# Brazilian Incubators and Science Parks' Resources and R&D Collaboration

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**Abstract:** One initiative largely stimulated through public policy to strengthen firms' innovation capacity is the creation and consolidation of Incubators and Science & Technology Parks (ISTPs). These habitats aim to foster innovation through, among other methods, the promotion of resource complementarity and action interdependence. Empirical studies, however, have not been conclusive about this. This article analyse the relations between resources provided by ISTPs and the elements of collaborative R&D. We conducted a survey with Brazilian ISTPs and analysed the results using a quantitative multilevel approach. Our study suggests that these innovative environments do affect collaborative R&D, but not by through the services and infrastructure they provide. We indicate possible alternatives to support future studies that analyse ISTPs in emerging countries.

**Keywords**: innovation; cooperation; innovation environments; tenant firms.

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## Introduction

Incubators and science & technology parks (ISTPs) are important institutional mechanisms that stimulate regional development, since they seek to sustain innovation ecosystems. These innovation environments mostly host small and medium-sized firms, which individually face many difficulties with keeping up-to-date and with developing and bringing innovations to market. In such cases, collaboration is a fundamental strategy for developing new products and services, characterizing the network as the locus of innovation (Nooteboom, 2008). Therefore, in order to promote innovation and regional development, ISTPs should direct their efforts not only to strengthen individual firms, but also to develop the networks to which these firms belong. The incubators in Chile, for example, emphasize the network when developing their tenants (Chandra & Medrano Silva, 2012).

Although there has been a growth in interest in collaboration and innovation in these *milieus* among government, academics and practitioners, the results of research remain ambiguous. Some studies indicate that ISTPs strengthen inter-organizational relations (Chan *et al.*, 2010; Phillimore, 1999; Tan, 2006; Vedovello, 1997) and innovation (Lindelöf & Löfsten, 2003; Tan, 2006). In Brazil, for instance, Lahorgue (2004) and Etzkowitz *et al.* (2005) indicated that incubators have been producing encouraging results in terms of generating employment and income for the population. Other studies, however, have not found empirical evidence that these environments positively influence inter-organizational relations (Bakouros *et al.*, 2002; Kihlgren, 2003; Lindelöf & Löfsten, 2003; Malairaja & Zawdie, 2008; Radosevic & Myrzakhmet, 2009; Vedovello, 1997) or innovation (Chan *et al.*, 2010; Massey *et al.*, 1992; Radosevic & Myrzakhmet, 2009; Westhead, 1997). Also, the adoption of models for these innovation environments is both criticized (Castells & Hall, 1994) and considered a practicable possibility (Etzkowitz & Leydesdorff, 2000).

With the exception of a small number of studies, the majority of quantitative analyses have compared firms inside these environments against firms from outside, assuming homogeneity of services and infrastructure and relatively context-independent sample characteristics. Qualitative studies, on the other hand, provide weak generalizability that is necessary for a comprehensive theoretical support. In addition, many studies focus on technologically developed countries, subjected to different institutional factors from developing countries.

Given the importance of ISTP development and the opportunities for contribution identified in the literature, our research objective is to investigate how do ISTP's environments affect R&D collaboration between their tenants. We conducted a multilevel analysis among Brazilian ISTPs, a developing country that has partially adopted ISTP conceptions and management models from other nations. Adopting two levels of analysis, we use a quantitative approach to observe three different types of relationships. Our intention is to contribute to the increasing understanding of the complex phenomenon of R&D collaboration within ISTPs by providing a basis for the conceptualization of its elements and antecedents. We expect that the results of this study can help policymakers and ISTP managers to understand the role of these habitats as active facilitators of innovation, thereby bringing complementary elements to their strategy formulation.

The present work is organized as follows: in the next section, we explain the design and research method. The, each of the constructs are detailed. We discuss ISTP resources, collaborative R&D and the elements that comprise it. In the following section, we describe the data collection process. The results are presented next and are followed by a discussion of the implications of this study for theory and practice. Our concluding remarks are presented in the final section, also describing this study's limitations.

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## Design and Method

Our study is designed with two level of analysis. First, in the lower level, we analyse the relationship between ISTPs resources and the elements of R&D collaboration. Conceptually, we understand resources (Barney, 1991) as services and infrastructure to which ISTP tenants have access. In this analysis, we use Partial Least Squares (PLS) to test eleven exploratory propositions developed in the section about the elements of collaborative R&D. Second, in the upper level of analysis, we used Analysis of Variance (ANOVA) to test whether there are differences between ISTPs relative to the elements of collaborative R&D. Finally, in this same level of analysis, variances in ISTP resources are contrasted with the participation of tenants in collaborative R&D projects, also using ANOVA. Our method is represented in Figure 1.

