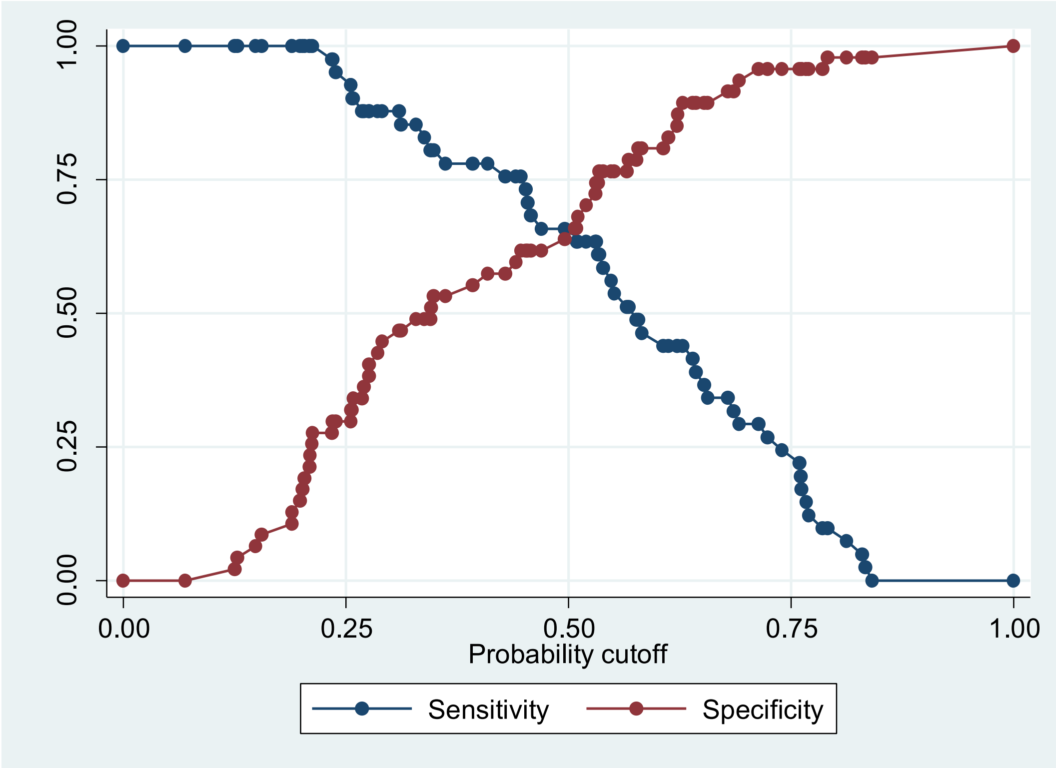
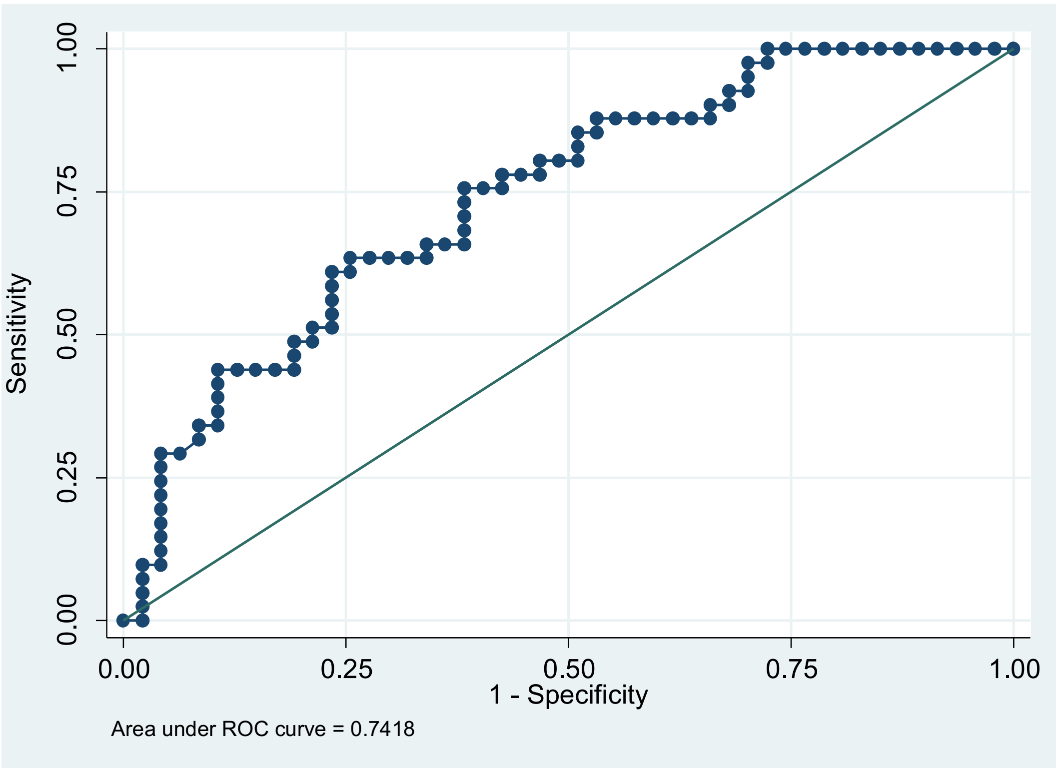




BASE 88

. logit Nov Z_STI Z_DUI Z_IC regiao idade seg_at porte





BASE 193

logit Sede Z_STI Z_DUI Z_IC regiao idade Seg_at Porte