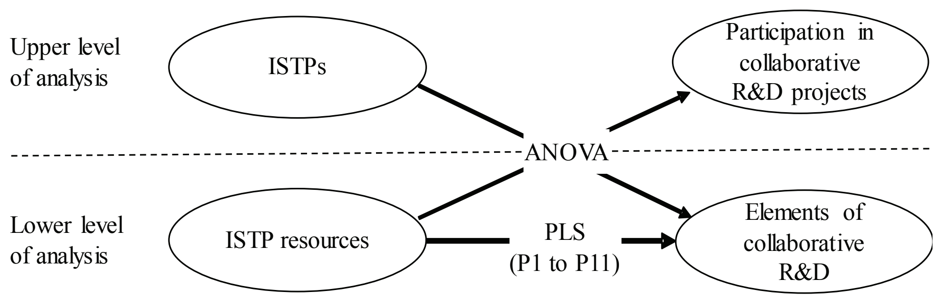


Figure 1. Study method

## ISTP Resources

Since collaboration is one of the strategies for learning and innovation (Dyer & Nobeoka, 2000; Ili *et al.*, 2010), ISTPs should provide hosted firms with access to resources that nurture inter-organizational relationships. Drawing on Barney (1991), ISTP resources can be classified as human, financial (which we also refer to as services), or physical (infrastructure). More specifically, human resources can be subdivided into those providing technical and scientific, legal, marketing and strategy competencies. Financial resources covers both capital from governmental funding agencies and from risk investors. Physical resources include those infrastructure items employed in technical and professional education, in the R&D process and for social activities. Although the literature on collaborative R&D in general does not specify which ISTP resources influence collaborative R&D, some are mentioned. These resources were synthetized and categorized according to the classification above, resulting in 25 variables we used in their operationalization. Table 1 below lists these resources and the respective references from the literature.

Table 1. Resources provided by innovation environments. Synthesized from the literature.

| Resource type | Resources | Variables | References |
|---|---|---|---|
| HUMAN RESOURCES (SERVICES) | Technical and scientific competencies | Student allocation (scholarships, trainee programs)<br>Teachers and researchers<br>Professionals from partner firms<br>Technical and scientific consultants<br>Research institutions | (Bakouros *et al.*, 2002; Etzkowitz *et al.*, 2005; Hansson *et al.*, 2005; Ku *et al.*, 2005; Lahorgue, 2004; Massey *et al.*, 1992) |
| | Legal Competencies | Legal consultancy<br>Intellectual property mechanisms | (Hansson *et al.*, 2005) |
| | Marketing competencies | Commercial feasibility<br>Market research<br>Channel and logistics<br>Price formation | (Hansson et al., 2005; Ku et al., 2005; Lahorgue, 2004; Massey et al., 1992; Radosevic & Myrzakhmet, 2009) |
| | Strategic competencies | Strategic planning<br>Business diagnosis and plan<br>Help with firm structuring | (Ku et al., 2005; Lahorgue, 2004; Massey et al., 1992; Radosevic & Myrzakhmet, 2009) |

| | | | |
|---|---|---|---|
| FINANCIAL RESOURCES (SERVICES) | Financial resources | Funding bids<br>Scholarships<br>Investors | (Hansson et al., 2005; Kihlgren, 2003; Lahorgue, 2004; Radosevic & Myrzakhmet, 2009) |
| PHYSICAL RESOURCES (INFRASTRUCTURE) | Educational infrastructure | Classrooms and auditoria<br>Multimedia equipment<br>Distance learning | (Hansson et al., 2005; Lahorgue, 2004) |
| | R&D infrastructure | Laboratories<br>Equipment | (Etzkowitz et al., 2005; Hansson et al., 2005; Ku et al., 2005; Lahorgue, 2004) |
| | Infrastructure for social activities | Social environments (restaurants, cafeterias, shops and leisure spaces)<br>Sports facilities<br>Spaces for cultural and organizational events | (Hansson et al., 2005; Lahorgue, 2004; Watkins-Mathys & Foster, 2006) |

## Elements of Collaborative R&D

From the literature on collaborative R&D, drawing in particular on Dyer and Singh (1998) and on Groen's networking approach (Groen, 2005), three elements that are potentially influenced by innovation environments were highlighted: Goal Congruency, Governance Mechanisms and Knowledge Complementarity. These elements are explored in detail below and their possible relationship with ISTP resources were translated into eleven exploratory propositions.

### Goal Congruency

The degree of alignment between the objectives of network members is one of the fundamental attributes of the networking process, since it can involve access to, or control of, complementary resources (Dyer & Singh, 1998; Oliver, 1990; Richardson, 2003). Achieving goal congruency is a challenge in formation of inter-organizational relations, since the objectives of members are frequently different and sometimes contradictory. This difficulties and its dependence on each actor's perceptions is translated by Castells (1998) when he calls it "coherency" of the network. For the purposes of this article, Goal Congruency is defined based on Cao *et al.* (2010), as the degree to which the participants in an R&D project perceive their own objectives are met by the objectives of the project.

ISTPs can enhance a given firm's Goal Congruency by providing tenant's access to the adequate network and, consequently, to the resources required for their innovation strategy (Chan *et al.*, 2010; Phillimore, 1999; Tötterman & Sten, 2005). Certain services and infrastructure offered by ISTPs possibly influence Goal Congruency, such as the interests involved in the production of knowledge based on scientific competencies and R&D infrastructure (Gray, 2008). At the same time, a clearer marketing vision stimulated by the development of strategic competencies and sustained by educational infrastructure can help firms realize common opportunities compatible with their internal resources. Firms can also reach agreements in order to obtain technology synergy and knowledge sharing (Oliver, 1990), as well as financial resources for innovation. Access to these resources and their potential relation to Goal Congruency within ISTPs leads to our exploratory propositions P1 to P4:

> *Goal Congruency for collaborative R&D in ISTPs is influenced by tenants' access to: (P1) technical and scientific competencies, (P2) strategy competencies, (P3) educational infrastructure, and (P4) R&D infrastructure.*

### Governance Mechanisms

In the context of collaborative R&D, especially among high technology firms in ISTPs, two governance mechanisms play important roles: Trust and Contract. If trust exists, partners may decide not to include safeguards that are more complete. In such cases, trust substitutes contract. If the intention is merely to formalize the relationship, then trust and contract may play complementary roles. Finally, if no trust exists, contract represents an important mechanism for preventing opportunism. In these cases, contract substitutes trust (Woolthuis *et al.*, 2005). For the purposes of this article, Trust is defined as by Zaheer *et al.* (1998), i.e. the "expectation that an actor (a) can be relied on to fulfil obligations, (b) will behave in a predictable manner, and (c) will act and negotiate fairly when the possibility for opportunism is present".

Business incubators have been found to induce accumulation of social capital and construction of trust relations (Tötterman & Sten, 2005), although Oakey (2007) says this process is limited by the fear of losing intellectual property. Where ISTPs provide infrastructure for social activities, such as restaurants, cafeterias, shops, etc., this can facilitate the exchange of tacit knowledge and help establish a common set of values (Hansson *et al.*, 2005; Ku *et al.*, 2005; Lahorgue, 2004; Watkins-Mathys & Foster, 2006). This sharing of values can improve understanding between the actors and help to create a trust environment (Nooteboom, 2007). Although trust also has wider institutional elements (Bachmann & Zaheer, 2008), empirical studies emphasize that ISTPs can provide fertile ground for trust relations (Castells & Hall, 1994). From this, we derive our exploratory proposition P5:

> *Trust for collaborative R&D in ISTPs is influenced by tenants' access to (P5) infrastructure for social activities.*

The other important dimension of governance refers to the completeness of contractual safeguards. In ISTPs, contractual safeguards may be more or less detailed, depending on the understanding of the contract's role from the actors involved (Woolthuis *et al.*, 2005). Considering ISTPs can provide access to intellectual property and general legal competencies, as well as to financial resources provided by the state, it is reasonable to propose that these resources will be associated with more complete contractual safeguards. This leads to our exploratory propositions P6 and P7:

> *Contractual completeness for collaborative R&D in ISTPs is influenced by tenants' access to (P6) legal competencies and (P7) financial resources.*

### Knowledge Complementarity

Network formation allows easier access to complementary resources for innovation (Dyer & Singh, 1998). In the case of collaborative R&D, complementary resources are primarily scientific, technical and commercial knowledge that complement the resources owned by a firm, enabling it to fulfil its innovation objectives (Dyer & Nobeoka, 2000; Ili *et al.*, 2010; Richardson, 2003). The definition of knowledge complementarity adopted for the purposes of this article is based on Cao *et al.* (2010) and Nonaka (1994) and is stated as "the exchange of tacit knowledge that fulfils or completes the performance of each partner in a collaborative R&D project by the sharing of experiences".

Results indicating that knowledge complementarity is positively influenced by incubators have been reported (Tötterman & Sten, 2005). In the case of science parks, however, the results are ambiguous. While some studies suggest a positive influence on knowledge complementarity (Phillimore, 1999; Tan, 2006; Watkins-Mathys & Foster, 2006), others have identified neutral or even negative influences (Bakouros *et al.*, 2002; Chan *et al.*, 2010; Malairaja & Zawdie, 2008; Westhead, 1997).

Some resources may encourage knowledge complementarity and synergy between ISTP firms, such as R&D laboratories(Löfsten & Lindelöf, 2005; Vedovello, 1997) and equipment (Kihlgren, 2003; Malairaja & Zawdie, 2008; Watkins-Mathys & Foster, 2006). ISTPs can enable access to resources that tenants do not possess, which may be the case of specific technical, scientific and marketing competencies. The origin of these competencies could be suppliers, customers, universities or research institutions; thereby connecting internal firms into a diversified network of relationships. Infrastructure for education can serve as means to become acquainted with the competencies of other tenants, leading to knowledge complementarity. On this basis, exploratory propositions P8 to P11 can be stated as follows:

> *Knowledge complementarity for collaborative R&D in ISTPs is influenced by tenants' access to: (P8) technical and scientific competencies, (P9) marketing competencies, (P10) educational infrastructure, and (P11) R&D infrastructure.*

In the next section, we explore the method used to achieve our study objectives.

## Data Collection

As an emerging country, Brazil is struggling to promote innovation and entrepreneurship. It has 384 incubators that have graduated 2,509 firms. These firms employ 29,205 persons and receive around US$ 1.8 billion in revenues (ANPROTEC, 2012). Data collection was conducted from April to May 2013. A list of 290 ISTPs was extracted from the website of the Brazilian IASP[1] subsidiary, ANPROTEC[2]. Each ISTP was telephoned, given an explanation of the research objectives and then requested to supply a list of their tenants, resulting in a list of 1,004 tenants. We called the person responsible for R&D at each tenant (defined as our respondent), and invited him to participate in our study. A list of 437 e-mail addresses was obtained. Data collection was conducted using SurveyMonkey[1] and respondents were informed that if they took part and completed the questionnaire they would be entered into a raffle to win a tablet, as an incentive to participate. After three reminders sent to non-respondents, 265 questionnaires had been answered. A non-significant number of cases with incomplete data was identified (Kline, 1998) and the mean for the variable in question was used as a substitute in such cases. Outliers were also non-significant, since only one variable from one questionnaire was identified as such.

The scale for independent variables, i.e., the services and infrastructure provided by ISTPs, was designed to measure respondents' opinions on the contribution that ISTPs made to their access to the resources listed in Table 1. The response scale ranged from zero, meaning the ISTP did not contribute to accessing the resource, to three, meaning it contributed greatly. Dependent variables were measured by adapting scales already available in the literature and that offered adequate validity and reliability. The scale for Goal Congruency was based on Cao *et al.* (2010); for Trust, on Zaheer *et al.* (1998); for Contract, on a formative construct from Woolthuis *et al.* (2005); and the measurement for Knowledge Complementarity was based on Wittmann *et al.* (2009) and Deitz *et al.* (2010). Precautions were taken to control common method biases (Podsakoff *et al.*, 2003), such as separating independent and dependent variables using different section of the online form and different scales, ensuring respondent anonymity and careful consideration of item wording constructions. A pre-test was also conducted with four respondents in firms located in ISTPs, which helped to improve ordering and wording of items.

## Results

### Sample Characteristics

The typical firm in our sample is small (83.4% with less than 10 employees), recently established (80.6% less than 5 years) and does business in the high technology market (72.9% in information technology, communications, biotechnology, etc.) Most firms are located within incubators (71.8%) while some of them are situated in science parks (19.6%). Other firms (8.6%) have either recently left their incubators or are hosted in mixed environments (science park and incubator). Most respondents have worked for their

(1) www.surveymonkey.com

company for more than one year (86.4%) and work at the strategic level (78.9%). Less than half of the firms (44.9%) have recently participated in collaborative R&D projects. From those, 51.5% of projects began less than one year previously, 79.8% had durations of less than two years and 69.3% had total values of more than US$ 40 thousand.

**Constructs Analysis**

As ISTP resources were not classified by the literature, these variables were subjected to Exploratory Factor Analysis (EFA) in order to verify subjacent constructs and simplify the theoretical framework. Two variables with lower communalities (< 0.5), “Professionals from partner firms” and “Distance learning”, were excluded, and the final analysis identified five components (Kaiser-Meyer-Olkin [KMO] = 0.913; Bartlett’s $p < 0.01$; total variance explained = 76.4%). Indicator variables were then submitted to re-specification in order to reduce the number of variables and simplify the model. In this process, variables with higher factor scores were selected to represent the constructs. This was performed based on both high correlations between variables and their theoretical contributions to the construct. The resulting structure is presented in Table 2.

Table 2. Factor scores of independent variables. Source: SPSS data

| Independent variable | Component | | | | |
|---|---|---|---|---|---|
| | **Management competencies** | **Technical-scientific competencies** | **R&D and social infra-structure** | **Educational infra-structure** | **Financial resources** |
| Commercial feasibility | 0.831 | | | | |
| Strategic planning | 0.829 | | | | |
| Legal consultancy | 0.732 | 0.353 | | | |
| Student allocation | | 0.809 | | | |
| Teachers and researchers | | 0.795 | | | |
| Research institutions | 0.384 | 0.591 | 0.311 | | |
| Social environments | | | 0.870 | | |
| Sports facilities | | | 0.831 | | |
| Equipment | | 0.363 | 0.676 | | |
| Laboratories | | | 0.582 | | 0.379 |
| Classrooms | | | | 0.899 | |
| Multimedia equipment | | | | 0.837 | |
| Spaces for cultural and organizational events | | | 0.481 | 0.585 | |
| Scholarships | | | | | 0.869 |
| Funding bids | | | | | 0.851 |
| Investors | 0.414 | | | 0.354 | 0.634 |

Note: in the interest of readability, only factor loadings above 0.3 are shown.

As the variables representing elements of R&D collaboration were based on the literature, we subjected them to Confirmatory Factor Analysis (CFA), using Structural Equations Modelling (SEM) (Anderson & Gerbing, 1988)K(. Except for Trust, all constructs showed good reliability (Average Variance Extracted >0.5). This was possibly due to the interpretation of reversed scales, which may have ambiguous meanings in Portuguese. However, since reliability was close to the cut-off limit of 0.5 and the construct already had the minimum number (three) of indicators (Hair *et al.*, 2009), we decided to retain it in the model. CFA resulted in an adequate model fit (RMSEA = 0.76 and CFI = 0.934). The maximum correlation between constructs was 0.549, indicating good divergent validity. Validity and reliability indicators and factor scores are shown in Table 3 below.

Table 3. Factor score weights of dependent variables. Source: AMOS output

| Validity and Reliability indicators | Parameters | Goal congruency | Trust | Contract | Knowledge complement. |
|---|---|---|---|---|---|
| Reliability (Cronbach's Alpha) | >= 0.6 | 0.829 | 0.691 | 0.777 | 0.897 |
| Average Variance Extracted (AVE) | >= 0.5 | 0.563 | 0.365 | 0.598 | 0.694 |
| Maximum Shared Variance | < AVE | 0.289 | 0.286 | 0.286 | 0.289 |
| Average Shared Variance | < AVE | 0.260 | 0.273 | 0.186 | 0.202 |
| **Measurement items** | | **Goal congruency** | **Trust** | **Contract** | **Knowledge complement.** |
| Our partners in the R&D project and we have arrived at a consensus on... | | | | | |
| ... the importance of collaboration on this project | | 0.250 | 0.029 | 0.031 | 0.012 |
| ... the importance of intended innovations and their benefits to all partners | | 0.319 | 0.037 | 0.039 | 0.015 |
| ... the objectives of the project. | | 0.158 | 0.018 | 0.019 | 0.007 |
| Our partners may use opportunities that arise to profit at our expense | | 0.006 | 0.087 | 0.016 | 0.002 |
| Based on past experience, we cannot with complete confidence rely on Supplier X to keep promises made to us | | 0.005 | 0.078 | 0.015 | 0.002 |
| Our partners are trustworthy | | 0.030 | 0.430 | 0.081 | 0.012 |
| Our contract is very detailed regarding... | | | | | |
| ... information leakage | | 0.012 | 0.032 | 0.296 | -0.001 |
| ... ownership rights | | 0.018 | 0.047 | 0.434 | -0.002 |
| ... relationship management | | 0.005 | 0.013 | 0.121 | -0.001 |
| Together, our firms aggregate substantial knowledge to the project | | 0.049 | 0.049 | -0.014 | 0.749 |
| Our partners and we have complementary knowledge that is useful to the project | | 0.007 | 0.007 | -0.002 | 0.107 |
| The R&D project involves knowledge and competencies that complement our own | | 0.008 | 0.008 | -0.002 | 0.129 |

The following sections analyse the three multilevel perspectives represented in Figure 1.

## Multilevel Analysis of Relationships

### *ISTP Resources and the Elements of R&D Collaboration*

Because more than half of the firms in the sample did not participate in joint R&D projects, the analysis of dependent variables could only be conducted for 119 cases. This, together with the number of parameters to estimate in the theoretical framework, makes Partial Least Squares (PLS) the most appropriate tool for multivariate analysis. The framework was translated into a PLS model in order to verify the theoretical propositions. The results indicated that all constructs had good predictive relevance, since the cross-validated redundancy measure ($Q^2$) was greater than zero (Hair *et al.*, 2012)2012 for all constructs.

However, as shown by the results in Table 4, since path coefficients did not reveal any significant relationships between constructs (sig.≤0.05), the empirical data did not support any of the propositions. This means that in our lower level of analysis, the resources provided by ISTPs are not significantly related to the elements of collaborative R&D.

Table 5. Path coefficients and significance of propositions. Source: SmartPLS output

| Prop. | Independent construct | Dependent construct | Path coefficient | t-value | Sig. |
|---|---|---|---|---|---|
| P1 | Technical and scientific competencies | Goal Congruency | 0.168 | 0.983 | 0.326 |
| P2 | Management competencies | Goal Congruency | 0.098 | 0.800 | 0.424 |
| P3 | Educational infrastructure | Goal Congruency | 0.019 | 0.120 | 0.904 |
| P4 | R&D and social infrastructure | Goal Congruency | -0.239 | 1.304 | 0.193 |
| P5 | R&D and social infrastructure | Trust | -0.141 | 0.575 | 0.565 |
| P6 | Management competencies | Contract | 0.169 | 0.781 | 0.435 |
| P7 | Financial resources | Contract | 0.102 | 0.574 | 0.566 |
| P8 | Technical and scientific competencies | Knowledge Complementarity | 0.089 | 0.629 | 0.530 |
| P9 | Management competencies | Knowledge Complementarity | 0.225 | 1.861 | 0.064 |
| P10 | Educational infrastructure | Knowledge Complementarity | -0.210 | 1.014 | 0.311 |
| P11 | R&D and social infrastructure | Knowledge Complementarity | -0.067 | 0.437 | 0.662 |

One of the propositions deserves attention, though. The relationship between management competencies and knowledge complementarity (P9) resulted in a significance (sig=0.064) which is bordering the level of 0.05. This indicates either a weak relationship or the effects of a small sample. Access to management competencies includes support to strategic planning, commercial feasibility and legal consultancy, which can give rise to a fruitful environment where firms can consider their core competencies, including those related to R&D. Increased awareness of internal resources and demands might lead companies to look for potential partners to complement them. ISTP managers may also be acting as knowledge brokers, mediating hosted firms' relationships with other actors and cultivating complementarity. As the significance level of this relationship is below an acceptable level, additional studies are required to explore these issues further.

Strictly speaking, the absence of significant relationships points to inconclusiveness at this level of analysis within ISTPs in Brazil, services, such as the allocation of researchers, students and specific competencies, and infrastructure, for example R&D laboratories and educational spaces, were not found to be significantly related to Goal Congruency, Knowledge Complementarity or Relational Governance.

### ISTPs and the Elements of Collaborative R&D

In order to verify whether other ISTP characteristics are influencing collaborative R&D, its elements were subjected to Analysis of Variance (ANOVA) across ISTPs. Variables with significant variances are indicated in Table 5.

| Collaborative R&D element | Measurement item | Sig. |
|---|---|---|
| Goal Congruency | Our partners and we have reached a consensus on the objectives of the project. | 0.048 |
| Trust | Our partners are trustworthy. | 0.031 |
| Contract | Our contract is very detailed regarding information leakage. | 0.036 |
| | Our contract is very detailed regarding ownership rights. | 0.046 |
| Knowledge Complementarity | Together, our firms aggregate substantial knowledge to the project | 0.005 |
| | Our partners and we have complementary knowledge that is useful to the project. | 0.036 |
| | The R&D project involves knowledge and competencies that complement our own | 0.038 |

Table 5 - Analysis of variance (ANOVA) across ISTPs. Source: SPSS output

Table 5 shows significant differences in variance between ISTPs in variables related to all collaborative R&D elements. In the case of Trust and Goal Congruency, the variable in question has a definition similar to the construct it belongs, when compared to other items. In the case of Contract, measurement items suggest a proximity to the concept of Intellectual Property, since confidentiality and ownership rights are included. All measurement items of Knowledge Complementarity presented significant difference in variance among ISTPs. These results indicate that within an upper level of analysis, ISTPs have, up to a certain point, influence in all collaborative R&D elements proposed here.

**ISTP Resources and Collaborative R&D**

Finally, in order to observe whether ISTP resources influence R&D collaboration, we analysed the variances of ISTP resources between two groups of tenants: those that participated recently in collaborative R&D projects (119 cases) and those that not participated (146 cases). The ANOVA results are represented in Table 6.

Table 6. Analysis of Variance of ISTP Resources. Source: SPSS output

| ISTP resources | Do not participate in R&D Project (n) | Participate in R&D Project (n) | Mean difference | Sig. |
|---|---|---|---|---|
| Financial Resources | | | | |
| Funding bids | 1.275 (131) | 1.806 (103) | 0.531 | 0.000 |
| Scholarships | 0.925 (134) | 1.441 (102) | 0.516 | 0.000 |
| Investors | 1.067 (135) | 1.337 (101) | 0.270 | 0.045 |
| Technical-scientific competencies | | | | |
| Teachers and researchers | 1.351 (134) | 1.698 (106) | 0.347 | 0.022 |
| Research institutions | 1.059 (135) | 1.396 (101) | 0.337 | 0.017 |
| R&D infrastructure | | | | |
| Laboratories | 0.823 (113) | 1.330 (94) | 0.507 | 0.002 |
| Equipment | 0.552 (96) | 0.928 (83) | 0.376 | 0.013 |

Table 6 shows that, in this upper level of analysis, significant differences between project's participants and non-participants are present concerning financial resources, technical-scientific competencies and R&D infrastructure. It is possible to observe some convergence in these categories of resources. Research competences and infrastructure, supported by financial resources, seems to be associated with tenants' engagement in collaborative R&D projects. Some studies contradict (Bakouros *et al.*, 2002; Vedovello, 1997) and others corroborate (Hansson *et al.*, 2005; Löfsten & Lindelöf, 2005) these results. Financial resources are the main drivers to innovation, especially to high technology start-ups (Lahorgue, 2004; Watkins-Mathys & Foster, 2006). Access to external sources of funding and lower fees are among the main motives for tenants to establish in these environments. Possibly, the promotion of funding calls and the incentive for tenants to submit projects are initiatives performed by ISTPs that are associated with these results. Once projects are submitted and approved, then funds are transferred, laboratories are built, research equipment is bought and researchers and students are allocated. In Brazil, governmental agencies, such as CAPES, CNPq and FINEP, are the primary sources of funding that support scientific projects. Direct investment flows from ISTPs to their tenants, as Chandra and Medrano Silva (2012) suggest, is less frequent. In this process, all three actors are performing their roles in the Triple Helix (Etzkowitz & Leydesdorff, 2000) model, but he primary protagonist in this process seems to be the Brazilian government and its policy towards the incentive of scientific research and technology development.

In Brazil, Almeida (2005) suggests that the creation and consolidation of incubators follows the Model III of Triple Helix (Etzkowitz & Leydesdorff, 2000), since it develops from the initiatives of the civil society and involves many types of organizations. In terms of collaborative R&D within these environments, however, since it seems to be government supported, Triple Helix Model I would fit this *modus operandi* better. Implications of these results for theory and practice will be explored in the next section.

## Implications for Theory and Practice

The results obtained here may have important implications for researchers, practitioners and policymakers. ISTPs are relatively recent in Brazil, in comparison with technologically developed regions in the world. The absence of significant relationships in the lower level of analysis, combined with the significant variances found in upper levels of analysis, suggests that factors other than ISTP resources, such as those related to the organizational, inter-organizational or institutional levels, are in fact influencing collaborative R&D.

At the organizational level, it is possible that hierarchy or market coordination structures in this empirical setting are more cost-attractive than those based on collaboration. Oakey (2007), for example, suggests that the ability to work hierarchically in highly focused groups is responsible for R&D success, rather than geographical proximity with potential partners. Other organizational-level variables, for example, legitimacy and reputation (Human & Provan, 1997), competency in relationship management (Powell *et al.*, 1996), perceived lack of control and internal conflicts (Gray, 2008), and absorptive capacity (Cohen & Levinthal, 1990) may be also influencing collaborative R&D.

At the inter-organizational level, variables such as network density (Powell *et al.*, 1996), business diversity in the same innovation environment (Tötterman & Sten, 2005), cognitive distance between actors (Nooteboom *et al.*, 2007), history of conflict, distrust or power differences among partners (Gray, 2008) or the criteria used to select firms (Bakouros *et al.*, 2002) may be influencing collaborative R&D. Institutional-level variables can also be included among the factors influencing collaborative R&D, such as collaborative culture or the national innovation system (Nelson, 1988).

The temporal dimension may also help to understand collaborative R&D within ISTPs. Most firms in our sample are recently founded, which is a reflection from the major presence of incubators. For these firms, relational experiences are still not developed enough to enhance reputation, reduce uncertainty and foster trust between potential partners (Ahuja, 2000). Zollo *et al.* (2002) indicate that firms with weak relational competencies can benefit most from capital-based partnerships, such as joint ventures. Within ISTPs, however, the time and stability needed to cultivate this kind of partnership may not match the firm's size or the dynamics imposed by R&D processes. Hu *et al.* (2005), and also Dittrich and Duysters (2007), support this idea, suggesting that R&D collaboration typically occurs in occasional, rather than continuous relationships. Temporary relationships suit innovation better, but present a challenge to build trust among tenants. This limiting factor may present a barrier to collaborative R&D that inhibits the effects of services or infrastructure. Figure 3 shows the revised theoretical framework that represents the actual findings of this study.

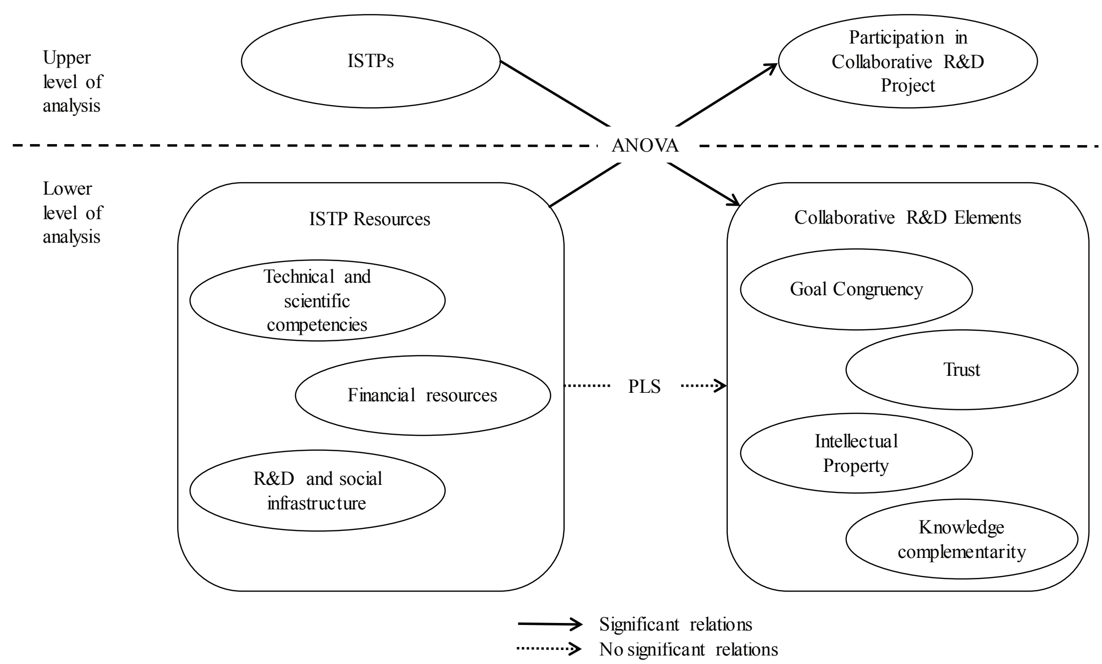


Figure 3. Revised theoretical framework

By acknowledging that ISTPs do influence R&D collaboration through characteristics other than its services or infrastructure, policymakers should realize that fostering innovation cultures is not a straightforward or a short-term agenda. Institutional, inter-organizational, organizational and path dependent factors, as well as all their interdependencies, might as well be considered. This may imply that viewing ISTPs with an instrumental perspective has several limitations, and a systemic approach might be necessary or, at least, recommended.

## Concluding remarks

We addressed multiple levels of analysis to study R&D collaboration within ISTPs, complementing previous efforts that have been made in order to understand these innovation environments better. Our results call the attention of both academics and policymakers to the limited effects of ISTPs' services and infrastructure on collaborative R&D. The specificity level with which we approached Brazilian ISTPs and the empirical relationships we explored contributed with the understanding of these environments and its role as promoters of tenants' collaboration, innovation and regional development. Our contribution indicates that ISTPs in Brazil influence collaborative R&D through elements other than its services or infrastructure.

Some research limitations and potential biases of the present study may also be considered. The sample used here is not representative of the population of Brazilian ISTP tenants, and caution is advisable while generalizing the results. Greater samples could also allow the testing of propositions with more robust multivariate statistical techniques, such as Structural Equations Modelling (SEM), and provide different significance levels. In addition, causality relations among constructs may not be implied, since the conditions for such testing were not met.

We understand that the phenomena of R&D collaboration within incubators and science parks transcends the relationships observed here, endorse previous studies and calls for further academic attention. Approaching this empirical environment is not an easy task. On one hand, idiosyncrasies of the context within which ISTPs are formed and developed and, on the other hand, the complexities inherent to collaborative R&D projects, may prevent identification of generalizable propositions. Considering the issues discussed here, future efforts to comprehend this phenomenon could be directed at exploring different levels of analysis. Theoretically, the exogenous variables discussed above, and epistemologically, complex systems theory, may offer some light.

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(Endnotes)

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